FOI 180818
Document 1

Title of Proposal - Toondah Harbour Development

Section 1 - Summary of your proposed action

Provide a summary of your proposed action, including any consultations undertaken.

1.1 Project Industry Type

Tourism and Recreation

1.2 Provide a detailed description of the proposed action, including all proposed activities.

In June 2013, the Queensland Government declared Toondah Harbour a Priority Development Area (PDA) under the Economic Development Act 2012 (ED Act) at the request of Redland City Council (RCC). PDAs are parcels of land within Queensland identified for specific accelerated development, with a focus on economic growth. The Minister for Economic Development Queensland (EDQ) manages the planning of the Toondah Harbour PDA.

The location was identified by the state and local government on the basis that the area includes the existing marine facility that serves as the base for water taxi, passenger and vehicular ferry services between the mainland and North Stradbroke Island, as well as a public boat ramp for recreational vessels. More than a million passengers and 200,000 vehicles move through the port annually.

The PDA has a total area of 67.4 hectares, encompassing 17.9 hectares of existing land and 49.5 hectares of marine and tidal environments, of which 42 ha overlaps with the Moreton Bay Ramsar Wetland. The area is of variable ecological quality as Toondah Harbour has undergone historical disturbance with a large portion of the PDA previously reclaimed from the 1960s onwards. The site continues to be disturbed by intermittent maintenance dredging and vessel traffic associated with the existing barge and ferry terminals and public boat ramp.

In May 2014, the Queensland Government approved the Toondah Harbour PDA Development Scheme to guide future land use, planning and development decisions in the PDA. The planning intent for the site is to reinforce Toondah Harbour PDA’s role as a community destination and the regional gateway to Moreton Bay and North Stradbroke Island. Further, the Queensland Government has committed to phasing out sand mining on North Stradbroke Island by 2019 and expanding the island’s existing industries to ensure a strong, sustainable economy for residents. The revitalisation of Toondah Harbour is important in supporting the economic transition of North Stradbroke Island from sand mining to ecotourism.

In September 2015, Walker Group Holdings, (the Proponent) was announced as the preferred development partner to redevelop underutilised public land in the PDA. In late 2015, the parties entered into binding commercial agreements for the Toondah Harbour Project (the Project), including a development agreement and an infrastructure agreement. Under the development agreement, the Proponent is responsible for designing, financing and delivering the Project including obtaining environmental and development approvals.

The Project will be constructed over a period of 15 – 20 years including the development or replacement of the existing barge and ferry terminals. The marine operations are part of the existing character of the Moreton Bay Ramsar Wetland and support current residential and tourism traffic to North Stradbroke Island and Moreton Bay. Tourism facilities, marina, mixed use, commercial and residential development, car parking, and public open space will support the new destination and the area's function as a world-class gateway to North Stradbroke Island and Moreton Bay. The project design will also ensure that all components are sympathetic to and support the ecological character of the Moreton Bay Ramsar Wetland to the greatest extent possible. For example, the Project will introduce new conservation areas and a wetland and cultural education centre.

The Project context is provided as Figure 1 with existing approved maintenance dredge areas shown on Figure 1a. A reference design and land use plan is also provided as Figure 2. This forms the referral area, which covers approximately 56 ha including 17.7 ha of waterways, sheltered coves and wetland edges that will not be reclaimed or permanently impacted by the development. Approximately 42 ha of the referral area is located within the boundary of the Ramsar wetland including 12.5 ha of waterways. The current masterplan includes approximately 32 ha of reclaimed land, 10 ha of which is new parklands and conservation areas. The Project has been designed to balance cut and fill with all dredged material to be used for the reclamation.

It is anticipated this footprint will be further refined through detailed ecological and engineering studies as part of the EIS process.

A detailed description of the Project is provided as Attachment 1, including: background to the PDA and Project location; how the Project will integrate with existing boat harbour and operations; a description of the proposed Project land uses; and an outline of how the Project integrates with the ecological character and demonstrates 'wise use' of this part of the Moreton Bay Ramsar Wetland.

1.3 What is the extent and location of your proposed action? Use the polygon tool on the map below to mark the location of your proposed action.

Area	Point	Latitude	Longitude
Referral Area	1	-27.523969866419	153.28637227378
Referral Area	2	-27.523760546769	153.28680142722
Referral Area	3	-27.523379964568	153.28680142722
Referral Area	4	-27.5222572394	153.28965529761
Referral Area	5	-27.533198563891	153.28969821296
Referral Area	6	-27.532684821717	153.28718766532
Referral Area	7	-27.531314830845	153.28523501715

Australian Government
Department of the Environment and Energy

Area	Point	Latitude	Longitude
Referral Area	8	-27.530173158742	153.28401192984
Referral Area	9	-27.529431065517	153.28195199332
Referral Area	10	-27.527851722232	153.28268155417
Referral Area	11	-27.527661438377	153.28199490866
Referral Area	12	-27.526538756929	153.28238114676
Referral Area	13	-27.526729042727	153.28313216529
Referral Area	14	-27.526272356258	153.28332528434
Referral Area	15	-27.526024983628	153.28476294837
Referral Area	16	-27.525244804767	153.28553542456
Referral Area	17	-27.523969866419	153.28637227378

1.5 Provide a brief physical description of the property on which the proposed action will take place and the location of the proposed action (e.g. proximity to major towns, or for off-shore actions, shortest distance to mainland).

Toondah Harbour PDA is located in Cleveland, which is Redland City's civic, commercial and cultural hub and a principal regional activity centre under the South East Queensland Regional Plan 2009-2031.

The referral area encompasses freehold land owned by Redland City Council and State land above and below High Water Mark. Current terrestrial uses of Project land include multiple ferry terminals and public boat ramp, extensive areas of surface car parking, an office complex, and a disused dredged material disposal pond. The overwater areas are made up of a mix of tidal and intertidal habitats with the majority being intertidal mudflat but also include the existing wet berths, swing basin and public navigation channel.

The Toondah Harbour PDA also contains privately owned land that is not Project land. This includes existing residential areas that are not part of the development proposal, and GJ Walter Park (an existing public park with heritage cricket field and off-leash dog park), which is to be retained.

A site and location plan for the area are provided as Figures 1 and 2.

1.6 What is the size of the proposed action area development footprint (or work area) including disturbance footprint and avoidance footprint (if relevant)?

The PDA has a total area of 67 ha. The referral area is approximately 52 ha

1.7 Is the proposed action a street address or lot?

Lot

1.7.2 Describe the lot number and title.L58 on SP115554, L1 on RP145396, L33-35 on C618, L20 on SP153278, L79 on SL7088, L119 on SL9713,

1.8 Primary Jurisdiction.

Queensland

1.9 Has the person proposing to take the action received any Australian Government grant funding to undertake this project?

No

1.10 Is the proposed action subject to local government planning approval?

Yes

1.10.1 Is there a local government area and council contact for the proposal?

Yes

1.10.1.0 Council contact officer details

1.10.1.1 Name of relevant council contact officer.

Peter Kelley, CEO Redland Investment Corp

1.10.1.2 E-mail

Peter.Kelley@redlandinvestmentcorp.com.au

1.10.1.3 Telephone Number

07 3829 8862

1.11 Provide an estimated start and estimated end date for the proposed action.

Start date 03/2020

End date 03/2040

1.12 Provide details of the context, planning framework and State and/or Local government requirements.

Project Assessment Process

The Department of Environment and Energy is the administrative authority in Australia that supports the Ramsar Convention. It meets Australia's obligations under the Ramsar Convention by:

§ Providing national wetland policy leadership;

§ Working with state and territory governments through the Standing Council on Environment and Water;

§ Implementing the EPBC Act; and

§ Developing programs to improve wetland management.

Australian state and territory governments, of which the Queensland Government is one, have primary legislative and policy responsibility for the listed wetlands in their jurisdiction including:

§ Management of listed wetlands;

§ Promoting the conservation and wise use of listed wetlands;

§ Reviewing the condition of listed wetlands;

§ Reporting on the status of listed wetlands; and

§ Leading the development of proposed Ramsar List nominations, including consultation and liaison with the Australian Government.

The Queensland Government has primary responsibility for the Moreton Bay Ramsar Site.

The Project will require approvals under Federal and State legislation.

Federal approvals will be required under the EPBC Act and it is anticipated that assessment will be via an EIS process.

Key State approval requirements and associated processes are outlined below.

Toondah Harbour PDA Development Scheme

On 29 May 2014, the State Government approved the Toondah Harbour PDA Development Scheme to guide future land use, planning and development decisions in the PDA.

The Project is located within the Toondah Harbour Priority Development Area (PDA) therefore is subject to the Toondah Harbour PDA Development Scheme which is implemented under the Economic Development Act 2012 (ED Act) and administered by Economic Development Queensland. The PDA Development Scheme is the regulatory document that controls land use, infrastructure planning and development in the PDA, rather than the local government planning scheme. The Development Scheme overrides other local and state government planning instruments related to the use of the land within the PDA.

The Land use plan part of the Development Scheme regulates development in the PDA and includes a vision, Structure plan, Precinct plan and a Height plan. The Infrastructure plan details the infrastructure necessary to support the Land use plan for the PDA and identifies applicable infrastructure charges. The Implementation strategy describes other strategies and mechanisms that will be used to complement the Land use plan and Infrastructure plan to achieve the outcomes for the PDA.

Development is permissible if it complies with the relevant PDA wide criteria and precinct provisions or does not conflict with the PDA vision and there are sufficient grounds to justify the approval of the development (i.e. superior design outcomes or community need).

The Development Scheme requires the design, siting and layout of development has regard to the environment and:

§ Seeks to first avoid, then minimise and mitigate impacts arising from development within the PDA to sensitive ecological values or Matters of State Environmental Significance within and adjoining the PDA, including koala habitat, intertidal mudflats, mangroves, seagrass beds and fisheries;

§ Seeks to achieve a net gain in koala and marine habitat through the use of compensatory offsets;

§ Establishes vegetated corridors through the PDA which support wildlife habitat, safe fauna movement and open space connections between community focal points;

§ Incorporates landscaping with endemic species, with a preference towards retaining existing vegetation where possible;

§ Utilises planting strategies which are site responsive and reflect the subtropical nature of South East Queensland;

§ Maintains and improves water quality and the functioning and characteristics of the existing hydrological network (including surface and groundwater interactions) and addresses overland flow paths; and

§ Minimises adverse impacts on receiving waters and appropriately manages stormwater including use of total water cycle management and water sensitive urban design principles.

Detailed assessment addressing these issues can be lodged as part of a preliminary approval application or Material Change of Use for the development if sufficient detail is provided.

It is of note that reclamation areas within the Moreton Bay Ramsar Wetland and Marine Park were always considered necessary for the development of Toondah Harbour and are included in the Development Scheme as Precinct 4 – Marina and Water Based Development. The intent of this precinct is to "include development and works undertaken in water based areas of the PDA. This will include the opportunity for a staged marina and land reclamation. Land reclamation, through the ongoing settlement of dredge spoil, provides an opportunity to create land that will be utilised for development in the future. Any areas created through land reclamation will be integrated with the adjoining precinct".

Following the EIS process under the EPBC Act, the Proponent will submit a development application under the ED Act for a Material Change of Use with Plan of Development and an Operational Works application. For the Toondah Harbour PDA, the Minister for Economic Development Queensland has delegated development assessment powers and authority under the ED Act to a Local Representative Committee (LRC) comprising representatives of the Department of State Development, Manufacturing, Infrastructure and Planning and Redland City Council.

Moreton Bay Marine Park

The PDA includes areas of water within a Habitat Protection Zone of Moreton Bay Marine Park and therefore any development proposed within these areas will require assessment and approval under the Marine Parks Act 2004.

As the Project incorporates major works that are likely to have a significant impact on the marine park, such as marinas, reclamation and capital dredging it will require a legislative amendment to declare a works area, or to revoke the area from the marine park prior to any permit assessment.

Section 62 of the Marine Parks (Moreton Bay) Zoning Plan 2008 sets out the process for declaring a works area. This requires satisfying the minister that:

a) there are no suitable alternatives to the proposed major works;

b) an assessment of the social, cultural, financial and environmental outcomes of the proposed major works has been undertaken and supports the location of the proposed major works;

c) the person proposing to carry out the major works has carried out an analysis of the adverse impacts of the proposed major works in the marine park, and has given sufficient details about how the adverse impacts will be addressed; and

d) sufficient public notice of the proposed major works has been given by the person proposing to carry out the major works.

In preparing an amendment to the Marine Park plan to set aside a works area, the Minister may also consider the nature and extent of anything else proposed to be done in addition to the major works that may be beneficial to the natural and cultural resources of the marine park and whether the proposed major works will provide facilities for use by, or for the benefit of, the public. The declaration of the works area allows revocation of that area from the Marine Park.

Under the Marine Parks Act 2004 an EIS can be required for carrying out a reclamation/revocation in a Marine Park, and must address the following information:

§ the proposed use of the reclaimed part of the marine park;

§ the potential impacts of the proposed reclamation on the park's environment and use and non-use values and the environment of areas of waters or land contiguous with or adjacent to the park; and

§ the Ramsar Wetland Information Sheet (RIS) about the proposed regulation revoking the declaration of the reclaimed part of the park.

The EIS does not need to be made specifically under the Marine Parks Act 2004 and can be made under another Act or a law of the Commonwealth or another State. The EPBC Act EIS will address all environmental issues associated with reclamation within the marine park. The Queensland Parks and Wildlife Service (QPWS) will be consulted throughout the assessment process to ensure their concerns are addressed. It is anticipated the Works area application will be lodged concurrently or shortly after the draft EIS is released for public consultation.

Other State and Local Approval Requirements

Certain development will also need to be assessed under new Queensland planning legislation, the Planning Act 2016 (PA), which came into effect in July 2017. Assessable development under the PA at Toondah Harbour will entail:

§ Material Change of Use for an Environmentally Relevant Activity (ERA 16- Extractive Industry – Dredging a total of 1000 tonnes or more of material from the bed of naturally occurring surface waters in a year).

Other approvals may be required under the PA if works are undertaken outside the PDA, however this will depend on the outcomes of the EIS process and the final footprint. These may include:

§ Operational work that is tidal works or work carried out completely or partly within a coastal management district if outside the PDA;

§ Disposing of dredge spoil or other solid waste material in tidal water if outside the PDA;

§ Operational work that in the removal, destruction or damage of a marine plant if outside the PDA;

§ Operational work that is clearing of native vegetation if outside the PDA; and

§ An allocation of quarry material under the Coastal Protection and Management Act 1994 if dredged material is placed above the high water mark.

The Chief Executive of DSDMIP is the Assessment Manager for these application types.

A flowchart conceptualising the approval process for the Project is included as Figure 4.

Other Policies and Strategies

The Project aligns with a range of government and community policies at national, state, regional, and local levels including:

Tourism 2020;

Regional Education, Skills and Jobs Plan for Queensland – Logan and Redlands (2013);

Smart Cities Plan;

Toondah Harbour Priority Development Area Development Scheme;

North Stradbroke Island Economic Transition Strategy;

Advancing our cities and regions strategy – delivering economic and community development outcomes;

ShapingSEQ (South East Queensland Regional Plan 2017);

State Infrastructure Plan 2017;

Queensland Charter for Local Content;

Queensland Government Building and Construction Training Policy;

Redland City Tourism Strategy and Action Plan 2015-2020;

Redland City Economic Development Framework 2014-2021; and

Redland City Corporate Plan 2015-20.

In December 2016, the Federal Minister for Trade, Tourism and Investment recognised the Project's national significance by granting it Tourism Major Project Facilitation (TMPF) status.

1.13 Describe any public consultation that has been, is being or will be undertaken, including with Indigenous stakeholders.

Prior to Walker's selection as preferred development proponent for the Toondah Harbour PDA, Redland City Council and Economic Development Queensland conducted comprehensive public consultation on the Toondah Harbour PDA Development Scheme. According to the State Government's public submissions report, consultation was undertaken in two separate phases:

§ The first phase of consultation occurred in August 2013. The reported purpose was to engage with the community in advance of planning for the Toondah Harbour PDA and inform residents of the PDA process. It is understood that engagement included targeted stakeholder meetings, Open House community forms and online surveys. Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC) representatives were consulted by RCC at this time.

§ A statutory consultation phase then occurred between 10 January and 24 February 2014 entailing public notification of the draft development scheme for Toondah Harbour PDA. It is understood that, in total, there were 10 community forums, an online submission process and distribution of five community mail-outs, advertisements, and public displays. More than 3000 people participated in these engagement activities and 583 submissions were received. The results of assessment were documented in the submissions report, which is publicly available on EDQ's website.

Based on feedback from the public during the consultation on the draft development scheme, the State Government planners amended elements of the draft development scheme to:

§ reduce maximum building heights to 10 storeys;

§ ensure no net loss of public open space within the PDA;

§ provide greater protection for the recreational function of GJ Walter Park;,

§ reduce the size of the proposed marina from a maximum of 800 berths to 400 berths; and

§ establish a vegetated corridor for koalas and their safe movement.

Further consultation will be undertaken as part of future Federal and State assessment processes. A communication and engagement plan has been prepared, which includes establishment of a project website with Fact Sheets, Project Team contacts, a program of public notices, formal correspondence, static information displays, newsletters, surveys, key stakeholder meetings and briefings, staffed information sessions and events.

Alongside the commissioning of technical studies, public notification and consultation with Indigenous stakeholders will form part of the assessment process, reflecting their important ongoing role and knowledge as custodians of land and sea country and Aboriginal cultural heritage.

Additionally, the State Government, as the owner of the state land, has advised that it intend to negotiate an Indigenous Land Use Agreement (ILUA) in the form of an Area Agreement with parties that hold native title in the area. Public notification of the proposed ILUA commenced in early November 2015.

On 8 March 2017, Queensland South Native Title Services submitted the Quandamooka Coast Claim (QC2017/004) with the National Native Title Tribunal. The claim area includes the Toondah Harbour PDA.

A cultural heritage survey and formal Cultural Heritage Management Plan process will be undertaken as required under Part 7 of the Aboriginal Cultural Heritage Act 2003 (Qld).

1.14 Describe any environmental impact assessments that have been or will be carried out under Commonwealth, State or Territory legislation including relevant impacts of the project.

If the Project is declared a ‘controlled action’ under the EPBC Act, the project assessment is proposed to be via EIS.

1.15 Is this action part of a staged development (or a component of a larger project)?

No

1.16 Is the proposed action related to other actions or proposals in the region?

No

Section 2 - Matters of National Environmental Significance

Describe the affected area and the likely impacts of the proposal, emphasising the relevant matters protected by the EPBC Act. Refer to relevant maps as appropriate. The interactive map tool can help determine whether matters of national environmental significance or other matters protected by the EPBC Act are likely to occur in your area of interest. Consideration of likely impacts should include both direct and indirect impacts.

Your assessment of likely impacts should consider whether a bioregional plan is relevant to your proposal. The following resources can assist you in your assessment of likely impacts:

• Profiles of relevant species/communities (where available), that will assist in the identification of whether there is likely to be a significant impact on them if the proposal proceeds;

• Significant Impact Guidelines 1.1 – Matters of National Environmental Significance;

• Significant Impact Guideline 1.2 – Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies.

2.1 Is the proposed action likely to have ANY direct or indirect impact on the values of any World Heritage properties?

No

2.2 Is the proposed action likely to have ANY direct or indirect impact on the values of any National Heritage places?

No

2.3 Is the proposed action likely to have ANY direct or indirect impact on the ecological character of a Ramsar wetland?

Yes

2.3.1 Impact table

Wetlands	Impact
Moreton Bay Ramsar Wetland	See attached the Protected Matters Search Tool results (Attachment 2) and technical note (Attachment 3) addressing the Potential Impacts on the Ecological Character of the Moreton Bay Ramsar Wetland from the Toondah Harbour Project. While the EPBC

Wetlands	Impact
	Significant Impact Guidelines provide some guidance on how to assess impacts to a Ramsar Wetland, the criteria are broad and difficult to apply at a site level to large and ecologically diverse wetlands. Moreton Bay covers an area of approximately 113,314 ha and contains a variety of ecosystems ranging from perched freshwater lakes and sedge swamps on the offshore sand islands, to intertidal mudflats, marshes, sandflats and mangroves next to the Bay’s islands and the mainland. To provide an accurate assessment of potential impacts to the Ramsar wetland at the site level, a significant impact assessment methodology was developed and provided with Attachment 3. The method is adapted from a previously accepted approach developed for the Great Barrier Reef World Heritage Area (Adaptive Strategies 2016), which, while protected under a different international convention, has many similarities in terms of ecological process and protection. The method comprises two components: 1. Contextual information about ecological character to provide a framework for the analysis; and 2. A process to be applied at the local scale. An ecological character description is still in preparation for Moreton Bay Ramsar wetlands (DoEE 2017a). In the absence of a formal ecological character description for the site, the ecological character of the Moreton Bay Ramsar wetland has been defined as those key environmental values that contribute to the listing criteria of the site. Based on this description a number of key attributes have been identified for the Wetland categorised under seven key environmental features; estuarine/intertidal areas, coastal and sub-coastal vegetation, migratory shorebirds, threatened plant species, marine fauna habitat, fish species, and lakes and enclosed water systems. Assessment of these categories were carried out at the site level with the result summarised below: Estuarine/Intertidal Areas – The PDA contains a moderate to minor presence of estuarine and intertidal habitats

Wetlands	Impact
	including sparse seagrass beds, a small area of mangroves and mud flats providing feeding habitat for migratory shorebirds. The PDA contains less than 0.007% of the total area of potential feeding habitat from migratory birds in Moreton Bay and would be considered to provide a minor contribution to the overall ecological character of the wetland. Coastal and sub-coastal vegetation - No swamps were identified by the terrestrial or aquatic ecological surveys as being present within or adjacent to the PDA therefore the site does not provide a contribution to the ecological character of the wetland for these attributes. Migratory shorebirds – The PDA area contains intertidal feeding habitat for a number of migratory shorebirds including the critically endangered Eastern Curlew, the critically endangered Great Knot and the vulnerable Bar-tailed Godwit (Western Alaskan). Similar habitat is found throughout Moreton Bay with the site providing less than 0.001% of this habitat type. Two high tide roost sites are located adjacent to the PDA being the Nandeebie Claypan and Cassim Island (refer to Plan 2). These areas are recognised as having high importance to shorebirds in the region and site design and management will focus on avoiding any permanent or long term impacts to these areas. The site is considered to provide a moderate to minor contribution to shorebird feeding habitat, while adjacent areas provide a significant contribution to shorebird roosting sites. Threatened Plant Species - No threatened flora species have been recorded within a 1 km radius of the study area on the databases that were searched, none were detected during the field survey of the study area, and the study area does not contain habitat suitable for any of the threatened flora species identified as having the potential to occur. The site does not provide a contribution to the ecological character of the wetland for these attributes. Marine Fauna Habitat - Twenty-one migratory marine species were listed as potentially occurring within 5 km of the Project using the protected matters

Wetlands	Impact
	search tool. Of these listed migratory species, 12 species are also listed as threatened species. Of the listed migratory species, loggerhead turtles, green turtles, Indo-Pacific humpback dolphins and dugong are highly likely and hawksbill turtles are moderately likely to occur in the potential area of impact. While potential habitat for these species is located in Toondah Harbour similar or better habitat is present throughout Moreton Bay. The site is considered to provide a minor contribution to the ecological character of the wetland for its marine fauna habitat attributes. Fish - No protected fish habitat is located within or adjacent to the PDA and no threatened fish species are expected to utilise the areas including Oxleyan pygmy perch, which are generally regarded as restricted to streams, swampy areas and lakes in coastal wallum. The site does not provide a contribution to the ecological character of the wetland for these attributes. Lakes and Enclosed Water Bodies - No lakes or enclosed water bodies are present within or adjacent to the PDA. The site does not provide a contribution to the ecological character of the wetland for these attributes. The Project is likely to result in permanent impacts to a small area of shorebird feeding habitat as a result of dredging and reclamation works. While the impact will be small in comparison to habitat for native species present throughout the Moreton Bay Ramsar wetland, as the impact will be permanent and affect an area of minor to moderate ecological character there is the potential for significant impacts to occur. If detailed studies identify significant impacts will occur, an offsets package would be developed in consultation with the DoEE and in accordance with the EPBC Act Environmental Offsets Policy (refer to section 4 of the referral for further details of proposed offsets and benefits). The proposed total works area within the Moreton Bay Ramsar Wetland is approx. 42 ha. This includes significant land uses that are considered ‘wise use’ in a Ramsar wetland setting, including marina, navigation channel,

Wetlands	Impact
	public open space and recreational facilities and a wetland education and cultural centre. The Ramsar principles of avoid, mitigate and compensate in the masterplanning for Toondah Harbour PDA have also been taken into consideration. Although complete avoidance is not possible given the PDA overlaps with the Moreton Bay Ramsar Wetland by approximately 42ha, substantial setbacks (minimum 250m) from Cassim Island and Nandeebie Claypan roost sites have been provided and more intensive land uses have been located in the non-Ramsar component of the site. Where there are residual post mitigation impacts, it will be necessary to compensate or offset the resultant negative change in ecological character. Ramsar Convention Resolution XI.9 sets out decision criteria to be considered during the development and implementation of compensation measures, which will be addressed as part of the formal EIS process. In addition to the increased buffer zones, the Project will be designed and managed to avoid any permanent impact on the adjacent high tide roost sites (Nandeebie Claypan and Cassim Island) through measures including: Construction of appropriate barriers, such as fences to restrict access; ideally, there should be limited/no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds; Landscape and urban design to include sympathetic lighting strategies, vegetation screening and sound attenuation; Increased community education through mechanisms including a wetland education and cultural centre, bird hides, walking trails and interpretive signs; and Creation of approximately 5.1 ha of new intertidal conservation areas. While impacts to the high tide roost sites that adjoin the PDA will be mitigated, it is acknowledged these areas provide a significant contribution to the ecological character of the Moreton Bay Ramsar Wetland. As such, the precautionary principle has been applied and therefore it is considered likely the Project will result in

Wetlands	Impact
	temporary impacts to the roost sites, which may have a significant impact on migratory shorebirds that would need to be mitigated. Further detailed studies will be carried out as part of future assessment processes including development of a shorebird management plan to ensure protection of the high tide roost sites is considered during the planning, construction and ongoing use phases of the development. It is also noted that the sites are mainly utilised by migratory shorebirds over the summer period (approximately December – March) therefore some mitigation measures will be designed to target these times. While appropriate management measures will minimise the potential to impact on the Moreton Bay Ramsar wetland it is acknowledged that, if a precautionary approach is applied, the potential for significant impacts exist. Therefore, the Project is referred as a controlled action to allow more detailed assessment under the EPBC Act to be carried out. It is noted that once projects are within a controlled action process offsets and benefits associated the Project can be considered. The Project will seek to provide an overall benefit to the Moreton Bay Ramsar Wetland through best practice design approaches, mitigation measures and an offsets/compensation package that will provide direct and indirect benefits to the wetland environment. Responses may include in situ and ex situ measures such identifying new areas in Moreton Bay to be designated to the Ramsar wetland, creation of new intertidal habitat around the reclamation area, increased protection of existing high value shorebird animals from disturbance by dogs and people, rehabilitation of areas offsite to increase habitat value, community awareness and education initiatives including a wetland education and cultural centre and improved management of the area through funding for a community ranger program. These beneficial actions will be explored further as part of the controlled action assessment process. There is an approximately 7ha area between the existing public navigation

Wetlands	Impact
	channel and the Nandeebie Claypan roost site, adjoining the PDA that was excluded from the Moreton Bay Ramsar Wetland at the time of mapping in the early 1990s, which has no purpose from a contemporary planning or operational perspective. While this area has high ecological value, it is unprotected and may have value as a direct local compensatory measure. This opportunity, along with other sites, will be assessed as part of the EIS process.

2.3.2 Do you consider this impact to be significant?

Yes

2.4 Is the proposed action likely to have ANY direct or indirect impact on the members of any listed species or any threatened ecological community, or their habitat?

Yes

2.4.1 Impact table

Species	Impact
Loggerhead Turtle (Caretta caretta) Green Turtle (Chelonia mydas) Hawksbill Turtle (Eretmochelys imbricate) Eastern Curlew (Numenius madagascariensis) Bar Tailed Godwit (Limosa lapponica bauera) Great Knot (Calidris tenuirostris) Curlew Sandpiper (Calidris ferruginea) Koala (Phascolarctos cinereus)	See attached technical note (Attachment 4) addressing the Potential Impacts on Threatened Species. Likelihood of occurrence assessments have been carried out by FRC environmental (marine species – refer to Attachment 5) and BAAM (terrestrial species including wader birds – refer to Attachment 6) and using information from the desktop and field surveys assessing the potential for each threatened species and community to utilise the site. The assessments were carried out based on a species potential to utilise any habitats found within the PDA. This approach is considered conservative as the development will not affect all areas of the PDA and the Project will incorporate new wetland and conservation areas that will provide additional habitat for many of the species that may currently utilise the site. Threatened species

Species	Impact
	considered likely to utilise the site are addressed below: Loggerhead Turtle - Moreton Bay supports a significant loggerhead turtle feeding population. Loggerhead turtles are moderately likely to occur in marine habitats within and adjacent to the Project, particularly in the seagrass beds. Green Turtle - Moreton Bay supports feeding populations of green turtles. Green turtles often are observed in the seagrass beds adjacent to the Project. They are highly likely to occur in marine habitats within and adjacent to Toondah Harbour, particularly in the seagrass beds. Hawksbill Turtle - Despite not providing critical habitat, there is a small resident population of hawksbill turtles in Moreton Bay that may feed in, or traverse, the proposed project area. There is a moderate likelihood that hawksbill turtles occur in marine habitats within and adjacent to the Project. Eastern Curlew - During the summer months October 2014 to February 2015, an average of 4.8 and maximum of 7 Eastern Curlew were recorded feeding on mudflats within the study area. Eastern Curlews were also recorded roosting at the Nandeebie Claypan roost site. Bar-tailed Godwit (Western Alaskan) - surveys identified an average of 24.8 and maximum of 36 Bar-tailed Godwits feeding on intertidal mudflats within the Toondah Harbour PDA. The feeding density recorded within the study area (average 0.62 birds/ha, maximum 0.9 birds/ha) is substantially less that the densities of 3 to 8 birds/ha recorded in the highest quality feeding habitats on the eastern side of Moreton Bay. Bar-tailed Godwits were also recorded roosting at the Nandeebie Claypan roost site and at Oyster Point (located 600 m from the PDA). Great Knot – Over all survey periods, a single Great Knot was recorded during the low tide feeding on intertidal mudflats within the Toondah Harbour PDA. The high tide survey results suggest that Great Knot occasionally roosts in relatively small numbers at the Nandeebie Claypan roost site as well as at Oyster Point roost site located 600 m from the PDA. Curlew Sandpiper - During the low tide

Species	Impact
	surveys, Curlew Sandpiper was not recorded feeding on intertidal mudflats within the Toondah Harbour PDA. Furthermore, very few, if any, Curlew Sandpipers appear to use nearby mudflats. This suggests that feeding habitat within the PDA and nearby mudflats is of marginal importance to Curlew Sandpiper. The high tide survey results suggest that Curlew Sandpiper very rarely roosts at the Nandeebie Claypan roost site south of the PDA. Koala - The initial field survey identified 286 koala habitat trees scattered across the western portion of the PDA as a component of the existing urban environment. Koala scats were observed under 33 of these trees, confirming recent Koala use of trees in the PDA. Two Koalas were also observed in habitat trees within the PDA, and up to three Koalas were observed in trees at Nandeebie Park immediately south of the PDA. In late 2016, eight koalas were fitted with tracking devices as part of study initiated by local community groups. Potential direct impacts relate to the removal of habitat or vegetation for infrastructure, dredging or reclamation. The loss of intertidal feeding habitat for threatened migratory shorebird species has the potential to lead to a corresponding decrease in the number of migratory shorebirds using the Moreton Bay wetlands proportional to the loss of habitat IF migratory shorebird populations in Moreton Bay were subject to density-dependent population regulation. However, migratory shorebirds are not currently subject to density-dependent population regulation in Moreton Bay due to the substantial loss of birds from the system. Migratory shorebird populations using Moreton Bay have undergone substantial declines due to outside factors. The declining numbers year on year are mainly associated with disruption in staging sites in other parts of the flyway such as mudflats in the Yellow Sea (refer to Studds et al, 2017). In this case, the loss of a relatively small area of intertidal feeding habitat is unlikely to lead to a corresponding reduction in the number of migratory shorebirds using Moreton

Species	Impact
	Bay. Therefore, the carrying capacity of the Moreton Bay wetlands for supporting migratory shorebirds is likely to be underutilised. The Project will be designed and managed to avoid any permanent impact on high tide roosting sites through the use of buffer areas and a number of other measures including: construction of appropriate barriers, such as fences to restrict access; The project will be designed to avoid public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds; landscape and urban design to include sympathetic lighting strategies, vegetation screening and sound attenuation; and increased community education through mechanisms such as interpretive signs at access points to shorebird habitats and educational programs through a wetland and cultural heritage centre. Potential impacts to marine turtles include loss of habitat (seagrass) for the green turtle, short-term disturbance through turbidity plumes, and an increased chance of collisions from an increase in boat traffic during construction and ongoing use of the marina. The masterplan has been revised to reduce indirect impacts on marine fauna by reducing the number of marina berths from an allowable 400 berths under the Development Scheme to approx. 200 berths. Management measures will be put in place to minimise the impacts to these species, including: developing thresholds for turbidity and suspended solids, and appropriate management (e.g. triggers for ceasing works) for seagrass and corals and monitoring water quality during construction; monitoring changes in seagrass and coral communities post-construction to determine any potential impacts; fitting the dredge draghead with turtle deflectors; putting in place procedures for observing and avoiding marine turtles during construction; and placing speed limits for areas within and around the harbour for all boat traffic The risk of impacts to marine fauna due to noise and boat strike will be reduced further by preparing a Fauna Management Plan including

Species	Impact
	procedures for observing and avoiding turtle species during construction. Once construction has been completed and residential and tourism uses (including the marina) commence there is the potential for ongoing impacts to threatened and migratory species. The actions with the most potential to cause ongoing impacts include: An increase in boating traffic and other recreational uses such as kayaking in and around the project area; An increase in lighting and noise associated with ongoing uses; and Ongoing maintenance dredging of the harbour, marina and entrance channel. Ongoing impacts to migratory birds and marine fauna can be managed through increased management of the site and surrounds, educational tools and awareness raising. A range of measures have been identified that will assist to minimise, mitigate and offset potential impacts to migratory birds and marine fauna, which will be explored in detail as part of the EIS process. Examples include: Increased management of the local area through a community ranger program; Wetland education and cultural centre; Community awareness campaigns; and Educational signage, in particular in areas surrounding high tide roost sites. Toondah Harbour and the 2.55km entrance channel is already subject to periodic maintenance dredging by the state government and impacts would not be expected to be significantly different to what currently occurs. It is of note that impacts from previous maintenance dredging campaigns are considered to be minor and have not previously required referral under the EPBC Act. All options for treatment and disposal of dredge spoil from maintenance dredging will be examined as part of the EIS process. Potential impacts to the Koala, if not carefully managed, include loss of food trees in an urban area, risk of mortality during clearing and increased risk of mortality due to increased vehicle traffic and dog ownership resulting from urbanisation. It is noted that the area is already highly urbanised and the park area surveyed includes a dog off

Species	Impact
	leash area therefore, these impacts are already present In the region. The potential impacts of the Project on Koalas will be mitigated by: Adopting a landscape and urban design that retains as many of the food trees as possible and includes a linear strip of public open space to serve as a corridor connecting retained Koala food trees with bushland habitat in Nandeebie Park to the south of the PDA; Planting additional Koala food trees both within the PDA and surrounding areas where possible, to mitigate any loss of Koala food trees within the PDA; Ensuring that the clearing of any trees during Project construction is performed under the guidance of a licenced fauna spotter; and Using Koala exclusion fencing to fence off areas that may pose a risk of injury to Koala during construction. While management measures will be put in place to mitigate impacts to threatened species, the removal of an area of low tide feeding habitat has some potential to reduce the area of occupancy for endangered and critically endangered wader bird species and/or disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population. While Moreton Bay's carrying capacity of migratory shorebirds and marine fauna species is unlikely to be affected, the project is referred as a controlled action to allow a more detailed assessment under the EPBC Act to be carried out.

2.4.2 Do you consider this impact to be significant?

Yes

2.5 Is the proposed action likely to have ANY direct or indirect impact on the members of any listed migratory species, or their habitat?

Yes

2.5.1 Impact table

Species	Impact
Eastern Curlew (Numenius madagascariensis) Bar Tailed Godwit (Limosa lapponica bauera) Great Knot (Calidris tenuirostris) Curlew Sandpiper (Calidris ferruginea) Whimbrel (Numenius phaeopus) Terek Sandpiper (Xenus cinereus) Grey tailed tattler (Tringa brevipes) Ruddy turnstone (Arenaria interpres) Red knecked stint (Calidris ruficollis) Black tailed godwit (Limosa limosa) Pacific golden plover (Pluvialis fulva)	See attached technical note (Attachment 4) addressing the Potential Impacts on Migratory Species. Database searches identified a total of 33 terrestrial fauna species or sub-species listed as migratory shorebird species under the EPBC Act that may occur within the study area or environs. Eleven of these species were recorded within or immediately adjacent to the study area during field surveys, and a further eight species were identified as having the potential to occur based on database records for the local area and presence of suitable habitat. The remaining 14 species or sub-species were assessed as unlikely to occur. Potential direct impacts relate to the removal of habitat or vegetation for infrastructure, dredging or reclamation. The loss of intertidal feeding habitat for threatened migratory shorebird species has the potential to lead to a corresponding decrease in the number of migratory shorebirds using the Moreton Bay wetlands proportional to the loss of habitat IF migratory shorebird populations in Moreton Bay were subject to density-dependent population regulation. However, migratory shorebird populations using Moreton Bay have undergone substantial declines due to factors outside of Moreton Bay, for example reclamation of mudflats in the Yellow Sea. Therefore, the carrying capacity of the Moreton Bay wetlands for supporting migratory shorebirds is likely to be underutilised. That is, migratory shorebirds are not currently subject to density-dependent population regulation in Moreton Bay due to the substantial loss of birds from the system. The declining numbers year on year are mainly associated with disruption in staging sites in other parts of the flyway (refer to Studds et al, 2017). In this case, the loss of a relatively small area of intertidal feeding habitat is unlikely to lead to a corresponding reduction in the number of migratory shorebirds using Moreton Bay. Other migratory species that may utilise the site include Dugongs and Indo-Pacific humpback dolphins. Potential impacts to these species include temporary disturbance in areas affected

Species	Impact
	by turbidity plumes, boat vessel strike during construction and ongoing use of the harbour and loss of habitat (i.e. seagrass for dugongs). Impacts on migratory species are not expected to be significant and a number of management measures will be put in place to mitigate any indirect impacts (refer to Attachment 4). While Moreton Bay's carrying capacity of migratory shorebirds and marine fauna species is unlikely to be affected, the project is referred as a controlled action to allow a more detailed assessment under the EPBC Act to be carried out.

2.5.2 Do you consider this impact to be significant?

Yes

2.6 Is the proposed action to be undertaken in a marine environment (outside Commonwealth marine areas)?

Yes

2.6.1 Is the proposed action likely to have ANY direct or indirect impact on the Commonwealth marine environment?

No

2.6.2 Describe the nature and extent of the likely impact on the whole of the environment.

Impacts to MNES associated with the marine environment are addressed through responses to section 2.3, 2.4 and 2.5. General impacts to the marine environment are also addressed in **Attachment 5**.

Potential direct impacts to the marine environment include the loss of habitat directly under the footprint of the proposed project. There will also be a gain of habitat in some of these areas. Marine fauna may also potentially be trapped or injured in wet extraction areas; however, management measures including the use of fauna spotters would mitigate the potential for fauna to become trapped or injured.

Indirect impacts to the marine ecosystem may include:

§ disturbance of sediments and soil (increasing turbidity, suspended solids, sedimentation, nutrients, contaminants and potential acid sulfate soils);

§ spills of hydrocarbons and other contaminants;

§ increased stormwater runoff (with greater non-permeable surfaces on the subject site) and associated contaminants and foreshore erosion;

§ altered hydrodynamics;

§ increased site access and boating;

§ spread of weeds and pests; and

§ increased litter.

Following dredging of Fison Channel, water quality is likely to improve around the channel, as deepening the channel will reduce the current disturbance of bottom sediments from boating activities (particularly large passenger and vehicle ferries).

The conceptual masterplan has been revised to reduce indirect impacts on marine fauna by reducing the number of marina berths from up to 400, which are permitted under the Toondah Harbour PDA Development Scheme, to approx. 200.

Significant effort has been invested in the planning and design of the project to minimise impacts on the marine environment and integrate the development with the aesthetic and environmental values of the Moreton Bay Ramsar Wetland. This is achieved through the adoption of ‘wise use’ principles and good practice achieved by successful wetland developments globally. The Project will set out to achieve best practice wetland conservation, education and eco-tourism.

In addition, a number of industry standard measures will be put in place to mitigate these impacts, including:

§ Using the project footprint for any temporary construction and storage;

§ Incorporating structures that provide valuable habitat for fish in the design;

§ Identifying and managing acid sulfate soils and other contaminants;

§ Using temporary enclosures (e.g. complete enclosures such as sheet piles) to reduce the intensity and spatial distribution of turbid plumes during construction;

§ Installing any temporary enclosures at low tide to minimise the number of marine vertebrates caught in the area;

§ Catching any animals that are trapped in the enclosures and releasing them in appropriate habitat outside the area;

§ Using trained marine mammal and turtle spotters prior to commencement of excavation and dredging activities and appropriate management tools to avoid impacts to them (e.g. triggers for cessation of excavation or dredging works);

§ Developing turbidity and suspended solids thresholds and appropriate management (e.g. triggers for ceasing works) for seagrass and corals and monitoring water quality during construction;

§ Avoiding disturbance of sediment and / or soils during important periods of reproduction for coral and seagrass (e.g. late spring and summer);

§ Minimising litter, waste and the use of hydrocarbons and other chemicals;

§ Following national and international best practice standards, including Australian standards relating to antifouling paints and contaminants, *Nature Conservation (Wildlife Management) Regulation 2006*, vessel and vehicle management and site management strategies and fuel storage and handling activities outlined in AS1940;

§ Implementing environmental management plans, including a Marine Fauna Management Plan, Stormwater Management Plan, Sediment and Erosion Management Plan, Waste Management Plan, Weed Management Plan and Spill Management Plan; and

§ Monitoring changes in seagrass and coral communities to determine any potential impacts.

With the use of appropriate mitigation measures, potential impacts to aquatic habitats and communities are likely to be of low significance, other than the direct impacts to marine plants and soft sediment within the footprint, and changes to water quality and soft sediment communities within the dredging and reclamation area.

2.6.3 Do you consider this impact to be significant?

No

2.7 Is the proposed action to be taken on or near Commonwealth land?

No

2.8 Is the proposed action taking place in the Great Barrier Reef Marine Park?

No

2.9 Is the proposed action likely to have ANY direct or indirect impact on a water resource related to coal/gas/mining?

No

2.10 Is the proposed action a nuclear action?

No

2.11 Is the proposed action to be taken by the Commonwealth agency?

No

2.12 Is the proposed action to be undertaken in a Commonwealth Heritage Place Overseas?

No

2.13 Is the proposed action likely to have ANY direct or indirect impact on any part of the environment in the Commonwealth marine area?

No

Section 3 - Description of the project area

Provide a description of the project area and the affected area, including information about the following features (where relevant to the project area and/or affected area, and to the extent not otherwise addressed in Section 2).

3.1 Describe the flora and fauna relevant to the project area.

All Flora and fauna relevant to the project area has been addressed through the assessment of MNES including the Moreton Bay Ramsar Wetland and threatened and migratory species (see **Attachments 3 and 4** to this referral).

Terrestrial and marine ecology technical reports are provided as **Attachments 5 and 6** to this referral.

3.2 Describe the hydrology relevant to the project area (including water flows).

Hydrology

The site is located on the shore of Moreton Bay, away from major rivers or estuarine systems. Consequently, the site is not affected by river flooding.

Being located on the coast, the site may be affected by storm surges. A storm tide hazard study was commissioned by RCC in 2009 to determine storm tide risks in Moreton Bay. The study determined that the 100-year planning level, taking into account storm surge and 0.8 metre sea level rise, should be 3.4 m AHD. This level will be adopted for finished floor levels for the Project.

It is possible that the proposed reclamation and channel dredging could affect coastal currents in the area. Potential impacts will be assessed through detailed hydrological modelling the scope of which will be discussed and agreed with DoEE prior to being carried out.

Existing Water Quality

Three turbidity loggers have been installed at and around Toondah Harbour since September 2015 to provide an indication of baseline water quality. Data collected between 9 September 2015 and 22 September 2017 was summarised and provided as **Attachment 7**.

The mean turbidity over the 24 months of sampling was 20.6 NTU, 30.5 NTU and 12.6 NTU at sites 1, 2 and 3 respectively with 95th percentiles of 74.9, 100 and 40.4. Overall, turbidity was generally highest during the wetter seasons of late spring and summer at all sites. During the wet season, sediment-laden runoff and resuspension of sediments by strong winds can lead to a reduction in water clarity.

Water quality in Queensland is protected under the Environmental Protection (Water) Policy 2009 (EPP (Water)) using Water Quality Objectives (WQOs). The Moreton Bay Environmental Values and Water Quality Objectives (June 2010) specifies a WQO for the project area for turbidity of 5 NTU. The median turbidity at all three sites over the 24 months (7.8 NTU to 11.1 NTU) exceeded the WQO.

Stormwater Management

Most stormwater runoff from the site is currently not captured or treated and enters Moreton Bay through overland and open channel flow, discharging either to the south into a mangrove area, or to the east through GJ Walter Park. Stormwater within the Project area will be captured and treated to meet best practice water quality requirements.

Within the reclamation area, stormwater would be managed through a combination of kerb and channel, pit and pipe and open channel drainage. Stormwater runoff will be discharged into the marina, Fison Channel, or along the new eastern shoreline. It is planned that Water Sensitive Urban Design (WSUD) features, such as constructed wetlands vegetated swales and/or in-pipe gross pollutant traps (GPT), will be incorporated into the stormwater management system for the development.

A Stormwater Quality Management Plan (SQMP) will developed for the site providing a conceptual assessment and plan of site runoff and how it will achieve stormwater quality management objectives during the operational phase of the development. Stormwater quality objectives for sites in Queensland are highly regulated and governed by the State Planning Policy (DSDIP 2013). Specific performance criteria include:

§ 80% reduction in total suspended solids;

§ 60% reduction in total phosphorus;

§ 45% reduction in total nitrogen; and

§ 90% reduction in gross pollutants.

Load reductions will be met and exceeded using a combination of public education and Water Sensitive Urban Design (WSUD) measures such as bioretention basins. Stormwater treatment modelling software such as MUSIC will be used to assess the generation, transportation and treatment of flows and pollutant loads from the site and ensure the reduction criteria will be met.

Education has significant potential to decrease pollutant loads at the source and increases people’s understanding and acceptance of water quality issues and stormwater treatment devices. It is proposed that signage be installed at appropriate locations (e.g. adjacent to proposed bioretention basins).

Such features will be developed further through the design process with the intention of protecting the environmental characteristics of the Moreton Bay Ramsar Wetland and achieving applicable water quality objectives consistent with the Moreton Bay environmental values and water quality objectives (State of Queensland, 2010) pursuant to the Environmental Protection (Water) Policy 2009.

3.3 Describe the soil and vegetation characteristics relevant to the project area.

The referral area is located in an area of known high risk of ASS presence. A significant volume of marine sediment will likely be dredged and used as reclamation material. The dewatering activities proposed may also generate acidic water with potential resulting risks to the adjacent environment if not treated properly.

Prior to any works occurring, a detailed assessment of the sediments within the project footprint, including the Fison Channel, will be undertaken for both potential contaminants and ASS in accordance with the relevant guidelines including the National Assessment Guidelines for Dredging 2009. Following the investigation, management plans describing the management of potential contaminants (if identified) and ASS will be prepared prior to any construction activities commencing.

ASS will be managed in accordance with the latest version of the Queensland Acid Sulfate Soil Management Guidelines.

3.4 Describe any outstanding natural features and/or any other important or unique values relevant to the project area.

All outstanding natural features present at the site are related to the Moreton Bay Ramsar Wetland. This includes:

Marine Fauna Habitat - 21 migratory marine species were listed as potentially occurring within 5 km of the proposed project using the protected matters search tool. Twelve of these species are also listed as threatened under the EPBC Act. Of the listed migratory species, loggerhead turtles, green turtles, Indo-Pacific humpback dolphins and dugong are highly likely and hawksbill turtles are moderately likely to occur in or near the PDA. While potential habitat for these species is located at Toondah Harbour similar or better habitat is present throughout Moreton Bay.

Estuarine/Intertidal Areas – The PDA contains moderate to minor presence of estuarine and intertidal habitats including sparse seagrass beds, a small area of mangroves and mud flats providing feeding habitat for migratory shorebirds. The PDA contains less than 0.001% of the total area for these habitat types in Moreton Bay.

Migratory shorebird Habitat – The PDA area contains intertidal feeding habitat for a number of migratory shorebirds including the critically endangered Eastern Curlew, the critically endangered Great Knot and the vulnerable Bar-tailed Godwit (Western Alaskan). Similar habitat is found throughout Moreton Bay with the site providing less than 0.001% of this habitat type. Two high tide roost sites are located adjacent to the PDA being the Nandeebie Claypan and Cassim Island. These areas are recognised as having high importance to shorebirds in the region and site design and management will focus on avoiding any permanent or long term impacts to these areas.

3.5 Describe the status of native vegetation relevant to the project area.

The Toondah Harbour PDA contains patches of vegetation currently mapped by the Queensland Government as remnant vegetation of the following two regional ecosystems (REs), both of which have a ‘least concern’ status under the VM Act:

§ RE 12.1.2 (Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains); and

§ RE 12.1.3 (Mangrove shrubland to low closed forest on marine clay plains and estuaries).

3.6 Describe the gradient (or depth range if action is to be taken in a marine area) relevant to the project area.

The existing land areas have elevations up to approximately 3 m AHD, gradually grading downwards to the eastern coastline. The tidal area of the PDA ranges in depth up to -1 m AHD (+0.25 m LAT); much of this area is exposed at low tide.

Fison Channel is relatively shallow, with depths of approximately -1.5 m LAT. Maintenance dredging target depths for the channel are -2.5m LAT.

3.7 Describe the current condition of the environment relevant to the project area.

At Toondah Harbour, previous land reclamation and dredging activities have altered the topography and coastline considerably. Part of the referral area under tidal waters and a broader area within the Bay were subject to a coral dredging lease in favour of Queensland Cement Limited until the 1990s.

The aquatic ecological field survey found that the habitats within the Moreton Bay Ramsar Wetland at Toondah Harbour were of varying quality and condition.

The mangrove forests along the foreshore within the referral area are highly disturbed. These mangrove forests receive local runoff from developed areas and litter was caught in the roots and along the shoreline. The mangroves along the shoreline and to the east of the PDA were in fair condition with evidence of insect damage.

The areas of intertidal and sub-tidal, unvegetated mud and sand habitat around Fison Channel are extremely disturbed by frequent boat and ferry traffic, with wash affecting exposed areas at low tide. The rest of the area is moderately disturbed, with runoff from developed areas and impacts due to recreational use.

There has been some disturbance of the seagrass meadows by recreational boat traffic and wash from ferries on the southern section adjacent to the channel. The seagrass meadows are in good condition, although there is some epiphytic algal growth on the leaves.

The saltmarsh near (but outside of) the referral area is highly disturbed, receiving runoff from developed areas along the foreshore. Rubbish was found throughout.

3.8 Describe any Commonwealth Heritage Places or other places recognised as having heritage values relevant to the project area.

No Commonwealth Heritage Places are located on or adjacent to the site.

The *Queensland Heritage Act 1992* (QH Act) protects historical (non-Indigenous) heritage that is of known or potential State significance, including archaeological remains and shipwrecks, and establishes the Queensland Heritage Register (QHR). A search of the National Shipwrecks database indicates that there are no known shipwrecks within 1km of the PDA. A search of the QHR indicates that there are seven State heritage sites in proximity to the Toondah Harbour PDA.

One of these, Fernleigh (SHR# 601374), is located within the PDA. An early residence with an external kitchen (formerly the Cleveland school) Fernleigh is situated on Shore Street, across allotments 14/C14563, 15/C14563 and 16/C14563. The proposed development does not impact on Fernleigh. There are a further three State listed sites adjacent to the PDA: St Pauls Anglican Church (SHR# 600769), the Grandview Hotel (SHR# 600771), and Cleveland Hotel (former) (SHR# 601130). Finally, there are three State heritage sites located within 500m of the PDA: Cleveland Police Station and Court House (former) (SHR#601933), Norfolk Island Pine Trees (SHR#602181) and Ye Olde Court House Restaurant (SHR#600770). The proposed development does not impact on any state listed sites in the vicinity of the PDA.

In addition to these registered heritage places, there is also potential for archaeological remains of state significance to be located in this area. Cleveland was an important wool trade port during the first half of the 19th century, boasting its own customs house, wool stores and stone jetty. There is the potential for remains of this early port activity, as well as of the daily lives of Cleveland’s inhabitants, to be preserved in and around the PDA.

The QH Act also protects local heritage places in conjunction with the Planning Act 2016 and local planning schemes, in this case the Redlands Planning Scheme. While the PDA supersedes the local planning measures, it should be noted that the Toondah Harbour PDA encompasses a local heritage place, GJ Walter Park, and part of the Cleveland Point Character Precinct, which are not part of the development proposal.

3.9 Describe any Indigenous heritage values relevant to the project area.

Toondah Harbour is located in the traditional lands of the Koobenpul peoples, a coastal tribe of the Jagera language group who spoke Jandai and whose territory extended from the mouth of the Brisbane River to Redland Bay. The *Aboriginal Cultural Heritage Act 2003* (ACH Act), administered by the Department of Aboriginal and Torres Strait Islander Partnerships (DATSIP), provides for the recognition, protection and management of Aboriginal cultural heritage.

A search has been undertaken of the Cultural Heritage Register to identify any known places, areas or objects of Indigenous or cultural heritage significance within the project area. No registered Aboriginal Cultural Heritage places were identified in the project area or environs through this search; however, this may be due to lack of survey information rather than the absence of Aboriginal cultural heritage.

The general duty of care under the ACH Act applies to any activity where Aboriginal cultural heritage is located regardless of whether or not it has been identified or recorded in a database. Land users must take all reasonable and practicable measures to ensure their activity does not harm Aboriginal cultural heritage. Potential remains for sub-surface Aboriginal archaeological objects to exist along the original coastal foreshore area.

On 8 March 2017, Queensland South Native Title Services submitted the Quandamooka Coast Claim (QC2017/004) with the National Native Title Tribunal. The claim area includes the Toondah Harbour PDA.

The native title party has successfully registered a cultural heritage body for the area as per the ACH Act. The Quandamooka Yoolooburrabee Aboriginal Corporation RNTBC Pty Ltd is now the registered Cultural Heritage Body for the area, and is the first point of contact for cultural heritage matters.

A Cultural Heritage Management Plan (CHMP) for the project will be developed under Part 7 of the ACH Act during the EIS process.

3.10 Describe the tenure of the action area (e.g. freehold, leasehold) relevant to the project area.

The development footprint comprises freehold land and State land including leasehold, reserve and unallocated state lands.

It is understood that the state land is to be vested in Economic Development Queensland (EDQ). In order for this to occur, EDQ has indicated that it intends to:

§ negotiate an ILUA with the native title party;

§ prepare interim leases/licences for current lessees (operators, RCC) during tenure conversion and future leases/licences for new ferry terminal area as appropriate to ensure no interruption to ferry operating services;

§ ensure that all state land that is currently held in trust or is the subject of a lease will be converted to appropriate tenure before it is made available to Walker for the purposes of the Project; and

§ seek a Development Lease under the *Land Act 1994* to facilitate construction of the marina and land reclamation activities on state land below high water mark, with a view to obtaining the freehold over reclaimed land at the completion of the works.

EDQ expects to maintain continuous ownership of the State land, including the reclamation area, throughout the construction phase of the Project.

The developed lots that are reclaimed land will eventually be transferred to private purchasers, with the exception of the ferry terminals and car parking which will be transferred to the ownership of Redland City Council and the foreshore park and road reserves which will be State reserves managed by Council.

The marina will be sold out of state ownership into private ownership either en globo or as a strata subdivision lot by lot.

3.11 Describe any existing or any proposed uses relevant to the project area.

The existing land uses within the Toondah Harbour PDA include:

§ GJ Walter Park, which includes fields, play space and an unfenced) off leash dog park;

§ commercial passenger and vehicle ferry operations and associated car parking;

§ a disused dredge material spoil pond;

§ public boat ramp;

§ former council office facilities subject to a short term lease by a private trade college; and

§ existing privately-owned low and medium density residential development, which is not part of the development proposal.

Large areas of surface car parking dominate the southern part of the PDA, while the green space of GJ Walter Park dominates the northern portion.

Fison Channel provides access for ferries and water taxis which operate between the mainland and North Stradbroke Island.

The proposed use is the Toondah Harbour Development as outlined in this referral.

Section 4 - Measures to avoid or reduce impacts

Provide a description of measures that will be implemented to avoid, reduce, manage or offset any relevant impacts of the action. Include, if appropriate, any relevant reports or technical advice relating to the feasibility and effectiveness of the proposed measures.

Examples of relevant measures to avoid or reduce impacts may include the timing of works, avoidance of important habitat, specific design measures, or adoption of specific work practices.

4.1 Describe the measures you will undertake to avoid or reduce impact from your proposed action.

Management measures specific to the various MNES that have the potential to be impacted by the action are outlined throughout this referral. In addition to these measures, it is expected that further detailed studies will be carried out as part of the controlled action assessment process. These studies will provide a more detailed analysis of the existing environment and impacting processes and it is expected that the design of the project site included in this referral will be modified in response to these studies

Key studies proposed are outlined below. These studies or expected to be mandated through tailored guidelines issued as part of the EPBC Act controlled action assessment process.

Wise Use through Design

The definition of 'wise use' was adopted by the Ramsar Parties in 1987 and updated in 2005 to state, '***wise use** of wetlands is the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of **sustainable development** '*.

Ramsar Handbook 1 Wise Use of Wetlands (4th edition) indicates that the phrase "*within the context of sustainable development*" is "*intended to recognise that whilst some wetland development is inevitable and that many developments have important benefits to society, developments can be facilitated in sustainable ways by approaches elaborated under the Convention*". The concept further allows for compromises ("trade-offs") and notes, "*adequate and sustainable financing for wetland conservation and wise use is essential and this can be helped by the use of innovative financial instruments and partnerships between those sectors and stakeholders outside the Ramsar Convention who might not have worked together on wetland issues in the past*".

Ramsar Convention *Guidance on marine and coastal area management* (the guidelines) acknowledges, "*human use on a sustainable basis is compatible with Ramsar principles and* *wetland conservation in general".* Human integration with Ramsar wetlands has the potential for significant benefits including education, conservation, mitigation of and adaption to climate change, and the prevention of disease and natural disaster as long as development is implemented utilising the 'wise use' concept.

The wise use concept under the Ramsar Convention sets out to maintain wetland values and functions, while at the same time delivering services and benefits now and into the future, for human well-being. The 'Ramsar Convention guidance on marine and coastal area management' outlines a number of values, functions, goods and services generally supplied by Ramsar and coastal wetlands. These include:

§ Maintenance of existing coastal processes including physical, biological and chemical processes;

§ Mitigation of impacts of natural hazards, pollution, and flooding;

§ Mitigation of, and adaptation to, impacts of climate change and sea-level rise;

§ Providing goods vital for the health, safety and welfare of local populations and services (such as water transport); and

§ Important reservoirs of high species biological diversity, including migratory and non-migratory species and threatened species.

The convention guidance highlights the need to ensure stakeholder participation in conservation and wise use of coastal wetlands. Measures identified include involving local communities and indigenous peoples that have customary rights or tenure in coastal wetlands, and implementing educational programmes that would increase the understanding of the need to protect and conserve coastal wetlands, and their values and functions.

In Australia, Ramsar Wetlands provide the following ecosystem components, processes and benefits:

§ Supporting the diversity and abundance of plants and animals, and providing important habitat and refuges for many migratory, rare or threatened species;

§ Forming part of the natural hydrochloric cycles, providing water passage and storage and the recharge of aquifers;

§ Nutrient cycling and improving water quality by trapping nutrients and sediments;

§ Flood mitigation and providing coastal protection against destructive natural events, such as cyclones;

§ Supporting species to adapt to the effects of climate change by providing refuge and landscape connectivity;

§ Contributing to the sequestration and storage of carbon, to mitigate against climate change;

§ Contributing to Australia's economic productivity by providing essential water sources for agricultural, urban and industrial uses, vital breeding, nursery and harvest sites for edible fish, molluscs and crustaceans, brood-stock for aquaculture and areas of pastures for stock;

§ Contributing to cultural heritage, spiritual values and day-to-day living of Aboriginal and Torres Strait Islander people; and

§ Contributing to the well-being of people through landscape diversity, heritage values, aesthetic appeal and recreation.

(Sourced from the Australian governments Wise Use of Wetlands in Australia Fact Sheet)

The ecological character of the Moreton Bay Ramsar Wetland, including land, water and living resources, have been considered through the master planning process of the Project. The conceptual masterplan has evolved with an emphasis on the ecological enhancement and appreciation of the wetland based on advice from wetland experts and government feedback.

Key themes that have been considered in revising the proposed project include:

§ Conservation – The Project has been revised to reduce its potential impact on the wetland to the extent possible and incorporate the character of the surrounding wetland in its design, while ensuring essential water transport services can be delivered safely and efficiently and the government's objectives for economic and community development of the Toondah Harbour PDA are achieved. Further, the Project will include measures to protect the overall values of the wetland including minimum 250m buffers to high tide roost sites and creation of new intertidal conservation area that will be protected from anthropogenic influences. Offsets for impacts to the Ramsar wetland will also be investigated including the potential to incorporate new areas into the wetland to compensate for reclamation areas.

§ Education – The Ramsar Convention emphasises the importance of education in conservation, having developed their own Capacity building, Education, Participation and Awareness (CEPA) program. This idea will be embraced at Toondah Harbour with the concept of an education/interactive centre in the development with wetland and cultural themes and activities, together with the Conservation Park, educational signage, public art, walking and kayak trails and bird hides.

§ Community welfare and economic transition – Redland City, and particularly North Stradbroke Island (Minjerribah), are undergoing a fundamental change to their economy. In 2016, the Queensland Government legislated to phase out sand mining on the island by 2019. An economic transition strategy is in place that is aimed at expanding the Island's other industries, to ensure a strong sustainable outcome for the community. As the regional gateway to North Stradbroke Island and Moreton Bay and a proposed tourism hub, the Project will support the economic transition from sand mining to eco-tourism. The Project will also offer construction jobs (estimated 1,000 construction related jobs each year during the construction phase) and prospects for permanent job opportunities after its completion (500 jobs each year).

§ Traditional owner involvement – On 8 March 2017 Queensland South Native Title Services filed the Quandamooka Coast Claim (QC2017/004) over 530 km2 of coastal areas and islands in Moreton Bay, including the Toondah Harbour area. The claim was registered by the National Native Title Tribunal from 12 May 2017. The native title party has registered a cultural heritage body for the area under the *Aboriginal Cultural Heritage Act 2003*, namely the Quandamooka Yoolooburrabee Aboriginal Corporation (QYAC). QYAC will lead the cultural heritage survey work for the Project and provide technical input to the EIS process. In addition, the Project will provide a significant business opportunity for indigenous tourism and sharing of cultural awareness (for example, via the wetland education and cultural centre, appropriate interpretation, public art and authentic traditional cultural experiences). It will also deliver an improved stepping off point to North Stradbroke Island (Minjerribah) and the 'Quandamooka Coast', which are ideally placed to become world-leading indigenous tourism destinations.

§ Coastal processes and hazards - A series of interconnected waterways, sheltered coves and wetland edges providing wet berths and marine facilities have been incorporated into the design not only to better integrate the development with the surrounding wetland but to mitigate against the impacts of coastal processes and sea-level rise. Newly created intertidal conservation areas have the potential to provide refuge for flora and fauna during natural hazards and in the event of sea level rise. Detailed hydrodynamic modelling will be carried out as part of the EIS process to further inform the design and maintain existing coastal processes in Moreton Bay.

In addition, key infrastructure items at Toondah Harbour need to be replaced or renewed. This requires substantial investment, and the State Government and Redland City Council have determined that the way to fund those infrastructure works is through redevelopment of the Toondah Harbour PDA. The development proposal within the PDA allows for the necessary improvement of the harbour and marine facilities, which is well overdue.

Site Level Assessment of Ecological Character

An ecological character description (ECD) is being prepared by the State Government for the Moreton Bay Ramsar Wetland. In the absence of a formal ecological character description for the site, this referral has defined the key ecological features of the Moreton Bay Ramsar wetland to be the environmental values that contribute to the listing criteria of the site (refer to **Attachment 3**). Further studies will be carried out early in the environmental impact assessment process to develop an understanding of the features critical to the ecological character of Toondah Harbour and the surrounding area at a site level, within the context of the wider Moreton Bay Ramsar Site.

The site level assessment will follow the approach outlined in the National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands (DEWHA, 2008). It will include a multi-disciplinary approach to conduct an initial evaluation of the ecological components, ecosystem processes and ecosystem services/benefits with information drawn from the Draft Moreton Bay Ecological Character Description, site-specific ecological studies, as well as empirical data and other sources.

Specific activities will include:

§ Identification of critical ecological components including physical form, soils and substrates, biota and physico-chemical components;

§ Identification of critical ecosystem processes including climate, geomorphology, hydrology, energy dynamics, physical processes, species interactions, and nutrient/biogeochemical cycling;

§ Identification of critical ecosystem services/ benefits including provisioning, regulating, cultural and supporting services and linkages with specific beneficiaries; and

§ Brief rationale for defining each of the elements as ‘critical’.

Attachment 3 of this referral provides a preliminary assessment of these features however, it is envisaged this will be further refined and detailed in consultation with DoEE and environment and wetland experts. The site level assessment of ecological character will then form an integral component of the EIS process.

Dredging Requirements and Sediment Analysis

Detailed assessment of all sediments to be dredged will be carried out including:

§ Quantification of the amount of material be dredged and a map of the dredge footprint including proposed staging of dredging activities;

§ Assessment of sediment according to the National Assessment Guidelines for Dredging 2009 (NAGD) including an assessment of the suitability of this material for land deposition and reclamation and offshore disposal at any proposed dredged material disposal ground;

§ Assessment of the risk and potential impacts of acid sulfate soils (ASS) and potential acid sulfate soils (PASS);

§ Consideration of potential impacts of mobilised sediments (e.g. metal or contaminant release);

§ Details of future maintenance dredging requirements over the life of the project. It is expected an on land disposal area will be incorporated into the development; and

§ It is expected that most of the dredged material will be used for the reclamation. However if other disposal options are required, detailed evaluation of all potential onshore and offshore disposal options will be carried out in accordance with the NAGD 2009 and Annex 2 of the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972 (as amended in 2006) (London Protocol) as part of the EIS process.

Dredge Plume Modelling

Peer reviewed, predictive three dimensional modelling of indirect impacts of dredge generated sediment will be carried out as follows:

§ Hydrodynamic modelling;

§ Sediment transport modelling where the range of particle fractions are all modelled;

§ Modelling will include all types of resuspension possibilities including currents and wave-induced bottom shear stresses as well as wave induced mud fluidisation. If not modelled a justification as to why this phenomena was not relevant will be provided;

§ Ecological responses will be included in modelling where possible;

§ The modelling will represent the conditions at the time of year in which the dredging will occur; and

§ Modelling will include likely dispersion and resuspension from both dredging operations and dredge material disposal (if relevant) during a range of probable hydrodynamic conditions, weather events and expected dredge equipment scenarios.

Reclamation

Detailed assessment of the impacts of the proposed reclamation on Moreton Bay will be carried out. Impact assessment will include direct and indirect impacts to ecological features such as seagrass beds, intertidal habitats and roost sites as well as changes to hydrodynamic and coastal processes. Information provided will include:

§ The boundary of the land to be reclaimed, tied to real property boundaries;

§ The location of the line of mean high water spring tide and highest astronomical tide in relation to the area of reclamation;

§ Existing levels of the land and proposed final levels of reclamation in relation to the lowest astronomical tide (LAT) or Australian Height Datum (AHD);

§ Location of marine plants and species habitat within the land to be reclaimed;

§ Typical cross section across the land to be reclaimed showing the proposed finished levels and method of protecting the seaward boundary of the reclamation from erosion;

§ Discussion of how the land reclamation may affect the current erosion and deposition patterns in terms of changes to the low water mark of the Moreton Bay Ramsar Wetland;

§ Discussion of the impacts to the roosting sites (sand bars) at Cassim Island and the Nandeebie Claypan due to potential hydrological changes from dredging and land reclamation. Impacts to other ecologically sensitive areas will also be addressed once modelling has been completed including intertidal habitat and marine vegetation; and

§ Three-dimensional modelling of the impacts of the land reclamation on the current sediment transport and hydrodynamic patterns within Moreton Bay.

Preliminary modelling will be carried out early in the assessment process to inform design of reclamation and other over water areas. The goal of this modelling will be to provide a high-level evaluation of the impact of the conceptual development proposal on the tidal, storm and sediment dynamics at and provide an initial evaluation of the presence of critical ecosystem processes at and around Toondah Harbour as elements of the ecological character of the area.

In addition the following details will be considered during the design of the reclamation and resulting impacts assessed:

§ Quantities and quality of tail water likely to be generated from dredging activities and the rate of their discharge;

§ The settling rate of fine sediments from all dredge material types;

§ Where relevant the residence time within settling ponds prior to discharge (related to dredge pumping rate, ratio of solids to water in the dredged material, settling rates, available capacity of the disposal and settling areas, potential bulking factor, intensity and duration of rainfall events with consideration given to the worst case scenario for these factors); and

§ The source of material for bunds and bund wall stability.

Ecological Studies

While initial terrestrial and marine ecology studies have been completed for the referral, a more detailed assessment will be carried out as part of the controlled action assessment process encompassing all areas that may be affected by the action. Additional ecological studies will include the following information:

§ Provide information on listed threatened and migratory species, including foraging, roosting, resting and nesting habitats, must include but not be limited to:

o describe and map critical habitat for threatened species, ecological communities and migratory species;

o the importance of habitat in a local, regional, national and international context;

o the status of the population (e.g. abundance) in the area likely to be affected by the proposed development relative to other areas outside the area likely to be affected;

o genetic diversity;

o the viability of the local, regional and overall populations;

o local and regional representation;

o conservation and biodiversity values;

o economic, social and cultural values of species;

o the extent (in hectares) of any areas of important or unique habitat; and

o seasonality influences:

§ Provide a description of biota/biotic habitats, including a map of marine/intertidal habitats (including information on seasonal fluctuations e.g. seagrass prevalence), likely to be affected by the proposed development;

§ Identify, describe and map reef communities and those species supported by reef communities in areas likely to be affected by the proposed development, including information on species diversity and abundance;

§ Identify, describe and map seagrass communities in areas likely to be affected by the proposed development, including information on species diversity, seasonality and abundance;

§ Identify, describe and map soft sediment fauna communities (e.g. infauna, benthic invertebrates) in areas likely to be affected by the proposed development, including information on species diversity, seasonality and abundance; and

§ Identify and describe the existing uses of the area and nearby areas that may be affected by the proposed action (for example; tourism, commercial and recreational fishing, research and traditional use activities).

Direct and indirect impacts to MNES will be assessed from construction to on-going use of the area as a marine transport hub, and for a marina and urban development using information obtained through the above studies. Impact assessment will include a detailed analysis of any effects on the ecological character of the Moreton Bay Ramsar Wetland by building on the assessment carried out for this referral (refer to **Attachment 3**). It is expected that the Method for Assessing Impacts on the Ecological Character of Moreton Bay Wetland will be modified in consultation with DoEE to ensure all potential impacts are addressed adequately. Impact assessment will include consequential and cumulative impacts on the Project area and Moreton Bay.

As previously stated , the development footprint, construction methodology and ultimate

uses of the different components of the development may be modified as a result of detailed assessment to ensure indirect impacts are minimised and mitigated.

Management Measures

Detailed assessment will include information on avoidance measures, proposed safeguards and mitigation measures to deal with the impacts of the action. Environmental management will meet or exceed industry standard and will include the following elements:

§ Identify the level of risk associated with potential impacts identified and those that require mitigation, monitoring or management to avoid or reduce impacts to an acceptable level;

§ A consolidated list of measures proposed to be undertaken to avoid, prevent, minimise or manage the impacts of the action;

§ Particular focus will be given to:

o determining factors in the planning of the proposal so as to avoid damage to the environment;

o measures to avoid or minimise damage to the character of the Moreton Bay Ramsar Wetland;

o articulating conservation objectives for individual MNES with a focus on receptors;

o describing how this project is likely to contribute to protection of MNES;

o outline how any avoidance, safeguards, management and mitigation measures will increase resilience of the environment, ecosystems and MNES within the region;

o demonstrate how impact management and mitigation measures would ensure that MNES in the affected region are maintained or improved;

o characterise, quantify and address uncertainties that may affect the effectiveness of management measures and therefore on the confidence that biodiversity values would be maintained (or improved) during and after the project;

o measures to avoid or minimise disturbance to fauna and flora found around and within the proposal area (particularly listed threatened species and communities and listed migratory species);

o management of the dredged material during the loading of the dredged material;

o management strategies for dredging, loading and dredged material disposal, including trigger levels for management actions linked to quantitative measurements of water quality and

Benthic Primary Producer Habitat (BPPH) based on baseline data;

o management of disposal for reclamation-based dredge material, including how water quality will be monitored and managed to ensure that water quality objectives for this area are achieved and the environmental values of the connected surface water and groundwater are maintained; and.

§ An outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the impacts of the action.

Environmental Benefits

While it is acknowledged offsets cannot be considered as part of the referral they provide an additional tool that can be used during project design and the environmental impact assessment process to ensure a project provides an overall benefit to any MNES impacted. A detailed offsets package will be developed through the controlled action assessment process however Walker Group have held discussions with a number of stakeholders to identify a range of offset measures to be put in place as part of the project. These measures may include:

§ Identifying new conservation areas using the following criteria:

o Be located within or adjacent to the Moreton Bay Ramsar Wetland;

o New areas should contain similar characteristics to those impacted; and

o Conservation outcomes associated with the new areas must be achievable and have an acceptable level of risk of success;

§ Investigating the possibility of modifying the Ramsar wetland boundary to designate new areas of shorebird bird habitat to the Ramsar site. This may include approximately seven hectares of Moreton Bay south of the PDA, which contains features of high ecological value such as mangroves and tidal flats. Tidal areas of Moreton Bay are owned and managed by the State therefore; negotiations will be held with the relevant agencies to identify how this could be accomplished;

§ Community ranger education and sponsorship programs to ensure active land and sea country management in Moreton Bay;

§ A feral pest management program;

§ Programs for improving water quality from the adjacent catchment;

§ Various remediation and rehabilitation projects within and adjacent to the Moreton Bay Ramsar Wetland. These could include management of mangrove incursion in Nandeebie Claypan and rehabilitation of salt marsh south of the PDA. Further opportunities will be discussed with the community and relevant government agencies;

§ Koala habitat tree planting in the PDA and surrounding koala movement corridors, and a collaring and monitoring program;

§ Use of sea life friendly propellers for vessels using marina (potential Australia first);

§ Development of a wetland centre within the development area;

§ Creation of new conservation park on eastern boundary with restricted access;

§ Implementation of bird hide/s in various areas;

§ Community awareness programs (koalas, birds, marine life, Aboriginal cultural heritage);

§ Exploration of Moreton Bay fishing net buy back partnership; and

§ A pilot migratory shorebird offset in the Yellow Sea, which would address one of the key reasons for a general decline in migratory birds in Moreton Bay.

4.2 For matters protected by the EPBC Act that may be affected by the proposed action, describe the proposed environmental outcomes to be achieved.

The project is expected to impact on the following MNES:

1. Wetlands of international importance

2. Listed threatened species and ecological communities

3. Listed migratory species.

Further information regarding these impacts is provided in this referral. Walker has committed to completing an environmental assessment as part of the approval process through which impacts to MNES will be assessed and environmental outcomes determined (refer to the response to section 4.1).

Where impacts to MNES or other environmental aspects are identified, these impacts will be addressed in accordance with the following mitigation hierarchy:

§ Avoid – measures taken to avoid creating impacts from the outset;

§ Minimise – measures taken to reduce the duration, intensity and/or extent of impacts that cannot be completely avoided;

§ Rehabilitate / restore – measures taken to improve degraded or removed ecosystems following exposure to impacts that cannot be completely avoided or minimised; and

§ Offset – measures taken to compensate for any residual, adverse impacts after full implementation of the previous three steps of the mitigation hierarchy.

Walker will explore the appropriateness of outcome-based conditions and advanced offsets as part of the EIS process.

Section 5 – Conclusion on the likelihood of significant impacts

A checkbox tick identifies each of the matters of National Environmental Significance you identified in section 2 of this application as likely to be a significant impact.

Review the matters you have identified below. If a matter ticked below has been incorrectly identified you will need to return to Section 2 to edit.

5.1.1 World Heritage Properties

No

5.1.2 National Heritage Places

No

5.1.3 Wetlands of International Importance (declared Ramsar Wetlands)

Wetlands of international importance - Yes

5.1.4 Listed threatened species or any threatened ecological community

Listed threatened species and communities - Yes

5.1.5 Listed migratory species

Listed migratory species - Yes

5.1.6 Commonwealth marine environment

No

5.1.7 Protection of the environment from actions involving Commonwealth land

No

5.1.8 Great Barrier Reef Marine Park

No

5.1.9 A water resource, in relation to coal/gas/mining

No

5.1.10 Protection of the environment from nuclear actions

No

5.1.11 Protection of the environment from Commonwealth actions

No

5.1.12 Commonwealth Heritage places overseas

No

5.2 If no significant matters are identified, provide the key reasons why you think the proposed action is not likely to have a significant impact on a matter protected under the EPBC Act and therefore not a controlled action.

No world heritage properties occur in or near the referral area.

No national heritage places occur in or near the referral area.

The referral area is not located within or adjacent to the Commonwealth Marine Environment.

No Commonwealth land occurs in or near the referral area.

The referral area is not locacted in or near the GBRMP.

The referral does not relate to a water resource, in relation to coal seam gas development and large coal mining development.

The referral does not relate to a nuclear action.

The referral does not relate to a Commonwealth action

Section 6 – Environmental record of the person proposing to take the action

Provide details of any proceedings under Commonwealth, State or Territory law against the person proposing to take the action that pertain to the protection of the environment or the conservation and sustainable use of natural resources.

6.1 Does the person taking the action have a satisfactory record of responsible environmental management? Please explain in further detail.

Walker Group Holdings Pty Ltd is the party taking the action and has a satisfactory record of responsible environmental management.

Lang Walker AO is the majority shareholder of both Walker Group Holdings and Walker Corporation Pty Ltd, which was established in the 1960s and is one of Australia's largest private, diversified development companies.

Walker entities have developed more than 1,000 projects in all states and territories and in all property sectors over a period spanning 50 years. Apart from three instances, outlined below, the companies have a strong record of responsible environmental management.

6.2 Provide details of any past or present proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against either (a) the person proposing to take the action or, (b) if a permit has been applied for in relation to the action – the person making the application.

Walker Group Holdings Pty Ltd has not been subject to proceedings under a Commonwealth, State or Territory Law.

A subsidiary of Walker Group Holdings, Kew Development Corporation was subject to proceedings under State law:

Kew Development Corporation Pty Ltd and Heritage Victoria:

In 2007 Kew Development Corporation (a Walker subsidiary) pleaded guilty to excavating within a Tree Preservation Zone at its Kew Cottages site in Melbourne resulting in the damage to the root of a tree. Kew Development Corporation was required to fund heritage tree protection measures in Kew Cottage's future stages. The tree was retained and is in good health today.

For transparency, Walker Corporation Pty Ltd has been subject to two proceedings under State law:

Director-General Department of Environment and Climate Change (NSW) Walker Corporation Pty Limited:

Walker was found guilty of clearing native vegetation without development consent on land at Picton Road, Wilton NSW on 14 May 2010.

Director-General Department of Environment and Climate Change (NSW) Walker Corporation Pty Limited:

Walker was found guilty of clearing native vegetation without development consent on land at Macquariedale Road, Appin NSW on 30 November 2011.

6.3 If it is a corporation undertaking the action will the action be taken in accordance with the corporation's environmental policy and framework?

Yes

6.3.1 If the person taking the action is a corporation, please provide details of the corporation's environmental policy and planning framework.

Walker Group Holdings Pty Ltd is not a publicly listed company and therefore there are no statutory requirements for it to have a formal environmental policy. However, in recognising the value of the surrounding natural environment, Walker is committed to ensuring the proposal is sustainable. All works will be controlled by conditions of consent associated with approvals issued under Federal and State environmental law.

6.4 Has the person taking the action previously referred an action under the EPBC Act, or been responsible for undertaking an action referred under the EPBC Act?

Yes

6.4.1 EPBC Act No and/or Name of Proposal.

On 25 November 2015, Walker Group Holdings Pty Ltd referred a proposed action to construct a residential, commercial and tourism based development, ferry terminals, open space, and marina at Toondah Harbour, located on the foreshore of Moreton Bay, Queensland (EPBC Act referral 2015/7612). The referral was formally withdrawn on 4 May 2017.

On 11 May 2017, Walker Group Holdings Pty Ltd submitted a new referral for the Toondah Harbour Project with a revised design and impact assessment (EPBC 2017/7939). The action was determined a controlled action on 8 June 2017.

Other Walker entities have previously referred an action, specifically:

· In 2009 Walker Corporation Pty Ltd lodged an EPBC referral for Precinct 1 of the

Australian Government
Department of the Environment and Energy

Buckland Park Residential Subdivision and Development (EPBC 2009/4903). The action was determined as not a controlled action.

· In 2010 Walker Corporation Pty Ltd's proposal to construct and operate a residential and marina development in in Ralphs Bay, Lauderdale was refused (EPBC 2006/3193).

· In 2013 Walker Group Constructions Pty Ltd lodged an EPBC referral for Precinct 2 of the Buckland Park Residential Subdivision and Development (EPBC 2013/6947). The action was determined as not a controlled action.

· In May 2016, Banksia Grove Development Nominees Pty Ltd – a joint venture arrangement in which Walker Corporation has an interest - sought a Prior Authorisation Exemption under the EPBC Act for the Banksia Grove development in Perth, WA.

· In May 2017, Walker Riverside Developments Pty Ltd submitted a referral for the redevelopment of the Adelaide Festival Centre Plaza (EPBC 2017/7945). The action was determined as not a controlled action.

Section 7 – Information sources

You are required to provide the references used in preparing the referral including the reliability of the source.

7.1 List references used in preparing the referral (please provide the reference source reliability and any uncertainties of source).

Reference Source	Reliability	Uncertainties
Studds et al 2017. Rapid population decline in migratory shorebirds relying on Yellow Sea tidal mudflats as stopover sites. Nature Communications 13 April 2017	High	NA
Adaptive Strategies 2016. Method for identifying the presence of OUV within the Great Barrier Reef World Heritage Area. Prepared for Queensland Department of State Development.	High	NA
FRC Environmental 2017. Toondah Harbour Marine Ecology Report.	High	NA
BAAM 2017. Toondah Harbour Terrestrial Ecology Assessment	High	NA

Section 8 – Proposed alternatives

You are required to complete this section if you have any feasible alternatives to taking the proposed action (including not taking the action) that were considered but not proposed.

8.0 Provide a description of the feasible alternative?

Alternative Location

The Toondah Harbour Development is unique based on its location, PDA status, tenure, history and existing use of the area.

Toondah Harbour is an existing marine transport facility that provides access to North Stradbroke Island for business, residents, and visitors.

The site has been subject to proposals dating back 50 years to develop a major boat harbour for recreational vessels and a ‘harbour town’ development, while providing improved marine transport facilities.

The Queensland Government declared Toondah Harbour a PDA in 2013 to accelerate economic development at the express request of RCC. The subsequent joint tendering of the underutilised public lands by RCC and the state government, and the execution of commercial project agreements, further underline the unique nature of the Toondah Harbour Development.

Underutilised public land on Moreton Bay not designated as public parkland or nature reserve is scarce in Redland City. This is a major constraint to tourism-supportive economic development activity in the central part of the Bay. In addition, RCC purchased key parcels of freehold land over a number of years for the express purpose of a development of Toondah Harbour.

The project is tied to the Toondah Harbour PDA, which was declared by regulation by the Queensland Government in 2013. Walker Group responded to an expression of interest issued by the State Government (EDQ) and RCC and the proposed action is consistent with the government parties’ proposal for the Toondah Harbour PDA, which is aimed at facilitating economic and community development. The project land is defined in the development agreement and Walker does not have an alternative location option.

Additionally the Toondah Harbour PDA is an existing marine transport facility, which acts as the base for barge and passenger ferry services to North Stradbroke Island. The existing pubic navigation channel, the Fison Channel, and the swing basin and ferry berths are dredged periodically without a requirement for an EIS process.

Reduced Footprint Options

Of the land above high water mark (HWM) in the PDA, less than 10 hectares is publicly owned and earmarked for development. This area includes the existing ferry terminals, associated car parking, boat ramp, form CSIRO/Council facilities and a dredge spoil pond. The balance land in the PDA is outside of the development footprint and includes GJ Walter Park and existing low density residential development on privately owned land.

More than 40 percent of the project land above HWM constitutes the existing ferry terminals and car parking. Staging and constructability of the development are key considerations given that at no time during the construction phase can disruption to ferry services or net loss of public car parking occur. Proposals for the areas development, past and present, have all involved dredging and reclamation of Toondah Harbour to provide a platform for staging of new development including the new marine transport facilities.

The current proposal envisages a balance of cut and fill so that the dredge material from the marina and public navigation channel will be beneficially reused to create developable land, open space and intertidal habitat. Early examination of options to transport the material for offsite disposal in a marine or terrestrial environment were unviable and gave rise to significant environmental issues and community impacts, which all parties are keen to avoid.

Without Project Option

The without project option would leave Redland City and the SEQ Region in the untenable position that has persisted for many years at Toondah Harbour: poor amenity, safety and operational issues, limited foreshore access, and dilapidated facilities that cannot cater for existing peak demand. These conditions will not support or foster the desired and necessary transition to ecotourism industry for North Stradbroke Island and Moreton Bay following the cessation of sand mining in 2019.

8.1 Select the relevant alternatives related to your proposed action.

8.27 Do you have another alternative?

No

Section 9 – Contacts, signatures and declarations

Where applicable, you must provide the contact details of each of the following entities: Person Proposing the Action; Proposed Designated Proponent and; Person Preparing the Referral. You will also be required to provide signed declarations from each of the identified entities.

9.0 Is the person proposing to take the action an Organisation or an Individual?

Organisation

9.2 Organisation

9.2.1 Job Title

General Manager Development

9.2.2 First Name

Peter

9.2.3 Last Name

Saba

9.2.4 E-mail

peter.saba@walkercorp.com.au

9.2.5 Postal Address

GPO Box 652
Brisbane QLD 4000
Australia

9.2.6 ABN/ACN

ABN

81001215069 - WALKER GROUP HOLDINGS PTY LIMITED

9.2.7 Organisation Telephone

07 3007 7400

9.2.8 Organisation E-mail

peter.saba@walkercorp.com.au

9.2.9 I qualify for exemption from fees under section 520(4C)(e)(v) of the EPBC Act because I am:

Not applicable

Small Business Declaration

~~I have read the Department of the Environment and Energy's guidance in the online form concerning the definition of a small a business entity and confirm that I qualify for a small business exemption.~~

~~Signature:.................................... Date: ....~~

9.2.9.2 I would like to apply for a waiver of full or partial fees under Schedule 1, 5.21A of the EPBC Regulations

No

9.2.9.3 Under sub regulation 5.21A(5), you must include information about the applicant (if not you) the grounds on which the waiver is sought and the reasons why it should be made

Person proposing the action - Declaration

I, Peter Saba, declare that to the best of my knowledge the information I have given on, or attached to the EPBC Act Referral is complete, current and correct. I understand that giving false or misleading information is a serious offence. I declare that I am not taking the action on behalf of or for the benefit of any other person or entity.

Signature:.................................... Date: 30/5/18

I, Peter Saba, the person proposing the action, consent to the designation of Walker Group Holdings Pty Ltd as the proponent of the purposes of the action describe in this EPBC Act Referral.

Signature:.................................... Date: 30/5/18

9.3 Is the Proposed Designated Proponent an Organisation or Individual?

Organisation

9.5 Organisation

9.5.1 Job Title

General Manager Development

9.5.2 First Name

Peter

9.5.3 Last Name

Saba

9.5.4 E-mail

peter.saba@walkercorp.com.au

9.5.5 Postal Address

GPO Box 652
Brisbane QLD 4000
Australia

9.5.6 ABN/ACN

ABN

81001215069 - WALKER GROUP HOLDINGS PTY LIMITED

9.5.7 Organisation Telephone

07 3007 7400

9.5.8 Organisation E-mail

peter.saba@walkercorp.com.au

Proposed designated proponent - Declaration

I, Peter Saba, the proposed designated proponent, consent to the designation of myself as the proponent for the purposes of the action described in this EPBC Act Referral.

Signature:........[signature].................. Date: ...30/5/18............

9.6 Is the Referring Party an Organisation or Individual?

Organisation

9.8 Organisation

9.8.1 Job Title

Principal Environmental Scientist

9.8.2 First Name

Sam

9.8.3 Last Name

Maynard

9.8.4 E-mail

sammaynard@saundershavill.com

9.8.5 Postal Address

9 Thompson Street
Bowen Hills QLD 4006
Australia

9.8.6 ABN/ACN

ABN

24144972949 - Saunders Havill Group Pty Ltd

9.8.7 Organisation Telephone

0732519434

9.8.8 Organisation E-mail

sammaynard@saundershavill.com

Referring Party - Declaration

Australian Government

Department of the Environment and Energy

I, Sam Maynard, I declare that to the best of my knowledge the information I have given on, or attached to this EPBC Act Referral is complete, current and correct. I understand that giving false or misleading information is a serious offence.

Signature:.................................. Date: 30/5/18

Appendix A - Attachments

The following attachments have been supplied with this EPBC Act Referral:

1. 8444_referral_area_v8.zip
2. att_1_-_project_description.pdf
3. att_2_-_pmst_output.pdf
4. att_3_-_ramsar_wetland_assessment.pdf
5. att_4_-_threatened_and_migratory_species_assessment.pdf
6. att_5_-_marine_ecology_technical_report.pdf
7. att_6_-_terrestrial_ecology_technical_report.pdf
8. att_7_-_water_quality_summary.pdf
9. att_7_-_water_quality_summary_revised.pdf
10. figures.pdf
11. submissions-report-toondah-harbour.pdf

Toondah Harbour Development Project Description

Background

In June 2013, the Queensland Government declared Toondah Harbour a Priority Development Area (PDA) under the Economic Development Act 2012 (ED Act) at the request of Redland City Council (RCC). PDAs are parcels of land within Queensland identified for specific accelerated development, with a focus on economic growth. The Minister for Economic Development Queensland (EDQ) manages the planning of the Toondah Harbour PDA.

The location was identified by the state and local government on the basis that the area includes the existing marine facility that serves as the base for water taxi, passenger and vehicular ferry services between the mainland and North Stradbroke Island, as well as a public boat ramp for recreational vessels. More than a million passengers and 200,000 vehicles move through the port annually.

The PDA has a total area of 67.4 hectares, encompassing 17.9 hectares of existing land and 49.5 hectares of marine and tidal environments, of which 42 ha overlaps with the Moreton Bay Ramsar Wetland. The area is of variable ecological quality as Toondah Harbour has undergone historical disturbance with a large portion of the PDA previously reclaimed from the 1960s onwards. The site continues to be disturbed by intermittent maintenance dredging and vessel traffic associated with the existing barge and ferry terminals and public boat ramp.

In May 2014, the Queensland Government approved the Toondah Harbour PDA Development Scheme to guide future land use, planning and development decisions in the PDA. The planning intent for the site is to reinforce Toondah Harbour PDA's role as a community destination and the regional gateway to Moreton Bay and North Stradbroke Island. Further, the Queensland Government has committed to phasing out sand mining on North Stradbroke Island by 2019 and expanding the island's existing industries to ensure a strong, sustainable economy for residents. The revitalisation of Toondah Harbour is important in supporting the economic transition of North Stradbroke Island from sand mining to ecotourism.

The proposed redevelopment of Toondah Harbour is not a market led proposal - it did not originate from the private sector or from the Proponent specifically. In June 2014, EDQ and RCC called for expressions of interest from the private sector to redevelop public lands in the Toondah Harbour PDA. The Expression of Interest Information Memorandum noted that there was 6.9 hectares of key developable land parcels included in the offering at Toondah Harbour, with opportunity to develop land within the PDA below the High Water Mark. The information memorandum stated, "*Development within the PDA provides an opportunity to support economic development and reinforce Toondah Harbour's strong community identity and role as the gateway to Moreton Bay and North Stradbroke Island. Development opportunities include mixed use, medium density residential, marine, tourism and retail based development and the potential for a private berth marina, subject to relevant approvals.*"

Additional infrastructure and public realm requirements were detailed as follows: "*Proponents will pay infrastructure charges for the development projects. However, in addition to the commercial elements of the project, proponents will also be expected to contribute to the delivery of additional PDA wide infrastructure or improvements that are required to realise the PDA vision and ensure the effective operating of the area as a transport and tourism hub. The government parties are seeking to upgrade or implement the following items and proponents should consider how they would contribute to the delivery of these items as an integral part of their proposals:*

- *the new waterfront plaza;*
- *provision for ferry terminals (minimum of two vehicle ferry terminals and two passenger ferry terminals);*
- *ticketing and information centre associated with the plaza;*

- *capital dredging to straighten and widen the Fison Channel and extend the swing basin;*
- *contiguous boardwalk promenade along the waterfront;*
- *improvements to GJ Walter Park;*
- *car parks associated with the ferry terminals to be delivered through a combination of at grade parking and managed off-street carparking; and*
- *a bus interchange."*

The proposed project provides for the delivery of all additional infrastructure and public realm requirements as part of a single integrated proposal at no cost to the ratepayer or taxpayer.

In September 2015, Walker Group Holdings, (the Proponent) was announced as the preferred development partner to redevelop underutilised public land in the PDA. In late 2015, the parties entered into binding commercial agreements for the Toondah Harbour Project (the Project), including a development agreement and an infrastructure agreement. Under the development agreement, the Proponent is responsible for designing, financing and delivering the project including obtaining environmental and development approvals.

The project will be constructed over a period of 15 – 20 years including the development or replacement of the existing barge and ferry terminals. The marine operations are part of the existing character of the Moreton Bay Ramsar Wetland and support current residential and tourism traffic to North Stradbroke Island and Moreton Bay. Tourism facilities, marina, mixed use, commercial and residential development, car parking, and public open space will support the new destination and the area's function as a world-class gateway to North Stradbroke Island and Moreton Bay. The project design will also ensure that all components are sympathetic to and support the ecological character of the Moreton Bay Ramsar Wetland to the greatest extent possible. For example, the project will introduce new conservation areas and a wetland and cultural education centre.

Integration of the Existing Boat Harbour and Operations

As noted above, the public tender process required the successful proponent to deliver, as an integral part of its proposal, capital dredging to straighten and widen the Fison Channel and extend the swing basin. This existing public navigation channel is 2.55km long and typically 45 metres wide. It extends from the swing basin immediately in front of the existing barge berths, via three significant bends to exit into deeper water approximately 1.5km past Cassim Island. The swing basin's existing diameter is significantly below the accepted minimum of 1.5 times the maximum length of vessels currently utilising the harbour.

Barges travelling to and from North Stradbroke Island are regularly observed 'bottoming out' in Fison Channel, generating turbidity plumes and risking damage to the vessels. The Fison Channel is periodically subject to maintenance dredging with the most recent dredging event approved in 2013 and carried out in 2014. This dredging event saw the Department of Transport and Main Roads receive approval for a Material Change of Use for Environmentally Relevant Activity (ERA) 16-(1c) Dredging >100,000 tonnes but <1,000,000 tonnes year, to dredge the channel to a depth of -2.5m Lowest Astronomical Tide (LAT). This previously approved maintenance dredging extended significantly into the Moreton Bay Ramsar wetland with dredge areas shown on Figure 1 and 1a.

The Proponent must also ensure that there is no impediment to the operation of existing ferry services or net loss of public car spaces at any stage during the construction of the Project, which necessitates delivery of a replacement terminal facility and car park area before the existing land assets are available for the Project.

The design approach Walker has adopted in response to this challenge is to:

- appropriately realign the channel to reflect the new terminal location;

- optimise the reduction of channel bends to minimise capital dredging and disturbance of previously undisturbed areas;
- provide an entrance channel width and depth to allow safe navigation for future vessel requirements, including the North Stradbroke Island barges in accordance with recognised and accepted international navigation authority standards;
- provide unimpeded turning basin area with a minimum diameter in accordance with accepted practice;
- provide stable dredge batter slopes for all new dredge area work; and
- consider ambient, prevailing and storm weather conditions, tidal, surge and wave conditions, climate change and sea level rise predictions.

On this basis capital dredging to deepen and widen the channel to a target depth of -3 m LAT with a base width of 75 metres is proposed, however this will be subject to detailed design and operational considerations. For example, greater target depths in areas of high sedimentation, such as channel bends, will be considered to reduce the frequency of maintenance dredging. A preliminary review of existing conditions suggests that the three existing channel bends could be reduced to two; however, this will be subject to detailed coastal processes and environmental investigation as part of the EIS process.

Preliminary engineering analysis indicates that a minimum of 500,000 cubic metres of material would need to be removed from the channel. Removing and disposing of this material at land or marine-based disposal sites outside of the PDA would be costly and presents significant environmental and logistical issues. An existing dredged material disposal pond is located to the south of the harbour; however, it is currently full and had a maximum capacity of 37,000m3 when empty. If reclamation is not carried out, dredged material would need to be transported offshore or to a new on land facility for disposal.

The National Assessment Guidelines for Dredging 2009 state: *"It is important to recognise the potential value of dredged material as a resource. Possible beneficial uses include engineered uses (land reclamation, beach nourishment, offshore berms, and capping material) agriculture and product uses (aquaculture, construction material, liners) and environmental enhancement (restoration and establishment of wetlands, upland habitats, nesting islands, and fisheries)."*

Beneficial reuse of dredge materials is therefore proposed to reclaim land for development areas and create new intertidal habitat including high tide roosting areas in preference to transporting material to an alternative marine or land-based location. The dredging and land reclamation activities are expected to occur in discrete stages that in aggregate amount to approximately three to five years of intermittent activity. The project is being designed with the intent of achieving a net balance between dredging and reclamation. If an additional dredged material disposal location is required options, including offshore, onshore and beneficial reuse will be investigated as part of the EIS and detailed design processes.

Proposed Uses

The Project context is provided as **Figure 1** with existing approved maintenance dredge areas shown on **Figure 1a**. A reference design and land use plan is also provided as **Figure 2**. This forms the referral area, which covers approximately 56 ha including 17.7 ha of waterways, sheltered coves and wetland edges that will not be reclaimed or permanently impacted by the development. Approximately 42 ha of the referral area is located within the boundary of the Ramsar wetland including 12.5 ha of waterways. It is anticipated this footprint will be further refined through detailed ecological and engineering studies as part of the EIS process.

Key components of the proposed development include:

Harbour precinct

The proposed new ferry terminal and upgraded harbour precinct will replace the existing dilapidated, industrial facilities. The concept master plan for the proposed development includes:

- three roll on/roll off vessel berths (same number as the existing facility);
- two passenger ferry berths (same number as the existing facility);
- ticket and tourist information centre;
- vehicle queuing areas;
- 1,010 ferry public car parks, with provision for a further 500 in a multi deck car park (the existing facility has 667 car parking spaces);
- public plaza;
- bus-ferry interchange;
- marine services building; and
- opportunity for charter boat berthing to facilitate new ecotourism operations and nature based tourism experiences for the local area, North Stradbroke Island and Moreton Bay.

The detailed technical studies to be undertaken as part of the EIS process will inform the detailed design of proposed marine infrastructure.

The harbour facilities will be designed, funded and constructed by the proponent and handed over to Redland City Council to own and operate.

Marina

Floating pontoons and berths will be located in waterways and coves within the development to minimise the size of the marina and impact on the wetland. The project will provide approximately 200 new berths for recreational and commercial vessels. This is a substantial reduction in the number of marina berths from the previous proposal. Navigation aids, lights and signage will be provided in compliance with Queensland marine safety requirements.

Open space and intertidal communities

The proposed master plan for Toondah Harbour reflects its bayside position and improves community access to Moreton Bay by delivering new public open space, conservation areas and community amenities. These include:

- A linear 3.5 ha conservation area, which provides a buffer zone between proposed development and the Cassim Island high tide roost site. This area is not intended for general public access but may have controlled access with supervision and guided walks associated with wetland education and community ranger programs;
- A wetland and cultural education centre, which will operate as the gateway into the conservation area and act as a focal point for promoting public education, community awareness, community ranger program, and Indigenous and nature based tourism experiences. It is anticipated that the centre will be designed in consultation with wetland experts, key local stakeholders including public and not for profit organisations and the registered Aboriginal cultural heritage body for the area. Its design, ownership, governance and programming will be determined during the EIS and detailed design processes;
- A linear 3.5 hectare foreshore parkland, which provides new public parklands, water park and boat launching facilities for recreational vessels;
- A range of boardwalks, plazas, nature trails, pocket parks and bio-retention areas integrated throughout the development; and
- Minor embellishments to GJ Walter Park, the existing public park, which will be retained.

Mixed uses

The mixed use precinct will include residential, retail (max 5000 m^2 GFA), commercial uses (max 2500 m^2 GFA), and tourism facilities.

Residential uses

Residential areas will generally comprise small 'village style' precincts of three to four buildings surrounded by walkways, waterways, urban wetlands and communal spaces to allow for integration with and appreciation of the Ramsar wetland. A concept for an urban development precinct is provided as Figure 3.

Up to 3,600 dwellings are proposed which would be delivered over a 15 to 20 year period, staged according to market demand. The maximum building height allowable under the Toondah Harbour PDA Development Scheme is 10 storeys; however, the proposed development will deliver a variety of buildings with heights ranging from two to 10 storeys. The taller buildings will be stepped well back from the roost sites and any buildings directly facing the roost sites will be in the two to three storey range.

Dredging and reclamation

Dredging will be carried out in two locations during the initial construction phase:

- Capital dredging within the marina basin and marina access channel; and
- Maintenance and capital dredging for expansion of the existing Toondah Harbour marine access (Fison Channel) to allow for safe navigation.

Material will be dredged using suitable equipment, such as a cutter suction dredger (CSD) or barge-mounted backhoe dredger. The preferred type of dredger will be selected based on the material properties of the dredged material. Dredged material will be transported directly to the reclamation areas through a pipeline or barges. A perimeter bund will be established around reclamation areas to contain the fill, and limit the amount of fine material to be released to the environment.

The current masterplan includes approximately 32 ha of reclaimed land, 10 ha of which is new parklands and conservation areas. The project has been designed to balance cut and fill with all dredged material to be used for the reclamation.

Maintenance dredging will also be considered as part of the EIS process. Options to be considered include the incorporation of an onshore material rehandling area into the project to provide temporary storage for maintenance dredged material or offshore disposal, for example, at the existing Mud Island material disposal area, subject to relevant permissions.

Wise Use of the Ramsar Wetland

It is noted that the development was previously referred in 2017 (Referral No. 2017/7939) however the proposal has undergone design changes to better integrate with the ecological character and demonstrate 'wise use' of this part of the Moreton Bay Ramsar Wetland.

The mission of the Ramsar Convention is "*the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world.*" Under the Ramsar Convention, projects and developments may occur in Ramsar wetlands, but they must maintain or enhance the ecological character of the site, and be in accordance with 'wise use'.

In Australia, ecological character is considered to be the critical components, processes and services of the Ramsar wetland. For the Moreton Bay Ramsar site, these will be set out in the Ecological Character Description (ECD), which is currently in draft format and has not been released publically. The wise use concept refers to maintaining wetland values and functions, while at the same time delivering services and benefits now and into the future, for human well-being. Wise use, in promoting maintenance of environmental, economic and social sustainability, encourages compromise (or trade-offs) between individual and collective interests. The Toondah Harbour project must ultimately meet the test of compatibility of the wise use and conservation purposes.

The Ramsar Convention identifies environmental impact assessment as a tool for Contracting Parties to work with developers to reduce the impact of development proposals with potential to alter the ecological character of wetlands on the Ramsar list, and to implement the wise use principle. Resolution VII.16 of the convention calls upon the Contracting Parties to ensure that such projects are subject to rigorous impact assessment procedures, with appropriate measures to address adverse impacts and monitoring to detect unforeseen impacts.

The project footprint has been modified to better reflect the ecological character and wise use of the wetland. This includes a minimum 250 m buffer between the high tide roost sites and any urban or tourism uses, reduction of the development footprint being entirely contained within the PDA (aside from the Fison Channel works) and a wetland education and cultural centre. Additional changes, including integration of wetlands and other habitats into the urban footprint, are addressed through this referral and summarised in section 4.1 of the referral.

The proposed development incorporates a number of land uses that are generally considered 'wise use' in the context of sustainable development in a Ramsar setting, including harbour, navigation channel, marina, public open space, conservation areas and recreational facilities.

Residential uses are considered necessary to provide a vibrant and financially sustainable destination and to ensure that the benefits in terms of employment, education and conservation will accrue from the project. The development and implementation of compensation measures for loss of wetland resources will be addressed as part of the EIS process.

By virtue of the PDA location, which has been established by regulation based on the siting of the existing harbour facility the Project cannot progress without some interaction with the Ramsar wetland. Effort has been invested in the planning and design of the project to minimise impacts and integrate the development with the aesthetic and environmental values of the wetland. This is achieved through the adoption of 'wise use' principles and modelling itself on successful wetland developments globally by incorporating world leading best practice wetland conservation, education and eco-tourism. This process is further detailed in section 4 – measures to avoid or reduce impacts – of this referral.

Australian Government
Department of the Environment and Energy

FOI 180818
Document 3

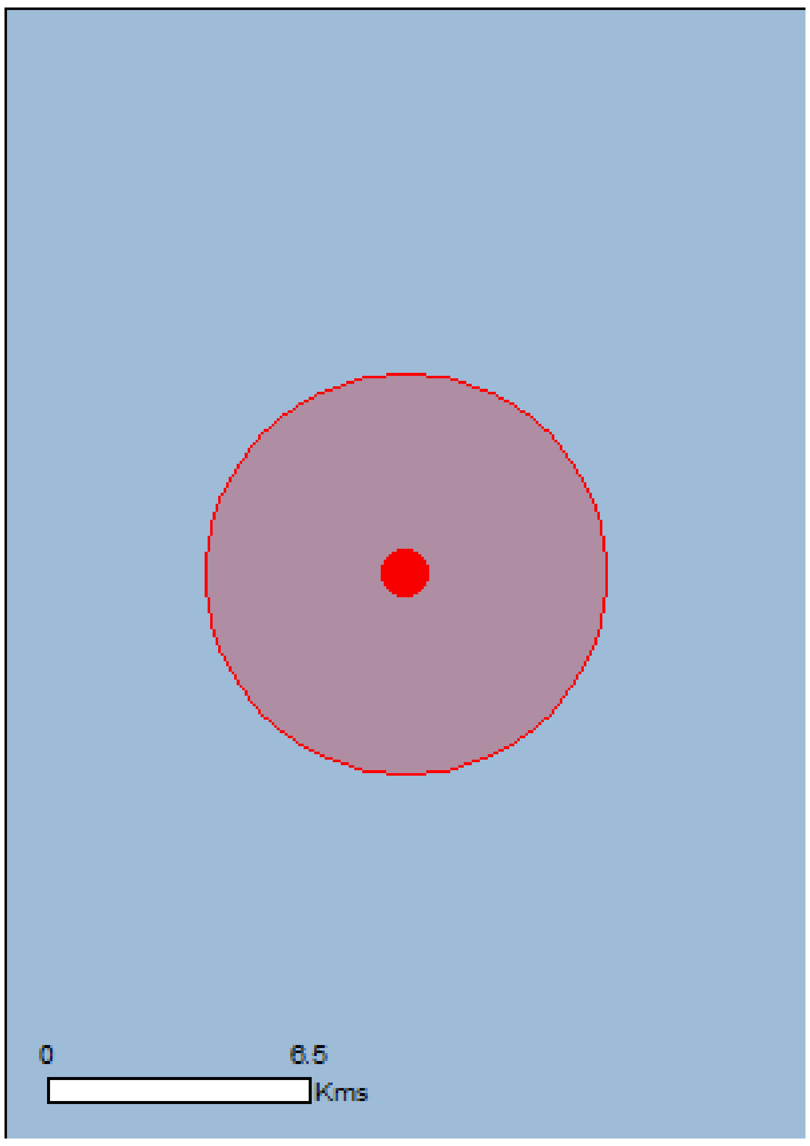
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 18/04/18 07:47:49



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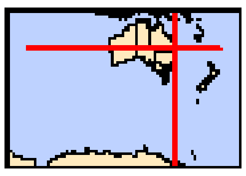

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	66
Listed Migratory Species:	76

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	111
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	40
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Moreton bay	Within Ramsar site

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community may occur within area
Lowland Rainforest of Subtropical Australia	Critically Endangered	Community may occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia		
Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus		
Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Dasyornis brachypterus		
Eastern Bristlebird [533]	Endangered	Species or species habitat may occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis gibsoni		
Gibson's Albatross [82270]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat likely to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat may occur within area
Insects		
Argynnis hyperbius inconstans Australian Fritillary [88056]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE mainland) [66645]	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Arthraxon hispidus Hairy-joint Grass [9338]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Baloghia marmorata Marbled Balogia, Jointed Baloghia [8463]	Vulnerable	Species or species habitat may occur within area
Cryptocarya foetida Stinking Cryptocarya, Stinking Laurel [11976]	Vulnerable	Species or species habitat may occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
Endiandra floydii Floyd's Walnut [52955]	Endangered	Species or species habitat may occur within area
Macadamia integrifolia Macadamia Nut, Queensland Nut Tree, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat may occur within area
Macadamia tetraphylla Rough-shelled Bush Nut, Macadamia Nut, Rough-shelled Macadamia, Rough-leaved Queensland Nut [6581]	Vulnerable	Species or species habitat likely to occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat likely to occur within area
Samadera bidwillii Quassia [29708]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Saiphos reticulatus Three-toed Snake-tooth Skink [88328]	Vulnerable	Species or species habitat may occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Sternula albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Name	Threatened	Type of Presence
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area

Name	Threatened	Type of Presence
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa incana Wandering Tattler [831]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus		
Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba		
Sanderling [875]		Roosting known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area

Name	Threatened	Type of Presence
Himantopus himantopus Black-winged Stilt [870]		Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat likely to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area

Name	Threatened	Type of Presence
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish [66193]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Corythoichthys ocellatus Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus kelloggi Kellogg's Seahorse, Great Seahorse [66723]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus andersonii Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Microphis manadensis Manado Pipefish, Manado River Pipefish [66258]		Species or species habitat may occur within area
Solegnathus dunckeri Duncker's Pipehorse [66271]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Laticauda laticaudata a sea krait [1093]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans

[Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Annona glabra Pond Apple, Pond-apple Tree, Alligator Apple, Bullock's Heart, Cherimoya, Monkey Apple, Bobwood, Corkwood [6311]		Species or species habitat may occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Protasparagus densiflorus Asparagus Fern, Plume Asparagus [5015]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Moreton Bay	QLD

Caveat
The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-27.52786 153.2871

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Attachment 3 - Assessment of Potential Impacts on the Ecological Character of the Moreton Bay Ramsar Wetland from the Toondah Harbour Project

Introduction

It is recognised that the proposed Toondah Harbour development has the potential to have a significant impact on the Moreton Bay Ramsar Wetland and is therefore referred as a controlled action warranting further assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). To assist proponents determine if their proposed action is likely to have a significant impact on matters of national environmental significance (MNES), the Commonwealth Government produced a series of guidelines on significant impacts. Most relevant for Ramsar wetlands are the *Significant Impact Guidelines 1.1 Matters of National Environmental Significance* (CoA 2013). These guidelines state that:

A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts. You should consider all of these factors when determining whether an action is likely to have a significant impact on matters of national environmental significance.

The guidelines goes on to identify specific significant impact criteria for each MNES. An action is likely to have a significant impact on the ecological character of a declared Ramsar wetland if there is a real chance or possibility that it will result in:

- areas of the wetland being destroyed or substantially modified;
- a substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland;
- the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected;
- a substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health; or
- an invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.

While the Significant Impact Guidelines provide some guidance on how to assess impacts to a Ramsar Wetland, the criteria are broad and difficult to apply at a site level to large and ecologically diverse wetlands. The Moreton Bay Ramsar Wetland covers an area of approximately 113,314 ha and contains a wide range of ecosystems ranging from perched freshwater lakes and sedge swamps on the offshore sand islands, to intertidal mudflats, marshes, sandflats and mangroves next to the Bay's islands and the mainland.

This assessment provides a methodology for identifying the ecological character at the whole of wetland and local scales and assessing significant impacts to the Moreton Bay Ramsar Wetland at the site level. A preliminary assessment of the Toondah Harbour Project against that methodology has also been carried out to identify potential for significant impacts to occur.

Methodology

The significant impact assessment methodology has been developed by Adaptive Strategies to assess potential impacts to the ecological character of the Moreton Bay Wetland. The method is adapted from previously accepted approach developed for the Great Barrier Reef World Heritage Area (Adaptive Strategies 2016), which while protected under a different international convention has many similarities in terms of scale, ecological process and protection. The methodology also incorporates aspects of the *National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands,* although it focusses on physical components of the wetland and does not include ecological processes or benefits which will be assessed through the EIS process.

The method comprises two components:

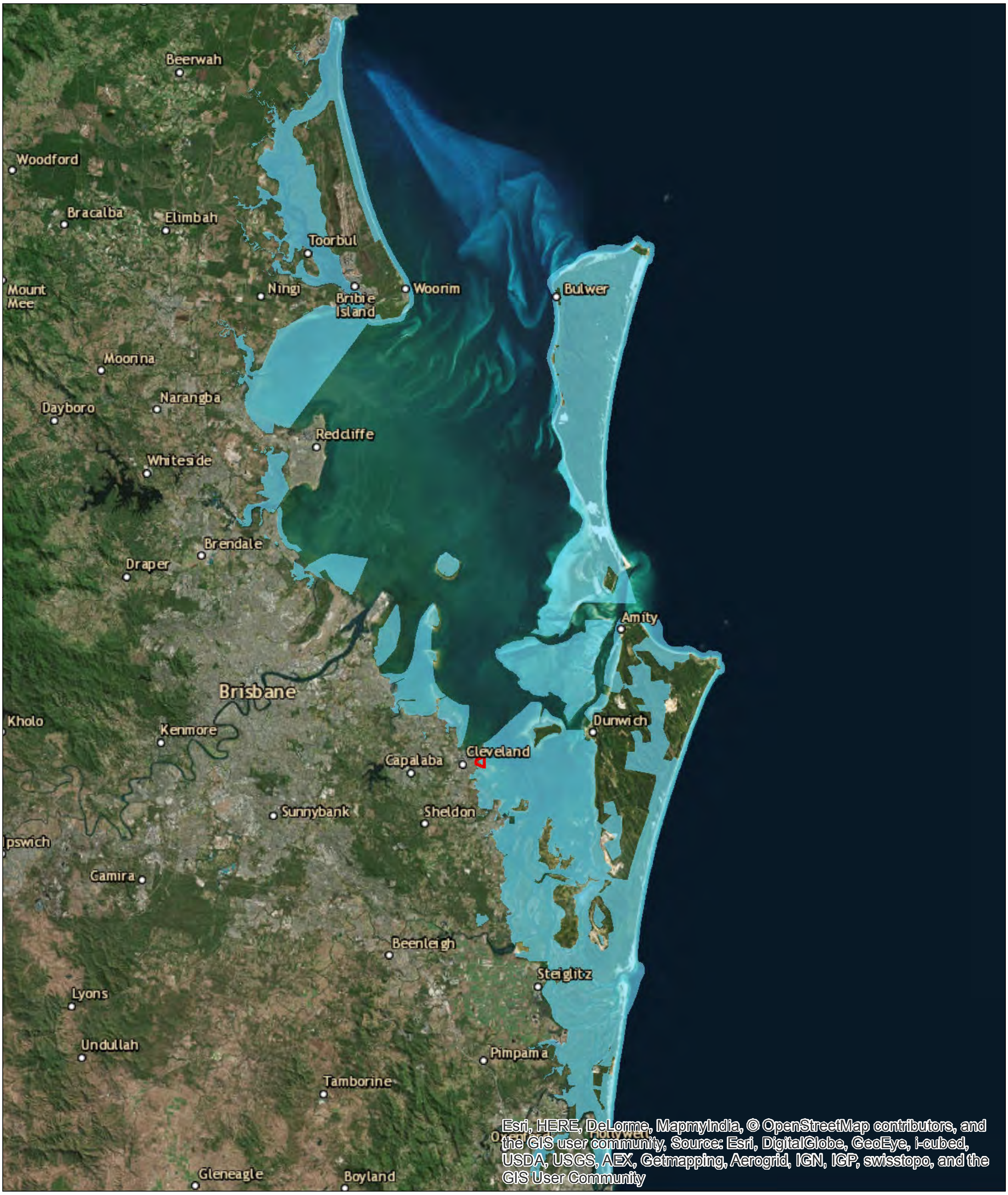
1. Contextual information about ecological character to provide a framework for the analysis; and
2. A process to be applied at the local scale.

The methodology including the rationale behind its development is attached to this technical note with the key components summarised within this assessment.

Moreton Bay Ramsar Wetland Contextual Information

The Criteria for Identifying Wetlands of International Importance were adopted by the 7th (1999) and 9th (2005) Meetings of the Conference of the Contracting Parties, superseding earlier Criteria adopted by the 4th and 6th Meetings of the COP (1990 and 1996), to guide implementation of Article 2.1 on designation of Ramsar wetlands.

Moreton Bay is listed as a Ramsar site as it fulfils six of the nine criteria for identifying wetlands of international importance. The criteria and key environmental values supported by Moreton Bay for each criterion is provided in **Table 1**. The extent of the Moreton Bay Ramsar Wetland is shown on **Figure 1**.



Legend

PDA - Toondah Harbour

Moreton Bay RAMSAR wetland

Figure 1 *Moreton Bay Ramsar Wetland*

File ref. 8444 E Site Context A
Date *20/04/2017*
Project *Toondah Harbour*

0 5 10 20 *Kilometers*

N

Scale (A4): 1:575,379 [GDA 1994 MGA Z56]

saunders havill group

Layer Sources QLD GIS Layers (QLD Gov. Information Service 2014)

Table 1: Summary of Moreton Bay key environmental values against Ramsar listing criterion (EPA 1999)

Criterion description	Moreton Bay key values
Criterion 1: the wetland contains a representative, rare or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region	Moreton Bay is one of the largest estuarine bays in Australia. The formation of large vegetated sand dunes on the eastern side of the Bay and river and creek flows entering the Bay to the west from the mainland have created a major wetland complex.
Criterion 2: the wetland supports vulnerable, endangered or critically endangered species or threatened ecological communities	The Bay supports threatened turtle species including the vulnerable green (*Chelonia mydas)* and hawksbill turtles (*Eretmochelys imbricata*) and endangered loggerhead turtles (*Caretta caretta*). The area is particularly important for the critically endangered wintering eastern curlew (*Numenius madagascariensis*). A number of threatened terrestrial flora and fauna are also present on the islands.
Criterion 3: the wetland supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	The Bay has a high diversity of marine plant and animal species including: over 355 species of marine invertebrates; 40 species of shorebirds; 55 species of algae associated with mangroves; seven mangrove species and seven seagrass species. The intertidal habitats of the Bay support over 30 species of migratory shorebirds.
Criterion 4: the wetland supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions	The Bay is a significant feeding ground for green turtles. Dugongs also use the area as a feeding and breeding ground. The area provides significant feeding areas for loggerhead turtles. The species is also known to nest on the islands of the Bay.
Criterion 5: the wetland regularly supports 20,000 or more waterbirds	The Bay supports greater than 50,000 wintering and staging shorebirds during the non-breeding season.
Criterion 6: the wetland regularly supports 1% of the individuals in a population of one species or subspecies of waterbird	The Bay supports greater than 1% of the known flyway populations of the eastern curlew (*Numensis madagascariensis)* and the grey-tailed tattler (*Tringa brevipes*).

An ecological character description is still in preparation for Moreton Bay Ramsar wetlands (DoEE 2017a). In the absence of a formal ecological character description for the site, this report has defined the ecological character of the Moreton Bay Ramsar wetland to be those key environmental values that contribute to the listing criteria of the site.

The Australian and Queensland governments have described the values of the wetland in various information documents including Moreton Bay — a wetland of international importance fact sheet and the Ramsar Information Sheet (RIS). These documents have been used to identify the key environmental features of the Moreton Bay wetland, which are listed below:

- One of the largest estuarine bays in Australia and sits in an 'overlap zone' where both tropical and temperate species occur. It supports extensive intertidal areas of seagrass, mangroves and saltmarsh that provide vital habitat for waterbirds, including significant populations of migratory shorebirds.
- Outstanding coastal wetland values and features. Many of its diverse habitat types retain a near-natural character and are interconnected with other habitats supporting biodiversity.
- Home to five nationally threatened plant species that are wetland dependant, such as the endangered swamp daisy, *Olearia hygrophila*, which is only found on North Stradbroke Island.
- Habitat for humpback whales and dolphins, as well as six of the world's seven species of marine turtles. Other threatened animals, including the grey nurse shark, dugong, wallum sedge frog, water mouse and Oxleyan pygmy perch fish, also live in the Bay or in surrounding waters and wetlands.
- A wetland habitat providing feeding areas, dispersal and migratory pathways, and spawning sites for many fish species. The region supports one of the most productive fisheries in Queensland.
- The perched wetlands on Moreton and North Stradbroke Islands, including lakes and swamps. Perched wetlands are abundant in the coastal Wallum regions of south-eastern Queensland and northern New

South Wales, but are scarce in most parts of the world. Perched wetlands form in depressions between dunes where impermeable layers develop in the sand and act like basins holding water higher in the landscape than the water table. They support many unique and interesting animals.

- One of the most important migratory shorebird sites in Australia, supporting both a large number and high diversity. During the summer months some 32 species of migratory shorebirds comprising over 40,000 individuals visit the Bay. This includes significant worldwide populations, including 20% of all eastern curlews and 50% of all grey-tailed tattlers.

Based on this description a number of key attributes have been identified for the Ramsar Wetland. The attributes are listed in **Table 2** and have been categorised according to the environmental features listed above. The attributes identified are all physical aspects of the environment such as seagrass beds, listed migratory shorebird species and perched sand lakes. Physical attributes were utilised as impacts to these features can be quantified and an assessment made on whether those impacts are considered a significant impact on the ecological character of the wetland.

It is acknowledged that impacts to ecological processes and services such as the tidal flows and sedimentation also have the potential to impact on the character of the wetland, although ultimate impacts from any changes to these processes would also be assessed through loss of the physical attributes (i.e. changes in tidal patterns may result in erosion of mud flats). These impacts would occur up and down stream of the development foot print and will be assessed through detailed hydrodynamic modelling carried out as part of the controlled action assessment process. If significant impacts outside of the footprint are identified the development footprint will be modified to mitigate these impacts.

Table 1: Key attributes of Moreton Bay Ramsar wetland

Environmental Feature	Attribute
Estuarine/Intertidal areas	Open beaches
	Seagrass
	Salt and mud flats, salt marshes
	Mangroves and related tree communities
	Rocky reefs
	Sand shoals
Coastal and sub-coastal vegetation	Tree swamp—Melaleuca spp. and Eucalyptus spp.
	Wet heath swamp
	Grass, sedge and herb swamp
Migratory shorebirds	Eastern curlew habitat (known)
	Grey tailed tattler habitat (known)
	Shorebird feeding areas (intertidal areas, beaches etc.)
	Shorebird roosting sites (above high water mark)

Environmental Feature	Attribute
Threatened plant species	*Olearia hygrophila* habitat
	Phaius australis habitat
	Phaius bernaysii habitat
	Thesium austral habitat
	Cryptocarya foetida habitat
	Other (specify)
Marine fauna habitat	Humpback whales
	Dolphins
	Marine turtles
	Dugong
	Grey nurse shark
	Wallum sedge frog
	Water mouse
Fish	Protected Fish Habitat Areas
	Oxleyan pygmy perch habitat
Lakes and enclosed water bodies	Window sand lakes
	Perched sand lakes
	Artificial water body habitats (dams, ring tanks etc.)

Local Scale Assessment

The process for determining the local representation and contribution of a feature to the ecological character of the wetland is based around understanding which attributes are present and how important those attributes are within the context of the wider wetland ecosystem. The process involves:

1. Identification of the attributes that occur within the local area (or surrounds)
2. Analysis of the 'importance' of the presence of those attributes within the context of the broader wetland.

In other words "what" and "where" are attributes located and "why" are they important in the context of the Ramsar listing?

Identification of attributes

Identification of the attributes that occur within the local area (or surrounds) should be based on the best available information including desktop (Government databases, regional level studies, etc) and site specific ecological surveys. Preliminary Terrestrial (BAAM 2017 – Attachment 6 to this referral) and Aquatic (FRC 2017 – Attachment 7 to this referral) ecological studies have been carried out for the site including desktop assessment and field survey within and adjacent to the PDA. Specific investigations relevant to the Ramsar wetland include:

- Benthic habitat survey within and adjacent to the PDA;
- Migratory shorebird surveys including five summer and one winter survey carried out between October 2014 and June 2015;
- Review of 20 years of high tide surveys conducted by the Queensland Wader Study Group at a high tide roost site to the south of the PDA (Nandeebie Claypan);
- On ground confirmation of remnant vegetation communities and mangrove and intertidal vegetation; and
- Assessment of the likelihood of protected marine and intertidal flora and fauna utilising the site.

The technical reports and summaries detailing the outcomes of the assessment are provided in response to sections 2.4 and 2.5 of the referral (refer to **Attachments 5 and 6** to the referral).

An analysis of the presence of the attributes was carried out based on the outcomes of the terrestrial and aquatic ecological assessment. Presence was attributed to one of the following categories:

- Not present: No evidence was available to indicate or suggest that the attribute is present at or near the location.
- Minor presence: These attributes occur in low abundance or across a small area (relative to the nature of the attributes broader presence across the wetland). Noting that a low abundant attribute that is rare may still be important. Temporary fluctuations or seasonal variation should be considered along with natural events that may affect short-term presence (e.g. storms). Example of low abundance might include:
  - Small isolated natural ecosystems (coral, vegetation communities etc.) of less than 10 hectares
  - Small number of non-breeding species (turtles, dolphins dugong etc.) that are foraging in the area
  - Individual occurrences of natural features (rocks, mangroves) that are not unique or notable in some manner.
- Moderate presence: These attributes occur in moderate abundance or across a moderately large area (relative to the nature of the attribute across the wetland). Examples may include:
  - Migratory shorebird aggregations of less than 0.1% of flyway population
  - Endangered ecosystems and habitats of 20-100 hectares
  - Minor nesting sites for common birds species (e.g. with small numbers of nesting individuals <10).
- Significant presence: These attributes are present in significant abundances or represent significant examples of the relevant attribute (relative to the nature of the attribute across the wetland). Examples:
  - Extensive continuous seagrass areas
  - Undisturbed natural vegetation
  - Migratory bird aggregations
  - 18 Mile Swamp (North Stradbroke Island).

Contribution to ecological character

The specific attributes of Moreton Bay are inconsistently spread across the whole Ramsar site with some more numerous than others. If an attribute was identified as being present within the PDA or in an area that could potentially be impacted by the Toondah Harbour development further assessment was carried out to identify how much it contributes to the ecological character of Moreton Bay.

A particular attribute may be present in a particular location and may well be of importance due to its locally high value in terms of representation, appreciation or biological contribution; while in another area it may be a lower value as it does not provide the same ecological function (e.g. recruitment and breeding), representation of value or amenity. The influences of human appreciation, geography, climatic distribution, geology, oceanography and ecological life cycles all influence where and at what level a particular attribute may contribute to ecological character.

Contribution to the character of Moreton Bay was attributed to one of the following categories:

- Minor contribution: The attribute is present however it occurs in low abundance or singularly and is not:
  - essential to the sustainability of the attribute (e.g. substantial breeding or flyway population)
  - recognised as a key feature of the Moreton Bay Ramsar wetland (e.g. seagrass meadow)
  - iconic, unique or a high quality example of the attribute.
- Moderate contribution: These attributes occur in moderate abundance or across a moderately large area but are not the prime occurrence or representation of the attribute within the wetland. The attribute does however represent a feature for which the wetland was listed as a Ramsar site.
- Significant contribution: These attributes represent locally important examples of the attribute relative to the nature of the attribute across the wetland. Such an attribute may be specifically referred to within the RIS or defined by other legislation, planning instrument or values assessment (e.g. MNES). The occurrence of the attribute locally is a prime example of the attribute.

Assessment of presence of an attribute and its contribution to the ecological character of the Moreton Bay Ramsar Wetland is provided in **Table 3**. As noted the assessment is based on site specific studies carried out by BAAM and FRC Environmental (Refer to **Attachments 5 and 6**) to the EPBC Referral. Impacts have been assessed for the development footprint and adjacent high value areas such as the high tide roost sites. As previously noted impacts up and down stream of the development will be addressed in detail as part of the controlled action assessment process and once hydrodynamic modelling has been completed.

Table 3: Attribute presence and assessment of contribution to the ecological character of the Moreton Bay Wetland

Environmental Feature	Site Description	Attribute	Presence of Attribute	Contribution to Ecological Character
Estuarine/Intertidal areas	There are approximately 32.7 ha of seagrass within the PDA. The seagrass meadows are predominantly in the intertidal and shallow subtidal zone between the foreshore and Cassim Island, the island of mangroves offshore adjacent to the Toondah Harbour PDA. Moreton Bay supports 189 km^2 of seagrass. The largest and most dense seagrass meadows are in the eastern bay surrounding South Passage between Moreton and Stradbroke islands; though there are also substantial meadows in the southern and western parts of the bay. With increasing urbanisation and industrial development, seagrass meadows within western Moreton Bay have been lost over the past decades. While some meadows have been lost as a direct result of infilling, a far greater area of seagrass has been lost as a result of changes in water quality. There are approximately 1.2 ha of saltmarsh south of (and none within) the PDA. The saltmarsh is in the upper most intertidal zone with the mangroves offshore. The saltmarsh is highly disturbed by the developed areas along the foreshore. Within Moreton Bay, there is approximately 2,034 ha of saltmarsh habitat. The eastern side of Moreton Bay is typically dominated by the rush *Juncus kraussii* due to abundant freshwater in the intertidal zone, while the western side of Moreton Bay is dominated by chenopod species of Sarcocornia and Suaeda due to the hypersaline intertidal sand flats. There are approximately 5.3 ha of mangroves within the PDA. The mangrove forests are along the upper intertidal zone and are bordered by mud and sand flats. The mangrove forests along the foreshore are highly disturbed by the developed areas. In the Moreton Bay Marine Park there are approximately 140 km^2 of mangroves, with the largest communities in Pumicestone Passage and the southern bay islands, south of Jacobs Well. There are scattered corals to the north and east of Cassim Island and there may also be some coral within and to the south of Fison Channel (the existing highly trafficked public navigation channel). There are areas of soft coral and hard coral reef to the east of Cassim Island, outside the PDA. While mangrove, seagrass and mud flat habitat is present within the PDA the amount present on site is minor in comparison to the broader Moreton Bay area (mangroves ~0.0002% and seagrass ~0.001%). These would all be considered to provide a minor contribution to the overall ecological character of the Moreton Bay Wetland.	Open beaches	Not present	Not Applicable
		Seagrass	Moderate Presence	Minor Contribution
		Salt and mud flats, salt marshes	Moderate Presence	Minor Contribution
		Mangroves and related tree communities	Minor Presence	Minor Contribution
		Rocky reefs	Not Present	Not Applicable
		Sand shoals	Not Present	Not Applicable
Coastal and sub-coastal vegetation	No Tree, wet heat swamps or Grass, sedge and herb swamps were identified by the terrestrial or aquatic ecological surveys as being present within or adjacent to the PDA.	Tree swamp—Melaleuca spp. and Eucalyptus spp.	Not Present	Not Applicable

Environmental Feature	Site Description	Attribute	Presence of Attribute	Contribution to Ecological Character
		Wet heath swamp	Not Present	Not Applicable
		Grass, sedge and herb swamp	Not Present	Not Applicable
Migratory shorebirds	Mudflats within the PDA were identified as providing feeding habitat for migratory shorebirds at low tide including known feeding habitat for the critically endangered Eastern Curlew (maximum of 7 birds observed), the critically endangered Great Knot (a single bird on a single survey) and the vulnerable Bar-tailed Godwit (Western Alaskan) (average of 25 and maximum of 36 birds). Two shorebird roost sites (Nandeebie Claypan and Cassim Island) recognised as important roosting habitat for migratory shorebirds are located immediately adjacent to the PDA boundary, and a third important roost site, Oyster Point, is located 600 m south of the PDA. The Nandeebie Claypan roost is used regularly by migratory shorebirds, particularly on spring high tides. During the summer months late September to March over the period 1995 to 2015, an average of 474 migratory shorebirds were recorded on the surveys when migratory shorebirds were present. Migratory shorebirds recorded using Nandeebie Claypan include the critically endangered Eastern Curlew (an average of 25 and maximum of 180 birds recorded on the 67% of summer surveys when the species was present), the critically endangered Great Knot (an average of 27 and maximum of 90 birds recorded on the 15% of summer surveys when the species was present), the critically endangered Curlew Sandpiper *Calidris ferruginea* very rarely present; only 1-2 birds recorded in 2 of 114 summer surveys) and the vulnerable Bar-tailed Godwit (an average of 609 and maximum of 2,300 birds recorded on the 56% of summer surveys when the species was present). Birds using the Nandeebie Claypan also use the nearby Oyster Point shoreline roost, moving between the two roost sites depending on the height of the tide and extent of disturbance at Oyster Point. The Cassim Island mangroves, located 30m from the PDA boundary, are used daily as a high-tide roost during the summer months by four migratory shorebird species; an average of 699 and maximum of 920 migratory shorebirds were recorded roosting during four summer high-tide surveys. Any works within the PDA (reclamation or dredging) will result in impacts on intertidal mudflats which are currently utilised by wader birds as feeding habitat. There are more than 75 km^2 of intertidal mudflat throughout Moreton Bay. Approximately 40 ha of mudflats including seagrass areas are located within the PDA boundary and therefore is the maximum direct impact that could occur. Even if all of these areas were impacted it would still only result in approximately 0.007% of intertidal mudflats within Moreton Bay being affected. It is noted that a small number of the critically endangered Eastern Curlew were observed feeding in these areas therefore there will be some potential for impact on this species.	Eastern curlew habitat (known) Grey tailed tattler habitat (known) Shorebird feeding areas (intertidal areas, beaches etc.) Shorebird roosting sites (above high water mark)	Moderate Presence Not Present Moderate Presence Not Present in PDA Significant Presence adjacent to PDA	Moderate Contribution Not Applicable Minor Contribution Significant Contribution

Environmental Feature	Site Description	Attribute	Presence of Attribute	Contribution to Ecological Character
	The Nandeebie Claypan and Cassim Island high tide roost site are located adjacent to the PDA and it is acknowledged that both of these areas provide high value habitat for migratory shorebirds. Site design and management measures will be targeted at avoiding any permanent or long term impacts to these areas and their ongoing use as roost sites.			
Threatened plant species	The EBPC Act Protected Matters Search Tool database search identified a number of threatened flora species that may or are likely to occur within the study area. No threatened flora species have been recorded within a 1 km radius of the study area on the databases that were searched, none were detected during the field survey of the study area, and the study area does not contain habitat suitable for any of the threatened flora species identified as having the potential to occur.	*Olearia hygrophila* habitat	Not Present	Not Applicable
		Phaius australis habitat	Not Present	Not Applicable
		Phaius bernaysii habitat	Not Present	Not Applicable
		Thesium austral habitat	Not Present	Not Applicable
		Cryptocarya foetida habitat	Not Present	Not Applicable
		Other (specify)	Not Present	Not Applicable
Marine fauna habitat	Twenty-one migratory marine species were listed as potentially occurring within 5 km of the proposed project using the protected matters search tool. Of these listed migratory species, 12 species are also listed as threatened species. The 'potential area of impact' for the purposes of this assessment comprised shallow inshore waters of Moreton Bay within and adjacent to Toondah Harbour, including Fison Channel. Of the listed migratory species, loggerhead turtles, green turtles, Indo-Pacific humpback dolphins and dugong are highly likely and hawksbill turtles are moderately likely to occur in the potential area of impact. The loggerhead turtle forages in a wide range of intertidal and subtidal habitats, including coral and rocky reefs, seagrass meadows, and non-vegetated sand or mud areas. They tend to maintain small home ranges within their foraging grounds (within approximately 10 to 15 km of coastline). Moreton Bay is an important foraging ground for the loggerhead turtle. Loggerhead turtles are moderately likely to occur in marine habitats within and adjacent to the Toondah Harbour project, particularly in the seagrass beds. Immature green turtles are carnivorous, while adults are generally herbivorous, feeding mostly on algae and seagrass. Adults will occasionally eat other items such as mangrove fruit, sponges and jellyfish. Adult green turtles typically forage in shallow benthic habitats, such as tidal and subtidal	Humpback whales	Not Present	Not Applicable
		Dolphins	Minor Presence	Minor Contribution
		Marine turtles	Minor Presence	Minor Contribution
		Dugong	Minor Presence	Minor Contribution
		Grey nurse shark	Not Present	Not Applicable
		Wallum sedge frog	Not Present	Not Applicable
		Water mouse	Not Present	Not Applicable

Environmental Feature	Site Description	Attribute	Presence of Attribute	Contribution to Ecological Character
	coral and rocky reefs and inshore seagrass beds and algae mats. Green turtles are likely to occur in marine habitats within and adjacent to the Toondah Harbour, particularly in the seagrass beds. Indo-Pacific humpback dolphins have only been recorded feeding in shallow waters. They feed in a variety of habitats, from mangroves to sandy bottom estuaries and embankments to rock and / or coral reefs. They are opportunist-generalist feeders, consuming a wide variety of coastal and estuarine fishes, but also reef, littoral and demersal fishes, and some cephalopods and crustaceans. Given their known population in Moreton Bay and preference for shallow coastal and estuarine areas, the Indo-Pacific humpback dolphin are likely to feed in or traverse within marine habitats of the Toondah Harbour project area. The population of dugongs in Moreton Bay has been estimated to range between approximately 503 to 1019 individuals. The eastern banks of Moreton Bay supported 80–98% of the dugong population at any one time. In this area, there are several dugong 'hot spots' generally associated with seagrass communities. Dugongs feed almost exclusively on seagrass, particularly H. uninervis, H. ovalis and H. spinulosa, and principally inhabit seagrass meadows of shallow, protected bays and mangrove channels. Dugong have been observed near Toondah Harbour and are likely to occur within the marine habitats of the Toondah Harbour project area, particularly in the seagrass beds.			
Fish	No protected fish habitat is located within or adjacent to the PDA and no threatened fish species are expected to utilise the areas including Oxleyan pygmy perch which are generally regarded as restricted to streams, swampy areas and lakes in coastal wallum.	Protected Fish Habitat Areas Oxleyan pygmy perch habitat	Not Present Not Present	Not Applicable Not Applicable
Lakes and enclosed water bodies	No lakes or enclosed water bodies are present within or adjacent to the PDA.	Window sand lakes	Not Present	Not Applicable
		Perched sand lakes	Not Present	Not Applicable
		Artificial water body habitats (dams, ring tanks etc.)	Not Present	Not Applicable

The assessment of the site's contribution to the environmental character of Moreton Bay can be summarised as follows:

- Estuarine/Intertidal Areas – The PDA contains moderate to minor presence of estuarine and intertidal habitats including sparse seagrass beds, a small area of mangroves and mud flats providing feeding habitat for migratory shorebirds. The PDA contains less than 0.001% of the total area for these habitat types in Moreton Bay and would be considered to provide a **minor contribution** to the overall ecological character of the wetland.
- Coastal and sub-coastal vegetation - No swamps were identified by the terrestrial or aquatic ecological surveys as being present within or adjacent to the PDA therefore the site **does not provide a contribution** to the ecological character of the wetland for these attributes.
- Migratory shorebirds – The PDA area contains intertidal feeding habitat for a number of migratory shorebirds including the critically endangered Eastern Curlew, the critically endangered Great Knot and the vulnerable Bar-tailed Godwit (Western Alaskan). Similar habitat is found throughout Moreton Bay with the site providing less than 0.001% of this habitat type. Two high tide roost sites are located adjacent to the PDA being the Nandeebie Claypan and Cassim Island. These areas are recognised as having high importance to shorebirds in the region and site design and management will focus on avoiding any permanent or long term impacts to these areas. The site is considered to provide a **moderate to minor contribution to shorebird feeding habitat** and a **significant contribution to shorebird roosting sites**. **Figure 2** shows the location of the shorebird habitat and roost sites in relation to the PDA.
- Threatened Plant Species - No threatened flora species have been recorded within a 1 km radius of the study area on the databases that were searched, none were detected during the field survey of the study area, and the study area does not contain habitat suitable for any of the threatened flora species identified as having the potential to occur. The site **does not provide a contribution** to the ecological character of the wetland for these attributes.
- Marine Fauna Habitat - 21 migratory marine species were listed as potentially occurring within 5 km of the proposed project using the protected matters search tool. Twelve of these species are also listed as threatened under the EPBC Act. Of the listed migratory species, loggerhead turtles, green turtles, Indo-Pacific humpback dolphins and dugong are highly likely and hawksbill turtles are moderately likely to occur in or near the PDA. While potential habitat for these species is located at Toondah Harbour similar or better habitat is present throughout Moreton Bay. The site is considered to provide a **minor contribution** to the ecological character of the wetland for its marine fauna habitat attributes.
- Fish - No protected fish habitat is located within or adjacent to the PDA and no threatened fish species are expected to utilise the areas including Oxleyan pygmy perch which are generally regarded as restricted to streams, swampy areas and lakes in coastal wallum. The site **does not provide a contribution** to the ecological character of the wetland for these attributes.
- Lakes and Enclosed Water Bodies - No lakes or enclosed water bodies are present within or adjacent to the PDA. The site **does not provide a contribution** to the ecological character of the wetland for these attributes.

Figure 2: Shorebird Habitat and Roosting Sites

Determination of Significant Impacts

EPBC Act Policy Statement 1.1 – Significant impact guidelines sets out the criteria for determining the likelihood of an action having a significant impact on the ecological character of a declared Ramsar wetland (refer to the introduction for specific criteria). Using the criteria along with the results of the local presence and contribution to the ecological character of the wetland assessment an approach to determining significant impacts at the site level is possible. As identified above the site contributes to the following wetland characteristics:

- Minor contribution to estuarine and intertidal habitat;
- Moderate to minor contribution to shorebird feeding habitat and a significant contribution to shorebird roosting sites; and
- Minor contribution to marine fauna habitat.

Using this information the significant impact criteria can be targeted at those areas of the site contributing to the ecological characteristics. **Table 4** provides a matrix of how the significant impact criteria should be applied based on the contribution to ecological character.

Table 4: Likelihood of Significant Impacts

Criteria	Contribution to Ecological Character			
	Not Present	Minor	Moderate	Significant
Areas of wetland being destroyed or substantially modified	N/A	Unlikely	Likely if changes are permanent	Almost certain unless change is temporary (less than 1-2 year)
A substantial and measurable change in the hydrological regime of the wetland	N/A	Unlikely if not measurable or is within natural variability	Likely if change is measurable, permanent and beyond natural variability	Almost certain resulting in a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland
Habitat or lifecycle of native species being seriously affected	N/A	Unlikely	Likely if permanent Unlikely if temporary or in low season (e.g. outside migratory visitation)	Almost certain if permanent Unlikely if in low season or non breeding (e.g. outside migratory visitation)
Permanent or long term substantial and measurable change in the water quality of the wetland	N/A	Unlikely	Likely	Almost Certain
Establishment of invasive species	N/A	Likely*	Almost certain	Almost certain

Areas of the wetland being destroyed or substantially modified

Areas of the site contributing to the wetland include the estuarine and intertidal habitat. These areas provide a minor contribution to the ecological character of the Moreton Bay wetland therefore potential for significant impacts are considered unlikely.

A substantial and measurable change in the hydrological regime of the wetland

While hydrological changes have not been assessed as part of these investigations any changes have the potential to result in impacts to parts of the wetland up and downstream of the project area. This includes areas adjacent to the PDA that contribute to the ecological character of the wetland such as a 1.2 ha of saltmarsh to the south of the PDA and additional intertidal habitat including seagrass and mudflats (refer to **Figure 2**). The reclamation may also result in changes to the tidal processes within Moreton Bay which may impact on ecologically sensitive areas within Moreton Bay

Detailed hydrodynamic modelling will be carried out as part of the controlled action assessment and will contribute to final design of the site footprint. The design will seek to minimise changes to hydrology and erosion and accretion outside the immediate impact area. The scope of the detailed modelling will be discussed and confirmed with DoEE through the ongoing assessment process.

As detailed modelling is yet to be carried out the precautionary principle has been applied and therefore it is considered likely the project will result in a measurable and permanent change to hydrodynamics in a zone of influence around the reclamation however is unlikely to result in a change that would affect the wetland as a whole.

The habitat or lifecycle of native species being seriously affected

The Toondah Harbour PDA and adjacent areas are considered to provide a minor contribution to the ecological character of the wetland for its marine fauna habitat attributes, a moderate to minor contribution to shorebird feeding habitat and, a significant contribution to shorebird roosting sites.

The project is likely to result in permanent impacts to a small area of shorebird feeding habitat as a result of dredging and reclamation works. While the impact will be small in comparison to habitat for native species present throughout the Moreton Bay Ramsar wetland, as they are permanent impacts and will affect an area of minor to moderate ecological character, there is the potential for significant impacts to occur. If detailed studies identify that significant impacts will occur an offsets package would be developed in consultation with the DoEE and in accordance with the EPBC Act Environmental Offsets Policy. Offsets would be designed at ensure the project results in an overall benefit on shorebirds. Specific activities may include rehabilitation of areas in the Ramsar Wetland to increase the quality and availability of shorebird habitat or implementation of management measures such as fences and noise barriers to improve existing areas of habitat.

It is noted that the assessment of impacts to migratory species found that the carrying capacity of the Moreton Bay wetlands for supporting migratory shorebirds is likely to be underutilised therefore migratory shorebirds may not currently be subject to density-dependent population regulation. This underutilisation is likely a result of factors outside Moreton Bay, in particular impacts to coastal mudflats in the Yellow Sea. A recent study carried out by Studds et al (2017) found "*Yellow Sea reliance was the single most important predictor of variation in population trends*" and that "*Population trends were strongly negatively related with Yellow Sea reliance*".

It is therefore likely any birds displaced as a result of the project would continue to feed in other areas of Moreton Bay.

The project will be designed and managed to avoid any permanent impact on the roosting sites through the use of buffer areas and a number of other measures including:

- A buffer from urban, tourism and retail uses of at least 250m to the Cassim Island roost area. The buffer distances exceed those identified through review of several studies on flight initiation distances for a range of migratory shorebird species (refer to Table 5.1 of **Attachment 6** –Terrestrial Impact Assessment - to this EPBC referral);

- construction of appropriate barriers, such as fences to restrict access; ideally, there should be no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds;
- landscape, architecture and urban design to include sympathetic lighting strategies, vegetation screening and sound attenuation; and
- increased community education through mechanisms such as educational program through a proposed wetland education and cultural centre and interpretive signs at access points to shorebird habitats.

While impacts to the high tide roost sites that adjoin the PDA will be mitigated, given these areas provide a significant contribution to the ecological character of the Moreton Bay Ramsar Wetland the precautionary principle has been applied and therefore it is considered likely the project will result in temporary impacts to the roost sites which may have a significant impact on migratory shorebirds. Further detailed studies will be carried out as part of future assessment processes including development of a shorebird management plan to ensure protection of the high tide roost sites is considered during the planning, construction and ongoing use phases of the development.

A substantial and measurable change in the water quality of the wetland
Three turbidity loggers have been installed at and around Toondah Harbour since September 2015 to provide an indication of baseline water quality. Data collected between 9 September 2015 and 22 September 2017 was summarised and provided as **Attachment 7** to the EPBC Act referral.

The mean turbidity over the 24 months of sampling was 20.6 NTU, 30.5 NTU and 12.6 NTU at sites 1, 2 and 3 respectively with 95th percentiles of 74.9, 100 and 40.4. Overall, turbidity was generally highest during the wetter seasons of late spring and summer at all sites.

Water quality in Queensland is protected under the *Environmental Protection (Water) Policy 2009* (EPP (Water)) using Water Quality Objectives (WQOs). The Moreton Bay Environmental Values and Water Quality Objectives (June 2010) specifies a WQO for the project area for turbidity of 5 NTU. The median turbidity at all three sites over the 24 months (7.8 NTU to 11.1 NTU) exceeded the WQO.

While there may be some short term impacts to water quality, in particular turbidity, as a result of dredging and reclamation works the harbour is already subject to high levels of turbidity. The project is expected to provide a long term benefit as dredging will fix existing issues with Fison Channel which frequently re-suspends sediments when used by boats and ferries.

Management measures will be put in place during construction activities to minimise the temporary impacts to water quality outside of the project footprint. Specific measures may include:

- designing the project to minimise the area of sediment and / or soils being disturbed;
- using temporary enclosures (complete enclosures such as sheet piles or alternate enclosures such as silt curtains) to reduce the intensity and spatial distribution of potential impacts;
- isolate the disturbance areas, for example by using sheet piles, silt curtains, oil spill booms, bunding, trenching and / or similar technologies;
- identification and management of acid sulfate soils and other contaminants, through a sediment sampling and analyses plan (SAP) developed in accordance with the National Assessment Guidelines for Dredging 2009;
- developing thresholds for turbidity and suspended solids, and appropriate management (e.g. triggers for ceasing works) for seagrass and corals and monitoring water quality during construction; and
- monitoring changes in seagrass and coral communities post-construction to determine any potential impacts.

Establishment of an invasive species

Management measures will be put in place to avoid establishment of invasive species therefore no significant impacts will result from this criteria.

Conclusion and Potential Benefits

While appropriate management measures will minimise the potential to impact on the Moreton Bay Ramsar wetland it is acknowledged that, if a precautionary approach is applied, the potential for significant impacts exist therefore the project will be referred as a controlled action to allow more detailed assessment under the EPBC Act to be carried out. It is noted that once projects are within a controlled action process offsets and benefits associated the project can be considered.

An ecological character description (ECD) is still in preparation by the State Government for the Moreton Bay Ramsar Wetland. In the absence of a formal ECD for the site, this referral has defined the ecological character of the Moreton Bay Ramsar Wetland to be those key environmental values that contribute to the listing criteria of the site. Further studies will be carried out early in the assessment process to develop an understanding of the critical elements of ecological character for the area around Toondah Harbour at a site level, and place these within the context of the wider Moreton Bay Ramsar Site.

This will include a multi-disciplinary approach to conduct an initial evaluation of the ecological components, ecosystem processes and ecosystem services/benefits. The approach will follow the National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands (DEWHA, 2008) and information will be drawn from the unpublished Moreton Bay ECD produced in 2008 as well as empirical data and other sources.

Specific activities will include:

- Identification of critical ecological components including physical form, soils and substrates, biota and physico-chemical components;
- Identification of critical ecosystem processes including climate, geomorphology, hydrology, energy dynamics, physical processes, species interactions, and nutrient/biogeochemical cycling;
- Identification of critical ecosystem services/ benefits including provisioning, regulating, cultural and supporting services and linkages with specific beneficiaries; and
- Brief rationale for defining each of the elements as 'critical'.

It is envisaged this will be further refined and detailed in consultation with DoEE and environment and wetland experts. The site level assessment will then form an integral component of the EIS process.

Walker Group have held discussions with a number of State and Local Government departments as well as community groups to identify a range of measures that would provide a benefit to the Moreton Bay Ramsar Wetland. These measures include:

- Identifying new conservation areas using the following criteria:
  - Be located within or adjacent to the Moreton Bay Ramsar Wetland;
  - New areas should contain similar characteristics to those impacted;
  - Conservation outcomes associated with the new areas must be achievable and have an acceptable level of risk of success.
- Investigating the possibility of modifying the Ramsar wetland boundary to designate new areas of waterfowl habitat to the Ramsar site. This may include approximately seven hectares of Moreton Bay south of the PDA into the Ramsar area which contains features of high ecological value such as mangroves and

tidal flats. Tidal areas of Moreton Bay are predominantly owned and managed by the State Government, therefore; negotiations will be held with the relevant agencies to identify how this could be accomplished.

- Community ranger education and sponsorship programs to ensure active land and sea country management in Moreton Bay;
- A feral pest management program;
- Programs for improving water quality from the adjacent catchment;
- Various remediation and rehabilitation projects within and adjacent to the Moreton Bay Ramsar Wetland. These could include management of mangrove incursion in Nandeebie Claypan and rehabilitation of salt marsh south of the PDA. Further opportunities will be discussed with the community and relevant government agencies;
- Koala habitat tree planting in the PDA and surrounding koala movement corridors, and a collaring and monitoring program;
- Use of sea life friendly propellers for vessels using marina (potential Australia first);
- Development of a wetland centre within the development area;
- Creation of new conservation park on eastern boundary with restricted access;
- Implementation of bird hide/s in various areas;
- Community awareness programs (koalas, birds, marine life, Aboriginal cultural heritage);
- Exploration of Moreton Bay fishing net buy back partnership; and
- A pilot migratory shorebird offset in the Yellow Sea, which would address one of the key reasons for a general decline in migratory birds in Moreton Bay.

Attachment 4 - Assessment of Potential Impacts on EPBC Act Threatened and Migratory Species

Introduction

It is recognised that the proposed Toondah Harbour development has the potential to have a significant impact on species listed as Threatened or Migratory under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and therefore the project will be a controlled action to allow more detailed assessment to be carried out.

An EPBC Act Protected Matters Search for the site using a 5 kilometre buffer zone (refer to **Attachment 2**) identified the following as having potential to occur on, or in vicinity to, the site:

- 3 Listed Threatened Ecological Communities:
    - *Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland* (endangered) - community likely to occur within the area
    - *Lowland Rainforest of Subtropical Australia* (critically endangered)- community likely to occur within the area
    - *Subtropical and Temperate Coastal Saltmarsh* (vulnerable) - community likely to occur within the area;
- 10 listed threatened flora species;
- 56 listed threatened fauna species; and
- 76 listed migratory Species.

A number of flora and fauna surveys including desktop (government databases, regional level studies, etc) and site specific ecological field surveys have been carried out at the site. This includes detailed terrestrial (BAAM 2017) and aquatic (FRC environmental 2017) ecological studies within and adjacent to the PDA. Specific investigations relevant to the Ramsar wetland include:

- Benthic habitat survey within and adjacent to the PDA;
- Migratory shorebird surveys including five summer and one winter survey carried out between October 2014 and June 2015;
- Review of 20 years of high tide surveys conducted by the Queensland Wader Study Group at a high tide roost site to the south of the PDA (Nandeebie Claypan); and
- On ground confirmation of remnant vegetation communities and mangrove and intertidal vegetation; and
- Assessment of the likelihood of protected marine and intertidal flora and fauna utilising the site.

The technical reports and summaries detailing the outcomes of the assessment are provided in response to sections 2.4 and 2.5 of the referral (refer to **Attachments 5 and 6** to the referral).

Threatened and Migratory Species Assessment Summary

A likelihood of occurrence assessment has been carried out by BAAM (terrestrial species including wader birds) and FRC environmental (marine species) using information from the desktop and field surveys assessing the potential for each threatened species and community to utilise the site. For detailed assessment of the likelihood of occurrence all species identified by the PMST search refer to **Attachments 5** and **6**. Those species considered to have a moderate or high likelihood of utilising the site are summarised in **Table 1**.

Migratory Species Likelihood of Occurrence

The protected matters database searches identified 17 marine, six terrestrial and 33 wetland bird migratory species as well as 20 marine migratory species (including whales, turtles and sharks) that may occur within the study area or surrounds.

Eleven migratory bird species (including three critically endangered and one vulnerable species as addressed in Table 1) were recorded within or immediately adjacent to the study area during field surveys, and a further eight species were identified as having the potential to occur based on database records for the local area and presence of suitable habitat. The remaining species or were assessed as unlikely to occur.

Refer to **Attachment 6 – Terrestrial Ecology Assessment** – of the referral for detailed assessment of these species.

Five marine migratory species (including whales, turtles and sharks) including two vulnerable and one endangered species as addressed in Table 1 were identified as having a moderate or high potential to occur within or near Toondah Harbour based on field survey, database records for the local area and presence of suitable habitat. The two marine migratory species not listed as threatened are the Dugong and Indo-Pacific humpback dolphin. These species were considered likely to occur as:

- Indo-Pacific humpback dolphins are known to occur in Moreton Bay and have a preference for shallow coastal and estuarine areas. They are likely to feed in or traverse marine habitats of the Toondah Harbour project area.
- Moreton Bay supports feeding and breeding populations of dugong. Dugong have been observed near Toondah Harbour and are likely to occur within the marine habitats of the Toondah Harbour project area, particularly in the seagrass beds.

Refer to **Attachment 5 – Marine Ecology Assessment** – of the referral for detailed assessment of these species.

Table 1: EPBC Act Threatened Species Likely to Utilise the Site

Common Name	Species	EPBC Act Threatened Status	Ecology	Likelihood of Occurrence
Loggerhead Turtle	*Caretta caretta*	Endangered	Loggerhead turtles are primarily found around coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia. Moreton Bay is an important foraging ground for the loggerhead turtle. <u>Feeding Areas</u> The loggerhead turtle forages in a wide range of intertidal and subtidal habitats, including coral and rocky reefs, seagrass meadows, and non-vegetated sand or mud areas. They tend to maintain small home ranges within their foraging grounds (within approximately 10 to 15 km of coastline). Moreton Bay is an important foraging ground for the loggerhead turtle. <u>Breeding Areas</u> Loggerhead turtles nest on open, sandy beaches. The three major nesting areas for loggerhead turtles in Queensland are in the Great Barrier Reef, and include: ▪ the Capricorn Bunker Island Groups, especially Wreck, Tryon and Erskine islands ▪ Mon Repos and adjacent beaches of the Woongarra Coast and Wreck Rock Beach, together with ▪ the islands of the Swain Reefs, especially Pryce Island and Frigate, Bylund, Thomas and Bacchi cays. A small number of loggerhead turtles nest on the local sand islands of Bribie, Moreton, and North and South Stradbroke. <u>Key Threats</u> Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change.	Moderate - Moreton Bay supports a significant loggerhead turtle feeding population. Loggerhead turtles are moderately likely to occur in marine habitats within and adjacent to the Toondah Harbour project, particularly in the seagrass beds.
Green Turtle	*Chelonia mydas*	Vulnerable	The green turtle is globally distributed in tropical and sub-tropical waters, and is usually associated with shallow marine habitats that support seagrass and algal communities. Green turtles are known to feed on the seagrass in Moreton Bay. <u>Feeding Areas</u> Immature green turtles are carnivorous, while adults are generally herbivorous, feeding mostly on algae and seagrass. Adults will occasionally eat other items such as mangrove fruit, sponges and jellyfish. Adult green turtles typically forage in shallow benthic habitats, such as tidal and subtidal coral and rocky reefs and inshore seagrass beds and algae mats. Green turtles are known to feed on the seagrass in Moreton Bay. <u>Breeding Areas</u>	High - Moreton Bay supports feeding populations of green turtles. Green turtles often are observed in the seagrass beds adjacent to the proposed project. Green turtles are highly likely to occur in marine habitats within and adjacent to the Toondah Harbour,

Common Name	Species	EPBC Act Threatened Status	Ecology	Likelihood of Occurrence
			Green turtles nest on sandy beaches. In Queensland, southern green turtle populations typically nest around the Capricorn Bunker Groups and adjacent islands in the southern Great Barrier Reef, but also nest on islands of the outer edge of the reef. There are no key nesting areas in Moreton Bay; however, some turtles nest on the sandy beaches of the outer islands. <u>Key Threats</u> Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change.	particularly in the seagrass beds.
Hawksbill Turtle	*Eretmochelys imbricate*	Vulnerable	The hawksbill turtle is globally distributed in tropical, sub-tropical and temperate waters. There is a small resident population of hawksbill turtles in Moreton Bay. <u>Feeding Areas</u> Hawksbill turtles are heavily reliant on coral reef and rocky habitats, where they forage mainly on sponges but also seagrass, algae, squid, gastropods, sea cucumbers, soft corals and jellyfish. As juveniles, they eat plankton. Feeding areas occur throughout eastern Queensland, from Torres Straight to Julian Rocks in northern New South Wales. <u>Breeding Areas</u> Hawksbill turtles nest on sandy beaches in the northern Great Barrier Reef and the Torres Strait. In Australia, the key nesting and inter-nesting areas include: ▪ Milman Island and the inner Great Barrier Reef Cays north from Cape Grenville Central ▪ Torres Strait islands ▪ Crab Island ▪ Murray Islands ▪ Darnley Island ▪ Woody Island ▪ Red Wallis and Woody Wallis Islands ▪ Bramble Cay and Johnson Islet (Torres Strait), and ▪ Western Cape York Peninsula (DEHP 2005). <u>Migration Routes</u> Hawksbill turtles that nest or forage on the east coast of Australia migrate to Indonesia, Papua New Guinea, the Solomon Islands, and Vanuatu.	Moderate - Despite not providing critical habitat, there is a small resident population of hawksbill turtles in Moreton Bay, and they may feed in, or traverse, the proposed project area. There is a moderate likelihood that hawksbill turtles occur in marine habitats within and adjacent to the Toondah Harbour project.

Common Name	Species	EPBC Act Threatened Status	Ecology	Likelihood of Occurrence
			Key Threats Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change.	
Eastern Curlew	*Numenius madagascariensis*	Critically Endangered	Habitat and ecology In Australia, Eastern Curlew feeds during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments with or without seagrass, and usually within 50 m of the low-water mark In Moreton Bay, the average summer density of feeding Eastern Curlews ranges between 3.7 and 71.9 birds per 100 ha of mudflat and is most strongly related to substrate resistance, with the birds preferring areas with softer sediments that they can more easily probe into to capture prey. During the high tide phase of the tidal cycle, Eastern Curlews roost in small to large flocks on sandy spits, sandbars, shallow lagoons, saltmarshes and claypans near the high-water mark. Migration Routes Migrating Eastern Curlews leave Moreton Bay over a period of about one month in March, but arrive back over a more extended period from August through to December; however 25% of Eastern Curlews in Moreton Bay do not migrate and remain through the austral winter. Most Eastern Curlews appear to migrate along the east coast of China and the Yellow Sea provides extremely important stopover feeding habitat for about 80% of the flyway population to replenish their fat reserves before continuing their migration. Key Threats Threats to Eastern Curlew in Australia include ongoing human disturbance at feeding and roost sites, habitat loss, habitat degradation from pollution, changes to the water regime and invasive plants. Key threats along their migration route are feeding habitat loss resulting from large land reclamation projects and habitat degradation resulting from aquaculture, gross pollution and invasion of salt marshes by exotic Spartina grass, particularly at key stopover migration staging sites in the Yellow Sea.	High - During the summer months October 2014 to February 2015, an average of 4.8 and maximum of 7 Eastern Curlew were recorded feeding on mudflats within the study area. Eastern Curlews were recorded roosting at the Nandeebie Claypan roost site.
Bar-tailed Godwit (Western Alaskan)	*Limosa lapponica baueri*	Vulnerable	Habitat and ecology In Australia, Bar-tailed Godwits feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments, usually foraging near the edge of the water or in shallow water. They feed on polychaete worms, molluscs, crustaceans and insects. In the highest quality feeding habitats on the eastern side of Moreton Bay, Bar-tailed Godwit feeding densities ranged between 3 and 8 birds per hectare of sandflat. During the high tide phase of the tidal cycle they roost in large flocks on sandy beaches, sandbars, spits	High - surveys identified an average of 24.8 and maximum of 36 Bar-tailed Godwits were recorded feeding on intertidal mudflats within the Toondah Harbour PDA. The feeding density recorded within the

Common Name	Species	EPBC Act Threatened Status	Ecology	Likelihood of Occurrence
			and in near-coastal saltmarsh. Bar-tailed Godwits have high fidelity to feeding and roosting sites in Moreton Bay, returning to the same feeding areas and roost sites both within and between seasons. <u>Migration Routes</u> Satellite tracking has shown that migrating Bar-tailed Godwits (western Alaska) leave Australia and New Zealand in March, making long flights (average 10,060 km) to staging sites in the Yellow Sea, where they stage for an average of 41 days to replenish their fat reserves before flying an average of 6,770 km to their breeding grounds. After completion of breeding, the birds stage for several weeks in southwest Alaska before either making non-stop flights across the Pacific Ocean to New Zealand (11,690 km in a complete track) or stopovers on islands in the south-western Pacific en route to New Zealand and eastern Australia. One satellite tracked bird made a non-stop flight of around 10,200 km in about eight days. After making these flights, the birds arrive starving on the staging sites; this highlights the critical importance of conserving sufficient intertidal feeding habitat in the staging areas to allow the birds to refuel. <u>Threats</u> The greatest threat facing Bar-tailed Godwits is habitat loss and degradation at key staging areas in the Yellow Sea, where about 80% of the East Asian-Australasian Flyway population stage on the northward migration. Other threats, including in Australia, include human disturbance at feeding and roosting sites, habitat loss and degradation from pollution, changes to the water regime and invasion of mudflats and coastal saltmarshes from the spread of mangroves.	study area (average 0.62 birds/ha, maximum 0.9 birds/ha) is substantially less that the densities of 3 to 8 birds/ha recorded in the highest quality feeding habitats on the eastern side of Moreton Bay. Bar-tailed Godwits were recorded roosting at the Nandeebie Claypan roost site (south of the existing ferry terminals, outside of the PDA) and at Oyster Point located 600 m from the PDA).
Great Knot	*Calidris tenuirostris*	Critically Endangered	<u>Habitat and ecology</u> In Australia, Great Knots feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments, often feeding in flocks in shallow water at the mudflat/sandflat edge. Great Knots feed mostly on bivalve and gastropod molluscs, polychaete worms and Brachyura and Ostracoda crabs. During the high tide phase of the tidal cycle, Great Knots roost in often large flocks on sandy spits, sandbars, shallow lagoons, saltmarshes and claypans, often at the water's edge or in shallow water near the high-water mark. <u>Migration Routes</u> Most migrating Great Knots leave Australia from the north coast in March-April, flying directly to the Yellow Sea region of China and Korea, with a few to Japan, where they stage and spend time feeding to replenish their fat reserves before continuing their migration north to the	Moderate - During the low tide surveys, only a single Great Knot was recorded feeding on intertidal mudflats within the Toondah Harbour PDA on a single survey. The high tide survey results suggest that Great Knot occasionally roosts in relatively small numbers at the Nandeebie Claypan roost (south of the PDA) site as well as at the Oyster Point roost site located 600 m from the PDA.

Common Name	Species	EPBC Act Threatened Status	Ecology	Likelihood of Occurrence
			breeding grounds. After the breeding season, most adults congregate in the western and southern Sea of Okhotsk in south-eastern Russia, then fly direct to northern Australia, while some others move south to Korea before flying direct to Australia from there, arriving in late August to September. <u>Key Threats</u> The greatest threat facing the Great Knot is habitat loss and degradation at key staging areas in the Yellow Sea, which support about 80% of the East Asian-Australasian Flyway population on the northward migration. Great Knot is considered more vulnerable to reclamation activities than most other waders due to the very specific species and sizes of shellfish that they eat. Other threats include disturbance at feeding and roosting sites and the longer-term impact of climate change that is expected to reduce the area of intertidal feeding habitat.	
Curlew Sandpiper	*Calidris ferruginea*	Critically Endangered	<u>Habitat and ecology</u> Curlew Sandpipers feed in both tidal and non-tidal wetlands. In tidal wetlands they forage on mudflats, sandflats and nearby shallow water. In non-tidal wetlands they usually feed while wading through shallow water. In Australia, Curlew Sandpipers have a varied diet, but feed mostly on annelid worms, gastropod molluscs, crustaceans and insects. During the high tide phase of the tidal cycle, they roost in open areas with a damp substrate, including on sandy beaches, sandspits and islets in coastal lagoons and other wetlands. <u>Migrations Routes</u> Curlew Sandpipers start migrating north from their non-breeding sites in Australia between mid-January and mid-April, most of them migrating through southern China, where Bahai Bay is an important staging site, before they begin arriving on the breeding grounds in late May to early June. After the breeding season, returning birds reach the northern shores of Australia in late August and early September. However, substantial numbers of Curlew Sandpipers remain in northern Australia throughout the nonbreeding season. <u>Threats</u> Threats in Australia include ongoing human disturbance, habitat loss and degradation from pollution, changes to the water regime and invasive plants.	Moderate - During the low tide surveys, Curlew Sandpiper was never recorded feeding on intertidal mudflats within the Toondah Harbour PDA. Furthermore, very few, if any, Curlew Sandpipers appear to use nearby mudflats. This suggests that feeding habitat within the PDA and nearby mudflats is of marginal importance to Curlew Sandpiper. The high tide survey results suggest that Curlew Sandpiper very rarely roosts at the Nandeebie Claypan roost site south of the PDA.
Koala	*Phascolarctos cinereus*	Vulnerable	<u>Habitat and ecology:</u> Koalas have a distinct association with eucalypt woodland and forest habitat types containing suitable food trees, particularly those growing on alluvial or other fertile soils. They are not necessarily restricted to bushland or remnant areas and are known to exist and	High - The initial field survey identified a total of 286 habitat trees important for Koala are scattered across the western portion of the PDA as a

Common Name	Species	EPBC Act Threatened Status	Ecology	Likelihood of Occurrence
			breed within farmland and the urban environment. Similarly, movement is not confined to vegetated corridors, as they also move across cleared rural land and through suburbs. They use a variety of trees, including many non-eucalypts, for feeding and resting. They do, however, have distinct, localised feeding preferences throughout their range, selecting some species in preference to others. Tree species preferences vary around Queensland; in the Redlands of south-east Queensland, the dominant diet species are Eucalyptus tereticornis (Hasegawa 1995) and E. microcorys (Tun 1993), whereas on North Stradbroke Island, Koalas prefer E. robusta (55% of diet), E. pilularis (13%), E. tereticornis (10%) and Lophostemon confertus (8%). Threats Current threats to Koalas include habitat destruction and fragmentation, bushfire and disease. Populations around urban areas are also at increased risk of mortality due to dog attack and vehicle strike.	component of the urban environment. Koala scats were observed under 33 of these trees, confirming recent Koala use of trees in the PDA, but no Koalas were observed. On later occasions, up to two Koalas were observed in habitat trees within the PDA, and up to three Koalas were observed in trees at Nandeebie Park south of the PDA.

Potential Impacts to Threatened and Migratory Species

The potential impacts of the Project on threatened and migratory species include the following:

- Direct impacts (reclamation areas) and indirect impacts to a small portion of the Moreton Bay Ramsar wetlands;
- Direct impact on an area of intertidal mudflats and sandflats that is recognised as important feeding habitat for migratory shorebirds, including known feeding habitat for two critically endangered and one vulnerable species;
- Indirect impacts on mudflats and sandflats adjacent to the PDA that are recognised as important feeding habitat for migratory shorebirds; indirect impacts relate to reduced food availability for migratory shorebirds in intertidal mudflats and sandflats adjacent to the PDA in the event that altered water quality or hydrodynamics affect benthic invertebrate abundance in intertidal mudflats and sandflats adjacent to the PDA;
- Increased disturbance to migratory shorebirds roosting at three important roost sites for migratory shorebirds located close to the Project, including roosts known to be used by three critically endangered and one vulnerable species (see further detail below). Increased disturbance has potential to lead to a substantial reduction in the use of the roost sites by migratory shorebirds;
- Increased disturbance to migratory shorebirds feeding on intertidal mudflats and sandflats adjacent to the PDA in the event that the Project facilitates greater pedestrian access to these areas at low tide, particularly the areas to the east of the Cassim Island mangroves that might be attractive to recreational walkers with dogs;
- Short term disturbance of sediments and soil (increasing turbidity, suspended solids, sedimentation, nutrients, contaminants and potential acid sulfate soils) during construction periods. Many fish and marine megafauna (e.g. dolphins, turtles and dugongs) are likely to avoid areas of high turbidity and suspended solids;
- Short term disturbance through increased noise and vibration during construction periods;
- Altered hydrodynamics;
- Increased site access and boating;
- Loss of food trees used by several individuals of the vulnerable Koala in an urban area that is not recognised as 'habitat critical to the survival of Koala';
- Risk of mortality of Koalas during clearing of Koala habitat trees prior to construction; and
- Increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation.

Potential Impacts to Migratory Shorebirds

Potential direct impacts relate to the clearing of habitat or vegetation associated with the reclamations and dredging associated with harbour and navigational upgrades and new wet berths and marine facilities. The loss of important intertidal feeding habitat for migratory shorebirds, including for threatened species, could be expected to lead to a corresponding decrease in the number of migratory shorebirds using the Moreton Bay Ramsar Wetland proportional to the loss of habitat if migratory shorebird populations in Moreton Bay were currently subject to density-dependent population regulation.

However, migratory shorebird populations using Moreton Bay have undergone substantial declines in recent years due to factors outside of Moreton Bay. This suggests the carrying capacity of the Moreton Bay wetlands for supporting migratory shorebirds is currently likely to be underutilised (i.e. migratory shorebirds are not subject to density-dependent population regulation due to the substantial loss of birds from the system as a result of declining numbers year on year mainly associated with disruption in other parts of the flyway). This underutilisation is likely a result of factors outside Moreton Bay, in particular impacts to coastal mudflats in the Yellow Sea. A recent study carried out by Studds *et al* (2017) found "*Yellow Sea reliance was the single most important predictor of variation in population trends*" and that "*Population trends were strongly negatively related with Yellow Sea reliance*". As a result, the loss of a relatively small area of intertidal feeding habitat (approximately 0.007% of intertidal mudflats within Moreton Bay – refer to **Attachment 3** of this referral) may not lead to a corresponding reduction in the number of migratory shorebirds using Moreton Bay.

Indirect impacts to migratory shorebirds include increased disturbance while utilising the roost sites. The development has the potential to increase disturbance to migratory shorebirds roosting in the mangroves of the Cassim Island roost site as a result of:

- Presence of built infrastructure and human activities closer to the roost site than at present;
- Increased noise, particularly during Project construction and pile driving;
- Increased lighting of the roost site at night from Project lighting;
- General project construction activities;
- Increased use of the waters within and adjacent to the roost by kayakers at high tide in the event that the Project provides launching points for kayakers; and
- Increased use of the waters within and adjacent to the roost by small recreational boats at high tide resulting from increased recreational boat traffic at Toondah Harbour.

Indirect impacts may include increased disturbance to migratory shorebirds roosting at the Nandeebie Claypan and Oyster Point roost sites (which are external to the Site) may result from:

- Increased pedestrian and cyclist traffic along the existing public walkway adjacent to the Nandeebie Claypan that increases the risk of people and dogs leaving the walkway to enter the roost site; and
- Increased recreational use of Oyster Point, where recreational activities already cause substantial disturbance to roosting shorebirds.

Potential Impacts to other Marine Fauna

The project is unlikely to result in direct impacts to marine fauna however increased human activity during construction, including changes in underwater noise levels, may affect the behaviour of fauna, particularly marine mammals.

Underwater noise and other loud sounds may affect marine mammals by interfering with their use of sounds in communication, especially in relation to navigation and reproduction. Marine mammals cease feeding, resting or social interaction at the onset of acoustic disturbance and to initiate alertness or avoidance behaviours. Marine mammals in the vicinity of frequent, high intensity noise are likely to be highly stressed or even physically harmed and consequently, are likely to stay well away from continuously operating acoustic disturbance. Therefore, any Indo-Pacific humpback dolphins, bottlenose dolphins or dugongs in the vicinity of the proposed development may vacate the area on commencement of the proposed in-water works such as wet excavation. Noise from on-land works is unlikely to disturb marine mammals. Any avoidance behaviour is likely to cease following completion of the work

Turtles have relatively poor hearing and are far less likely to be impacted by underwater acoustic disturbance. In the unlikely event that underwater construction does audibly disturb turtles, they may temporarily leave the area.

Fish, turtles and marine mammals may also become trapped in excavation areas during dredging and reclamation works. Impact to these marine fauna will depend on the time taken to excavate and the turbidity of the water during excavation, with higher turbidity and longer periods more likely to negatively impact marine fauna. A number of management measures will be put in place to reduce the risk of impact to fauna including the use of temporary barriers and visual monitoring.

Operational Impacts

Once construction has been completed and residential and tourism uses (including the marina) commence there is the potential for ongoing impacts to threatened and migratory species. The actions with the most potential to cause ongoing impacts include:

- An increase in boating traffic and other recreational uses such as kayaking in and around the project area;
- An increase in lighting and noise associated with ongoing uses; and
- Ongoing maintenance dredging of the harbour, marina and entrance channel.

Moreton Bay is adjacent to the most populated region in Queensland and already subject to significant boat traffic and recreational use. Toondah Harbour is an existing boat harbour including multiple ferry terminals and a public boat ramp. The proposed development is unlikely to result in an overall increase in recreational uses in Moreton Bay, but may result in an intensification of use around the site.

The proposed development may result in an increase in daily boat trips in the immediate area which could result in additional risk of boat strike for marine fauna, in particular dugongs and turtles which risk injury when coming to the water surface for air. There are a number of 'go slow' areas located in turtle and dugong hotspots throughout the Moreton Bay Marine Park. However, these areas are generally located around the bay islands, in particular North Stradbroke Island, with none located near Toondah Harbour.

Although the statutory plan for the PDA allows up to 400 marina berths, the proponent recognises the increased risk of boat strike to marine fauna from recreational vessels, and has reduced the number of proposed marina berths to approximately 200. Mandating sealife friendly propellers for vessels using the marina is also under consideration as an innovative response to minimising injury should marine fauna be subject to vessel strike.

While lighting and noise may increase compared to existing conditions at the site, which has the potential to cause disturbance to shorebirds, a minimum 250m buffer has been proposed between development and Cassim Island and Nandeebie Claypan high tide roost sites. This exceeds best practice requirements to avoid impacts on migratory species. The concept master plan for the development has been amended to ensure that most intensive human activities are conducted in areas furthest from the roost sites. Sympathetic lighting strategies, vegetation screening and sound attenuation will also be incorporated during detailed design to ensure impacts are avoided and minimised.

Overall potential impacts to migratory birds and marine fauna can be managed through increased management of the site and surrounds, educational tools and awareness raising. A range of measures have been identified that will assist to minimise, mitigate and offset potential impacts to migratory birds and marine fauna, which will be explored in detail through the EIS process. This includes:

- Increased management of the local area through a community ranger program
- Wetland education and cultural entre
- Community awareness campaigns
- Educational signage, in particular in areas surrounding high tide roost sites.

Toondah Harbour and the 2.55km entrance channel is already subject to periodic maintenance dredging by the state government and impacts would not be expected to be significantly different to what currently occurs. It is of note that impacts from previous maintenance dredging campaigns are considered to be minor and have not previously required referral under the EPBC Act. All options for treatment and disposal of dredge spoil from maintenance dredging will be examined through the EIS process.

Significant Impacts to MNES

To assist proponents to determine if their proposed action is likely to have a significant impact on matters of national environmental significance (MNES), the Commonwealth Government produced a series of guidelines on significant impacts. Most relevant for Ramsar wetlands are the *Significant Impact Guidelines 1.1 Matters of National Environmental Significance* (CoA 2013). These guidelines state that:

An action is likely to have a significant impact on a threatened species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of an important population (or any population for endangered and critically endangered species);
- reduce the area of occupancy of an important population (or the species in general for endangered and critically endangered species);
- fragment an existing important population into two or more populations (or any population or endangered and critically endangered species);
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of an important population (or any population for endangered and critically endangered species);
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

While management measures will be put in place to mitigate any indirect impacts to threatened species (see below), the removal of an area of low tide feeding habitat has some potential to reduce the area of occupancy for endangered and critically endangered species and/or disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species (defined at a national level as 0.1% of the estimated national population of the species, and at an international level as 1% of the population of the species).

While Moreton Bay's carrying capacity of migratory shorebirds and marine fauna species is unlikely to be affected the project will be referred as a controlled action to allow more detailed assessment under the EPBC Act to be carried out. It is noted that once projects are within a controlled action process offsets and benefits associated the project can be considered.

Management Measures

A number of management measures will be put in place through the design, construction and ongoing use of the Toondah Harbour project to avoid potential impacts on MNES. Some of the key management measures are outlined below however it is noted these will be refined and added to over the course of the assessment process.

Migratory Shorebirds

The project will be designed and managed to avoid any permanent impact on high tide roosting sites through the use of buffer areas and a number of other measures including:

- construction of appropriate barriers, such as fences to restrict access; ideally, there should be no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds;
- landscape and urban design to include sympathetic lighting strategies, vegetation screening and sound attenuation; and
- increased community education through mechanisms such as educational programs delivered through proposed wetland education and cultural centre, and interpretive signs at access points to shorebird habitats.

The implementation of a buffer zone around the Cassim Island shorebird roost site will likely be critical to mitigating potential impacts on this important roost site. A buffer of approximately 250 m from any urban development to the outer edge of the core roost site would keep disturbance to roosting shorebirds to a minimum.

In the event that the Project provides launch points for kayakers, implementation of a buffer exclusion zone, with no public access to the roost site, would be critical for mitigating disturbance to roosting shorebirds. Effective implementation of such a buffer exclusion zone would require interpretative signage specific to the Cassim Island roost site to be placed at shoreline entry points as well as sufficient resources to regularly enforce the exclusion zone over the long term. It is noted that kayakers and small motorised vessels such as jet skis already launch from the boat ramp at Toondah Harbour therefore exclusion zones and educational signage would result in an improvement to the current situation at Cassim Island.

The impact of disturbance from general Project construction activities, particularly activities such as dredging and pile driving near sensitive areas, can be mitigated by timing these activities to occur over the winter months May to August when most migratory shorebirds are absent from Moreton Bay. Construction will be staged over several years therefore works can also be staged to ensure impacts are minimised.

The maintenance of tall mangrove vegetation between the north-western edge of the roost site and the Project footprint would assist with screening the roost site from Project infrastructure and construction and operational activities. Construction of a barrier fence and vegetation screening along the boundary of the public walkway adjoining the Nandeebie Claypan roost site, together with site-specific information signs erected along the barrier fence would help minimise the risk of public and dog access to the Nandeebie Claypan roost site. The suitability of the Nandeebie Claypan roost site for migratory shorebirds could be enhanced though control of mangroves that are slowly encroaching on the roost site, particularly along the eastern boundary of the roost site.

Other Marine Fauna

Management measures will be put in place during construction activities to minimise the temporary impacts to water quality outside of the project footprint. Specific measures may include:

- designing the project to minimise the area of sediment and / or soils being disturbed;
- using temporary enclosures (complete enclosures such as sheet piles or alternate enclosures such as silt curtains) to reduce the intensity and spatial distribution of potential impacts;
- isolating the disturbance areas, for example by using sheet piles, silt curtains, oil spill booms, bunding, trenching and / or similar technologies;
- identifying and managing acid sulfate soils and other contaminants, through a sediment sampling and analyses plan (SAP) in accordance with the National Assessment Guidelines for Dredging 2009;
- developing thresholds for turbidity and suspended solids, and appropriate management (e.g. triggers for ceasing works) for seagrass and corals and monitoring water quality during construction; and
- monitoring changes in seagrass and coral communities post-construction to determine any potential impacts.

The risk of impacts to marine fauna as a result of noise and boat strike will be reduced further by preparing a Fauna Management Plan. Measures to minimise potential impacts to marine fauna may include:

- where dredging or pile driving activities are occurring, every morning before works begin, or after works have ceased for more than two hours and prior to it beginning again, appropriately trained Marine Fauna Observers (MFOs) inspect the area around all pile driving activities for 30 minutes;
- all vessel crew maintaining a look out for marine mammals and turtles during all operations;
- if prior to works, a marine mammal or turtle is identified within 150 metres, then pile driving does not commence until the animal has passed;
- if after works have commenced (including a soft start phase), a marine mammal or sea turtle is observed within 100 m of the noise emitting source, then pile driving ceases until the animal has passed;
- if a marine mammal or turtle are sighted in the pre-defined observation and exclusion zones, project vessels operating in the area are notified and piling ceases until the animal has passed;
- have a ‘soft-start’ for all pile driving, slowly increasing intensity of the driving hammer power;
- site inductions for all vessel crew covering procedures to minimise disturbance to marine fauna;
- training of all vessel crew in the identification of marine mammals and turtles;
- routine maintenance and inspection of all noise-generating equipment (including vessel engines, drill and piling equipment) to reduce unnecessary increases in noise levels from the equipment;
- where practical, engines, thrusters and auxiliary plant are not left on standby or running mode; and
- adherence to speed limits of all vessels involved in construction.

Marine pest species can be introduced via ballast water and hull fouling. While this risk is predominantly from vessels that have been in international waters, there is also a risk of boats spreading pests established in other ports. The introduction and spread of marine pest species can be minimised by following protocols of the National System for the Prevention and Management of Marine Pest Incursions, which aims to prevent new marine pests from arriving in Australia, and minimize the spread of pests within Australian waters. To reduce the risk of inadvertently spreading marine biofouling pests, vessel operators need to minimise the amount of biofouling on their vessels (Australian Government 2010).

Increased usage of the shoreline may lead to an increase in weed cover in mangrove and saltmarshes. This may be a result of dumping of garden refuse, by seeds and propagules being inadvertently spread along access tracks and paths by vehicles or on foot, and by the air and water borne spread of seeds and propagules from gardens and landscaped areas.

A weed management plan, and a strategy for the maintenance of native plant areas on the proposed site would reduce this risk of introduced plant pests.

Koala

The potential impacts of the Project on Koalas that currently utilise feed trees within the PDA can be mitigated by:

- adopting a landscape and urban design that retains as many of the primary food trees as possible;
- planting additional primary Koala food trees both within the PDA and surrounding areas where possible, to mitigate the potential loss of a small number of Koala food trees within the PDA. Planting of trees in advance of impacts will be considered noting that it will take years for the plantings to reach a size that they begin to provide food for Koalas;
- including traffic calming designs for roads crossing the open space corridor, and implementing a maximum speed limit of 40 km/hr;
- ensuring that the clearing of any trees during Project construction is performed under the guidance of a licenced fauna spotter; and
- using Koala exclusion fencing to fence off areas that may pose a risk of injury to Koala during construction.

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Document 6

Toondah'Harbour'
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Marine'Ecology'
EPBC'Referral'

Prepared'for:'

Walker!Group!Holdings!Pty!Ltd!

frc environmental

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Contents'

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Tables'

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Background'

Toondah! Harbour! is! located! at! Cleveland,! within! the! Redland! City! Local! Government! Areas! (LGA),! approximately! 30!km! from! Brisbane! in! south^east! Queensland.! ! In! June! 2013,! at! the! request! of! Redland! City! Council! (RCC),! Toondah! Harbour! was! declared! a! priority! development! area! (PDA)! by! the! State! Government! under! the! *Economic' Development' Act' 2012.'* In! June! 2015,! Walker! Group! Holdings! Pty! Ltd! (Walker)! was! selected! as! the! preferred! developer! and! is! now! responsible! for! designing,! financing! and! constructing! the! project.! ! The! proposed! master! plan! includes! a! new! ferry! and! tourism! precinct,!marina,!increased!residential!living!with!a!diversity!of!housing!types,!and!a!retail,! entertainment! and! dining! precinct! integrated! with! parks,! plazas,! boardwalks! and! recreational!facilities.!!

frc!environmental!was!commissioned!to!undertake!environmental!assessment!services!to! inform! a! referral! under! the! Commonwealth's! *Environment' Protection' and' Biodiversity' Conservation' Act' 1999*! (EPBC! Act)! with! respect! to! marine! (including! estuarine)! ecology.!! Specifically,! this! report! describes! the! existing! marine! habitats! and! communities! in! and! adjacent! to! the! PDA,! describes! and! assesses! the! likely! occurrence! of! marine! Matters! of! National! Environmental! Significance! (MNES)! protected! under! the! EPBC! Act,! identifies! potential! impacts! to! the! marine! environment! as! a! result! of! the! construction! and! operation! of!the!proposed!project,!and!suggests!mitigation!measures.!

Marine'Habitats'

The!PDA!and!adjacent!areas!supports!a!diversity!of!intertidal!and!shallow!subtidal!habitat,! including!saltmarsh,!intertidal!mangrove!forest,!intertidal!and!subtidal!seagrass!meadows,! coral! and! rubble! assemblages,! and! intertidal! and! subtidal! mudflats! and! sand^banks.!! These! habitats! have! a! high! to! very! high! ecological! value! and! were! surveyed! in! the! PDA! area!in!2014!(Table!1.1!and!Map!1).!

Marine!plant!communities,!including!saltmarsh,!mangrove!and!seagrass,!are!an!important! fish!habitat!and!are!of!high!ecological!value.!!Coral!communities!in!the!area!are!unique!in! that! they! are! likely! to! represent! the! marginal! range! of! several! species! and! are! of! high! ecological! value.! ! Similarly,! mudflat! and! sandbank! habitats! support! a! relatively! diverse! and!abundant!invertebrate!assemblage,!providing!an!important!source!of!food!for!fish!and! other! invertebrates! and! are! of! moderate! ecological! value.! Each! of! these! habitat! types! extends!beyond!the!PDA!and!each!is!extensively!distributed!throughout!western!Moreton! Bay.!!!

Table'1.1' Habitats'of'the'PDA'and'adjacent'areas.'

Description+	**Biota+Observed+**	**Ecological+Value+**
Shellfish+Reefs+ Historically'dominated'the'area,'currently'functionally'extinct.''Remnant'oysters'likely'to'be' restricted'to'intertidal'areas.'	Not'surveyed'	**Not+Applicable+** Shellfish'reefs'are'currently'functionally' extinct' '
Saltmarsh+ There'are'approximately'1.2'ha'of'saltmarsh'south'of'(and'none'within)'the'PDA'(Map'1).'' The'saltmarsh'is'in'the'upper'most'intertidal'zone'with'the'mangroves'offshore.' The'saltmarsh'is'highly'disturbed'by'the'developed'areas'along'the'foreshore.''The'saltmarsh' receives'run‑off'from'developed'areas'and'rubbish'was'found'throughout.'	**Plants+** Grey'mangrove,'river'mangrove,'sea'rush,'seablite,'samphire,'couch,'benthic'algae'	**High+–+important+fisheries+value+** Diversity'of'flora'was'low'and'patchy.'' Some'of'the'saltmarsh'area'is'listed'as'a' vulnerable'threatened'ecological' communities'under'the'EPBC'Act.'
Intertidal+Mangrove+Forests+ There'are'approximately'5.3'ha'of'mangroves'within'the'PDA'(Map'1).' The'mangrove'forests'are'along'the'upper'intertidal'zone'and'are'bordered'by'mud'and'sand' flats.' The'mangrove'forests'along'the'foreshore'are'highly'disturbed'by'the'developed'areas.''These' mangrove'forests'receive'run‑off'from'developed'areas.''There'was'rubbish'within'the' mangrove'roots'and'along'the'shoreline'throughout'the'PDA.'	**Plants:++** Grey'mangrove,'river'mangrove,'stilted'mangrove,'yellow'mangrove,'algae' **Invertebrates+** Hercules'mud'whelks,'barnacles,'periwinkles,'nerites,'estuarine'slugs,'hermit'crabs,' sand'bubblers,'fiddler'crabs,'mangrove'crabs,'polychaetes'	**High+–+important+fisheries+value+and+ high+diversity+of+fauna+** Diversity'of'flora'was'low,'but'cover'was' high.''The'diversity'of'fauna'was'high,'but' abundances'were'low.'''
Intertidal+and+Subtidal+Seagrass+ There'are'approximately'32.7'ha'of'seagrass'within'the'PDA'(Map'1).' The'seagrass'meadows'are'predominantly'in'the'intertidal'and'shallow'subtidal'zone'between' the'foreshore'and'island'of'mangroves'offshore'within'the'PDA.''There'are'also'some'sparse' seagrass'meadows'in'the'lower'intertidal'zone'adjacent'to'the'subtidal'areas.' There'has'been'some'disturbance'of'the'seagrass'meadows'by'recreational'boat'traffic'and' wash'from'ferries'on'the'southern'section'adjacent'to'the'channel.'	**Plants+** Seagrass,'macroalgae' **Invertebrates+** Hermit'crabs,'sea'cucumbers,'anemones,'swimmer'crabs,'polychaetes,'soft'corals,' jellyfish,'prawns,'mussel,'clams' **Vertebrates+** Fish,'stingrays.''	**Very+High+–+important+fisheries+value,+ potential+foraging+area+for+threatened+ species+(turtles+and+dugong)+** There'was'moderate'diversity'and' abundance'of'flora'and'fauna.''The'area'is' likely'to'be'used'by'several'fish'species'of' commercial'importance.''The'area' potentially'provides'significant'habitat'and' foraging'ground'for'marine'turtles'and' dugongs.
Coral+and+Rubble+Assemblage+ There'are'scattered'corals'to'the'north'and'east'of'Cassim'Island'and'there'may'also'be'some' coral'within'and'to'the'south'of'Fison'Channel.''There'are'areas'of'soft'coral'and'hard'coral' reef'to'the'east'of'Cassim'Island,'outside'the'PDA.'	Not'surveyed'+	**High+–+supports+distinctive+species+** Marginal'range'of'several'species,'unique' communities'
intertidal+and+Subtidal+Mudflats+and+Sand+banks+ This'zone'includes'the'current'dredged'channel'for'boat'and'ferry'access'to'Moreton'Bay,'and' shallow'unvegetated'intertidal'flats'(Map'1).' The'area'around'the'channel'is'extremely'disturbed'by'the'frequent'boat'and'ferry'traffic,'with' wash'affecting'exposed'areas'at'low'tide.''The'rest'of'the'area'is'moderately'disturbed,'with' run‑off'from'developed'areas'and'some'recreational'use.'	**Plants+** Benthic'algae' **Invertebrates+** Hercules'mud'whelks,'hermit'crabs,'fiddler'crabs,'mangrove'crabs,'polychaetes' **Vertebrates+** Fish,'stingrays'	**High+–+important+fisheries+value+** Invertebrate'fauna'was'relatively'diverse' and'abundant.'

Toondah Harbour Marine Ecology
EPBC Referral

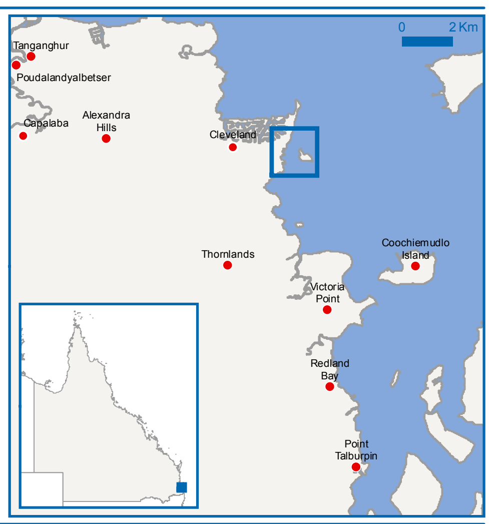
Map 1:
Marine habitats of Toondah Harbour and the PDA

LEGEND

Toondah Harbour PDA

Dominant Marine Habitats

Avicennia marina
Rhizophora stylosa
Aegiceras corniculatum
Ceriops tagal var. australis
Saltpan / Saltmarsh
Juncus kraussii
Seagrass
Rubble
Sand / Mud



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SOURCES

DATE	DRAWN BY	VERSION	PROJECTION
2017-03-27	CB	01	Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator Datum: GDA 1994

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Matters of National Environmental Significance

The proposed project is within the Moreton Bay Ramsar wetland boundary, which is a wetland of national importance. Threatened and migratory loggerhead turtles and green turtles are highly likely, and hawksbill turtles are moderately likely to intermittently occur in the potential area of impact. While these species are unlikely to nest in the vicinity of the PDA, they are likely to use the area as a foraging ground. Migratory Indo-Pacific humpback dolphins and dugong are also highly likely to intermittently occur in the potential area of impact. Both these species tend to occur in estuarine and shallow coastal areas and may use the area for feeding.

Loggerhead turtles, green turtles, hawksbill turtles Indo-Pacific humpback dolphins and dugong also occur within the wider Moreton Bay and along the east coast of Queensland. The area in the immediate vicinity of the proposed works is unlikely to provide critical significant habitat for these species.

Potential Impacts

Potential Impacts from the proposed project include:

- direct loss of habitat directly under the footprint of the proposed project
- gain of habitat in some of these areas
- marine fauna trapped or injured in wet excavation areas
- disturbance of sediments and soil (potentially increasing turbidity, suspended solids, sedimentation, nutrients and/or contaminants and disturbing potential acid sulfate soils)
- spills of hydrocarbons and other contaminants
- increased stormwater runoff (with greater non-permeable surfaces on the subject site) and associated contaminants and foreshore erosion
- altered hydrodynamics
- increased site access and boating activity
- spread of weeds and pests
- increased litter, and
- long-term improvement in water quality around the Fison Channel.

A number of industry standard measures could be put in place to mitigate these impacts, including:

- designing the project to minimise the area of disturbance (project footprint); the volume of sediment and / or soils disturbed; and, any changes to hydrodynamics
- using the project footprint for any temporary construction and storage
- incorporating structures that provide valuable habitat for fish in the design
- identifing and managing acid sulfate soils and other contaminants
- using temporary enclosures (e.g. complete enclosures such as sheet piles) to reduce the intensity and spatial distribution of turbid plumes during construction
- installing any temporary enclosures at low tide to minimise the number of marine vertebrates caught in the area
- catching any animals that are trapped in the enclosures and releasing them in appropriate habitat outside the area
- using trained marine mammal and turtle spotters prior to commencement of excavation and dredging activities and appropriate management tools to avoid impacts to them (e.g. triggers for cessation of excavation or dredging works)
- developing turbidity and suspended solids thresholds and appropriate management (e.g. triggers for ceasing works) for seagrass and corals and monitoring water quality during construction
- avoiding disturbance of sediment and / or soils during important periods of reproduction for coral and seagrass (e.g. late spring and summer) and / or during low
- minimising litter, waste and the use of hydrocarbons and other chemicals
- following national and international best practice standards, including Australian standards relating to antifouling paints and contaminants, Nature Conservation (Wildlife Management) Regulation 2006, vessel and vehicle management and site management strategies and fuel storage and handling activities outlined in AS1940
- implementing environmental management plans, including a Marine Fauna Management Plan, Stormwater Management Plan, Sediment and Erosion Management Plan, Waste Management Plan, Weed Management Plan and Spill Management Plan
- monitoring changes in seagrass and coral communities to determine any potential impacts.

With' the' use' of' appropriate' mitigation' measures,' potential' impacts' to' aquatic' habitats' and' communities' are' likely' to' be' of' low' significance,' other' than' the' direct' impacts' to' marine' plants' and' soft' sediment' within' the' footprint,' and' changes' to' water' quality' and' soft' sediment' communities' within' the' dredging' and' reclamation' area.'

1 Background

Toondah Harbour is located at Cleveland, within the Redland City Local Government Areas (LGA), approximately 30 km from Brisbane in south-east Queensland. Toondah Harbour is an existing marina area that serves as the base for water taxi, passenger and vehicular ferry services between the mainland and North Stradbroke Island.

In June 2013, at the request of Redland City Council (RCC), Toondah Harbour was declared a priority development area (PDA) by the State Government under the *Economic Development Act 2012*. The PDA was declared to provide opportunities for mixed use and medium density residential development in addition to tourism and retail based development, ferry terminals, open space and a marina. In June 2015, Walker Group Holdings Pty Ltd (Walker) was selected as the preferred developer and is now responsible for designing, financing and constructing the project. Economic Development Queensland (EDQ) and Redland City Council (RCC) are the landowners and will work closely with Walker to implement the shared vision for the project over the next 15 to 20 years.

The PDA has a total area of 68.4 hectares, encompassing 17.9 hectares of existing land and 50.5 hectares of marine and tidal environments. Much of the landward portion of the PDA was previously reclaimed from the 1960s onwards.

The proposed master plan includes a new ferry and tourism precinct, marina, increased residential living with a diversity of housing types, an a retail, entertainment and dining precinct integrated with parks, plazas, boardwalks and recreational facilities.

1.1 Scope of Work

frc environmental was commissioned to undertake environmental assessment services to inform a referral under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) with respect to marine [1] ecology. Specifically, frc environmental was requested to:

- describe the existing marine habitats and communities, based on field surveys (done in 2014), available data on the spatial distribution of habitats, and on a review of recent literature
- describe the marine Matters of National Environmental Significance (MNES) protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in and adjacent to the PDA

[1] With the definition of 'marine' ecology including estuarine ecology.

- assess the likely occurrence of listed marine MNES in the PDA
- assess potential impacts and risk to the marine environment as a result of the construction and operation of the proposed project, and
- identify mitigation measures that may avoid, reduce or remedy potential impacts.

2 Marine Habitats and Communities

2.1 Overview

The PDA and adjacent areas supports a diversity of intertidal and shallow subtidal habitat, notably:

- saltmarsh
- intertidal mangrove forest
- intertidal and subtidal seagrass meadows
- coral and rubble assemblages, and
- intertidal and subtidal mudflats and sand-banks.

These habitats were surveyed and mapped for the PDA area in 2014 (refer to Map 1 and Table 1.1 in the Summary and to Appendix A for methods). Each of these habitat types extends beyond the PDA and each is extensively distributed throughout western Moreton Bay (Map 2). Prior to European settlement, shellfish reefs were also extremely abundant in coastal bays and estuaries of southern Queensland, including Moreton Bay. Subtidal shellfish reefs are now likely to be functionally extinct in the area (Diggles 2015).

Estuarine systems are a 'seascape' of interconnected patches of habitat (including seagrasses, mangroves, saltmarshes, oyster or coral reefs and rubble banks, and un-vegetated sand-banks and mudflats), linked actively through the movement of organisms and passively through the waterborne transport of primary production (Irlandi & Crawford 1997; Loneragan et al. 1997; Micheli & Peterson 1999; Rapoza & Oviatt 2000; Connolly & Guest 2002; Skilleter & Loneragan 2003; Skilleter et al. 2005). These habitats provide a range of ecological values and are important for the maintenance of fisheries resource, biodiversity and ecosystem services, and often support a high abundance and diversity of fish and invertebrates (Beck et al. 2001; Table 1.1). In addition to sustaining adult populations, which are harvested by inshore fisheries, many habitats are widely recognised for their role as 'nurseries' for juvenile fish, crabs and prawns, and their contribution to the productivity of offshore fisheries (Coles & Lee-Long 1985; Connolly 1994; Laegdsgaard & Johnson 1995; Halliday & Young 1996; West & King 1996; Blaber 1997; Butler et al. 1999; Beck et al. 2001; Chargulaf et al. 2011).

A description of each habitat in or adjacent to the PDA and in the Moreton Bay region, as well as a summary of the ecological significance of each habitat, is provided below. Information has been sourced from a field survey in 2014 (refer to Appendix A for field and laboratory methods) as well as a review of available data and literature.

2.2 Shellfish Reefs

Historical Extent

Shellfish (oyster) reef habitat was presumed to dominate southern Moreton Bay (including the PDA) prior to European settlement (Figure 2.1; Diggles 2015). Today, subtidal shellfish reefs are functionally extinct throughout most of southern Queensland (Beck et al. 2011; Diggles 2013). Shellfish reefs have also declined worldwide, with an estimated 85% of reefs lost globally (Beck et al. 2011). Shellfish reefs remaining in Moreton Bay are likely to be restricted to low numbers (individuals or clumps), mainly in the intertidal. In southern Moreton Bay the decline of shellfish reefs has resulted from a combination of events including overfishing, disease, increased sediment loads and declining water quality (Smith 1981; Diggles 2013).

Subtidal shellfish reefs in southern Queensland are unlikely to be restored by natural recruitment, thus active intervention to identify successful locations and to determine the most effective methods for restoration of shellfish reefs is underway. Current projects in Pumicestone Passage (north east Moreton Bay) as well as in several other locations around Australia are aimed at restoring shellfish habitat (TropWATER 2017).

Ecological Significance

Shellfish reefs have several important ecological functions, including providing structure and food, filtering sediments and nutrients, and stabilising the shoreline.

Oysters provide the basis of entire ecosystems, providing hard structure (in predominantly soft sediment environments) by the constant adhesion of new larvae to existing shells. Fouling and encrusting flora and fauna attach to, and grow on oyster reefs including algae, sponges, hydroids, bryozoans, gastropods and other bivalves. The shell matrices and crevices provide refuge, and the reef ecosystem provides food for many species, including polychaetes, crustaceans, gastropods and fish. Several species of fish also use the reefs for laying eggs, as a nursery (NOAA 2017) and as a corridor between shelter and foraging grounds (Grabowski & Peterson 2007). Intertidal shellfish reefs in Australia are also likely to provide foraging habitat for migratory shore birds protected under bilateral migratory bird agreements such as CAMBA and JAMBA (TropWATER 2017).

Being filter feeders, oysters filter detritus and phytoplankton from the water column. Consumed organic matter is used for growth, some of which is consumed by predators or degraded by bacteria and other organisms when the oysters die (NOAA 2017). Forming calcium carbonate shells, oysters remove carbon from the water column and act as a carbon sink (Grabowski & Peterson 2007). Waste material is excreted as faeces and inorganic nutrients, either directly from the oyster or via predators and other reef and benthic organisms. Deposit feeder and other organisms in the sediment use some of the excreted material as food. Inorganic nutrients are used by primary producers. In systems with high ratios of oyster biomass to water volume, the removal of suspended organic particles controls nutrient flow, and therefore the amount of phytoplankton, zooplankton, and other components of the ecosystem. Thus, the loss of large areas of shellfish reef can result in a shift from a benthic-pelagic system to a planktonic-microbial system (NOAA 2017). Shellfish reefs promote the health of other estuarine habitats, such as seagrass, by increasing light penetration and minimising negative effects of eutrophication (Grabowski & Peterson 2007).

Shellfish reefs also create a physical barrier and enhance deposition (Borsje et al. 2011). They attenuate wave energy and reduce shoreline erosion, effectively protecting other estuarine habitats such as saltmarsh (Grabowski & Peterson 2007).

Figure 2.1 Presumed extent of biogenetic reef forming shellfish resources in south east Queensland prior to European settlement (grey)(Diggles 2015).

'

2.3! Saltmarsh!

Adjacent!to!the!PDA!

There' is' an' area' of' saltmarsh' south' of' the' PDA' that' extends' from' the' landward' edge' of' the' mangrove' zone' up' to' the' terrestrial' zone' (Figure' 2.2,' Map' 3).' ' The' saltmarsh' community' is' dominated' by' marine' couch' (*Sporobolus' virginicus*)' with' patches' of' common' samphire' (*Sarcocornia' quinqueflora*)' (Figure' 2.3)' and' seablite' (*Suaeda' australis*).' ' Along' the' upper' most' portion' of' the' saltmarsh,' there' is' a' dense' zone' of' sea' rush' (*Juncus' kraussii*)' (Figure' 2.4).'

There' are' approximately' 1.2' ha' of' saltmarsh' south' of' the' PDA,' and' none' within' it' (as' mapped' in' 2014' on' Map' 1T**Error!!Reference!source!not!found.**).'

Figure' 2.2' '

'

Saltmarsh' south' of' the' PDA.''

'

Figure' 2.3' '

'

Common' samphire.'

'

Figure 2.4

Sea rush.

Saltmarsh of the Region

Claypan habitats in Moreton Bay are commonly unvegetated, but may also be dominated samphires or grasslands (Map 3) (Dowling & Stephens 2001). Samphire communities are dominated by samphire (*Sarcocornia* spp.) and seablite (*Suaeda* sp.). Grassland communities are dominated by marine couch (*Sporobolus virginicus*), saltwater couch (*Paspalum vaginatum*) and patches of rush, such as *Juncus kraussii* (Dowling & Stephens 2001).

Within Moreton Bay, there are approximately 368 ha of samphire and 2 034 ha of claypan habitat (Beumer et al. 2012). The eastern side of Moreton Bay is typically dominated by the rush *Juncus kraussii* due to abundant freshwater in the intertidal zone, while the western side of Moreton Bay is dominated by chenopod species of *Sarcocornia* and *Suaeda* due to the hypersaline intertidal sand flats (Lovelock et al. 2014).

Subtropical and temperate coastal saltmarsh is listed as vulnerable under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999*. The listed coastal saltmarsh community consists of dense to patchy areas of mainly salt-tolerant vegetation that is generally less than 0.5 m high and bare sediment (clay). This habitat occurs throughout Moreton Bay, including south of the PDA (Map 3).

Ecological Significance of Saltmarsh

Saltmarsh areas provide permanent habitat for a number of animals, including crabs, mosquitoes and other insects. Large clutches of crab larvae are produced in saltmarsh areas during the spring tides when the marsh is inundated. The highest concentration of zooplankton in estuaries are found in spring tides in saltmarshes (Saintilan & Mazumder 2004). This concentrated release of plankton into the water column can be an important food source for other organisms, such as fish, including some commercially important species (Saintilan & Mazumder 2004; Mazumder et al. 2006). As well as providing prey for shore birds and other animals, crabs bioturbate the sediment and contribute to cycling nutrients in the estuary.

Saltmarshes stabilise bare mud flats, act as fish habitats during inundation, re-mineralise terrestrial and marine debris, contribute to the nutrient cycling of estuaries, and may buffer the water bodies from excess terrestrial nutrient run-off (Adam 1990). They may also reduce erosion in the upper intertidal zone (van Erdt 1985, cited in Adam 1990). Recent studies indicate saltmarshes sequester carbon and that the carbon in these sediments may help mitigate increases of carbon dioxide in the atmosphere (Lovelock et al. 2014). Within the Tweed Moreton Bioregion in south-east Queensland, only 84 km^2 of saltmarsh communities remain (Dixon et al. 2011).

While our understanding of the direct use of saltmarshes by finfish and nektonic crustaceans is comparatively poor (Connolly 1999), some studies have indicated that fish of commercial and recreational importance rarely use upper littoral saltmarsh habitat (Morton et al. 1987; Connolly et al. 1997), while others have found widespread use of saltmarshes by a range of common and commercially important fish species (Thomas & Connolly 2001). Fish communities found using saltmarshes are typically dominated by smaller fish families (e.g. Ambassidae and Gobiidae) but also include whiting, flathead and prawns (Saintilan & Rogers 2013).

Vertebrate animals are also commonly found using the resources located in saltmarshes, as it provides foraging habitats for shore birds, bats, the water mouse and on occasion kangaroos and reptiles (e.g. snakes and goannas) (Saintilan & Rogers 2013). Thirteen insectivorous bats have been recorded using saltmarshes as a foraging ground with some species preferring to forage over saltmarsh vegetation where mosquitoes were in high abundance (Gonsalves 2012).

2.4 Intertidal Mangrove Forests

Mangroves of the PDA

The mangrove forest along the shoreline of the PDA is dominated by the grey mangrove (*Avicennia marina*) and the stilted mangrove (*Rhizophora stylosa*), with sparse river mangroves (*Aegiceras corniculatum*) and yellow mangroves (*Ceriops australis*) in the upper intertidal zone. The grey mangrove dominates the lower and upper intertidal zones, while the stilted mangrove dominates the middle intertidal zone (Figure 2.5). In the 2014 field survey there was evidence of insect damage (Figure 2.6) throughout the PDA, and some yellowing of leaves (Figure 2.7), which is likely to be due to stress such as low rainfall and high salinity in the sediment. There were few dead mangrove trees, however in some area up to 20% of the branches were dead. The density of seedlings was low with most seedlings recorded in the mangrove forest north of the current ferry terminal.

Mangrove communities offshore, east of the PDA, are dominated by the grey mangrove, with some stilted mangrove in the middle of the island (as mapped in 2014 on Map 1). In 2014, the condition of these mangroves was similar to those along the shoreline, with some dead branches and insect damage.

Epifauna of the mangroves was dominated by various mollusc species. Whelks and periwinkles were common on mangrove branches and roots (Figure 2.8), while Hercules mud whelks (*Pyrazus ebeninus*) were common on the substrate. Nerites (*Nerita* spp.) were also recorded on mangrove branches and roots (Figure 2.9). Maroon mangrove crabs (*Perisesarma messa*) were caught in pitfall traps, while broad-fronted mangrove crabs (*Metopograpsus frontalis*) (Figure 2.10) were recorded using crab holes around pneumatophores.

Mangrove communities of the PDA were typical of south-east Queensland being low in diversity and dominated by the grey mangrove. There are approximately 5.3 ha of mangroves within the PDA that are likely to be of good fisheries and aquatic ecological value (as mapped in 2014 on Map 1).

Figure 2.5

Dense *Rhizophora stylosa* south of the current ferry terminal within the PDA.

Figure'2.6'

Insect'damage'on'grey'mangrove' leaves.'

Figure'2.7'

Yellowing'leaves'of'stilted' mangroves.'

Figure'2.8'

Mangrove'whelk'(*Batillaria' australis*)'on'mangrove'trunk.''

Figure 2.9

Nerite on stilted mangrove prop root.

Figure 2.10

Broad-fronted mangrove crab.

Mangroves of the Region

The mangroves of Queensland have been divided into three broad communities: high rainfall forest communities; low rainfall claypan communities; and subtropical communities (Dowling & McDonald 1982). Within the Toondah Harbour PDA, mangroves are typical of the subtropical communities. Subtropical mangrove communities are floristically less diverse than the other two community types, primarily because they are at the southern limit of many species ranges (Dowling & McDonald 1982).

There are seven species of mangrove in Moreton Bay (and in the Moreton Bay Marine Park); grey mangroves (*Avicennia marina)* river mangroves (*Aegiceras corniculatum*), large-leaved mangroves (*Bruguiera gymnorrhiza*), yellow mangroves (*Ceriops australis*), milky mangroves (*Excoecaria agallocha*), white flowered black mangroves (*Lumnitzera* *racemosa*), and stilted mangroves (*Rhizophora stylosa*). The mangrove fern, *Acrostichum speciosum*, is also common (Dowling 1979; 1986; Hyland & Butler 1988; Dowling & Stephens 2001). In the Moreton Bay Marine Park there are approximately 140 km^2 of mangroves, with the largest communities in Pumicestone Passage and the southern bay islands, south of Jacobs Well (DERM 2010a).

Ecological Significance of Mangroves

Mangroves help protect coastlines from recession by dampening wave energy (Alongi 2008), can moderate the impact of extreme events (i.e. tropical storms) (Zhang et al. 2012) and can act as a buffer between the land and sea (Dahdouh-Guebas & Jayatissa 2009). Mangrove forests are also important nursery grounds for many species of juvenile fishes, including commercially important species (Robertson & Blaber 1992; Laegdsgaard & Johnson 1995; Halliday & Young 1996; Blaber 1997) (e.g. sea mullet, Figure 2.11). Juveniles of seven of the ten commercially harvested fish species in Moreton Bay are most abundant in mangroves (Laegdsgaard & Johnson 1995). Further, Morton (1990) reported that 46% by species and 94% by weight, of fishes associated with an *A. marina* forest in Moreton Bay were of direct commercial significance.

Mangrove lined creeks support a variety of fish species that have habitat-specific distributions according to individual species requirements for food and shelter (Zeller 1998). Mangrove forests can act as carbon sources for estuarine, inshore, and offshore waters, through the export of leaf and fruit material (Lee 1995). Decomposing mangrove material provides both soluble nutrients and detrital fragments that are eaten by crustaceans, such as prawns and crabs, and some fish. Decaying plant and animal matter are consumed by juvenile and adult greasy back prawns, and juvenile banana prawns, both of which are obligate residents of mud banks adjacent to mangroves (Staples & Vance 1985). Adult banana prawns eat both small benthic invertebrates feeding on detritus in channels draining mangroves, and benthic algae on adjacent mud flats (Newell et al. 1995). Mangroves also trap, accumulate and release nutrients (and in some cases pollutants) and particulate matter (silt) from surrounding land, thus acting as a buffer to the direct effects of run-off. They also protect the shoreline from erosion from the water (e.g. waves and boat wash) or the land (run-off), and contribute to the establishment of islands and the extension of shorelines (Blamey 1992). Similar to saltmarshes, mangroves also play a major role in carbon sequestration (Lovelock et al. 2014).

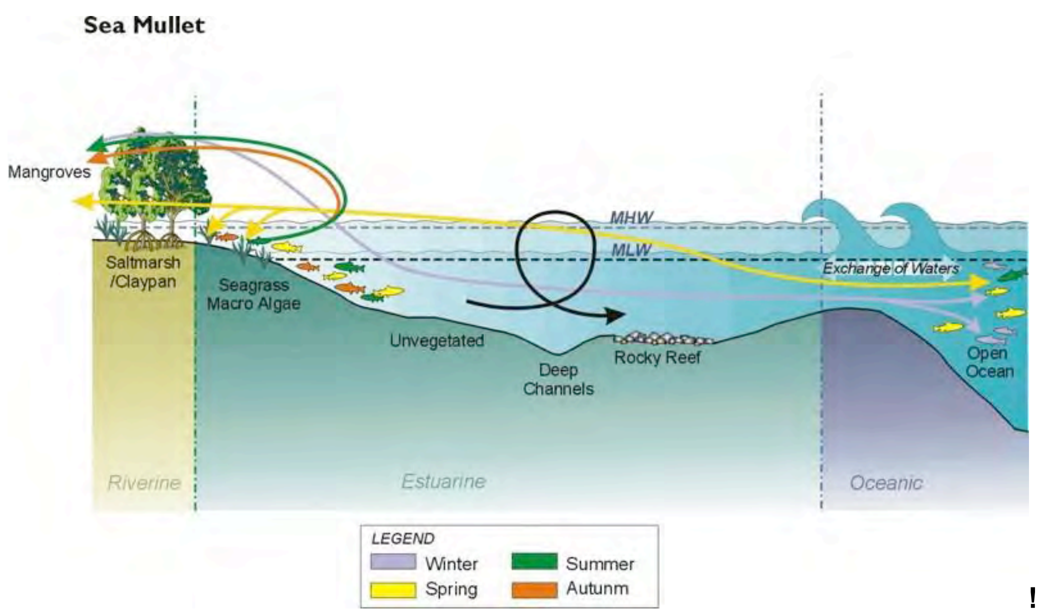


Figure 2.11 Mangroves provide critical habitat for young sea mullet.

2.5 Intertidal and Subtidal Seagrass

Seagrass in and in the Vicinity of the PDA

There are approximately 32.7 ha of seagrass in the PDA, primarily in the lower intertidal and subtidal area in the eastern section of the PDA (as mapped in 2014 on Map 1). The seagrass meadows are dominated by *Zostera muelleri* with some *Halophila ovalis* (Figure 2.12), and *Halophila spinulosa* (Figure 2.13). The percent cover of seagrass in the PDA ranges from 1% to 85%, with an average percent cover of 33% (Healthy Land and Water and Science Under Sail 2015).

There are extensive beds of seagrass to the north and south of the PDA, these beds are dominated by *Zostera muelleri* with some *Halophila ovalis*. In surveys in 2011 seagrass patches within the PDA and to the south of the existing channel were recorded as being between 1 and 25% cover, with patches of up to 50% cover to the north of the channel and offshore (Roelfsema et al 2013). More recent surveys (2015 and 2016) indicate there are patches of *Halophila spinulosa* offshore (Healthy Land and Water and Science Under Sail 2015) (Map 4).

In the 2014 survey of seagrass in the PDA, density was highest in the low intertidal and subtidal zone between the current ferry terminal and Cassim Island (Figure 2.14), and sparser in the higher intertidal area adjacent to the mud and sand flats.

In the survey in 2014, seagrass meadows were in good conditionThowever, there were some patches of seagrass that were covered in filamentous algae. Within the seagrass meadows there were several species of macroalgae, including:

- sargassum (*Sargassum flavicans*)
- *Padina gymnospora*
- oyster thief (*Colpomenia sinuosa*), and
- *Halimeda* spp.

Stingrays were observed foraging in the seagrass at low tide, and several species of fish were observed entering the seagrass meadow on the incoming tide

Epifauna of the seagrass beds in this survey was sparse, with low numbers of individuals recorded. At low tide, Hercules mud whelks were in the seagrass near the more exposed areas (Figure 2.15), while blue swimmer crabs (*Portunus armatus*) were present in the subtidal areas (Figure 2.16). Two bivalves were recorded: the strawberry cockle (*Fragum unedo*) (Figure 2.17) and the razor clam (*Pinna bicolor*). Several anemone species and some small colonies of soft corals were also recorded. One sea cucumber was found under a rock in the seagrass bedsThowever, no other sea cucumbers were observed on the seagrass in the intertidal or subtidal zone.

Benthic infauna was dominated by polychaetes and crustaceans, with some bivalves and gastropods. Polychaete communities comprised several families including Capitellidae, Cirratulidae, Syllidae and Spionidae. Crustacean communities comprised Gammarid amphipods, snapping shrimp (family Alpheidae) and hermit crabs (family Diogenidae). Brittle stars (class Ophiuroidea) were recorded at one site in the shallower subtidal area. The abundance and taxonomic richness of benthic infauna was highest at this site (Table 2.1), despite the other seagrass site being deeper and less exposed at low tide.

Table 2.1 Mean abundance of benthic infauna per square metre and total taxonomic richness of benthic infauna at each site.

Site	Mean Abundance (±SE)	Total Taxonomic Richness
Seagrass 1	333 (±17)	13
Seagrass 2	1583 (±246)	24

Figure 2.12

Seagrass meadow comprising *Zostera meulleri* and *Halophila ovalis* in the PDA.

Figure 2.13

Halophila spinulosa.

Figure 2.14

Dense seagrass in the lower intertidal zone.

Figure'2.15'

Hercules'mud'whelk'in'shallow' seagrass.''

Figure'2.16'

Blue'swimmer'crab'in'the' seagrass.'

Figure'2.17'

Cockle'exposed'at'low'tide.'

Seagrass of the Region

There are seven species of seagrass in Moreton Bay (and in Moreton Bay Marine Park): *Cymodocea serrulata, Halophila ovalis, Halophila spinulosa, Halophila decipiens, Halodule uninervis, Syringodium isoetifolium*, and *Z. muelleri*. *Z. muelleri* is the dominant species in terms of area. Most seagrass in Moreton Bay is intertidal, with subtidal seagrass generally found in water less than 3 m deep at low tide (Hyland et al. 1989). Over 280 species of macroalgae have been recorded from Moreton Bay (Tibbetts et al. 1998). An algae, *Caulerpa taxifolia,* is also commonly found in Moreton Bay in the same shallow, soft sediment niche as seagrass (Phillips & Price 2002; Thomas 2003).

Moreton Bay supports 189 km^2 of seagrass (Roelfsema et al. 2009). The largest and most dense seagrass meadows are in the eastern bay surrounding South Passage between Moreton and Stradbroke islands; though there are also substantial meadows in the southern and western parts of the bay. With increasing urbanisation and industrial development, seagrass meadows within western Moreton Bay have been lost over the past decades. While some meadows have been lost as a direct result of infilling, a far greater area of seagrass has been lost as a result of changes in water quality (EHMP 2006).

Seagrass meadows occur in areas of Moreton Bay with poor water quality, providing some evidence of the resistance to these impacts (Gibbes et al. 2014). This resilience is likely a result of the uptake of nutrients from the water column reducing nutrient available for algal growth, the trapping of sediments from the water column improving water clarity, and the harbouring of grazers minimising the growth of epiphytic algae. Evidence of resilience has been shown after flood events in Moreton Bay, where seagrass biomass remained constant throughout the year in meadows close to flood plumes (high in suspended sediments and nutrients) compared to meadows in less impacted areas. Meadows in flood impacted areas had longer and wider leaves, and higher concentrations of chlorophyll *a*, allowing greater absorption of light and sediment baffling than meadows in less impacted areas (Gibbes et al. 2014). Large-scale loss of seagrass has historically occurred in some areas of Moreton Bay (e.g. Bramble Bay and southern Deception Bay) (Dennison & Abal 1999). Recovery in these area can be limited by sediments that are more easily resuspended, nutrients released into the water column available for algal growth and reduced grazing rates of algae. However, recent surveys in Moreton Bay show recovery in areas where seagrass was previously completely lost (Gibbes et al. 2014). Both *H. ovalis* and *H. spinulosa* are opportunistic species, producing large quantities of seeds and with relatively high growth rates. This enables them to quickly colonise areas when conditions are suitable; however, they also rapidly disappear when conditions deteriorate.

Ecological Significance of Seagrass

Seagrasses are primary producers (Hillman et al. 1989) that are recognised as playing a critical role in coastal marine ecosystems (Poiner & Roberts 1986; Hyland et al. 1989; Pollard 1984). They provide shelter and refuge for resident and transient adult and juvenile finfish, crustaceans and cephalopods, many of which are of commercial and recreational importance, others of which are the preferred foods of these species (Dredge et al. 1977; Hutchings 1982; McNeill et al. 1992; Coles et al. 1993; Edgar & Shaw 1995; Gray et al. 1996; Connolly 1997) (Figure 2.18). They also have a number of other ecological functions including providing large amounts of substrate for encrusting animals and plants (Harlin 1975; Klumpp et al. 1989) and trapping detritus and dissolved organic matter, increasing local nutrient cycling (Moriarty et al. 1984).

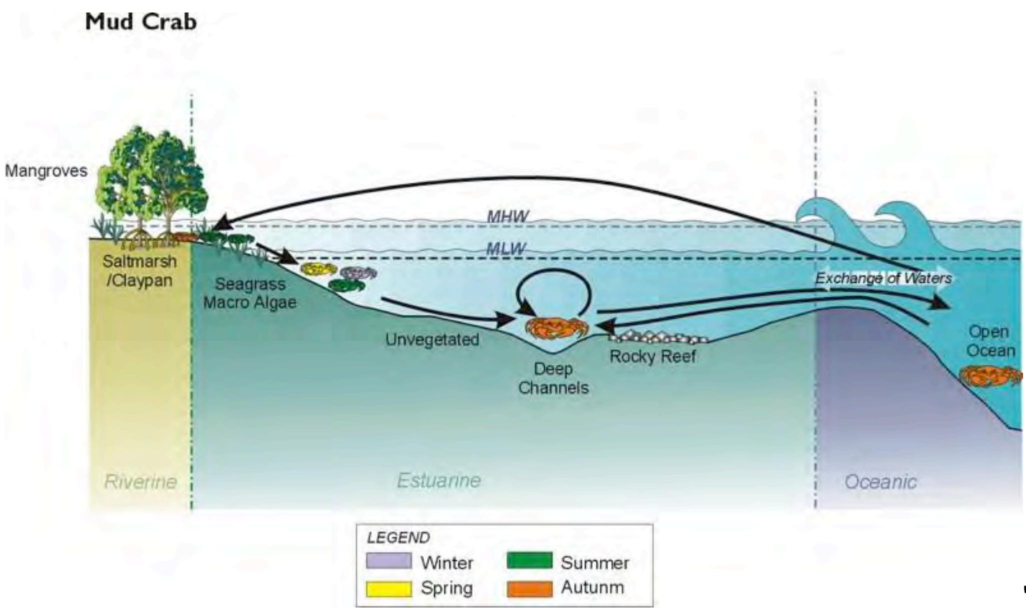
Whilst the abundances of juveniles of many fish and crustacean species are commonly higher in seagrass habitats than over bare sand or mud, there are also significant differences in abundance between seagrass meadows (e.g. Gray et al. 1996). Some sites have consistently higher recruitment (McNeill et al. 1992), whilst other sites may periodically or temporarily have higher abundances (Gray et al. 1996; Connolly 1999). This may be due to a variety of factors including structural complexity of the seagrass meadows; location of the seagrass meadows with respect to currents and the dispersal of larvae; and natural fluctuations (patchiness) in population sizes (Gray et al. 1996; Connolly 1999). To date the importance or fisheries values of seagrass has largely been measured by the absolute abundance of fauna found in it. However, seagrass habitat may also provide important linkages and refuges between different habitat types (e.g. mangroves and seagrass), and between up and downstream communities. Thus, whilst a seagrass meadow may not support high abundances of fish or crustaceans at any one time, over a period of time many individuals may use it as they pass through to other areas. In Moreton Bay, marine reserves and connectivity influenced the abundance of fish in seagrass meadows, with effects likely to vary between different species (Henderson et al. 2017).

Seagrass distribution is most affected by light intensity, desiccation, and nutrient levels. Other factors, such as currents, substrate suitability, prior patterns of distribution, dispersion of propagules, grazing by turtles and dugongs, and episodic events (including cyclones and floods) also play roles in determining the distribution of seagrass.

Of these factors, light availability is often the most important in determining the distribution of seagrass. The amount of light reaching a seagrass meadow is the combination of the light intensity at the surface, the depth at which the seagrass is growing, the turbidity of the water, and the presence or absence of epiphytes on the seagrass. Light availability, or specifically the duration of light intensity exceeding the photosynthetic light saturation point controls the depth distribution of seagrass (Dennison & Alberte 1985; Dennison

1987T Abal' &' Dennison' 1996).' ' For' example,' on' average' 30%' of' surface' lightT'a' light' attenuation' coKefficient' of' less' than' 1.4' m^{K1}' and' median' total' suspended' solids' of' less' than' 10' mg/L' are' required' for' the' survival' of' *Z.' muelleri*' (Abal' &' Dennison' 1996TLongstaff' et' al.' 1998).' ' *H.' ovalis*,' on' the' other' hand,' has' a' particularly' low' tolerance' to' light' deprivation' caused' by' pulsed' turbidity,' such' as' floods' and' dredging' (Longstaff' et' al.' 1998).'

Availability' of' light' also' affects' the' productivity' of' seagrass.' ' Seagrass' exposed' to' high' light' intensity' are' more' productive' than' seagrass' in' less' intense' light' (Grice' et' al.' 1996).'' Consequently,' impacts' associated' with' dredging' may' result' in' at' least' a' temporary' decrease' in' seagrasses' productivity.' ' Light' also' controls' the' population' dynamics' of' macroalgae' (Lukatelich' &' McComb' 1986aTcited' in' Lavery' &' McComb' 1991).'' '



Figure' 2.18' Seagrass' meadows' provide' important' shelter' for' juvenile' mud' crabs.'

2.6! Coral!and!Rubble!Assemblages!!

Coral!and!Rubble!adjacent!to!the!PDA!

No' significant' areas' of' live' corals' were' recorded' in' the' PDA' during' the' 2014' survey' (as' mapped' in' 2014' on' Map' 1).' ' Scattered' isolated' hard' coral' individuals' on' sand' or' rubble' as' well' as' rubble' and' rock' supporting' algae,' soft' coral' and' sponges' have' recently' been' observed' to' the' north' and' east' of' Cassim' Island' (Figure' 2.19' and' Figure' 2.20T' frc' environmental,' pers.' obs.).' ' Areas' of' algae' (approximately' >25%' cover)' on' unK consolidated' surface' (e.g.' sand' or' rubble)' where' patchy' coral' may' be' present' were' also' recently' mapped' north' and' east' of' Cassim' Island' as' well' as' within' and' to' the' south' of'

Fison Channel (Roelfsema et al. 2017) (Figure 2.21, Map 5). There were also areas of soft coral (approximately >25% cover) on un-consolidated surface and hard coral (approximately >20% cover) on consolidated surface (e.g. reef matrix or rock) east of Cassim Island (Roelfsema et al. 2017) (Figure 2.21).

Figure 2.19

Isolated hard coral on sand and rubble east of Cassim Island.

Figure 2.20

Rocky assemblages supporting algae, soft coral and sponges east of Cassim Island.

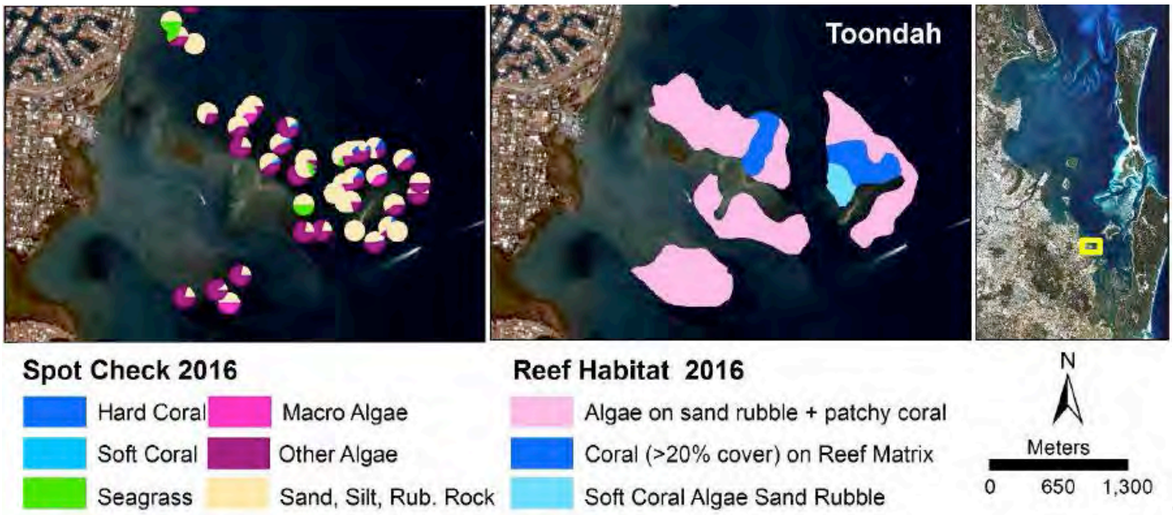


Figure 2.21 Reefal areas around Toondah Harbour. Spot-check survey sites with charts indicating benthic composition (right) and mapped reef habitat area (left). Source: (Roelfsema et al. 2009).

Coral and Rocky Reefs of the Region

Coral habitats in Moreton Bay are mainly distributed in shallow (> 3 m LAT), inshore areas and are characterised by a mixture of soft and hard corals and algae (Roelfsema et al. 2009). Fringing reefs occur around many of the inshore islands, including Peel, Mud, Saint Helena, King, Green, King, Macleay and Goat, North Stradbroke, Coochiemudlo islands (Figure 2.22). There is approximately 13.5 km^2 of coral in Moreton Bay (Gibbes et al. 2014).

Moreton Bay hosts marginal reefs of coral communities that are unique in that they are in a transitional area where tropical, sub-tropical and temperate species co-exist (Beger et al. 2014; Perry & Larcombe 2003). Coral communities in Moreton Bay comprise:

- 64 scleractinian coral species (from 26 genera and 13 families) in the inner bay, and
- 125 species (from 35 genera) in the outer bay (Wallace et al. 2009).

Coral communities on high-latitude coastal reefs of eastern Australia are typically widely distributed, generalist and stress-tolerant species with massive and horizontal morphologies (Sommer et al. 2014). In Moreton Bay substantial living coral assemblages remain, and they are currently at their highest recorded living diversity (Wallace et al. 2009). The corals of inshore Moreton Bay show a remarkable persistence through time

(78% are also recorded in the Holocene fossil record) and space (72% occur in outer Moreton Bay and 59% in New South Wales), indicating an inbuilt resilience (Wallace et al. 2009). This may be a result of a naturally dynamic system, where intermittent loss of species due to severe natural impacts is mitigated by external recruitment (Wallace et al. 2009). Coral reefs in marine reserves of Moreton Bay resisted impacts of major floods compared to other areas (that were fished), which may reflect a greater ecological resilience due to a greater biomass of herbivores influencing herbivory on macroalgae and coral recruitment dynamics (Olds et al. 2014).

Herbivorous fish in reef habitats of Moreton Bay include pencil surgeonfish (*Acanthurus dussumieri*), black rabbitfish (*Siganus fuscescens*), Australian sawtail (*Prionurus microlepidotus*), parrotfish (*Scarus ghobban*) and Bengal sergeant fish (*Abudefduf bengalensis*), unicornfish (*Naso unicornis* and *N. bankieri*), white-bar anthias (*Pseudanthias leucozonus*), stripey (*Microcanthus strigatus*), angelfish (*Pomacanthus semicirculatus* and *Centropyge tibicen*) and striped trumpeter (*Pelates octolineatus*) (Yabsley et al. 2016). Reef habitat in reserve areas of Moreton Bay supported a greater biomass of herbivorous fishes and had greater grazing of turf algae (Yabsley et al. 2016).

Historically, reef growth in Moreton Bay has been episodic, responding to natural environmental variation throughout the Holocene (Lybolt et al. 2011). The only significant change in coral species composition occurred between approximately 200 and 50 years ago, following anthropogenic alterations of the Moreton Bay and its catchments (Lybolt et al. 2011). Moreton Bay was dominated by *Acropora* species, but nutrient enrichment and sediment inputs following European settlement was likely to have resulted in the shift to massive corals (e.g. *Cyphastrea*, *Favia* and *Goniopora* species), which now dominate communities (Wallace et al. 2009; Zann et al. 2012).

In 2015, the reefs of the inshore Moreton Bay region had an average hard coral cover of 20% and experienced the highest average bleaching relative to other regions (i.e. Sunshine Coast, Outer Moreton Bay and the Gold Coast in 2015) (Pentti et al. 2016). In Moreton Bay, coral growth is limited by environmental factors (e.g. light penetration and water chemistry) (Fellegara & Harrison 2008; Kleypas et al. 1999) and in particular by eutrophication (Gibbes et al. 2014), sedimentation and fishing pressure (Roelfsema et al. 2017). Nonetheless, Moreton Bay coral communities have persisted with communities fluctuating with water quality and freshwater flooding after heavy rainfall (Queensland Museum 2017). Coral populations of Moreton Bay have the potential to be self-sustaining, however, isolated reef areas may be slow to recover from disturbance (Fellegara et al. 2013).

Overall, inner Moreton Bay corals are naturally subject to large fluctuations in salinity, temperature, turbidity and nutrients (Dennison & Abal 1999). The project area is unlikely to contain complex carbonate reefs, but may contain scattered corals on rubble. These coral' assemblages' are' likely' to' provide' an' important' contribution' to' carbonate' sediment' production' (Dennison' &' Abal' 1999).' ' Reproduction' is' likely' to' occur' in' late' spring' and' summer' (Fellegara' et' al.' 2013).'' '

Ecological!Significance!of!Coral!and!Rocky!Reefs!

Coral' and' rocky' reefs' have' several' important' ecological' functions' including:'

!' physical' structure' (e.g.' protection' of' shorelines' from' waves' and' storms' reducing' beach' erosion)'

!' biotic' (e.g.' spawning,' nursery,' breeding' and' foraging' grounds' for' marine' life)'

!' biogeochemical' (e.g.' nitrogen' fixation)'

!' information' (e.g.' reef' organisms' used' as' monitoring' and' pollution' records),' and'

!' social' /' cultural' (e.g.' recreational' and' aesthetic' values)' (Maragos' et' al.' 1996T Moberg' &' Folke' 1999).'

Reefs' are' also' highly' connected' to' other' marine' and' freshwater' habitats,' such' as' mangroves,' seagrass' and' estuaries,' with' many' marine' organisms' utilising' a' variety' of' these' habitats' throughout' their' lifecycles.' ' For' example,' adult' mangrove' jacks' live' on' coral' reefs,' but' use' freshwater' rivers' and' creeks' as' juveniles' (GBRMPA' 2017).'

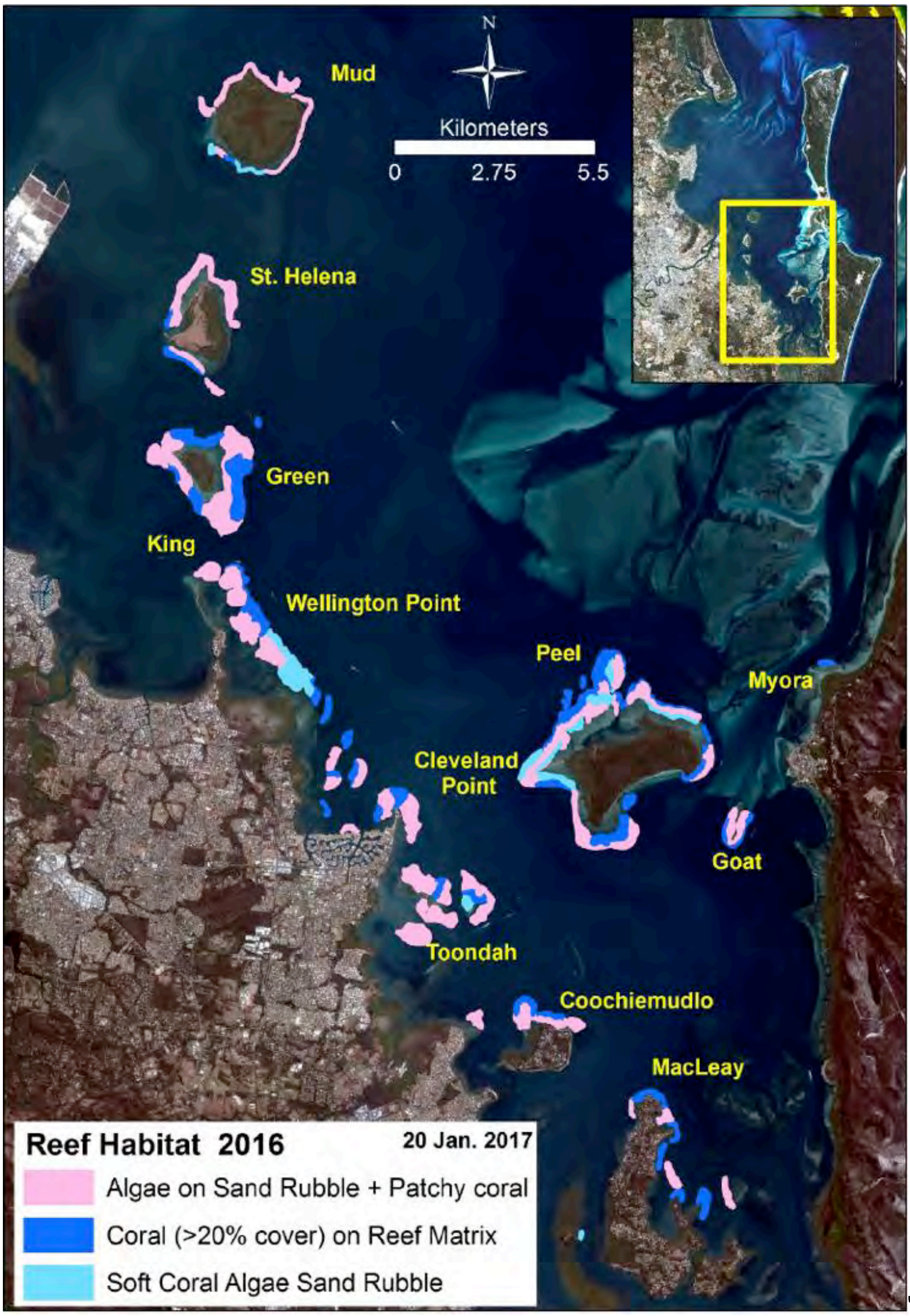


Figure 2.22 Inshore Moreton Bay reefal areas. Source: Roelfsema et al 2017.

2.7 Intertidal and Subtidal Mudflats and Sandbanks

Mudflats and Sandbanks of the PDA

The sediments within and adjacent to the PDA are bioturbated muds and sands, with sparse areas of exposed rubble (comprising rocky material and shell fragments). There is a layer of rubble that is below the muds and sands throughout the PDA ranging from 0.1 to 0.6 m below the surface. in the 2014 survey, the area of muds and sands typically extended from the mangroves into the existing channel or to seagrass beds north of the channel. The muds and sands were not compacted, and were easily dispersed. There were numerous holes created by burrowing fauna (i.e. crabs and polychaetes) (Figure 2.23).

Epifauna of the intertidal mudflats and sandbanks was dominated by Hercules mud whelks. There were also fiddler crabs (*Uca* spp.) and sand bubbler crabs (along with evidence of their foraging) on the mudflats.

Benthic infauna on the intertidal mudflats and sandbanks were dominated by polychaetes with some crustaceans, bivalves and gastropods. Polychaetes were dominated by individuals from the family Capitellidae, which are considered to be indicators of organic pollution (Beesley et al. 2000; Dean 2008). Benthic communities of the intertidal mudflats have been sampled at two sites in the PDA, with mean abundance varied between 267 ± 109 and 967 ± 303 per square meter between the sites. Taxonomic richness was similar between sites (9 to 10 species). Benthic communities of the intertidal sandflats have also been sampled at two sites in the PDA, with mean abundance varying between 83 ± 67 and 200 ± 0 per square meter between the sites and taxonomic richness relatively similar between sites (3 to 6 species).

The mud and sand habitats were similar to those found throughout Moreton Bay (e.g. Godwin Beach, Manly and Nudgee Beach) although the sediment is less compacted.

In 2014, benthic communities of subtidal mud of the channel were sampled at two sites, which were both dominated by polychaetes, with some crustaceans. Polychaete communities were dominated by the families Magelonidae and Cossuridae, while crustaceans were dominated by the family Tanaidacea. The abundance (550 ± 144 to 700 ± 200 per square metre) and taxonomic richness (8 to 11 species) in the channel were similar between sites.

Figure 2.23

Mudflat substrate and associated fauna burrows within the PDA.

Mudflats and Sandbanks the Region

Bioturbated mud and sand is the dominant habitat of western Moreton Bay, with over 422 km^2 of subtidal un-vegetated habitat and 75 km^2 of intertidal flats in Moreton Bay (Ozcoasts 2009) (Figure 2.24).

Sand from the Brisbane River has been deposited in a river delta protruding into the bay, some of this material has been transported by waves to form tidal flats, predominantly to the north. A belt of river-derived mud (up to 5 m thick) has been deposited along the western side of the bay, extending to about 10 – 15 m water depth (Maxwell 1970; Hekel et al. 1979; Jones & Stephens 1981).

Marine sand has been deposited between Bribie Island and Moreton Island, and between Moreton Island and North Stradbroke Island. The central, deeper part of the bay receives no sand and very little mud.

There are two relatively diverse bioregions for invertebrate communities within Moreton Bay: the western bay – dominated by estuarine species; and the eastern bay – dominated by marine species (Davie 1998). Diversity in the western bay is largely attributable to infaunal communities (living within the sediment), while communities in the eastern bay comprise a large number of infaunal and epibenthic (on the surface) invertebrates such as corals and ascidians.

Communities in the western bay are characterised by infaunal or mobile epibenthic species tolerant of high turbidity and sedimentation levels, such as crustaceans, worms and echinoderms (Davie 1998).

Diversity in the western bay is highest near the mouth of the Brisbane River and declines steadily to the north (Davie 1998). Some unvegetated sandbanks are exceptionally species poor, while others throughout Moreton Bay support diverse assemblages of finfish and decapod crustaceans (Lasiak 1986; Brown & McLachan 1990; Kailola et al. 1993; Morrison 1996). Bare sand and mud flats support different communities to vegetated areas, and are particularly important for some species of whiting and prawn.

The structure of benthic macroinvertebrates communities is influenced by a suite of factors including nutrient loads, sediment grain size and turbidity. As they are largely immobile, and quickly respond to changes in these factors, changes in their community structure can be used as a tool to assess the ecological health of waterways, and to identify characteristics of pressures acting on those waterways. With the use of control sites, and temporally replicated baseline monitoring, they can also be used to assess the impacts of a development.

Increases in sediment organic and nutrient loads often leads to a reduction in community diversity and species richness, which is associated with a shift in community composition and trophic group structure (Pearson & Rosenberg 1978; Tsutsumi 1990; Meksumpun & Meksumpun 1999; Coleman & Cook 2003; Rossi 2003). Changes in sedimentation rates lead to shifts in trophic groups, with the abundance of suspension feeders decreasing in more turbid waters.

Following nutrient enrichment, the population density of opportunistic deposit feeders usually increases dramatically, and macroinvertebrate communities typically become dominated by polychaetes (Pearson & Rosenberg 1978; Tsutsumi 1990; Meksumpun & Meksumpun 1999). These worms are characterised by their ability to respond rapidly to environmental change and are widely recognised as useful indicators of environmental health (Pearson & Rosenberg 1978; ANZECC & ARMCANZ 2000).

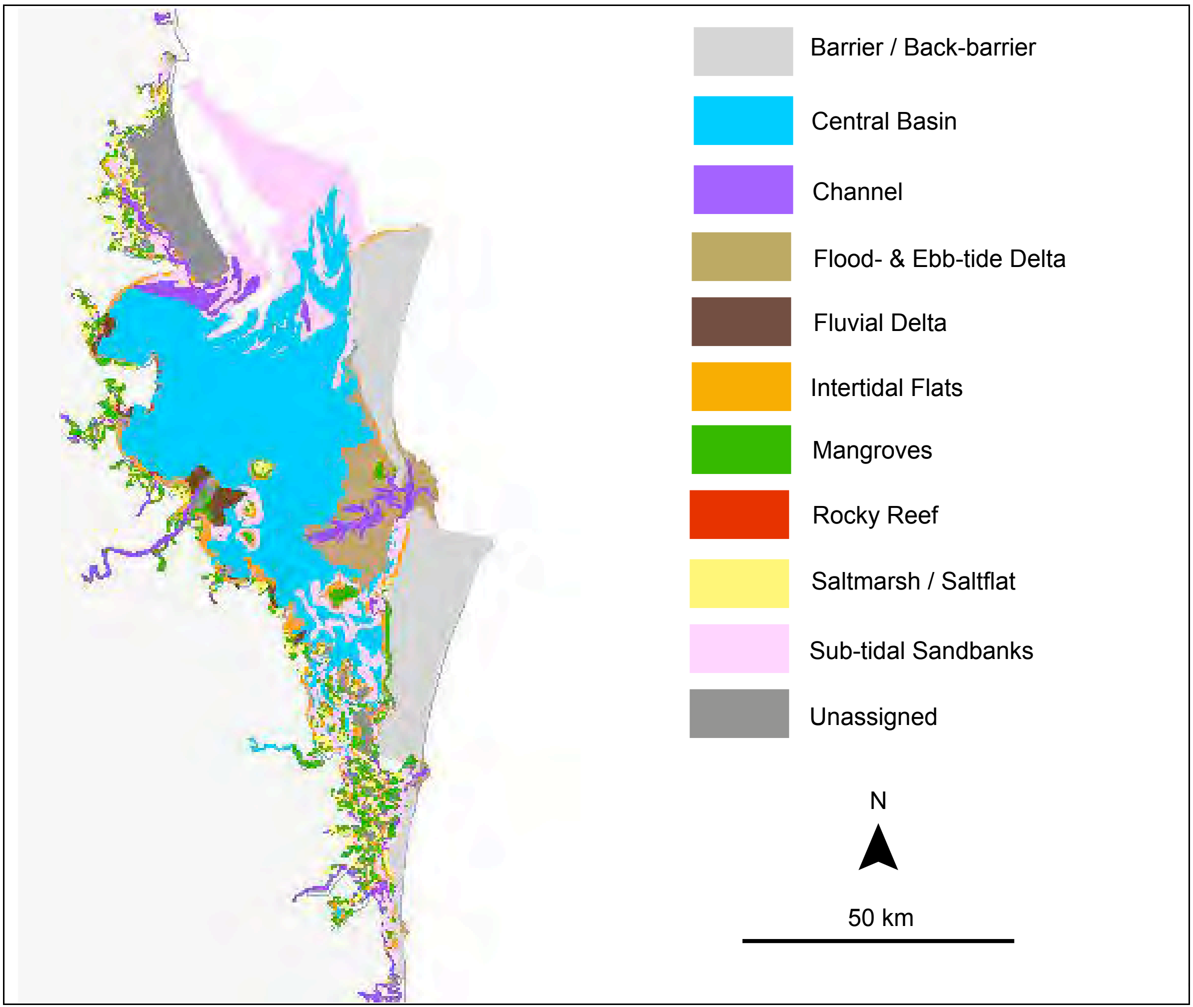


Figure 2.24 Geomorphic Habitats in Moreton Bay.

Ecological Significance of Mudflats and Sandbanks

Areas of sandy and muddy sediment, whilst commonly considered to be not as productive as areas supporting seagrass, are also important to the ecosystem. Where sediments are stable, microalgae communities become established within both the intertidal and shallow subtidal. The microalgae support an associated community of small benthic invertebrates (e.g. polychaete and nematode worms, cumaceans, copepods and soldier crabs), which in turn are an important source of food for fishes, such as bream and whiting (Weng 1983). Soft sediment tidepools are formed at low tide, which support a variety of fishes and can serve as a nursery for juveniles, such as whiting (Chargulaf et al. 2011). Laegdsgaard and Johnson (1995) suggest mudflat habitats may be transitional zones between juvenile and adult habitats. Bare substrates in shallow waters may also provide shelter from larger predators, with whiting, flathead and flounder commonly associated with bare substrate habitat.

Intertidal and shallow subtidal sand flats support a variety of fish species. Fish, such as whiting and flathead, feed in sandy areas; whereas fish, such as bream and mullet, prefer the fauna associated with muddy areas (Figure 2.25). In southern Moreton Bay, the yellowfin bream is perhaps the best known example of a species that migrates to surf bars to spawn (Pollock et al. 1983). Shallow surf bars are also the spawning grounds for whiting, flathead, luderick, tailor and mullet.

Bream, juvenile sand whiting and other species of commercial and recreational importance feed over and along the edges of sand banks (Morton et al. 1987). Female sand crabs are associated with sand banks, whilst males are likely to be found in adjacent gutters (Smith & Sumpton 1987). Bait species important to both commercial and recreational fishers inhabit intertidal and shallow subtidal banks of sheltered bays (e.g. worms) and estuaries (e.g. yabbies) (Zeller 1998).

Bare and soft sediment areas are typically dominated by burrowing faunal species (Barnes & Hamylton 2013) and the fauna associated with soft sediment habitats are typically determined by the character of the sediment: its grain size and stability; and with the presence or absence (Poiner 1980; Humphries et al. 1992), or proximity of seagrass (Ferrell & Bell 1991). Grain size influences the ability of organisms to burrow, and the stability of 'permanent' burrows. Unstable sediments support less diverse benthic communities than those that are relatively stable. Bare sediments within 10 m of seagrass meadows supported a similar total abundance of fishes, but a reduced diversity of species compared with nearby *Zostera* seagrass meadows; whereas bare substrate 100 m distant from the seagrass meadows supported significantly fewer individuals and species (Ferrell & Bell 1991). In partial contrast, studies of bare substrate and nearby *Ruppia* meadows showed finfish diversity to be higher over bare substrate, but abundance and biomass highest in the seagrass meadows (Humphries et al. 1992).

Shallow water, bare sediment communities are characterised by widely fluctuating abundances, species richness and diversity. These fluctuations are correlated with severe abiotic disturbances (e.g. wind and wave activity). During calmer months, shallow bare sand developed similar communities to deep-water bare sand habitats (Poiner 1980).

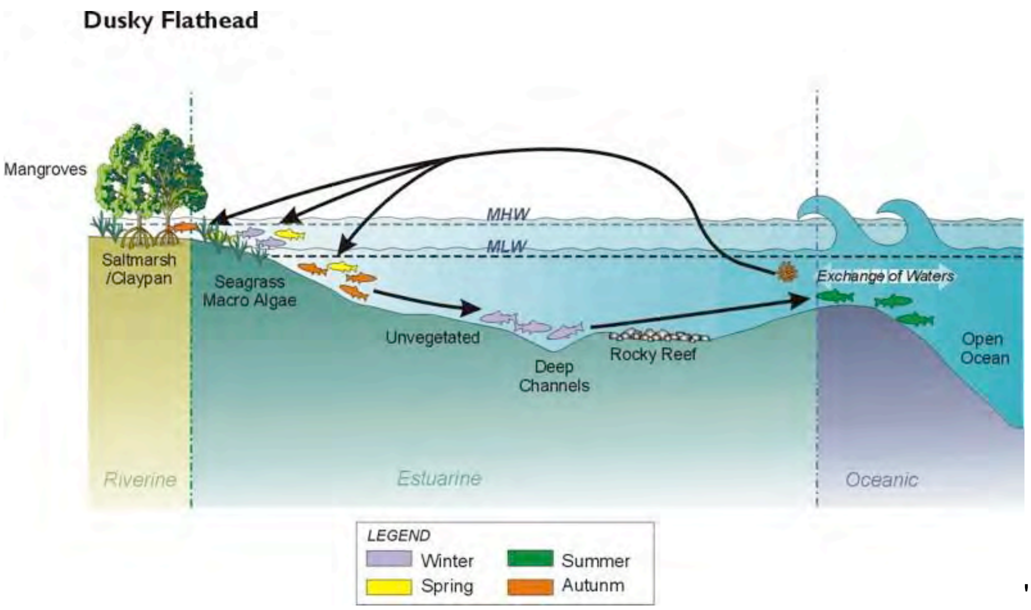


Figure 2.25 Un-vegetated sand and mud substrates are a preferred habitat of dusky flathead.

3 Matters of National Environmental Significance

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as Matters of National Environmental Significance (MNES) (DoTE 2014a).

The nine MNES to which the EPBC Act applies are:

- world heritage properties
- national heritage places
- wetlands of international importance (Ramsar wetlands)
- nationally threatened species and ecological communities
- migratory species
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions, and
- a water resource in relation to coal seam gas development and large coal mining development.

In addition, the EPBC Act confers jurisdiction over actions that have a significant impact on the environment where the actions affect, or are taken on, Commonwealth land, or are carried out by a Commonwealth agency (even if that significant impact is not on one of the nine MNES).

3.1 Protected Matters Search

The Protected Matters Search Tool was used to assist in determining whether marine MNES were likely to occur in or near the area potentially impacted by the proposed Toondah Harbour development. The search area included the subject site and a 5 km buffer zone. This search area was considered to include all marine areas that are within the likely extent of impact, in order to adequately identify all marine MNES that could potentially be impacted by the proposed project.

The following MNES relevant to marine ecology (excluding avian fauna) were listed in this search:

- World Heritage Properties – none
- National Heritage Places – none
- Wetlands of International Importance – 1
- Great Barrier Reef Marine Park – none
- Commonwealth Marine Areas – none
- Listed Threatened Ecological Communities – 1
- Listed Threatened Species – 14
- Listed Migratory Species – 21

There are no World Heritage Properties, National Heritage Places, Commonwealth Lands, Commonwealth Heritage Places, Commonwealth reserves or critical habitats in the vicinity of the Project Area. Likewise, the Great Barrier Reef Marine Park is approximately 350 km north of the proposed project and will not be affected. The Temperate East Marine Bioregional Plan (Commonwealth of Australia 2012) has been prepared under section 176 of the EPBC Act for Commonwealth Marine Area (which extend from 3 to 200 nautical miles from the coastline). The Commonwealth Marine Area is approximately 25 km east of the proposed project, and will not be affected by the proposed project.

Other matters listed in the search results included 43 listed marine species (excluding avian fauna) and 14 whales and other cetaceans. Listed 'marine species' and 'whales and other cetaceans' are protected in Commonwealth Marine Areas under the EPBC Act. The closest Commonwealth Marine Area is approximately 25 km east of the proposed project. The Project will not have a significant impact on Commonwealth Marine Areas and thus listed 'marine species' and species listed only as 'marine species' or 'whales and other cetaceans' are not considered further in this report. However, species that are also listed as 'migratory' or 'threatened' are also protected in state waters (i.e. coastal waters to three nautical miles and other waters under Queensland jurisdiction) under the EPBC Act.

Under section 34 of the EPBC Act, threatened ecological communities listed as vulnerable are not protected under Part 3 'Requirements for Environmental Approvals' of the Act. The listed threatened ecological community in the vicinity of the proposed project is the Subtropical and Temperate Coastal Saltmarsh, which is listed as 'vulnerable', and is consequently not considered further in this report.

‘Wetlands' of' international' importance’,' ‘threatened' species’' and' ‘migratory' species’' are' discussed' in' the' following' sections.'

Results' of' the' EPBC' Act' Protected' Matters' Search' for' within' 5' km' of' the' subject' site' are' provided' in' Appendix' B.' ' These' results' are' indicative' only.' ' Further' assessment' is' required' (DoTE' 2014b),' and' is' provided' in' the' remainder' of' this' Chapter.'

3.2! Wetlands!of!International!Importance!(Ramsar!Wetlands)!

The' proposed' project' is' within' the' Moreton' Bay' Ramsar' wetland' boundary' (Map' 6).' ' This' wetland' is' approximately' 113,314' ha' in' its' entirety,' and' comprises:'

- Moreton' Island'
- parts' of' North' Stradbroke' Island'
- parts' of' South' Stradbroke' Island'
- parts' of' Bribie' Island'
- some' of' the' Southern' Bay' Islands'
- waters' and' tributaries' of' Pumicestone' Passage'
- intertidal' and' subtidal' areas' of' the' western' bay,' southern' bay' and' sandy' channels' of' the' Broadwater' region'
- marine' areas' and' sand' banks' within' the' central' and' northern' bay,' and'
- beach' habitats' (DoTE' 2014c).'

Aquatic' habitats' within' the' Moreton' Bay' Ramsar' wetland' include' seagrass' and' shoals,' tidal' flats,' mangroves,' saltmarshes,' coral' communities,' freshwater' wetlands,' peat' land' habitats,' ocean' beach' and' foredunes.'

Moreton' Bay' Ramsar' wetland' was' declared' as' it:'

- is' one' of' the' largest' estuarine' bays' in' Australia' which' is' enclosed' by' a' barrier' island' of' vegetated' sand' dunes '
- plays' a' substantial' role' in' the' natural' functioning' of' a' major' coastal' system' through' its' protection' from' oceanic' swells' providing' habitat' for' wetland' development,' receiving' and' channelling' the' flow' of' all' rivers' and' creeks' east' of' the' Great' Dividing' Range' from' the' McPherson' Range' in' the' south' to' the' north' of' the' D’Aguilar' Range'

- supports over 355 species of marine invertebrates, at least 43 species of shorebirds, 55 species of algae associated with mangroves, seven species of mangrove and seven species of seagrass
- is a significant feeding ground for green turtles and is a feeding and breeding ground for dugong. Moreton Bay also has the most significant concentration of young and mature loggerhead turtles in Australia, and is ranked among the top ten dugong habitats in Queensland
- supports more than 50,000 wintering and staging shorebirds during the non-breeding season. At least 43 species of shorebirds use intertidal habitats in the Bay, including 30 migratory species listed by JAMBA and CAMBA, and
- is particularly significant for the population of wintering Eastern curlews (3,000 to 5,000) and the Grey-tailed tattler (more than 10,000).

3.3 Listed Threatened Marine Species

Fourteen threatened (endangered or vulnerable) marine species were listed as potentially occurring within 5 km of the proposed project using the protected matters search tool. The likelihood that these species are present in the area potentially impacted by the proposed Toondah Harbour project, was assessed using the criteria in Table 3.1.

Table 3.1 Criteria used to assess the likelihood of occurrence of species.

Likelihood of Occurrence	**Definition**
low	The species is considered to have a low likelihood of occurring in the area potentially impacted by the Project, or occurrence is infrequent and transient. Existing database records are considered historic, invalid or based on predictive habitat modelling. The habitat does not exist for the species, or the species is considered locally extinct. Despite a low likelihood based on the above criteria, the species cannot be totally ruled out of occurring in the potentially impacted area.
moderate	There is habitat for the species; however, it is either marginal or not particularly abundant. The species is known from the wider region.
high	The species is known to occur in the potentially impacted area, and there is core habitat in this area.

Ecological information used in the assessment of the likelihood of occurrence of each threatened marine species included:

'

- the'results'of'literature'search''
- the'results'of'field'surveys,'and'
- professional'experience.'

The' likelihood' of' occurrence' of' each' species' was' supported' by' evidence' of' their' habitat' preferences,' and' the' availability' and' distribution' of' critical' habitats' close' to' the' proposed' project' and' of' the' wider' region.'' Habitats' of' particular' importance' to' Commonwealth' listed' marine' and' estuarine' species' (i.e.' critical' habitats)' include' their' preferred' /' key:'

- nesting' /' breeding' areas'
- feeding' habitats,' and'
- migration' corridors' (Reeves' 2008T Stern' 2009).'

It' also' includes' areas' where' the' species' may' not' presently' occur,' which' are' critical' if' the' species' is' to' recover' from' its' currently' threatened' state' (Gibson' &' Wellbelove' 2010).'' The' presence' and' condition' of' these' key' areas' /' habitats,' and' other' habitats' that' are' vital' for' the' dayKtoKday' survival' of' listed' species,' can' assist' in' determining' whether' a' species' is' likely' to' occur' within' a' particular' area.'' The' likelihood' of' occurrence' of' a' species' within' an' area' will' in' turn' influence' the' extent' of' likely' impacts' on' the' population' from' any' proposed' project.'

The' 'potential' area' of' impact'' for' the' purposes' of' this' assessment' comprised' shallow' inshore' waters' of' Moreton' Bay' within' and' adjacent' to' Toondah' Harbour,' including' Fison' Channel.'' Of' the' listed' threatened' species,' loggerhead' turtles' and' green' turtles' are' highly' likely' and' hawksbill' turtles' are' moderately' likely' to' occur' in' the' potential' area' of' impact' (Table' 3.2).'

3.4! Listed!Migratory!Marine!Species!

TwentyKone' migratory' marine' species' were' listed' as' potentially' occurring' within' 5' km' of' the' proposed' project' using' the' protected' matters' search' tool.' ' Of' these' listed' migratory' species,' 12' species' are' also' listed' as' threatened' species.'''

The' 'potential' area' of' impact'' for' the' purposes' of' this' assessment' comprised' shallow' inshore' waters' of' Moreton' Bay' within' and' adjacent' to' Toondah' Harbour,' including' Fison' Channel.' ' Of' the' listed' migratory' species,' loggerhead' turtles,' green' turtles,' IndoKPacific' humpback' dolphins' and' dugong' are' highly' likely' and' hawksbill' turtles' are' moderately' likely' to' occur' in' the' potential' area' of' impact' (Table' 3.3).''

Table 3.2 Threatened marine species listed as potentially occurring within 5 km of subject site on the online Protected Matters search tool, and their likelihood of occurrence in the area potentially impacted by the Toondah Harbour project.

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
Mammals				
Balaenoptera musculus	blue whale	E	While the blue whale may occur in coastal and continental shelf waters off eastern Australia, they are typically found around the southern coastline off Western Australia and South Australia, where there are a number of known coastal aggregation sites associated with migratory routes (DSEWPAC 2012b). Blue whales are considered to be occasional visitors to the Moreton Bay region, with 1 stranding recorded from Moreton Island, 1 sighting reported from North Stradbroke Island and 1 animal whaled at the Tangalooma whaling station when in operation (Chilvers et al. 2005). *Feeding Areas* Blue whales feed at the ocean surface and at depth (Gill & Morrice 2003; McCauley et al. 2004). Within Australian waters, there are two known major feeding areas; off the South Australian, and, Western Australian coastlines. The blue whale feeds primarily on krill, but will also consume fish and squid (Kawamura 1980). The distribution of the primary krill prey extends into Eastern Australian waters (Blackburn 1980); however, feeding areas within this region are unknown. *Breeding Areas* Blue whales calve in deep waters off tropical island shelfs outside of Australian waters (DoTE 2016b). *Migration Routes* The blue whale migrates from Antarctic and sub-Antarctic waters in the summer into Western Australian waters en route to Indonesian Archipelago waters for breeding (Double et al. 2012; Double et al. 2014). In Australia, they primarily use western and southern coastal waters during migration (DEWHA 2008). *Key Threats* Key threats include whaling, climate change, noise interference and vessel disturbance (DoTE 2016b). ***Summary*** **Moreton Bay is not considered to be core habitat for this species, and the area is unlikely to support important populations or offer habitat critical to the survival of this species. There is a low likelihood that blue whales will occur in marine habitats within and adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	low
Eubalaena australis	southern right whale	E	Southern right whale sightings in Australian waters are seasonal, typically occurring between May and November (DoTE 2016j). They are primarily found around the southern coastline off southern Western Australia and far west as South Australia, where there are a number of known coastal aggregation sites (DoTE 2016j). Sightings in Queensland waters are rare, but this species has been observed off Moreton Island, North Stradbroke Island and in Moreton Bay (Noad 2000). *Feeding Areas* Southern right whales are thought to feed in deep, offshore waters. Australian populations of southern right whales are likely to forage between 40°S and 65°S, generally south of Australia. The species typically consumes copepods in the northern part of these waters, while at higher latitudes (south of 50°S), krill is the main prey item (DoTE 2016j). *Breeding Areas* Southern right whales calve very close to the coast in Australia, usually in waters <10 m deep, primarily in Western Australia and South Australia (DSEWPAC 2012b). Nursery grounds are occupied from May to October (DoTE 2016j). *Migration Routes* The migratory paths between calving and feeding areas are not well understood. However, there is substantial movement along the coast, indicating that	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			connectivity of coastal habitats is important (DoTE 2016j). *Key Threats* Key threats include whaling, climate change, vessel disturbance, competition with fisheries for prey, noise interference and habitat degradation (DoTE 2016j). ***Summary*** **While they may migrate along the coast, inshore coastal waters have no particular significance to southern right whales. Moreton Bay is not considered to be core habitat, unlikely to support important populations, or offer habitat critical to the survival of this species. There is a low likelihood that southern right whales will occur in marine habitats within and adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	
Megaptera novaeangliae	humpback whale	V	Humpback whales occur in two separate populations within Australian waters, the west coast and the east coast populations. Sightings along the coastlines are highly seasonal and linked to the northerly and southerly migration routes to breeding areas in tropical waters (DoTE 2016p). The migratory pathway of humpback whales is on the eastern side of the large sand islands that separate Moreton Bay and the Pacific Ocean. Moreton Bay is an important resting area for humpback whales during migration, particularly during the southward migration in September and October (Chilvers et al. 2005). *Feeding Areas* Eastern Australian humpback whales are likely to forage at higher latitudes, south of 55°S, and will only feed opportunistically upon arrival into coastal Australian waters (DoTE 2016p). *Breeding Areas* Calving takes place during winter in tropical waters at low latitudes (15°S to 20°S) (Chittleborough 1965; W.H. 1966). The breeding area for the eastern population of the humpback whale is presumed to be off the coast between central and northern Queensland (Smith et al. 2012). *Migration Routes* During summer, humpback whales feed in high latitudes and during winter move north to tropical waters for calving, using close, coastal waters (DoTE 2016p). During migration, resting is undertaken around the Hervey Bay region (Chaloupka et al. 1999; Paterson et al. 2001; Double et al. 2010) and around Moreton Bay (DEH 2005b). *Key Threats* Key threats include whaling, climate change, competition with fisheries for prey, noise interference and habitat degradation (DoTE 2016p). ***Summary*** **While some areas in the north of Moreton Bay are important resting areas for humpback whales, the area potentially impacted by the proposed Toondah Harbour project is not considered to be core habitat and is unlikely to support important populations or offer habitat critical to the survival of this species. There is a low likelihood that humpback whales will occur in marine habitats within and adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	low
Reptiles				
Caretta caretta	Loggerhead Turtle	E	Loggerhead turtles are primarily found around coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia (Limpus et al. 1992; Prince 1994; Limpus 1995a). Moreton Bay is an important foraging ground for the loggerhead turtle (DoTE 2013a) and loggerhead turtle have been reported in the vicinity of the project (ALA 2017). *Feeding Areas* The loggerhead turtle forages in a wide range of intertidal and subtidal habitats, including coral and rocky reefs, seagrass meadows, and non-vegetated sand or mud areas (Limpus 2008b). They tend to maintain small home ranges within their foraging grounds (within approximately 10 to 15 km of coastline).	high

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Moreton Bay is an important foraging ground for the loggerhead turtle (DoTE 2013a). *Breeding Areas* Loggerhead turtles nest on open, sandy beaches (Spotila 2004). The three major nesting areas for loggerhead turtles in Queensland are in the Great Barrier Reef, and include: - the Capricorn Bunker Island Groups, especially Wreck, Tryon and Erskine islands - Mon Repos and adjacent beaches of the Woongarra Coast and Wreck Rock Beach, together with - the islands of the Swain Reefs, especially Pryce Island and Frigate, Bylund, Thomas and Bacchi cays. A small number of loggerhead turtles nest on the local sand islands of Bribie, Moreton, and North and South Stradbroke (DNPRSR 2007). *Migration Routes* Loggerhead turtles show fidelity to both their feeding and breeding areas, and can make reproductive migrations between foraging and nesting areas of over 2,600 km (Limpus et al. 1992). *Key Threats* Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016e). ***Summary*** **While there is unlikely to be any nesting loggerhead turtles in the vicinity of the PDA, Moreton Bay supports a significant loggerhead turtle feeding population. Loggerhead turtles are highly likely to occur in marine habitats within and adjacent to the Toondah Harbour project, particularly in the seagrass beds and coral or rubble areas, which they may use as feeding habitats.**	
Chelonia mydas	green turtle	V	The green turtle is globally distributed in tropical and sub-tropical waters, and is usually associated with shallow marine habitats that support seagrass and algal communities (DoTE 2013b). Green turtles are known to feed on the seagrass in Moreton Bay (DNPRSR 2007) and have been observed during fortnightly water quality surveys in the vicinity of the PDA (frc environmental, pers. obs.). *Feeding Areas* Immature green turtles are carnivorous (Brand-Gardner et al. 1999), while adults are generally herbivorous, feeding mostly on algae and seagrass. Adults will occasionally eat other items such as mangrove fruit, sponges and jellyfish (Pendoley & Fitzpatrick 1999; Forbes 1994). Adult green turtles typically forage in shallow benthic habitats, such as tidal and subtidal coral and rocky reefs and inshore seagrass beds and algae mats (Musick & Limpus 1997; Poiner & Harris 1996; Robins et al. 2002). Green turtles are known to feed on the seagrass in Moreton Bay (DNPRSR 2007). *Breeding Areas* Green turtles nest on sandy beaches. In Queensland, southern green turtle populations typically nest around the Capricorn-Bunker Groups and adjacent islands in the southern Great Barrier Reef (Limpus et al. 2003), but also nest on islands of the outer edge of the reef (DoTE 2013b). There are no key nesting areas in Moreton Bay; however, some turtles nest on the sandy beaches of the outer islands. *Migration Routes* Green turtles can migrate more than 2,600 km between their feeding and nesting grounds. *Key Threats* Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016f).	high

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Summary **While there are unlikely to be any nesting green turtles in the vicinity of the PDA, Moreton Bay supports a significant feeding populations of green turtles. Green turtles are frequently observed in the seagrass beds adjacent to the proposed project (frc environmental, pers. obs. during fortnightly water quality surveys). Green turtles are highly likely to occur in marine habitats within and adjacent to the Toondah Harbour, particularly in the seagrass beds, which they may use as feeding habitat.**	
Dermochelys coriacea	leatherback turtle	E	The leatherback turtle is a pelagic species in tropical, subtropical and temperate waters. On the Australian east coast, leatherback turtles typically occur from south-east Queensland to central New South Wales. As the most pelagic of all marine turtles, the leatherback turtle spends much of its time in the open ocean and venturing close to shore, mainly during the nesting season (Lutz & Musick 1996; Benson et al. 2007; GBRMPA 2011). There is no known resident population of leatherback turtles in Moreton Bay (DNPRSR 2007). *Feeding Areas* The leatherback turtle is a pelagic feeder, primarily consuming gelatinous organisms such as jellyfish and salps (Bjorndal 1997; Kaplan 1995). Their distribution reflects the distribution of their food, and can be explained by 'hot spots' of jellyfish abundance (Leary 1957; Lazell 1980). Foraging leatherbacks have been recorded as far south as Bass Strait and through the Gulf of Carpentaria (GBRMPA 2011). *Breeding Areas* Leatherback turtles require sandy beaches to nest. There are no large leatherback turtle rookeries in Australia; however, leatherback turtles occasionally nest within the Great Barrier Reef, with nesting recorded at Wreck Rock and adjacent beaches near Bundaberg (one to three nests per annum) (GBRMPA 2011). Sporadic nesting has been recorded at other widely scattered sites in Queensland; however, there is a strong likelihood that leatherback turtles have not nested in Queensland since 1996 (Hamman et al. 2006; GBRMPA 2011). *Migration Routes* The leatherback turtle spends much of its time in the open ocean and may traverse thousands of kilometres over its lifetime from feeding areas to nesting beaches (Lutz & Musick 1996; Benson et al. 2007). Leatherback turtles are known to migrate from Australia to rookeries in Indonesia, Papua New Guinea and Solomon Islands (Hamman et al. 2006; Limpus 1995b). *Key Threats* Key threats include commercial and recreational fishing, coastal infrastructure and development (including industrial, residential and tourism development), Indigenous harvest, feral animal predation, and climate change (DoTE 2016g). ***Summary*** **Given that there is no known population in Moreton Bay, there are no key nesting habitats and it's largely pelagic existence, there is a low likelihood that leatherback turtles occur in marine habitats within and adjacent to Toondah Harbour.**	low
Eretmochelys imbricata	hawksbill turtle	V	The hawksbill turtle is globally distributed in tropical, sub-tropical and temperate waters (GBRMPA 2013c). There is a small resident population of hawksbill turtles in Moreton Bay. *Feeding Areas* Hawksbill turtles are heavily reliant on coral reef and rocky habitats, where they forage mainly on sponges but also seagrass, algae, squid, gastropods, sea cucumbers, soft corals and jellyfish (GBRMPA 2013c). As juveniles, they eat plankton (Meylan 1984). Feeding areas occur throughout eastern Queensland, from Torres Straight to Julian Rocks in northern New South Wales. *Breeding Areas* Hawksbill turtles nest on sandy beaches in the northern Great Barrier Reef and the Torres Strait. In Australia, the key nesting and inter-nesting areas include:	moderate

Species'	Common' Name'	EPBC'Act' Threatened' Status'	Ecological'Information''	Likelihood'of' Occurrence'in' Area'of'Potential' Impact''
			!' Milman'Island'and'the'inner'Great'Barrier'Reef'Cays'north'from'Cape'Grenville Central' !' Torres'Strait'islands' !' Crab'Island' !' Murray'Islands' !' Darnley'Island' !' Woody'Island' !' Red'Wallis'and'Woody'Wallis'Islands' !' Bramble'Cay'and'Johnson'Islet'(Torres'Strait),'and' !' Western'Cape'York'Peninsula'(DEHP'2005).' *Migration*Routes** Hawksbill'turtles'that'nest'or'forage'on'the'east'coast'of'Australia'migrate'to'Indonesia,'Papua'New'Guinea,'the'Solomon'Islands,'and'Vanuatu'(GBRMPA' 2013c).' *Key*Threats*' Key'threats'include'commercial'and'recreational'fishing,'coastal'infrastructure'and'development'(including'industrial,'residential'and'tourism'development),' Indigenous'harvest,'feral'animal'predation,'and'climate'change'(DoTE'2016i).' ***Summary*** **Despite'not'providing'critical'habitat,'there'is'a'small'resident'population'of'hawksbill'turtles'in'Moreton'Bay,'and'they'may'feed'in,'or'traverse,'the' proposed'project'area.''There'is'a'moderate'likelihood'that'hawksbill'turtles'occur'in'marine'habitats'within'and'adjacent'to'the'Toondah'Harbour' project.''**	
Lepidochelys olivacea**	olive'ridley' turtle'	E'	Olive'ridley'turtles'occur'in'tropical'and'sub[tropical'regions'of'the'Pacific'and'Indian'oceans.'In'Australia,'they'are'found'in'soft[bottomed,'shallow,'protected' waters'from'the'Joseph'Bonaparte'Gulf'in'Western'Australia'to'southern'Queensland'(GBRMPA'2013d).'They'are'typically'not'associated'with'coral'reef' habitat'or'shallow'inshore'seagrass'flats'(Limpus'2008a).''Very'few'individuals'have'been'recorded'in'Moreton'Bay'(e.g.'only'3'reported'captures'by'fishers'in' trawl'netsTRobins'&'Mayer'1998).' *Feeding*Areas** Olive'Ridley'turtles'feed'in'continental'shelf'waters'on'crabs,'echinoderms,'shellfish'and'gastropods'(GBRMPA'2013d).''A'substantial'part'of'the'immature' and'adult'population'forage'over'shallow'benthic'habitats'(Harris'1994'cited'in'Limpus'2008a)T'however,'large'juvenile'and'adult'olive'ridley'turtles'have'been' recorded'in'both'benthic'and'pelagic'foraging'habitats'(Musick'&'Limpus'1997).'Foraging'habitat'can'range'from'depths'of'several'metres'(Conway'1994)'to' over'100'm'(Whiting'et'al.'2005).' *Breeding*Areas** There'are'two'main'breeding'areas'for'olive'ridley'turtles'in'Australia,'one'in'the'Northern'Territory'with'about'1,000'nesting'females'per'year,'and'the'other'in' the'Gulf'of'Carpentaria'with'less'than'100'nesting'females'per'year'(GBRMPA'2013d).''There'are'no'records'of'nesting'from'the'east'coast'of'Australia.' *Migration*Routes** Studies'in'the'eastern'Pacific'and'Atlantic'Ocean'show'long'distance'reproductive'migratory'behaviour'for'olive'ridley'turtles,'which'is'similar'to'other'sea' turtle'species'(Meylan'1982).' *Key*Threats**	low'

Species'	Common' Name'	EPBC'Act' Threatened' Status'	Ecological'Information''	Likelihood'of' Occurrence'in' Area'of'Potential' Impact''
			Key'threats'include'commercial'and'recreational'fishing,'coastal'infrastructure'and'development'(including'industrial,'residential'and'tourism'development),' Indigenous'harvest,'feral'animal'predation,'and'climate'change'(DoTE'2016m).' ***Summary*** **Moreton'Bay'does'not'provide'critical'habitat'and'is'unlikely'to'support'important'populations'or'offer'habitat'critical'to'the'survival'of'this' species.'Further,'very'few'individuals'have'been'recorded'in'Moreton'Bay.''There'is'a'low'likelihood'that'olive'ridley'turtles'occur'in'marine' habitats'within'and'adjacent'to'the'Toondah'Harbour'project.''**	
Natator depressus**	flatback'turtle'	V'	Unlike'other'marine'turtles,'the'flatback'turtle'lacks'an'oceanic'phase'and'remain'in'the'surface'waters'of'the'continental'shelf'throughout'its'life.''Little'is' known'about'their'foraging'habits'and'habitat,'although'juvenile'and'adult'turtles'seem'to'occupy'similar'habitats'and'both'forage'on'soft[bodied'(mostly' benthic)'organisms'(Limpus'et'al.'1994).' *Feeding*Areas** The'flatback'turtle'tends'to'forage'in'shallow'continental'shelf'waters'with'soft'substrates,'feeding'on'a'variety'of'soft[bodied'animals,'including'soft'corals,'sea' pens,'sea'cucumbers'and'jellyfish'(Limpus'2007).''Catch'records'from'trawlers'(as'bycatch)'indicate'that'the'flatback'turtle'also'feeds'in'turbid,'shallow'(depth' of'10'm'to'40'm)'inshore'waters.''The'foraging'distribution'for'the'eastern'Australian'stock'encompasses'from'Hervey'Bay'to'Torres'Strait'and'possibly'into' the'Gulf'of'Papua'(Limpus'2007).' *Breeding*Areas** Flatback'turtle'nesting'habitat'includes'sandy'beaches'in'the'tropics'and'subtropics,'with'all'recorded'nesting'beaches'in'Australia'(Limpus'et'al.'1989).'In' eastern'Queensland,'flatback'turtles'nest'between'Bundaberg'in'the'south'to'the'Torres'Strait'in'the'north.''The'main'nesting'sites'in'the'southern'Great' Barrier'Reef'are:'' !' Curtis'Island'' !' Peak'Island'' !' Facing'Island'' !' Hummock'Hill'Island,'and'' !' Wild'Duck'islands'(Limpus'1971T'Limpus'et'al.'1983).' Scattered'aperiodic'nesting'occurs'along'the'mainland'and'on'inshore'islands'between'Townsville'and'the'Torres'Strait'(Limpus'et'al.'1994).''Nesting'activity' is'greatest'between'late'November'and'early'December'ceasing'sometime'in'late'January.' *Migration*Routes** Flatback'Turtles'make'long'reproductive'migrations'similar'to'other'species'of'sea'turtles,'although'most'of'these'movements'are'restricted'to'the'continental' shelf'(DoTE'2013c).'Migrations'have'been'recorded'between'Australia'and'Indonesia,'Papua'New'Guinea,'Solomon'Islands'and'Vanuatu'(GBRMPA'2013a).' *Key*Threats*' Key'threats'include'commercial'and'recreational'fishing,'coastal'infrastructure'and'development'(including'industrial,'residential'and'tourism'development),' Indigenous'harvest,'feral'animal'predation,'and'climate'change'(DoTE'2016q).' ***Summary*** **Moreton'Bay'is'not'considered'to'be'core'habitat'and'is'unlikely'to'support'important'populations'or'offer'habitat'critical'to'the'survival'of'this' species.'Further,'very'few'individuals'have'been'recorded'in'Moreton'Bay.''There'is'a'low'likelihood'that'flatback'turtles'occur'in'marine'habitats' within'and'adjacent'to'the'Toondah'Harbour'project.'**	low'

Species'	Common' Name'	EPBC'Act' Threatened' Status'	Ecological'Information''	Likelihood'of' Occurrence'in' Area'of'Potential' Impact''
Fish'and'Sharks'		'	'	'
Epinephelus daemelii**	black'rockcod'	V'	The'black'rockcod'occurs'in'warm'temperate'and'subtropical'waters'of'the'south[western'Pacific,'including'south[eastern'Australia'and'parts'of'New'Zealand' (DSEWPaC'2012a).'Black'rockcod'generally'inhabit'near[shore'rocky'and'offshore'coral'reefs'at'depths'down'to'50'm,'but'are'occasionally'recorded'from' deeper'waters.'In'coastal'waters'adult'black'rockcod'are'found'in'rock'caves,'rock'gutters'and'on'rock'reefs.'Recently'settled'juveniles'are'often'found'in' coastal'rock'pools,'while'older'juveniles'can'be'found'in'estuaries'(DSEWPaC'2012a).'' *Feeding*Areas** Black'rockcod'are'a'large,'opportunistic'carnivore'that'preys'on'smaller'fishes'and'crustaceans'(McCulloch'1922TPogonoski'et'al.'2002a).'It'is'likely'that'they' feed'in'and'around'rocky'or'coral'reef'habitats.' *Breeding*Areas** Little'is'known'about'their'reproductive'behaviour,'but'they'are'known'to'aggregate'during'spawning'(Malcolm'&'Harasti'2010).' *Key*Threats** Current'threats'to'black'rockcod'are'incidental'by[catch'by'commercial'and'recreational'fishers,'and'illegal'fishing'activities'(DSEWPaC'2012a).'Modification' of'estuarine'habitat'is'considered'a'potential'threat'to'juvenile'black'cod'(DSEWPaC'2012a).' ***Summary*** **Given'the'banks'are'predominantly'lined'by'mangroves'with'sandy'or'muddy'substrates,'there'is'a'low'likelihood'that'black'rockcod'occur'in' marine'habitats'within'and'adjacent'to'the'Toondah'Harbour'project.'**	low''
Carcharias taurus**	grey'nurse' shark'	CE'	The'grey'nurse'shark'occurs'in'two'distinct'populations'on'the'east'and'west'coast'of'Australia.'The'eastern'coastal'species'is'distributed'from'southern' Queensland'to'southern'New'South'Wales,'with'sharks'primarily'aggregating'within'inshore'rocky'reefs'and'islands'(DoTE'2016c).'Critical'habitat'for'the' shark'includes'those'sites'used'for'aggregation'and'several'of'these'are'noted'within'the'Moreton'Bay'Marine'Park'(Environment'Australia'2014).' *Feeding*Areas** Grey'nurse'sharks'may'work'cooperatively'to'feed'(Compagno'1984TIreland'1984)'and'feed'on'a'variety'of'smaller'vertebrate,'squids'and'crustaceans' (Compagno'1984).'It'is'likely'that'feeding'takes'place'around'aggregate'areas.' *Breeding*Areas** Little'data'is'present'on'the'breeding'areas'of'the'grey'nurse'sharkThowever,'the'females'may'give'birth'at'select'pupping'grounds'(DoTE'2016c).'Within' pregnant'grey'nurse'sharks'of'eastern'Australia,'a'southerly'migration'is'noted'to'pupping'grounds'from'northerly'mating'and'gestation'aggregation'sites' (Bansemer'&'Bennett'2008).' *Migration*Routes** North'to'south'migration'between'key'critical'habitats'in'grey'nurse'sharks'occurs'between'aggregation'sites'for'both'male'and'female'sharks'(Bansemer'and' Bennett'2008).' *Key*Threats*' Key'threats'include'commercial'fisheries'bycatch'and'tourism'(DoTE'2016c).' ***Summary*** **As'the'area'of'the'subject'site'does'not'meet'key'habitat'requirements'for'this'species,'there'is'a'low'likelihood'that'this'species'would'occur'in' marine'habitats'within'or'adjacent'to'the'Toondah'Harbour'project.**	low'
*Carcharodon**	great'white'	V'	Great'white'sharks'are'found'in'most'coastal'waters'of'Australia,'with'the'exception'of'the'Northern'Territory.''The'shark'generally'inhabits'both'inshore'	low'

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
carcharias	shark		coastal and continental habitats (Pogonoski et al. 2002 in DEWHA 2009). However, within Australian waters, the great white shark primarily inhabits those areas from the coast to 100 metres (DoTE 2016d). There are few records of great white sharks in Moreton Bay (Karczmarski et al. 1997). *Feeding Areas* Juvenile individuals selectively hunt smaller prey classes (e.g. fish and other sharks), while larger individuals appear to selectively hunt marine mammals (Estrada et al. 2006; Malcolm et al. 2001). Seasonal site fidelity appears to occur (CMAR 2007). *Migration Routes* Seasonal migration is apparent in both juvenile and adult great white sharks and display highly directional, coastal migration up the eastern coast with through interconnected habitat areas during autumn to winter (Bruce et al. 2006). *Breeding Areas* Limited data is available for particular breeding areas, however it is expected to occur from spring through to summer in temperate areas (Francis 1996; Uchida et al. 1996). *Key Threats* Key threats include commercial fisheries bycatch and human protective measures (DoTE 2016d). ***Summary*** **There is a low likelihood that great white sharks occur in marine habitats within or adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	
Pristis zijsron	green sawfish	V	In Australian waters, green sawfish have historically been recorded in the coastal waters off Broome, Western Australia, around northern Australia and down the east coast as far as Jervis Bay in New South Wales (Stevens et al. 2005). However, there have been no records of this species south of Cairns since the 1960s (Stevens et al. 2005). The green sawfish inhabits inshore marine waters, estuaries and river mouths with both sandy and muddy bottom habitats (Allen 1997; Peverell et al. 2004; Stevens et al. 2005). It has been recorded in very shallow water (<1 m) to offshore trawl grounds in over 70 m of water (Stevens et al. 2005). *Feeding Areas* Sawfish feed on fishes and benthic invertebrates. They are relatively active on the mud and sand flats on a moving tide, presumably feeding (GBRMPA 2012). *Breeding Areas* Estuarine habitats are used as nurseries with juveniles migrating into marine waters (Thorburn et al. 2007). *Key Threats* Key threats include fisheries pressure and habitat degradation (DoTE 2016t). ***Summary*** **The green sawfish has not been recorded south of Cairns since the 1960s. There is an extremely low likelihood for the species to be in marine or freshwater habitats within or adjacent to the Toondah Harbour project.**	low
Rhincodon typus	whale shark	V	The whale shark is found in all oceanic and coastal waters around Australia. However, is more common in those of northern Western Australia, the Northern Territory and Queensland (Compagno 1984; Last & Stevens 1994). Whale sharks prefer warmer surface waters with cold-water upwellings (Pogonoski et al. 2002b). It is noted as a pelagic shark, but will also come into coastal waters (DoTE 2016u). *Feeding Areas* Whale sharks primarily feed on planktonic and nektonic prey using a suction filter feeding technique (Compagno 1984). The shark appears to aggregate	low

Species'	Common' Name'	EPBC'Act' Threatened' Status'	Ecological'Information''	Likelihood'of' Occurrence'in' Area'of'Potential' Impact''
			seasonally'in'response'to'a'pulse'surge'in'prey'in'the'areas'around:' !' Ningaloo'Reef'(DoTE'2016u)' !' Christmas'Island'(DEH'2005b)' !' Coral'Sea'(DEH'2005b)' Overall'feeding'appears'typically'to'occur'near'or'at'the'water'surface'(Compagno'1984).' *Breeding*Areas** Data'on'sexual'activity'of'the'whale'shark'is'limited,'and'no'evidence'of'pupping'has'yet'been'recorded'(Rowat'&'Brooks'2012).'As'no'observations'have' occurred'off'the'highly'populated'coastline'of'Eastern'Australia,'it'would'presume'to'only'occur,'in'remote'areas'offshore.' *Key*Threats** Key'threats'include'predation,'habitat'degradation,'competition'with'fisheries'and'tourism'(DoTE'2016u).' ***Summary*** **As'the'adjacent'area'does'not'meet'habitat'requirements'of'this'species,'there'is'an'extremely'low'likelihood'for'whale'sharks'to'occur'in'marine' habitats'within'or'adjacent'to'the'Toondah'Harbour'project.'**	

Source:'(DoTE'2014b)'

CE' Critically'EndangeredT'E' endangeredT'V' vulnerable'

Table 3.3 Migratory marine species listed as potentially occurring within 5 km of the subject site, on the online Protected Matters search tool, and their likelihood of occurrence in the area potentially impacted by the Toondah Harbour project.

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
Mammals				
Balaenoptera edeni	Bryde's whale	[	Bryde's whales occur within all Australian waters except Northern Territory, and, are found in both inshore and offshore waters (Bannister et al. 1996). There are a limited number of sightings in Australia. Bryde's whale is an occasional visitor to the Moreton Bay region, with two sightings recorded from Moreton and North Stradbroke islands (Chilvers et al. 2005). *Feeding Areas* Bryde's whales feed on a variety of prey items (Kato 2002; Martin 1990) and are broken into two key 'forms' (Best 1977). The coastal whale will consume schooling fishes while the offshore whale ingest crustaceans and cephalopods (Best 1960; 1977; Kawamura 1980; Nemoto & Kawamura 1977; Ohsumi 1977). No specific feeding areas are known for Bryde's whale; however, it appears that the whale may follow local movements of prey (DoTE 2016a). Limited dive times have led to the whale being considered as pelagic (DoTE 2016a). *Breeding Areas* There are no known breeding areas for Bryde's whale; however, the offshore form does travel northerly to tropical waters during winter and may be for breeding and calving (Kato 2002). *Migration Routes* Limited migration occurs for Bryde's whale. The inshore form appears to display limited movement while the offshore form migrates from subtropical to tropical waters, presumably for reproductive purposes. *Key Threats* Key threats include competition with fisheries and oceanic pollution (DoTE 2016a). ***Summary*** **Moreton Bay is not considered to be core habitat for this species, and the area is unlikely to support important populations or offer habitat critical to the survival of this species. There is a low likelihood that Bryde's whales occur in marine habitats within or adjacent to the Toondah Harbour project, particularly given the relatively shallow water in the area.**	low
Balaenoptera musculus	blue whale	E	See Table 3.2.	low
Eubalaena australis	southern right whale	E	See Table 3.2.	low
Megaptera novaeangliae	humpback whale	V	See Table 3.2.	low
Orcaella heinsohni (previously known as *Orcaella brevirostris)*	Australian snubfin dolphin	–	This species is listed as *Orcaella brevirostris* (Irrawaddy dolphin) in the EPBC search results. However, in 2005, genetic analysis showed the dolphin described as the Irrawaddy dolphin in Australia was actually a different species, now described as the Australian snubfin dolphin, *Orcaella heinsohni* (Beasley et al. 2005). While Irrawaddy dolphins occur across southern Asia and the Gulf of Papua New Guinea, in both coastal and freshwater systems (Culik 2010), the Australian snubfin dolphin occur only in waters off the northern half of Australia and is Australia's only endemic dolphin species. The Australian snubfin dolphin occurs from approximately Broome on the west coast to the Brisbane River on the east coast, of which the latter was considered outside the normal range (Parra et al. 2002). There appears to be 'hotspots' of higher densities along the Queensland coast (Parra et al. 2002) and preliminary data suggest that they occur in small, localised populations (Stacey & Arnold 1999). They appear to inhabit shallow waters <15 m deep within 10 km of the coast and up to 20 km of a river mouth, often in proximity to seagrass meadows (GBRMPA 2013b). It is doubtful that they venture very far upstream in river systems, although occasional vagrants may venture upstream	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			(Parra et al. 2002). *Feeding Areas* Like the Irrawaddy dolphin the Australian snubfin dolphin is assumed to be an opportunistic-generalist feeder, taking food from the bottom and water column. Diet consists primarily of fish, but includes cephalopods (squid and octopus) and crustaceans (prawns and crabs). Feeding may occur in a variety of habitats, from mangroves to sandy bottom estuaries and embayments, to rock and / or coral reefs. Feeding primarily occurs in shallow waters (less than 20 m) close to river mouths and creeks (DoTE 2016r). *Breeding Areas* There is limited information on the breeding and calving areas of the Australian snubfin dolphin; however, mating is likely to occur year round (DoTE 2016r). *Migration Routes* Limited information exists on their migration routes; however, home ranges and territories for appear to be large (DoTE 2016r). *Key Threats* Key threats include competition with fisheries, incidental capture in nets, habitat destruction and degradation, pollution and interaction with vessels (DoTE 2016r). ***Summary*** **The Brisbane River is considered the southern-most extent of the Australia snubfin dolphin range, and even so tenuously. Therefore, there is a low likelihood that Irrawaddy dolphin or Australian snubfin dolphins occur in marine habitats within or adjacent to the Toondah Harbour project, which is south of the Brisbane River.**	
Sousa chinensis	Indo-Pacific humpback dolphin	–	The distribution of Indo-Pacific humpback dolphins appears to be continuous along the east coast of Queensland (Corkeron et al. 1997). The Indo-Pacific humpback dolphin usually inhabits shallow coastal waters in association with rivers or creeks, estuaries, enclosed bays and coastal lagoons (Hale et al. 1998; Parra 2006). Recent surveys conducted in the far northern section of the Great Barrier Reef Marine Park showed that most sightings of Indo-Pacific humpback dolphins occurred in waters less than 5 km from land, 20 km from the nearest river mouth, and in waters less than 15 m deep (Parra et al. 2006b). Moreton Bay is one of the southernmost bay systems with a resident Indo-Pacific humpback dolphin population and is estimated to have approximately 100 and 163 individuals, predominantly in the western side of the bay (Chilvers et al. 2005; Parra et al. 2006a). *Feeding Areas* Indo-Pacific humpback dolphins have only been recorded feeding in shallow waters. They feed in a variety of habitats, from mangroves to sandy bottom estuaries and embankments to rock and / or coral reefs (DSEWPC 2013; DEHP 2013). They are opportunist-generalist feeders, consuming a wide variety of coastal and estuarine fishes, but also reef, littoral and demersal fishes, and some cephalopods and crustaceans (Parra 2005). *Breeding Areas* No key calving areas are known in Australian waters (Bannister et al. 1996). *Migration Routes* Indo-Pacific humpback dolphins are considered to be migratory, with evidence of migration across international boundaries (Culik 2003). In Queensland, there is evidence to indicate possible seasonality between different habitats (DEHP 2013). Home ranges appear to be large. *Key Threats* Key threats include habitat destruction and degradation, bycatch in gillnets and shark nets, illegal sport killing, overfishing of prey species, pollution and human interaction threats arising from tourism and transport (DoTE 2016v). ***Summary***	high

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Given their known population in Moreton Bay and preference for shallow coastal and estuarine areas, the Indo-Pacific humpback dolphin are highly likely to feed in or traverse within marine habitats of the Toondah Harbour project area.	
Dugong dugon	dugong	-	Dugong occur in all northern coastal waters from Broome in Western Australia to Moreton Bay in Queensland (Marsh et al. 2002; Marsh et al. 2011). The population of dugongs in Moreton Bay has been estimated to range between approximately 503 to 1019 individuals. The eastern banks of Moreton Bay supported 80–98% of the dugong population at any one time. In this area, there are several dugong 'hot spots' generally associated with seagrass communities (Lanyon 2003; Chilvers et al. 2005). *Feeding Areas* Dugongs feed almost exclusively on seagrass, particularly H. uninervis, H. ovalis and H. spinulosa, and principally inhabit seagrass meadows of shallow, protected bays and mangrove channels (Preen 1992; Preen et al. 1995; Lanyon & Morris 1997; Marsh et al. 2011). Their dependence on seagrass for food generally limits them to waters within 20 km of the coast, although individuals have been sighted further from the coast during aerial surveys (e.g. Marsh & Lawler 2002) and they have been observed feeding in deep-water (water depth of more than 20 m) seagrass (Lee Long et al. 1997). *Breeding Areas* Limited data suggests that dugong utilise tidal sandbanks and estuaries for calving (Marsh et al. 1984; Marsh et al. 2011). Mating herds have been observed in Moreton Bay (Marsh et al. 2011). *Migration Routes* Dugongs prefer shallow and protected areas with seagrass meadows, however they can be highly migratory due to their search for suitable seagrass or warmer waters (Marsh et al. 2002) and are known to travel several hundred kilometres. Dugongs have evolved to cope with the inherently unpredictable and patchy nature of seagrass meadows by moving to alternative areas known to support seagrass in the past. *Key Threats* Key threats include habitat degradation, pollution, anthropogenic noise and interaction with fisheries (DoTE 2016h). ***Summary*** **Moreton Bay supports feeding and breeding populations of dugong. Dugong have been observed near Toondah Harbour (frc environmental, pers. obs.) and are highly likely to occur within the marine habitats of the Toondah Harbour project area, particularly in the seagrass beds.**	high
Lagenorhynchus obscurus	dusky dolphin	-	Dusky dolphins mostly occur in temperate and sub-Antarctic, inshore waters (Ross 2006; DoTE 2016k). There are only thirteen records of the dusky dolphin in Australian waters (Bannister et al. 1996; Gill et al. 2000; Ross 2006). *Feeding Areas* Dusky dolphins are considered to be surface feeders (DoTE 2016k). Limited evidence suggests they feeds offshore during the night and rests inshore during the day (Sekiguchi et al. 1992; Bannister et al. 1996; Würsig et al. 1997). No Australia-specific feeding information is available; however, it would be expected that Australian populations of the dusky dolphin exhibit similar behaviour. *Breeding Areas* No breeding or calving areas are identified in Australian waters (DoTE 2016k). *Migration Routes* Limited information is available for seasonal movement patterns in Australia, but movement patterns may be linked to the position of the Subtropical Convergence and / or ENSO events (DoTE 2016k). *Key Threats*	low

Species'	Common' Name'	EPBC'Act' Threatened' Status'	Ecological'Information'	Likelihood'of' Occurrence'in'Area'of' Potential'Impact'
			Key'threats'include'pollution'and'interaction'with'fisheries.' ***Summary'*** **Moreton'Bay'is'not'considered'to'be'core'habitat'for'this'species,'and'the'area'is'unlikely'to'support'important'populations'or'offer'habitat' critical'to'the'survival'of'this'species.''There'is'a'low'likelihood'that'dusky'dolphins'will'occur'in'marine'habitats'within'or'adjacent'to'the' Toondah'Harbour'project,'particularly'given'the'relatively'shallow'water'in'the'area.'**	
*Orcinus*orca**	killer'whale'	['	Killer'whales'are'found'throughout'Australian'state,'continental'and'oceanic'waters.'Within'these'waters,'killer'whales'are'predominantly'found'in' southern'state'waters'(Ling'1991TChatto'&'Warneke'2000).' *Feeding*Areas** Killer'whales'feed'on'an'abundance'of'prey'types'including'fish,'invertebrates,'birds'and'marine'mammals'(Bannister'et'al.'1996TSaulitis'et'al.'2000).' In'Australia,'foraging'generally'occurs'in'coastal'or'oceanic'waters'(DoTE'2016s).'Therefore,'foraging'by'killer'whales'within'Moreton'Bay'would'be' highly'unlikely.' *Breeding*Areas** No'calving'areas'are'known'in'Australian'waters'(DoTE'2016s).' *Migration*Routes** Killer'whales'are'noted'to'probably'follow'migratory'routes'(DoTE'2016s)T'however,'these'migratory'routes'would'generally'occur'along'typical' habitatsToceanic'or'continental'shelf'waters.' *Key*Threats** Key'threats'include'pollution,'targeted'hunting'and'illegal'killing,'and'interactions'with'fisheries,'including'the'potential'for'incidental'capture'(DoTE' 2016s).' ***Summary'*** **Moreton'Bay'is'not'considered'to'be'core'habitat'for'this'species,'and'the'area'is'unlikely'to'support'important'populations'or'offer'habitat' critical'to'the'survival'of'this'species.''There'is'a'low'likelihood'that'killer'whales'will'occur'in'marine'habitats'within'or'adjacent'to'the' Toondah'Harbour'project.''**	low'
Reptiles'	'	'	'	'
*Caretta*caretta**	loggerhead' turtle'	E'	See'Table'3.2.'	high'
*Chelonia*mydas**	green'turtle'	V'	See'Table'3.2.'	high'
Dermochelys coriacea**	leatherback' turtle'	E'	See'Table'3.2.'	low'
Eretmochelys imbricata**	hawksbill' turtle'	V'	See'Table'3.2.'	moderate'
Lepidochelys olivacea**	olive'ridley' turtle'	E'	See'Table'3.2.'	low'
*Natator*depressus**	flatback'turtle'	V'	See'Table'3.2.'	low'

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Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
Fish and Sharks				
Pristis zijsron	green sawfish	V	See Table 3.2.	low
Rhincodon typus	whale shark	V	See Table 3.2.	low
Carcharodon carcharias	great white shark	V	See Table 3.2.	low
Lamna nasus	mackerel shark	–	The mackerel shark is a wide ranging coastal and oceanic species found in temperate and cold-temperate waters worldwide, preferring water temperatures below 18°C (Stevens et al. 2006). In Australia, this species occurs from southern Queensland to south-west Australia (Last & Stevens 2009). They typically occur in oceanic waters off the continental shelf, although they occasionally enter coastal waters (Francis et al. 2002). *Feeding Areas* Mackerel sharks are thought to be reasonably flexible in the types of habitat used for foraging (Pade et al. 2009). The mackerel shark feeds on pelagic fish and cephalopods, with elasmobranchs forming a small part of their diet (Joyce et al. 2002). *Breeding Areas* Mackerel sharks in the southern hemisphere are thought to give birth off New Zealand and Australia in winter (Francis & Stevens 2000); however, little is known of their key pupping areas. *Migration Routes* The mackerel shark is known to undertake seasonal migrations, although the timing and details of these migratory movements are not well-understood (Saunders et al. 2011). *Key Threats* The key threat to this species is overfishing (DoTE 2016l). ***Summary*** **Mackerel sharks typically occur in waters off the continental shelf. While they may venture into the coastal area of Moreton Bay, the marine habitats within or adjacent to the Toondah Harbour project are unlikely to provide significant habitat for them.**	low
Rays				
Manta birostris	giant manta ray	–	The taxonomy of mantra rays has recently been revised and the genus *Manta* now includes two distinct species: - *Manta birostris* a more oceanic species that migrates large distances in cooler waters, and - *Manta alfredi* more common on the continental shelf, around tropical and subtropical coral and rocky reefs, islands and along coastlines (Marshall 2008; Marshall et al. 2009; Couturier et al. 2011; see below). *Feeding Areas* The manta rays feeds on plankton, and can be encountered in large numbers along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts (Marshall et al. 2011). They can also be encountered on shallow reefs while being cleaned or feeding at the surface inshore and offshore. In inshore areas, they can occasionally be observed in sandy bottom areas and seagrass beds (Marshall et al. 2011). *Breeding Areas* There is little information on the reproductive biology of the giant manta ray (Marshall et al. 2011).	low

Species	Common Name	EPBC Act Threatened Status	Ecological Information	Likelihood of Occurrence in Area of Potential Impact
			Migration Routes While the manta rays is widely distributed and appears to be a migratory species, regional populations appear to be small considering the scale of their habitat (Marshall et al. 2011). *Key Threats* No threat data is available (DoTE 2016o). ***Summary*** **The area adjacent to the Toondah Harbour project does not provide critical habitat for *M. birostris*, and there is a low likelihood they will occur in marine habitats within or adjacent to the project area.**	
Manta alfredi	Reef Manta Ray		As above, the taxonomy of mantra rays has recently been revised and the genus *Manta* now includes two distinct species: - *Manta birostris* a more oceanic species that migrates large distances in cooler waters (see above), and - *Manta alfredi* more common on the continental shelf, around tropical and subtropical coral and rocky reefs, islands and along coastlines (Marshall 2008; Marshall et al. 2009; Couturier et al. 2011). Of the two giant manta ray species, the most likely species to occur near the coastline is *M. alfredi*. This species shows high site affinity that is likely to be related to feeding areas, cleaning stations, reproductive sites and migratory landmarks (Couturier et al. 2011). *Feeding Areas* The manta rays feeds on plankton, and can be encountered in large numbers along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts (Marshall et al. 2011). They can also be encountered on shallow reefs while being cleaned or feeding at the surface inshore and offshore. In inshore areas, they can occasionally be observed in sandy bottom areas and seagrass beds (Marshall et al. 2011). *Breeding Areas* There is little information on the reproductive biology of the manta rays (Marshall et al. 2011). *Migration Routes* While the manta rays is widely distributed and appears to be a migratory species, regional populations appear to be small considering the scale of their habitat (Marshall et al. 2011). *Key Threats* No threat data is available (DoTE 2016n). ***Summary*** **While the area adjacent to the Toondah Harbour project may provide some habitat requirements for vagrant *M. alfredi*, there is an extremely low likelihood that they will occur in marine habitats within or adjacent to the area.**	low

Source: (DoTE 2014b)

E endangered; V vulnerable

4 Assessment of Potential Impacts and Mitigation Measures

The discussion of potential impacts presented here is preliminary, and based on a combination of professional experience gained working on similar projects and the preliminary master plan. As detailed design and construction methods are yet to be finalised, the discussion of potential impacts is generic, and subject to further design information.

Potential direct impacts include:

- loss of habitat directly under the footprint of the proposed project
- gain of habitat in some of the footprint area
- marine fauna becoming trapped or injured in wet excavation areas.

Indirect impacts to the marine ecosystem may include:

- disturbance of sediments and soil (increasing turbidity, suspended solids, sedimentation, nutrients, contaminants and potential acid sulfate soils)
- spills of hydrocarbons and other contaminants
- increased stormwater runoff (with greater non-permeable surfaces on the subject site) and associated contaminants and foreshore erosion
- altered hydrodynamics
- increased site access and boating
- spread of weeds and pests, and
- increased litter.

Following dredging of Fison Channel, water quality is likely to improve around the channel as deepening the channel will reduce the current disturbance of bottom sediments from boating activities (particularly large passenger and vehicle ferries).

4.1 Loss of Habitat

Direct impacts that may result from the construction of the proposed project are the physical removal of, and damage to aquatic habitats.

The proposed project will result in the direct loss of aquatic habitat under the project footprint. While the design of the footprint is yet to be finalised, it is likely to include at least a portion of the PDA area, and thus result in a loss of habitat in the PDA, which includes:

- approximately 5.3 ha of mangroves
- approximately 32.7 ha of seagrass (ranging in cover from 1% to 85%)
- isolated and clumps of algae and potentially coral growing on bare sediments and rocks
- non-vegetated[2] soft sediments and the associated macrobenthos.

Other habitats along the foreshore including natural and artificial rock, pylons and concrete walls will also be either removed or incorporated into the project design.

The risk of direct disturbance to aquatic habitats during construction can be minimised by limiting the area of disturbance, for example by using areas within the project footprint for any temporary construction and storage, and by marking any marine plants that are to be retained and avoiding their disturbance.

4.2 Gain of Habitat

The installation of the pylons and other structures will provide hard-substrate that will likely be colonised by algae and invertebrates such as oysters and barnacles, and shelter for a range of fishes and mobile invertebrates (such as prawns).

Artificial structures such as the proposed pylons provide valuable habitat for fish as they:

- provide protection from predators
- feeding opportunities
- shelter from currents
- shade, which is also important in attracting many fish species (de la Moriniere et al. 2004; Verweii et al. 2006), and
- extra settlement habitat for recruitment (Derbyshire 2006).

[2] Devoid of macroscopic flora; benthic microalgae are expected to be associated with the surface sediments

The characteristics of artificial structures and the organisms growing on those structures influences the type of fish and other fauna that it is likely to support. Studies of natural and artificial habitat indicate that each support a fish fauna of similar species richness, yet of different, but often overlapping, assemblages (Fujita et al. 1996; Clark & Edwards 1999).

Fish-friendly structures should be incorporated into the design where possible. The Fisheries Guideline for Fish-Friendly Structures outlines several general and specific fish-friendly design features intended for developments that require aquatic infrastructure (Section 4.2 in Derbyshire 2006). Design options that may be considered for the structures associated with the upgrade may include:

- incorporating artificial habitat modules under piers and other supporting structures of the marina
- use of revetments constructed from different sized pieces of rock that offer more habitat than walls made out of smooth concrete
- gently sloping revetments rather than vertical revetments, and
- not using materials such as polystyrene, tyres, treated wood and uncured concrete.

4.3 Marine Fauna Trapped in Excavation Areas

Fish, turtles and marine mammals may become trapped in excavation areas during excavation, dredging and reclamation works. Impact to these marine fauna will depend on the time taken to excavate and the turbidity of the water during excavation, with higher turbidity and longer periods more likely to negatively impact marine fauna.

A management plan for minimising the risk of impacting marine vertebrates should be formulated prior to in- or on-water construction activities. Mitigation options to be considered include:

- installing sheet piles, silt curtains or other temporary barriers at low tide to minimise the number of marine vertebrates caught in the area
- capturing fish within the area confined by the sheet piles, silt curtains or other temporary barriers and releasing them outside the area
- visual observations by a trained marine mammal and turtle spotter prior to commencement of excavation and dredging activities

- cessation of excavation or dredging if a dolphin, dugong or turtle is observed within the area, until the animal can be removed from the area being excavated, and
- using mechanical noise to drive marine mammals away from an area prior to completion of the installation of sheet piles, silt curtains or other temporary barriers.

4.4 Disturbance of Sediments and Soils

Disturbance of sediment and / or soils may lead to:

- changes in benthic community structures
- increases in turbidity, sediment suspension and smothering
- nutrient enrichment of surrounding waters
- release of contaminants, and
- exposure of acid sulfate soils (ASS).

Sediments may be disturbed by construction activities such as clearing and earthworks, dredging and reclamation, and pile placement. The risk and severity of these potential impacts will be related to the intensity, duration, spatial extent and frequency of exposure that results from the construction works. Potential impacts to each habitat type are outlined in the remainder of this section. Communities that are most sensitive to disturbances of sediment and / or soils in the area are seagrass meadows and scattered corals on rubble. Measures to reduce potential impacts to these communities include:

- designing the project to minimise the area of sediment and / or soils being disturbed
- using temporary enclosures (complete enclosures such as sheet piles or alternate enclosures such as silt curtains) to reduce the intensity and spatial distribution of potential impacts
- isolate the disturbance areas, for example by using sheet piles, silt curtains, oil spill booms, bunding, trenching and / or similar technologies
- identification and management of acid sulfate soils and other contaminants, through a sediment sampling and analyses plan (SAP)
- developing thresholds for turbidity and suspended solids, and appropriate management (e.g. triggers for ceasing works) for seagrass and corals and monitoring water quality during construction, and

- monitoring changes in seagrass and coral communities post-construction to determine any potential impacts.

Measures such as avoiding disturbance of sediment and / or soils during important periods of reproduction for coral and seagrass (e.g. late spring and summer) or during low tide when water is shallower and dredge plumes may be more concentrated may also reduced potential impacts. Further, given corals in the area are isolated individuals on rubble (rather than reef complexes), a coral translocation and replantation program, where coral are moved to nearby area/s during construction and returned to the area post construction would also reduce impacts to coral assemblages.

A complete enclosure (e.g. by installing temporary sheet piles) of areas where sediments and soils are to be disturbed, including the marina and reclamation areas, would isolate increases in turbidity, suspended sediment (and hence smothering), nutrient enrichment, contaminants and acid sulphate soils to the adjacent marine environment. Temporary sheet piles have been used successfully in other reclamation and marina project in Queensland and are likely to be the best practice method for minimising impacts of disturbances of sediment and soils. The design and application of comprehensive Erosion and Sediment Control Management Plans and an Acid Sulfate Management Plan will also minimise and manage potential impacts of disturbing sediment and soil in the marina and reclamation areas.

The development and application of thresholds for turbidity and suspended solids over seagrass and corals would also contribute to minimising impacts. Such thresholds would include maximum allowable exceedances above ambient levels and limits to the duration of plumes, along with appropriate management responses (e.g. triggering cessation of works). Thresholds should be site specific, and take into account the variability in local ambient levels and the sensitivities of local species (Erftemeijer & Robin Lewis 2006; Erftemeijer et al. 2012).

Impacts to Benthic Communities

Excavating or dredging soft sediment habitats in the proposed marina as well as dredging Fison Channel may impact macroinvertebrate communities. Impacts to soft-sediment benthic macroinvertebrate communities are likely to be temporary (recovering in a few months), although where the freshly exposed substrate is physically or chemically different from the removed sediment, community structure may change. Community structure may also change due to increases in depth, decreases in light penetration associated with a deeper environment, and with changes in currents in the water column.

Soft sediment communities within the marina and channel are likely to be deeper and in some areas of the marina will receive shade from the structures, leading to reduced benthic microalgal (BMA) biomass. Due to the relatively small area that will be disturbed, any shifts in benthic macroinvertebrate community structure are unlikely to significantly impact fisheries productivity on a local or regional scale.

Increased Turbidity, Suspended solids and Sedimentation

Disturbance of substratum may result in sediment (and associated chemicals) becoming suspended. The effects of increased turbidity suspended solids and sedimentation resulting from dredging / excavation and spoil handling are highly variable. The likelihood of increases in suspended sediments and of smothering are closely related to the characteristics of the sediment. Coarse sediments settle from the water column quickly and are unlikely to move away from the excavation site. Fine sediments remain suspended longer; may be carried further before settling, and consequently are more likely to smother marine organisms.

Seagrass and Macroalgae Communities

The temporary increase in turbidity associated with excavation and spoil handling typically reduces or alters the penetration of light through the water column (McMahon et al. 2017). Light availability, or specifically the duration of light intensity exceeding the photosynthetic light saturation point, controls the depth distribution of seagrasses (Dennison & Alberte 1985; Dennison 1987; Abal & Dennison 1996). For example, on average 30% of surface light; a light attenuation coefficient of less than 1.4m^{-1} and total suspended solids of less than 10 mg/L are required for the survival of *Zostera muelleri* in Moreton Bay (Longstaff et al. 1998; Abal & Dennison 1996). *H. ovalis* another common species in the area, has a particularly low tolerance to light deprivation caused by pulsed turbidity such as floods and dredging (Longstaff et al. 1998). However, *H. ovalis* can quickly recolonise areas due to its high growth rate and high seed production.

Availability of light also affects the productivity of seagrasses. Seagrass exposed to higher light intensity is more productive than seagrass in less intense light (Grice et al. 1996). Consequently, impacts associated with dredging may result in at least a temporary decrease in seagrasses productivity. Light also controls the population dynamics of macroalgae (Lukatelich & McComb 1986a; cited in Lavery & McComb 1991).

When suspended solids settle on seagrass communities, the burial can result in increased seed germination, decrease in shoot density and productivity, changes in growth (e.g. increase vertical and rhizome growth) and mortality (Cabaço et al. 2008).

The sensitivity of seagrass to turbidity and sedimentation varies within and between species and life histories (Erftemeijer & Robin Lewis 2006). Local conditions influence the sensitivity of seagrass species, with areas experiencing large fluctuations in background turbidity often displaying greater resilience (Erftemeijer & Robin Lewis 2006). Further, the deepest edge of meadows are often more susceptible to changes in light levels (Ralph et al. 2007). Thus, increases in turbidity and sedimentation are likely to result in adverse environmental effects when the turbidity generated (by dredging for example) is significantly larger than the ambient (or baseline) variation of turbidity and sedimentation rates in the area (Erftemeijer & Robin Lewis 2006).

Coral and Rubble Assemblages

Most coral are host to symbiotic zooxanthellae (algae) that can produce the majority of the corals energy requirements through photosynthesis. Turbidity and suspended sediments (which can result from dredging, excavation and reclamation works) reduce light levels and hence the ability of the zooxanthellae to photosynthesise (Erftemeijer et al. 2012). Sediment settling on coral can also clog filtering and feeding apparatus, smother coral and / or further reduce the light available for photosynthesis by shading symbiotic zooxanthellae. Energy is expended on clearance of settling sediments, such as the production of mucus (Erftemeijer et al. 2012; Bessell-Browne et al. 2017a). With the production of mucous sheets and effective bioindictor of sediment related exposure for massive Porites corals (Russell-Browne et al. 2017). Embryo and larval stages of coral tolerate higher sediment loads and are less sediment-sensitive than other life-history pelagic stages (Ricardo et al. 2016).

Suspended sediments can also effect reproduction and recruitment processes which underlie the maintenance of communities and their resilience to disturbance. Never the less, light limitation is thought to have a greater impact on coral health than suspended sediments (Bessell-Browne et al. 2017b).

Overall impacts to corals from increased turbidity, suspended sediment and smothering include reduced growth, lower calcification rates and reduced productivity, bleaching, increased susceptibility to diseases, physical damage, reduced regeneration and mortality (Erftemeijer et al. 2012). This can result in changes in community structure, decrease in density and diversity of coral and loss of reef habitat if sediment disturbances are severe and long-lasting (Erftemeijer et al. 2012). Fine sediments tend to have a greater impact on corals than coarser sediment (Erftemeijer et al. 2012).

Soft Sediment Benthos

The fauna associated with soft sediment habitats is typically determined by the character of the sediment: its grain size and stability and with the presence or absence of seagrass. Grain size influences the ability of organisms to burrow, and the stability of ‘permanent’ burrows. Unstable sediments support less diverse benthic communities than those that are relatively stable. Resuspension of fine sediments can interfere with the feeding and respiration of benthic fauna.

Increases in the concentration of suspended solids may impact the respiration and feeding of a variety of taxa reducing abundance, species diversity and productivity. The deposition of fine sediment over existing substrate is likely to influence the community structure in favour of those species most able to cope with fine sediment substrate to the disadvantage of those less able. Filter feeding and gilled fauna are most likely to be affected. Whilst dredging may impact soft sediment invertebrate communities within the dredge plume, impacts are typically temporary and reversible.

Fish and Marine Megafauna

Although some fish and marine megafauna (e.g. dolphins, turtles and dugongs) may avoid areas of high turbidity and suspended solids, areas of high turbidity and suspended solids may also be attractive to a range of fish, particularly juveniles, as it confers a greater degree of protection from predators (Blaber & Blaber 1980). Reduced visibility can also change the behaviour of mobile marine fauna. Suspended sediment in the water column can cause physiological effects to fish, such as clog gills or influence reproduction (e.g. fertilisation, or survival of eggs or larvae). Although, there is evidence that levels high enough to directly affect fish physiology are limited to the immediate vicinity of the dredging and disposal operations (McCook et al. 2015 and references herein). Fish and marine megafauna may be indirectly impacted by the loss or degradation of habitats, and effects on food webs, connectivity, and changes in ecosystem processes.

Nutrient Enrichment of Surrounding Waters

The proposed development may result in an increase in nutrients in the surrounding water, for example by disturbance of the sediment. Such increases are likely to be minor where development is controlled by an appropriate Environmental Management Plan. Never the less potential impacts of an increase are nutrients are discussed below.

Mangroves and Saltmarsh

Increased nutrients can have positive impacts on the productivity of mangrove communities; commonly there is an increase in growth and productivity associated with low levels of nutrient enrichment (e.g. Onuf et al. 1977; Clough et al. 1983; Dunstan 1990; McLaughlin 1987). Available data suggests that nitrogen availability is limiting mangrove growth in south east Queensland waters, such as Moreton Bay (Dennison et al. 1998). However, as there was no increase in leaf turnover rates, the capacity of mangroves in Moreton Bay to convert dissolved nutrients to particulate nutrients via litter fall may be limited (Dennison et al. 1998). That is, increasing nutrients may lead to an initial increase in biomass of mangroves; however, this uptake may not be sustained. In northern Australia, leaf production increased with nitrogen fertilisation (Boto & Wellington 1983). It has been suggested that the response of mangrove forest to nutrient enrichment could be in two stages, with an initial increase in leaf production followed by an increased foliar nutrient concentration (Dennison et al. 1998).

Seagrass

Nutrients released from disturbed sediments may alter the community composition of floral and consequently faunal communities. Increased nutrient loads may to lead to an increase in phytoplankton densities, and consequently a reduction in water clarity and seagrass depth distribution (Dennison et al. 1993).

Moderate amounts of additional nutrients in the water column can also increase seagrass growth (McRoy & Helfferich 1980). However, as macroalgae are more efficient at absorbing nutrients from the water column than seagrasses or coral, higher levels of nutrient enrichment can lead to an increase in macroalgae growth at the expense of seagrass and coral (Wheeler & Weidner 1983; Zimmerman & Kremer 1986; Koop et al. 2001; Lapointe 1997; McCook 1999). Consequently, benthic macroalgae may overgrow and displace seagrass, whilst drift and epiphytic algae may physically shade seagrass and coral, reducing their growth and distribution (Twilley et al. 1985; Silberstein et al. 1986; Maier & Pregnall 1990; Tomasko & Lapointe 1991). Epiphytic algae may also reduce diffusive exchange of dissolved nutrients and gases at leaf surfaces (Twilley et al. 1985; Neckles et al. 1993). Acute nutrient enrichment may also stimulate the growth of mangrove and saltmarsh (Adam 1990; Adam 1995).

The trophic structure of benthic invertebrate communities often changes with increased nutrient levels, becoming dominated by small opportunistic deposit feeders. In eutrophic estuaries deposit feeding spionid and capitellid polychaete worms often tend to dominate benthic communities.

Macroalgae and Phytoplankton

Elevated nutrients can rapidly be taken up and stored by macroalgae and phytoplankton during pulsed discharge events (Furnas 2003). Phytoplankton is very abundant in coastal waterways and has high nutrient uptake rates. As a result, phytoplankton is commonly the principal flora assimilating nitrogen and phosphorus within coastal estuaries of southern Queensland.

Nutrients exported to or released within the coastal zone can significantly increase the productivity and competitive potential of some macroalgal species (Schaffelke & Klumpp 1998a; Schaffelke & Klumpp 1998b), with macroalgal cover often being significantly correlated with distance from rivers mouths and positively correlated with turbidity, chlorophyll-a and current speed (van Woesik et al. 1999).

Phytoplankton communities are sensitive indicators of nutrient enrichment. Increased nutrient availability has been linked with not only increased phytoplankton biomass, but also with a shift in the community composition of the phytoplankton. Whilst correlations between increased water column nutrient levels and increased phytoplankton abundance are common, phytoplankton assemblages can incorporate nutrients so rapidly that there is no apparent increase in nutrients in the water column. Phytoplankton has the ability to uptake nutrients in various forms, such as ammonium (the preferred form of N), nitrate, urea and phosphate (Dennison & Abal 1999).

The diatom-cyanobacteria fraction of the phytoplankton community is often the first to respond to increased nutrient availability (Parsons et al. 1978, cited in Hallegraeff 1996), consequently diatoms are typically associated with algal blooms in tropical and sub-tropical coastal waters. However, chronic elevations in available nutrients can result in pronounced shifts from high biomass microplankton communities dominated by diatoms, to highly productive pico-nanoplankton communities (Harding 1994).

Phytoplankton growth is primarily limited by light, nutrients (principally phosphorous and nitrogen) and temperature. However, other macronutrients such as silicate and micronutrients (vitamins, trace elements and chelators) are also important in controlling growth and community composition (Hallegraeff 1996).

The Ecosystem Health Monitoring Program administered by the Healthy Waterways Partnership investigated factors limiting phytoplankton growth in Moreton Bay and the surrounding river estuaries. Phytoplankton growth responses are substantially lower in Moreton Bay than in the river estuaries, due to a lower abundance of phytoplankton in the bay. Throughout Moreton Bay and the river estuaries nitrogen is the major nutrient limiting growth.

Coral and Rubble Assemblage

Nutrient enrichment can reduce coral calcification and fertilization rates and exacerbate coral disease (Fabricius 2005). Macroalgae abundance can also be enhanced (Fabricius 2005), which may compete with coral in some areas.

Soft Sediment Benthos

Benthic microalgae play an important role in sediment nutrient processes, and are hypothesised to be highly efficient at denitrification and the absorption of nutrients (Dennison et al. 1998).

However, turbidity limits benthic microalgae productivity – for example, in the turbid reaches of the Brisbane River, benthic microalgae concentrations are 0 – 20 mg/m^2, compared to concentrations of around 50 mg/m2 at some sites in Moreton Bay, where there is low turbidity and growth is not nutrient-limited (e.g. southern Pumicestone Passage) (Dennison & Abal 1999).

Increases in sediment organic and nutrient loads often lead to a reduction in community diversity and species richness, which is associated with a shift in community composition and trophic group structure (Pearson & Rosenberg 1978; Tsutsumi 1990; Meksumpun & Meksumpun 1999; Rossi 2003).

Population densities of opportunistic deposit feeders characteristically increase in areas impacted by organic enrichment and macro-invertebrate communities typically become dominated by polychaetes (Pearson & Rosenberg 1978; Tsutsumi 1990; Meksumpun & Meksumpun 1999). These worms are characterised by their ability to respond rapidly to environmental change and are widely recognised as useful indicators of environmental health (Pearson & Rosenberg 1978; ANZECC & ARMCANZ 2000). In particular the polychaete families Capitellidae and Spionidae have been identified as indicators that are sensitive to organic enrichment (Tsutsumi 1990; ANZECC & ARMCANZ 2000). The densities of capitellid polychaetes in environments with high nutrient and organic loads typically exceed 1000 individuals per m^2 (Tsutsumi 1990; Hutchings et al. 1993). Such densities are generally indicative of organic enrichment and are used as the trigger levels for ANZECC & ARMCANZ guidelines.

Many benthic macro-invertebrate species are metal sensitive and increased concentrations have been shown to affect benthic invertebrates at the population and community level (Morrisey et al. 1996; Ward & Hutchings 1996; Reish & Gerlinger 1997). Increases in the concentration of trace metals in estuarine sediments remove metal sensitive species and facilitates the explosion of polychaete populations, which can selectively exploit metal contaminated conditions (Ward & Hutchings 1996). Changes in community structure are usually accompanied by a reduction in the richness and diversity of benthic macro-invertebrate communities.

Nutrient enrichment increases the cycling of sulphur through the sediment. Under normal aerobic conditions, hydrogen sulphide (H_2S) and sulphuric acid (H_2SO_4) produced during sulphate (SO_4) reduction rapidly convert back to SO_4 and have little impact on macroinvertebrate communities (Edgar 2001). Similarly, H_2S is not usually a problem in most anaerobic sediments, because it is quickly bound to Fe to form pyrite and iron mono-sulphides. However, H_2S may become a problem when the Fe scavenging capacity of the sediments is exceeded, that is, where there are very high organic loadings. In heavily organically enriched environments with low dissolved oxygen, H_2S and H_2SO_4 concentrations can increase dramatically (Coleman & Cook 2003), and allow these poisonous compounds to build up in the sediment, and potentially negatively impact macro-invertebrate communities (Coleman & Cook 2003).

Marine Fauna

Nutrient enrichment can result in localised eutrophication and depletion of oxygen in the water column. Many species of fish become stressed when DO concentrations drop below 4 mg/L, and levels of <2 mg/L are fatal to most species. Similarly, invertebrates of the bed and bank are impacted by low DO concentrations.

Conditions of low DO, high H_2S and low redox potentials usually occur simultaneously and their impacts on macroinvertebrate populations are difficult to separate in their effect on community structure (Wu 2002). Under these conditions there is often a reduction in the richness and diversity of macroinvertebrate communities, which is associated with a trophic shift toward deposit feeding taxa (Wu 2002; Coleman & Cook 2003).

Release of Contaminants

The absorption of heavy metals from solution occurs in plants and animals by passive diffusion across gradients created by adsorption at the surface, and by binding by constituents of the surface cells, body fluids, etc. An alternative pathway for animals is when metals are adsorbed onto or are present in food, and by the collection of particulate or colloidal metal by food gathering mechanisms. Depending upon the types and concentrations of heavy metals release, impacts could range from the reduction of reproductive capacity of some species to the mortality of aquatic flora and fauna. The effect of chronic heavy metal pollution is still largely unresolved, and effects depend on the interrelationships of many physical and chemical factors. Threshold concentrations of toxicants to ensure the protection of aquatic ecosystems have been developed by the Australian and New Zealand Environment and Conservation Council (ANZECC & ARMCANZ 2000). With the implementation of an appropriate Environmental Management Plan, there are unlikely to be any significant impacts from the release of contaminants.

Disturbance of Acid Sulfate Soils

Sediments from Toondah Harbour have potential acidity (frc environmental 2010). Disturbance of intertidal and marine sediments may expose acid sulfate soils to oxidising (acidifying) conditions. Acid sulfate materials are formed when pyrite in sediments is exposed to oxidation. Pyrite (FeS_2) is unstable in the presence of specialised bacteria and atmospheric oxygen, decomposing to the form ferrous iron and sulfuric acid.

The effects of acidification can be chronic or acute. The effects of chronic acidification on Australian estuarine biota, including fishes, is poorly understood; however, sudden acidification has been responsible for fish-kills, disease and other disturbances (Sammut et al. 1993). Chronic low-level acidity may reduce vigour and predispose marine biota to other diseases. Historical fluctuations in commercial finfish and prawn catches may be partially attributable to periods of increased acidity in estuarine waters (Leadbitter 1993).

Other environmental effects of oxidation of pyrite include: the dissolution of clay minerals and the release of soluble aluminium, which is highly toxic to gilled animals (including fish, molluscs and crustaceans) and aquatic plants; the release of soluble iron, also toxic to aquatic life in high concentration; and the oxidation of ferrous iron causing large decreases in dissolved oxygen.

With the implementation of an appropriate Environmental Management Plan, there are unlikely to be any significant impacts from acid sulfate sediments.

4.5 Spills of Hydrocarbons and Other Contaminants

Hydrocarbon spills from machinery during construction activities can negatively affect aquatic flora and fauna. It is possible that hydrocarbon spills could occur during the transportation of fuel or during equipment refuelling in the construction phase of the project. Concentrations of dissolved oil fractions below 0.01 ppm have not been shown to have adverse effects on any aquatic organism either in the short or long term, at any stage of development or at a cellular or sub-cellular level. Between 0.01 ppm and

0.1 ppm, some adult animals show sub-lethal behaviour and physiological disturbance, while developmental stages may show retarded growth or increased abnormalities. In general, the developmental stages of a species are far more susceptible than are adults, frequently by one or two orders of magnitude (Brown 1985).

Whilst acute (or at least a one off) contamination may result in severe ecological consequences, recovery is in most cases inevitable. In contrast, chronic contamination can result in the permanent (or at least for the duration of contamination) morbidity or localised extinction of flora and fauna. Chronic small spills, though probably influencing a lesser area, effectively prevent recovery and lead to cumulative impacts. Frequent spills from diffuse locations within a waterway can result in an enduring impact over a very wide area.

Chronic hydrocarbon pollution can result from the synergistic effects of small, frequent spills, these small scale spills are frequently associated with the refuelling of smaller crafts at marinas, other purpose built and ad hoc refuelling facilities and boat ramps (GBRMPA 1998; Cullen Grummitt & Roe Pty Ltd 2000). Marinas that support considerable activity, including pleasure boat marinas, boat repair facilities and commercial fishing operations have significantly higher levels of both aromatic and aliphatic hydrocarbons than estuaries seldom used by boats (Voudrias & Smith 1986). The small-scale spills commonly associated with small-scale refuelling operations are rarely reported or treated: the petrol, diesel or oils are left to disperse under natural conditions.

Floral communities and sessile faunal communities are most at risk from chronic hydrocarbon pollution. As these communities often form a critical component of habitat (providing structural complexity, shelter and often food), a permanent impact to these communities may have a consequentially widespread impact on the mobile components of the faunal community including fishes and crustaceans. Both petroleum and petroleum by-products are harmful to mangroves (Odum & Johannes 1975) causing mechanical damage by blocking the pores in the pneumatophores and effecting respiration, photosynthesis and translocation (Mackey & Smail 1995). Hydrocarbons are also known to cause reproductive disorders, immune deficiencies, tumours and cyst development in marine mammals and reptiles, especially when they are stressed (Schaffelke et al. 2001).

Low levels of petroleum hydrocarbons in the aquatic environment are adsorbed onto, or incorporated into, the sediments, where they may persist for years (Voudrias & Smith 1986; Pelletier et al. 1991). A large number of small-scale oil spills may lead to a significant increase in hydrocarbons over time, in effect resulting in a permanent impact. Mangrove sediments in particular may serve as long-term reservoirs for chronic contamination holding hydrocarbons for periods in excess of 5 years (Burns et al. 1994).

Where fuel storage and handling activities are undertaken in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols), the risk of impacts to aquatic flora and fauna due to chronic and acute fuel spills is considered minor.

4.6 Increased Stormwater Runoff

Contaminants and nutrients may enter the aquatic environment from stormwater run-off from the proposed development site. The release of toxicants to the marina and surrounding waters will be minimised by treating stormwater (with water sensitive urban design techniques) to comply with local water quality criteria (Hyder 2010). Further, the sediment and erosion control plan is developed to minimise the release of sediment-bound nutrients and toxicants to the water. A storm water management plan is developed that complies with the most recent version of the *Urban Stormwater Quality Planning Guidelines* (DERM 2010b). With these in place, it is unlikely that suspended sediments and toxins become critically elevated in the waters of, and adjoining, the marina due to storm water runoff, and are therefore unlikely to cause an adverse ecological impact.

4.7 Altered Hydrodynamics

Changes in water velocity around the proposed development may alter (increase or decrease) the suitability of habitat for marine plants as well as change the composition of benthic macroinvertebrates. Marine plants may be influenced by changes in velocity resulting in removal of sediment, changes in sediment composition and chemistry, as well as changes in turbidity levels. Benthic macroinvertebrate communities are also likely to change with any changes to water velocity: in low flow environments predators exert more influence on benthic community structure than in high flow environments (Leonard et al. 1998). Any changes to sediment grain size would also alter the composition of benthic macroinvertebrate communities.

Reduced velocities may result in an accumulation of fine sediment and may also result in changes to sediment chemistry and water turbidity. Marine plants are unlikely to be negatively impacted by reduced flows and may even show a positive response. The composition of benthic macroinvertebrates is likely to change due to lower water velocities in this area.

4.8 Increased Human Activity

Increased human activity during construction, including changes in underwater noise levels, may affect the behaviour of fauna, particularly marine mammals.

Underwater noise and other loud sounds may affect marine mammals by interfering with their use of sounds in communication, especially in relation to navigation and reproduction (Weilgard 2007; Wright & Burgin 2007). Marine mammals cease feeding, resting or social interaction at the onset of acoustic disturbance and to initiate alertness or avoidance behaviours (Richardson et al. 1995). Marine mammals in the vicinity of frequent, high intensity noise are likely to be highly stressed or even physically harmed and consequently, are likely to stay well away from continuously operating acoustic disturbance (Smith 1997). Therefore, any Indo-Pacific humpback dolphins, bottlenose dolphins or dugongs in the vicinity of the proposed development may vacate the area on commencement of the proposed in-water works such as wet excavation. Noise from on-land works is unlikely to disturb marine mammals. Any avoidance behaviour is likely to cease following completion of the work.

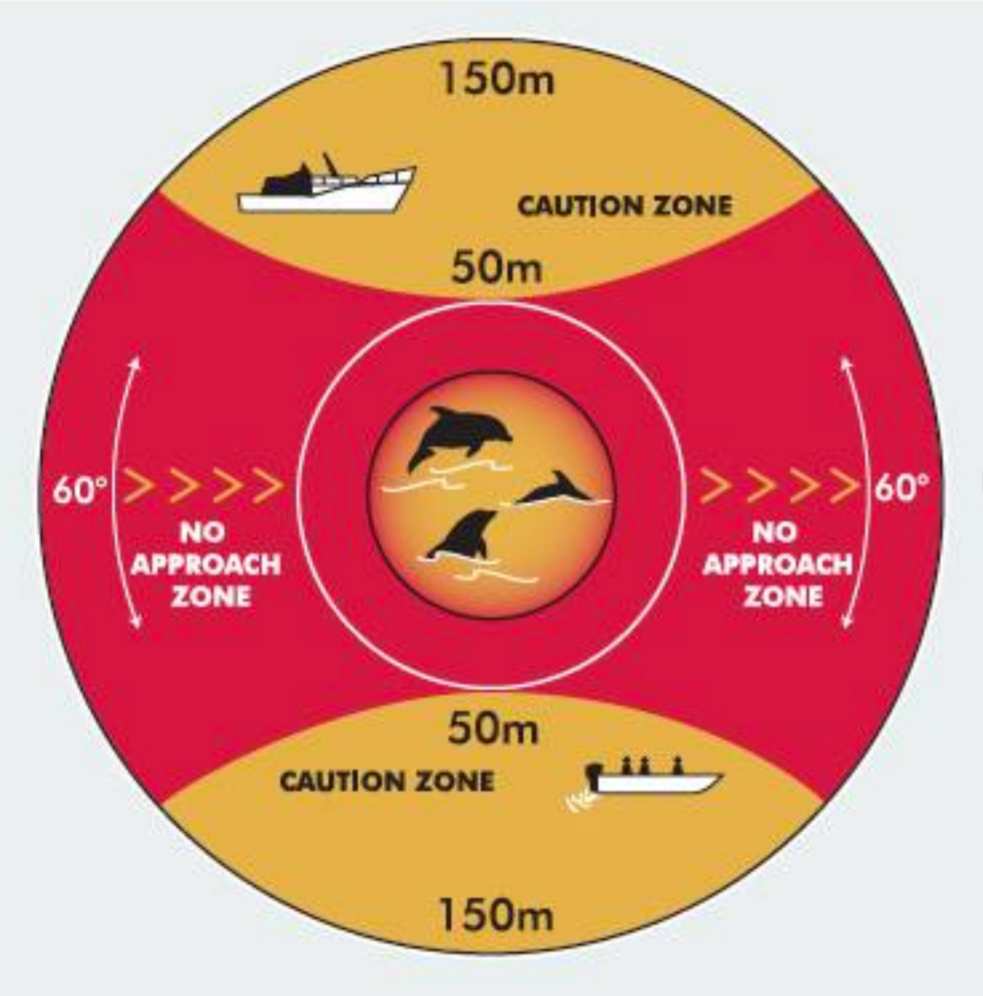
Turtles have relatively poor hearing and are far less likely to be impacted by underwater acoustic disturbance. In the unlikely event that in- and underwater construction does audibly disturb turtles, they may temporarily leave the area. Similarly, underwater construction noise may disturb some local fish, which may vacate the area for a short time.

The risk of impacts to marine fauna as a result of noise will be reduced further by preparing a Fauna Management Plan. Measures to minimise potential impacts to marine fauna may include:

- where dredging or pile driving activities are occurring, every morning before works begin, or after works have ceased for more than two hours and prior to it beginning again, appropriately trained Marine Fauna Observers (MFOs) inspect the area around all pile driving activities for 30 minutes
- all vessel crew maintaining a look out for marine mammals and turtles during all operations
- if prior to works, a marine mammal or turtle is identified within 150 metres, then pile driving does not commence until the animal has passed
- if after works have commenced (including a soft start phase), a marine mammal or sea turtle is observed within 100 m of the noise emitting source, then pile driving ceases until the animal has passed

- if a marine mammal or turtle are sighted in the pre-defined observation and exclusion zones, project vessels operating in the area are notified and piling ceases until the animal has passed
- have a 'soft-start' for all pile driving, slowly increasing intensity of the driving hammer power
- site inductions for all vessel crew covering procedures to minimise disturbance to marine fauna
- training of all vessel crew in the identification of marine mammals and turtles
- routine maintenance and inspection of all noise-generating equipment (including vessel engines, drill and piling equipment) to reduce unnecessary increases in noise levels from the equipment
- where practical, engines, thrusters and auxiliary plant are no left on standby or running mode
- adherence to speed limits of all vessels involved in construction
- movement restrictions including:
  - if a vessel in transit approaches a marine mammal or turtle (or vice versa), the vessel will take all care to avoid collisions, including stopping, slowing down, and/or steering away
  - vessels will not intercept the path of travel, either behind or ahead of the animal, or approach head on, and will not pursue marine mammals or turtles
  - vessels will keep clear of the no approach zone (Figure 4.1)
  - vessels will have a maximum speed of 5 knots in the caution zone (Figure 4.1)
  - vessels will not change speed or course suddenly in the caution zone (Figure 4.1)
  - vessels will not enter the caution zone if animals are stranded, entangled or in distress, and
  - vessels will avoid separation of adult and young marine mammals.

It is also recommended that daily logbooks are kept of all marine mammal and turtle sightings and interactions, and any management actions taken to avoid damage to them.



Figure'4.1' Caution'and'no'approach'zones'for'dolphins'and'turtles'(DEH'2005a).'

Any' distressed' or' damaged' marine' mammals' or' turtles' should' be' reported' to' RSPCA' QLD' on' 1300' 284625' (the' designated' call' centre' for' Queensland' National' Parks' and' Wildlife'Service'for'marine'mammal'and'turtles'strandings).'

4.9" Increased"Boat"Activity"and"Access"

Antifouling' paints' used' on' the' exterior' of' boats' often' contain' heavy' metals,' particularly' copper,' that' can' build' up' in' marine' organisms.' ' In' south‐east' Queensland,' many' anchorages' have' exceeded' the' ANZECC/ARMCANZ' trigger' values' for' copper,' with' copper'concentrations'in'the'water'column'correlated'with'vessel'numbers'(Warnken'et'al.' 2004).' ' The' proposed' development' may' increase' the' concentration' of' heavy' metals,' particularly copper in the water. This risk is reduced where International and Australian standards relating to antifouling paints are followed (National Heritage Trust 2007).

Increased boat traffic may increase the chance of collisions between boats and marine vertebrates, particularly turtles, both in the immediate vicinity of the proposed development and in the broader environs of the Marine Park.

Boat strikes are responsible for the largest proportion of all human-related turtle strandings or mortalities (Greenland et al. 2004). In general, the shallower the area and the larger the boat, the greater the risk of a boat strike to turtles. Turtles feed on the intertidal flats at high and mid tides, and drop into deeper waters (which can include the waters of navigation channels) at low tide, where they can be struck by passing traffic. This habit of moving into navigation channels increases the risk of boat strike. Exclusion devices for marine megafauna (e.g. dolphins, turtles and dugongs) are used in Queensland to reduce the risk of being caught in dredges (McCook et al. 2015).

Dolphins are likely to be able to avoid approaching boats; however, at least nine dolphins were killed in Queensland by boat strike in a period of 8 years (Greenland & Limpus 2007b). Dugong will also avoid approaching boats; however, they are slower than dolphins and more vulnerable to vessel strike. Since dugongs were included in the Marine Wildlife Stranding and Mortality Database in 1996, between 2 and 7 individuals have died each year due to boat strike (Greenland & Limpus 2007a). The majority of these boat strikes occurred in Moreton Bay due to the high amount of boat traffic. The vulnerability of dugongs (with slow breeding rates and slow maturity) means that any dugong deaths may contribute to a population decline.

Go slow areas in Moreton Bay Marine Park limit speed in areas that are recognised as particularly significant for dugongs and turtles. Exclusion devices for marine megafauna (e.g. dolphins, turtles and dugongs) are used in Queensland to reduce the risk of being caught in dredges (McCook et al. 2015). The Nature Conservation (Wildlife Management) Regulation 2006 also outlines measures to protect marine mammals including marine mammal approach distances for vessels and aircraft.

4.10 Spread of Weeds and Pests

Marine pest species can be introduced via ballast water and hull fouling. While this risk is predominantly from vessels that have been in international waters, there is also a risk of boats spreading pests established in other ports. The introduction and spread of marine pest species can be minimised by following protocols of the National System for the Prevention and Management of Marine Pest Incursions, which aims to prevent new marine pests from arriving in Australia, and minimize the spread of pests within Australian waters. To reduce the risk of inadvertently spreading marine biofouling pests, vessel operators need to minimise the amount of biofouling on their vessels (Australian Government 2010).

Increased usage of the shoreline may lead to an increase in weed cover in mangrove and saltmarshes. This may be a result of dumping of garden refuse, by seeds and propagules being inadvertently spread along access tracks and paths by vehicles or on foot, and by the air and water borne spread of seeds and propagules from gardens and landscaped areas.

A weed management plan, and a strategy for the maintenance of native plant areas on the proposed site would reduce this risk of introduced plant pests.

4.11 Increased Litter

Seven turtles in Moreton Bay were found to have ingested synthetic materials in 2001, and nine turtles in 2002 (Greenland et al. 2004). Of these, most had ingested fishing line, and only two animals were released alive (Greenland et al. 2004). In 2001 and 2002, entanglement in fishing ropes / lines, bags and ghost nets accounted for 21-35% of the annual human-induced turtle stranding or deaths (Greenland et al. 2004).

Dugongs have also been stranded / killed by ingesting fishing line or hooks (e.g. 2 individuals in Moreton Bay in 2003), or becoming entangled in ropes, fishing line and crab pots etc. (0-2 individual each year) (Greenland & Limpus 2005).

A waste management plan will reduce impacts from increased litter. Measures may include:

- complete removal from site of all construction waste
- waste storage facilities secured to avoid removal of waste either unintentionally or through vandalism
- reduction of waste at the source, reuse and recycling as well as recovery of materials or conversion of waste into useable materials
- educational signage, explicitly stating the risk to wildlife of disposing rubbish in the water

4.12 Improve Water Quality

Water quality in Fison Channel is currently impacted by the disturbance and re-suspension of sediment from boats, particularly to large vehicle and passenger ferries. Plumes of turbid water are created from the movement of these boats, particularly at low tide when water is relatively shallow in the channel. While dredging the channel will create short-term sediment plumes (refer to potential impacts in Section 4.4), following dredging there is likely to be a long term improvement in water quality as the water level will be deeper and thus turbid plumes from boating will be reduced.

5" Risk"Assessment"

A' risk' assessment' of' potential' impacts' has' been' undertaken' (Table' 5.1),' and' a' summary' of' potential' and' residual' risk' is' presented' in' Table' 5.2.' ' 'Best' practice'' assessment' and' practices' will' be' employed' to' minimise' the' impacts' associated' with' both' construction' and' operation' of' the' proposed' Project.' ' Table' 5.2' provides' a' summary' of' mitigation' measures' and' the' associated' residual' risk.' '

Table' 5.1' Risk' assessment' matrix.'

"	Consequence"				
Probability'	Catastrophic' Irreversible' Permanent' ' (5)'	Major' Long' Term' (4)'	Moderate' Medium' Term' (3)'	Minor' Short' Term' Manageable' (2)'	Insignificant' Manageable' (1)'
Almost' Certain' (5)'	(25)' Extreme'	(20)' Extreme'	(15)' High'	(10)' Medium'	(5)' Medium'
Likely' (4)'	(20)' Extreme'	(16)' High'	(10)' Medium'	(8)' Medium'	(4)' Low'
Possible' (3)'	(15)' High'	(12)' High'	(9)' Medium'	(6)' Medium'	(3)' Low'
Unlikely' (2)'	(10)' Medium'	(8)' Medium'	(6)' Medium'	(4)' Low'	(2)' Low'
Rare' (1)'	(5)' Medium'	(4)' Low'	(3)' Low'	(2)' Low'	(1)' Low'

Table'5.2' Preliminary'analyses'of'potential'impacts.'

Design'	Construction'	Operation'	Potential'Impact'	Extent'of'Impacts'	Potential'Mitigation'Measure'	Significance'of'Impact'(Unmitigated)'	Significance'of'Residual'(Mitigated' Impact)'
●'	●'	'	Direct'impacts'to'marine'plants,'and'soft' sediment'under'the'footprint'	LongFterm,'predictable'and'irreversible''	Limiting'the'area'of'disturbance'(project'footprint)'where' possible' Using'the'project'footprint'for'any'temporary'construction'and' storage' '	Water'quality'(1)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(15)'High'' Seagrass'and'macroalgae'(15)'High' Coral'and'rocky'communities'(12)'High' Soft'sediment'communities'(15)'High' Mobile'biota'(2)'Low' Listed'species'(2)'Low'	Water'quality'(1)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(15)'High'' Seagrass'and'macroalgae'(15)'High' Coral'and'rocky'communities'(12)'High' Soft'sediment'communities'(15)'High' Mobile'biota'(2)'Low' Listed'species'(2)'Low'
●'	●'	'	Direct'gain'of'habitat'	LongFterm,'predictable'and'irreversible''	Design'fishFfriendly'structures' Build'artificial'structure'that'provide'valuable'habitat'for'fish' '	Not'applicable'–'beneficial'potential'impact'	Not'applicable'–'beneficial'potential' impact'
●'	●'	'	Trapping'or'injuring'of'marine'fauna' during'wet'excavation'	ShortFterm,'predictable'and'reversible'	Install'the'sheet'piles,'silt'curtains'or'other'temporary'barriers' at'low'tide'to'minimise'the'number'of'marine'vertebrates' caught'in'the'area' Capture'fish'within'the'area'confined'by'the'sheet'piles,'silt' curtains'or'other'temporary'barriers'and'release'outside' the'area' Visual'observations'by'a'trained'marine'mammal'and'turtle' spotter'prior'to'commencement'of'excavation'and' dredging'activities' Cessation'of'excavation'or'dredging'if'a'dolphin,'dugong'or' turtle'is'observed'within'the'area,'until'the'animal'can'be' removed'from'the'area'being'excavated,'and' Drive'fauna'away'from'an'area'prior'to'completion'of'the' installation'of'sheet'piles,'silt'curtains'or'other'temporary' barriers'by'mechanical'noise,'such'as'banging'an'iron' pipe'underwater''	Water'quality'(1)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(1)'Low' Seagrass'and'macroalgae'(1)'Low' Coral'and'rocky'communities'(1)'Low' Soft'sediment'communities'(1)'Low'' Mobile'biota'(9)'Medium' Listed'species'(9)'Medium'	Water'quality'(1)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(1)'Low' Seagrass'and'macroalgae'(1)'Low' Coral'and'rocky'communities'(1)'Low' Soft'sediment'communities'(1)'Low' Mobile'biota'(3)'Low' Listed'species'(4)'Low'
●'	●'	'	Disturbance'of'sediments'and'soils' '	ShortFterm,'predict'table'	Design'the'project'to'minimise'the'area'of'sediment'and'/'or' soils'being'disturbed' Use'temporary'enclosures'(complete'enclosures'such'as'sheet' piles'or'alternate'enclosures'such'as'silt'curtains)'to' reduce'the'intensity'and'spatial'distribution'of'potential' impacts' Isolate'the'disturbance'areas,'for'example'by'using'sheet' piles,'silt'curtains,'oil'spill'booms,'bunding,'trenching'and'/' or'similar'technologies' Identify'and'manage'acid'sulfate'soils'and'other'contaminants,' through'a'sediment'sampling'and'analyses'plan'(SAP)' Developing'turbidity'and'suspended'solids'thresholds'and' appropriate'management'(e.g.'triggers'for'ceasing'works)'	Water'quality'(15)'High' Sediment'quality'(3)'Low' Saltmarsh'and'Mangroves'(3)'Low'' Seagrass'and'macroalgae'(15)'High' Coral'and'rocky'communities'(15)'High' Soft'sediment'communities'(10)'Medium' Mobile'biota'(3)'Low' Listed'species'(3)'Low'	Water'quality'(8)'Medium' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(2)'Low'' Seagrass'and'macroalgae'(4)'Low' Coral'and'rocky'communities'(4)'Low' Soft'sediment'communities'(8)'Medium' Mobile'biota'(1)'Low' Listed'species'(1)'Low'

Design'	Construction'	Operation'	Potential'Impact'	Extent'of'Impacts'	Potential'Mitigation'Measure'	Significance'of'Impact'(Unmitigated)'	Significance'of'Residual'(Mitigated' Impact)'
					for'seagrass'and'corals'and'monitoring'water'quality' during'construction' Monitoring'changes'in'seagrass'and'coral'communities'postF construction'to'determine'any'potential'impacts.' Avoiding'disturbance'of'sediment'and'/'or'soils'during' important'periods'of'reproduction'for'coral'and'seagrass' (e.g.'late'spring'and'summer)'and'/'or'during'low' Coral'translocation'and'replantation'program'		
●'	●'	●'	Spills'of'hydrocarbons'and'other' contaminants'	ShortFterm,'predictable'and'irreversible'	Minimise'the'use'of'hydrocarbons'and'chemical'where' possible' BestFpractice'vessel'and'vehicle'management'and'site' management' Fuel'storage'and'handling'activities'will'be'in'accordance'with' AS1940' Spill'kits,'training'of'personnel'and'a'Hazardous'Materials' Register,'a'register'of'Materials'Safety'Data'Sheets'' Any'fuel,'oil'or'chemical'spills'are'contained'and'cleaned'up' immediately' Spill'Management'Plan'(EMP)'	Water'quality'(15)'High' Sediment'quality'(10)'Medium' Saltmarsh'and'Mangroves'(10)'Medium' Seagrass'and'macroalgae'(10)'Medium' Coral'and'rocky'communities'(10)'Medium' Soft'sediment'communities'(10)'Medium' Mobile'biota'(10)'Medium' Listed'species'(10)'Medium'	Water'quality'(4)'Low' Sediment'quality'(4)'Low' Saltmarsh'and'Mangroves'(4)'Low' Seagrass'and'macroalgae'(4)'Low' Coral'and'rocky'communities'(4)'Low' Soft'sediment'communities'(4)'Low' Mobile'biota'(4)'Low' Listed'species'(4)'Low'
●'	●'	'	Increased'stormwater'runoff''	LongFterm,'predictable'and'irreversible'	Sediment'and'Erosion'Management'Plan'(EMP)' Stormwater'Management'Plan'	Water'quality'(15)'High' Sediment'quality'(3)'Low' Saltmarsh'and'Mangroves'(3)'Low'' Seagrass'and'macroalgae'(15)'High' Coral'and'rocky'communities'(15)'High' Soft'sediment'communities'(10)'Medium' Mobile'biota'(3)'Low' Listed'species'(3)'Low'	Water'quality'(4)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(2)'Low'' Seagrass'and'macroalgae'(4)'Low' Coral'and'rocky'communities'(4)'Low' Soft'sediment'communities'(4)'Low' Mobile'biota'(1)'Low' Listed'species'(1)'Low'
●'	'	●'	Altered'hydrodynamics'	longFterm,'predictable'and'irreversible'	Design'project'to'minimise'changes'to'hydrodynamics'	Water'quality'(4)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(1)'Low' Seagrass'and'macroalgae'(4)'Low' Coral'and'rocky'communities'(4)'Low' Soft'sediment'communities'(4)'Low' Mobile'biota'(1)'Low' Listed'species'(1)'Low'	Water'quality'(3)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(1)'Low' Seagrass'and'macroalgae'(3)'Low' Coral'and'rocky'communities'(3)'Low' Soft'sediment'communities'(3)'Low' Mobile'biota'(1)'Low' Listed'species'(1)'Low'
●'	●'	●'	Increased'boat'activity'and'access'	long'term,'predictable,'reversible'	Follow'international'and'Australian'standards'relating'to' antifouling'paints'and'contaminants' Marine'Fauna'Management'Plan,'including'Go'slow'areas' Follow'the'Nature'Conservation'(Wildlife'Management)'	Water'quality'(8)'Medium' Sediment'quality'(8)'Medium' Saltmarsh'and'Mangroves'(1)'Low' Seagrass'and'macroalgae'(1)'Low'	Water'quality'(3)'Low' Sediment'quality'(3)'Low' Saltmarsh'and'Mangroves'(1)'Low' Seagrass'and'macroalgae'(1)'Low'

Design'	Construction'	Operation'	Potential'Impact'	Extent'of'Impacts'	Potential'Mitigation'Measure'	Significance'of'Impact'(Unmitigated)'	Significance'of'Residual'(Mitigated' Impact)'
					Regulation'2006' '	Coral'and'rocky'communities'(4)'Low' Soft'sediment'communities'(1)'Low' Mobile'biota'(3)'Low' Listed'species'(8)'Medium'	Coral'and'rocky'communities'(1)'Low' Soft'sediment'communities'(1)'Low' Mobile'biota'(1)'Low' Listed'species'(3)'Low'
●'	●'	●'	Spread'of'pest'species' '	long'term,'predictable,'reversible'	Weed'Management'Plan'	Water'quality'(1)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(8)'Medium' Seagrass'and'macroalgae'(8)'Medium' Coral'and'rocky'communities'(8)'Medium' Soft'sediment'communities'(8)'Medium' Mobile'biota'(3)'Low' Listed'species'(3)'Low'	Water'quality'(1)'Low' Sediment'quality'(1)'Low' Saltmarsh'and'Mangroves'(3)'Low' Seagrass'and'macroalgae'(3)'Low' Coral'and'rocky'communities'(3)'Low' Soft'sediment'communities'(3)'Low' Mobile'biota'(3)'Low' Listed'species'(3)'Low'
●'	●'	●'	Litter'and'waste'	long'term,'predictable,'reversible'	Waste'Management'Plan'' Minimise'litter'and'waste,'where'possible'	Water'quality'(8)'Medium' Sediment'quality'(8)'Medium' Saltmarsh'and'Mangroves'(3)'Low'' Seagrass'and'macroalgae'(3)'Low' Coral'and'rocky'communities'(3)'Low' Soft'sediment'communities'(3)'Low' Mobile'biota'(8)'Medium' Listed'species'(8)'Medium'	Water'quality'(3)'Low' Sediment'quality'(3)'Low' Saltmarsh'and'Mangroves'(3)'Low' Seagrass'and'macroalgae'(3)'Low' Coral'and'rocky'communities'(3)'Low' Soft'sediment'communities'(3)'Low' Mobile'biota'(3)'Low' Listed'species'(3)'Low'
●'	'	●'	Improve'water'quality'in'and'adjacent'to' Fison'Channel'	long‐term,'predicable'	Design'channel'to'minimise'turbid'plumes'	Not'applicable'–'beneficial'potential'impact'	Not'applicable'–'beneficial'potential' impact'

6 References

Abal, E. G. & Dennison, W. C. 1996. Seagrass depth range and water quality in southern Moreton Bay, Queensland, Australia. *Marine and Freshwater Research,* 47, 763-771.

Adam, P. 1990. *Saltmarsh Ecology,* Cambridge University Press, Cambridge.

Adam, P. 1995. Saltmarsh. *In:* Zann, L. P. & Kailola, P. (eds.) *State of the Marine Environment Report for Australia, Technical Annex 1. The Marine Environment.* Department of the Environment, Sport & Territories: Canberra.

ALA. 2017. *Occurrence records: Caretta caretta* [Online]. Atlas of Living Australia. Available: http://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:910b27e8-19c3-4194-b55a-1d95a80ccdf9 [Accessed 3 Feb 2017].

Allen, G. R. 1997. *Marine fishes of tropical Australia and South-East Asia – A field guide for anglers and divers. Third Revised Edition,* Western Australian Museum, Perth, Western Australia.

Alongi, D. M. 2008. Mangrove forests: resilience, protection from tsunamis, and responses to global climate change. *Estuarine, Coastal and Shelf Science,* 76, 1-13.

ANZECC & ARMCANZ 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* National Water Quality Management Strategy, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Bannister, J. L., Kemper, C. M. & Warneke, R. M. 1996. *The Action Plan for Australian Cetaceans*. Canberra: Australian Nature Conservation Agency.

Bansemer, C. S. & Bennett, M. B. 2008. Reproductive periodicity, localised movements and behavioural segregation of pregnant Carcharias Taurus at Wolf Rock, southeast Queensland, Australia *Marine Ecology Progress Series,* 374, 215-27.

Barnes, R. & Hamylton, S. 2013. Abrupt transitions between macrobenthic faunal assemblages across seagrass bed margins. *Estuarine, Coastal and Shelf Science,* 131, 213-223.

Beasley, I., Robertson, K. & Arnold, P. 2005. Description of a new dolphin, the Australian snubfin dolphin *Orcaella heinsohni* sp. n. (Cetacea, Delphinidae). *Marine Mammal Science,* 21, 365-400.

Beck, M. W., Brumbaugh, R. D., Airoldi, L., Carranza, A., Coen, L. D., Crawford, C., Defeo, O., Edgar, G. J., Hancock, B., Kay, M. C. & Lenihan, H. S. 2011. Oyster reefs at risk on recommendations for conservation, restoration, and management. *Bioscience,* 61, 107-116.

Beck, M. W., Heck, K. L., Able, K. W., Childers, D. L., Eggleston, D. B., Gillanders, B. M., Halpern, B., Hays, C. G., Hoshino, K., Minello, T. J., Orth, R. J., Sheridan, P. F. & Weinstein, M. P. 2001. The Identification, Conservation and management of estuarine and marine nurseries for fish and invertebrates. *Bioscience,* 51, 633-641.

Beesley, P. L., Ross, G. J. B. & Glasby, C. J. 2000. *Polychaetes & Allies: The Southern Synthesis,* CSIRO Publishing, Melbourne xii.

Beger, M., Sommer, B., Harrison, P., Stephen, D. A. & Pandolfi, J. M. 2014. Conserving potential coral reef refuges at high latitudes. *Diversity and Distributions,* 20, 245-257.

Benson, S. R., Dutton, P. H., Hitipeuw, C., Samer, B., Bakarbessy, J. & Parker, D. 2007. Post-Nesting Migrations of Leatherback Turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. *Chelonian Conservation and Biology,* 6, 150-154 [Online]. Chelonian Research Foundation.

Bessell-Browne, P., Fisher, R., Duckworth, A. & Jones, R. 2017a. *Mucous sheet production in Porites: an effective bioindicator of sediment related pressures,* Marine Pollution Bulletin 2017.

Bessell-Browne, P., Negri, A. P., Fisher, R., Clode, P. L., Duckworth, A. & Jones, R. 2017b. *Impacts of turbidity on corals: The relative importance of light limitation and suspended sediments,* Ecological Indicators 2017.

Best, P. B. 1960. Further information on Bryde's whale (Balaenoptera edeni Anderson) from Saldanha Bay, South Africa. *Norsk Hvalfangst-Tidende,* 49, 201-215.

Best, P. B. 1977. Two allopatric forms of Bryde's whale off South Africa. *Report of the International Whaling Commission (Special Issue 1)*, 10-38.

Beumer, J. P., Sully, D. W. & Couchman, D. 2012. *Fish Habitat Vulnerability Mapping in Coastal Queensland*, Queensland Government.

Bjorndal, K. A. 1997. Foraging ecology and nutrition of sea turtles. *In:* Lutz, P. & Musick, J. A. (eds.) *The Biology of Sea Turtles.*

Blaber, S. J. M. 1997. *Fish and Fisheries of Tropical Estuaries,* Chapman and Hall, London.

Blaber, S. J. M. & Blaber, T. G. 1980. Factors affecting the distribution of juvenile estuarine and inshore fish. *Journal of Fish Biology,* 17, 143-162.

Blackburn, M. 1980. *Observations on the distribution of Nyctiphanes australis Sars (Crustacea, Euphausiidae) in Australian waters*, CSIRO Australian Division of Fisheries and Oceanography Report 119.

Blamey, R. 1992. *Economics and the evaluation of coastal wetlands,* Queensland Department of Primary Industries.

Borsje, B. W., van Wesenbeeck, B. K., Dekker, F., Paalvast, P., Bouma, T. J., Van Katwijk, M. M. & de Vries, M. B. 2011. How ecological engineering can serve in coastal protection. *Ecological Engineering,* 37, 113-122.

Boto, K. G. & Wellington, J. T. 1983. Phosphorus and nitrogen status in a northern Australian mangrove forest. *Marine Ecology Progress Series,* 11, 63-69.

Brand-Gardner, S. J., Lanyon, J. M. & Limpus, C. J. 1999. Diet selection by immature green turtles, *Chelonia mydas*, in subtropical Moreton Bay, South-East Queensland. *Australian Journal of Zoology,* 47, 181-191.

Brown, A. C. 1985. The effects of crude oil pollution on marine organisms: a literature review. *The South African context: conclusions and recommendations.* Foundation for Research Development, Council for Scientific and Industrial Research: Pretoria.

Brown, A. C. & McLachan, A. 1990. *Ecology of Sandy Shores,* Elsevier, Amsterdam.

Bruce, G. D., Stevens, J. D. & Malcolm, H. 2006. Movements and swimming behaiour of white sharks (*Carcharodon carcharias*) in Australian waters. *Marine Biology,* 150, 161-172.

Burns, K. A., Garrity, S. D., Jorissen, D., MacPherson, J., Stoelting, M., Tierney, J. & Yelle-Simmons, L. 1994. The Galeta oil spill. II. Unexpected persistence of oil trapped in mangrove sediments. *Estuarine, Coastal and Shelf Science,* 38, 349-364.

Butler, A., Jernakoff, P. & (eds) 1999. *Seagrass in Australia – Strategic Review and Development of an R&D Plan*. CSIRO Publishing.

Cabaço, S., Santos, R. & Duarte, C. M. 2008. The impact of sediment burial and erosion on seagrasses: a review. *Estuarine, Coastal and Shelf Science,* 79, 354–366.

Chaloupka, M., Osmond, M. & Kaufman, G. 1999. Estimating seasonal abundance trends and survival probabilities of humpback whales in Hervey Bay (east coast Australia). *Marine Ecology Progress Series,* 184, 291–301.

Chargulaf, C. A., Townsend, K. A. & Tibbettts, I. R. 2011. Community structure of soft sediment pool fishes in Moreton Bay Australia. *Journal of Fish Biology,* 78, 479–494.

Chatto, R. & Warneke, R. M. 2000. Records of cetacean strandings in the Northern Territory of Australia. *The Beagle. Records of the Museums and Art Galleries of the Northern Territory,* 16, 163–175.

Chilvers, B. L., Lawler, I. R., Macknight, F., Marsh, H., Noad, M. & Paterson, R. 2005. Moreton Bay, Queensland, Australia: an example of the co-existence of significant marine mammal populations and large-scale coastal development. *Biological conservation,* 122, 559–571.

Chittleborough, R. G. 1965. Dynamics of two populations of the humpback whale, *Megaptera novaeangliae* (Borowski). *Australian Journal of Marine and Freshwater Research,* 16, 33–128.

Clark, S. & Edwards, A. J. 1999. An evaluation of artificial reef structures as tools for marine habitat rehabilitation in the Maldives. *Aquatic Conservation: Marine and Freshwater Ecosystems,* 9, 5–21.

Clough, B. F., Boto, K. G. & Attiwill, P. M. 1983. Mangroves and sewage: a re-evaluation. *In:* Teas, H. J. (ed.) *Biology and Ecology of Mangroves.* The Hague.

CMAR 2007. New insights into white shark movements in Australia – information page. CSIRO Marine and Atmospheric Research (CMAR).

Coleman, P. S. J. & Cook, F. S. 2003. *St Kilda Bay Restoration Options*. Delta Environmental Consulting for the St Kilda Progress Association.

Coles, R. G., Lee Long, W. J., Watson, R. A. & Derbyshire, K. J. 1993. Distribution of seagrasses, and their fish and penaeid prawn communities, in Cairns Harbour, a tropical estuary, Northern Queensland, Australia. *Australian Journal of Marine and Freshwater Research,* 44, 193–210.

Coles, R. G. & Lee–Long, W. J. Juvenile prawn biology and the distribution of seagrass prawn nursery grounds in the southeastern Gulf of Carpentaria. *In:* Rothlisberg, P. C., Hill, B. J. & Staples, D. J., eds. Second Australian National Prawn Seminar, NPS2, 1985 Cleveland, Australia. 55–60.

Commonwealth of Australia 2012. *Marine bioregional plan for the Temperate East Marine Region*, and under the Environment Protection and Biodiversity Conservation Act 1999.

Compagno, L. J. V. 1984. Part 1 – Hexanchiformes to Lamniformes. FAO Species Catalogue, Vol. 4., Sharks of the World. An Annotated and Illustrated Catalogue of Sharks Known to Date. *FAO Fisheries Synopsis,* 4, 1–249.

Connolly, R. M. 1994. Removal of seagrass canopy: effects on small fish and their prey. *Journal of Experimental Marine Biology and Ecology,* 184.

Connolly, R. M. 1997. Differences in composition of small, motile invertebrate assemblages from seagrass and unvegetated habitats in a southern Australian estuary. *Hydrobiologia,* 346, 137–148.

Connolly, R. M. 1999. *Fish use of subtropical saltmarsh habitat*, Report on FRDC Project 97/203, Fisheries Research and Development Corporation.

Connolly, R. M., Dalton, A. & Bass, D. A. 1997. Fish use of an inundated saltmarsh flat in a temperate Australian estuary. *Australian Journal of Ecology,* 22, 222–226.

Connolly, R. M. & Guest, M. A. 2002. *Critical estuarine habitats for foodwebs supporting fisheries in Port Curtis, central Queensland*.

Conway, S. 1994. *Diets and feeding biology of adult olive Ridley (Lepidochelys olivacea) and loggerhead (Caretta caretta) sea turtles in Fog Bay, Northern Territory.* Hons., Northern Territory Unviversity.

Corkeron, P. J., Morisette, N. M., Porter, L. J. & Marsh, H. 1997. Distribution and status of humpback dolphin, *Sousa chinensis*, in Australian waters. *Asian Marine Biology,* 14, 49–59.

Couturier, L. I. E., Jaine, F. R. A., Townsend, K. A., Weeks, S. J., Richardson, A. J. & Bennett, M. B. 2011. Distribution, site affinity and regional movements of the manta ray, *Manta alfredi* (Krefft, 1868), along the east cost of Australia. *Marine and Freshwater Research,* 62, 628–637.

Culik, B. 2003. *Sousa chinensis. Review on Small Cetaceans: Distribution, Behaviour, Migration and Threats. [Online]*, Compiled for the Convention on Migratory species (CMS).

Culik, B. 2010. *Odontocetes. The toothed whales: "Orcaella brevirostris"*. UNEP/CMS.

Cullen Grummitt & Roe Pty Ltd 2000. *Brisbane River Vessel Refueling Strategy Study*, Brisbane River Management Group.

Dahdouh-Guebas, F. & Jayatissa, L. P. 2009. A bibliometrical review on pre- and posttsunami assumptions and facts about mangroves and other coastal vegetation as protective buffers. *Ruhuna Journal of Science,* 4, 28–50.

Davie, P. 1998. *Wild Guide to Moreton Bay: Wildlife and Habitats of a Beautiful Australian Coast – Noosa to the Tweed,* Queensland Museum.

de la Moriniere, E. C., Nagelkerken, I., van der Meij, H. & van der Velde, G. 2004. What attracts juvenile coral reef fish to mangroves: habitat complexity or shade? *Marine Biology,* 144, 139–145.

Dean, H. K. 2008. The use of polychaetes (Annelida) as indicator species of marine pollution: a review. *Revista De Biologia Tropical,* 56, 11–38.

DEH 2005a. *Australian National Standard for whale and dolphin watching*. Department of Environment and Heritage.

DEH. 2005b. Whale Shark (*Rhincodon typus*) Recovery Plan: Issues Paper.

DEHP 2005. *Issues paper for six species of marine turtles found in Australian waters that are listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*. Canberra: Commonwealth Department of Environment and Heritage.

DEHP. 2013. *Indo-Pacific Humpback Dolphin* [Online]. Available: https://http://www.ehp.qld.gov.au/wildlife/animals-az/indopacific_humpback_dolphin.html [Accessed].

Dennison, W. C. 1987. Effects of light on seagrass photosynthesis, growth and depth distribution. *Aquatic Botany,* 27, 15–26.

Dennison, W. C. & Abal, E. G. 1999. *Moreton Bay Study: A scientific basis for the healthy waterways campaign,* South-East Queensland Regional Water Quality Management Strategy, Brisbane.

Dennison, W. C. & Alberte, R. S. 1985. Role of daily light period in the depth distribution of *Zostera marina* (Eelgrass). *Marine Ecology Progress Series,* 25, 51-61.

Dennison, W. C., Orth, R. J., Moore, K. A., Stevenson, J. C., Carter, V., Kollar, S., Bergstrom, P. W. & Batiuk, R. A. 1993. Assessing water quality with submerged aquatic vegetation - Habitat requirements as barometers of Chesapeake Bay health. *Bioscience,* 43, 86-94.

Dennison, W. C., Udy, J. W., Chaston, K. A., Rogers, J. L., Duke, N. C., Prange, J. A., Duffy, E. J. & Harriot, V. J. 1998. *(Draft) Task BFND: Benthic flora nutrient dynamics, Phase II Final Report*, Brisbane River & Moreton Bay Wastewater Management Study, (BR&MBWMS), Marine Botany, The University of Queensland, and Southern Cross University.

Derbyshire, K. 2006. *Fisheries Guidelines for Fish-Friendly Structures*. Department of Primary Industries, Queensland. Fish Habitat Guideline FHG 006, 64 pp.

DERM. 2010a. *Mangroves in Moreton Bay Marine Park* [Online]. Available: http://www.derm.qld.gov.au/parks/moreton-bay/about.html [Accessed].

DERM 2010b. Urban stormwater quality planning guidelines. Department of Environment and Resource Management.

DEWHA 2008. *North-West Marine Bioregional Plan: Bioregional Profile: A Description of the Ecosystems, Conservation Values and Uses of the North-West Marine Region*. Canberra: Department of the Environment, Water, Heritage and the Arts.

DEWHA 2009. *White Shark Issues Paper [Online}*. Canberra, ACT: Department of the Environment Water Heritage and the Arts.

Diggles, B. 2015. *Protection and Repair of Australia's Shellfish Reefs – Southern Queensland Report*, report prepared for National Environmental Science Program.

Diggles, B. K. 2013. Historical epidemiology indicates water quality decline drives loss of oyster (Saccostrea glomerata) reefs in Moreton Bay, Australia. *New Zealand Journal of Marine and Freshwater Research,* 47, 561-581.

!

Dixon,! M.,! Johns,! L.! &! Beumer,! J.! Saltmarsh! habitats! –! Queensland's! fisheries! haven! under!threat!of!coastal!squeeze.!!Queensland!Coastal!Conference!2011,!2011.!

DNPRSR.! 2007.! *Turtles' –' Moreton' Bay' Marine' Park'* [Online].! Available:! http://www.nprsr.qld.gov.au/parks/moretonNbay/zoning/informationNsheets/turtles.html![Accessed].!

DoTE.!2013a.!*Species'Profile'and'Threats'Database:'Caretta'caretta'–'loggerhead'turtle'* [Online].! Available:! http://www.environment.gov.au/cgiNbin/sprat/public/publicspecies.pl?taxon_id=1763![Accessed].!

DoTE.! 2013b.! *Species' Profile' and' Threats' Database:' Chelonia' mydas' –' Green' Turtle'* [Online].! Available:! http://www.environment.gov.au/cgiNbin/sprat/public/publicspecies.pl?taxon_id=1765![Accessed].!

DoTE.!2013c.!*Species'Profile'and'Threats'Database:'Natator'depressus'–'Flatback'turtle'* [Online].! Available:! http://www.environment.gov.au/cgiNbin/sprat/public/publicspecies.pl?taxon_id=59257![Accessed].!

DoTE.! 2014a.! *Environment' Protection' and' Biodiversity' Conservation' Act' 1999' (EPBC' Act)'* [Online].!Australian!Government!Department!of!the!Environment.!Available:! http://www.environment.gov.au/topics/aboutNus/legislation/environmentNprotectionNandNbiodiversityNconservationNactN1999![Accessed].!

DoTE.! 2014b.! *EPBC' Protected' Matters' Search' Tool'* [Online].! Available:! http://www.environment.gov.au/arcgisNframework/apps/pmst/pmstNcoordinate.jsf! [Accessed].!

DoTE.! 2014c.! *Moreton' Bay'* [Online].! Available:! http://www.environment.gov.au/cgiNbin/wetlands/ramsardetails.pl?refcode=41![Accessed].!

DoTE.! 2016a.! *Balaenoptera' edeni' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.!2016b.!*Balaenoptera'musculus'in'Species'Profile'and'Threats'Database'*[Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016c.! *Carcharias' taurus' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

!

DoTE.!2016d.!*Carcharodon'carcharias'in'Species'Profile'and'Threats'Database'*[Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016e.! *Caretta' caretta' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016f.! *Chelonia' mydas' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.!2016g.!*Dermochelys'coriacea'in'Species'Profile'and'Threats'Database'*[Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016h.! *Dugong' dugon' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.!2016i.!*Eretmochelys'imbricata'in'Species'Profile'and'Threats'Database'*[Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016j.! *Eubalaena' australis' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016k.! *Lagenorhynchus' obscurus' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.!2016l.!*Lamna'nasus'in'Species'Profile'and'Threats'Database'*[Online].!Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat! [Accessed!March!2016].!

DoTE.!2016m.!*Lepidochelys'olivacea'in'Species'Profile'and'Threats'Database'*[Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.!2016n.!*Manta'alfredi'in'Species'Profile'and'Threats'Database'*[Online].!Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat! [Accessed!March!2016].!

DoTE.! 2016o.! *Manta' birostris' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.!2016p.!*Megaptera'novaeangliae'in'Species'Profile'and'Threats'Database'*[Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016q.! *Natator' depressus' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016r.! *Orcaella' brevirostris' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.!2016s.!*Orcinus'orca'in'Species'Profile'and'Threats'Database'*[Online].!Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat! [Accessed!March!2016].!

DoTE.!2016t.!*Pristis'zijsron'in'Species'Profile'and'Threats'Database'*[Online].!Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat! [Accessed!March!2016].!

DoTE.! 2016u.! *Rhincodon' typus' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

DoTE.! 2016v.! *Sousa' chinensis' in' Species' Profile' and' Threats' Database'* [Online].! Department! of! the! Environment,! Canberra.! Available:! http://www.environment.gov.au/sprat![Accessed!March!2016].!

Double,! M.,! Jenner,! K.,! Jenner,! M.,! Ball,! I.,! Laverick,! S.! &! Gales,! N.! 2012.! *Satellite' tracking'of'pygmy'blue'whales'(Balaenoptera'musculus'brevicauda)'off'Western' Australia,'*Australian!Marine!Mammal!Centre,!Kingston.!

Double,!M.!C.,!AndrewsNGoff,!V.,!Jenner,!K.!C.!S.,!Jenner,!M.!N.,!Laverick,!S.!M.,!Branch,! T.! A.! &! Gales,! N.! J.! 2014.! Migratory! movements! of! pygmy! blue! whales! (Balaenoptera! musculus! brevicauda)! between! Australia! and! Indonesia! as! revealed!by!satellite!telemetry.!*PloS'one,*!9:!e93578.!

Double, M. C., Gales, N., Jenner, K. C. S. & Jenner, M. N. 2010. *Satellite tracking of south-bound humpback whales in the Kimberley region of Western Australia*. Report to the Western Australian Marine Science Institution.

Dowling, R. A. & McDonald, T. J. 1982. Mangrove communities of Queensland. *In:* Clough, B. J. (ed.) *Mangrove Ecosystems of Australia. Structure, Function and Management.* AIMS in Association with ANU Press: Canberra.

Dowling, R. A. & Stephens, K. 2001. *Coastal Wetlands of south eastern Queensland, Mapping and Survey*, Queensland Herbarium, Environmental Protection Agency.

Dowling, R. M. The mangrove communities of Moreton Bay. *In:* Bailey, A. & Stevens, N. C., eds. Northern Moreton Bay Symposium, 1979 Australia. Royal Society of Queensland, pp 54-62.

Dowling, R. M. 1986. The mangrove vegetation of Moreton Bay. *Queensland Botanical Bulletin,* 6.

Dredge, M., Kirkman, H. & Potter, M. 1977. *A short-term biological survey Tin Can Inlet / Great Sandy Strait*, CSIRO.

DSEWPaC 2012a. *Advice to the Minister for Sustainability, Environment, Water, Population and Communities from the Threatened Species Scientific Committee (the Committee) on Amendment to the list of Threatened Species under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. Canberra: Commonwealth of Australia.

DSEWPAC 2012b. *Conservation Management Plan for the Southern Right Whale*. Canberra: Commonwealth of Australia.

DSEWPC. 2013. *Species Profile and Threats Database: Sousa chinensis – Indo-Pacific Humpback Dolphin* [Online]. Available: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=50 [Accessed].

Dunstan, D. J. 1990. Some early environmental problems and guidelines in New South Wales estuaries. *Wetlands (Australia),* 9, 1-6.

Edgar, G. J. 2001. *Australian Marine Habitats in temperate waters,* Reed New Holland, Sydney.

Edgar, G. J. & Shaw, C. 1995. The production and trophic ecology of shallow-water fish assemblages in southern Australia, II. Diets of fishes and trophic relationships between fishes and benthos at Western port, Victoria. *Journal of Experimental Marine Biology and Ecology,* 194, 83–106.

EHMP 2006. Ecosystem Health Monitoring Program 2004–2005, Annual Technical Report. Brisbane: Moreton Bay Waterways and Catchment Partnership.

Environment Australia 2014. Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*).

Erftemeijer, P. & Robin Lewis, R. 2006. Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin,* 52, 1553–1572.

Erftemeijer, P. L. A., Riegl, B., Hoeksema, B. W. & Todd, P. A. 2012. Environmental impacts of dredging and other sediment disturbances on corals: A review. *Marine Pollution Bulletin,* 64, 1737–1765.

Estrada, J. A., Rice, A. N., Natanson, L. J. & Skomal, G. B. 2006. Use of isotopic analysis of vertebrae in reconstructing ontogenetic feeding ecology in white sharks. *Ecology,* 87, 829–34.

Fabricius, K. E. 2005. Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. *Marine Pollution Bulletin,* 50, 125–146.

Fellegara, I., Baird, A. H. & Ward, S. 2013. Coral reproduction in a high-latitude, marginal reef environment (Moreton Bay, south-east Queensland, Australia). *Invertebrate Reproduction & Development,* 57, 219–223.

Fellegara, I. & Harrison, P. L. 2008. Status of the subtropical scleratinian coral communities in the turbid environment of Moreton Bay, south east Queensland. *Memoirs of the Queensland Museum,* 54, 227–291.

Ferrell, D. J. & Bell, J. D. 1991. Differences among assemblages of fish associated with *Zostera capricorni* and bare sand over a large spatial scale. *Marine Ecology Progress Series,* 72, 15–24.

Forbes, G. A. *The diet of the green turtle in an algal-based coral reef community-Heron Island, Australia*. *In:* Schroeder, B. A. & Witherington, B. E., eds. Proceedings of the Thirteenth Annual Symposium on Sea turtle on Biology and Conservation, 1994. 57–59.

Francis, M., Natanson, L. & Campana, S. 2002. The Biology and Ecology of the Porbeagle Shark, *Lamna nasus*. *In:* Camhi, M., Pikitch, E. & E., B. (eds.) *Sharks of the Open Ocean: Biology, Fisheries and Conservation.* Blackwell Publishing: United Kingdom.

Francis, M. P. 1996. Observations on a pregnant white shark with a review of reproductive biology. *In*: Klimley, A. P. & Ainley, D. G. (eds.) *Great White Sharks: the Biology of Carcharodon carcharias.* Academic Press: United States of America.

Francis, M. P. & Stevens, J. D. 2000. Reproduction, embryonic development, and growth of the porbeagle shark, *Lamna nasus*, in the southwest Pacific Ocean. *Fisheries Bulletin,* 98, 41-63.

frc environmental 2010. *Toondah Dredge Spoil Acid Sulfate Soil Testing*, Redland City Council.

Fujita, T., Kitagawa, D., Okuyama, Y., Jih, Y., Ishito, Y. & Inada, T. 1996. Comparison of fish assemblages among an artificial reef, a natural reef and a sandy-mud bottom site on the shelf off Iwate, northern Japan. *Environmental Biology of Fishes,* 46, 351-364.

Furnas, M. 2003. Catchments and Corals: terrestrial runoff to the Great Barrier Reef. *Australian Institute of Marine Science*, 334.

GBRMPA 1998. Shipping and oil spills. *State of the Great Barrier Reef World Heritage Area.*

GBRMPA. 2011. *Leatherback turtle* [Online]. Available: http://www.gbrmpa.gov.au/about-the-reef/animals/marine-turtles/leatherback [Accessed].

GBRMPA 2012. *A Vulnerability Assessment for the Great Barrier Reef: Sawfish*, Australian Government, Great Barrier Reef Marine Park Authority.

GBRMPA. 2013a. *Flatback turtle* [Online]. Available: http://www.gbrmpa.gov.au/about-the-reef/animals/marine-turtles/flatback [Accessed].

GBRMPA 2013b. *Great Barrier Reef Region Strategic Assessment: Strategic Assessment Report*, GBRMPA, Townsville.

GBRMPA. 2013c. *Hawksbill turtle* [Online]. Available: http://www.gbrmpa.gov.au/about-the-reef/animals/marine-turtles/hawksbill [Accessed].

GBRMPA. 2013d. *Olive Ridley turtle* [Online]. Available: http://www.gbrmpa.gov.au/about-the-reef/animals/marine-turtles/olive-Ridley [Accessed].

GBRMPA. 2017. *Great Barrier Reef coastal ecosystems* [Online]. Available: http://www.gbrmpa.gov.au/about-the-reef/great-barrier-reef-coastal-ecosystems [Accessed 14 March 2017].

Gibbes, B., Grinham, A., Neil, D., Olds, A., Maxwell, P., Connolly, R., Weber, T., Udy, N. & Udy, J. 2014. Moreton Bay and its estuaries: a sub-tropical system under pressure from rapid population growth. *Estuaries of Australian in 2050 and beyond*. Springer: Netherlands.

Gibson, L. & Wellbelove, A. 2010. Protecting critical marine habitats: The key to conserving our threatened marine species. *WWF-Australia, Ultimo, NSW*.

Gill, P. C. & Morrice, M. G. 2003. *Cetacean observations, blue whale compliance aerial surveys. Santos Ltd seismic survey program, Vic/P51 and P52, November – December 2002*.

Gill, P. C., Ross, G. J. B., Dawbin, W. H. & Wapstra, H. 2000. *Confirmed sightings of dusky dolphins (Lagenorhynchus obscurus) in southern Australian waters*. *Marine Mammal Science,* 16, 452–459.

Gonsalves, L. 2012. *Saltmarsh, mosquitoes and insectivorous bats : seeking a balance*. Doctoral thesis, Australian Catholic University.

Grabowski, J. H. & Peterson, C. H. 2007. Restoring oyster reefs to recover ecosystem services. *Theoretical ecology series,* 4, 281–298.

Gray, C. A., McElligott, D. J. & Chick, R. C. 1996. Intra- and Inter-estuary differences in assemblages of fishes associated with shallow seagrass and bare sand. *Australian Journal of Marine and Freshwater Research,* 47, 723–735.

Greenland, J. A. & Limpus, C. J. 2005. *Marine Wildlife Stranding and Mortality Database Annual Report 2004, I. Dugong, Conservation and Technical Data Report*, Wildlife Ecology Unit, Environmental Protection Agency, Brisbane.

Greenland, J. A. & Limpus, C. J. 2007a. *Marine Wildlife Stranding and Mortality Database Annual Report 2007: I. Dugong* [Online]. Available: http://www.epa.qld.gov.au/publications/p02634.html [Accessed].

Greenland, J. A. & Limpus, C. J. 2007b. *Marine Wildlife Stranding and Mortality Database Annual Report 2007: II. Dolphins* [Online]. Available: http://www.epa.qld.gov.au/publications/p02635.html [Accessed].

Greenland, J. A., Limpus, C. J. & Currie, K. J. 2004. *Marine Wildlife Stranding and Mortality Database Annual Report 2001–2002: III. Marine Turtles* [Online]. Available: http://www.epa.qld.gov.au/nature_conservation/wildlife/caring_for_wildlife/marine_strandings/ [Accessed 10 March 2009].

Grice, A. M., Loneragan, N. R. & Dennsion, W. C. 1996. Light intensity and the interactions between physiology, morphology and stable isotope ratios in five species of seagrass. *Journal of Experimental Biology and Ecology,* 195, 91–110.

Hale, P., Long, S. & Tapsall, A. 1998. Distribution and conservation of delphinids in Moreton Bay. *In:* Tibbets, I. R., Hall, N. J. & Dennison, W. D. (eds.) *Moreton Bay and catchment.* School of Marine Science, The University of Queensland: Brisbane.

Hallegraeff, G. M. 1996. Marine phytoplankton communities in the Australian region, The marine environment, Technical Annex 1. State of the Marine environment report for Australia, eds Zann, L.P. and Kailoloa, P.

Halliday, I. A. & Young, W. R. 1996. Density, biomass and species composition of fish in a subtropical *Rhizophora stylosa* mangrove forest. *Marine and Freshwater Research.,* 47, 609–615.

Hamman, M., Limpus, C., Hughes, G., Mortimer, J. & Pilcher, N. 2006. *Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South East Asia*. Bangkok: IOSEA Marine Turtle MoU Secretariat.

Harding, L. W. 1994. 'Long term trends in the distribution of phytoplankton in Chesapeake Bay: roles of light, nutrients and streamflow' Marine Ecology Progress Series, 104:267–291.

Harlin, M. M. 1975. Epiphytes – host relationships in seagrass communities. *Aquatic Botany,* 27, 59–78.

Hekel, H., Ward, T. W., Jones, M. & Searle, D. E. Geological development of northern Moreton Bay. *In:* Bailey, A. & Stevens, N. C., eds. Northern Moreton Bay Symposium: 7–18, 1979. Royal Society of Queensland.

Henderson, C. J., Olds, A. D., Lees, S. Y., Gilby, B. L., Maxwell, P. S., Connolly, R. M. & Stevens, T. 2017. Marine reserves and seascape context shape fish assemblages in seagrass ecosystems. *Marine Ecology Progress Series,* 566, 135–144.

Hillman, K., Walker, D. I., Larkum, A. W. D. & McComb, A. J. 1989. Productivity and nutrient limitation. *In:* Larkum, A. W. D., McComb, A. J. & Shepherd, S. A. (eds.) *Biology of seagrasses with special reference to the Australian region.* Elsevier Science Publishers: Amsterdam.

Humphries, P., Potter, I. C. & Loneragan, N. R. 1992. The fish community of the shallows of a Western Australian estuary: relationship with the density of the seagrass Ruppia megacarpa. *Estuarine Coastal and Shelf Science,* 34, 325–346.

Hutchings, P. The fauna of Australian seagrass beds. Proceedings of the Linnean Society of New South Wales, 1982. 413, 181–200.

Hutchings, P. A., Ward, T. J., Waterhouse, J. H. & Walker, L. 1993. Fauna of Marine Sediments and Seagrass Beds of upper Spencer Gulf near Port Pirie, South Australia. *Transactions of the Royal Society of South Australia,* 117, 1–15.

Hyder 2010. GCIMP Maintenance Dredging. Southport: Hyder Consulting Pty Ltd.

Hyland, S. J. & Butler, C. T. 1988. The distribution and modification of mangroves and saltmarsh – claypans in Southern Queensland Information Series Q189010. Queensland Department of Primary Industries.

Hyland, S. J., Courtney, A. J. & Butler, C. T. 1989. *Distribution of seagrass in the Moreton Region from Coolangatta to Noosa*, Queensland Department of Primary Industries, Brisbane.

Ireland, D. 1984. The Grey Nurse Shark. *Underwater,* 11, 10–13.

Irlandi, E. A. & Crawford, M. K. 1997. Habitat Linkages: The effects of intertidal saltmarshes and adjacent subtidal habitats on adundance, movement and growth of estuarine fish. *Oecologia,* 110, 222–230.

Jones, M. R. & Stephens, A. W. Quarternary geological framework and resource potential in Moreton Bay. *In:* Hofmann, G., ed. 1981 Field Conference, Brisbane – Ipswich Area: 17–23, 1981. Geological Society of Australia.

Joyce, W., Campana, S., Natanson, L., Kohler, N., Pratt Jr., H. & Jensen, C. 2002. Analysis of stomach contents of the porbeagle shark (*Lamna nasus Bonnaterre*) in the northwest Atlantic. *ICES Journal of Marine Science,* 53, 1263–1269.

Kailola, P. J., Williams, M. J., Stewart, P. C., Reichelt, R. E., McNee, A. & Grieve, C. 1993. *Australian Fisheries Resources,* Bureau of Resources Sciences and Fisheries Resources and Development Corporation, Canberra.

Kaplan, I. C. 1995. A risk assessment for Pacific leatherback turtles (*Dermochelys coriacea*). *Canadian Journal Fishery and Aquatic Sciencies,* 62, 1710–1719.

Karczmarski, L., Thornton, M. & Cockroft, V. G. 1997. Description of selected behaviors of humpback dolphins Sousa chinensis. *Aquatic Mammals,* 23, 127–133.

Kato, H. 2002. Bryde's Whale *Balaenoptera edeni* and *B. brydei*. *In:* Perrin, W. F., Wrsig, B. & Thewissen, H. G. M. (eds.) *Encyclopedia of Marine Mammals.* Academic Press.

Kawamura, A. 1980. A review of food of balaenopterid whales. *Scientific Reports of the Whales Research Institute,* 32, 155–197.

Kleypas, J. A., McManus, J. W. & Menez, L. A. 1999. Environmental Limits to Coral Reef Development: Where Do We Draw the Line? *American Zoologist,* 39, 146–159.

Klumpp, D. W., Howard, R. K. & Pollard, D. A. 1989. Trophodynamics and nutritional ecology of seagrass communities. *In:* Larkum, A. W. D., McComb, A. J. & Shepherd, S. A. (eds.) *Biology of seagrasses: a treatise on the biology of seagrass with special reference to the Australian region.* Elsevier Science Publishers: Amsterdam.

Koop, K., Booth, D., Broadbent, A., Brodie, J., D., B., D., C., Coll, J., Dennison, W. C., Erdmann, M., Harrison, P., Hoegh-Guldberg, O., Hutchings, P., Jones, G. B., Larkum, A. W. D., O'Neil, J., Steven, A., Tentori, E., Ward, S., Williamson, J. & Yellowlees, D. 2001. ENCORE: The Effect of Nutrient Enrichment on Coral Reefs. Synthesis of Results and Conclusions. *Marine Pollution Bulletin,* 42, 91–120.

Laegdsgaard, P. & Johnson, C. R. 1995. Mangrove habitats as nurseries: unique assemblages of juvenile fish in subtropical mangroves in eastern Australia. *Marine Ecology Progress Series,* 126, 67–81.

Lanyon, J. M. 2003. Distribution and abundance of dugongs in Moreton Bay, Queensland, Australia. *Wildlife Research,* 30, 397–409.

Lanyon, J. M. & Morris, M. G. 1997. *The Distribution and Abundance of Dugongs in Moreton Bay, South-East Queensland*, Queensland Department of Environment, Brisbane.

Lapointe, B. E. 1997. Nutrient thresholds for bottom-up control of macroalgal blooms on coral reefs in Jamaica and southeast Florida. *Limnology and Oceanography,* 42, 1119–1131.

Lasiak, T. A. 1986. Juveniles, Food and the Surf Zone Habitat: Implications for Teleost Nursery Areas. *South Africa Journal of Zoology,* 21, 51–56.

Last, P. R. & Stevens, J. D. 1994. *Sharks and Rays of Australia,* CSIRO, Australia.

Last, P. R. & Stevens, J. D. 2009. *Sharks and Rays of Australia,* CSIRO Publishing, Collingwood, Victoria.

Lavery, P. S. & McComb, A. J. 1991. Macroalgal–sediment nutrient interactions and their importance to macroalgal nutrition in a eutrophic estuary. *Estuarine and Coastal Shelf Science,* 32, 281–295.

Lazell, J. D. 1980. *New England waters: critical habitat for marine turtles*. *Copeia,* 1980, 290–295.

Leadbitter, D. *The acid test: basic concerns of the fishing industry about coastal floodplain management in NSW*. *In:* Bush, R., ed. Proceedings of the National Conference on Acid Sulphate Soils, 24–25th June 1993 Coolangatta Qld. CSIRO, NSW Agriculture, & Tweed Shire Council, pp 62–70.

Leary, T. R. 1957. A schooling of leatherback turtles *Dermochelys coriacea*, on the Texas Coast. *Copeia,* 3, 232.

Lee, D. P. Non-native fish issues and management in California. American Fisheries Society Symposium, volume 15, abstract only, 1995.

Lee Long, W. J., Coles, R. G. & McKenzie, L. J. 1997. Issues for seagrass conservation management in Queensland. *Pacific Conservation Biology,* 5, 321–328.

Leonard, G., Levine, J., Schmidt, P. & Bertness, M. 1998. Flow-driven variation in intertidal community structure in a Maine estuary. *Ecology,* 79, 1395–1411.

Limpus, C. J. 1971. The flatback turtle, *Chelonia depressa* Garman, in southeast Queensland, Australia. *Herpetologica,* 27, 431–436.

Limpus, C. J. 1995a. *Conservation of marine turtles in the Indo-Pacific region*. Brisbane: Queensland Department of Environment and Heritage.

Limpus, C. J. 1995b. *Global overview of the status of marine turtles: a 1995 viewpoint. In: Bjorndal, KA,* ed. *Biology and Conservation of Sea Turtles. Revised edition*. Washington: Smithsonian Institution Press.

Limpus, C. J. 2007. *A Biological Review of Australian Marine Turtles. 5. Flatback Turtle Natator depressus (Garman)*. Brisbane: Environmental Protection Agency.

Limpus, C. J. 2008a. *A biological review of Australian marine turtle species. 6. Olive Ridley Turtle, Lepidochelys olivacea (Eschscholtz)*. Queensland Environmental Protection Agency available from: http://www.epa.qld.gov.au/publications/p02836aa.pdf/A_Biological_Review_Of_A ustralian_Marine_Turtles_4_Olive_Ridley_Turtle_emLepidochelys_olivacea/em_Escholtz.pdf.

Limpus, C. J. 2008b. *A Biological Review of Australian Marine Turtles. 2. Green Turtle Chelonia mydas (Linnaeus)*. Brisbane: Environmental Protection Agency.

Limpus, C. J., Couper, P. J. & Read, M. A. 1994. The loggerhead turtle, *Caretta caretta*, in Queensland: population structure in a warm temperate feeding area. *Memoirs of the Queensland Museum,* 37, 195–204.

Limpus, C. J., Miller, J. D., Parmenter, C. J. & Limpus, D. J. 2003. The green turtle, *Chelonia mydas*, population of Raine Island and the northern Great Barrier Reef: 1843–2001. *Memoirs Queensland Museum,* 49, 349–440.

Limpus, C. J., Miller, J. D., Parmenter, C. J., Reimer, D., McLachlan, N. & Webb, R. 1992. Migration of green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles to and from eastern Australian rookeries. *Wildlife Research,* 19, 347–358.

Limpus, C. J., Parmenter, C. J., Baker, V. & Fleay, A. 1983. The Crab Island sea turtle rookery in north eastern Gulf of Carpentaria. *Australian Wildlife Research,* 10, 173–184.

Limpus, C. J., Zeller, D., Kwan, D. & Macfarlane, W. 1989. Sea-turtle rookeries in northwestern Torres Strait (Australia). *Australian Wildlife Research,* 16, 517–526.

Ling, J. K. 1991. Recent Sightings of Killer Whales, Orcinus orca (Cetacea: Delphinidae), in South Australia. *Transactions of the Royal Society of South Australia,* 115, 95–98.

Loneragan, N. R., Bunn S. E. & Kellaway, D. M. 1997. Are mangrove and seagrasses sources of organic carbon for penaeid prawns in a tropical Australian estuary? A multiple stable isotope study. *Marine Biology,* 130, 289–300.

Longstaff, B. J., Dennison, W. C., Prange, J. A., Loneragan, N. & Drew, E. A. 1998. *Task SLR: Seagrass/Light Relationships*, Brisbane River and Moreton Bay Wastewater Management Study, Brisbane.

Lovelock, C. E., Adame, M. F., Bennion, V., Hayes, M., O'Mara, J., Reef, R. & Santini, N. S. 2014. Contemporary Rates of Carbon Sequestration Through Vertical Accretion of Sediments in Mangrove Forests and Saltmarshes of South East Queensland, Australia. *Estuaries and Coasts,* 37, 763–771.

Lutz, P. L. & Musick, J. A. 1996. *The Biology of Sea Turtles,* CRC Press, United States of America.

Lybolt, M., Neil, D., Zhao, J., Feng, Y., Yu, K. F. & Pandolfi, J. 2011. Instability in a marginal coral reef: the shift from natural variability to a human- dominated seascape. *Frontiers in Ecology and the Environment,* 9, 154–160.

Mackey, A. P. & Smail, G. 1995. Spatial and temporal variation in litter fall of Avicennia marina (Forssk.) in the Brisbane River, Queensland. *Aquatic Botany,* 52, 133–142.

Maier, C. M. & Pregnall, A. M. 1990. Increased macrophyte nitrate reductase activity as a consequence of groundwater input of nitrate through sandy beaches. *Marine Biology,* 107, 263–271.

Malcolm, H., Bruce, B. D. & Stevens, J. D. 2001. *A Review of the Biology and Status of White Sharks in Australian Waters*, Report to Environment Australia, Marine Species Protection Program, CSIRO Marine Research, Hobart.

Malcolm, H. & Harasti, D. 2010. Baseline data on the distribution and abundance of black cod Epinephelus daemelii at 20 sites in Northern Rivers marine waters. NSW Marine Parks Authority: Northern Rivers Catchment Management Authority.

Maragos, J. E., Crosby, M. P. & McManus, J. W. 1996. Coral reefs and biodiversity: A critical and threatened relationship. *Oceanography,* 9, 83–99.

Marsh, H., Heinsohn, G. E. & Marsh, L. M. 1984. Breeding cycle, life history and population dynamics of the dugong, *Dugong dugon* (Sirenia: Dugongidae). *Australian Journal of Zoology,* 32, 767–788.

Marsh, H. & Lawler, I. 2002. *Dugong distribution and abundance in the northern Great Barrier Reef Marine Park November 2000*. School of Tropical Environment Studies and Geography, James Cook University.

Marsh, H., O'Shea, T. J. & Reynolds, J. R. 2011. *The ecology and conservation of sireniaj dugongs and manatees,* Cambridge University Press, London.

Marsh, H., Penrose, H., Eros, C. & Hughes, J. 2002. *Dugong status report and action plans for countries and territories. UNEP Early Warning and Assessment Report Series, Keya*.

Marshall, A., Bennett, M. B., Kodja, G., Hinojosa-Alvarez, S., Galvan-Magana, F., Harding, M., Stevens, G. & Kashiwagi, T. 2011. *Manta birostris*. Available: http://www.iucnredlist.org [Accessed Downloaded on 05 September 2014.].

Marshall, A. D. 2008. *Biology and population ecology of Manta birostris in southern Mozambique.* The University of Queensland, Brisbane.

Marshall, A. D., Compagno, L. J. V. & Bennett, M. B. 2009. Redescription of the genus *Manta* with resurrection of *Manta alfredi* (Krefft, 1868) (Chondrichthyes: Myliobatoidei: Mobulidae). *Zootaxa,* 2301, 1–28.

Martin, A. R. 1990. *Whales and Dolphins,* Salamander Books Ltd, London, UK.

Maxwell, W. G. H. 1970. The sedimentary framework of Moreton Bay, Queensland. *Australian Journal of Marine and Freshwater Research,* 21, 71–88.

Mazumder, D., Saintilan, N. & Williams, R. 2006. Trophic relationships between itinerant fish and crab larvae in a temperate Australian saltmarsh. *Marine and Freshwater Research,* 57, 193–199.

McCauley, R. D., Bannister, J., Burton, C., Jenner, C., Rennie, S. & Kent, C. S. 2004. *Western Australian Exercise Area Blue Whale Project. Final Summary Report. Milestone 6, September 2004. CMST Report R2004-29, Project 350. 71pp.*

McCook, L. J. 1999. Macroalgae, nutrients and phase shifts on coral reefs: scientific issues and management consequences for the Great Barrier Reef. *Coral Reefs,* 18 (4), 357–367.

McCook, L. J., Schaffelke, B., Apte, S. C., Brinkman, R., Brodie, J., Erftemeijer, P., Eyre, B., Hoogerwerf, F., Irvine, I., Jones, R., King, B., Marsh, H., Masini, R., Morton, R., Pitcher, R., Rasheed, M., Sheaves, M., Symonds, A. & Warne, M. S. J. 2015. *Synthesis of current knowledge of the biophysical impacts of dredging and disposal on the Great Barrier Reef*, Report of an Independent Panel of Experts, Great Barrier Reef Marine Park Authority, Townsville.

McCulloch, A. R. 1922. *Checklist of the Fishes and Fish-like Animals of New South Wales*. Sydney: Royal Zoological Society of New South Wales.

McLaughlin, L. 1987. Mangroves and grass swamps: Changes in the shoreline vegetation of the middle Lane Cove River, Sydney. *Wetlands (Australia),* 7, 13–24.

McMahon, K., Lavery, P., McCallum, R. & Hernawan, U. 2017. *Current state of knowledge regarding the effects of dredging-related 'pressure' on seagrasses*, report of

Theme 5 – Project 5.1.1 prepared for the Dredging Science Node, Western Australia Marine Science Institution, Perth, Western Australia.

McNeill, S. E., Worthington, D. G., Ferrell, D. J. & Bell, J. D. 1992. Consistently outstanding recruitment of five species of fish to a seagrass bed in Botany Bay, NSW. *Australian Journal of Ecology,* 17**,** 359–365.

McRoy, C. P. & Helfferich, C. 1980. Applied aspects of seagrasses. *In:* Phillips, R. C. & McRoy, C. P. (eds.) *Handbook of Seagrass Biology: an Ecosystem Perspective.* Garland STPM Press: York and London.

Meksumpun, C. & Meksumpun, S. 1999. Polychaete – Sediment Relations in Rayong, Thailand. *Environmental Pollution,* 105**,** 447–456.

Meylan, A. 1982. *Report to the Department of the Environment and Water Resources., ed. Biology and Conservation of Sea Turtles. 1st ed.*, Smithsonian Institute Press, Washington D.C.

Meylan, A. B. 1984. *Feeding ecology of the Hawksbill Turtle (Eretmochelys imbricata): spongivory as a feeding niche in the Coral Reef Community.* University of Florida.

Micheli, F. & Peterson, C. H. 1999. Estuarine Vegetated Habitats as Corridors for Predator Movements. *Conservation Biology,* 13**,** 869–881.

Moberg, F. & Folke, C. 1999. Ecological goods and services of coral reef ecosystems. *Ecological Economics,* 29**,** 215–233.

Moriarty, D. J. W., Boon, P. I., Hansen, J. A., Hunt, W. G., Poiner, I. R., Pollard, P. C., Skyring, G. W. & White, D. C. 1984. Microbial biomass and productivity in seagrass beds. *Geomicrobiology Journal,* 4**,** 21–51.

Morrisey, D. J., Underwood, A. J. & Howitt, L. 1996. Effects of copper on the faunas of marine soft-sediments: An experimental field study. *Marine Biology,* 125**,** 199–213.

Morrison, M. A., Francis, M. P., Hartill, B. W. & Parkinson, D. M. 1996. Diurnal and Tidal Variation in the Abundance of Fish Fauna of a Temperate Tidal Mudflat. *Estuarine Coastal Shelf Science.*

Morton, R. 1990. Community structure, density and standing crop of fishes in a subtropical Australian mangrove area. *Marine Biology,* 105**,** 385–394.

Morton, R. M., Pollock, B. R. & Beumer, J. P. 1987. The occurrence and diet of fishes in a tidal inlet to a saltmarsh in southern Moreton Bay, Queensland. *Australian Journal of Ecology,* 12, 217–237.

Musick, J. A. & Limpus, C. J. 1997. Habitat utilisation and migration in juvenile sea turtles. *In:* Lutz, L. & Musick, J. A. (eds.) *The Biology of Sea Turtles.* CRC Press.

National Heritage Trust 2007. *Antifouling Performance Standards for the Maritime Industry: Development of a Framework for the Assessment, Approval and Relevance of Effective Products*. Thompson Clarke Shipping Pty Ltd.

Neckles, H. A., Wetzel, R. I. & Orth, R. J. 1993. Relative effects of nutrient enrichment and grazing on epiphyte-macrophyte (*Zostera Marina L.*) dynamics. *Oecologia,* 93, 285–295.

Nemoto, T. & Kawamura, A. 1977. Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales. *Report of the International Whaling Commission (Special Issue 1)*, 80–87.

Newell, R., Marshall, N., Sasekumar, A. & Chong, V. 1995. Relative importance of benthic microalgae, phytoplankton, and mangroves as sources of nutrition for penaeid prawns and other coastal invertebrates from Malaysia. *Marine Biology,* 123, 595–606.

NOAA. 2017. *Value of Oysters* [Online]. Available: http://www.habitat.noaa.gov/pdf/value_of_oysters.pdf [Accessed].

Noad, M. J. 2000. A Southern Right Whale Eubalaena australis (Desmoulins, 1822) in southern Queensland waters. *Scientific Reports of the Whales Research Institute, Tokyo,* 45, 556.

Odum, W. E. & Johannes, R. E. 1975. The response of mangroves to man-induced environmental stress. *In:* Ferguson, E. J. & Johannes, R. E. (eds.) *Tropical Marine Pollution.* Amsterdam.

Ohsumi, S. 1977. Bryde's whales in the Pelagic whaling ground of the North Pacific. *Report of the International Whaling Commission (Special Issue 1)*, 140–150.

Olds, A. D., Pitt, K. A., Maxwell, P. S., Babcock, R. C., Rissik, D. & Connolly, R. M. 2014. Marine reserves help coastal ecosystems cope with extreme weather. *Global Change Biology,* 20, 3050–3058.

Onuf, C. P., Teal, J. M. & Valiela, I. 1977. Interactions of nutrients, plant growth and herbivory in a mangrove ecosystems. *Ecology.,* 58, 514–526.

Ozcoasts. 2009. *Moreton Bay Estuary Search [online]* [Online]. Available: http://www.ozcoasts.org.au/search_data/detail_result.jsp [Accessed].

Pade, N., Queiroz, N., Humphries, N., Witt, M., Jones, C., Noble, L. & Sims, D. 2009. First results from satellite-linked archival tagging of Porbeagle shark, Lamna nasus: area fidelity, wider-scale movements and plasticity in diel depth changes. *Journal of Experimental Marine Biology and Ecology,* 370, 64–74.

Parra, G., Corkeron, P. & Marsh, H. 2006a. Population sizes, site fidelity and residence patterns of Australian snubfin and Indo-Pacific humpback dolphins: Implications for conservation. *Biological Conservation,* 129, 167–180.

Parra, G. J. 2005. *Behavioural ecology of Irrawaddy, Orcaella brevirostris (Owen in Gray, 1866), and Indo-Pacific humpback dolphins, Sousa chinensis (Osbeck, 1765), in northeast Queensland, Australia: a comparative study*. Ph.D., James Cook University.

Parra, G. J. 2006. Resource partitioning in sympatric delphinids: Space use and habitat preferences of Australian snubfin and Indo-Pacific humpback dolphins. *Journal of Animal Ecology,* 75, 862–874.

Parra, G. J., Preen, A. R., Corkeron, P. J., Azuma, C. & Marsh, H. 2002. Distribution of Irrawaddy dolphins, *Orcaella brevirostris* in Australian waters. *Raffles Bulletin of Zoology,* 10, 141–154.

Parra, G. J., Schick, P. & Corkeron, P. J. 2006b. Spatial distribution and environmental correlates of Australian snubfin and Indo-Pacific humpback dolphins. *Ecography,* 29, 496–506.

Paterson, R. A., Paterson, P. & Cato, D. H. 2001. Status of humpback whales, *Megaptera novaeangliae*, in east Australia at the end of the 20th century. *Memoirs of the Queensland Museum,* 47, 579–586.

Pearson, T. H. & Rosenberg, R. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology Annual Review,* 16, 229–311.

Pelletier, E., Ouellet, S. & Paquet, M. 1991. Long-term chemical and cytochemical assessment of oil contamination in estuarine intertidal sediments. *Marine Pollution Bulletin,* 22, 273–81.

Pendoley, K. & Fitzpatrick, J. 1999. Browsing of mangroves by green turtles in Western Australia. *Marine Turtle Newsletter.*

Pentti, R., Loder, J., Salmond, J., Passenger, J. & Schubert, J. 2016. *Reef Check Australia South East Queensland Season Summary Report 2015*, Reef Check Foundation Ltd.

Perry, C. T. & Larcombe, P. 2003. Marginal and non-reef-building coral environments. *Coral Reefs,* 22, 427–432.

Peverell, S. N., Gribble, N. & Larson, H. 2004. Sawfish. *National Oceans Office, Description of Key Species Groups in the Northern Planning Area.* Commonwealth of Australia: Hobart, Tasmania.

Phillips, J. A. & Price, I. R. 2002. How different is Mediterranean *Caulerpa taxifolia* (Caulerpales: Chlorophyta) to other populations of the species? *Marine Ecology Progress Series,* 238, 61–71.

Pogonoski, J. J., Pollard, D. A. & Paxton, J. R. 2002a. *Black Rock-cod'. Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes*. Environment Australia.

Pogonoski, J. J., Pollard, D. A. & Paxton, J. R. 2002b. *Conservation overview and action plan for Australian threatended and potentially threatened marine and estuarine fish species*. Commonwealth of Australia.

Poiner, I. R. 1980. A comparison between species diversity and community flux rates in the macrobenthos of an infaunal sand community and a seagrass community of Moreton Bay, Queensland. *Proceedings of the Royal Society of Queensland.,* 91, 297–308.

Poiner, I. R. & Harris, A. N. M. 1996. Incidental capture, direct mortality and delayed mortality of sea turtles in Australia's northern prawn fishery. *Marine Biology,* 125, 813–825.

Poiner, I. R. & Roberts, G. 1986. 'A brief review of seagrass studies in Australia', in Proceedings of the National Conference on Coastal Management, Coffs Harbour, NSW, pp. 243–9.

Pollard, D. A. 1984. A review of ecological studies on seagrass-fish communities, with particular reference to recent studies in Australia. *Aquatic Botany,* 18, 3–42.

Pollock, B. R., Weng, H. & Moreton, R. M. 1983. The seasonal occurrence of postlarval stages of yellowfin bream, *Acanthopagrus australis* (Gunther), and some factors affecting their movement into an estuary. *Journal of Fish Biology,* 22, 409–415.

Preen, A. R. 1992. *Interactions between dugongs and seagrasses in a subtropical environment.* (unpublished) Ph.D. Thesis, James Cook University of North Queensland.

Preen, A. R., Lee Long, W. J. & Coles, R. G. 1995. Flood and cyclone related loss, and partial recovery of more than 1000km2 of seagrass in Hervey Bay, Queensland, Australia. *Aquatic Botany,* 52, 3–17.

Prince, R. I. 1994. Status of the Western Australian marine turtle populations: the Western Australian Marine Turtle Project 1986–1990. *Russell, J., ed. Proceedings of the Australian Marine Turtle Conservation Workshop, Gold Coast 14–17 November 1990.* Queensland Department of Environment and Heritage: Canberra.

Queensland Museum. 2017. *Sponges & Corals* [Online]. Available: http://www.qm.qld.gov.au/microsites/biodiscovery/03sponges-and-corals/corals-of-moreton-bay.html [Accessed].

Ralph, P. J., Durako, M. J., Enriquez, S., Collier, C. J. & Doblin, M. A. 2007. Impact of light limitation on seagrasses. *Journal of Experimental Marine Biology and Ecology,* 350, 176–193.

Rapoza, K. B. & Oviatt, C. A. 2000. The influence of contiguous shoreline type, distance from shore and vegetation biomass on nekton community structure in eelgrass beds. *Estuaries,* 1, 46–55.

Reeves, R. R. Critical or important habitats for cetaceans: what to protect. First International Conference on Marine Mammal Protected Areas, March 30 – April 3, 2009, 2008 March 30–April 3, 2009, Maui, Hawaii, USA (In Press).

Reish, D. J. & Gerlinger, T. V. 1997. A Review of the Toxicological Studies with Polychaetous Annelids. *Bulletin of Marine Science,* 2, 584–607.

Ricardo, G. F., Jones, R. J., Clode, P. L. & Negri, A. P. 2016. Mucous Secretion and Cilia Beating Defend Developing Coral Larvae from Suspended Sediments. *PLoS ONE,* 11, e0162743. doi:10.1371/journal.pone.0162743.

Richardson, W. J., Greene, C. R., Malme, C. I. & Thomson, D. H. 1995. *Marine Mammals and Noise*, San Diego.

Robertson, A. I. & Blaber, S. J. M. 1992. 'Plankton, epibenthos and fish communities', in Tropical mangrove ecosystems, eds A. I. Robertson & D. M. Alongi, American Geophysical Union, Washington DC, pp. 173–224.

Robins, C. M., Goodspeed, A. M., Poiner , I. & B.D., H. 2002. *Monitoring the catch of turtles in the Northern Prawn Fishery,* Department of Agriculture, Fisheries & Forestry: Canberra.

Roelfsema, C. M., Loder, J., Host, R. & Kovacs, E. 2017. *Final Draft Report: Benthic Inventory of Reefal Areas of Inshore Moreton Bay, Queensland, Australia*, Remote Sensing Research Centre, School of Geography, Environmental Management and Planning, The University of Queensland, Brisbane, Australia and Reef Check Australia, Brisbane, Australia.

Roelfsema, C. M., Phinn, S. R., Udy, N. & Maxwell, P. 2009. An integrated field and remote sensing approach for mapping seagrass cover, Moreton Bay, Australia. *Journal of Spatial Science,* 54, 45–62.

Ross, G. J. B. 2006. *Review of the Conservation Status of Australia's Smaller Whales and Dolphins*, Report to the Australian Department of the Environment and Heritage, Canberra.

Rossi, F. 2003. Short-term response of deposit-feeders to an increase of the nutritive value of the sediment through seasons in an intertidal mudflat (Western Mediterranean, Italy). *Journal of Experimental Marine Biology and Ecology,* 290, 1–17.

Rowat, D. & Brooks, K. S. 2012. A review of the biology, fisheries and conservation of the whale shark Rhincodon typus. *Journal of Fish Biology,* 80, 1019–1056.

Saintilan, N. & Mazumder, D. Mangroves and Saltmarsh in SE Australia. Workshop Notes: Recent Techniques in Protection, Creation and Rehabilitation of Coastal Saltmarshes, 3–4 June 2004 Olympic Park, Sydney. Wetland Education and Training (WET) Programs Workshop.

Saintilan, N. & Rogers, K. 2013. The significance and vulnerability of Australian saltmarshes: implications for management in a changing climate. *Marine and Freshwater Research,* 64, 66–79.

Sammut, J., Callinan, R. B. & Fraser, G. C. *The impact of acidified water on freshwater and estuarine fish populations in acid sulphate soil environments*. Proceedings of the National Conference on Acid Sulphate Soils, 1993 June 24, 1993 Coolangatta, NSW. 26–40.

Saulitis, E., Markin, C., Heise, K., Barrett, L. & Ellis, G. 2000. Foraging strategies of sympatric killer whale (Orcinus orca) populations in Prince William Sound, Alaska. *Marine Mammal Science,* 16, 94–109.

Saunders, R., Royer, F. & Clarke, M. 2011. Winter migration and diving behaviour of Porbeagle shark, *Lamna nasus*, in the Northeast Atlantic. *ICES Journal of Marine Science,* 68, 166–174.

Schaffelke, B. & Klumpp, D. W. 1998a. Nutrient-limited growth of the coral reef macroalga Sargassum baccularia and experimental growth enhancement by nutrient addition in continuous flow culture. *Marine Ecology Progress Series,* 164, 199–211.

Schaffelke, B. & Klumpp, D. W. 1998b. Short-term nutrient pulses enhance growth and photosynthesis of the coral reef macroalga Sargassum baccularia. *Marine Ecology Progress Series,* 170, 95–105.

Schaffelke, B., Waterhouse, J. & Christie, C. 2001. *A Review of Water Quality Issues Influencing the Habitat Quality in Dugong Protection Areas*, Water Quality Unit, Great Barrier Reef Marine Park Authority, Townsville.

Sekiguchi, K., Klages, N. T. W. & Best, P. B. 1992. Comparative analysis of the diets of smaller odontocete cetaceans along the coast of southern Africa. *South African Journal of Marine Science,* 12, 843–861.

Silberstein, K., A.W., C. & McComb, A. J. 1986. The loss of seagrass in Cockburn Sound, Western Australia: The effect of epiphytes on productivity of *Posidonia australis* Hook. *Aquatic Botany,* 24, 355–371.

Skilleter, G., Zharikov, Y., Cameron, B. & Mcphee, D. 2005. Effects of harvesting callianassid (ghost) shrimps on subtropical benthic communities. *Journal of Experimental Marine Biology and Ecology,* 320, 133–158.

Skilleter, G. A. & Loneragan, N. R. 2003. Assessing the importance of coastal habitats for fisheries, biodiversity and marine reserves: a new approach taking into account "habitat mosaics". *In:* Beumer, J. P., Grant, A. & Smith, D. C. (eds.) *Aquatic protected areas – what works best and how do we know?* University of Queensland Printery: St Lucia, Queensland.

Smith, G. & Sumpton, W. 1987. Sand crabs a valuable fishery in south-east Queensland. *The Queensland Fisherman,* 5, 13–15.

Smith, G. S. 1981. Southern Queensland's oyster industry. *Journal of the Royal Historical Society of Queensland,* 11, 45–58.

Smith, J. N., Grantham, H. S., Gales, N., Double, M. C., Noad, M. J. & Paton, D. 2012. Identification of humpback whale breeding and calving habitat in the Great Barrier Reef. *Marine Ecology Progress Series,* 447, 259–272.

Smith, P. 1997. *Management Manual for Marine Mammals in NSW,* NSW National Parks and Wildlife Service, Hurstville.

Sommer, B., Harrison, P. L., Beger, M. & Pandolfi, J. M. 2014. Trait- mediated environmental filtering drives assembly at biogeographic transition zones. *Ecology,* 95, 1000–1009.

Spotila, J. R. 2004. *Sea turtles: a complete guide to their biology, behavior, and conservation,* The Johns Hopkins University Press and Oakwood Arts, Baltimore, Maryland.

Stacey, P. J. & Arnold, P. W. 1999. *Orcaella brevirostris*. *Mammalian Species,* 616, 1–8.

Staples, D. J. & Vance, D. J. 1985. Short-term and long-term influences on the immigration of postlarval banana prawns Penaeus merguiensis, into a mangrove estuary of the Gulf of Carpentaria, Australia. *Marine Ecology Progress Series.,* 23, 15–29.

Stern, J. S. 2009. Migration and Movement Patterns. *In:* Perrin, W., Wursig, B. & Thewissen, J. G. M. (eds.) *Encyclopaedia of Marine Mammals.* Elsevier, L London.

Stevens, J., Fowler, S. L., Soldo, A., McCord, M., Baum, J., Acuna, E., Domingo, A. & Francis, M. 2006. *Lamna nasus. In: IUCN 2013. IUCN Red List of Threatened Species Version 2013.2.* [Online]. Available: http://www.iucnredlist.org [Accessed].

Stevens, J. D., Pillans, R. D. & Salini, J. 2005. *Conservation assessment of* Glyphis sp. A *(speartooth shark),* Glyphis sp. C *(northern river shark),* Pristis microdon *(freshwater sawfish) and* Pristis zijsron *(green sawfish)*. Canberra: Department of the Environment and Heritage, Commonwealth of Australia.

Thomas, B. E. & Connolly, R. M. 2001. Fish use of subtropical saltmarshes in Queensland, Australia: relationships with vegetation, water depth and distance onto the marsh. *Marine Ecology Progress Series,* 209, 275–288.

Thomas, J. 2003. Caulerpa Taxifolia in Moreton Bay – distribution and seagrass interactions, Honours thesis, Department of Botany, University of Queensland, Australia.

Thorburn, D. C., Morgan, D. L., Rowland, A. J. & Gill, H. S. 2007. Freshwater sawfish *Pristis microdon* Latham, 1794 (Chondrichthyes: Pristidae) in the Kimberley region of Western Australia. *Zootaxa,* 1471, 27–41.

Tibbetts, I. R., Hall, N. J. & Dennison, W. C. 1998. *Moreton Bay and Catchment,* School of Marine Science, Brisbane, Australia.

Tomasko, D. A. & Lapointe, B. E. 1991. Productivity and biomass of *Thalassia testudinum* as related to water column nutrient availability: field observations and experimental studies. *Marine Ecology Progress Series,* 75, 9–17.

TropWATER. 2017. *Shellfish Restoration* [Online]. Available: https://research.jcu.edu.au/tropwater/research-programs/coastal-estuarine-ecology/shellfish-reef-protection-and-repair [Accessed].

Tsutsumi, H. 1990. Population Persistence of *Capitella* sp. (Polychaeta: Capitellidae) on a Mudflat Subject to Environmental Disturbance by Organic Enrichment. *Marine Ecology Progress Series,* 63, 147–156.

Twilley, R. R., Kemp, W. M., Staver, K. W., Stevenson, J. C. & Boynton, W. R. 1985. Nutrient enrichment of estuarine submerged vascular plant communities, 1. Algal growth and effects on production of plants and associated communities. *Marine Ecology Progress Series,* 23, 179–191.

Uchida, S., Toda, M., Teshima, K. & Yano, K. 1996. Pregnant sharks and full-term embryos from Japan. *In:* Klimley, A. P. & Ainley, D. G. (eds.) *Great White Sharks: The Biology of Carcharodon carcharias.* Academic Press: San Diego, C.A.

van Woesik, R., Tomascik, T. & Blake, S. 1999. Coral assemblages and physico-chemical characteristics of the Whitsunday Islands: Evidence of recent community changes. *Marine Freshwater Research,* 50, 427–440.

Verweii, M. C., Nagelkerken, I., de Graff, D., Peters, M., Bakker, E. J. & van der Velde, G. 2006. Structure, food and shade attract juvenile coral reef fish to mangrove and seagrass habitats: a field experiment. *Marine Ecology Progress Series,* 306, 257–268.

Voudrias, E. A. & Smith, C. L. 1986. Hydrocarbon pollution from marinas in estuarine sediments. *Estuarine Coastal and Shelf Science,* 22, 271–284.

W.H., D. 1966. The Seasonal Migratory Cycle of Humpback Whales. *In:* Norris, K. R. (ed.) *Whales, Dolphins and Porpoises.* University of California Press: Berkeley and Lost Angeles.

Wallace, C. C., Fellegara, I., Muir, P. R. & Harrison, P. L. The scleractinian corals of Moreton Bay, eastern Australia: high latitude, marginal assemblages with increasing species richness. *In:* Davie, P. J. F. & Phillips, J. A., eds. Proceedings of the Thirteenth International Marine Biological Workshop, The Marine Fauna and Flora of Moreton Bay, Queensland. Memoirs of the Queensland Museum — Nature, 2009 Brisbane. 1–118.

Ward, T. J. & Hutchings, P. A. 1996. Effects of trace metals on infaunal species composition in polluted intertidal and subtidal marine sediments near a lead smelter, Spencer Gulf, South Australia, Marine Ecology Progress Series, 135:123–135.

Warnken, J., Dunn, R. J. K. & Teasdale, P. R. 2004. Investigation of recreational boats as a source of copper at anchorage sites using time-integrated diffusive gradients in thin film and sediment measurements. *Marine Pollution Bulletin,* 49, 833–843.

Weilgard, L. 2007. A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology,* 20.

Weng, H. T. 1983. 'Identification, habitats and seasonal occurrence of juvenile whiting (Sillaginidae) in Moreton Bay, Queensland', Journal of Fish Biology, 23:195–200.

West, R. J. & King, R. J. 1996. Marine, brackish, and freshwater fish communities in the vegetated and bare shallows of an Australian coastal river. *Estuaries,* 19, 31–41.

Wheeler, W. N. & Weidner, M. 1983. 'Effects of external inorganic nitrogen concentration on metabolism, growth and activities of key carbon and nitrogen assimilatory enzymes of *Laminaria saccharina* (Phaeophyceae) in culture', Journal of Phycology, 19:92–6.

Whiting, S. D., Long, J., Hadden, K. & Lauder, A. 2005. *Identifying the links between nesting and foraging grounds for the Olive Ridley (Lepidochelys olivacea) sea turtles in northern Australia*, Report to the Department of the Environment and Water Resources.

Wright, I. & Burgin, S. 2007. Species richness and distribution of eastern Australian lake chironomids and chaoborids. *Freshwater Biol,* 52, 2354–2368.

Wu 2002. Hypoxia: From molecular responses to ecosystem responses. *Marine Pollution Bulletin,* 45, 35–45.

Würsig, B., Cipriano, F., Slooten, E., Constantine, R., Barr, K. & Yin, S. 1997. Dusky dolphin (Lagenorhynchus obscurus) off New Zealand: status of present knowledge. *Report of the International Whaling Commission,* 47, 715–722.

Yabsley, N. A., Olds, A. D., Connolly, R. M., Martin, T. S., Gilby, B. L., Maxwell, P. S., Huijbers, C. M., Schoeman, D. S. & Schlacher, T. A. 2016. Resource type influences the effects of reserves and connectivity on ecological functions. *Journal of Animal Ecology,* 85, 437–444.

Zann, M., Phinn, S. & Done, T. 2012. Towards marine spatial planning for Hervey Bay's coral reefs. *Proceedings of the 12th International Coral Reef Symposium.* Cairns, Australia.

Zeller, B. 1998. *Queensland's Fisheries Habitats, Current Condition and Recent Trends*, Q198025, Information Series, Queensland Department of Primary Industries.

Zhang, K., Liu, H., Li, Y., Xu, H., Shen, J., Rhome, J. & Smith, T. J. 2012. The role of mangroves in attenuating storm surges. *Estuarine, Coastal and Shelf Science,* 102–103, 11–23.

Zimmerman, R. C. & Kremer, J. N. 1986. In situ growth and chemical composition of the giant kelp, *Macrocystis pyrifera* – responses to temporal changes in ambient nutrient availability. *Marine Ecology Progress Series,* 27, 277–285.

Appendix A Survey and Laboratory Methods

A1 Survey of Habitat

Surveys of habitat and associated flora and fauna were conducted from 5 to 6 November 2014. Habitats were assessed visually and differences in habitats were marked using a handheld GPS. The GPS waypoints were also compared to recent aerial imagery and then mapped. The entire PDA, including a small areas outside of the PDA boundary, were surveyed.

A2 Description of Marine Plant Communities

Marine plant communities were classified according to the dominant species present and the relevant understorey or sub-dominant species present.

A3 Condition of Marine Plant Communities

The marine plant communities were also qualitatively assessed for their relative value to aquatic ecology and fisheries. The abundance of crabs or crab burrows was used as an indicator of the ability of the site to support marine fauna. The availability of physical habitat for fauna, the amount of human or cattle disturbance, the ponding of water, and the relative proximity of each point to permanent water at low tide (to assess the likely frequency of tidal inundation) were also assessed. Categories used to describe the habitat value of marine plants to aquatic ecology and fisheries are described in Table A1 and Table A2.

!

Table!A1! Categories!used!to!qualitatively!assess!the!value!of!marine!plants!excluding! seagrass!and!macroalgae!to!aquatic!ecology!and!fisheries.!!

Value"	**Criteria"**
Excellent!!	High!abundance!of!fauna!/!crab!burrows!present,!very!complex!structural! habitat!for!fauna,!likely!to!be!regularly!inundated!
Very!Good!!	High!abundance!of!fauna!/!crab!burrows!present,!complex!structural! habitat!for!fauna,!likely!to!be!regularly!inundated,!but!some!disturbance!
Good!!	Some!fauna!/!crab!burrows!present,!periodical!tidal!inundation,!some! structural!habitat!for!fauna!provided,!little!anthropogenic!disturbance!
Fair!!	Low!abundance!of!fauna!/!crab!burrows,!habitat!is!disturbed,!little! structural!habitat!provided!to!fauna,!infrequent!tidal!inundation!
Poor!!	Little!to!no!fauna!present,!poorly!flushed,!little!/!no!structural!habitat! provided!to!fauna,!habitat!is!heavily!disturbed,!infrequent!or!no!tidal! inundation,!only!opportunistic!species!present!

!

Table!A2! Categories! used! to! qualitatively! assess! the! value! of! seagrass! and! macroalgae!to!aquatic!ecology!and!fisheries.!

Value"	**Criteria"**
Very!good!	High!percent!cover!and!biomass!of!seagrass,!offering!complex!structural! habitat!for!fauna,!proximal!to!mangroves,!high!densities!of!fauna!/!crab! burrows!and!no!damage!such!as!burning!or!discolouration!
Good!	Moderate!percent!cover!and!biomass!of!seagrass,!offering!good!structural! habitat,!proximal!to!mangroves,!moderate!densities!of!fauna!/!crab! burrows!and!little!damage!evident!
Fair!!	Moderate!percent!cover!and!biomass!of!seagrass,!offering!some! structural!habitat,!proximal!to!limited!mangroves,!some!fauna!/!crab! burrows!and!some!damage!evident!
Poor!	Low!percent!cover!and!biomass!of!seagrass,!offering!little!structural! habitat,!distal!to!mangroves,!few!fauna!/!crab!burrows!and!damage! evident!
Very!poor!!	Very!low!percent!cover!and!biomass!of!seagrass,!offering!very!little! structural!habitat,!distal!to!mangroves!or!mangroves!absent,!very!few! fauna!/!crab!burrows!with!only!opportunistic!species!present!and! extensive!damage!evident!

1.1.1 Structural Elements

Structural elements, such as trees, seedlings, aerial roots and pneumatophores, provide habitat for marine organisms. Leaf litter on the forest floor, such as fallen mangrove leaves, and large debris (including dead tree trunks), also provide structural habitat in mangrove forests. However, very high cover of litter (>50%) suggests that an area has a low frequency of tidal inundation and is poorly flushed, which reduces the fisheries value of the habitat.

Smaller structures, such as pneumatophores, seedlings and small aerial roots, provide habitat for certain species, while larger structures, such as tree trunks and large aerial roots, provide habitat for other species. The presence of structural elements with a range of different sizes provides heterogeneity of habitat, thereby offering a greater range of habitats to a larger number of different species of fish and crustaceans. That is, each structural element provides a degree of structural habitat, yet the presence of multiple structural elements provides structural heterogeneity and generally supports a more diverse community of marine organisms.

1.1.2 Abundance of Infauna

The abundance of infauna, such as crabs and molluscs, is a direct indicator of habitat use and food availability. Relative densities of crab burrows also provide an indication of used however, the number of burrows does not necessarily equate to the number of individual crabs using the habitat, as some species create more than one burrow while others share burrows. Crabs and molluscs also provide food for fishes and large crustaceans.

Benthic Epi- and Infauna

Epifauna was visually observed at low tide in each habitat, except for the channel. Additionally, pitfall traps were set in mangrove habitats at low tide and remained in the sediment for one tidal cycle. After 24 hours (+/-2 hrs) the pitfall traps were retrieved and fauna was identified and counted and all fauna was returned to the environment.

Benthic infauna was assessed by taking three invertebrate cores at two sites from each habitat, except mangrove habitat (Map 2). Cores were collected using an Eyer's corer with a diameter of 10.5 cm to a depth of 30 cm. Samples were sieved in the field through a 500 µm sieve and preserved using ethanol solution. The samples were transported to the laboratory where they were stained with Rose Bengal and macroinvertebrates were picked, sorted and identified to the lowest taxonomic level, in most instances to family.

1.1.3 Data Analysis

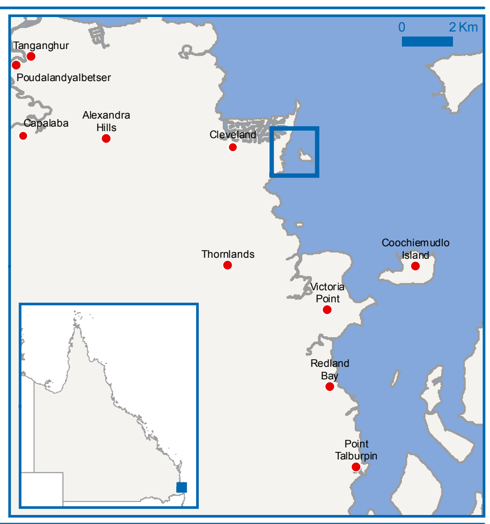
Means of abundance (total number of individuals) and taxonomic richness (family richness) were determined for each site.

Toondah Harbour Marine Ecology
EPBC Referral

Map A1:
Macroinvertebrate sites surveyed

LEGEND

- Macroinvertebrate Sampling Site
- Toondah Harbour PDA



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SOURCES

DATE	DRAWN BY	VERSION	PROJECTION
2017-03-27	CB	01	Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator Datum: GDA 1994

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Appendix'B" EPBC'Protected'Matter'Search'Results"

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EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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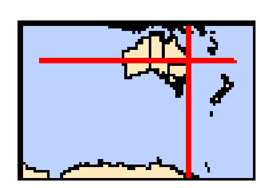

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	68
Listed Migratory Species:	72

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	111
Whales and Other Cetaceans:	14
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	42
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar)	[Resource Information]
Name	Proximity
Moreton bay	Within Ramsar site

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered	Community likely to occur within area
Lowland Rainforest of Subtropical Australia	Critically Endangered	Community may occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia		
Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus		
Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Roosting known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Cyclopsitta diophthalma coxeni		
Coxen's Fig-Parrot [59714]	Endangered	Species or species habitat may occur within area
Dasyornis brachypterus		
Eastern Bristlebird [533]	Endangered	Species or species habitat may occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat may occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat may occur within area
Insects		
Phyllodes imperialis smithersi Pink Underwing Moth [86084]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [331]	Endangered	Species or species habitat may occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Arthraxon hispidus Hairy-joint Grass [9338]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Baloghia marmorata Marbled Balogia, Jointed Baloghia [8463]	Vulnerable	Species or species habitat may occur within area
Bosistoa transversa Three-leaved Bosistoa, Yellow Satinheart [16091]	Vulnerable	Species or species habitat likely to occur within area
Corchorus cunninghamii Native Jute [14659]	Endangered	Species or species habitat likely to occur within area
Cryptocarya foetida Stinking Cryptocarya, Stinking Laurel [11976]	Vulnerable	Species or species habitat likely to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
Macadamia integrifolia Macadamia Nut, Queensland Nut Tree, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat likely to occur within area
Macadamia tetraphylla Rough-shelled Bush Nut, Macadamia Nut, Rough-shelled Macadamia, Rough-leaved Queensland Nut [6581]	Vulnerable	Species or species habitat likely to occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat likely to occur within area
Phaius bernaysii Yellow Swamp-orchid [4918]	Endangered	Species or species habitat may occur within area
Samadera bidwillii Quassia [29708]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Name	Status	Type of Presence
Saiphos reticulatus Three-toed Snake-tooth Skink [88328]	Vulnerable	Species or species habitat may occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Migratory Marine Species		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Roosting known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Roosting known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Roosting known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur

Name	Threatened	Type of Presence
		within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Roosting known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba		
Sanderling [875]		Roosting known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Roosting known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Roosting known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat may occur within area
Charadrius bicinctus		
Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus		
Red-capped Plover [881]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area
Himantopus himantopus Black-winged Stilt [870]		Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat may occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area

Name	Threatened	Type of Presence
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish [66193]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys ocellatus Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Hippocampus kelloggi Kellogg's Seahorse, Great Seahorse [66723]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus andersonii Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Microphis manadensis Manado Pipefish, Manado River Pipefish [66258]		Species or species habitat may occur within area
Solegnathus dunckeri Duncker's Pipehorse [66271]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Laticauda laticaudata a sea krait [1093]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area

Name	Status	Type of Presence
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Bird Island	QLD
Dawson Road	QLD
Goat Island	QLD
Teerk Roo Ra	QLD
Teerk Roo Ra	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Rattus rattus		
Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides		
Alligator Weed [11620]		Species or species habitat likely to occur within area
Annona glabra		
Pond Apple, Pond-apple Tree, Alligator Apple, Bullock's Heart, Cherimoya, Monkey Apple, Bobwood, Corkwood [6311]		Species or species habitat may occur within area
Anredera cordifolia		
Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus		
Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Cabomba caroliniana		
Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. rotundata		
Bitou Bush [16332]		Species or species habitat likely to occur within area
Cryptostegia grandiflora		
Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista monspessulana		
Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis		
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Parthenium hysterophorus		
Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Prosopis spp.		
Mesquite, Algaroba [68407]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Protasparagus densiflorus Asparagus Fern, Plume Asparagus [5015]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Moreton Bay	QLD

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-27.525453 153.279669,-27.513806 153.305075,-27.513502 153.332455,-27.52355 153.344042,-27.533597 153.351166,-27.544784 153.351338,-27.553688 153.33606,-27.553764 153.29778,-27.544936 153.284133,-27.537554 153.278468,-27.525833 153.279326,-27.525453 153.279669

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix'C" 'Maps"'

!

Toondah Harbour Marine Ecology
EPBC Referral

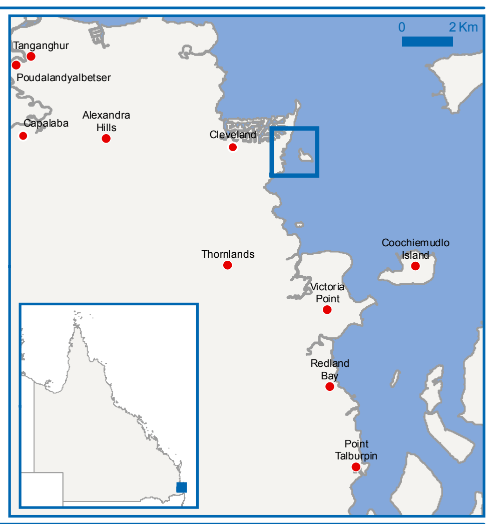
Map 1:
Marine habitats of Toondah Harbour and the PDA

LEGEND

Toondah Harbour PDA

Dominant Marine Habitats

Avicennia marina	Saltpan / Saltmarsh
Rhizophora stylosa	*Juncus kraussii*
Aegiceras corniculatum	Seagrass
Ceriops tagal var. australis	Rubble
	Sand / Mud



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Document Path: Y:\Projects\2017\170301_WGH_Toondah_additional_work\Mapping\Workspaces\170301_Map1_Marine_Habitats_frc_17-03-23_CB.mxd

N

SCALE

0 100 200

Metres

Scale: 1:5,641 @ A3

Toondah Harbour Marine Ecology EPBC Referral

Map 2:
Marine habitats in the vicinity of the PDA

LEGEND

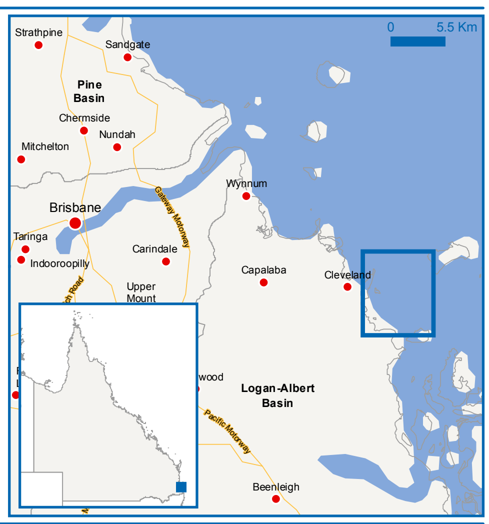
Toondah Harbour PDA

Habitat Type

- Inshore, algae/sponge habitat
- Inshore reef
- Mangrove/intertidal habitat
- Riverine/estuarine

Road Network

- Main Road



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SCALE

0 100 200 400 600 800 1,000

Metres

Scale: 1:25,000 @ A3

Toondah Harbour Marine Ecology EPBC Referral

Map 3:
Mangrove and saltmarsh habitat
in the vicinity of the PDA

LEGEND

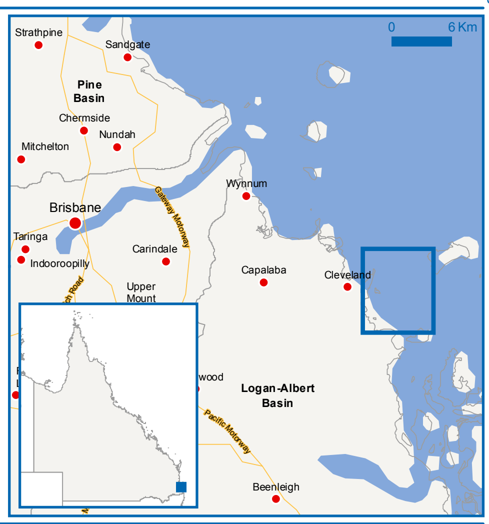
Toondah Harbour PDA

Species and Habitats

- *Aegiceras corniculatum* closed-scrub, open-scrub, low closed-scrub, low open-scrub
- *Avicennia marina* subsp. australasica closed-forest, open-forest, woodland, low closed-forest, low open-forest, low woodland, low open-woodland
- *Avicennia marina* subsp. australasica closed-scrub, open-scrub
- *Avicennia marina* subsp. australasica low open-scrub, low shrubland, low open-shrubland
- *Avicennia marina* subsp. australasica tall shrubland, tall open-shrubland
- *Ceriops australis* low open-scrub, low shrubland, low open-shrubland
- *Rhizophora stylosa* closed-scrub, open-scrub, tall shrubland, tall open-shrubland
- *Sporobolus virginicus* closed grassland, grassland
- Claypan

Road Network

Main Road



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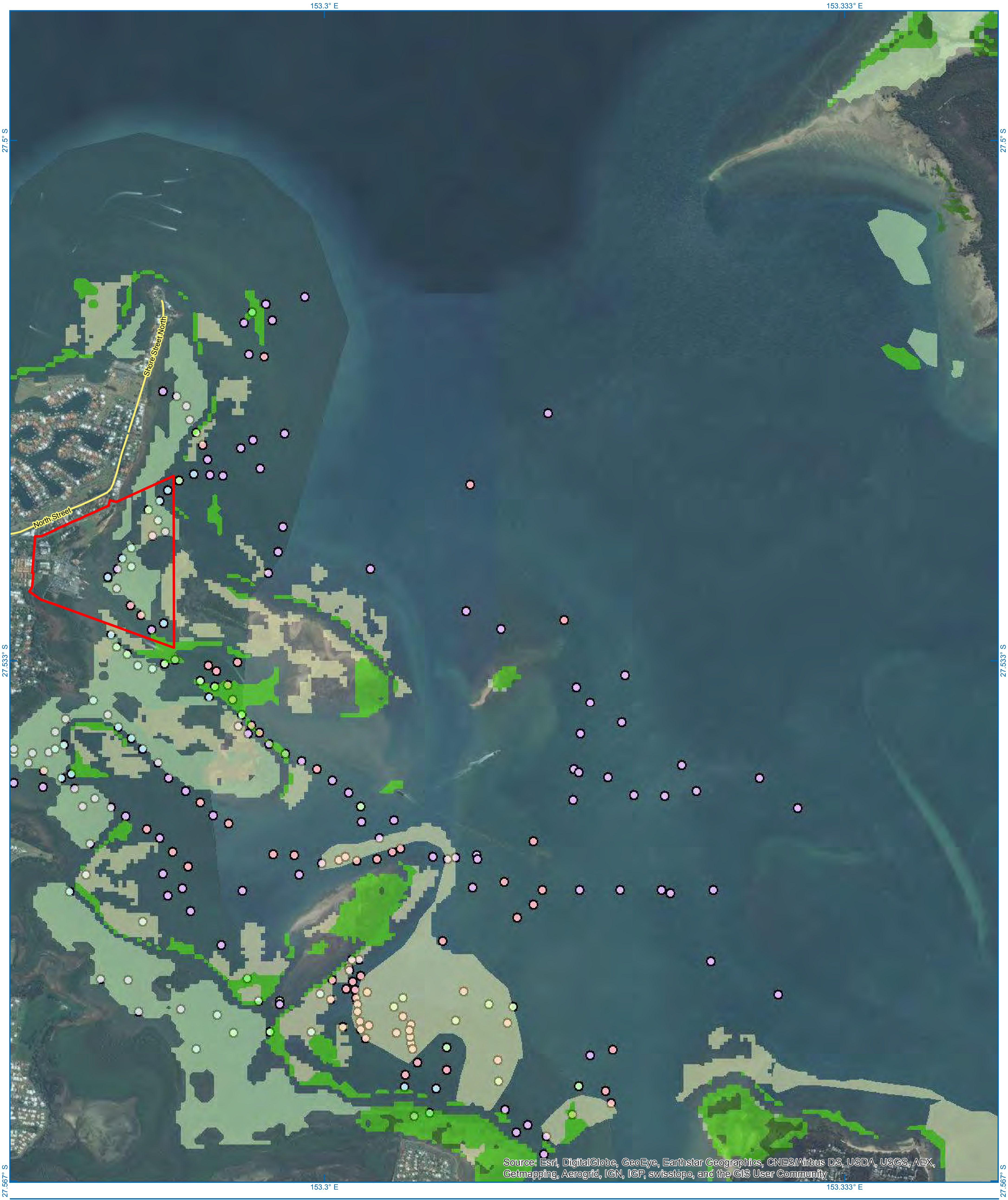
Metres

Scale: 1:25,000 @ A3



Toondah Harbour Marine Ecology EPBC Referral

Map 4: Seagrass habitat in the vicinity of the PDA

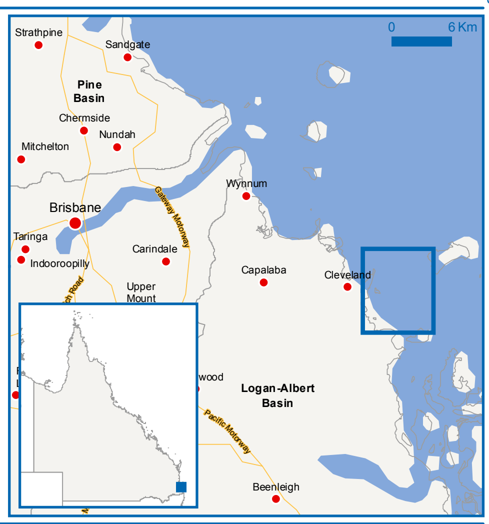
LEGEND

Toondah Harbour PDA

Seagrass Cover Moreton Bay (2011)
- 1-25%
- 25-50%
- 50-75%
- 75-100%
- Sand

Dominant species 2015-16
- *Halophila ovalis*
- *Halophila spinulosa*
- *Zostera muelleri*
- No Seagrass Recorded

Road Network
- Main Road



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© Roelfsema, C.M., E. Kovacs, S.R. Phinn, M. Lyons, M. Saunders and P. Maxwell: Challenges of Remote Sensing for Quantifying Changes in Large Complex Seagrass Environments. In Journal Estuarine, Coastal and Shelf Science, 2013
© Healthy Land and Water and Science Under Sail, 2015

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Metres

Scale: 1:25,000 @ A3

Toondah Harbour Marine Ecology EPBC Referral

Map 5:
Coral and algal habitat in the vicinity of the PDA

LEGEND

Toondah Harbour PDA

Coral Cover

- Medium
- Sparse
- Sparse - Med-Dense
- Sparse - Medium

Substrate type (Healthy Waterways (2015))

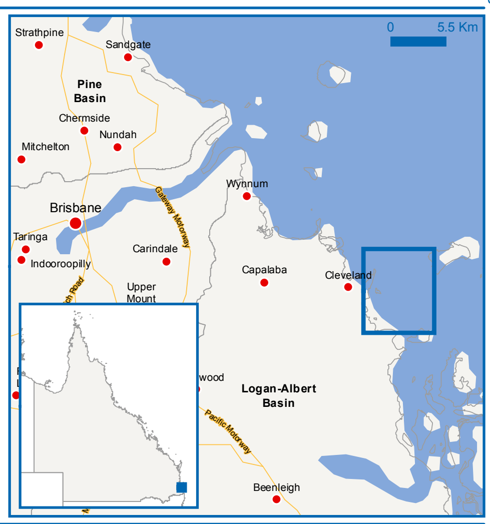
- Coral
- Coral Rubble

Algae

- Algae
- *Caulerpa taxifolia*
- Macro

Road Network

- Main Road



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SCALE

0 100 200 400 600 800 1,000

Metres

Scale: 1:25,000 @ A3

Toondah Harbour Marine Ecology EPBC Referral

Map 6: Ramsar wetlands in the vicinity of the PDA

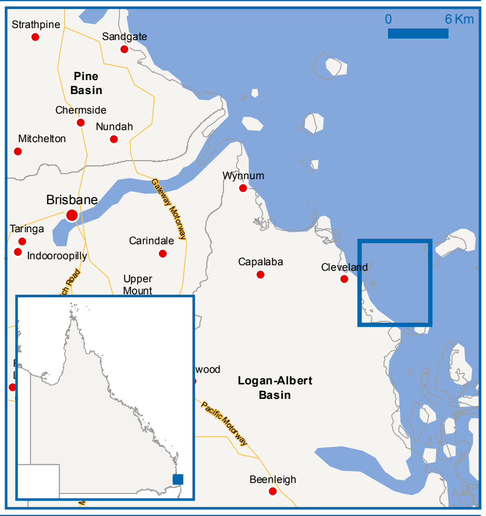
LEGEND

Toondah Harbour PDA

Ramsar Wetlands

Road Network

Main Road



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SCALE

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Metres

Scale: 1:25,000 @ A3

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31 October 2017 frc ref: 171006Ri

Re: Toondah Harbour: Preliminary Turbidity Analyses

This report by letter provides a summary of the turbidity data collected at Toondah Harbour between 9 September 2015 and 22 September 2017.

Summary of the Turbidity Logging Program

Potential impacts of excavation and dredging works on aquatic ecosystems include changes to water quality, and in particular increased suspended sediment in the water column. Increased loads of suspended sediments reduce the amount of light available to key sensitive receptors, such as seagrass and coral, negatively impacting photosynthesis. The distribution of seagrasses in western Moreton Bay is influenced by light availability, with the bottom of the seagrass depth range generally indicating the minimum light requirements.

The objective of the turbidity logging at Toondah Harbour was to provide a long term baseline of turbidity conditions, which can then be used to derive trigger levels for the proposed works. The turbidity data can also be used in the water quality modelling (when correlated with TSS data also collected in late 2015).

Turbidity was logged at three sites (Map 1):

- Logger 1 was located offshore of the PDA boundary (528776.42 m E; 6955817.37 m S): this site was selected to establish a baseline for turbidity in an area that may be impacted by reclamation of the PDA area, and is at the bottom edge of the seagrass.
- Loggers 2 and 3 were located near the Fison Channel (529220.27 m E; 6953925.39 m S; 530487.58 m E; 6954314.20 m S): these sites were selected to provide baseline data for the area that may be impacted by

dredging the channel. Both sites were at the bottom edge of seagrass, and there was also some sparse coral at Site 3.

Loggers were placed in a mounting structure that was secured in the sediment with star pickets (Figure 1). Equipment was clearly labelled with ‘frc environmental Pty Ltd’ and ‘Permit number QS2014/CVL125’ and was marked with a floating buoy. Loggers measured turbidity (NTU) generally every 15 minutes. Loggers were serviced approximately every 2 weeks, which involved downloading data, cleaning any biofouling, replacing batteries and calibrating the loggers.

Data logged between 9 September 2015 and 22 September 2017 was cleaned and analysed by Truii (refer to Appendix A). After cleaning there were between 51,542 and 57,275 individual turbidity readings for each of the three loggers.

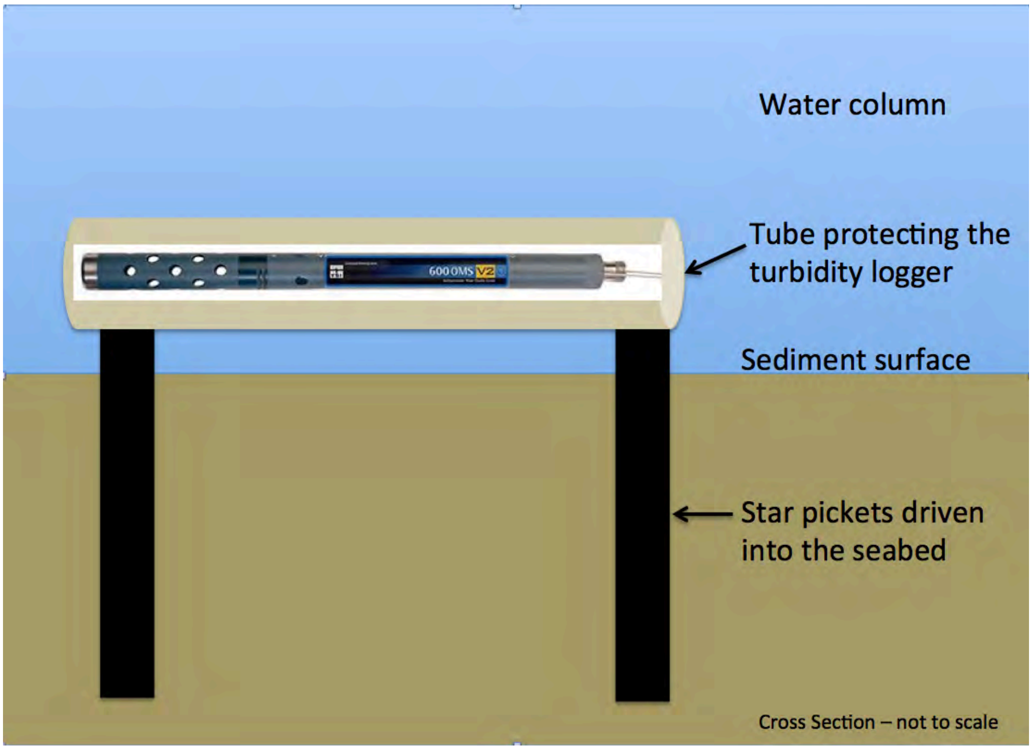

Figure.1 Cross section of turbidity logger placed in Toondah Habour.

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Toondah Harbour
Installation and Maintenance of Loggers

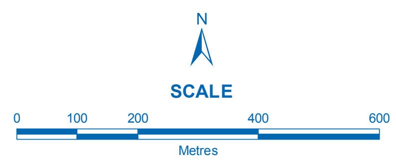
Map 1:
Toondah Harbour loggers

SOURCES

Document Path: Y:\Projects\2015\150803_AEC_Toondah_turbidity\Mapping\Workspaces\150803_Logger_Locations_Sep16.mxd

LEGEND

Logger



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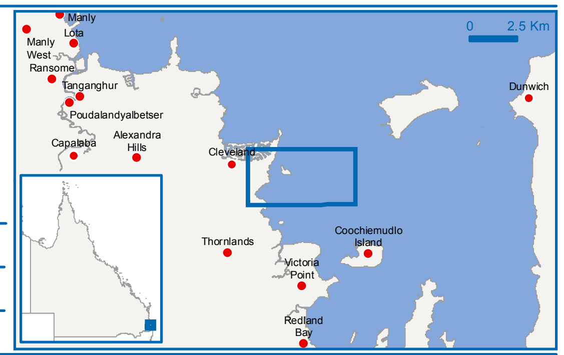


Summary of Data

The mean turbidity over the 24 months of sampling was lower at site 3 (12.6 NTU) than at sites 1 (20.6 NTU) and 2 (30.5 NTU). Overall, turbidity was generally highest during the wetter seasons of late spring and summer at all sites (Appendix A). During the wet season, sediment laden runoff and resuspension of sediments by strong winds can lead to a reduction in water clarity.

Water Quality Objectives

Water quality in Queensland is protected under the *Environmental Protection (Water) Policy 2009 (EPP (Water))* using Water Quality Objectives (WQOs). The *Moreton Bay Environmental Values and Water Quality Objectives (June 2010)* specifies a WQO for the project area (Area C2 on Plan WQ1441) for turbidity of 5 NTU. The median turbidity at all three sites over the 24 months (7.8 NTU to 11.1 NTU) exceeded the WQO. Turbidity at all three sites generally complied with the WQO in winter and exceeded the WQO during late spring and summer. Consequently, it is advisable to set local water quality objectives or trigger levels for this area, before development work starts. The *Queensland Water Quality Guidelines 2009* recommends that trigger levels should be based on data collected preferably over 24 months in order to capture two complete annual cycles. Data has been collected over 24 months at Toondah Harbour and thus can be used to calculate local trigger levels for the development. However, given data is currently still being logged at the three sites, it is advisable to calculate trigger levels on completion of the program when the loggers are removed to incorporate all available data.

Analysis of Data Regarding Ferry Movements

There is a visible increase in turbidity in Fison Channel associated with ferry movements. This has been observed by staff when downloading data from the loggers. Site 2 is located very close to Fison Channel. However there was no obvious relationship detected between ferry passing and turbidity levels at site 2.

Given turbidity levels can be visually seen as a result of the passing ferry, we recommend this is investigated further. This could be done by moving the position of the loggers to specifically target areas likely to be impacted by ferry movements and by recording passing ferries. This will assist in determining the likely impacts of the proposed works (i.e. deepening the channel is likely to reduce turbidity associated with ferry movements).

Consequently identifying the contribution of ferry movement to current turbidity levels will be a key consideration in assessing impacts from the proposed development.

Analysis of Data Regarding Tides, Rainfall and Wind

Typically turbidity in Moreton Bay is highest in the late spring and summer when strong south-east and north-east winds resuspend the sediment and rainfall is more prominent. However, there was no significant relationship between tide, rainfall or wind and turbidity when assessed throughout the 24 month period (Appendix A).

Conclusion

Turbidity is a measurement of water clarity and provides important information on the potential impact of dredge and reclamation works on the marine environment. Higher turbidity indicates reduced light reaching key benthic habitats, such as seagrass and coral.

Turbidity has been logged (approximately every 15 minutes) at three sites near seagrass and / or coral habitat near the proposed development at Toondah Habour over 24 months. The median turbidity over 24 month at all three sites exceeded the WQO, with median values generally compiling with the WQO in winter months and exceeding the WQO in late spring and summer months. During the wet season, sediment laden runoff and resuspension of sediments by strong winds are likely to lead to a reduction in water clarity. Consequently, it is advisable to set local trigger levels for this area before development work starts. Data has been collected over 24 months at Toondah Harbour and thus can be used to calculate local trigger levels in accordance with the *Queensland Water Quality Guidelines 2009* prior to the development.

Given turbidity levels can be visually seen as a result of the passing ferry, we recommend this is investigated to assist in determining the likely impacts of the proposed works, including whether deepening the channel is likely to reduce turbidity associated with ferry movements. This could be done by moving the position of the loggers to specifically target areas likely to be impacted by ferry movements and recording passing ferries.

Seagrass and coral survival and growth is related to the amount of light they receive, in particular the amount of photosynthetically active radiation (PAR). The amount of PAR light they receive is dependent on a number of factors including day length, cloud cover, surface light intensity, water depth, water colour and water clarity. While turbidity gives an indication of the amount of light available to seagrass it does not give an accurate measurement. To ensure the most appropriate minimum light requirements are established for the seagrass and coral habitat adjacent to Toondah Harbour, we recommend PAR is logged in addition to turbidity.

Kelli, if you have any further queries related to this data analyses, please let me know.

Yours sincerely,

Liz West
on behalf of frc environmental

Appendix A Detailed Statistical Analyses

Cleveland Turbidity analysis

Prepared for FRC Environmental

21 October 2017

Dr Nick Marsh

Managing Director

1 Executive summary

There where statistically significant associations between all of the potential influencers of turbidity and the turbidity value, however the overall variability in turbidity explained by these parameters is low.

No correlations with predictive power between turbidity and environmental (rainfall, wind speed, tide height) or ferry passing were detected.

2 Background

FRC environmental commissioned Truii Pty Ltd to conduct analysis on three turbidity loggers located in Moreton Bay (near Cleveland). The brief was to investigate the relationship between turbidity levels and environmental factors (rainfall, wind speed and direction and tidal influence) as well as the impact that ferry's may have on turbidity levels. Specifically the turbidity for Logger 2, located near the ferry channel.

3 Input data and preparation

3.1Supplied data - Turbidity

Data from three turbidity loggers was supplied. The turbidity data spans the period 9 September 2015 – 22 September 2017.

The turbidity data was cleaned based on the following procedures

- All negative turbidity values were removed.
- Isolated turbidity spikes above 50NTU were removed, where a spike was defined as exceeding the mean of the preceeding ten samples by a factor of 3 (see Figure 1).
- Specific periods where obvious drift occurred and data removed as noted in table.

Table 1: specific periods where data was removed due to apparent logger drift (extended elevated NTU records)

Start	end	logger	rationale
04 Oct 2015	10 Oct 2015	1	Consistently >500NTU
02/03/2016	12/03/2016	1	Drift period
19/04/2016	27/04/2016	1	Consistently >500NTU
1/9/2016	13/09/2016	1	
23/09/2016	11/10/2016	1	Elevated – doesn't return to baseline
03/11/2016	11/11/2016	1	Elevated – doesn't return to baseline
21/5/2017	1/7/2017	1	Elevated – doesn't return to baseline
22/12/2015	29/12/2015	2	Very high for several days
03/07/2016	15/07/16	2	drift
28/07/16	13/08/16	2	drift
2/3/17	10/4/17	3	Drift
29/6/17	21/7/17	3	drift

Even after the above data cleaning steps there are many very high spikes > 200NTU (especially for logger 2) which may need further investigation.

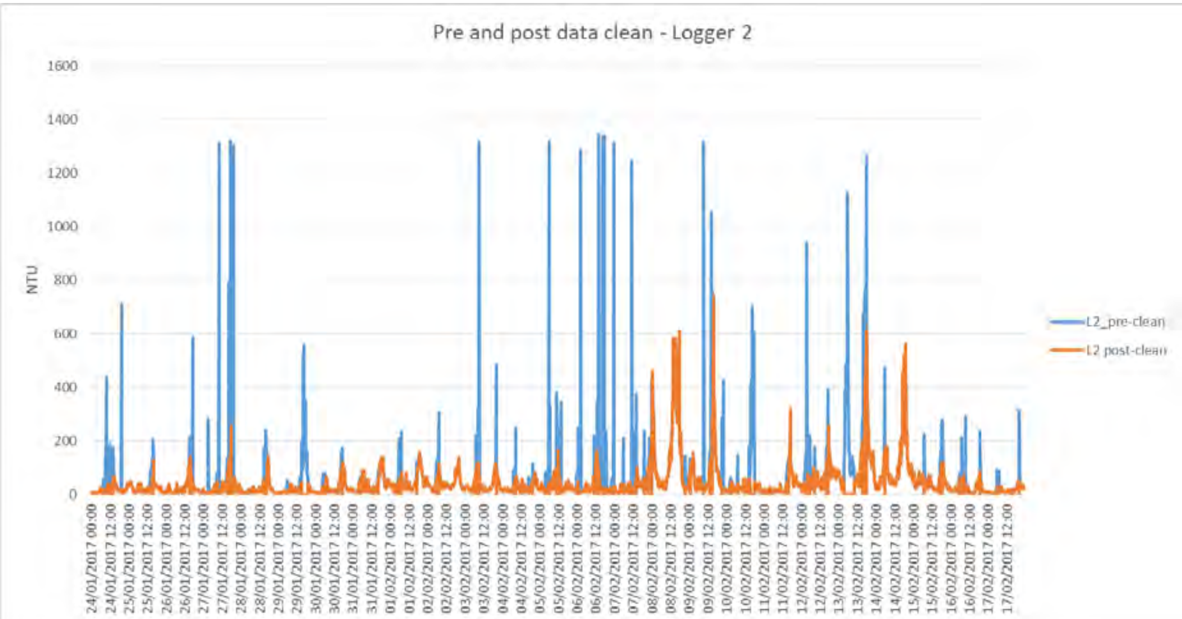


Figure 1: Example of unexplained peak NTU value removal for logger 2.

3.1.1 Turbidity data summary

After cleaning there were 50,000-57,000 individual turbidity samples for each of the three loggers (data summary in Table 3). The long term median turbidity value for the area was approximately

10NTU (Table 2). Logger 2 (near the ferry channel) had a similar median (baseline) but more and higher peaks demonstrated by the 95th percentile of 100NTU.

The coloured cells in Table 3show that there is a consistent temporal pattern across the three loggers (high months are high in all three loggers).

Table 2: long term turbidity values

	Logger1	Logger2	Logger3
Count	51542	57275	55375
Mean	20.6	30.5	12.6
StDev	31.1	81.0	19.5
median	9.7	11.1	7.8
95th%ile	74.9	100.0	40.4
5th%ile	1.2	0.9	0.8

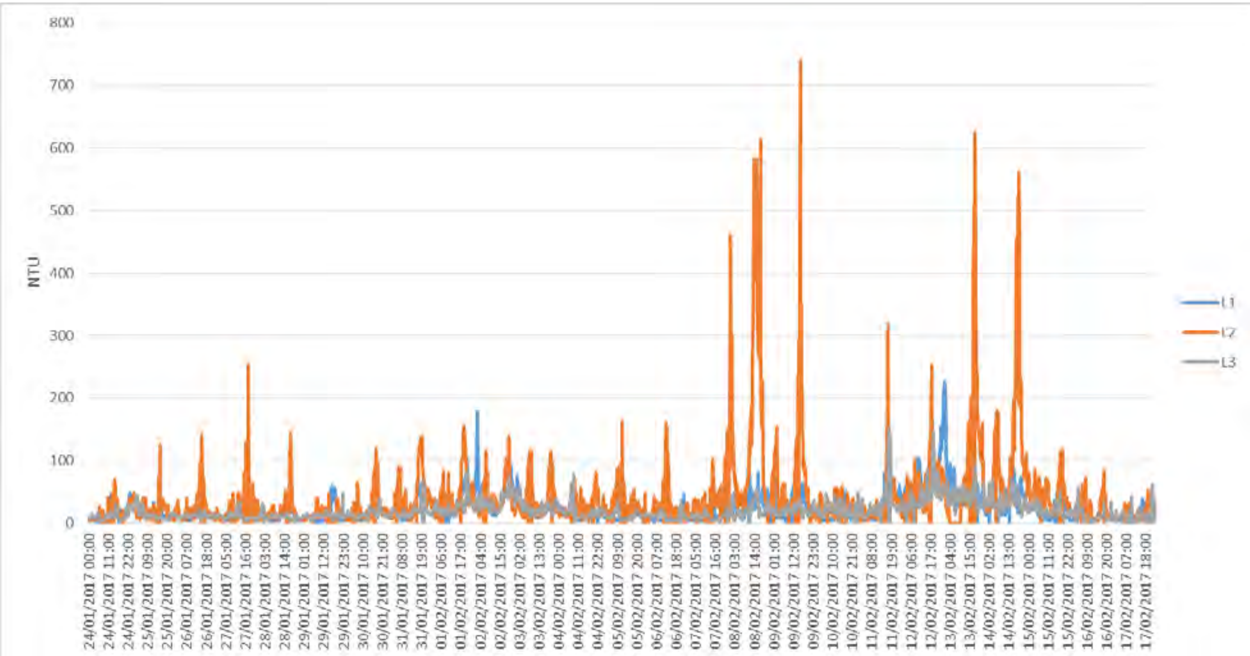


Figure 2: Example month sampling across three turbidity loggers (cleaned data).

Table 3: Cleaned turbidity data summary

Yr	mnth	Logger 1						Logger 2						Logger 3					
		n	Mean	StDev	median	95th%ile	5th%ile	n	Mean	StDev	median	95th%ile	5th%ile	n	Mean	StDev	median	95th%ile	5th%ile
Monthly summary																			
15	9	155	18.6	16.8	14.0	51.3	0.0	651	30.5	19.2	5.6	51.05	0.3	826	5.6	5.0	4.1	12.6	1.8
15	10	2071	21.2	31.0	11.1	69.1	3.5	2503	23.8	29.3	13.5	76.0	1.9	2448	11.2	17.9	6.4	36.2	0.9
15	11	2832	39.1	45.6	22.2	129.4	4.0	2694	39.0	50.4	22.0	137.9	5.5	2838	19.6	16.8	13.8	52.6	4.9
15	12	2857	25.6	34.5	14.8	79.8	4.7	2187	39.0	51.2	23.4	121.4	7.2	2918	16.9	13.4	12	46.2	6.1
16	1	2937	19.5	25.7	10.1	75.6	2.8	2734	20.5	26.8	10.8	69.4	1.7	2826	19.8	24.8	11.9	63.2	4.0
16	2	1555	27.3	23.2	18.1	76.4	5.5	2521	31.4	36.6	18.3	104.9	5	2715	16.1	12.8	12.5	44.9	5.6
16	3	1926	10.4	10.0	6.4	28.6	3.1	2610	11.7	14.6	6.9	37.3	1.4	2495	7.5	5.7	6.1	15.9	2.8
16	4	2067	12.3	10.9	8.6	32.5	3.8	2432	13.1	16.2	7.4	48.7	0.5	1830	4.8	5.0	3.3	14.1	0.9
16	5	1995	7.9	16.2	4.0	20.7	0.6	2882	7.0	11.2	2.9	30.5	0.4	2067	4.2	4.2	2.9	11.5	1.0
16	6	2796	10.2	24.8	3.4	40.0	0.8	2695	16.1	19.7	7.2	54.5	2.3	2850	3.7	6.2	1.6	15.8	0.2
16	7	2826	5.1	13.9	2.1	19.4	0.1	1345	12.0	16.2	4.8	45.2	0.6	2946	1.4	2.1	0.9	4.1	0.2
16	8	2916	5.5	6.1	3.4	18.4	0.6	1652	9.1	12.5	3.9	37.9	1.1	2949	6.8	14.7	2.5	48.2	0.5
16	9	927	31.1	30.9	21.9	96.2	3.2	2699	19.3	23.9	10.8	67.1	3.29	2595	21.0	60.2	5.9	78.4	2.0
16	10	1829	25.4	22.9	19.4	63.9	3.4	2797	18.5	24.6	11.1	58.0	2.4	2884	11.0	11.8	7.8	31.1	2.8
16	11	1889	29.1	39.8	13.0	109.2	2.1	2687	18.1	20.2	11.6	54.4	2.5	2111	14.2	12.5	10.1	41.8	3.6
16	12	2627	44.4	45.9	29.6	133.1	3.3	2474	56.6	70.8	37.7	164.1	1.665	2128	24.0	21.1	19.85	55.7	4.8
17	1	2613	29.7	31.0	19.5	90.7	3.9	2500	53.1	63.6	30.9	190.1	5.9	2602	19.9	14.9	15	48.0	5.9
17	2	2658	28.8	25.9	21.3	79.9	4.0	2332	190.5	300.1	42.4	924.2	8.7	2627	19.6	14.7	15.8	47.6	5.0
17	3	546	16.9	17.8	10.3	51.8	4.1	2643	51.0	106.9	15.8	212.9	2.6	86	15.6	5.5	14.9	25.7	8.3
17	4	2773	20.7	20.6	13.0	56.0	3.9	1759	46.5	64.0	20.4	180.9	1	1766	16.2	10.0	13.6	36.3	6.1
17	5	860	17.5	17.8	11.0	53.6	1.0	2710	12.3	17.1	6.1	48.7	1	2316	10.7	8.0	8.8	26.1	2.3
17	6	60	13.2	11.5	7.4	31.7	1.4	2768	8.6	12.6	3.5	35.3	0.3	2100	10.6	10.1	7.4	31.8	1.4
17	7	2947	7.0	10.9	3.6	27.3	0.7	1801	8.5	13.4	3.2	34.4	0.1	1039	6.9	9.1	4.1	24.4	1.5
17	8	2958	16.5	33.4	7.1	54.7	1.3	2434	9.5	13.5	3.9	38.0	0.2	1911	11.7	13.4	6.8	40.9	1.4

Yr	mnth	Logger 1						Logger 2						Logger 3					
		n	Mean	StDev	median	95th%ile	5th%ile	n	Mean	StDev	median	95th%ile	5th%ile	n	Mean	StDev	median	95th%ile	5th%ile
17	9	1930	29.4	56.5	11.4	121.2	2.4	767	18.1	25.8	9.4	55.6	0.6	1509	7.8	13.9	3	33.4	0.7
Annual Summary																			
15		7915	29.2	38.6	16.1	98.3	3.9	8035	32.2	44.1	18.4	105.7	2.7	9030	15.1	16.0	10.4	46.6	2.2
16		26290	17.7	27.9	7.6	70.3	0.9	29528	19.8	31.9	9.3	70.8	1.1	30396	11.1	22.8	5.6	38.3	0.6
17		17345	20.9	31.2	10.5	69.5	1.6	19714	45.8	127.8	11	182.0	0.6	15956	13.9	13.1	10.2	40.4	1.6

3.2 Sourced and derived data

3.2.1 Wind Speed and direction

The wind speed and direction data for the Birsbane airport was sourced from the Bureau of Meterology. The last 14 months of daily summaries only is available (August 2016 – September 2017).

The maximum daily wind speed and direction was disaggregated to apply to all 15 minute time steps for the record. The wind direction was converted to four primary prevailing wind directions (N, E, S, W).

3.2.2 Rainfall

Daily rainfall data for the Brisbane Airport was used for the period august 2016-september 2017. The daily rainfall data for Cleveland (from SILO point drill) was used to represent rainfall from September 2015 – August 2016).

3.2.3 Ferry times

The possible passing of ferry times was based on the ferry timetables for the North Stradbroke Island vehicle ferry and the bay islands vehicle ferry (https://www.stradbrokeferries.com.au/timetables/). The arrival times for the North Stradbroke island vehicle ferry were estimated based on the Dunwich departure times +50 minutes as the advertised travel time.

In order to develop a time series represent when the ferries would pass logger 2 (which is 5 minutes travel time from the ferry terminal) each of the ferry arrival times was reduced by five minutes and each departure time was increased by five minutes. A data set was then created at the same 15minute time intervals as the turbidity logger data. Each record presents a score of potential ferry impact at the site. The scoring schema used was:

Score = 3 if ferry passed within 0-5 minutes of logger sample time

Score = 2 if ferry passed within 5-10 minutes of logger sample time

Score = 1 if ferry passed within 10-15 minutes of logger sample time

Score = 0 if ferry passed logger >15 minutes from sampling time

The ferry impact series takes account of the varying Ferry timetables for different days of the week (mon-thur, Fri, Sat, Sun). the ferry series does not take account of public holiday timetables.

3.2.4 Tidal data

The hourly measured Brisbane bar height (data sourced from https://uhslc.soest.hawaii.edu/data/?fd#uh331). The hourly water levels where linearly interpolated to give an approximate water level at the 15 minute turbidity sampling intervals.

Where low tide was specifically analysed, this has been assessed as the lower 1/3 of water levels across the analysis period.

4 Analysis

The basic approach for the analysis was to determine the impact if any of local ferry traffic on turbidity levels. The turbidity values are high variable through time. The first steps of this anslysis where therefore to identify and remove the effect of rainfall and wind induced wave action from the turbidity data. The residuals (turbidity not due to rainfall and wind) were then considered in terms of the potential contribution to the turbidity from local ferry movements (particularly at low tide).

4.1Effect of rainfall on Turbidity

The first consideration was to look at the effect of large rainfall events on the local turbidity either through major river outflows (multiple day impacts) or local stormwater impacts (single day). The overlay of rainfall timeseries and turbidity data showed no clear relationship (see Figure 3). Similarly a correlation test between rainfall and turbidity showed no significant relationship (slope of best fit not significantly different from zero (@P<0.05).

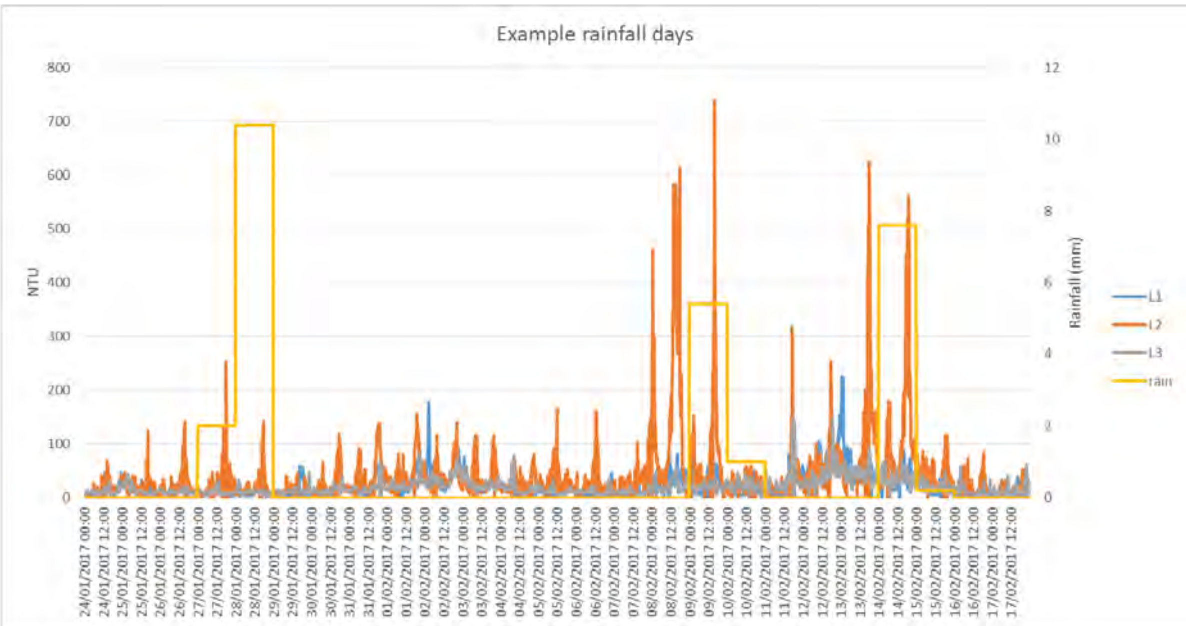


Figure 3: There is no discernible pattern between rainfall and the local turbidity values over the data collection period.

Given the low overall correlation between rainfall and turbidity, rainfall was not considered further in the analysis.

4.2Effect of wind direction

The dominant wind direction was divided into four wind quadrants (N, E, S, W) for the 13 month period of available wind data. For each of the prevailing wind direction subsets of data, the correlation between the speed of the maximum wind gust for the day and the logger2 turbidity values was tested.

Table 4 shows that the relationship between wind speed and turbidity for logger 2 was significant ($P<0.05$) for each quadrant, however the predictive power was very low (low R^2). The exception is the wind from the south which describes around 12% of the variance in turbidity. The reason for this higher correlation with southerlies is because the wind speed range for southerly was lower (max wind gust ~60km/h – compared to a 156km/h gust from the north).

To further explore the influence on wind direction and speed on turbidity, each of the four quadrant datasets was further subset to only include turbidity observations taken in the bottom third of the tide. The hypothesis here is that wind speed and direction is the primary driver of wave action in Moreton Bay. At low tide, the depth to the bay bed on average is reduced, increasing the opportunity for wave derived sediment resuspension during windy days. There was very little difference in the variance in turbidity explained by wind speed for the low tide subset data.

Given the low overall correlation between turbidity and wind the influence of wind direction and speed was not considered further.

Table 4: wind quadrant analysis summary

Wind Quadrant	Number of turbidity samples	Adjusted R2 for correlation	P value
N	12263	0.0264	1.64E-73
E	6277	0.01267	2.26E-19
S	8760	0.1245	1.8E-255
W	3071	0.030778	7.20E-23

4.3Tidal impact

One would expect a greater turbidity value at low tide, simply due to wave action interacting with the bed. Figure 4 shows a regular pattern of turbidity spike in logger 2. However this does not maintain an in-phase association with the tidal cycle. A regression analysis between water level and logger 2 turbidity gives a significant P value ($p<0.05$) however the variance in turbidity explained by water level is very low (R^2 0.011). We further partitioned the data to just look at this relationship for low tide (bottom 1/3 of the tidal cycle). The r2 was slightly improved but still very low (R^2 0.015)

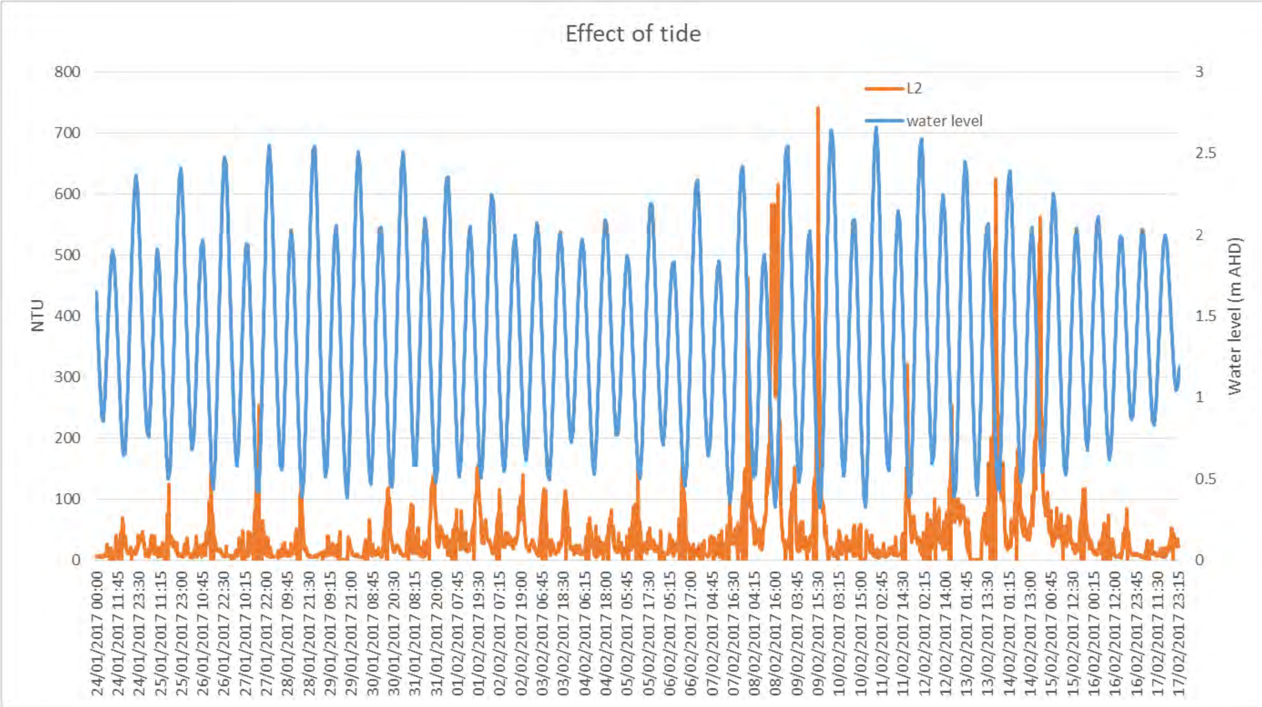


Figure 4: effect of tide on Logger 2 turbidity. Turbidity spikes roughly coincide with low tide, but there are several exceptions.

4.4Ferry impact

Logger 2 is located very close to the main ferry channel. This analysis is to consider how the turbidty values are correlated with the time since ferry passing. The purpose of the analysis is to determine if the ferries are significantly increasing the turbidity. From Figure 5 there is no obvious relationship between ferry passing and turbity levels. This is demonstrated by a correlation check (R^2 0.0015). Even if we only consider the low tide (bottom third of tidal range) then the effect of ferry passing only explains about 0.6% (R^2=0.006) of the variation in turbidity values.

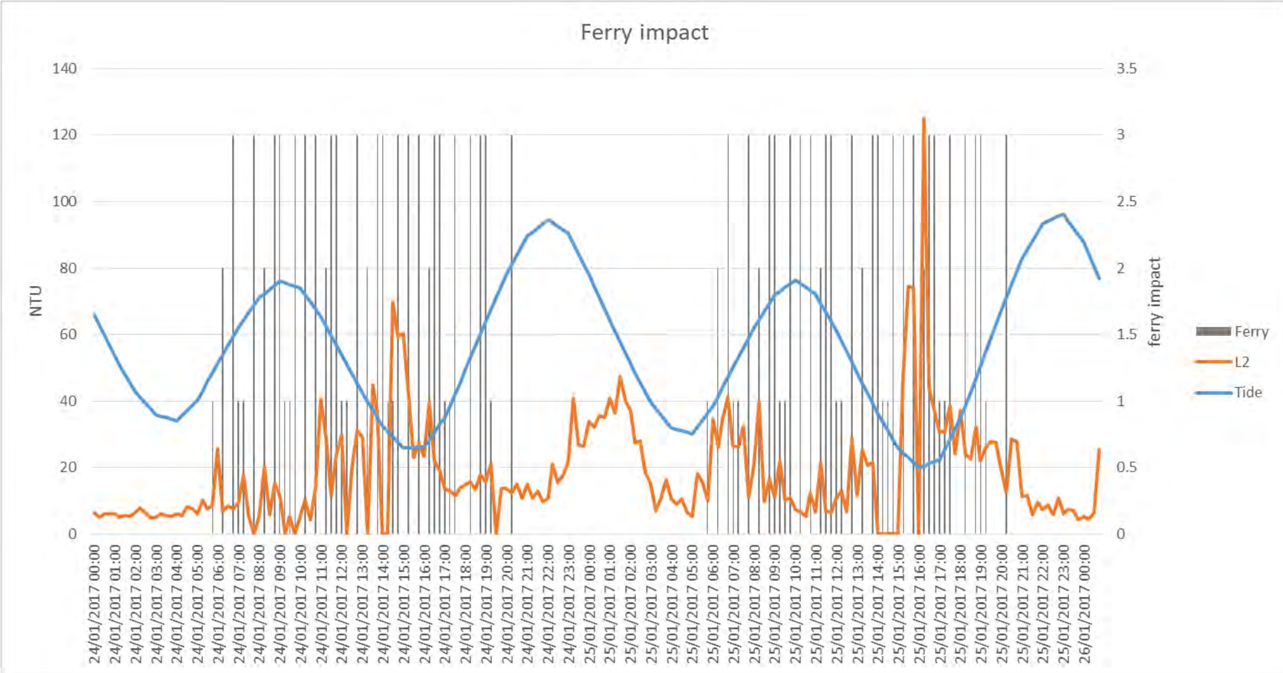
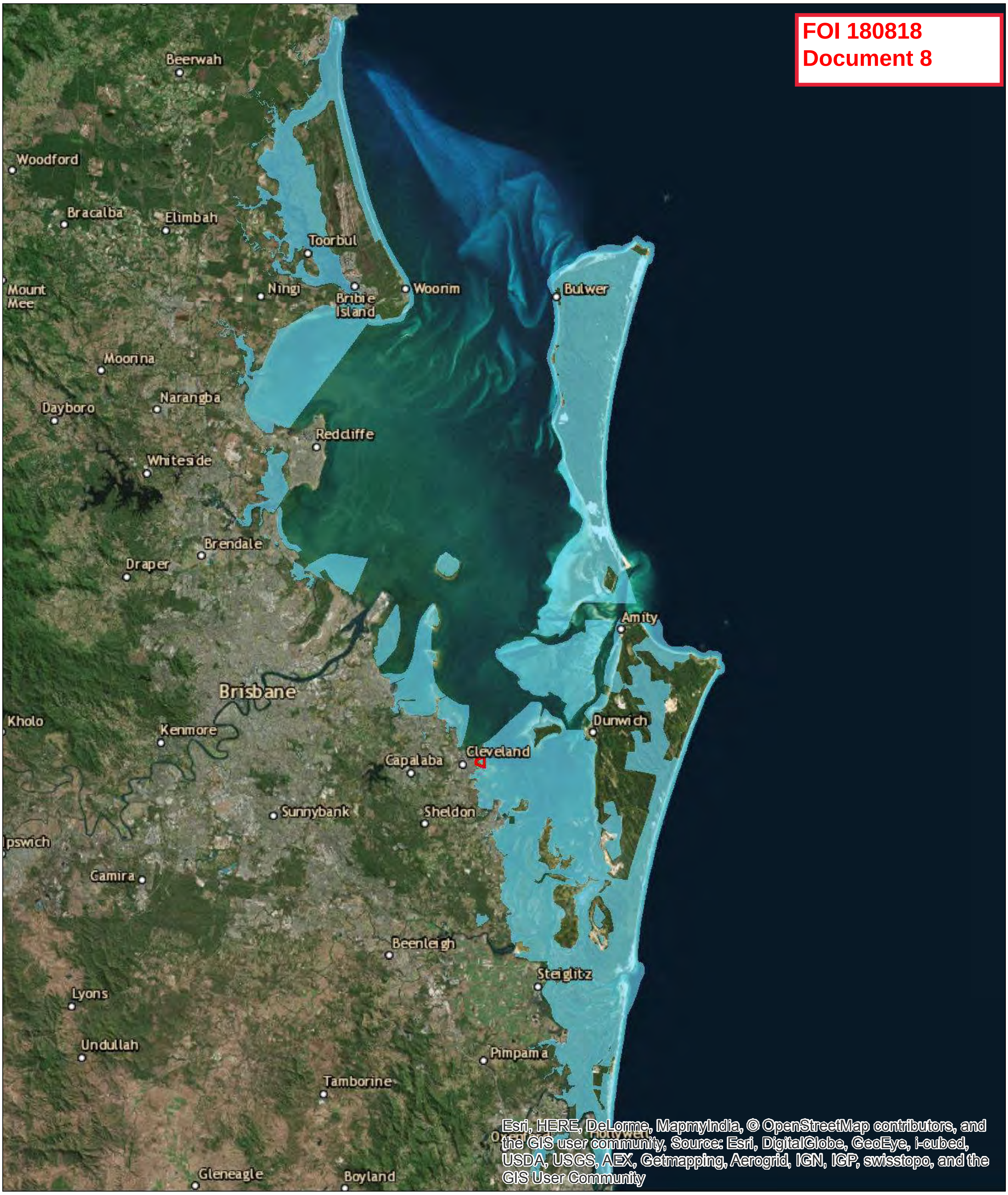


Figure 5: ferry impact (grey bars) shows no correlation with turbidity. There appears to be no strong tidal influence.



Legend

- PDA - Toondah Harbour
- Moreton Bay RAMSAR wetland

Figure 1 *Site Context*

File ref. 8444 E Site Context A
Date *20/04/2017*
Project *Toondah Harbour*

0 5 10 20 *Kilometers*

N

Scale (A4): 1:575,379 [GDA 1994 MGA Z56]

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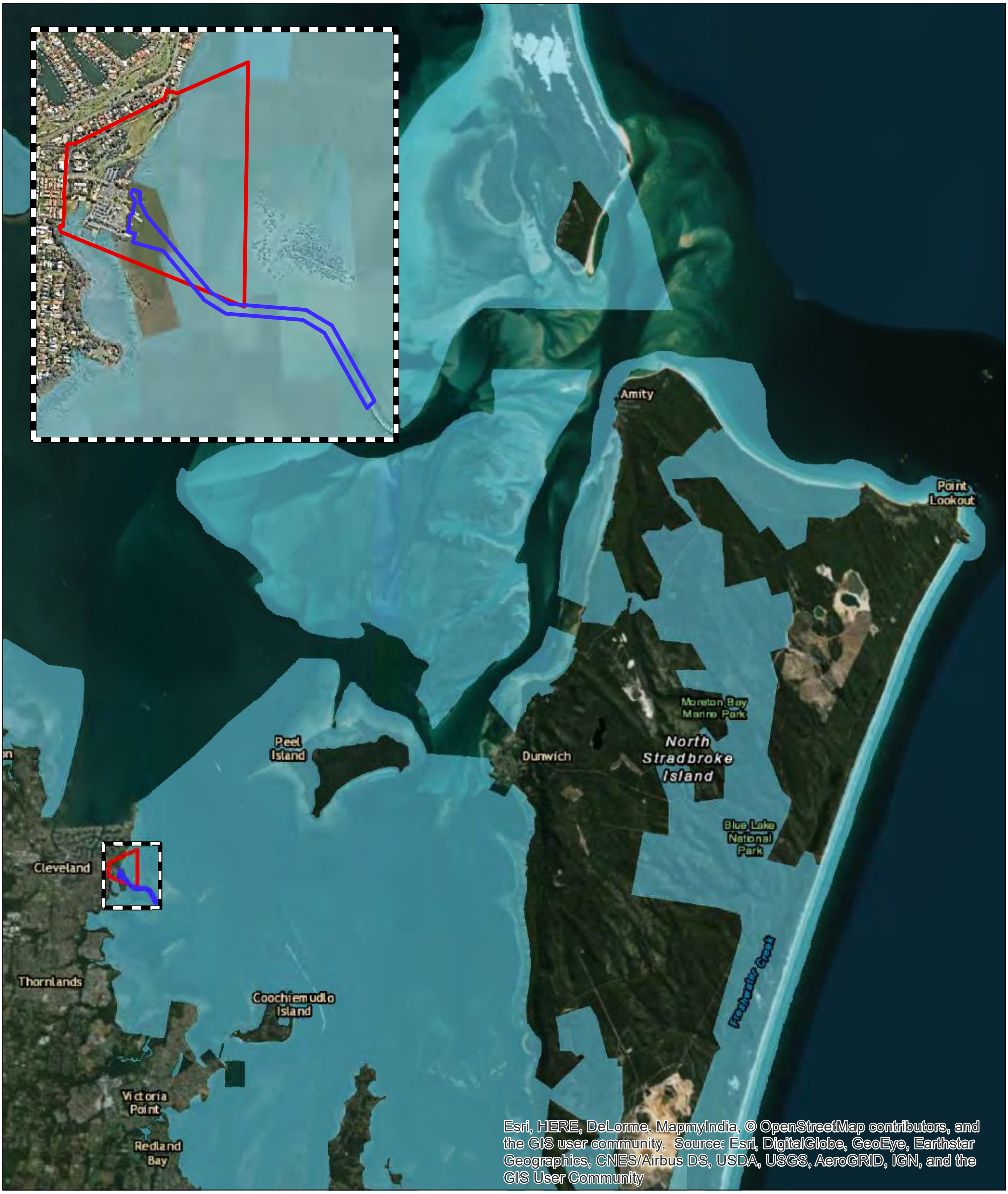
Layer Sources QLD GIS Layers (QLD Gov. Information Service 2014)



Legend

- PDA - Toondah Harbour
- Approved dredge area
- Moreton Bay RAMSAR wetland

Figure 1a *Site Context*

File ref. *8444_E_01_Context_approved_DA_A*
Date *4/05/2018*
Project *Toondah Harbour*

0 1 2 3 4 5 6 km

Scale (A4): 1:160,000 [GDA 1994 MGA Z56]

N

walker

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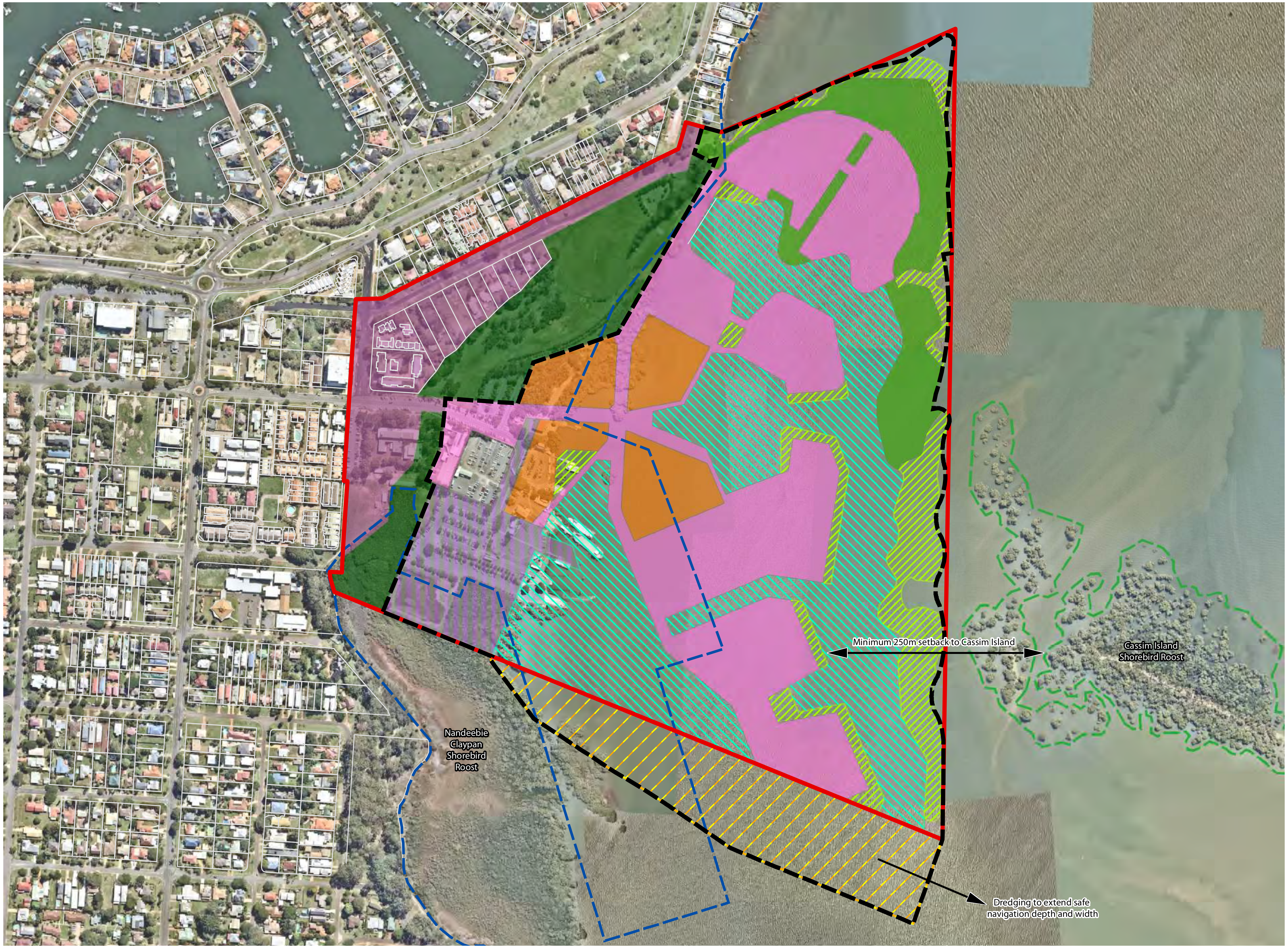
Layer Sources QLD GIS Layers (QLD Gov. Information Service 2018)

2. MASTER PLAN - BROAD LAND USES



NOTES
This plan was prepared as a desktop assessment tool.
The information on this plan is not suitable for any other purpose.
Property dimensions, areas, numbers of lots and contours and other physical features shown have been compiled from existing information and may not have been verified by field survey. These may need verification if the development application is approved and development proceeds, and may change when a full survey is undertaken or in order to comply with development approval conditions. No reliance should be placed on the information on this plan for detailed design or for any financial dealings involving the land. Saunders Havill Group therefore disclaims any liability for any loss or damage whatsoever or howsoever incurred, arising from any party using or relying upon this plan for any purpose other than as a document prepared for the sole purpose of accompanying a development application and which may be subject to alteration beyond the control of the Saunders Havill Group. Unless a development approval states otherwise, this is not an approved plan.

Layer Sources
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Legend

- Toondah Harbour PDA
- Referral Area
- Indicative Entrance Channel
- QLD DCDB
- Ramsar Wetland Boundary
- Mangroves

Broad Land Uses

- Mixed use centre
- Urban uses & wetlands (including walkways, pocket parks & communal spaces)
- Existing Infrastructure and Buildings
- Wetland Retention and Rehabilitation
- Open Space
- Retained Open Space & Intertidal Communities
- Upgraded Harbour
- Waterways

Issue	Date	Description	Drawn	Checked
A	14/03/2018	Preliminary	MC	SM
F	30/05/2018	Lodgement	MC	SM

0 25 50 100 150 200 m

Transverse Mercator | GDA 1994 | Zone 56 | 1:5,500 @ A3

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TOONDAH HARBOUR, CLEVELAND

Figure 3 Concept urban Development Precinct

File ref. 8444_E_F3_Concept_urban_dev_A
Date 30/05/2018
Project Toondah Harbour

0 50 100 200 300 Meters
Scale (A4): 1:8,000 [GDA 1994 MGA Z56]
N

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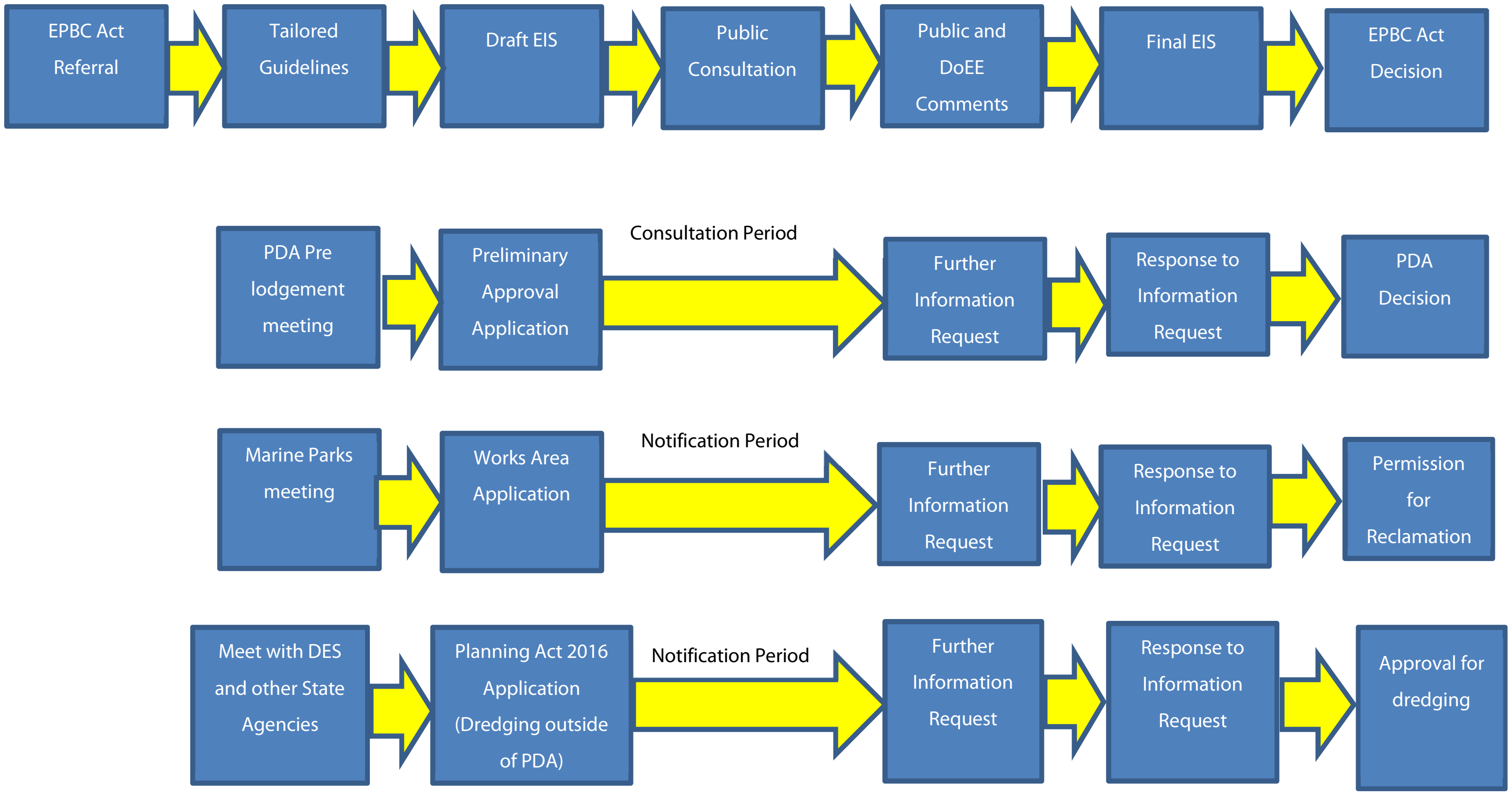

Figure 4: Approvals Flowchart

Toondah Harbour Priority Development Area Development Scheme

Submissions Report

Under the *Economic Development Act 2012*

May 2014

Contents

1. Introduction

The Toondah Harbour Priority Development Area (PDA) was declared at the request of Redland City Council (RCC) on 21 June 2013. Planning of the Toondah Harbour PDA has been managed by the Minister for Economic Development Queensland (MEDQ) in partnership with RCC.

The Toondah Harbour PDA is located on the southern shores of Moreton Bay in Cleveland, approximately one kilometre east of the Cleveland CBD. The PDA covers landholdings located at Middle Street, Cleveland and covers a total area of approximately 67 hectares, including 17.5 hectares over land and 49.5 hectares over water within Moreton Bay.

It is a recognised boat landing and acts as the point of departure and arrival for vehicular ferry and water taxi services between the mainland and North Stradbroke Island. The area is also comprised of residential and open space.

Development of the PDA provides an opportunity to support economic development and will seek to reinforce Toondah Harbour as a community focus and a regional gateway to Moreton Bay and North Stradbroke Island. Development will include opportunities for mixed use and medium density residential development as well as tourism and retail based development, dedicated ferry terminals, public open space and the potential for a private berth marina.

The public notification and submission period for the Toondah Harbour PDA Proposed Development Scheme was undertaken from 10 January to 24 February 2014. This period coincided with the public notification of the Weinam Creek PDA Proposed Development Scheme which is also within the RCC Local Government Area.

Following the end of the public notification, submissions received were considered by the MEDQ and RCC and the proposed development scheme was amended as considered appropriate in response to issues raised. This report has been prepared to summarise the submissions received by the MEDQ and RCC, provide information on the merits of the submissions and the extent to which the proposed development scheme has been amended.

The MEDQ and RCC engaged with state agencies in the drafting of the development scheme and have incorporated comments where appropriate.

The MEDQ has now made the development scheme which is available to view on the Department of State Development Infrastructure and Planning (DSDIP) website at www.dsdip.qld.gov.au/toondahPDA. The MEDQ will publish a notice in the local newspaper advising the public of the approval of the scheme. Additionally each person who made a submission during the submission period will be notified that the scheme has been approved and that this report and the development scheme can be viewed on the DSDIP website.

2. Overview of public notification process

2.1. Community engagement

The public notification and the submission period for the Toondah Harbour PDA Proposed Development Scheme was held from 10 January to 24 February 2014. A structured program of community engagement undertaken involving a range of approaches and media as follows:

- Council and state government officers have undertaken engagement on the PDAs since May 2013, including speaking directly with stakeholders and holding engagement sessions on the mainland and islands.
- Both the RCC and DSDIP websites and a dedicated developer's website *Redlands Open for Business and Investment* included frequently asked questions and information about the project. The DSDIP website also provided an online submission portal and the proposed development scheme for download.
- Hundreds of online comments were received via the DSDIP online portal, RCC website, Have your say website and through the interest register, which was set up in May 2013.
- Over 20 meetings have been held with key stakeholders for both Toondah Harbour and Weinam Creek to discuss issues, concerns and opportunities since June 2013.
- Widespread community consultation on the PDAs has included:
    - 10 community forums
    - website information
    - online submissions
    - ongoing interest register since May 2013
    - five community mail-outs
    - advertisements in local and state wide media
    - posters and other advertising at ferry terminals and on ferries
    - stakeholder meetings
    - articles in city wide RCC magazines and e-newsletters
    - Australia-first technology that allows a 3D view of the potential development in each PDA
    - telephone survey of 300 people
    - radio interviews (Bay FM and ABC)
    - display of the proposed development schemes throughout the statutory consultation period at 14 local libraries and three major Redlands shopping centres.

Three community information forums were held for the Toondah Harbour PDA Proposed Development Scheme, which were well attended. The locations of these forums were:

- Saturday 1 February 2014, 1pm - 3pm at Island View Cafe, Toondah Harbour Ferry Terminal
- Friday 7 February 2014, 3.30pm - 5.30pm at Island View Cafe, Toondah Harbour Ferry Terminal
- Saturday 8 February 2014, 1pm - 3pm at Dunwich Community Hall, Dunwich, North Stradbroke Island.

Other speaking engagements and presentations to key stakeholders were also provided to explain the development scheme.

2.2. Submission registration and review process

Submissions were received in hard copy at community information forums, by post, email, fax and via the online submission portal. Once a submission was received, submissions were registered and reviewed. This process was established to:

- consider all submissions in an objective, equitable and fair manner
- assist in the preparation of the submissions report
- provide guidance and advice to the Minister and the RCC in respect of preparing the final development scheme
- enable the Minister to comply with the requirements of the *Economic Development Act* 2012 (ED Act).

All submissions were treated as confidential. Some individual submitters chose to make the contents of their submissions public.

Where duplicate submissions were received which were exactly the same from the same submitter, the submission was counted only once. If a submitter lodged more than one submission covering different issues, the submissions were counted as separate submissions.

An EDQ submissions database was established to assist in the registration, classification and summary of submissions.

Table 1 below provides an overview of the submission registration and review process.

Table 1: Submission registration and review process

Step	Action / detail
1: Registration and acknowledgement of submissions	Submissions were registered and given a submission number Submitter was sent an acknowledgement letter
2: Classification of submissions	Submissions were classified by location, submitter and submission type. For further information see Section 3 below.
3: Summarising submission issues	Each submission was read and the different matters raised were entered into the submissions database under relevant topics. The database was then used to summarise and collate the matters raised into the Submissions Report. Each submission often covered a number of topics or issues, therefore allowance was made for the same or similar issues being raised in a number of submissions. This included receiving multiple submissions with similar views on a particular issue or submissions having different views on the same issue. For this reason, common issues across submissions were identified and these issues were summarised under common issue topics in the submissions report.
4: Evaluation and responses to issues	After all issues had been summarised under issue topics, the issues were assessed and responses were prepared. The assessment and response to issues was undertaken by EDQ and RCC in partnership. Where required further information from state agencies or specialist consultants was sought. Relevant changes to the document were identified. In evaluating submissions, allowance was made for the same or similar issues being raised in different submissions. For this reason, assessment of issues and resulting development scheme changes were made in relation to issue topics rather than a submission by submission basis.
5: Submissions report	The submissions report was prepared which collates steps 3 and 4 above, therefore providing a summary of the submissions considered, information about the merits of the submissions, recommendations on amendments to the proposed development scheme to reflect submissions and details of all changes to the proposed development scheme. To facilitate presentation and review of issues, issues were summarised into concise dot points under a common format.
6: Council workshops to consider submissions	RCC held two workshops with councillors on 4th and 11th of March 2014 to review and provide feedback on issues raised and suggested responses to those issues. RCC reviewed key issues raised and made recommendations on development scheme amendments at the Council meeting on 20th March

	2014.
7: ED Board meeting	The Economic Development (ED) Board reviewed key issues raised and considered RCC's recommendations for amendment to the development scheme at the ED Board meeting on 26th March 2014.
8: MEDQ approval	The final submissions report and development scheme was submitted to the MEDQ for his review and approval.
9: Governor in Council approval and adoption of development scheme and notice to submitters	After the MEDQ approved the submissions report and development scheme the *Economic Development Regulation 2013* was amended by the Governor in Council to give effect to the Toondah Harbour Development Scheme, which supersedes the Interim Land Use Plan. As soon as practicable after the development scheme takes effect, the MEDQ will publish the scheme and submissions report on the DSDIP website. The MEDQ will also publish in at least one newspaper circulating in the local area, a notice stating the scheme has been approved and it can be inspected on the department's website, along with the submissions report. Additionally the MEDQ will notify RCC and each person who made a submission within the submission period, that the scheme has been approved and is available on the department's website along with the submissions report.

3. Overview of submissions

3.1. Submitter type

A total of 583 submissions were received during the submission period, including submissions from private individuals, community organisations, businesses, commercial organisations and professional organisations. 44 submissions were received after the submission period had closed.

Refer to Table 2 for a breakdown of submissions received during the submission period, from different submitter types.

Table 2: Breakdown of submissions by submitter type

Type of submitter	Number of submissions received
Private individual	568
Community organisations	5
Professional organisations	3
Commercial organisations	7
Total submissions	583

3.2. Submitter location

The origin of submitters (by suburb) is shown in Table 3.

Table 3: Breakdown of submissions by submitter location

Location	Number of submissions received
Within PDA or immediate adjoining suburbs (postcodes 4160, 4161, 4163, 4164)	323
Other submissions from Redland City Council local government area	114
Other submissions from South East Queensland	32
Submissions from other areas	0
Submissions received via email with no address details	114
Total submissions	583

3.3. Submission type

A number of different types of submissions were received including general letters or online submissions, form letters or petitions.

Submissions were considered to be form letters where they used a pro-forma document or a standard set of words, which was then signed by individuals or organisations, and eight or more of this type of submissions were received.

Submissions were also received in the form of petitions signed by a number of people. These were treated as a single general submission and were registered under the name of the person submitting the petition. Table 4 below provides a breakdown of submissions by submission type.

Table 4: Breakdown of submissions by submission type

Type of submission	Number of submissions received
Letter or hard copy submission form	49
Email	188
Online submission	122
Form letter	218
Petition	1
fax	5
Total submissions	583

3.4. Overarching areas of support

Submissions raised a complex variety of different opinions on different matters. Submissions often supported some aspects of the development scheme but had concern for others. Below is a summary of the overarching areas of support identified in submissions.

- General support for redevelopment of the area and underutilised land within the PDA.
- Support for improvements to island access and the enhancement of the area as a gateway to North Stradbroke Island, including revitalisation of the car and passenger ferry terminals. Many submitters suggested that the redevelopment of the ferry terminals was overdue and a much needed improvement to the area.
- Support for improvements to pedestrian and cycle networks, particularly where they provide increased access to the foreshore and bay.
- Support for improvements to local roads and public transport infrastructure.
- Support for the creation of world class facilities which will attract tourists and visitors to the area, as well as creating and supporting employment opportunities.
- Support for the improvement and enhancement of the public realm and open space including the delivery of the public foreshore promenade.

3.5. Overarching areas of concern

Submissions raised a complex variety of different opinions on different matters. Submissions often supported some aspects of the development scheme but had concern for others. Below is a summary of the overarching areas of concern identified in submissions.

- There is concern about building heights identified in the scheme. In particular, potential impacts to amenity, loss of views and breezes and development which conflicts with the character of the area.
- There are concerns that the impact on habitat, animals, environmental processes and ecosystems is not adequately considered and that these are not protected in the development.
- There is concern regarding the traffic network and parking provisions in regard to meeting the demand of the current and future population of the area. Many submitters were concerned that the current network would be unable to support the needs of the proposed development and population.
- Significant concern about the future use of GJ Walter Park. Many residents were concerned that medium or high density residential development would be detrimental to the amenity and negatively impact the heritage and community value of the park. Concerns related to the reduction in size of GJ Walter Park and that open space provision will fall short of the demand of the area.
- There are some concerns that the marina development will reduce access to the foreshore, park and promenade and impact park area.
- There are concerns that the marina development, dredging and ferry movements will impact on the ecology of the bay.
- Concern regarding the public consultation period, in which many submitters voiced concerns that the community views and values were not adequately represented in the proposed scheme. Submitters were concerned that consultation was tokenistic and that their wishes would be disregarded in favour of private development.

- Concern that additional costs may be incurred by ratepayers due to new and upgraded infrastructure i.e. car parking (subsidies and facilities), ongoing dredging of the marina and ferry services.

4. Summary and merits of submissions relating to development scheme content

4.1. Vision and overall approach

Matter #	Summary and merits of matters raised in submissions: **Vision**	Assessment	Amendment Y / N
Vision			
1.	A similar 1980s proposal was widely opposed and did not go ahead. Question why a PDA has been declared here and why development of the area is again being considered.	The PDA was declared under the *Economic Development Act 2012* at the request of RCC. The Act's purpose is to facilitate economic development and development for community purposes. The development scheme therefore seeks to support opportunities for economic development which will provide new public infrastructure and facilities that will benefit both mainland and island communities. It was identified that development outcomes could be more efficiently facilitated under the *Economic Development Act 2012* and a development scheme, than what could be achieved under the *Sustainable Planning Act 2004* and the Redlands Planning Scheme.	N
2.	Support for the overall vision for the PDA. Believe development is timely and will encourage increased investment, tourism and employment opportunities in the area. Specific areas of support included: • The proposed plan adequately caters for the needs of the local community. • The redevelopment of Toondah Harbour and GJ Walter Park will enhance the Cleveland area and complement the existing CBD and harbour. • Support for the harbour to be transformed into a world class development that attracts residents and tourists. • The plan will support growth and tourism for Stradbroke Island post-sand mining and should provide connections to Cleveland CBD. • Believe the development will attract the younger generations to commit and invest	Noted.	N

Matter #	Summary and merits of matters raised in submissions: **Vision**	Assessment	Amendment Y / N
	in the future of Redlands.		
3.	Some comments were received in relation to the size and boundary of the PDA including: • The size of the PDA is too big and the boundary should be reduced. • The projected population of 3,500 is too high for the size of the site. • The boundary should be extended to the northern side of Oyster Point.	The PDA boundary was determined with consideration of key catalyst development sites, of which most are government owned. The boundary also includes some privately owned land adjoining catalyst sites to allow for effective long term development integration.	N
4.	A number of submissions raised concerns about impacts to local residents, the environment and the local character of the area. More detailed comments are included in specific sections of the document. Some general matters raised included: • The development should protect the local village/bayside character and should compensate local residents with improvements to public amenity and facilities. • The scheme should provide for less intensive activities and development. • The scheme caters for developers and government rather than the community. Concerned development will result in loss of local amenities in favour of profit. • Establishing a sense of character unique to Toondah Harbour is important. Future development should avoid any development similar to Raby Bay and waterfront developments at the Gold Coast, Townsville and Cairns.	A key priority of the development scheme is to provide for improvements to the existing bus, ferry and parking arrangements and other public infrastructure within the PDA. It is intended these improvements will enhance pedestrian and cycle connections, open space and the overall amenity of the area. Development will contribute to improvements to public facilities and infrastructure. It is acknowledged that there are a number of existing areas within the PDA which the community value and utilise. The development scheme requires applications to have regard to existing residential development and local character in the way new development is designed and delivered. Minor amendments have been made to the Urban design section of the PDA-wide criteria to clarify this requirement. The development scheme seeks to create a framework which balances diverse interests. The vision for Toondah Harbour has been designed to clearly distinguish it from other locations in South East Queensland. It provides for a harbour as well as a place to live and relax within a setting that is unique.	Y
5.	Submitters raised questions around the role of tourism in development of the PDA. Some key matters raised included: • Questioning whether the area can be an	It is intended that the PDA serve both a transport and tourism function. Significant improvements to public infrastructure and amenities will attract people to the area who	N

Matter #	Summary and merits of matters raised in submissions: **Vision**	Assessment	Amendment Y / N
	effective tourist destination if it is primarily a transport hub. • Concerned about promoting this as a tourism gateway. Supporting an increase in tourism for Moreton Bay and North Stradbroke Island will be detrimental. • Concerned that the PDA will not attract the projected number of tourists to compete with other destinations. • The scheme needs to be flexible and allow for future tourism related development opportunities. • A resort/hotel should be considered as a preferred land use to increase tourist numbers. • A tourism information centre or kiosk should be co-located with an environmental/marine science museum with interactive displays to educate visitors about the bay area. • The mix of uses should support the tourism industry and services that will be utilised by and attract tourists.	may also travel to the islands. The vision and PDA-wide criteria provide sufficient guidance and flexibility for a range of uses to be considered.	
6.	A number of submitters raised concerns about development of the site and the relationship with its function as a port. Some key matters raised included: • Once sand mining activities conclude on Stradbroke Island there will be no need for increased services and amenities. • Support for redevelopment and improvements to the vehicle ferry terminal but not for other development on the site. • The area is a port, not a village, and should be planned accordingly. • Concerned that development will negatively impact island residents.	A key priority of the development scheme is to provide for improvements to the existing bus, ferry and parking arrangements and other public infrastructure within the PDA. It is intended these improvements will enhance pedestrian and cycle connections, open space and the overall amenity of the area. Development will contribute to paying for improvements to public facilities and infrastructure. The development scheme seeks to create a framework which balances diverse interests. The preparation of the development scheme was informed by specialist consultant advice including civil engineering, economic, environmental, stormwater management, traffic engineering and urban design advice. This information was then reinforced by advice from	N

Matter #	Summary and merits of matters raised in submissions: **Vision**	Assessment	Amendment Y / N
		Council and state agencies. It is intended that investment in development in this location will attract people to the area who also may choose to travel to the Islands. Additionally, island residents will have the opportunity to access and benefit from improvements to public infrastructure and amenities in the PDA.	
7.	There are concerns that the redevelopment of the precinct will inflate property prices and drive out current residents due to affordability issues.	It is not possible to predict with certainty what will happen in the private market in the future. However the key reason the PDA was declared was to support opportunities for economic development which will provide new public infrastructure and facilities that will benefit both mainland and island communities. The development scheme provides opportunities for additional housing which will support efficient development outcomes.	N
8.	The proposed plan should be withdrawn and replaced by a new scheme promoting a healthy natural environment and green living.	It is considered that the development scheme provides a balance between environmental, social and economic interests and can deliver development that will contribute positively to the development of the Redlands. Development applications will still require rigorous assessment to ensure community interests are addressed.	N

Matter #	Summary and merits of matters raised in submissions: **Document structure, content or language**	Assessment	Amendment Y / N
Document structure, content or language			
9.	A number of submissions raised concerns there was insufficient detail provided in the document. Specific comments are discussed in the relevant sections of this document below. Some general matters raised included: • The document does not provide enough information on development outcomes or benefits. • The precinct provisions are unclear and it is not easy to understand what will happen in each precinct and how this relates to the vision. • The proposed scheme contains poor, qualitative statements. • It is difficult to interpret maps 3, 4 and 5 from the information provided. • The document is vague and only includes a conceptualised plan.	The preparation of the development scheme was informed by specialist consultant advice including civil engineering, economic, environmental, stormwater management, traffic engineering and urban design advice. This information was then reinforced by advice from Council and state agencies. The development scheme is a high level planning framework which seeks to balance diverse interests. It is not an application for development and detailed designs have not yet been undertaken. The development scheme identifies principles which future development applications will need to address. The detailed design, location of buildings and nature of development will be determined in future development applications assessed through the development assessment process. Some changes have been made to the maps to clarify specific issues.	Y
10.	It is unclear if background studies have been undertaken to inform the content of the document. Further information and background studies are required to justify the development.	The preparation of the development scheme was informed by specialist consultant advice including civil engineering, economic, environmental, stormwater management, traffic engineering and urban design advice. This information was then reinforced by advice from Council and state agencies. Background reports have now been made available to the community to show how specialist consultant advice has informed the preparation of the development scheme.	N
11.	The development scheme contains terminology which make it difficult for the public to understand. Punctuation used throughout the development scheme is incorrect.	The scheme has been reviewed and minor amendments have been made to clarify criteria, improve the readability of the document and correct typographical errors.	Y
12.	Comments received about some definitions in the plan: • The term 'catalyst project' (page 20 of the	The scheme has been reviewed and minor amendments have been made to clarify criteria and improve the readability of the document.	Y

Matter #	Summary and merits of matters raised in submissions: **Document structure, content or language**	Assessment	Amendment Y / N
	proposed scheme) is not defined. • There is no definition for 'compensatory offset' which 'seeks to achieve a net gain in koala and marine habitat' in the development scheme. • Sustainability is inadequately defined and the scheme does not contain a widely accepted definition.		
13.	Some submissions raised concerns regarding the title of the PDA, including: • The PDA name should be changed to 'Toondah Harbour and GJ Walter Park Redevelopment PDA' to reflect true intention. • The name of the PDA is misleading given the PDA boundary includes adjacent land, open space and parts of Moreton Bay.	The PDA title is a legal title, as defined in the *Economic Development Regulation 2013* and therefore cannot be changed without a statutory amendment to the regulation which is considered unnecessary.	N
14.	There are concerns that mapping is inaccurate, with discrepancies between RCC material and the PDA boundary map (i.e. the spoil area is included in the PDA map but excluded from council material).	Submitters were invited to comment on the publicly notified proposed development scheme which included correct maps.	N
15.	The pictures used throughout the document are misleading as they depict buildings of up to 7 storeys, yet the scheme allows up to 15.	These images are examples of potential development which may occur in the future and are for illustration purposes only. Future building designs will be subject to a development assessment process. The scheme has been amended to reduce height limits to 10 storeys in specified locations.	Y
16.	The proposed scheme has no relationship to the objectives or community values in the South East Queensland Regional Plan, Redlands Community Plan and Redlands Planning Scheme.	The PDA was declared under the *Economic Development Act 2012* at the request of RCC. The Act's purpose is to facilitate economic development and development for community purposes. The development scheme therefore seeks to support opportunities for economic development which will provide new public infrastructure and facilities that will benefit both mainland and island communities.	N

Matter #	Summary and merits of matters raised in submissions: **Document structure, content or language**	Assessment	Amendment Y / N
		It was identified that development outcomes could be more efficiently facilitated under the *Economic Development Act 2012* and a development scheme, than what could be achieved under the *Sustainable Planning Act 2004* and the Redlands Planning Scheme. The development scheme has been prepared in partnership between the state government and RCC.	
17.	Concerned that the community will have no say in relation to exempt development. Question why exempt development is included in the scheme when other assessable development must be assessed against criteria.	The RCC planning scheme currently provides for exempt development. Exempt development is generally development of a lower order or development that provides a public benefit and the requirement for an application would be costly and an imposition on the proponent Additionally, the scheme provides for future exempt development where it is in accordance with an existing approval. This means developers submit an initial development application which establishes key design requirements and considerations to be addressed but removes the need for secondary approvals. This streamlined process reduces red tape and therefore cost and time to developers and government.	N
18.	Concerned that the document is too flexible and development can be approved where it is inconsistent with the criteria in the document.	The development scheme is a high level planning framework which seeks to balance diverse interests. It identifies principles which future development applications will need to address. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. A development application may propose something which is different to the PDA-wide criteria or Precinct provisions, provided it is not inconsistent with the vision. This is intended to provide an appropriate amount of flexibility for alternative options to be lodged and considered. A development application of this nature would need to be publicly notified and provide sufficient	N

Matter #	Summary and merits of matters raised in submissions: **Document structure, content or language**	Assessment	Amendment Y / N
		justification of a superior design outcome or overwhelming community need to support the proposal.	

4.2. Land uses and proposed development

Matter #	Summary and merits of matters raised in submissions. **General land use**	Assessment	Amendment Y / N
General land use			
19.	Development should be restricted to infill and not greenfield areas.	The redevelopment of Toondah Harbour is considered to be infill development.	N
20.	Support for a number of land use outcomes proposed in the scheme including: • The development of modern ferry terminals, attractive on-land infrastructure, modest residential and social facilities and widening and maintaining Fison channel to assist current and future ferry operations. • The marina development and associated apartments. • The redevelopment of the former CSIRO building.	Noted.	N
21.	Concerned about the mix of uses proposed within the area and that some types of development are not compatible. For example, car parking with residential or high density development next to environmental sanctuaries.	The development scheme identifies principles which future development applications will need to address. The detailed design, location of buildings and nature of development will be determined in future development applications assessed through the development assessment process.	N
22.	Do not support the scale, nature or mix of development types proposed and believe they are inconsistent with the character of the area.	It is acknowledged that there are a number of existing areas within the PDA which the community value and utilise. The development scheme requires applications to have regard to existing residential development and local character in the way new development is designed and delivered. Minor amendments have been made to the Urban design section of the PDA-wide criteria to clarify this requirement. The development scheme seeks to create a framework which balances diverse interests. The vision for Toondah Harbour has been designed to clearly distinguish it from other locations in South East Queensland. It provides	Y

Matter #	Summary and merits of matters raised in submissions. **General land use**	Assessment	Amendment Y / N
		for a harbour as well as a place to live and relax within a setting that is unique.	
23.	The proposed plan should include other public cultural uses (such as a library, maritime museum, art gallery, revitalised horticulture research centre and indigenous training facilities) creating a multi-purpose destination rather than just a launch pad to the islands.	The development scheme allows for these uses to be established in the PDA	N
24.	The plan should include major employment nodes such as hospitals, industry and universities outlined in the document. The proposal should include opportunities for a university and tech park to enhance employment opportunities and strengthen the local community and economy.	A university or hospital would require a large area of land that is unlikely to be accommodated within the PDA and which would be better located in other more suitable places within the Redlands.	N
25.	A free serviced camping ground with provisions for caravans, tents and motorhomes should be provided.	A tourist park would require a large area of land that is unlikely to be accommodated within the PDA.	N
26.	Concerned about the impact of the development on personal safety, particularly at night, including concern that crime would increase.	The development scheme requires development to consider how its design and the design of public places promote safety. This is called Crime Prevention Through Environmental Design and is a well-accepted urban design tool used to maximise community safety in new development.	N
27.	Land within the PDA should be allocated for the Australian Navy Cadets Training Ship Diamantina.	This is not specifically proposed in the development scheme, however this use could be proposed in the future, subject to the availability of funding and a delivery proponent.	N

Matter #	Summary and merits of matters raised in submissions. **Residential development**	Assessment	Amendment Y / N
Residential development			
28.	Support for residential development which is consistent with the character of the area.	Noted.	N
29.	Some submitters did not support high density or high rise development which is discussed in the Building height and density section below.	The development scheme seeks to create a framework which balances diverse interests. The preparation of the development scheme included looking at potential development yields, the potential arrangement of different land uses, how development should be designed, where heights would be best located and how development should contribute towards infrastructure upgrades, in order to create an attractive and liveable community and viable development outcomes. The development densities and heights proposed are maximums and are based on potential ultimate numbers. The delivery of development will be subject to market forces.	Y
30.	Support for residential development similar to Raby Bay.	Noted.	N
31.	The proposal should accommodate public and affordable housing options.	The development scheme allows for public and private housing to be established in the PDA if a provider chose to locate there. Land and house prices will be determined by the private market.	N
32.	Residential development, including low-rise and medium density development, should cater for different household types, including retirees, couples and single person households.	The final mix of housing types to be delivered will be determined by market forces. The development scheme is underpinned by the EDQ Guidelines which include a guideline on best practice design of medium and high rise buildings and encompass consideration of diversity of housing types. Development will be required to address how it delivers on the principles of the development scheme and related guidelines through the development assessment process.	N
33.	Concerned about residential development occurring close to an operating port facility.	The development scheme includes requirements for development to ensure	N

Matter #	Summary and merits of matters raised in submissions. **Residential development**	Assessment	Amendment Y / N
	Believe residential development is proposed too close to diesel fumes and noise of ferries and will conflict with other land uses of the area.	adequate visual and noise amenity. The way this is to be achieved and the detailed design and nature of development will be determined in future development applications assessed through the development assessment process. Potential conflicts between port related and residential activity will be assessed and managed through the development process.	
34.	Suggests that the residential area in Precinct 4 is developed closer to the shoreline so that it is not reliant on land reclamation.	The height map is indicative only and does not confer use rights for buildings over the entire area water. The inclusion of water within the PDA boundary was to allow for potential water based uses and land reclamation. The timing and delivery of land reclamation would be subject to funding, detailed assessment and approvals The height map is intended to be read in conjunction with other parts of the document including Map 2 – Structure plan. If land reclamation occurs, the height map provides guidance on building heights which may occur on reclaimed land.	N

Matter #	Summary and merits of matters raised in submissions: **Retail and commercial development and relationship with Cleveland**	Assessment	Amendment Y / N
Retail and commercial development and relationship with Cleveland			
35.	There are concerns about how the development of Toondah Harbour sits within the wider centres network in the Redlands area. Council's focus should be on upgrading and supporting the existing CBD with a mix of residential and retail rather than redeveloping the foreshore land. A number of submitters did not support mixed use retail or commercial development in the area. Specific matters raised in relation to this included: • Retail provisions should provide for no more than 600sqm in total for local service retail and food and beverage businesses. • The development of a new hotel will compete with existing services in the local area and should be removed. • A supermarket is not required as the area is well serviced by supermarkets already. • The proposed supermarket is too large but a smaller supermarket or convenience store may be appropriate. • The type of retail which may locate there will not complement the local character. • Mixed use development should be deferred until demand is assessed. • Restaurants and pubs will lead to safety issues as a result of alcohol consumption. The redevelopment will not activate commercial development or create jobs.	The development scheme provides limits for retail and commercial uses in the Precinct Provisions and requires development to demonstrate consideration of how it complements the Cleveland CBD. The development scheme acknowledges that out of centre development can result in inefficient development, and impact surrounding centres. Furthermore, measures proposed within the development scheme will ensure that residents will have the opportunity to access the Cleveland CBD by walking, bicycling or public transport. The Cleveland CBD is currently receiving support from Council via a CBD incentives package and revitalisation strategy.	
36.	A number of submitters supported mixed use retail and commercial development in the area, including cafes and restaurants along the foreshore.	Noted.	N
37.	Submissions included suggestions for specific services which should be provided in the mixed	The development scheme allows for these uses to be established in the PDA if a provider	N

Matter #	Summary and merits of matters raised in submissions: **Retail and commercial development and relationship with Cleveland**	Assessment	Amendment Y / N
	use node. Some examples include: • specialty retail shops such as hair dressers, service stations and post office • cafes and seafood stores • a marine education / research facility.	chooses to locate there and they address any issues raised as part of the development assessment process. The delivery of development is subject to market forces.	
38.	Some submitters suggested specific design considerations including more parking and public amenities (shaded seating etc.) and central square.	The development scheme is a high level planning framework which seeks to balance diverse interests. It is not an application for development and detailed designs have not yet been undertaken. The development scheme identifies principles which future development applications will need to address. The detailed design, location of buildings and nature of development will be determined in future development applications assessed through the development assessment process.	N
39.	Retail and commercial uses should be provided in Precinct 1 only and these uses should focus on tourism only.	The detailed design, location of buildings and nature of development will be determined in future development applications assessed through the development assessment process.	N
40.	There is an incorrect reference to "Hostel" as a preferred land use rather than hotel.	The development scheme has been amended to change "Hostel" to "Hotel."	Y
41.	Clarify why the plan states that retail is limited to 2,500sqm yet the map shows the mixed use node as 12,000sqm.	The development scheme limits retail uses to 5,000sqm and commercial uses to 2,500sqm. The location of the mixed use node is indicative and is intended to provide some flexibility for where businesses may choose to locate. The mixed use node provides for retail, commercial and residential development.	Y

Matter #	Summary and merits of matters raised in submissions: **Marina development**	Assessment	Amendment Y / N
Marina development			
42.	A number of submitters provided general support for the development of a marina and improved marina car parking.	Noted.	N
43.	Other submitters did not support a marina in this location for a range reasons. Specific matters raised in relation to this: • Development should focus on improving recreational opportunities rather than developing a marina. • Raby Bay Marina should not be used as the model for the Toondah Harbour Marina. • The scale of the proposed marina has not been supported by appropriate economic assessment. Vacancy rates in existing marinas are high, including the Wynnum and Manly marinas. A marina is not required and may be commercially unviable. • Concerned marine life and habitats will be adversely impacted by the marina and rock wall or from erosion from boat movements and storm events. • Concerned about conflicts between the marina and associated industrial uses and other nearby land uses including open space and residential areas. • Concerned about the marina being located in shallow water and the cost of capital and maintenance dredging of the marina. Believe that this may result in increased rates for local residents. • Concerned that prevailing winds blowing against the proposed site would make the marina inoperable for long periods of time. Notes that the location of the Marina is most exposed to weather conditions. • Question if an economic impact	Based on community feedback, further analysis and recommendations from RCC, the development scheme has been amended to limit the number of marina berths to up to 400. The development scheme identifies principles which future development applications will need to have regard to including providing for the community to access the waterfront and environmental considerations. The detailed design and nature of development, such as a marina, will be determined in future development applications assessed through the development assessment process. The development of a marina is dependent on private sector interest. Therefore the timing of when development will occur will be determined by market forces. Additionally the timing and delivery of any marina or dredging would be subject to detailed assessment and approvals for development under the *Marine Parks Act 2004* including where required, environmental impact statements.	Y

Matter #	Summary and merits of matters raised in submissions: **Marina development**	Assessment	Amendment Y / N
	assessment has been undertaken. • Suggest any marina be located elsewhere, such as Point Halloran. • Suggest that a public jetty is sufficient and a marina is not required. • Concerned that a marina will only benefit a small number of boat owners, and will detract from public access to the waterfront. • The marina should be located away from GJ Walter Park and other open space areas.		
44.	Some submitters provided suggestions on how the marina should be delivered and designed. Suggestions raised included: • Marina berths and associated infrastructure should have restricted access. • Support for a marina of a smaller size. • The marina should be developed in one stage rather than in incremental upgrades, to ensure the design remains consistent with the character of the area. • Incorporate an attractive, clean and accessible entry to Toondah Harbour. • Designated bays for small boats. • Tourist operators should be allowed to operate out of the marina providing water activities for locals. • Marina facilities should incorporate temporary berthing for vessels up to 35m length (and 10m breadth).	Based on community feedback, further analysis and recommendations from RCC, the development scheme has been amended to limit the number of marina berths to up to 400. The development scheme identifies principles which future development applications will need to have regard to including providing for the community to access the waterfront and environmental considerations. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. The development of a marina is dependent on private sector interest. Therefore the timing of when development will occur will be determined by market forces. Additionally the timing and delivery of any marina or dredging would be subject to detailed assessment and approvals for development under the *Marine Parks Act 2004* including where required, environmental impact statements. .	Y

4.3. Urban and building design

Matter #	Summary and merits of matters raised in submissions: **General building and housing design**	Assessment	Amendment Y / N
General building and housing design			
45.	A number of submitters made suggestions about the design of buildings. Examples of comments received include: • Concerned development will be of a low quality. • Unique building design should be encouraged to create development that is iconic, beautiful and functional. • The interface between Moreton Bay and land should be integrated into the design of waterfront buildings to create a strong sense of place. • Support for development which consists of brick or block on slab and underground parking. Other submitters did not support this development type and suggested buildings be timber and of light weight construction.	The development scheme includes criteria for development to have regard to views, access to the waterfront, environmental impacts and traffic impacts in how buildings and streets are designed. In addition to the development scheme, applications will need to consider the EDQ Guidelines which provide further detailed advice on how buildings should be designed	N
46.	Building design should be sympathetic to existing development in the area and the Cleveland CBD and retain views and breezes.	The PDA-wide criteria in the development scheme have been amended to ensure there is an appropriate interface between new development and existing residential development. They have also been amended to strengthen and clarify the intent for development to have regard to views, breezes and local character in its design and delivery.	Y
47.	Buildings should promote sustainable outcomes, incorporate innovative green design techniques, including natural cooling and heating, and have regard to the existing natural environment.	The development scheme and associated EDQ Guidelines support this as an outcome.	N
48.	The development scheme should provide more detail on the design of higher density buildings. Specific matters raised in submissions included: • The design principles are too flexible and	The development scheme includes criteria for development to have regard to access to the waterfront, environmental impacts and traffic impacts in how buildings and streets are designed.	N

Matter #	Summary and merits of matters raised in submissions: **General building and housing design**	Assessment	Amendment Y / N
	general and do not clearly depict how conflicting uses will be resolved. • No examples of building designs have been provided; therefore it is difficult to comment on form and design. • Privacy of residential dwellings must be considered in landscaping and building design. • Acoustic design treatments and noise management strategies should be included to mitigate noise issues for future residents.	The development scheme is also underpinned by the EDQ Guidelines which includes a guideline on best practice design of medium and high rise buildings including consideration of privacy, noise, safety and building design. Development will be required to address how it delivers on the principles of the development scheme and related guidelines through the development assessment process.	
49.	Residential development in Precinct 2 should reflect current RCC planning standards.	The development scheme includes criteria for development to have regard to access to the waterfront, environmental impacts and traffic impacts in how buildings and streets are designed. The development scheme is also underpinned by the EDQ Guidelines which includes a guideline on best practice design of medium and high rise buildings including consideration of privacy, noise, safety and building design. Development will be required to address how it delivers on the principles of the development scheme and related guidelines through the development assessment process.	N
50.	Concerned that deep piling will make development unviable and buildings unaffordable.	The nature of the type of development to be delivered will be determined by market forces. Residential and other development exists within the PDA.	N

Matter #	Summary and merits of matters raised in submissions: **Building height and density**	Assessment	Amendment Y / N
Building height and density			
51.	A number of submitters opposed high rise and high density development in the area. A number of alternative height maximums were suggested, ranging from 2-15 storeys. Concerns raised included: • Insufficient detail is provided about the total number of residential dwellings and the proposed building heights. • High rise and high density buildings are out of character with the area and will negatively impact on amenity and local heritage. • Do not create another Gold Coast or development which will take away from unique qualities of the area. • Concerned about environmental, privacy, amenity, traffic and waterfront access impacts. • Infrastructure capacity and the need for upgrades. • Concerned about negative impacts to the value of existing properties.	The development scheme has been amended to reduce maximum potential building heights to ten storeys in some specified parts of the site. RCC supported this amendment. These maximum heights provide an opportunity to achieve higher densities where criteria in the development scheme such as consideration of views, access to the waterfront, environmental impacts and traffic impacts have been addressed. Development applications will also need to consider the EDQ Guidelines which provide further detailed advice on how buildings should be designed to provide for appropriate privacy, safety and high quality design. The PDA-wide criteria in the development scheme have been amended to ensure there is an appropriate interface between new development and existing residential development. They have also been amended to strengthen and clarify the intent for development to have regard to views, breezes and local character in its design and delivery. The development scheme enables an appropriate balance to be achieved between attracting development through higher potential yields and protecting and enhancing matters such as visual amenity, open space and public infrastructure.	Y
52.	Other submitters supported high rise development and increased density in the area. Comments made included: • The impacts from height are negligible provided buildings are appropriately designed and aesthetically pleasing. • Support for the 15 storey height limit as higher density residential buildings require less developable land minimising destruction of existing vegetation and koala	Noted.	N

Matter #	Summary and merits of matters raised in submissions: **Building height and density**	Assessment	Amendment Y / N
	habitats. • Support for the location of high density development. • Agree that high density buildings are required to support the proposed retail and commercial uses.		
53.	Concerned that the Grand View Hotel's viability and tourist potential will be threatened if the current view and outlook is lost due to high rise being built in front of it.	The development scheme has been amended to reduce maximum potential building heights to ten storeys in some specified parts of the site. RCC supported this amendment. These maximum heights provide an opportunity to achieve higher densities where criteria in the development scheme such as consideration of views, access to the waterfront, environmental impacts and traffic impacts have been addressed. The PDA-wide criteria in the development scheme have been amended to strengthen and clarify the intent for development to have regard to views, breezes and local character in its design and delivery. The development scheme enables an appropriate balance to be achieved between attracting development through higher potential yields and protecting and enhancing matters such as visual amenity, open space and public infrastructure.	Y

Matter #	Summary and merits of matters raised in submissions: **Heritage**	Assessment	Amendment Y / N
Heritage			
54.	The proposed scheme does not adequately address that future development falls within a heritage zone. There is a lack of information on how heritage has been considered and how it will be impacted by development.	The development scheme requires future development to demonstrate how it responds to and conserves local site characteristics, settings, places of heritage significance, landmarks and views and uses built form and natural features to provide specific identify and character. Additionally, three lots of heritage significance are recognised on Map 2 – Structure plan.	N
55.	Further research should be undertaken into the local Indigenous traditions, farming history and importance of local mudflats, to underpin the scheme and ensure protection of heritage.	The development scheme requires future development to demonstrate how it responds to and conserves local site characteristics, settings, places of heritage significance, landmarks and views and uses built form and natural features to provide specific identify and character.	N
56.	The references to cultural and Aboriginal heritage in the proposed scheme are insufficient and too generic and do not have regard to the Quandamooka People. Planning and development at Toondah Harbour should be undertaken in consultation with the Quandamooka people to achieve place-specific landscape and building design.	Key stakeholders including representatives of the Quandamooka People were involved in the design workshops as well as private meetings to inform the preparation of the proposed development scheme. Further consultation and consideration of cultural and Aboriginal heritage can occur as part of the development process. The development scheme has been amended to make further reference to consideration of cultural and Aboriginal heritage issues.	Y
57.	The scheme does not respect the historical significance of GJ Walter Park and the "Fernleigh" precinct which should be highlighted in the scheme as heritage assets and of regional significance.	The development scheme refers to heritage values in the PDA-wide criteria and on Map 2 – Structure Plan. The development scheme requires future development to demonstrate how it responds to and conserves local site characteristics, settings, places of heritage significance, landmarks and views and uses built form and natural features to provide specific identify and character. The development scheme has been amended to protect the recreational function of GJ Walter	Y

Matter #	Summary and merits of matters raised in submissions: **Heritage**	Assessment	Amendment Y / N
		Park as a public open space area.	
58.	Heritage should be displayed and emphasised in the public realm through statues, seats and trees.	The detailed design of public open space will be determined through the development assessment process. The development scheme requires future development to demonstrate how it responds to and conserves local site characteristics, settings, places of heritage significance, landmarks and views and uses built form and natural features to provide specific identity and character.	N

4.4. Sustainability and the natural environment

Matter #	Summary and merits of matters raised in submissions: **General sustainability and the natural environment**	Assessment	Amendment Y / N
General sustainability and the natural environment			
59.	Submitters raised general concerns about the impacts of development on the environment. A number of specific queries are discussed in sections below. Some general comments received included: • Concerned that environmental impact studies have not been completed to underpin the planning process. • Concerned that environmental constraints are not addressed or planned for in the development scheme. • Concerned that increased population will destroy the quality of the environment and increase pollution. • Development should not extend beyond existing bitumen or developed areas. • Development should protect and emphasise character environmental elements including koalas, place of red earth, mangroves, mud flats and Moreton Bay, through open space and development. • There is concern that the scheme will impact existing ecological habitats.	The PDA was declared under the *Economic Development Act 2012* at the request of RCC. The Act's purpose is to facilitate economic development and development for community purposes. The development scheme therefore seeks to support opportunities for economic development which will provide new public infrastructure and facilities that will benefit both mainland and island communities. The development scheme seeks to create a framework which balances diverse interests while meeting the purpose of the Act. The preparation of the development schemes was informed by specialist consultant advice including environmental advice and detailed environmental assessments will be undertaken as part of the development assessment process, where relevant. Through this process it was determined that the framework identified in the proposed development scheme was the most appropriate option to manage state and local interests and provide for economic development and development for community purposes. The development scheme includes criteria relating to sustainability which development must respond to in future development applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on Environment and Natural Resources Sustainability. The development scheme recognises and refers to the State Planning Policy and associated mapping. This mapping includes Matters of State Environmental Significance. Development must address how it will seek to avoid, minimise and mitigate impacts to sensitive areas, through the development assessment process.	Y

Matter #	Summary and merits of matters raised in submissions: **General sustainability and the natural environment**	Assessment	Amendment Y / N
		Background reports have now been made available to the community to show how specialist consultant advice has informed the preparation of the development scheme. The scheme has been amended to reduce height limits to 10 storeys, reduce maximum marina berths to 400 and to protect the recreational function of GJ Walter Park.	
60.	There is general support for section 3.4.4 (Natural environment) of the proposed scheme; however there are concerns that these considerations are not reflected through the rest of the document.	The PDA-wide criteria in section 3.4 including Natural environment apply to all assessable development within the PDA.	N
61.	Section 5.2 (Development staging strategy), degrades the importance of environmental sustainability and prioritises development outcomes.	The PDA-wide criteria in section 3.4 apply to all assessable development within the PDA.	N
62.	GJ Walter Park was previously used for landfill and consideration should be given to potential contamination.	The development scheme includes criteria relating to sustainability which development must respond to in future development applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on Environment and Natural Resources Sustainability.	N
63.	Concerned that the PDA contains acid sulfate soils.	This will be addressed through the development assessment process. The development scheme includes criteria relating to the identification of acid sulfate soils which development must address in future development applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on Environment and Natural Resources Sustainability.	N
64.	Concerns were raised in relation to impacts from dredging. Matters raised include: • The development of the proposed marina would require extensive and constant dredging, which will have adverse	The timing and delivery of any marina or dredging would be subject to detailed assessment and approvals for development under the *Marine Parks Act 2004*, including where required, environmental impact statements.	N

Matter #	Summary and merits of matters raised in submissions: **General sustainability and the natural environment**	Assessment	Amendment Y / N
	environmental impacts on the local area. • The scheme should have stronger references to issues associated with dredging, including effects on the marine environment and acid sulfate soils. • Dredging spoil is not suitable for landfill. • Concerned there will be increased siltation due to changes to water flow from dredging. • Request further information on how dredge spoil will be managed, including dredge ponds and how this relates to land reclamation. • Question what environmental assessment will be undertaken to ensure there is limited impact to the environment and bay. • Suggest that dredging may have Native Title implications. • Dredging should be carried out in consultation with the relevant environmental bodies.		
65.	A number of submissions raised concerns in relation to land reclamation and its impacts on the environment. Specific comments included: • Believe there is sufficient land available for development without the need to create new areas. • Uncertainly about where the fill will come from and what it might contain. • Concerned that a large portion of Moreton Bay is shown as 15 storey development. Suggest proposed land reclamation should be reduced to conserve the existing natural habitat for migratory birds, mangroves and other marine vegetation. • Land reclamation should be used for park and visitor facilities only.	The inclusion of water within the PDA boundary was to allow for potential water based uses and land reclamation. The timing and delivery of land reclamation would be subject to funding, detailed assessment and approvals for development under the *Marine Parks Act 2004* including where required, environmental impact statements. The height map is indicative only and does not confer use rights for buildings over the entire area water. The development scheme has been amended to reduce building heights to 10 storeys and clarify its intent. The height map is intended to be read in conjunction with other parts of the document including Map 2 – Structure plan. If land reclamation occurs, the height map provides guidance on building heights which may occur on reclaimed land.	Y

Matter #	Summary and merits of matters raised in submissions: **General sustainability and the natural environment**	Assessment	Amendment Y / N
66.	There was general support for limited land reclamation around the harbour to support ferry operations, marine services and a small mixed use precinct.	Noted.	N

Matter #	Summary and merits of matters raised in submissions: **Flora and fauna and the Moreton Bay Marine Park**	Assessment	Amendment Y / N
Flora and fauna and the Moreton Bay Marine Park			
67.	Concerned that the RAMSAR areas are not adequately protected and that development would contravene the RAMSAR international treaty.	Commonwealth legislation still applies to relevant development within the Toondah Harbour PDA. Development in the PDA may trigger assessment against the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*, which recognises the RAMSAR treaty.	N
68.	Concerned that loss of mangroves will be exacerbated by development and increased pollution. Mangroves surrounding Toondah Harbour should be protected. More detail should be provided to demonstrate how the environmentally rich mudflats fronting GJ Walter Park will be preserved and integrated into the PDA.	The preparation of the development schemes was informed by specialist consultant advice including environmental advice and detailed environmental assessments will be undertaken as part of the development assessment process, where relevant. The development scheme recognises and refers to the State Planning Policy and associated mapping. This includes Matters of State Environmental Significance and how they must be considered in a development assessment. Development must address how it will seek to avoid, minimise and mitigate impacts to sensitive areas, through the development assessment process.	N
69.	Other submitters noted that the mangroves are of low quality in this area and any impact to them will have a negligible impact.	Noted.	N
70.	Significant trees and other native vegetation (Moreton Bay Figs and Norfolk Pines) in GJ Walter Park and the PDA should be retained.	The development scheme includes requirements for development to seek to retain existing mature trees where possible. Additionally, the development scheme has been amended to strengthen the protection of the recreational function of GJ Walter Park and the proposed north south link has been removed.	Y
71.	Concerned that the scale of development will not allow for deep planting.	The development scheme and associated EDQ Guidelines support this as an outcome. Areas indicated for urban development will be	N

Matter #	Summary and merits of matters raised in submissions: **Flora and fauna and the Moreton Bay Marine Park**	Assessment	Amendment Y / N
		required to provide street trees and landscaping. Areas of open space will allow for deep planting of trees.	
72.	Existing animal species in the local area will be adversely impacted by the proposed development which fails to prescribe criteria for protecting existing wildlife species, with particular concern for koalas, turtles, dugongs and rare bird species. Development should incorporate vegetation buffers and design features to protect local animals. Concerned the identified koala corridor will not sufficiently protect existing koala habitat from the proposed high density development, particularly due to its close proximity to a road and dog park. Concerned the koalas will be driven away or killed. Suggest that the width of the koala corridor be increased to protect the koala's habitat. Suggest that reference to the koala corridor in the proposed scheme be amended to "establishing a vegetated corridor for wildlife habitat and provide for koalas and their safe movement".	The development scheme seeks to create a framework which balances diverse interests. The preparation of the development scheme was informed by specialist consultant advice including environmental advice on fauna movements through the area, which the development scheme seeks to support. Detailed environmental assessments will be undertaken as part of the development assessment process, where relevant. The development scheme recognises and refers to the State Planning Policy and associated mapping. This mapping includes Matters of State Environmental Significance. Development must address how it will seek to avoid, minimise and mitigate impacts to sensitive areas, through the development assessment process. A minor amendment to the development scheme wording has been reflected to strengthen the role of the vegetated corridor.	Y
73.	A number of concerns were raised in relation to impacts from development on the Moreton Bay Marine Park Some key matters raised included: • Greater protection of marine zones should be provided. • The development scheme does not abide by the Moreton Bay Marine Park Guideline. • Concerned about the impact on fisheries, fishing and bait collection. • Concerned about the impact on coral due to increased turbidity and nutrient load.	The preparation of the development schemes was informed by specialist consultant advice including environmental advice and detailed environmental assessments will be undertaken as part of the development assessment process, where relevant. Additionally the timing and delivery of land reclamation would be subject to funding, detailed assessment and approvals for development under the *Marine Parks Act 2004* including, environmental impact statements, where required.	N

Matter #	Summary and merits of matters raised in submissions: **Coastal hazards, stormwater, water quality and flooding**	Assessment	Amendment Y / N
Coastal hazards, stormwater, water quality and flooding			
74.	There are concerns that foreshore development will cause erosion.	The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. The development scheme includes criteria relating to sustainability which development must respond to in future development applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on Environment and Natural Resources Sustainability. The development scheme also recognises and refers to the State Planning Policy and associated mapping. This includes Matters of State Environmental Significance and how they must be considered in a development assessment. Development must address how it will seek to avoid, minimise and mitigate impacts to sensitive areas, through the development assessment process.	N
75.	Some comments were made in relation to stormwater management including: • The re-use of stormwater for irrigation and in open spaces should be encouraged. • Additional open space should be provided for stormwater management to compensate for increased hard stand areas.	The development scheme and associated EDQ Guidelines support this as an outcome.	N
76.	Some submitters were concerned parts of the PDA are affected by flood and storm surge. Matters raised in relation to this included: • Concerned development will result in increased stormwater runoff during storm events. • Measures to minimise this risk are not adequately covered in the PDA-wide criteria.	The development scheme is consistent with and is to be read in conjunction with the State Planning Policy and associated mapping. This mapping includes erosion prone areas, storm surge and flood prone areas and Matters of State Environmental Significance. The development scheme includes criteria relating to sustainability, community safety and development constraints which development must respond to in future development	N

Matter #	Summary and merits of matters raised in submissions: **Coastal hazards, stormwater, water quality and flooding**	Assessment	Amendment Y / N
	• The scheme should take account of future sea level rise (e.g. 1000m rise).	applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on Environment and Natural Resources Sustainability. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. Further detailed flood modelling will be required as part of the development assessment process, where relevant.	
77.	Concerned about drainage issues in the south west corner of the PDA, which may negatively impact parish land which has riparian rights.	The development scheme requires development to demonstrate that stormwater runoff does not exceed that which presently exists and that there is no net worsening of flood conditions at the PDA boundary. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. Further detailed flood modelling will be required in association with future development applications, where relevant.	N
78.	Sediment studies should be included to determine the extent to which water quality will be affected.	The development scheme includes criteria relating to sustainability, community safety and development constraints which development must respond to in future development applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on Environment and Natural Resources Sustainability. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. Further detailed water quality modelling will be required as part of the development assessment process, where relevant.	N

4.5. Street and movement network

Matter #	Summary and merits of matters raised in submissions: **Pedestrian, cyclist and active transport networks**	Assessment	Amendment Y / N
Pedestrian, cyclist and active transport networks			
79.	Support for improvements to existing footpaths and the creation of new pedestrian and cycle networks.	Noted.	N
80.	A number of suggestions were raised in relation to active transport including pedestrian and cycle paths. Examples of suggestions include: • Provide shared access zones. • Pedestrian and cycle paths should be incorporated into new development and given priority over vehicular access. • Paths should be comfortable to use and include protection for the weather, seating and water fountains. • Pedestrian paths should be clearly separated from cycle paths. • Cycle paths should be clearly separated from roads. • Cycling facilities should be provided to improve external connections to public transport. • Some existing pedestrian paths should be retained such as the Erobin Street path. • The cycle path should be extended through the koala corridor to the south rather than to the west of the external road network. • Pedestrian safety is currently being jeopardised on Passage Street due to a lack of footpaths, except for a section outside the primary school.	The preparation of the development scheme was informed by specialist consultant advice including advice on the design of an efficient and safe movement network. The development scheme supports the delivery of an extensive pedestrian and cycle path network which will ultimately link to the city wide trunk pedestrian and cycle network. The development scheme includes criteria relating to the efficient design of the street and movement network which development must respond to in future development applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on Street and movement networks and best practice design. The detailed design and construction of pedestrian and cycle paths will be determined in future development applications assessed through the development assessment process. Map 2 – Structure plan has been amended to clarify the intent for the waterfront promenade to be a green open space connection which promotes waterfront access.	Y

Matter #	Summary and merits of matters raised in submissions: **Public transport and ferry services**	Assessment	Amendment Y / N
Public transport and ferry services			
81.	Public transit is already running at capacity, and will require significant upgrades to accommodate future demand. Transport upgrades should be constructed with priority.	A key priority of the development scheme is to provide for improvements to the existing bus, ferry and parking arrangements.	N
82.	A number of submissions requested improvements in public transport provision in the area. Suggestions included: • A subsidised shuttle from Cleveland Station to and from Toondah Harbour. • The extension of the rail line connecting Toondah Harbour to Cleveland Station. • An overhead automated monorail to connect areas. • Construction of a light rail between Toondah Harbour and Cleveland • Coordination of timetables to improve efficient connections between different modes and locations. • An upgrade to the Cleveland line and station facilities.	The preparation of the development scheme was informed by specialist consultant advice including advice on the traffic and transport network. The development scheme seeks to support opportunities to improve public transport efficiency. Some of the suggested improvements are not matters for consideration in the development scheme.	N
83.	Concerned that the proposed scheme does not provide any direct benefit to island residents in regard to travel time.	A key priority of the development scheme is to provide for improvements to the existing bus, ferry and parking arrangements within the PDA. The implementation strategy includes anticipated future actions to be delivered such as improvements to ferry terminals, the Fison Channel and ferry movements. The development scheme also supports the potential for a second ferry operator to be located within the PDA. It is intended these improvements will support more efficient ferry services.	N
84.	Support for upgrades and improvements to the existing ferry and water taxi terminals and associated parking and services.	Further detailed levels of planning through the development process will be the main tool for ensuring bus and ferry services are planned	N

Matter #	Summary and merits of matters raised in submissions: **Public transport and ferry services**	Assessment	Amendment Y / N
	Believe there should be better integration between the passenger and car ferry terminals The terminal should provide protection from the weather and appropriate facilities including toilets and seating.	and developed in an integrated way with various land uses and infrastructure. Improvements to terminal facilities will be considered as part of this process.	
85.	Support for increased dredging and improvements to the width and depth of the water channel and suggest this will improve access for ferry services, which have issues at low tide. Support expressed for improvements to barge and water taxi services. The development scheme should support dredging and the construction of a retaining wall to address these issues.	Noted.	N
86.	Ferry services are currently being monopolised due to a lack of competition and only a limited number of service providers operating in the area. A variety of transport options and services providers should be supported in this precinct. Some submitters suggested new development should incorporate two vehicle and passenger ferry services. Conversely some submitters are concerned an increase in passenger/vehicle ferry operators will force existing operators out of business.	The number of ferry operators in the area is not determined by the development scheme and is determined by other legislation and processes. The development scheme does however allow for a second ferry operator to locate within the PDA.	N
87.	A number of comments were received in relation to the location of ferries and conflicts between users. These included: • The development scheme should provide for an integrated northern access point and/or channel for passenger and vehicle ferries. • Access for ferries and private vessels should be limited to only one area with the rest left as natural environment. • Relocating car ferries will increase traffic queuing and have a negative impact on the community and environment • There is potential for conflict between the location of the marina, recreational boat	The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. The development scheme identifies principles which future development applications will need to have regard to including providing for the community to access the waterfront, appropriate provision of car parking and queuing areas, boat safety and environmental considerations. Operational arrangements for ferries and boating and detailed design, including dredging, parking, and the design of the marina will be considered through the development process.	N

Matter #	Summary and merits of matters raised in submissions: **Public transport and ferry services**	Assessment	Amendment Y / N
	traffic and ferries. Ferries turning and reversing will compete with recreational boating over the weekend if the channel. Lack of dredging may exacerbate this issue.		
88.	Residential and mixed use development should not impact on the operation of the vehicle and passenger ferries and should provide for future expansion of the terminals. Some submissions were concerned with potential noise impacts from ferries and suggested a need to establish a process for managing noise complaints.	The development scheme includes requirements for development to ensure adequate visual and noise amenity. The way this is to be achieved and the detailed design and nature of development will be determined in future development applications assessed through the development assessment process. Prevention of conflicts between ferries and recreational boats and potential conflicts between port related and residential activity and detailed design, including dredging, parking, and the design of the marina will be considered through the development process.	N

Matter #	Summary and merits of matters raised in submissions: **Boat ramp and recreational boating**	Assessment	Amendment Y / N
Boat ramp and recreational boating			
89.	A number of submissions offered suggestions in relation to the boat ramp. Matters raised in relation to this included: • The existing boat ramp is suitable for use by only small lightweight trailer boats at high tide only due to a build-up of soft mud over the base of the ramp. This facility should be upgraded. • A large multi-lane sheltered deep water boat ramp should be constructed as part of the PDA, including a wide sandy beach area for boat queuing. • Support the provision of increased number of boat ramps in the future. • Water and refuelling facilities should be provided for recreational boats. • Parking for boat trailers should be prioritised at the boat ramp and should not conflict with other demands for parking.	The preparation of the development scheme was informed by specialist consultant advice. The development scheme allows for the ongoing use of the existing boat ramp, and there are no proposals at this point in time to change its location or configuration. The development scheme is a high level planning framework which identifies principles that future development applications will need to address. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process.	N

Matter #	Summary and merits of matters raised in submissions: **Car parking**	Assessment	Amendment Y / N
Car parking			
90.	Submissions raised concerns around access and provision of adequate parking. Matters raised in relation to this included: • It is unclear how many car parks will be provided in the future. The scheme should clearly state the parking standards for different development types and densities. • It is unclear from Map 2 exactly where car parking will be provided and how large the parking facilities will be. • Concerned that insufficient space has been allocated. • Concerned that existing residents will be impacted by car parks. • Unclear how development will be staged to ensure there is no reduction in access to parking as a result of development. • Request further information be included about the type of parking to be provided, for example free, short-term, long-term, multi deck etc.	A key priority of the development scheme is to provide for improvements to the existing bus, ferry and parking arrangements within the PDA. The development scheme is a high level planning framework which identifies principles that future development applications will need to address. It identifies the preferred location of key parking areas and key considerations development will need to address in providing parking within the PDA. The detailed design and nature of development will be determined through the Expression of Interest process and in future development applications assessed through the development assessment process. The quantity of parking provided for new development will be dependent on the scale and nature of development proposed.	N
91.	A number of suggestions were received in relation to how and where parking should be provided including: • Support for underground car parking for residential and commercial buildings. Concerns that underground parking will be prone to flooding. • Both support and opposition to multi deck car parking. • Request to maintain car parks within the existing bitumen area. • Car parking should be removed from the waterfront. • Concern that parking would cause safety issues and conflict with other users,	The quantity of parking provided for new development will be dependent on the scale and nature of development proposed. It is intended that RCC in partnership with the state government, will undertake an Expression of Interest process to identify a development proponent or proponents to stage and deliver key catalyst development and infrastructure. Further detailed levels of planning through the development process will be the main tool for ensuring parking is planned and developed in an integrated way with various land uses and infrastructure.	N

Matter #	Summary and merits of matters raised in submissions: **Car parking**	Assessment	Amendment Y / N
	including boat trailers and pedestrians. • Car parking should be provided closer to the ferry terminal. • More parking is required near parks. • Car parking should not be developed near GJ Walter Park. • Requests for more free parking. • Suggestions of paid parking and use of pay stations. • Suggestions on the number of parks per unit/dwelling. • Parking should be prioritised for islanders and not for the general public. • Parking should be aesthetically pleasing and should not negatively impact existing residential areas. • Landscaping and shade should be improved for ferry car park.		

Matter #	Summary and merits of matters raised in submissions: **Road network and traffic congestion**	Assessment	Amendment Y / N
Road network and traffic congestion			
92.	Concerned that traffic impact studies have not been undertaken to inform the planning for the area. If studies have not been undertaken, then it has not been determined what effects the increased population will have on the road network and whether the proposed network is adequate. Traffic studies should be made publicly available.	The preparation of the development scheme was informed by specialist consultant advice including traffic engineering advice on potential development scenarios, impacts to the road network and recommendations on the design of an efficient and safe street and movement network. This also considered where upgrades, new roads and network changes that may be required. Background reports have now been made available to the community to show how specialist consultant advice has informed the preparation of the development scheme.	N
93.	A number of general concerns were raised about the road network and traffic congestion, including the following: • Concerned that conflict between residential and industrial uses will cause traffic congestion and noise pollution. A buffer between residential and vehicle loading area is required. • Concerned there is insufficient capacity in the existing road network for new development. • Roads and intersections will need to be upgraded and it is unclear how and when this will be done. • The number of entry and exit points to the precinct should be increased to improve traffic flow. • The road network should be appropriately landscaped. • Concerned there will be an increase in 'hoon' drivers.	The development scheme includes criteria relating to the efficient design of the street and movement network which development must respond to in future development applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on street and movement networks. It is intended that RCC in partnership with the state government, will undertake an Expression of Interest process to identify a development proponent or proponents to stage and deliver key catalyst development and infrastructure.	N
94.	A number of suggestions and concerns regarding specific roads were raised by submitters, including: • Passage and Long Streets are already at	The preparation of the development scheme was informed by specialist consultant advice including traffic engineering advice on potential development scenarios, impacts to the road	Y

Matter #	Summary and merits of matters raised in submissions: **Road network and traffic congestion**	Assessment	Amendment Y / N
	capacity and will require urgent attention to meet the requirements of future development. • A truck connector street should be provided to ease congestion on Passage Street. • Access to the harbour (via Middle Street) should be restricted to public transport, cyclists, pedestrians and passengers to North Stradbroke Island. • Upgrades will be required to Middle Street to ensure pedestrian safety and provide for increased tourists traffic. • The proposed new street between Middle Street and North Shore Street will destroy koala habitat. Shore Street East should be blocked off from through traffic. • Do not support the extension of Queen Street. • Upgrades to Shore Street West and the bridge over Ross Creek are required. • Heavy vehicles should avoid residential areas. • Concerned that access to properties on Shore Street North will be limited due to proposed road changes. • The proposed south link from Cross Street in the north should be extended directly into the PDA to create a larger load road and ease traffic congestion. • The bottom of Queen Street should be enhanced rather than additional streets through the koala corridor.	network and recommendations on the design of an efficient and safe street and movement network. This also considered where upgrades, new roads and changes would be required. The development scheme includes criteria relating to the efficient design of the street and movement network which development must respond to in future development applications. The development scheme is also underpinned by the EDQ Guidelines, which includes a guideline on Street and movement networks. It is intended that RCC in partnership with the state government, will undertake an Expression of Interest process to identify a development proponent or proponents to stage and deliver key catalyst development and infrastructure. The detailed design and construction of new roads including minimising conflicts between transport modes will be addressed through the Expression of Interest process or the development assessment process. In response to concerns regarding the future use of GJ Walter park, the proposed north-south link road connection from Middle Street to shore Street East has been removed. Passage and Long Streets are external to the PDA and not subject to the provisions of the development scheme. There are currently no plans to extend Queen Street to connect with the internal PDA road network.	
95.	The PDA should be extended to incorporate the delivery of the bypass from Moreton Bay Road, Capalaba to Wellington Road, Alexandra Hills.	This is not a matter for consideration in the development scheme.	N
96.	There are concerns that large heritage trees will inhibit proposed road changes from being implemented or that trees will be lost when new roads are developed.	The proposed north south link has been removed from the development scheme in order to retain natural features in this location. The development scheme also requires	Y

Matter #	Summary and merits of matters raised in submissions: **Road network and traffic congestion**	Assessment	Amendment Y / N
		development to retain existing mature trees wherever possible. This will be assessed through the development assessment process.	
97.	Sufficient access through streets and at ferry and public transport terminals is required for emergency services vehicles.	Any proposed road systems and networks will be designed in accordance with relevant standards to ensure that emergency vehicles can access the site and associated public transport facilities.	N

4.6. Open space

Matter #	Summary and merits of matters raised in submissions: **Public open space, public amenity and recreation**	Assessment	Amendment Y / N
Public open space, public amenity and recreation			
98.	There is general support for how open space has been addressed in the proposed scheme, including support for improvements to open space, walkways and waterfront access.	Noted.	N
99.	Suggestions on specific matters and the types of improvements required included: • More information should be provided about where improved facilities are proposed or how they will be developed. • Map 2 should clarify if the foreshore is intended to be a public open space area. • Landscaped parks and grassed areas should be provided. • Existing trees, particularly mature pine trees, should be retained. • Additional child and family friendly facilities and recreational activities should be provided. • Diverse recreational services, sporting facilities and activities are needed in the area. • Bins should be provided on footpaths and decorated with bay scenes. • A beach and water park area should be included. • Lighting should be installed along the waterfront. • Precinct 1 should include an arts precinct and sculpture park. • Kayaking and kayak storage facilities should be provided. • Precinct 1 should include a park. • Make reference to connectivity of the PDA with adjacent parks.	The development scheme is a high level planning framework which seeks to balance diverse interests. It is not an application for development and detailed designs have not yet been undertaken. The development scheme identifies principles which future development applications will need to address. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. It is intended that the development scheme will support development opportunities which improve the character of the area and enhance the current amenity, pedestrian and cycle connections and open space within the PDA. The document seeks to improve public access and enjoyment of the waterfront through maintaining and improving the recreational function of GJ Walter park, as well as providing a pedestrian/cycle path along the length of the waterfront and promoting mixed use retail café opportunities in the mixed use node. This will enhance opportunities for the public to access and enjoy the water and bay through both active and passive recreation. Significant parks, gardens and public spaces will contribute to increased enhanced open space and public realm. When the site is developed, open space will include mixed use plazas, waterways, parks, gardens and building forecourts. Within the PDA, waterfront promenades and pedestrian corridors and creek corridors will also contribute to open space.	Y

Matter #	Summary and merits of matters raised in submissions: **Public open space, public amenity and recreation**	Assessment	Amendment Y / N
		The delivery of park embellishments and facilities will be determined through the development assessment process and in accordance with RCC's open space policies. Other considerations contributing to open space and public realm would be the potential use of integrated artworks with functional properties such, as seating, bollards, lighting, rails, and other hard surfaces. This would be considered through the development assessment process. Map 2 – Structure plan has been amended to clarify the intent for the waterfront promenade to be a green open space connection which promotes waterfront access.	
100.	Some submitters were concerned there was insufficient open space provided in the scheme. Specific matters raised in relation to this included: • Suggest that more land should be provided as open space for environmental conservation, nature corridors, recreation opportunities, buffers to beaches and a waterpark play area and also to support the increased population • Additional areas of open space will be required to cater for development and increased population in the area. Some submitters were also concerned areas of existing open space would be lost to development and expressed concern about the potential loss of public and community assets. A number of submitters opposed new development on existing open space.	The preparation of the development scheme was informed by specialist consultant advice including civil engineering, economic, environmental, stormwater management, traffic engineering and urban design advice. This information was then reinforced by advice from Council and state agencies. The document seeks to improve public access and enjoyment of the waterfront through maintaining and improving the recreational function of GJ Walter park, as well as providing a pedestrian/cycle path along the length of the waterfront and promoting mixed use retail café opportunities in the mixed use node. This will enhance opportunities for the public to access and enjoy the water and bay through both active and passive recreation. The Development Scheme seeks to achieve a balance between land identified for community, open space, residential and commercial uses. Accordingly the Development Scheme aims to ensure no net loss of public open space within the PDA. Maps 2 & 4 have been amended to provide greater protection to the recreational function of GJ Walter Park. Background reports have now been made	Y

Matter #	Summary and merits of matters raised in submissions: **Public open space, public amenity and recreation**	Assessment	Amendment Y / N
		available to the community to show how specialist consultant advice has informed the preparation of the development scheme.	

Matter #	Summary and merits of matters raised in submissions: **Use of GJ Walter Park**	Assessment	Amendment Y / N
Use of GJ Walter Park			
101.	A number of submitters raised concerns about impacts from development on GJ Walter Park. Matters raised in relation to this included: • Clarify in Map 4 whether GJ Walter Park is an area to be developed. • Concerned that the beach will be lost due to the marina development. • Concerned the heritage value and regional significance has not been considered and will be compromised by development. • The plan should specify the size of the playground. • Concerned that development will impact the useability of existing walkways and public space in the park. • Suggest that the seawall in the north of GJ Walter Park is located too far north, making the existing beach in the park unusable due to safety issues associated with fishing and swimming in marinas.	The value of GJ Walter Park to the community and the many functions and activities its hosts has been acknowledged through the protection of the recreational function of the park. The development scheme, including Map 4 – Height map, has been amended to strengthen the intent to protect the recreational function of GJ Walter Park. The Development Scheme seeks to achieve a balance between land identified for community, open space, residential and commercial uses. Accordingly the Development Scheme aims to ensure no net loss of public open space within the PDA.	Y
102.	Some submitters thought the dog park should be protected and more detail should be provided about its size to demonstrate how it will be incorporated into the new scheme. Other submitters believe the dog park should be moved away from the waterfront to improve public use and amenity of open space in GJ Walter Park. Suggested alterative locations include between Sommersea Drive and North Street, and Island Street.	The value of GJ Walter Park to the community and the many functions and activities it hosts had been acknowledged through the protection of the recreational function of the park. The development scheme, including Map 4 – Height map, has been amended to strengthen the intent to protect the recreational function of GJ Walter Park. The Development Scheme seeks to achieve a balance between land identified for community, open space, residential and commercial uses. Accordingly the Development Scheme aims to ensure no net loss of public open space within the PDA.	Y
103.	The ownership, protection and management of the park should to be clarified.	The value of GJ Walter Park to the community and the many functions and activities its hosts had been acknowledged through the protection	Y

Matter #	Summary and merits of matters raised in submissions: **Use of GJ Walter Park**	Assessment	Amendment Y / N
	Concern expressed about the tenure of the park. In particular whether Council had resolved to surrender trusteeship of the park and what process was used with regard to the responsibility under the Land Act. Concern that the purpose of the reserve must be protected.	of the recreational function of the park. The development scheme, including Map 4 – Height map, has been amended to strengthen the intent to protect the recreational function of GJ Walter Park. The Development Scheme seeks to achieve a balance between land identified for community, open space, residential and commercial uses. Accordingly the Development Scheme aims to ensure no net loss of public open space within the PDA. Any changes to tenure under the *Land Act 1994* will follow normal legislative processes.	
104.	Additional information should be included in the infrastructure plan on improvements to open space including GJ Walter Park. Suggestions to improve the amenity of GJ Walter Park include: • A waterpark facility or swimming pool. • Improved shading and lighting. • Safe playground equipment for all abilities. • Amenities including toilets, parent rooms, picnic tables and barbeque facilities. • Shared walkways around permitter. • The reclaimed extension of GJ Walter Park should be moved south along the existing beach. • Sand spots and shallow areas should be filled with sand from Stradbroke Island to create beaches.	The development scheme, including Map 4 – Height map, has been amended to strengthen the intent to protect the recreational function of GJ Walter Park. The development scheme includes the requirement to demonstrate how development provides opportunities for the community to engage with the heritage and coastal habitats of Moreton Bay through new and improved areas of waterfront public open space. The development scheme is a high level planning framework which seeks to balance diverse interests. It is not an application for development and detailed designs have not yet been undertaken. The development scheme identifies principles which future development applications will need to address. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. Accordingly the Development Scheme aims to ensure no net loss of public open space within the PDA. The delivery of park embellishments and facilities will be determined through the development assessment process, in accordance with RCC's open space policies. The infrastructure plan also identifies	Y

Matter #	Summary and merits of matters raised in submissions: **Use of GJ Walter Park**	Assessment	Amendment Y / N
		improvements to GJ Walter Park.	

Matter #	Summary and merits of matters raised in submissions: **Access to the waterfront**	Assessment	Amendment Y / N
Access to the waterfront			
105.	The development scheme should provide more information to identify how access to the waterfront will be impacted by development and to emphasise the protection of the waterfront for community use. Some submitters believed the majority of waterfront should be protected from development and be primarily a publicly accessible area. Some submitters supported some retail and commercial development provided it did not prevent the public from accessing the waterfront. Concerned the construction of a boardwalk or marina will disrupt views and public access, resulting in environmental degradation.	The development scheme is a high level planning framework which seeks to balance diverse interests. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process. The development scheme includes the requirement to demonstrate how development provides opportunities for the community to engage with the heritage and coastal habitats of Moreton Bay through new and improved areas of waterfront public open space. The document seeks to improve public access and enjoyment of the waterfront through maintaining and improving the recreational function of GJ Walter park, as well as providing a pedestrian/cycle path along the length of the waterfront and promoting mixed use retail café opportunities in an idyllic water front setting, open to the public and residents alike.. This will enhance opportunities for the community to access and enjoy the water and bay through both active and passive recreation. The development scheme shows a new pedestrian / cycle area and waterfront road which will provide a buffer between development and the foreshore, increase activity and therefore safety and enhance public access to the waterfront. Development adjoining this public space and road would provide opportunities for mixed use retail café uses – further enhancing the public's opportunity to enjoy the waterfront. Map 2 – Structure plan has been amended to clarify the intent for the waterfront promenade to be a green open space connection which promotes waterfront access.	Y
106.	Support for the provision of a public pier, including opportunities for walking and fishing.	Noted.	N

Matter #	Summary and merits of matters raised in submissions: **Access to the waterfront**	Assessment	Amendment Y / N
107.	Suggest provisions be included for a jetty to be built out towards Cassim Island together with interlinked broadwalks.	Noted. The detailed design and nature of development will be determined in future development applications assessed through the development assessment process.	N

4.7. Infrastructure, implementation and funding

Matter #	Summary and merits of matters raised in submissions: **Development and infrastructure funding and delivery**	Assessment	Amendment Y / N
Development and infrastructure funding and delivery			
108.	A number of concerns were raised about how development and infrastructure would be funded. Matters raised included: • Detailed information is required regarding costing and funding arrangements for delivery and ongoing maintenance of infrastructure. • The funding framework is vague with regard to the financing and commitments from the state and developers. • There are concerns that the cost of development and infrastructure will be passed on to local residents and businesses through increased housing costs. • State funded infrastructure upgrades should be investigated. • Upgrades to ferry facilities should be co-funded by operators and users. • Developers should be required to meet all costs associated with infrastructure connection, upgrades and augmentations for the road, water and sewerage network.	Infrastructure and development will be funded by development in the normal way, as it would have been funded prior to a PDA being declared. The development scheme includes an explanation that infrastructure charges will be based on RCC's applicable infrastructure charging document for the area or an Infrastructure Agreement. There is no intention or indication in the development scheme that levies or increased rates will be used to fund infrastructure.	N
109.	Infrastructure should be designed to complement the existing natural environment.	Noted.	N
110.	Existing schools are at capacity and will not be able to service new residents from Toondah Harbour.	Noted.	N
111.	There are concerns that the proposed scheme will result in public assets (i.e. GJ Walter Park and parts of the Moreton Bay Marine Park) being given to developers.	The state government and RCC are committed to efficiently utilising resources including public land to achieve improvements for the community.	Y

Matter #	Summary and merits of matters raised in submissions: **Development and infrastructure funding and delivery**	Assessment	Amendment Y / N
		The development scheme, including Map 4 – Height map, has been amended to strengthen the intent to protect the recreational function of GJ Walter Park.	
112.	Concerned there is insufficient infrastructure capacity for the increased development and population growth.	The preparation of the development scheme was informed by specialist consultant advice including advice on the capacity of trunk infrastructure and whether any upgrades would be required to accommodate development.	N

Matter #	Summary and merits of matters raised in submissions: **Timing and implementation of development**	Assessment	Amendment Y / N
Timing and implementation of development			
113.	A number of comments were raised in relation to staging of development. These included: • Concerned that if would be difficult to effectively stage development as it is unclear when and how much private capital will be provided. The scheme should include information on capital raising process. • Concerned development outcomes and staging will be fragmented and that this will negatively impact the viability of the project.	The development scheme includes a development staging strategy which identifies the anticipated sequencing of development throughout the PDA. However, the specific timing of when development will occur will be determined by market forces and the Expression of Interest process.	N
114.	Consideration should be given to minimising the impacts of dust, noise and odour on the existing community from construction activities.	The development scheme requires developers to minimise adverse impacts on amenity during construction and must demonstrate how this will be managed as part of the development assessment process.	N
115.	The proposed redevelopment is not commercially viable in the current market. There is no demand for high density residential development and there are a number of unit developments in the area which are currently vacant. If development is vacant it will not be well maintained and will decrease existing property values.	The development scheme seeks to create a framework which balances diverse interests. It is a long term plan for the area and development completion may take many years to be realised. The timing and nature of development will be determined by the private market and the development process.	N
116.	There are concerns that new residential development will compete with existing projects yet to be completed due to poor uptake.	The development scheme seeks to create a framework which balances diverse interests. It is a long term plan for the area and development completion may take many years to be realised. The timing and nature of development will be determined by the private market and the development process.	N
117.	Question how capital works associated with the redevelopment of the ferry will be funded. Ferry providers should not be made to pay	Infrastructure will be funded by development in the normal way, as it would have been funded prior to a PDA being declared. The	N

Matter #	Summary and merits of matters raised in submissions: **Timing and implementation of development**	Assessment	Amendment Y / N
	additional infrastructure charges or contributions to upgrade the facilities. Concerned this cost will be transferred to the customer and result in increased fares or will force the operator out of business.	development scheme includes an explanation that Infrastructure charges will be based on RCC's applicable infrastructure charging document for the area or an Infrastructure Agreement. An Infrastructure agreement may provide for alternative funding arrangements and take into account matters such as value uplift, however this would be negotiated with the developer and would not rely on Council rates. Further detailed levels of planning through the development process will be the main tool for negotiating infrastructure charges or an infrastructure agreement to ensure infrastructure is planned, funded and developed in an integrated way with various land uses and development.	

4.8. Other matters

Matter #	Summary and merits of matters raised in submissions: **Plan making and public notices**	Assessment	Amendment Y / N
Plan making and public notices			
118.	A number of comments were raised in relation to consultation timeframes and processes. Key matters raised included: • Concerned that the scheme has not taken into account the concerns and comments raised by the community during previous consultation. For example, a large portion of the community supported low scale redevelopment and an 800 berth marina as preferred uses through this consultation. • The scale of the plan does not enable individuals to provide informed feedback. It is not possible to provide effective feedback on a conceptualised plan. • The consultation period did not provide sufficient time or information for the community to provide effective feedback. • There has been a lack of transparency and accountability in the consultation, planning and design process. • Aspects of the community consultation and online submission forms were difficult to interpret or complete making it unclear how issues raised will be considered and implemented in the final plan. • There are concerns that public submissions will not be taken into consideration in the final scheme. • The final plan should be voted on by the local community. • Concerned about the manner in which the public consultations were handled and run. • Concerned the submission process does not disclose the final decisions. • The scheme has lacked consultation with local community and business.	A comprehensive community engagement program has been carried out as part of the preparation of the development scheme. This program is outlined in section 2 of the submissions report. Some amendments have been made to the development scheme in response to submissions.	Y

Matter #	Summary and merits of matters raised in submissions: **Plan making and public notices**	Assessment	Amendment Y / N
	• Concerned the community will have no further consultation once EOIs are received. • Concerned that opposing opinions of different community groups will delay or stop development. • Concerned that only the loudest are heard and that the loudest may not represent the views of the community.		
119.	Some concerns were raised in relation to the plan making process. Comments raised included: • Believe the plan making process timeframe is inadequate and does not allow for the correct investigations to occur. • Concerned that PDA legislation bypasses normal requirements for impact studies. • Studies undertaken to inform the development of the scheme should be made publicly available. • Further analysis and emphasis of the economic benefits of Toondah Harbour as a gateway to Bay Islands is required. • Private enterprise should undertake PDA planning.	The development scheme is a high level planning framework which seeks to balance diverse interests. It is not an application for development and detailed designs have not yet been undertaken. The development scheme identifies principles which future development applications will need to address. It is intended that RCC in partnership with the state government, will undertake an Expression of Interest process to identify a development proponent or proponents to stage and deliver key catalyst development and infrastructure. Further detailed levels of planning through the development process will be the main tool for ensuring development, including parking and the bus and ferry terminal is planned and developed in an integrated way with various land uses and infrastructure. RCC and the state Government will continue to provide information and updates to the community on the EOI process and any publicly notified development applications within the PDA. The preparation of the development scheme was informed by specialist consultant advice including civil engineering, economic, environmental, stormwater management, traffic engineering and urban design advice. This information was then reinforced by advice from Council and state agencies. Background reports have now been made available to the community to show how specialist consultant advice has informed the	N

Matter #	Summary and merits of matters raised in submissions: **Plan making and public notices**	Assessment	Amendment Y / N
		preparation of the development scheme.	
120.	Submissions raised concerns around project governance. Comments raised included: • Concerned about statements made by politicians regarding the community's involvement in the preparation of the scheme. • Concerned that the State Government and Council are treating the proposed scheme as a 'done deal'. • Concerned that Council has taken a hands-off approach to planning for the area. • Concerned that the development assessment responsibility for the PDA has been taken away from council and lacks transparency.	The PDA was declared under the *Economic Development Act 2012* at the request of RCC. The commissioning of consultants was undertaken by RCC and the drafting of the development scheme was undertaken by the state government in partnership with RCC and utilising information provided from the specialist consultants. Development assessment powers are currently delegated from the Minister for Economic Development Queensland to RCC. The Act's purpose is to facilitate economic development and development for community purposes. The development scheme therefore seeks to support opportunities for economic development which will provide new public infrastructure and facilities that will benefit both mainland and island communities. It is intended that RCC in partnership with the state government, will undertake an Expression of Interest process to identify a development proponent or proponents to stage and deliver key catalyst development and infrastructure. Further detailed levels of planning through the development process will be the main tool for ensuring development, including parking and the bus and ferry terminal is planned and developed in an integrated way with various land uses and infrastructure.	N
121.	Concerns were raised about the legislative process for PDAs, in particular: • The process and the Economic Development Act 2012. • Concerned that the PDA process denies the public a normal right of appeal. • Concerned about the MEDQ acting as a 'corporation sole'.	Allowing for appeal processes similar to those under other planning legislation could lead to substantial delays in the development of the PDA, which undermines the objective of the *Economic Development Act 2012* in ensuring economic development and development for community purposes is completed in a timely way. However, opportunities for the public to comment on publicly notified development applications are provided for in the	N

Matter #	Summary and merits of matters raised in submissions: **Plan making and public notices**	Assessment	Amendment Y / N
		development scheme.	
122.	There is concern that development approvals will be granted for proposals that are inconsistent with the PDA if there is sufficient grounds for approval.	A development application may propose something which is different to the PDA-wide criteria or Precinct provisions, as long as it is not inconsistent with the vision. This is intended to provide an appropriate amount of flexibility for alternative options to be lodged and considered. A development application of this nature would need to be publicly notified, provide sufficient justification of a superior design outcome or overwhelming community need to support the proposal.	N
123.	There were comments raised that planning and development should be undertaken in consultation with the Quandamooka people to achieve place-specific landscape and building design. Comments raised included: • Request that development be subjected to a tender process which incorporates further consultation with the Quandamooka people. • Concerned that Quandamooka people will be displaced from economic opportunities which should be addressed in the scheme and have not been adequately considered. • Suggests that the Queensland Aboriginal and Torres Strait Islander Economic Participation Framework 2013 should be implemented in the PDA process.	The development scheme is a high level planning framework which seeks to balance diverse interests. It is not an application for development and detailed designs have not yet been undertaken. Accordingly place specific landscape and building design are not matters considered in the document and will be addressed through the development assessment process. The development scheme identifies principles which future development applications will be required to address. For Toondah Harbour this includes delivering development which considers indigenous heritage. Key stakeholders including representatives of the Quandamooka People were involved in the design workshops as well as private meetings to inform the preparation of the proposed development scheme. Further consultation and consideration of cultural and Aboriginal heritage can occur as part of the development assessment process. The development scheme has been amended to make further reference to consideration of cultural and Aboriginal heritage issues.	Y
124.	Concerned that not all ideas put forward in the plan will be built.	The development scheme is a high level planning framework which seeks to balance diverse interests. It is not an application for development and detailed designs have not yet	N

Matter #	Summary and merits of matters raised in submissions: **Plan making and public notices**	Assessment	Amendment Y / N
		been undertaken. The development scheme identifies principles which future development applications will need to address and allows sufficient flexibility for consideration of a variety of development proposals where they are not in conflict with the vision. It is intended that RCC in partnership with the state government, will undertake an Expression of Interest process to identify a development proponent or proponents to stage and deliver key catalyst development and infrastructure. Further detailed levels of planning through the development process will be the main tool for ensuring development, including parking and the bus and ferry terminal is planned and developed in an integrated way with various land uses and infrastructure.	

Matter #	Summary and merits of matters raised in submissions: **Other concerns relating to Toondah Harbour**	Assessment	Amendment Y / N
Other concerns relating to Toondah Harbour			
125.	A number of questions and comments were received in relation to areas which were outside of the PDA boundary or the scope of the project. Matters raised include: • Water speed limits are not enforced in the harbour. • Consideration should be given to how Dunwich and One Mile will be integrated into future development. • Planning issues in North Stradbroke should be the priority over Toondah Harbour. • There should be better connections between Stradbroke Island and public transport opportunities on the mainland. • Vehicle ferry services to other islands should also be improved. • Suggests a complementary plan for the development for the ferry terminals and surrounds on the Stradbroke side. • Improved landscaping and shading should be provided at Dunwich ferry terminal. • Ferry facilities at Dunwich should be upgraded in parallel to any upgrades at Toondah Harbour to provide a consistent experience between the mainland and North Stradbroke Island. • The scheme does not include potential development sites at Dunwich and North Stradbroke Island. • Provide a bridge connection to Cassim Island. • Concerned that development will destroy Cassim Island and Sandy Island and impact adversely on Peel Island and Banana Banks. • Concerned Cassim Island will be reclaimed and developed under the scheme.	These matters have been noted by EDQ and RCC and may be further investigated via other government projects. They are not matters for consideration in the development scheme.	N

5. List of all amendments to the development scheme

Amendment #	Section details	Nature of amendment	Reason for amendment
General			
1.	Throughout the document	Amend the terminology through the document from "*proposed development scheme*" to now read "*development scheme*"	To reflect finalisation and adoption of the scheme.
2.	Front cover	Amend the date of the cover from "*January 2014*" to "*May 2014.*"	To reflect the month the scheme was adopted.
3.	Back cover	Amend the date of the back cover from "*January 2014*" to "*May 2014.*"	To reflect the month the scheme was adopted.
1.0 Introduction			
4.	Introduction	Insert a new section 1.5 "*State interests*" and footnote to read as follows: "Relevant matters of state interests have been considered in the preparation of this development[1]." The footnote is to read as follows: [1]*For the purposes of addressing state interests in development assessment, the State Assessment and Referral Agency (SARA) online mapping provides guidance in identifying if a state interest is relevant to the assessment of a PDA development application (refer to: http://www.dsdip.qld.gov.au/about-planning/sara-mapping-online-system.html). Where the MEDQ delegates development assessment functions and powers, applicants and the delegate should also refer to http://www.dsdip.qld.gov.au/resources/guideline/pda/practice-note-14-state-interests.pdf (note: the functions and powers of the MEDQ under the definition of state interest are not delegated)"*	To clarify how state interests have been considered in the preparation of the development scheme and how they will be addressed through the development assessment process.

Amendment #	Section details	Nature of amendment	Reason for amendment
2.0 Strategic context			
5.	Section 2.1 Location	Amend paragraph 3, first sentence from: *"Toondah Harbour acts as the main point of departure and arrival for vehicular ferry and water taxi services between the mainland and North Stradbroke Island."* to now read: *"Toondah Harbour is the main point of departure and arrival for vehicular ferry and water taxi services between the mainland and North Stradbroke Island."*	To improve readability of the document.
3.0 Land use plan			
3.2 Development assessment			
6.	Section 3.2.3 Development approval	Delete" *footnote 3*" at end of paragraph 2.	To reflect finalisation and adoption of the scheme.
7.	Section 3.2.5 Development inconsistent with the scheme	Delete "*footnote 4*" in paragraph 1.	To reflect finalisation and adoption of the scheme.
8.	Section 3.2.6 Demonstrating development is consistent with the scheme, sub heading: Preliminary approval	Amend paragraph 2 from: *"In this regard preliminary approvals may demonstrate how development achieves the requirements of the scheme at an intermediate level of spatial planning between the broad spatial framework of the Structure plan and Precinct provisions and the individual development proposals and associated Plans of Development (PoDs)."* to now read: *"In this regard Preliminary approvals may demonstrate how development achieves the requirements of the scheme within the broad spatial framework of the Structure plan and Precinct provisions and the individual development proposals and associated Plans of Development (PoDs)."*	To improve readability of the document.

Amendment #	Section details	Nature of amendment	Reason for amendment
9.	Section 3.2.6 Demonstrating development is consistent with the scheme, sub heading: Plan of Development	Amend paragraph 2 from: *"A PoD is prepared by an applicant and may include maps, graphics and text that collectively demonstrate how proposed uses, works and lots will contribute towards the achievement of the vision and will be consistent with the relevant PDA development requirements and Precinct provisions."* to now read: *"A PoD is prepared by an applicant and may include maps, graphics and text that collectively demonstrate how proposed uses, works and lots will contribute towards the achievement of the vision. It should also be consistent with the relevant PDA development requirements and Precinct provisions."*	To improve readability of the document.
3.3 Vision			
10.	Section 3.3 Vision - *Map 2 – Structure plan*	Delete Map 2 – Structure plan and insert new map with following amendments: • removal of North South link • waterfront promenade made more distinct • GJ Walter Park icon and Koala Corridor removed and replaced with land area graphic • note added to legend to ensure plan is read in conjunction with Maps 3 and 4 • PDA boundary graphical treatment changed • minor reduction to the extent of mixed use node.	To reflect changes made to the text.
11.	Section 3.3 Vision	Delete the words "*and Map 2 – Structure Plan*" and amend wording in paragraph 1 to read: *"The Toondah Harbour PDA vision describes the overall outcomes to be achieved in the PDA and is articulated through the vision statement and the structural elements."*	To clarify that Map 2 – Structure plan is supporting information to the vision, but is not part of the vision.

Amendment #	Section details	Nature of amendment	Reason for amendment
12.	Section 3.3 Vision	Amend paragraph 2 to read: *"…is articulated in Map 2 – Structure plan, the PDA-wide criteria, Precinct provisions, Infrastructure plan and Implementation strategy."*	To clarify that Map 2 – Structure plan is supporting information to the vision, but is not part of the vision.
13.	Section 3.3.1 Vision statement,	Amend paragraph 1, second sentence from: *"Development establishes a strong community identity which benefits from the amenity of Moreton Bay and a mixture of residential, retail, commercial and community uses."* to now read: *"Development establishes a strong community identity which benefits from the indigenous heritage and amenity of Moreton Bay and a mixture of residential, retail, tourism, commercial and community uses."*	To clarify the intention to respect indigenous heritage through development of the PDA.
14.	3.3.1 Vision statement	Delete last sentence of paragraph 2: "*The existing southern channel is widened to accommodate passenger and vehicle ferry traffic.*"	To provide for the consideration of alternative water access routes in the future, if it can be demonstrated that they do not conflict with the vision, they are deliverable and there is funding available.
15.	3.3.1 Vision statement	Amend paragraph 3, second sentence from: *"Development establishes Toondah Harbour as a high quality urban environment that capitalises on the high amenity of Moreton bay and provides opportunities for a range of activities including outdoor dining, residential, commercial development, marina and a public beach."* to now read: *"Development establishes Toondah Harbour as a high quality urban environment that capitalises on the high amenity of Moreton bay and provides opportunities for a range of activities including outdoor dining, tourism*	To clarify the intent to provide for tourism facilities to locate in the PDA.

Amendment #	Section details	Nature of amendment	Reason for amendment
		facilities, residential, commercial development, marina and a public beach."	
16.	Section 3.3.1 Vision statement	Amend paragraph 4 to insert a new sentence after the last sentence to read: *"The functioning of existing parks is protected and there is no net loss of public open space within the Toondah Harbour PDA, including GJ Walter Park."*	To clarify the intent to ensure there is no net loss of public open space.
17.	Section 3.3.1 Vision statement	Amend paragraph 6 to insert a new sentence after the last sentence to read: *"Adequate parking is provided to meet the scale of development and anticipated growth."*	To clarify the intent to provide sufficient parking with consideration of development and growth.
18.	Section 3.3.2 Structural elements	Amend dot point 3 from: *"creating a mixed use node incorporating medium density residential development, commercial offices, tourist accommodation including a boutique hotel, restaurants, cafes and shops"* to now read: *"creating a mixed use node incorporating medium density residential development, commercial offices, cultural facilities, tourist accommodation including a boutique hotel, restaurants, cafes and shops"*	To clarify the intent to provide for cultural facilities to locate in the PDA.
19.	Section 3.3.2 Structural elements	Amend dot point 4 from: *"improving access to the waterfront and public open space through pedestrian waterfront links and a new waterfront promenade connecting the harbour to GJ Walter Park which is safe, protects coastal resources and establishes connections north and south of the PDA."* to now read: *"improving access to the waterfront and public open space through pedestrian waterfront links and a new waterfront promenade connecting the harbour to GJ Walter Park which is safe, contributes to the open space network, protects*	To clarify the intent for the waterfront pedestrian and cycle link to be designed and delivered in a way that contributes to the open space network.

Amendment #	Section details	Nature of amendment	Reason for amendment
		coastal resources and establishes connections north and south of the PDA."	
20.	Section 3.3.2 Structural elements	Amend dot point 5 from: *"providing for passenger ferry operations in proximity to the mixed use plaza"* To now read: *"providing for passenger ferry operations in proximity to a mixed use plaza"*	To clarify that the location of the mixed use plaza on Map 2 – Structure plan is indicative and may ultimately be located in an alternative location where it is not in conflict with the vision.
21.	Section 3.3.2 Structural elements	Amend dot point 6 from: *"providing for vehicle ferry services to operate in the south of the PDA where vehicle and vessel traffic conflicts can be minimised"* to now read: *"providing for vehicle ferry services to operate where vehicle and vessel traffic conflicts can be minimised"*	To clarify that the location of the vehicle ferry on Map 2 – Structure plan is indicative and may ultimately be located in an alternative location where it is not in conflict with the vision.
22.	Section 3.3.2 Structural elements	Amend dot point 9 from: *"establishing a vegetated corridor providing for koala habitat and movement* to now read: *"establishing a vegetated corridor for wildlife habitat and provide for koalas and their safe movement"*	To clarify intent and improve readability of the document.
3.4 PDA-wide criteria			
23.	Section 3.4.1 Urban design	Amend dot point 3 from: *"create an active place characterised by a high quality public realm and safe, attractive pedestrian areas which encourage community interaction and support active, healthy lifestyles"* to now read: *"create an active place characterised by a high quality public realm and safe pedestrian areas which encourage community interaction and*	To improve readability of the document.

Amendment #	Section details	Nature of amendment	Reason for amendment
		support healthy lifestyles"	
24.	Section 3.4.1 Urban design	Delete dot point 5: *"are integrated with or complement development in neighbouring sites and precincts, having regard to the marina and potential filling or land reclamation"* and replace with: *"appropriately interfaces with existing residential development within and adjoining the PDA boundary and mitigates impacts from density or height by providing:* • *visual buffers and setbacks or graduation in height* • *appropriate access arrangements, and* • *complementary uses."*	To improve readability of the document and clarify the intent for development to have an appropriate interface with adjoining residential development.
25.	Section 3.4.1 Urban design	Amend dot point 7 from: *"are designed to enhance the relationship with the waterfront"* to now read: *"enhance the relationship with the waterfront"*	To improve readability of the document.
26.	Section 3.4.1 Urban design	Delete dot point 9 which currently reads: *"responds to and conserve local site characteristics, settlings, places of heritage significance, landmarks and views, and uses built form and natural features to provide specific identity and character, by avoiding or minimising impacts and considering the nature and scale of development that may impact cultural heritage"* and replace with new dot point that reads: *"conserve local site characteristics, settings, places of heritage significance, landmarks, breezes and views"*	To improve readability of the document and clarify intent for development to also have regard to breezes in its design.
27.	Section 3.4.1 Urban design	Insert new dot point after dot point 9 to read: *"uses built form and natural features to provide*	To improve readability of the document.

Amendment #	Section details	Nature of amendment	Reason for amendment
		specific identity, which complements existing local character and cultural heritage"	
28.	Section 3.4.4 Natural environment	Amend dot point 3 from: *"establishes linear corridors through the PDA which support fauna movement and open space connections between community focal points"* to now read: *"establishes vegetated corridors through the PDA which support wildlife habitat, safe fauna movement and open space connections between community focal points"*	To clarify intent and improve readability of the document.
29.	Section 3.4.5 Open space	Amend paragraph 1 and insert two new dot points to read: *"protects the functioning of existing parks and ensures no net loss of public open space"* *and* *"protects the recreational function of GJ Walter Park as an area of open space"*	To clarify the intent to protect the recreational function of GJ Walter Park.
30.	Section 3.4.5 Open space	Amend dot point 3 from: *"provide opportunities to connect to open space areas within and adjoining the PDA and delivers parks identified in Map 2"* to now read: *"provide opportunities to connect to open space areas within and adjoining the PDA and delivers parks identified in Map 2 – Structure plan"*	To improve readability of the document.
31.	Section 3.4.5 Open space	Amend dot point 6 from: *"ensures the waterfront promenade is designed to provide opportunities for the public to access and enjoy the waterfront"* to now read: *"ensures the waterfront promenade is designed to contribute to the open space network and provide opportunities for the public to access*	To clarify the intent for the waterfront pedestrian and cycle link to be designed and delivered in a way that contributes to the open space network.

Amendment #	Section details	Nature of amendment	Reason for amendment
		and enjoy the waterfront"	
32.	Section 3.4.5 Open space	Amend dot point 7 from: *"retain existing significant areas and incorporate existing natural features to the greatest extent possible having regard to the achievement of natural environment criteria in Section 3.4.4"* to now read: *"incorporate existing natural features to the greatest extent possible having regard to the achievement of the natural environment criteria in Section 3.4.4"*	To improve readability of the document.
33.	Section 3.4.6 Community safety and development constraints	Amend dot point 2 from: *"have regard to and mitigate impacts from erosion prone areas"* to now read: *"mitigate impacts from erosion prone areas"*	To improve readability of the document.
34.	Section 3.4.6 Community safety and development constraints	Amend dot point 3 from: *"have regard to and mitigate impacts from contaminated land"* to now read: *"mitigate impacts from contaminated land"*	To improve readability of the document.
3.5 Precinct provisions			
35.	Section 3.5.2 Precinct 1 – Mixed use village, sub heading *Residential development and the mixed use node*	Amend paragraph 2, dot point 3 from: *"support the creation of the mixed use node where active commercial or retail uses are focused, providing convenience retail and commercial uses…"* to now read: *"support the creation of the mixed use node where active commercial or retail uses are focused, providing convenience retail, tourist and commercial uses…"*	To clarify the intent to provide for tourism facilities to locate in the PDA.

Amendment #	Section details	Nature of amendment	Reason for amendment
36.	Section 3.5.2 Precinct 1 – Mixed use village, sub heading *Open space*	Amend paragraph 1 which currently reads: *"Development in Precinct 1 will contribute to reconfiguring GJ Walter Park to improve overall access to the waterfront within the PDA and protect key activities within the remaining open space area. Development will also contribute to establishing a waterfront promenade along the eastern length of Precinct 1 which will form part of the movement network, but be designed to enhance public access and enjoyment of the waterfront."* to now read: *"Development in Precinct 1 will improve overall access to the waterfront within the PDA. Development will protect the recreational function of GJ Walter Park as an area of public open space. Development will also contribute to establishing a waterfront promenade along the eastern length of Precinct 1 which will form part of the open space and movement network, but be designed to enhance public access and enjoyment of the waterfront. Development in Precinct 1 will ensure no net loss of public open space."*	To clarify the intent to protect the recreational function of GJ Walter Park and for the waterfront pedestrian and cycle link to be designed and delivered in a way that contributes to the open space network.
37.	Section 3.5.2 Precinct 1 – Mixed use village, sub heading *Street and movement network*	Delete dot point 4 under paragraph 3 which read: *"provides a new road connection to the south of GJ Walter Park along the western boundary of the precinct, extending from Shore Street East to connect to Middle Street which has regards to the protection of the koala corridor and seeks to minimise impacts to flora and fauna while servicing development to the east and improving connectively through the PDA"*	To protect the recreational function of GJ Walter Park.
38.	Section 3.5.2 Precinct 1 – Mixed use village, sub heading *Preferred land uses*	Delete dot point 9 from "*Hostel*" and replace with "*Hotel*"	To amend an error.
39.	Section 3.5.5 Precinct 4 – Marina and water based	Amend dot point 1 from:	To improve readability of the

Amendment #	Section details	Nature of amendment	Reason for amendment
	development, sub heading *Precinct intent*	*"avoiding conflict between recreational and commercial boating activity and the safety of all boating movements"* to now read: *"avoiding conflict between recreational and commercial boating activity and ensuring the safety of all boating movements"*	document.
40.	Section 3.5.5 Precinct 4 – Marina and water based development, sub heading *Precinct intent*	Under dot point *"a marina which"*, amend sub dot point 3 from: *"…is designed to enable gradual expansion up to 800 berths"* to now read: *"…is designed to enable gradual expansion up to 400 berths"*	To reduce the intended maximum size of the marina.
41.	Section 3.5.5 Precinct 4 – Marina and water based development, sub heading *Precinct intent*	Under dot point "a mixed use pier / land reclamation area which", amend sub dot point 4 from: *"supports high density mixed-use development with a focus on marine associated business and residential development"* to now read: *"supports high density mixed-use development with a focus on marine associated business, tourist and residential development"*	To clarify the intent to provide for tourism facilities to locate in the precinct.
42.	Section 3.5 Precinct provisions – *Table 1 – levels of assessment*	Delete 'extractive industry" from Column 3B.	To clarify that dredging may be proposed within the PDA.
43.	Section 3.5 Precinct provisions – *Map 3 – Precinct plan*	Delete Map 3 – Precinct plan and insert new map with following amendments: • Removal of north south link.	To reflect changes made to the text.
44.	Section 3.5 Precinct provisions – *Map 4 – Precinct plan*	Delete Map 4 – Height plan and insert new map with following amendments: • reduce 15 storeys control to 10 storeys control • graphical changes to reflect extent of	To reflect the reduction of maximum building heights and to protect the recreational function of GJ Walter Park.

Amendment #	Section details	Nature of amendment	Reason for amendment
		developable land.	
4.0 Infrastructure Plan			
45.	Section 4.0 Infrastructure plan table	Amend first row grouped under Pedestrian / cycle networks from: *"Establish pedestrian and cycle connections that provides safe and convenient access along the waterfront, between the harbour to GJ Walter Park, within and between precincts and linking the PDA to the broader network."* to now read: *"Establish pedestrian and cycle connections that contribute to the open space network and provides safe and convenient access along the waterfront, between the harbour to GJ Walter Park, within and between precincts and linking the PDA to the broader network."*	To clarify the intent for the waterfront pedestrian and cycle link to be designed and delivered in a way that contributes to the open space network.
46.	Section 4.0 Infrastructure plan table	Amend first row grouped under Roads and transport from: *"Make adequate provision for the nature and number of vehicles expected including…"* to now read: *"Make adequate provision for the nature and number of vehicles expected having regard to projected population growth including…"*	To clarify intent for development to have regard to population growth in the provision of future car parking.
47.	Section 4.0 Infrastructure plan table	Delete fourth row grouped under Roads and transport which read: *"Deliver a new north south road link connects Middle Street in Precinct 1 to Shore Street east.*	To protect the recreational function of GJ Walter Park.
5.0 Implementation Strategy			
48.	Section 5.2 Implementation strategy table	Delete second point in *"Desired outcomes"* column, first row under short term header.	To clarify intent to provide for more fauna movement.
49.	Section 5.2 Implementation strategy	Delete first dot point in "*The actions*" column,	To protect the recreational

Amendment #	Section details	Nature of amendment	Reason for amendment
	table	fifth row under short term header.	function of GJ Walter Park.
Schedule 1: Exempt development			
50.	All aspects of development	Insert new row which reads: *"Development undertaken for the purposes of a dwelling house where extending or replacing an existing dwelling house, where complying with the acceptable solutions in the Queensland Development Code MP1.1 – Design and siting standards for single detached housing and MP1.2 – Design and siting standards for single detached housing"*	To correct an omission and allow for applicants with an existing house to undertake renovations or build a new house, without requiring planning approval.

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Document 10

TERRESTRIAL ECOLOGY ASSESSMENT

TOONDAH HARBOUR PRIORITY DEVELOPMENT AREA, REDLAND CITY

Prepared for
Walker Corporation



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Client: Walker Corporation

Project Title: Terrestrial Ecology Assessment, Toondah Harbour Priority Development Area, Redland City

Project Author/s: Dr Penn Lloyd, Adrian Caneris, Dr Jo Chambers and Lui Weber

Project Summary: This report provides an assessment of the terrestrial ecology values present within the Toondah Harbour Priority Development Area (PDA) in Redland City, south-east Queensland, the potential impacts on these values of development of the PDA, and potential impact mitigation and management measures.

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Biodiversity Assessment and Management Pty Ltd has produced this report in its capacity as {consultants} for and on the request of Walker Corporation (the "Client") for the sole purpose of providing an assessment of the terrestrial ecology values present within the Toondah Harbour Priority Development Area (PDA) in Redland City, south-east Queensland, the potential impacts on these values of development of the PDA, and potential impact mitigation and management measures (the "Specified Purpose"). This information and any recommendations in this report are particular to the Specified Purpose and are based on facts, matters and circumstances particular to the subject matter of the report and the Specified Purpose at the time of production. This report is not to be used, nor is it suitable, for any purpose other than the Specified Purpose. Biodiversity Assessment and Management Pty Ltd disclaims all liability for any loss and/or damage whatsoever arising either directly or indirectly as a result of any application, use or reliance upon the report for any purpose other than the Specified Purpose.

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Signed on behalf of Date: 05/04/2017
Biodiversity Assessment and Management Pty Ltd

Managing Director

EXECUTIVE SUMMARY

PURPOSE OF THE REPORT

This report provides an assessment of the terrestrial ecology values present within the Toondah Harbour Priority Development Area (PDA) in Redland City, south-east Queensland, the potential impacts on these values of the Walker Group's proposal for the development of the PDA, and potential impact mitigation and management measures. The development proposal (the Project) includes residential, retail, marina, hotel, port facilities and tourism infrastructure to be developed within the PDA.

STUDY APPROACH

The report integrates the results of a number of previous terrestrial ecology studies that have been undertaken to inform the Toondah Harbour PDA development proposal with a revised review of publically available databases, including extensive shorebird survey data collected by the Queensland Wader Study Group, and published literature relevant to the terrestrial ecology values within the study area. Previous studies included a 1-day general ecological survey and at least four summer surveys and one winter survey for migratory shorebirds during both low-tide and high-tide phases of the tide cycle.

MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

Matters of national environmental significance (MNES) regulated under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that occur within the PDA boundary include:

- a small portion of the Moreton Bay wetlands, listed as internationally significant wetlands under the *Convention on Wetlands of International Importance 1971* (Ramsar Convention);
- intertidal mudflats and sandflats that are recognised as important feeding habitat (due to them being part of the Moreton Bay shorebird area that is recognised as internationally important for migratory shorebirds) for migratory shorebirds at low tide (average of 101 and maximum of 158 birds use the habitats in summer, representing 0.33% and 0.53% respectively of the estimated total of 30,000 migratory shorebirds that use Moreton Bay), including known feeding habitat for the critically endangered Eastern Curlew *Numenius madagascariensis* (average of 5 and maximum of 7 birds), the critically endangered Great Knot *Calidris tenuirostris* (a single bird on a single survey) and the vulnerable Bar-tailed Godwit (Western Alaskan) *Limosa lapponica baueri* (average of 25 and maximum of 36 birds);
- several individuals of the vulnerable Koala *Phascolarctos cinereus* regularly utilise food trees that are scattered across the western portion of the PDA as a component of the urban environment; while these trees, which include primary Koala food trees, are used regularly by several Koalas, the urban habitat is not identified as ‘habitat critical to the survival of Koala’ in accordance with the referral guidelines habitat assessment tool; and
- a small patch of Subtropical and Temperate Coastal Saltmarsh threatened ecological community, listed as vulnerable, is present in the south-western corner of the PDA.

Two shorebird roost sites (Nandeebie Claypan and Cassim Island) recognised as important roosting habitat (due to them being part of the Moreton Bay shorebird area that is recognised as internationally important for migratory shorebirds) for migratory shorebirds are located immediately adjacent to the PDA boundary, and a third important roost site, Oyster Point, is located 600 m south of the PDA.

The Nandeebie Claypan roost is used regularly by migratory shorebirds, particularly on spring high tides. During the summer months late September to March over the period 1995 to 2015, an average of 474 and maximum of 2,560 migratory shorebirds were recorded on the 83% of surveys when migratory shorebirds were present; however over the past ten years (since 2007) the average and maximum numbers were 397 and 1,406 respectively. Migratory shorebirds recorded using Nandeebie Claypan include the critically endangered Eastern Curlew (an average of 25 and maximum of 180 birds recorded on the 67% of summer surveys when the species was present over the period 1995-2015, reducing to an average of 22 and maximum of 60 birds over the past ten years since 2007), the critically endangered Great Knot (an average of 27 and maximum of 90 birds recorded on the 15% of summer surveys when the species was present), the critically endangered Curlew Sandpiper *Calidris ferruginea* (very rarely present; only 1-2 birds recorded in 2 of 114 summer surveys) and the vulnerable Bar-tailed Godwit (an average of 609 and maximum of 2,300 birds recorded on the 56% of summer surveys when the species was present over the period 1995-2015, reducing to an average of 556 and maximum of 1,400 birds over the past ten years since 2007). Birds using the Nandeebie Claypan also use the nearby Oyster Point shoreline roost, moving between the two roost sites depending on the height of the tide and extent of disturbance at Oyster Point.

The Cassim Island mangroves, located 30 m from the PDA boundary, are used daily as a high-tide roost during the summer months by four migratory shorebird species that can roost in mangrove trees; an average of 699 and maximum of 920 migratory shorebirds were recorded roosting during four summer high-tide surveys.

MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

Matters of state environmental significance (MSES) regulated under the Queensland *Nature Conservation Act 1992* (NC Act) or *Vegetation Management Act 1999* (VM Act) that occur within the PDA boundary include:

- patches of remnant vegetation of two regional ecosystems (REs) that have a ‘least concern’ status under the VM Act: RE 12.1.2 (Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains); and RE 12.1.3 (Mangrove shrubland to low closed forest on marine clay plains and estuaries);
- feeding habitat used by two species listed as vulnerable under the NC Act, namely Eastern Curlew and Koala;
- a total of 286 non-juvenile Koala habitat trees, including 58 within areas mapped as ‘medium value rehabilitation’ within a priority koala assessable development area under the South East Queensland Koala Conservation State Planning Regulatory Provisions (SPRP);
- High ecological significance (HES) wetlands on the Map of Referable Wetlands; and
- Wildlife habitat for threatened wildlife and special least concern animals under the NC Act.

POTENTIAL IMPACTS OF THE PROJECT

As the Project is still at the planning stage of development, potential impacts are identified in general terms.

Potential impacts on matters of national environmental significance

The potential impacts of the Project on matters of national environmental significance include the following:

- Direct and indirect impacts on a small portion of the Moreton Bay Ramsar wetlands;
- Direct impact on an area of intertidal mudflats and sandflats that is recognised as important feeding habitat for migratory shorebirds, including known feeding habitat for two critically endangered and one vulnerable species;

- Indirect impacts on mudflats and sandflats adjacent to the PDA that are recognised as important feeding habitat for migratory shorebirds, including known and likely feeding habitat for three critically endangered, two endangered and one vulnerable species; indirect impacts relate to reduced food availability for migratory shorebirds in intertidal mudflats and sandflats adjacent to the PDA in the event that altered water quality or hydrodynamics affects benthic invertebrate abundance in intertidal mudflats and sandflats adjacent to the PDA;
- Increased disturbance to migratory shorebirds roosting at three important roost sites for migratory shorebirds located close to the Project, including roosts known to be used by three critically endangered and one vulnerable species; increased disturbance has potential to lead to a substantial reduction in the use of the roost sites by migratory shorebirds;
- Increased disturbance to migratory shorebirds feeding on intertidal mudflats and sandflats adjacent to the PDA in the event that the Project facilitates greater pedestrian access to these areas at low tide, particularly the areas to the east of the Cassim Island mangroves that might be attractive to recreational walkers with dogs;
- Loss of food trees used by several individuals of the vulnerable Koala in an urban area that is not recognised as 'habitat critical to the survival of Koala';
- Mortality of Koalas during clearing of Koala habitat trees prior to construction;
- Increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation; and
- Direct or indirect impacts on a small area of the vulnerable Temperate Coastal Saltmarsh threatened ecological community.

Potential direct impacts relate to the clearing of habitat or vegetation for infrastructure, marina basin or reclamation.

Potential impacts on matters of state environmental significance

The potential impacts of the Project on matters of state environmental significance include the following:

- direct impact on small areas of remnant regional ecosystems listed as having least concern status under the VM Act;
- loss of food trees used by several individuals of the vulnerable Koala in an urban area, including non-juvenile Koala habitat trees within areas mapped as medium value rehabilitation under the SPRP;
- increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation;
- direct and indirect impacts on High ecological significance (HES) wetlands on the Map of Referable Wetlands; and
- direct and indirect impacts on wildlife habitat for threatened and special least concern fauna species.

POTENTIAL IMPACT MITIGATION AND MANAGEMENT MEASURES

The direct impact of the Project on loss of feeding habitat for migratory shorebirds can be mitigated by minimising the area of intertidal feeding habitat in the development footprint of the Project design.

Potential impacts of disturbance on migratory shorebirds can be mitigated through the implementation of the following measures:

- buffer zones around important areas for migratory shorebirds, particularly important roost sites; ideally there should be no Project activities or public access within the buffer zones;
- construction of appropriate barriers, such as fences around important habitat to restrict access; ideally, there should be no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds;
- landscape and urban design to include sympathetic lighting strategies, vegetation screening and sound attenuation; and
- increased community education through mechanisms such as interpretive signs at access points to shorebird habitats.

The potential impacts of the Project on Koalas that currently utilise feed trees within the PDA can be mitigated by:

- adopting a landscape and urban design that retains as many of the primary food trees as possible;
- adopting a landscape and urban design that includes a linear strip of public open space to serve as a corridor connecting retained Koala food trees with bushland habitat in Nandeebie Park to the south of the PDA;
- planting additional primary Koala food trees both within the PDA and surrounding areas where possible, to mitigate the likely loss of some Koala food trees within the PDA, noting that it will take years for the plantings to reach a size that they begin to provide food for Koalas;
- including traffic calming designs for roads crossing the open space corridor, and implementing a maximum speed limit of 40 km/hr;
- ensuring that the clearing of any trees during Project construction is performed under the guidance of a licenced fauna spotter; and
- using Koala exclusion fencing to fence off areas that may pose a risk of injury to Koala during construction e.g. deep pits that Koala may fall into.

TERRESTRIAL ECOLOGY ASSESSMENT

TOONDAH HARBOUR PRIORITY DEVELOPMENT AREA, REDLAND CITY

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Table of Terms and Abbreviations

BAAM	Biodiversity Assessment and Management Pty Ltd
DERM	Queensland Department of Resource Management (now EHP)
DoEE	Commonwealth Department of the Environment and Energy
ED Act	Queensland *Economic Development Act 2012*
EDQ	Economic Development Queensland
EHP	Queensland Department of Environment and Heritage Protection
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
MNES	Matters of National Environmental Significance (under the EPBC Act)
MSES	Matters of State Environmental Significance (under the SPP)
NC Act	Queensland *Nature Conservation Act 1992*
PDA	Priority Development Area
QWSG	Queensland Wader Study Group
Ramsar Convention	*Convention on Wetlands of International Importance 1971*
RCC	Redland City Council
RE	Regional Ecosystem
SPP	Queensland State Planning Policy

SPRP	South East Queensland Koala Conservation State Planning Regulatory Provisions
TEC	Threatened Ecological Community (under the EPBC Act)
VM Act	Queensland *Vegetation Management Act 1999*

1.0 INTRODUCTION

1.1 BACKGROUND

Toondah Harbour was declared as Priority Development Areas (PDA) in Redland City by the State Government under the *Economic Development Act 2012* (ED Act) on 21 June 2013. Redland City Council (RCC) has identified the potential for Toondah Harbour PDA to revitalise the waterfront site through mixed-use development to deliver long-term, sustainable economic growth for Redland City in a number of ways, including but not limited to:

- the generation of employment in a range of sectors across the economy;
- providing much needed infrastructure that will generate economic activity and improved public amenity both for the mainland and as a regional gateway to North Stradbroke Island and Moreton Bay; and
- working towards Council's goal of employment containment within the City through the generation of increased economic activity and industry growth.

Planning for the area was undertaken by the Queensland Government, in partnership with Redland City Council, and a final development scheme was approved on 29 May 2014. The development scheme includes mixed-use, low and medium density residential development as well as tourism and retail-based development, dedicated ferry terminals, public open space and the potential for a private berth marina.

In late 2014, following a rigorous expression of interest process, Walker Group Holdings was selected by the Queensland State Government and Redland City Council as the preferred development partner for Toondah Harbour PDA. The Walker Group's proposal includes residential, retail, marina development, hotel, port facilities and tourism infrastructure.

1.2 OBJECTIVES OF THE REPORT

This technical report has been prepared for Walker Corporation for the purpose of providing an independent assessment of:

- the terrestrial ecology values within the Toondah Harbour PDA, particularly in relation to:
  - matters of national environmental significance (MNES) reflecting those protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); and
  - matters of state environmental significance (MSES) reflecting those natural values and areas protected under Queensland's *Nature Conservation Act 1992* (NC Act) and *Vegetation Management Act 2009* (VM Act).
- potential impacts on these terrestrial ecology values from the proposed development of the PDA; and
- potential impact mitigation and management measures.

Since the declaration of the Toondah Harbour PDA in June 2013, several terrestrial ecology studies have been undertaken to inform the development scheme and Walker Group's proposal. This technical report reviews and integrates the results of these previous studies into a single report that interprets the results in relation to the current statutory framework.

1.3 Study Area

Toondah Harbour PDA is located on the southern shores of Moreton Bay in Cleveland, approximately 33 km east of the Brisbane city centre. It is a recognised boat landing and acts as the point of departure and arrival for vehicular ferry and water taxi services between the mainland and North Stradbroke Island. The area is also comprised of residential and open space lands. The PDA covers landholdings located at Middle Street, Cleveland, and incorporates both land and sea areas with a total area of approximately 67 hectares (17.5 hectares over land, and 49.5 hectares within Moreton Bay).

Cleveland and its water transport facilities at Toondah Harbour are recognised as the main regional gateway to North Stradbroke Island. The harbour serves as the principal base for water taxi, passenger and vehicular ferry services to and from the island. The harbour is also utilised for the launch of recreational boats and trailers. Continuing growth of user numbers at Toondah Harbour will increase demand and place pressure on the existing small scale harbour facilities, which may have an impact on the environment.

For the purposes of this report, the study area for assessment comprises the area within the mapped extent of the PDA, as well an area of mangroves (known as Cassim Island) east of the PDA boundary and an area of mangroves and saltmarsh (known as Nandeebie Claypan) to the south of the PDA boundary (see **Figure 3.1**).

1.4 Statutory Framework

Statutory instruments relevant to this ecological assessment cover Commonwealth and State Government legislation and other instruments.

1.4.1 Commonwealth legislation

The Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) protects matters of national environmental significance (MNES), which include the following with potential relevance to the study area:

- listed threatened species and ecological communities;
- migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- World Heritage properties; and
- National Heritage places.

Should a project propose to take an action that will have, or is likely to have, a significant impact on a matter of national environmental significance, the proponent must refer that action to the Commonwealth Department of the Environment and Energy (DoEE) for assessment as to whether the action is a ‘controlled action’ requiring Commonwealth approval for the project or proposed action. A ‘significant impact’ is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (Commonwealth of Australia 2009).

1.4.2 State legislation

Nature Conservation Act 1992

The *Nature Conservation Act 1992* (NC Act) is the principal legislation for the conservation and management of the State's native flora and fauna species and is administered by the Queensland Department of Environment and Heritage Protection (EHP). The key goal of the NC Act is the protection of endangered, vulnerable and near threatened (EVNT) species of flora and fauna as listed under the *Nature Conservation (Wildlife) Regulation 1994*.

Under section 253 of the *Nature Conservation (Wildlife) Regulation 1994*, a flora survey must be undertaken in accordance with the Flora Survey Guidelines - Protected Plants.

Under section 332 of the *Nature Conservation (Wildlife) Regulation 1994*, an approved species management program is required for tampering with an animal breeding place that is being used by a protected animal (including least concern native species) to incubate or rear the animal's offspring.

Vegetation Management Act 1999

The purpose of the *Vegetation Management Act 1999* (VM Act) is to regulate the clearing of native remnant vegetation mapped as Endangered, Of Concern and Not of Concern Regional Ecosystems (REs) to maintain ecological processes, ensure there is no loss of biodiversity or increase in land degradation from vegetation clearing, and manage the effects of clearing. In addition, some areas of remnant vegetation are further classified as Essential Habitat under the VM Act with specific reference to significant species listed under the NC Act.

2.0 PROJECT APPROACH AND METHODS

This report integrates the results of a number of previous terrestrial ecology studies that have been undertaken to inform the Toondah Harbour PDA development proposal with a revised review of publically available databases and published literature relevant to the terrestrial ecology values within the study area.

2.1 DESKTOP REVIEW

2.1.1 Previous studies

The following previous studies that reported on the terrestrial ecology of the Toondah Harbour PDA were reviewed for integration in this terrestrial ecology assessment:

- BAAM and frc environmental (2014). Expert advice in ecology (marine and terrestrial) and coastal processes for input to the preparation of a structure plan and development scheme for Toondah Harbour and Weinam Creek Priority Development Areas. Report prepared for Redland City Council.
- BAAM (2014). Migratory shorebird assessment, Toondah Harbour and Weinam Creek Priority Development Areas. Report prepared for Walker Corporation.
- BAAM (2015). Toondah Harbour and Weinam Creek Priority Development Area migratory shorebird survey results. Technical memorandum prepared for Walker Corporation.

2.1.2 Published literature and databases

The following publically available databases were reviewed to identify MNES and MSES that are known or predicted to occur in the study area or immediate environs:

- the EPBC Act Protected Matters Search Tool online database;
- the Atlas of Living Australia online database;
- the Queensland Government's Regional Ecosystem and Essential Habitat mapping;
- the Queensland Government's Koala Habitat mapping;
- the Queensland Government's Wildlife Online database;

Data on migratory shorebird use of shorebird habitats in or adjoining the study area were also sourced from the Queensland Wader Study Group (QWSG) for review and analysis. The QWSG is a special interest group within Birds Queensland that monitors shorebird populations in Queensland and conducts regular shorebird surveys of different parts of the Queensland coast that have large shorebird populations.

The published literature, particularly that dealing with the population ecology, habitat requirements and sensitivity to habitat change and disturbance of conservation significant species assessed as known or likely to occur in the study area was reviewed to inform the assessment.

2.2 FIELD SURVEYS

The previous studies listed under **Section 2.1.1** above conducted several field surveys to assess terrestrial ecology values within the study area. The approaches adopted during these field surveys are outlined in the following sections.

2.2.1 General terrestrial ecology survey

A general terrestrial ecology field survey was undertaken by a team of three terrestrial ecologists in fine, sunny weather on 5th July 2013, and involved ground-truthing of existing habitat mapping within the study area, including:

- verification of regional ecosystem (RE) mapping;
- assessment of the actual or likely presence of significant terrestrial species and associated habitat;
- verification of habitat boundaries (using GPS plotters) and characterisation of the quality, condition and connectivity of the habitats present; and
- obtaining a photographic record of each of the habitat types present.

A particular focus of the terrestrial fauna survey was surveying all non-juvenile habitat trees for Koala within the study area; i.e. food trees of the *Eucalyptus*, *Corymbia*, *Melaleuca* or *Lophostemon* genera, or preferred shelter species such as *Angophora* species, with a height of more than four metres, or a trunk with a circumference of more than 31.5 centimetres at 1.3 metres above the ground (Queensland Government 2015). This involved identifying and taking a GPS point at each non-juvenile habitat tree (or group of clustered trees), estimating the tree height and searching the base of the tree for Koala scats as confirmation of recent Koala activity.

2.2.2 Migratory shorebird surveys

Five summer surveys and one winter survey for migratory shorebirds were conducted within the study area between October 2014 and June 2015 by Dr Penn Lloyd (Principal Ecologist) in accordance with the survey guidelines outlined in the Commonwealth's EPBC Act *Policy Statement 3.21: Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (Commonwealth of Australia 2015a). Specifically:

- the surveys for foraging shorebirds were conducted as close to the time of low tide as practicable and at a maximum of no more than two hours either side of low tide;
- the surveys for roosting shorebirds were conducted as close to the time of high tide as practicable and at a maximum of no more than two hours either side of high tide;
- the surveys were not undertaken during periods of high rainfall or strong winds, or when activities that cause disturbance to the birds were taking place;
- the surveys determined the total number of individuals of each species present, to enable assessment of site and habitat importance; and
- the surveys collected spatial data of the area used by shorebirds for roosting and feeding to facilitate mapping of roosting and foraging habitat.

During the low tide surveys, shorebirds feeding on intertidal mudflats were surveyed using a high-powered Swarovski spotting telescope mounted on a sturdy tripod. Habitat areas were surveyed from suitable vantage points that provided an unobstructed view of the entire area, without causing disturbance to the shorebirds.

A known migratory shorebird roost site in an offshore area of mangroves located immediately east of Toondah Harbour (referred to as Cassim Island) was surveyed from a boat (first survey) or kayak (subsequent surveys). During the first survey, the boat was driven slowly around the perimeter of the mangroves. Birds roosting in the mangrove trees were counted using Leica 10x42 binoculars; this count was facilitated by the fortuitous overflight of a White-bellied Sea-eagle

(*Haliaeetus leucogaster*) during the survey that caused most migratory shorebirds to take flight and circle the roost site (when they could be counted in the air) before settling again. During the kayak surveys, the kayak was paddled around the fringe of the mangroves to flush roosting birds, which were then counted in flight. A further known migratory shorebird roost site on saltmarsh/claypan adjoining Nandeebie Park, immediately to the south of the Toondah Harbour PDA boundary, was surveyed using a Swarovski spotting telescope and/or Leica 10x42 binoculars.

The total number of people, dogs and boats present on the on-land portions of the study area during each survey were also recorded as a measure of the potential level of disturbance to roosting and foraging shorebirds.

3.0 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The desktop review identified a number of matters of national environmental significance (MNES) relevant to terrestrial ecology that are known or predicted to occur within or adjoining the Toondah Harbour PDA. These matters are summarised in **Table 3.1** and discussed in further detail in the following sections.

Table 3.1 Matters of national environmental significance identified as known or predicted to occur within or adjoining the Toondah Harbour PDA.

Matter of National Environmental Significance	Number identified
Wetlands of international importance (Ramsar)	1
Listed threatened ecological communities	3
Listed threatened terrestrial flora species	12
Listed threatened terrestrial fauna species	40
Listed migratory terrestrial fauna species	51

3.1 WETLANDS OF INTERNATIONAL IMPORTANCE

A portion of the intertidal area of Toondah Harbour PDA occurs within the bounds of the Moreton Bay wetland of international importance, listed under the *Convention on Wetlands of International Importance 1971* (Ramsar Convention) (**Appendices 1** and **2**). The existing channel of the harbour and some intertidal areas immediately adjoining the channel are mapped as being outside of the Ramsar area, with the remainder of the intertidal area occurring within the Ramsar area (**Figure 3.1**).

The Moreton Bay Ramsar site wetlands are nationally and internationally significant as one of the largest estuarine bays in Australia, enclosed by barrier islands of vegetated dunes, which together with the permanent lakes of the sand island components provide a diverse and rich suite of wetland habitats. Moreton Bay contains a complex system of intertidal flats totalling 23,000 ha at low tide (Blackman and Craven 1999).In relation to terrestrial fauna species, the wetlands are particularly significant as habitat for wetland birds, particularly migratory shorebirds (see **Section 3.5**), regularly supporting more than 50,000 waterbirds. The Moreton Bay shorebird area, which stretches 130 km from Caloundra in the north to Southport in the south and incorporates approximately 23,000 ha of intertidal mudflat/sandflat at low tide (Blackman & Craven 1999 cited in Finn et al. 2001), has been reported to support over 40,000 migratory shorebirds during the summer months (Driscoll et al. 1993, Watkins 1993) and over 3,500 resident shorebirds (Driscoll 1997). However, the total populations of at least 11 migratory shorebird species have undergone significant declines in Moreton Bay over the 15 year period 1992-2008, declining an average 62% over this period, largely as a consequence of the loss of feeding habitat at critical migration stopover sites in the Yellow Sea (Wilson *et al*. 2011; Yang *et al*. 2011). Consequently, Moreton Bay currently supports an estimated total of around 30,000 migratory shorebirds during summer (David Milton, QWSG, personal communication).


LEGEND
PDA Boundary
Temperate Coastal Saltmarsh TEC
Migratory Shorebird Roost Sites
Migratory Shorebird Feeding Habitat Values
Moreton Bay Ramsar Wetlands Boundary
Koala Food Trees
Primary
Secondary
Other
Scale 1 : 7500
0
100
250m
Aerial Photo: Nearmap September 2016
Raby Bay
Moreton Bay Ramsar Wetlands Boundary
E 528500
E 529000
N 6956000
N 6955500
N 6955000
N 6954500
N 6954000
E 528000
N
MGA94 Z56
Moderate
Moderate
Moderate
High
Low
Low
Low
Moderate
Moderate
Low
Cleveland
Toondah Harbour
Cassim Island
Shorebird Roost
Cassim Island
Nandeebie
Claypan
Shorebird
Roost
Oyster Point
Shorebird Roost
BAAM
ECOLOGICAL CONSULTANTS
Client
Walker Corporation
Project
Terrestrial Ecology Assessment
Toondah Harbour PDA
Design
BAAM
16.03.2017
Drawn
Bentline | MP
16.03.2017
Scale
1:7500
0107-005
Cad File
BAAM_Toondah01.dwg
NTP 74
Title
Matters of National
Environmental Significance
FIGURE
3.1

3.2 THREATENED ECOLOGICAL COMMUNITIES

Three threatened ecological communities (TEC) were identified from the database search results as having potential to occur within the Toondah Harbour PDA (**Appendix 1**), namely:

- Lowland Rainforest of Subtropical Australia (EPBC Act: Critically Endangered);
- Littoral Rainforest and Coastal Vine Thickets of Eastern Australia (EPBC Act: Critically Endangered); and
- Subtropical and Temperate Coastal Saltmarsh (EPBC Act: Vulnerable).

The field survey confirmed that a small patch of Subtropical and Temperate Coastal Saltmarsh TEC, which corresponds with RE 12.1.2 (saltpan vegetation including grassland, herbland and sedgeland on marine clay plains), occurs within the south-western corner of the Toondah Harbour PDA (**Figure 3.1**). The field survey also confirmed that neither the Lowland Rainforest of Subtropical Australia TEC nor the Littoral Rainforest and Coastal Vine Thickets of Eastern Australia TEC occur within or adjacent to the PDA.

3.3 THREATENED FLORA SPECIES

The EBPC Act Protected Matters Search Tool database search (see **Appendix 1**) identified 12 threatened flora species that may or are likely to occur within the study area. However, no threatened flora species have been recorded within a 1 km radius of the study area on the databases that were searched (see **Appendix 2**), none were detected during the field survey of the study area, and the study area does not contain habitat suitable for any of the 12 threatened flora species that may occur (see likelihood of occurrence assessment presented in **Appendix 3**). It should be noted that the EPBC Online Protected Matters Search Tool, whilst based on some species records, relies on modelling of suitable habitats and is largely predictive.

3.4 THREATENED FAUNA SPECIES

The database searches (**Appendices 1** and **2**) identified a total of 40 terrestrial fauna species listed as threatened species under the EPBC Act that may occur within the study area or environs. Five of these species (three critically endangered and two vulnerable) were recorded within or immediately adjacent to the study area during field surveys, and a further four species (two endangered and two vulnerable) were assessed as having potential to occur based on database records for the local area, field observations of the species in areas adjacent to the study area and presence of suitable habitat (**Table 3.2**). The remaining 31 species were assessed as unlikely to occur (see **Appendix 3** for details). Profiles for the nine species that are known to occur or have potential to occur are provided below. Additional information on the seven migratory shorebird species included in **Table 3.2** is provided in **Section 3.5** dealing with migratory shorebirds.

Table 3.2. Terrestrial fauna species listed as threatened species under the EPBC Act that are known or have potential to occur in the study area.

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
Numenius madagascariensis	Eastern Curlew	CE, M	V	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Limosa lapponica baueri	Bar-tailed Godwit (Western Alaskan)	V, M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris	Great Knot	CE, M	S	**Known**. Feeds on intertidal mudflats within and adjacent to

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
tenuirostris				the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris ferruginea	Curlew Sandpiper	CE, M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Phascolarctos cinereus	Koala	V	V	**Known**. Feeds on food trees (*species of Eucalyptus, Corymbia, Lophostemon* and *Melaleuca*) growing in the urban environment within and adjacent to the study area.
Calidris canutus	Red Knot	E, M	S	**Potential**. While it has not been recorded within the study area, the species is known to occur within 1 km of the study area and it has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius mongolus	Lesser Sand Plover	E, M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius leschenaultii	Greater Sand Plover	V, M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Pteropus poliocephalus	Grey-headed Flying-fox	V	LC	**Potential**. While it has not been recorded within the study area, the species is known from the local area and it has potential to be a regular seasonal visitor to feed on flowing trees within the study area.

[1] Status under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act): CE = critically endangered; E = endangered; M = migratory; V = vulnerable.
[2] Status under the *Nature Conservation Act 1992* (NC Act): LC = least concern, S = special least concern (migratory), V = vulnerable.

3.4.1 Eastern Curlew (Numenius madagascariensis)

Status: EPBC Act: Critically Endangered; NC Act: Vulnerable.

Distribution: The Eastern Curlew is the world's largest migratory shorebird and it is endemic to the East Asian-Australasian Flyway (EAAF). It breeds in north-eastern Asia during the northern summer and migrates through eastern Asia to spend the non-breeding season in the Philippines, Indonesia and Papua New Guinea (25% of the population), Australia (73% of the population) or New Zealand (2% of the population) during the austral summer.

Habitat and ecology: In Australia, Eastern Curlew feeds during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments with or without seagrass, and usually within 50 m of the low-water mark (Finn et al. 2007). In Moreton Bay, the average summer density of feeding Eastern Curlews ranges between 3.7 and 71.9 birds per 100 ha of mudflat (Finn 2010) and is most strongly related to substrate resistance, with the birds preferring areas with softer sediments that they can more easily probe into to capture prey (Finn et al. 2007, 2008). In Moreton Bay, Eastern Curlews feed primarily on crustaceans, particularly Mictyridae (soldier crabs), Brachyura (other crabs), Caridea (shrimp) and Thalassinidea (yabbies), which made up 15.4%, 9.8%, 4.7% and 2.8% of food items consumed respectively, and small molluscs (Finn et al. 2008). During the high tide phase of the tidal cycle, Eastern Curlews roost in small to large flocks on sandy spits, sandbars, shallow lagoons, saltmarshes and claypans near the high-water mark.

Migrating Eastern Curlews leave Moreton Bay over a period of about one month in March, but arrive back over a more extended period from August through to December (Driscoll and Ueta 2002); however 25% of Eastern Curlews in Moreton Bay do not migrate and remain through the austral winter (Finn et al. 2001). Most Eastern Curlews appear to migrate along the east coast of China (Driscoll and Ueta 2002) and the Yellow Sea provides extremely important stopover feeding habitat for about 80% of the flyway population to replenish their fat reserves before continuing their migration (TSSC 2015).

Threats: Threats to Eastern Curlew in Australia include ongoing human disturbance at feeding and roost sites, habitat loss, habitat degradation from pollution, changes to the water regime and invasive plants (Milton et al. 2011, TSSC 2015). Key threats along their migration route are feeding habitat loss resulting from large land reclamation projects and habitat degradation resulting from aquaculture, gross pollution and invasion of salt marshes by exotic *Spartina* grass, particularly at key stopover migration staging sites in the Yellow Sea (Yang et al. 2011, Murray et al. 2014, Melville et al. 2016, Moores et al. 2016).

Population trend: The estimated population size of Eastern Curlew within the 20-year period 1986-2006 was 28,000 birds spending the non-breeding season in Australia, making up 74% of the total flyway population estimate of 38,000 (Bamford et al. 2008). However the flyway population has experienced a substantial decline since this estimate. Over the 19 years 1996-2014, the rate of decline has been greater in southern Australia (6.95% per year) than in northern Australia (2.91% per year), with an overall rate of decline of 3.2% nationally (Clemens et al. 2016). The annual rate of decline of the Eastern Curlew population using Moreton Bay over the 15 year period 1992-2008 was estimated at 2.4% per year (Wilson et al. 2011). The most recent analysis suggests the population of Eastern Curlew migrating to Australia has undergone a severe population decline of 66.8% over 20 years (5.8% per year) and 81.4 % over 30 years, which for this species is equal to three generations (TSSC 2015). This decline is thought to be largely due to ongoing loss of intertidal feeding habitat at key migration staging sites in the Yellow Sea (see **Section 3.5.2** for more details).

Occurrence in the Toondah Harbour PDA: During the summer months October 2014 to February 2015, an average of 4.8 and maximum of 7 Eastern Curlew were recorded feeding on the approximately 40 ha mudflats within the study area (see **Section 3.5.4** for further details). The observed average summer density of Eastern Curlews feeding in the Toondah Harbour PDA (average 12.0 birds per 100 ha) is greater than the average density of 4.0 birds per 100 ha recorded over 223 ha of mudflats in the Cleveland area in 2000, but less than the maximum of 71.9 birds per 100 ha recorded in the highest quality feeding area for the species in Moreton Bay at Moreton Island (Finn 2010). Eastern Curlews were recorded roosting at the Nandeebie Claypan roost site on 67% of 114 surveys between late September and March over the period 1995 to 2015, with an average of 25 and maximum of 180 birds recorded on surveys when the species was present, reducing to an average and maximum of 22 and 60 birds respectively over the past ten years since 2007 (see **Section 3.5.4** for more details). These data confirm that Nandeebie Claypan is a moderately important roost site for Eastern Curlew in the vicinity of the Toondah Harbour PDA.

3.4.2 Great Knot (Calidris tenuirostris)

Status: EPBC Act: Critically Endangered; NC Act: Special Least Concern.

Distribution: The Great Knot is a migratory shorebird that breeds in north-eastern Siberia during the northern summer and migrates through eastern Asia to spend the non-breeding season in Australia (most of the population) or south-east Asia during the austral summer.

Habitat and ecology: In Australia, Great Knots feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments, often feeding in flocks in shallow water at the mudflat/sandflat edge. Great Knots feed mostly on bivalve and gastropod molluscs, polychaete worms and Brachyura and Ostracoda crabs (Tulp and Goeij 1994, Zhang et al. 2011). During the high tide phase of the tidal cycle, Great Knots roost in often large flocks on sandy spits, sandbars, shallow lagoons, saltmarshes and claypans, often at the water's edge or in shallow water near the high-water mark.

Most migrating Great Knots leave Australia from the north coast in March-April, flying directly to the Yellow Sea region of China and Korea, with a few to Japan, where they stage and spend time feeding to replenish their fat reserves before continuing their migration north to the breeding grounds. After the breeding season, most adults congregate in the western and southern Sea of Okhotsk in south-eastern Russia, then fly direct to northern Australia, while some others move south to Korea before flying direct to Australia from there, arriving in late August to September (TSSC 2016).

Threats: The greatest threat facing the Great Knot is habitat loss and degradation at key staging areas in the Yellow Sea (see **Section 3.5.2** for more details), which support about 80% of the East Asian-Australasian Flyway population on the northward migration. Great Knot is considered more vulnerable to reclamation activities than most other waders due to the very specific species and sizes of shellfish that they eat. Other threats include disturbance at feeding and roosting sites and the longer-term impact of climate change that is expected to reduce the area of intertidal feeding habitat (TSSC 2016).

Population trend: The estimated population size of Great Knot within the 20-year period 1986-2006 was 360,000 birds spending the non-breeding season in Australia, making up 95% of the total flyway population estimate of 380,000 (Bamford et al. 2008). However, the flyway population has experienced a substantial decline since this estimate. The maximum and average abundance of Great Knot within Moreton Bay over the 28-year period 1978-2006 was reported as 1,975 and 831 birds respectively (Clemens et al. 2008). However, a more recent analysis over the 15 year period 1992-2008 found a significant decline in abundance in Moreton Bay estimated at 4.4% per year, from estimates of up to 2,750 birds in the 1990s to estimates of around 1,250 in the mid- to late-2000s (Wilson et al. 2011). Over the 19 years 1996-2014, the rate of decline has been greater in southern Australia (11.15% per year) than in northern Australia (0.98% per year), with an overall rate of decline of 3.2% nationally (Clemens et al. 2016). This decline is thought to be largely due to ongoing loss of intertidal feeding habitat due to a long history of ongoing land reclamation at key migration staging sites in the Yellow Sea (see **Section 3.5.2** for more details). At one of the largest land reclamation projects at Saemangeum in the South Korean Yellow Sea, approximately 104,000 Great Knots were lost from the flyway population, presumed to have died, following the reclamation of 29,000 ha of tidal flats in 2006 (Moores et al. 2016). The most recent analysis suggests that the Australian population of Great Knot has declined 83% over the past 25 years (TSSC 2016).

Occurrence in the Toondah Harbour PDA: During the low tide surveys, only a single Great Knot was recorded feeding on intertidal mudflats within the Toondah Harbour PDA on a single survey (see **Section 3.5.4** for more details). Furthermore, only small numbers of Great Knots appear to use nearby mudflats. This suggests that feeding habitat within the PDA and nearby mudflats is of marginal importance to Great Knot. The high tide survey results suggest that Great Knot occasionally roosts in relatively small numbers at the Nandeebie Claypan roost site (an average of 27 and maximum of 90 birds recorded on the 15% of summer surveys when the species was present) as well as at the nearby Oyster Point roost site (see **Section 3.5.4** for more details).

3.4.3 Curlew Sandpiper (*Calidris ferruginea*)

Status: EPBC Act: Critically Endangered; NC Act: Special Least Concern.

Distribution: The Curlew Sandpiper is a migratory shorebird that breeds across the Russian Arctic during the northern summer and migrates through Europe, North Africa and Asia to spend the non-breeding season in Africa, southern Asia and Australasia during the austral summer. Approximately 13% of the global population occurs in the East Asian-Australasian Flyway (TSSC 2015b).

Habitat and ecology: Curlew Sandpipers feed in both tidal and non-tidal wetlands. In tidal wetlands they forage on muflats, sandflats and nearby shallow water. In non-tidal wetlands they usually feed while wading through shallow water. In Australia, Curlew Sandpipers have a varied diet, but feed mostly on annelid worms, gastropod molluscs, crustaceans and insects. During the high tide phase of the tidal cycle, they roost in open areas with a damp substrate, including on sandy beaches, sandspits and islets in coastal lagoons and other wetlands (TSSC 2015b).

Curlew Sandpipers start migrating north from their non-breeding sites in Australia between mid-January and mid-April, most of them migrating through southern China, where Bahai Bay is an important staging site, before they begin arriving on the breeding grounds in late May to early June. After the breeding season, returning birds reach the northern shores of Australia in late August and early September. However, substantial numbers of Curlew Sandpipers remain in northern Australia throughout the nonbreeding season (TSSC 2015b).

Threats: Threats in Australia include ongoing human disturbance, habitat loss and degradation from pollution, changes to the water regime and invasive plants (TSSC 2015b).

Population trend: The estimated population size of Curlew Sandpiper within the 20-year period 1986-2006 was 118,000 birds spending the non-breeding season in Australia, making up 65% of the total flyway population estimate of 180,000 (Bamford et al. 2008). However, the flyway population has experienced a substantial decline since this estimate. The maximum and average abundance of Curlew Sandpiper within Moreton Bay over the 28-year period 1978-2006 was reported as 5,229 and 1,087 birds respectively (Clemens et al. 2008). An analysis over the 15 year period 1992-2008 found a significant decline in abundance in Moreton Bay estimated at 4.0% per year (Wilson et al. 2011). Over the 19 years 1996-2014, the rate of decline has been greater in southern Australia (11.15% per year) than in northern Australia (0.98% per year), with an overall rate of decline of 6.1% nationally (Clemens et al. 2016). The national Curlew Sandpiper population is estimated to have declined 76% over 20 years (TSSC 2015b).

Occurrence in the Toondah Harbour PDA: During the low tide surveys, Curlew Sandpiper was never recorded feeding on intertidal mudflats within the Toondah Harbour PDA (see **Section 3.5.4** for more details). Furthermore, very few, if any, Curlew Sandpipers appear to use nearby mudflats. This suggests that feeding habitat within the PDA and nearby mudflats is of marginal importance to Curlew Sandpiper. The high tide survey results suggest that Curlew Sandpiper very rarely roosts at the Nandeebie Claypan roost site (only 1-2 birds recorded in 2 of 114 summer surveys) or at the nearby Oyster Point roost site (see **Section 3.5.4** for more details).

3.4.4 Bar-tailed Godwit (western Alaskan) (*Limosa lapponica baueri*)

Status: EPBC Act: Vulnerable; NC Act: Special Least Concern.

Distribution: The Bar-tailed Godwit is a relatively large migratory shorebird with a variety of subspecies that together occupy a large global range. The subspecies *L. l. baueri* breeds in north-east Siberia and west Alaska in the northern summer and migrates down the East Asian-Australasian Flyway to spend the non-breeding season in northern and eastern Australia and New Zealand during the austral summer (TSSC 2016b).

Habitat and ecology: In Australia, Bar-tailed Godwits feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments, usually foraging near the edge of the water or in shallow water. They feed on polychaete worms, molluscs, crustaceans and insects (TSSC 2016b). In the highest quality feeding habitats on the eastern side of Moreton Bay, Bar-tailed Godwit feeding densities ranged between 3 and 8 birds per hectare of sandflat (Zharikov and Skilleter 2003). During the high tide phase of the tidal cycle they roost in large flocks on sandy beaches, sandbars, spits and in near-coastal saltmarsh (TSSC 2016b). Bar-tailed Godwits have high fidelity to feeding and roosting sites in Moreton Bay, returning to the same feeding areas and roost sites both within and between seasons (Coleman and Milton 2012).

Satellite tracking has shown that migrating Bar-tailed Godwits (western Alaska) leave Australia and New Zealand in March, making long flights (average 10,060 km) to staging sites in the Yellow Sea, where they stage for an average of 41 days to replenish their fat reserves before flying an average of 6,770 km to their breeding grounds. After completion of breeding, the birds stage for several weeks in southwest Alaska before either making non-stop flights across the Pacific Ocean to New Zealand (11,690 km in a complete track) or stopovers on islands in the south-western Pacific en route to New Zealand and eastern Australia. One satellite tracked bird made a non-stop flight of around 10,200 km in about eight days. After making these flights, the birds arrive starving on the staging sites; this highlights the critical importance of conserving sufficient intertidal feeding habitat in the staging areas to allow the birds to refuel (TSSC 2016b).

Threats: The greatest threat facing Bar-tailed Godwits is habitat loss and degradation at key staging areas in the Yellow Sea (see **Section 3.5.2** for more details), where about 80% of the East Asian-Australasian Flyway population stage on the northward migration. Other threats, including in Australia, include human disturbance at feeding and roosting sites, habitat loss and degradation from pollution, changes to the water regime and invasion of mudflats and coastal saltmarshes from the spread of mangroves (TSSC 2016b).

Population trend: The estimated EAAF population size of Bar-tailed Godwit (western Alaskan) within the 20-year period 1986-2006 was estimated at 155,000 birds, of which approximately 61,000 spend the non-breeding season in Australia with the remaining 94,000 in New Zealand (Bamford et al. 2008, TSSC 2016b). However, the flyway population has experienced a substantial decline since this estimate. The maximum and average recorded abundance of Bar-tailed Godwit within Moreton Bay over the 28-year period 1978-2006 was reported as 13,233 and 6,018 birds respectively (Clemens et al. 2008). An analysis over the 15 year period 1992-2008 found a significant decline in abundance in Moreton Bay estimated at 6.4% per year (Wilson et al. 2011), and total numbers using Moreton Bay are estimated to have declined by 68% between 1993 and 2008 (TSSC 2016b). Over the 19 years 1996-2014, the rate of decline has been greater in northern Australia than in southern Australia, with an overall rate of decline of 3.2% nationally (Clemens et al. 2016). The most recent analysis suggests Bar-tailed Godwit (western Alaskan) has experienced a substantial national population decline of 32.4% over 29 years (1.4% per year) (TSSC 2016b).

Occurrence in the Toondah Harbour PDA: During the summer months October 2014 to March 2015, an average of 24.8 and maximum of 36 Bar-tailed Godwits were recorded feeding on intertidal mudflats within the Toondah Harbour PDA (see **Section 3.5.4** for more details). The feeding density recorded within the study area (average 0.62 birds/ha, maximum 0.9 birds/ha within the approximately 40 ha of mudflats in the study area) is substantially less that the densities of 3 to 8 birds/ha recorded in the highest quality feeding habitats on the eastern side of Moreton Bay (Zharikov and Skilleter 2003). Bar-tailed Godwits were recorded roosting at the Nandeebie Claypan roost site on 56% of 114 surveys between late September and March over the period

1995 to 2015, with an average of 609 and maximum of 2,300 birds recorded on surveys when the species was present, reducing to an average and maximum of 556 and 1,400 birds respectively over the past ten years since 2007 (see **Section 3.5.4** for more details). These data confirm that Nandeebie Claypan is an important roost site for Bar-tailed Godwits that feed in southern Moreton Bay, particularly on spring high tides. The nearby Oyster Point roost site is similarly important; Bar-tailed Godwits typically roost initially at Oyster Point on the rising tide, moving to Nandeebie Claypan (or other alternative roost sites further north, such as the Geoff Skinner Reserve in Wellington Point or Manly Harbour) when the rising spring tides or human disturbance displace the birds from Oyster Point.

*3.4.5 Red Knot (***Calidris canutus***)*

Status: EPBC Act: Endangered; NC Act: Special Least Concern.

Distribution: The Red Knot is a migratory shorebird that has a global distribution and an extremely large range. Two subspecies of Red Knot utilise the East Asian-Australasian Flyway: *C. c. piersmai* breeds in the New Siberian Islands and tends to overwinter almost exclusively in north-western Australia; and *C. c. rogersi* breeds in Chukotka, in far-eastern Siberia and tends to overwinter in eastern Australia and New Zealand (Rogers et al. 2010, TSSC 2013c).

Habitat and ecology: In Australia, Red Knots feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments, often feeding in flocks in shallow water at the mudflat/sandflat edge. Red Knots feed on worms, bivalves, gastropods, crustaceans and echinoderms (TSSC 2016c). During the high tide phase of the tidal cycle, Red Knots roost in often large flocks on sandy spits, sandbars, shallow lagoons, saltmarshes and claypans, preferring open areas far away from potential cover for predators, but close to feeding grounds, and often where the substrate is damp (Rogers et al. 2006). Red Knots leave Tasmania from February–May and leave south-east mainland Australia from late February or late March to early April. Returning birds arrive in northern Australia from late August and arrive in south-west Australia from September (TSSC 2016c). During migration, the Yellow Sea is extremely important as stopover habitat for Red Knot, with over 45% of the EAAF population using a single site at Bohai Bay, China during their migration (Rogers et al. 2010).

Threats: The greatest threat facing Red Knots is habitat loss and degradation at key staging areas in the Yellow Sea (see **Section 3.5.2** for more details). Other threats, including in Australia, include human disturbance at feeding and roosting sites, habitat loss and degradation from pollution, changes to the water regime and invasion of mudflats and coastal saltmarshes from the spread of mangroves (TSSC 2016c).

Population trend: The population of Red Knot using the EAAF was previously estimated to be around 220,000 birds (Bamford et al. 2008), but a revised estimate for the flyway is 112,000 individuals, of which 68,000 occur in Australia (Rogers et al. 2010, Garnett et al. 2011). The population of Red Knot is Australia is estimated to have experienced a severe population decline of 62.0% over 23 years (4.4% per year), and numbers of Red Knots using Moreton Bay have declined by 75% between 1993 and 2008 (TSSC 2016c). The primary cause of this decline is attributed to ongoing loss of intertidal mudflat habitat at key migration staging sites in the Yellow Sea (Murray et al. 2014, TSSC 2016c).

Occurrence in the Toondah Harbour PDA: Surveys have not detected Red Knots feeding in the PDA, and there are no historical records of Red Knot roosting in the vicinity of the PDA. However, the species has been recorded within a 1 km radius of the PDA. Red Knots have potential to feed on mudflats adjacent to the study area, particularly extensive mudflat areas to the south of the PDA. The species has potential to occasionally visit mudflats within the PDA; however, the lack of survey records suggests mudflat habitat within the PDA is of marginal value to Red Knots.

*3.4.6 Lesser Sand Plover (***Charadrius mongolus***)*

Status: EPBC Act: Endangered; NC Act: Special Least Concern.

Distribution: The Lesser Sand Plover is a migratory shorebird that has a global distribution and an extremely large range. Four of the five subspecies occur in the EAAF, and two of these, *C. m. mongolus* and *C. m. stegmanni*, occur in Australia during the non-breeding season; *C. m. mongolus* breeds in inland eastern Siberia whereas *C. m. stegmanni* breeds mostly in Kamchatka, on the northern Kuril and Commander Islands and on the Chukotka Peninsula in Russia (TSSC 2016d).

Habitat and ecology: In Australia, Lesser Sand Plovers feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats in estuaries or beaches, or in shallow ponds in saltworks. They feed on insects, crustaceans (especially crabs and amphipods), molluscs (especially bivalves) and polycheate worms (TSSC 2016d). During the high tide phase of the tidal cycle, Lesser Sand Plovers roost in often large flocks on beaches or in estuarine lagoons close to feeding grounds. During migration, Lesser Sand Plovers arrive in northern and eastern Australia during August-October, and leave again during March-April. The Yellow Sea is a very important staging area for this species as it supports about 50% of the EAAF population during northern migration, and Lesser Sand Plovers are also common in the Yellow Sea during southern migration (TSSC 2016d).

Threats: The greatest threat to Lesser Sand Plover is indirect and direct habitat loss, particularly at critical migration staging areas through eastern Asia. In Australia, threats include habitat loss, habitat degradation and human disturbance (TSSC 2016d).

Population trend: The population of Lesser Sand Plovers visiting Australia is estimated to be approximately 25,360 birds (Clemens et al. 2016). A recent analysis suggests that the Lesser Sand Plovers over-wintering in Australia have experienced a severe population decline of 74.8% over 24 years (6% per year), in large part due to ongoing loss of intertidal mudflat habitat at key migration staging sites in the Yellow Sea (TSSC 2016d). The estimated rate of decline in Australia is 7.2% per year over the period 1973 to 2014 and 13.4% per year over the period 1996 to 2014 (Clemens et al. 2016).

Occurrence in the Toondah Harbour PDA: Surveys have not detected Lesser Sand Plovers feeding in the PDA, and there are no historical records of Lesser Sand Plovers roosting in the vicinity of the PDA. However, the species was observed foraging on the more extensive mudflat areas adjacent to the PDA to the south (east of Oyster Point). The species has potential to occasionally visit mudflats within the PDA; however, the lack of survey records suggests mudflat habitat within the PDA is of marginal value to Lesser Sand Plovers.

*3.4.7 Greater Sand Plover (***Charadrius leschenaultii***)*

Status: EPBC Act: Vulnerable; NC Act: Special Least Concern.

Distribution: The Greater Sand Plover is a migratory shorebird that has a global distribution and an extremely large range. The subspecies C*. l. leschenaultii* occurs in the EAAF, breeding in Mongolia, north-western China and southern Siberia during the northern hemisphere summer and migrating along the EAAF to spend the non-breeding period in Australia (75% of the EAAF population) or south-east Asia (Bamford et al. 2008).

Habitat and ecology: In Australia, Greater Sand Plovers feed during the low tide phase of the tide cycle from the surface of wet sand or mud on open intertidal mudflats or sandflats in estuaries, lagoons or beaches; they are more often associated with firm sandy flats than soft muddy ones. They feed mostly on molluscs, worms, crustaceans (especially small crabs and sometimes shrimps) and insects (TSSC 2016e). During the high tide phase of the tidal cycle, Greater Sand Plovers roost in often large flocks on beaches, estuarine lagoons, adjacent areas of saltmarsh and occasionally on rocky points, usually close to their feeding grounds. During migration, Greater Sand Plovers arrive in northern Australia from late July, and leave again between late February and April (TSSC 2016e).

Threats: The greatest threat to Greater Sand Plover habitat loss and degradation, particularly at critical migration staging areas through eastern Asia. In Australia, threats include habitat loss, habitat degradation and human disturbance (TSSC 2016d).

Population trend: The population of Greater Sand Plover visiting Australia is estimated to be approximately 75,000 birds, representing 75% of the population using the EAAF (Bamford et al. 2008). The annual rate of decline of the Greater Sand Plover population using Moreton Bay over the 15 year period 1992-2008 was estimated at 6.0% per year (Wilson et al. 2011). Overall, the evidence suggests there has been a population decline of 30-49% over 17 years across the EAAF (Garnett et al. 2011).

Occurrence in the Toondah Harbour PDA: Surveys have not detected Greater Sand Plovers feeding in the PDA, and there are no historical records of Greater Sand Plovers roosting in the vicinity of the PDA. However, the species was observed foraging on the more extensive mudflat areas adjacent to the PDA to the south (east of Oyster Point). The species has potential to occasionally visit mudflats within the PDA; however, the lack of survey records suggests mudflat habitat within the PDA is of marginal value to Greater Sand Plovers.

3.4.8 Koala (Phascolarctos cinereus)

Status: EPBC Act: Vulnerable; NC Act: Vulnerable.

Distribution: Koalas are widely distributed throughout north-east, central and south-east Queensland, extending south through New South Wales and Victoria into South Australia and Kangaroo Island. In Brisbane, they are renowned throughout the well forested outer suburbs, particularly to the south-east (Low 1995).

Habitat and ecology: Koalas have a distinct association with eucalypt woodland and forest habitat types containing suitable food trees (Hume and Esson 1993; Moore and Foley 2000; Martin et al. 2008), particularly those growing on alluvial or other fertile soils (Moore et al. 2004, Crowther et al. 2009). They are not necessarily restricted to bushland or remnant areas and are known to exist and breed within farmland and the urban environment (Dique et al. 2004). Similarly, movement is not confined to vegetated corridors, as they also move across cleared rural land and through suburbs (Martin et al. 2008).

They use a variety of trees, including many non-eucalypts, for feeding and resting (Dique et al. 2004; Martin et al. 2008). They do, however, have distinct, localised feeding preferences throughout their range, selecting some species in preference to others (Pahl and Hume 1990). Tree species preferences vary around Queensland; in the Redlands of south-east Queensland, the dominant diet species are *Eucalyptus* tereticornis (Hasegawa 1995) and *E. microcorys* (Tun 1993), whereas on North Stradbroke Island, Koalas prefer *E. robusta* (55% of diet), *E. pilularis* (13%), *E. tereticornis* (10%) and *Lophostemon confertus* (8%) (Woodward et al. 2008). Koala preference for certain species and individual trees appears to be based on: high leaf moisture content, high leaf nitrogen content (which is often related to low fibre content making leaves more palatable) and low amounts of chemical compounds produced by eucalypts to resist herbivory (Pahl and Hume 1990; Hume and Esson 1993; Moore and Foley 2000).

Individual animals, although solitary, coexist within overlapping home ranges, which contain sufficient feed trees that are visited repeatedly and often shared with other individuals (Martin et al. 2008). Home range sizes vary their distribution, but the average home range size is 34 ha and 15 ha for males and females respectively in south-east Queensland (White 1999). Koala densities reported in south-eastern Queensland include density estimates of 0-0.76 koalas/ha (mean 0.16 koalas/ha) in high koala density bushland sites in the former Pine Rivers Shire (Dique et al. 2003a), 0.75 koalas/ha at Burbank in the Koala Coast (Dique et al. 2003a) and 0.02-1.26 koalas/ha on the Koala Coast (Dique et al. 2004).

Breeding occurs in spring/summer when males become territorial, attacking and fighting rivals, and using loud bellows to advertise their presence (Martin et al.2008). Young permanently leave the females pouch after seven months, but continue to ride on the mothers back until 12 months and the beginning of a new breeding season. After this time adolescent females may remain in the natal habitat, but males generally disperse to new territories between 1-3 years of age (Dique et al. 2003b; Martin et al. 2008).

<u>Threats</u>: Current threats to Koalas include habitat destruction and fragmentation, bushfire and disease (Maxwell et al. 1996). Populations around urban areas are also at increased risk of mortality due to dog attack and vehicle strike (Preece 2007, DERM 2009; Rhodes et al. 2011). To maintain and conserve a landscape that contains a sufficient amount of habitat to sustain a viable koala population, at least 40- 50% of the landscape should comprise primary and secondary koala habitat across landscape extents of 1 km radius around where koalas occur (McAlpine et al. 2007). Furthermore, to maintain and restore koala habitat patches (or clusters of highly connected patches) that are large enough to sustain viable koala populations, primary and secondary koala habitat patches should be larger than 50-100 ha in size, unless they are part of a cluster of highly connected patches (i.e., patches separated by less than 100-200 m), in which case highly connected patches should be larger than 100 ha in total area (McAlpine et al. 2007).

<u>Population trend</u>: There has been a rapid decline in Koala population densities in the ‘Koala Coast’ region (the mainland portion of Redland City, the eastern portion of Logan City and the south-eastern portion of Brisbane City) and the Pine Rivers region; between 1996 and 2014 there has been an 80% decline in Koala Coast populations and an estimated 54% decline in Pine Rivers populations, with the rate of decline increasing in recent years (Rhodes et al. 2015). In light of this pattern and rate of decline, Rhodes et al. (2015) concluded that the loss of Koalas from many sites in the Koala Coast is imminent due to the extent of urban development. The remaining Koala populations in southeast Queensland are inferred to have declined from an estimated 15,000 animals in 1995; while the extent of the decline has not yet been quantified, the populations face similar threats but at lower intensity (TSSC 2011).

<u>Occurrence in the Toondah Harbour PDA</u>: The initial field survey identified a total of 286 habitat trees important for Koala are scattered across the western portion of the PDA as a component of the urban environment (**Figure 3.1**). Koala scats were observed under 33 of these trees, confirming recent Koala use of trees in the PDA, but no Koalas were observed. On later occasions, up to two Koalas were observed in habitat trees within the PDA, and up to three Koalas were observed in trees at Nandeebie Park immediately south of the PDA. These observations of Koala in the trees within the PDA, together with the high frequency of Koala scats observed under suitable food trees across the PDA during the field survey, indicates these trees support at least several individuals of the local urban Koala population whose home ranges incorporate portions of the PDA. These Koalas are known to move regularly through the western portion of the PDA, visiting favoured food trees. Other important food trees these Koalas will be visiting include larger patches of suitable habitat along the foreshore immediately south of the PDA boundary, and

scattered food trees in the urban footprint to the west of the PDA. There is a very limited occurrence of Koala food trees north of the PDA.

The results of the habitat assessment performed in accordance with the EPBC Act referral guidelines for Koala habitat assessment tool (Commonwealth of Australia 2014) are summarised in **Table 3.3**. The total habitat score from this assessment was 3; as this total score is less than 5, Koala habitat within the study area is not recognised as 'habitat critical to the survival of Koala' under the EPBC Act referral guidelines, largely because the study area occurs within an urban matrix that has poor habitat connectivity (key existing threats to Koala).

3.4.9 Grey-headed Flying-fox (Pteropus poliocephalus)

Status: EPBC Act: Vulnerable; NC Act: Least Concern.

Distribution: Grey-headed Flying-fox occurs throughout coastal south-eastern Australia, from Mackay in Queensland south to Melbourne in Victoria. Its range extends inland to the western slopes of the Great Dividing Range (Roberts *et al.* 2008; Curtis *et al.* 2012).

Habitat and ecology: Two habitat characteristics are important for Grey-headed Flying-foxes: foraging resources and roosting sites. As a canopy-feeding frugivore and nectarivore, Grey-headed Flying-foxes utilise rainforests, open eucalypt forests, woodlands, melaleuca swamps and banksia woodlands. Roosts are commonly within dense vegetation close to water, primarily rainforest patches, stands of melaleuca, mangroves or riparian vegetation (Nelson 1965), but colonies may use exotic vegetation in urban areas (Birt *et al.* 1998). The species congregates in large camps of up to 200,000 individuals from early until late summer, with the number of bats within a camp being influenced by the availability of blossom in the surrounding area. Adults normally disperse during the winter and can migrate up to 750 km as individuals or small groups (Eby 1991, Churchill 2008).

Threats: Grey-headed Flying-foxes are subject to several threatening processes, the most severe being loss of habitat. Habitat loss is thought to have resulted in a 50% decline in the population by the 1930s (Duncan *et al.* 1999). The loss of habitat, particularly reliable winter feeding resources along the east coast, has continued to lead to population decline. The species will also forage within commercial fruit farms, sometimes significantly reducing their yield. This has resulted in direct culling or the destruction of camps by harassment. Other threatening processes include accumulation of lethal levels of lead in urban areas (Hariono *et al.* 1993), and electrocution on overhead powerlines, which disproportionately kills lactating females (Duncan *et al.* 1999).

Occurrence in the Toondah Harbour PDA: While there are no historical records of Grey-headed Flying-fox from within the PDA, the species is known to roost seasonally at a flying-fox camp in the Black Swamp wetlands, located 2 km west of the PDA. Given the close proximity of the PDA to a known roosting camp, Grey-headed Flying-foxes may visit occasionally to feed on seasonally flowering trees in the PDA. However, the relatively few trees in the PDA will not support a regionally significant proportion of the population of this species.

Table 3.3. Koala habitat assessment tool results summary.

Attribute	Score	Coastal area criteria	Score	Assessment details
Koala occurrence	+2 (high)	Evidence of one or more Koalas within the last 2 years	**2**	**Desktop:** The EPBC Act Protected Matters Search Tool report identified the Koala as 'known to occur' in the study area. The Wildlife online point buffer search identified 420 Koala records since 1980 within a 1 km radius of the study area. **On-ground:** During a one day survey, the majority of the study area was traversed on foot searching for Koala resting in trees and for scats at the base of food trees. No Koala was directly observed on this survey, but scats consistent with Koala were found at multiple locations across the study area. Up to two Koalas were observed in habitat trees within the PDA study area subsequently.
	+1 (medium)	Evidence of one or more Koalas within 2 km of the edge of the impact area within the last 5 years		
	0 (low)	None of the above		
Vegetation Composition*	+2 (high)	Has forest or woodland with 2 or more known koala food tree species, OR 1 food tree species that alone accounts for >50% of the vegetation in the relevant strata.	**0**	**Desktop:** The Queensland RE mapping identifies that terrestrial vegetation within the study area is all non-remnant. The SPRP Map of Assessable Development Area Koala Habitat Values maps portions of the study area as Medium Value Rehabilitation. **On-ground:** A total of 286 non-juvenile habitat trees for Koala are scattered across the western portion of the PDA as a component of the urban environment, including the known important Koala food tree species *Eucalyptus tereticornis* and *E. robusta*. While many trees are mature trees, the majority appear to have been planted. No terrestrial forest or woodland occurs within the study area.
	+1 (medium)	Has forest or woodland with only 1 species of known koala food tree present.		
	0 (low)	None of the above		
Habitat connectivity	+2 (high)	Area is part of a contiguous landscape ≥ 500 ha.	**0**	The study area is located in an extensive urban environment on the coast and is not part of a contiguous landscape; therefore, there is very poor habitat connectivity.
	+1 (medium)	Area is part of a contiguous landscape < 500 ha but ≥300 ha.		
	0 (low)	None of the above		
Key existing threats	+2 (high)	Little or no evidence of Koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for Koala occurrence. Areas which score 0 for koala occurrence and have no dog or vehicle threat present.	**0**	**Desktop:** The Queensland Government database on Koala mortalities records numerous Koala mortalities from vehicle strike and dog attack in the local area. **On-ground:** The study area is located within an urban matrix that includes residential areas with high-volume-traffic roads, with the ocean on the eastern boundary. Therefore, the study area is surrounded by key existing threats to Koala, including high risk of vehicle strike and dog attack that can be expected to result in a relatively high frequency of Koala mortality relative to the population density of Koala in the area.
	+1 (medium)	Evidence of infrequent or irregular Koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for Koala occurrence, or areas which score 0 for koala occurrence and are likely to have some degree dog or vehicle threat present.		

Attribute	Score	Coastal area criteria	Score	Assessment details
	0 (low)	Evidence of frequent or regular Koala mortality from vehicle strike or dog attack in the study area at present, or areas with score 0 for Koala occurrence and have a significant dog or vehicle threat present.		
Recovery value **	+2 (high)	Habitat is likely to be important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1 of the referral guidelines (Commonwealth of Australia 2014).	**1**	Habitat in the study area comprises mostly planted trees in an urban matrix with key existing threats to Koala, particularly from vehicle strike and dog attack. While these trees support several Koalas in an urban context, the study area is not part of a large, connected area of forest or woodland habitat. Furthermore, the local population has a high incidence of disease, but does breed successfully. However, the Koala population of the Koala Coast, which includes Redland City, is regarded as a significant Koala population because of its relatively large population density and size (despite a large proportion of the population occurring in an urban environment) and the genetic distinctiveness of Koalas in this population compared with other Koalas in South East Queensland (Lee *et al*. 2010, DERM 2012). There is therefore uncertainty as to whether the habitat is important for achieving the interim recovery objectives, based on uncertainty in how successfully koalas in an urban context can be managed to ensure the long-term persistence of the population.
	+1 (medium)	Uncertainty exists as to whether the habitat is important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1 of the referral guidelines (Commonwealth of Australia 2014).		
	0 (low)	Habitat is unlikely to be important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1 of the referral guidelines (Commonwealth of Australia 2014).		
Total Score			**3**	As the total score is less than 5, Koala habitat within the study area is not recognised as 'habitat critical to the survival of Koala' under the draft EPBC Act referral guidelines.

* Koala food tree species are based on published, location-specific food tree preferences in Redland City (Hasegawa 1995, Tun 1993, Woodward et al. 2008).
** Interim recovery objective in coastal areas is to protect and conserve large, connected areas of Koala habitat, particularly large, connected areas that support Koalas that are: genetically diverse/distinct; or free of disease or have a very low incidence of disease; or breeding (i.e. presence of back young or juveniles).

3.5 MIGRATORY SHOREBIRD SPECIES

In this section, background information on migratory shorebird ecology, population trends and threats is provided whereafter detailed information on migratory shorebird use of the study area from the surveys is provided.

3.5.1 Migratory shorebird ecology

A shorebird is a bird species in the order Charadriiformes (Colwell 2010). Most shorebirds live on or near the coast, on beaches, reefs and tidal mudflats, though some also frequent, or are largely confined to, freshwater habitats (Colwell 2010). Most coastal species feed on flat, tidal shores with extensive muddy or sandy intertidal areas. Most species are gregarious, wary and fly strongly and swiftly (Geering *et al*. 2007, Colwell 2010).

A large proportion of Australia's shorebird species are migratory, spending their non-breeding season (the Austral summer) in Australia and migrating up to 13,000 km north along the East Asian–Australasian Flyway to breeding grounds in eastern Siberia and western Alaska (most species, Bamford *et al*. 2008) or south to New Zealand (Double-banded Plover (*Charadrius bicinctus*), Pierce 1999). They are highly dependent on a relatively small number of key feeding grounds at stop-over sites on their migration routes and on their non-breeding grounds in order to replenish their fat reserves for migration. If their feeding rates are reduced and they do not manage to lay down sufficient reserves of fat, their subsequent survival on migration is severely compromised (Baker *et al*. 2004).

On their over-wintering grounds in Australia, coastal migratory shorebirds have a daily activity pattern driven largely by the tidal cycle, roosting in flocks at sites above the high water mark at high tide and moving to intertidal sandflat and mudflat feeding areas as the tide recedes (Colwell 2010). They are capable of feeding during both the day and night. Shorebirds feed on a wide variety of benthic invertebrates, including crustaceans, molluscs and polychaete worms that are taken either on the surface of intertidal areas or extracted from soft muddy or sandy sediments by probing with their often elongated bills. Different shorebird species specialise on different prey, prey sizes and feeding styles depending on their evolved bill morphology and body size (Lifjeld 1984; Baker 1989; Barbosa and Moreno1999; Durell 2000). Species with long, slender bills that depend on deep probing of sediments for locating prey tend to prefer feeding in softer sediments with less resistance to bill probing (Finn *et al*. 2008).

Migratory shorebirds also depend on roosting areas near their feeding areas that allow them to rest (during times when their feeding habitat is inundated at high tide) without losing too much energy to disturbance (Colwell 2010). Migratory shorebirds select roost sites on the basis of: distance from feeding areas (preferring sites close to feeding areas); distance from tall cover (preferring sites with little cover to ensure a clear view of approaching predators); climate (preferring sites at the water's edge to stay cool); height of the tide (whether the site will be inundated); and background colour of the roost site (providing camouflage against predators) (Rogers *et al*. 2006a). There is also some evidence that feeding site selection is influenced by distance from available roost sites (Rogers *et al*. 2006a), since energy expended flying between feeding and roosting sites reduces the birds' ability to store fat for migration (Rogers 2003). As a result of these requirements, both feeding and roosting habitats are essential to migratory shorebirds.

3.5.2 Threats to migratory shorebirds and population trends

Many of these key feeding and roosting sites for migratory shorebirds are coastal wetlands that are increasingly threatened by development for aquaculture, industry and housing (Wetlands International 2006; Yang *et al*. 2011; MacKinnon *et al*. 2012; Murray *et al.* 2014), particularly at key stop-over sites on their migration routes through east Asia. This makes migratory shorebirds particularly susceptible to habitat loss, disturbance and environmental change (Gill *et al*. 2001; Piersma and Baker 2000; Baker *et al*. 2004; Wilson *et al*. 2011; Melville *et al.* 2016; Moores *et al*. 2016; Piersma *et al*. 2016). Consequently, migratory shorebirds are in decline around the world (Donaldson *et al*. 2000; Baker *et al*. 2004; Wetlands International 2006), including in Australia (Close & Newman 1982; Nebel *et al*. 2008; Wilson *et al*. 2011; Clemens *et al*. 2016).

An analysis of shorebird population trends in Moreton Bay over 15 years (1992-2008) found that the abundances of at least seven migratory shorebird species declined significantly by between 43% and 79% over this period, whereas the abundances of resident shorebird species showed no significant trends. The primary cause of the population declines of migratory shorebirds in Moreton Bay was attributed to habitat loss at key migration stopover sites in the Yellow Sea region (Wilson et al. 2011). Similarly, a more recent analysis revealed significant Australia-wide decreases in abundance in 12 of 19 migratory shorebird species, with estimated annual rates of decline of between 1.98% and 9.53% (Clemens et al. 2016).

The Yellow Sea supports the most important stop-over feeding habitats for migratory shorebirds on the East Asian-Australasian Flyway. In the 1950’s, tidal flats occupied 1.12 million ha in the Yellow Sea in the mid-1950’s, but this had reduced to 545,000 ha by the 1980’s and 389,000 ha by the 2000’s, representing a loss of up to 65% over 50 years (Murray et al. 2014). This loss of tidal feeding habitat has largely resulted from extensive land reclamation for agriculture, aquaculture, urban and industrial development, and is ongoing (Murray et al. 2014, Moores et al. 2016). The largest single reclamation project has been at Saemangeum, South Korea, where approximately 29,000 ha of tidal flats were impounded behind a 33-km long sea-wall in 2006. These Saemangeum tidal flats supported at least 330,000 migratory shorebirds prior to the reclamation, including 30% of the world population of Great Knot. Following the completion of the impoundment, an estimated 130,000 migratory shorebirds disappeared from the flyway population within the first two years and 300,000 had disappeared by 2013 including an estimated 104,000 Great Knots; these missing birds are presumed to have died following the loss of habitat (Moores et al. 2016). These studies highlight why past and ongoing feeding habitat loss at key staging sites in the Yellow Sea is the single biggest threat to migratory shorebirds on the East-Australasian Flyway. Other threats, including in Australia, include human disturbance at feeding and roosting sites, habitat loss and degradation from pollution, changes to the water regime and invasion of mudflats and coastal saltmarshes from the spread of mangroves.

3.5.3 Migratory shorebird species in the Toondah Harbour PDA

The database searches (**Appendices 1** and **2**) identified a total of 33 terrestrial fauna species or sub-species listed as migratory shorebird species under the EPBC Act that may occur within the study area or environs. Eleven of these species (including three critically endangered and one vulnerable species) were recorded within or immediately adjacent to the study area during field surveys, and a further eight species (including two endangered and one vulnerable species) were assessed as likely to occur based on database records for the local area and presence of suitable habitat (**Table 3.4**). The remaining 14 species or sub-species were assessed as unlikely to occur (see **Appendix 3** for details).

Table 3.4. Terrestrial fauna species listed as migratory shorebird species under the EPBC Act that are known or likely to occur in the study area.

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
Numenius madagascariensis	Eastern Curlew	CE, M	V	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Limosa lapponica baueri	Bar-tailed Godwit (Western Alaskan)	V, M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris tenuirostris	Great Knot	CE, M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris ferruginea	Curlew Sandpiper	CE, M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within (rarely) and adjacent to the study area.
Numenius phaeopus	Whimbrel	M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Xenus cinereus	Terek Sandpiper	M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Tringa brevipes	Grey-tailed Tattler	M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Arenaria interpres	Ruddy Turnstone	M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Calidris ruficollis	Red-necked Stint	M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within (rarely) or adjacent to the study area.
Limosa limosa	Black-tailed Godwit	M	S	**Known**. Recorded rarely at roost sites within and adjacent to the study area.
Pluvialis fulva	Pacific Golden Plover	M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within (rarely) and adjacent to the study area.
Calidris canutus	Red Knot	E, M	S	**Potential**. While it has not been recorded within the study area, the species is known to occur within 1 km of the study area and it has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius mongolus	Lesser Sand Plover	E, M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius leschenaultii	Greater Sand Plover	V, M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Calidris acuminata	Sharp-tailed Sandpiper	M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
				mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Tringa nebularia	Common Greenshank	M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Tringa stagnatilis	Marsh Sandpiper	M	S	**Potential**. While it has not been recorded within the study area, the species is known from the local area and it has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Actitis hypoleucos	Common Sandpiper	M	S	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius bicincutus	Double-banded Plover	M	S	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.

[1] Status under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act): CE = critically endangered; E = endangered; M = migratory; V = vulnerable.
[2] Status under the *Nature Conservation Act 1992* (NC Act): S = special least concern (migratory), V = vulnerable.

Migratory shorebirds utilise two different types of habitat within or adjacent to the Toondah Harbour PDA, namely intertidal mudflats that provide feeding habitat when exposed during low tide, and stands of mangrove trees, offshore sandbars and shoreline saltmarsh and claypan areas that provide high tide roost sites. Shorebird use of these two habitat types is discussed in more detail below.

3.5.4 Migratory shorebird use of intertidal mudflats for feeding during low tide

Intertidal mudflats within the study area extend from the shoreline in the west of the PDA to the astronomical low tide level in the east, including areas both to the north and south of the dredged ferry channel (see **Figure 3.1, Photo 1**). Areas of high, moderate and low value for feeding are mapped based on a rapid assessment of the relative density of benthic invertebrates (BAAM and frc environmental 2014).

The results of six summer surveys and one winter survey conducted from October 2014 to June 2015 within the Toondah Harbour PDA are summarized in **Table 3.5** below. Migratory shorebirds were observed foraging throughout the mapped distribution of intertidal foraging habitat within the PDA, but foraging birds were more concentrated in, and spent more time within the mapped areas of high and moderate habitat value (see **Figure 3.1**). Data from the QWSG, which conducted a total of 17 low tide surveys within the PDA over the months June to October 2014, are summarized in **Table 3.6** below. These surveys recorded the same five species of migratory shorebird as the BAAM surveys. During the winter months, only Grey-tailed Tattler was present, but the number and abundance of migratory shorebird species increased from September as migratory shorebirds migrated into the area for the austral summer. During the summer months October to March, the number of migratory shorebirds recorded feeding within the PDA averaged 101 with a maximum of

158, representing 0.33% and 0.53% respectively of the estimated total of 30,000 migratory shorebirds that use Moreton Bay. The respective numbers for the critically endangered Eastern Curlew were an average of 4.5 and maximum of 7 and for the vulnerable Bar-tailed Godwit were an average of 24.8 and maximum of 36 birds. A single individual of the critically endangered Great Knot was observed on a single survey.

Table 3.5. Summary of migratory shorebirds foraging within and immediately adjoining the Toondah Harbour PDA area during the low tide surveys from October 2014 to June 2015 (BAAM 2014, 2015).

Species	Common name	EPBC[1]	NCA[2]	31/10/2014	06/11/2014	26/12/2014	09/01/2015	24/02/2015	19/03/2015	18/06/2015
Low tide height (m)				0.6	0.4	0.4	0.5	0.6	0.3	0.4
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S	32	6	33	27	9	30	
Numenius phaeopus	Whimbrel	M	S	6	13	15	19	12	16	
Numenius madagascariensis	Eastern Curlew	CE,M	V	4	2	7	4	4	1	
Tringa brevipes	Grey-tailed Tattler	M	S	88		60	41	55	91	
Calidris tenuirostris	Great Knot	CE,M	S			1				
Calidris ruficollis	Red-necked Stint	M	S					1		
Xenus cinereus	Terek Sandpiper	M	S	7		42		26		
Total migratory shorebirds				**137**	**21**	**158**	**91**	**107**	**138**	**0**

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: V = vulnerable; S = special least concern (migratory).

Table 3.6. Average (and maximum) numbers of migratory shorebird species foraging within Toondah Harbour PDA each month during QWSG low tide surveys in 2014.

	Month in 2014			Jun	Jul	Aug	Sep	Oct
	Number of surveys			3	4	2	3	5
Species	**Common name**	**EPBC[1]**	**NCA[2]**					
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S	0	0	0	0	27.6 (36)
Numenius phaeopus	Whimbrel	M	S	0	0	0	9.0 (17)	12.0 (18)
Numenius madagascariensis	Eastern Curlew	CE,M	V	0	0	2.0 (3)	4.0 (5)	5.4 (6)
Tringa brevipes	Grey-tailed Tattler	M	S	9.0 (27)	20.0 (52)	14.0 (20)	26.7 (43)	52.8 (92)
Xenus cinereus	Terek Sandpiper	M	S	0	0	0	0	4.0 (11)
Total				**9.0 (27)**	**20.0 (52)**	**16.0 (23)**	**39.7 (53)**	**101.8 (144)**

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: V = vulnerable; S = special least concern (migratory).

3.5.5 Migratory shorebird use of roost sites during high tide

There are no migratory shorebird roost sites within the boundaries of the Toondah Harbour PDA; however, there are two high tide roost sites located immediately adjacent to the PDA (see **Figure 3.1**):

- Most mangrove trees in the cluster of mangroves around Cassim Island near the eastern boundary of the PDA and north of the harbor entrance channel (**Photo 2**) are used daily as a high tide roost by several migratory shorebird species that can roost in mangrove trees, namely Whimbrel (**Photo 3**), Grey-tailed Tattler, Terek Sandpiper and Ruddy Turnstone; and
- An area of saltmarsh and claypan known as the Nandeebie Claypan (**Photo 4**) to the south of the PDA is used infrequently by a variety of migratory shorebirds, particularly on spring high tides.

Photo 1. Intertidal mudflat in the Toondah Harbour PDA exposed at low tide (looking from the mainland towards the mangroves of Cassim Island), foraging habitat for migratory shorebirds.

Photo 2. Offshore mangroves of Cassim Island (on the eastern boundary of Toondah Harbour PDA) at high tide, an important roost site for migratory shorebirds.

Photo 3. Whimbrel roosting in mangrove tree at Cassim Island.

Photo 4. Proximity of a public walkway (foreground) to the Nandeebie Claypan migratory shorebird roost site (background, inundated by a spring high tide).

A further high tide roost site that is used regularly by migratory shorebirds is located further to the south at Oyster Point (see **Figure 3.2**).

The high tide survey results of roosting migratory shorebirds are summarised in **Tables 3.7** and **3.8** for Cassim Island and the Nandeebie Claypan, respectively. An average of 699 and maximum of 920 migratory shorebirds of four species were recorded roosting at Cassim Island during four summer high-tide surveys (**Table 3.6**). Most of the roosting shorebirds were concentrated in the western and south-western portions of the mangroves of the Cassim Island roost (i.e. closest to the PDA boundary), with smaller numbers occasionally using the outer trees along the north-western edge. The birds may select these areas for protection from the prevailing south-easterly winds. The smaller shorebirds (Grey-tailed Tattler, Terek Sandpiper, Ruddy Turnstone) preferred to roost in the trees close to the waterside edge, whereas Whimbrels were more dispersed over a greater area of mangroves.

Up to 1,060 migratory shorebirds were recorded roosting at the Nandeebie claypan at high tide, but numbers were highly variable, with greater numbers tending to be recorded on spring high tides. Furthermore, migratory shorebirds were observed moving between the Nandeebie Claypan and the nearby Oyster Point roost site depending on the tide height (moving from Oyster Point to Nandeebie on the rising tide and vice versa as the tide receded) and extent of disturbance at Oyster Point.

Table 3.7. Summary of migratory shorebirds roosting in the mangroves of Cassim Island during four summer and one winter survey over the period November 2014 to June 2015 (BAAM 2014, 2015).

Species	Common name	EPBC[1]	NCA[2]	06/11/2014	09/1/2015	16/2/2015	19/3/2015	18/6/2015
Numenius phaeopus	Whimbrel	M	S	184	270	160	140	0
Tringa brevipes	Grey-tailed Tattler	M	S	215	600	570	460	0
Arenaria interpres	Ruddy Turnstone	M	S	10	20	50	26	0
Xenus cinereus	Terek Sandpiper	M	S	8	30	30	22	0
Total				**417**	**920**	**810**	**648**	**0**

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: M = migratory.
[2] Status under the Queensland *Nature Conservation Act 1992*: S = special least concern (migratory).

Table 3.8. Summary of migratory shorebirds roosting on the Nandeebie Claypan during 15 summer and one winter survey over the period November 2014 to June 2015 (BAAM 2014, 2015).

Species	Common name	EPBC[1]	NCA[2]	30/10/2014	31/10/2014	05/11/2014	06/11/2014	21/11/2014	25/11/2014	26/11/2014	27/11/2014	08/12/2014	09/12/2014	06/01/2015	08/01/2015	16/02/2015	03/03/2015	20/03/2015	18/06/2015
High tide height (m)				2.2	2.2	2.3	2.4	2.3	2.5	2.4	2.3	2.5	2.4	2.5	2.4	2.4	2.3	1.6	1.9
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S					43							1026	730	841		
Numenius phaeopus	Whimbrel	M	S	5			1			103	2	23				124			
Numenius madagascariensis	Eastern Curlew	CE,M	V	14	6		1	6	1	2	2	2	1	1	34	45	36		
Calidris tenuirostris	Great Knot	CE,M	S													1	5		
Total migratory shorebirds				**19**	**6**	**0**	**2**	**49**	**1**	**105**	**4**	**25**	**1**	**1**	**1060**	**900**	**882**	**0**	**0**

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: S = special least concern (migratory); V = vulnerable.

A relatively large number of Bar-tailed Godwits utilising the Nandeebie Claypan roost were observed with engraved leg flags (see **Appendix 4** for combinations) that are used to monitor the movements of individually identifiable birds both within Moreton Bay and the East Australasian flyway more broadly.

The QWSG conducted a total of 148 high tide surveys (98 of these surveys in the summer months late September to March) of the Nandeebie Claypan roost site between March 1995 and May 2014, with a gap in surveys in the summers of 2004/5 to 2006/7. Combining these surveys with the BAAM (2014, 2015) surveys, the maximum roost counts each summer are shown in **Figure 3.2** and the average roost count each year for surveys in the months of October to March inclusive are shown in **Figure 3.3**. The maximum roost count each year has typically ranged between 500 and 1,500 migratory shorebirds, with a maximum count of 2,562 migratory shorebirds in February 1996. During the summer months late September to March over the period 1995 to 2015, an average of 474 and maximum of 2,560 migratory shorebirds were recorded on the 83% of surveys when migratory shorebirds were present; however over the past ten years (since 2007) the average and maximum numbers were 397 and 1,406 respectively, reflecting the decline in migratory shorebirds within Moreton Bay more generally. Species specific data are summarised in **Table 3.9**.

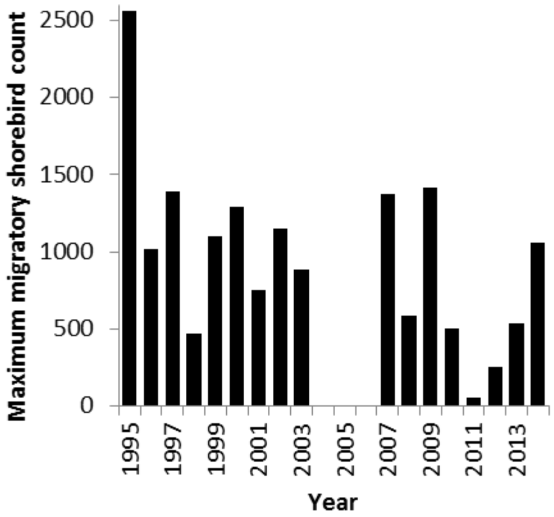


Figure 3.2. Maximum count of migratory shorebirds roosting at Nandeebie claypan each season of 1995/6 to 2003/4 and 2007/8 to 2014/15.

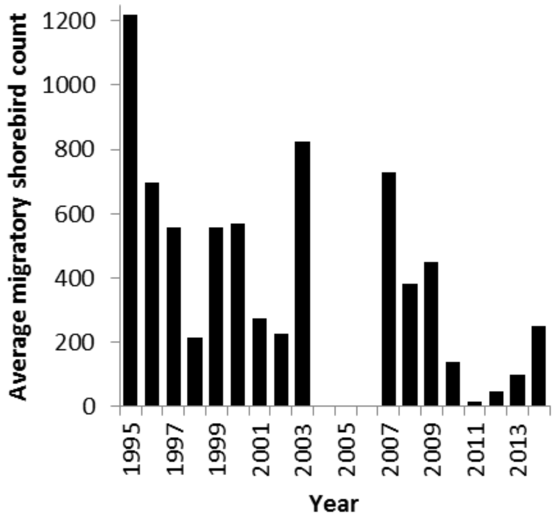


Figure 3.3. Average count of migratory shorebirds roosting at Nandeebie claypan over the months October to March each season of 1995/6 to 2003/4 and 2007/8 to 2014/15.

Table 3.9. Migratory shorebird species recorded roosting at the Nandeebie claypan during 114 surveys over summer months (late September to March) over the period 1995 to 2015, the number (N) and percentage (%) of summer surveys in which the species was recorded, the average count of the species when present, and the maximum count over all surveys (summarising data from QWSG, BAAM 2014, 2015).

Species	Common name	EPBC	NCA	N	% of surveys	Average count	Maximum count
Calidris ferruginea	Curlew Sandpiper	CE,M	S	2	1.8	1.5	2
Calidris tenuirostris	Great Knot	CE,M	S	17	14.9	27.2	90
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S	64	56.1	608.8	2,300
Limosa limosa	Black-tailed Godwit	M	S	1	0.9	2.0	2
Numenius madagascariensis	Eastern Curlew	CE,M	V	76	66.7	24.7	180
Numenius phaeopus	Whimbrel	M	S	56	49.1	64.5	508

Species	Common name	EPBC	NCA	N	% of surveys	Average count	Maximum count
Pluvialis fulva	Pacific Golden Plover	M	S	1	0.9	1.0	1
Tringa brevipes	Grey-tailed Tattler	M	S	2	1.8	29.5	56

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: S = special least concern (migratory); V = vulnerable.

There appears to have been a reduction in migratory shorebird use of the Nandeebie claypan for roosting since 2009, and the reasons for this may be threefold. First, it may reflect the ongoing decline in the populations of many migratory shorebird species. Second, there has been a gradual encroachment of mangroves colonising what was originally a larger and more open claypan, reducing the suitability of the site for migratory shorebirds, which prefer roost sites less enclosed by taller vegetation, as more open sites provide less cover for approaching predators (Rogers 2003; Rogers *et al*. 2006a). Third, a concrete walkway/cycleway was constructed along the shoreline in 2004. This walkway is not screened from the roost site (see **Photo 4**) and facilitates the movement of walkers, cyclists, dogs etc. to within 30-50 m of the edge of the area occupied by roosting birds. The construction of the walkway and the increasing population of Cleveland has likely increased disturbance to roosting shorebirds at this site over time.

3.5.6 Importance of the Toondah Harbour PDA for migratory shorebirds

EPBC Act Policy Statement 3.21 provides definitive guidelines for assessing the significance of sites for migratory shorebirds. Under these guidelines, if a shorebird area has already been identified as internationally important for shorebirds, then shorebird habitat within that shorebird area is recognised as important habitat under the EPBC Act. The guidelines define a shorebird area as:

"*Following Clemens et al. (2010) a shorebird area is defined as: the geographic area that had been used by the same group of shorebirds over the main non-breeding period. This is effectively the home range of the local population when present. Shorebird areas may include multiple roosting and feeding habitats. While most migratory shorebird areas will represent contiguous habitat, non-contiguous habitats may be included as part of* the *same area where there is evidence of regular bird movement between them. Migratory shorebird areas may therefore extend beyond the boundaries of a property or project area, and may also extend beyond Ramsar boundaries for internationally important areas*".

As outlined under **Section 3.1.1** earlier, the Moreton Bay shorebird area is recognised as an internationally important wetland under the Ramsar Convention, particularly for migratory shorebirds. Since the shorebird feeding and roosting habitats within the Toondah Harbour PDA are encompassed within the Moreton Bay Ramsar wetlands, these habitats are defined as important habitat for migratory shorebirds under the EPBC Act. The relative importance of the shorebird habitats within the Toondah Harbour PDA can be described as a function of the total numbers of migratory shorebirds they regularly support in relation to the Moreton Bay shorebird area as a whole. The approximately 40 ha of intertidal mudflat/sandflat habitat at low tide within the PDA constitutes 0.17% of the 23,000 ha of intertidal flats within Moreton Bay (Blackman and Craven 1999 cited in Finn et al. 2001). The average of 101 and maximum of 158 birds that feed on the intertidal flats within the PDA in summer represent approximately 0.33% and 0.53% respectively of the estimated total of 30,000 migratory shorebirds that use Moreton Bay.

3.6 OTHER MIGRATORY SPECIES

The desktop assessment identified 18 species (excluding migratory shorebird species that are dealt with under the previous section) listed as migratory species under the EPBC Act as having potential to occur in the Toondah Harbour PDA study (**Appendices 1** and **2**). Four of these species were recorded within or immediately adjacent to the study area during field surveys, and a further six species were assessed as having potential to occur (as regular or rare seasonal visitors) based on database records for the local area and presence of suitable habitat (**Table 3.10**). The remaining eight species were assessed as unlikely to occur (see **Appendix 3** for details).

Table 3.10. Terrestrial fauna species listed as migratory species (excluding migratory shorebirds) under the EPBC Act that are known or likely to occur in the study area.

Species	Common name	EPBC[1]	NCA[2]	Likelihood of occurrence details
Pandion cristatus	Eastern Osprey	M	S	**Known**. Single birds were seen flying over the study area on two of the low-tide surveys. Forages for fish over open waters. No nest site occurs in the study area, but the species nests on a number of shipping lane buoys between Toondah Harbour and North Stradbroke Island, and elsewhere close to the coast of Moreton Bay.
Gelochelidon nilotica	Gull-billed Tern	M	S	**Known**. Feeds over open waters and intertidal mudflats (maximum 7 birds recorded); rarely roosts at Nandeebie Claypan (maximum 32 roosting birds).
Hydroprogne caspia	Caspian Tern	M	S	**Known**. Feeds over open waters and intertidal mudflats (maximum 2 birds); rarely roosts at Nandeebie Claypan (maximum 14 roosting birds).
Sternula albifrons	Little Tern	M	S	**Known**. Feeds over open waters (maximum 1 bird recorded); while it is known to roost at Oyster Point, it was not recorded roosting at Nandeebie Claypan.
Chlidonias leucopterus	White-winged Black Tern	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Thallaseus bergii	Crested Tern	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a regular visitor, feeding on fish over open waters, the study area is not important habitat for this species.
Sterna hirundo	Common Tern	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Hirundapus caudacutus	White-throated Needletail	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a regular seasonal visitor feeding on insects in the air, the study area is not important habitat for this species.
Cuculus optatus	Oriental Cuckoo	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Rhipidura rufifrons	Rufous Fantail	M	S	**Potential**. The species has not been recorded within 1 km of the study area, but suitable mangrove forest habitat occurs in the southern portion of the PDA. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.

[1] Status under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act): M = migratory.
[2] Status under the *Nature Conservation Act 1992* (NC Act): S = special least concern (migratory).

The four migratory bird species known to occur in the study area are all marine species that hunt for fish over open waters in sheltered coastal bays or near-shore seas. Of these species, only Eastern Osprey is known to nest in the vicinity of Toondah Harbour PDA, but not within the PDA.

3.6.1 Importance of the Toondah Harbour PDA for other migratory birds

The referral guideline for 14 birds listed as migratory species under the EPBC Act (Commonwealth of Australia 2015b) provides guidelines for assessing the importance of habitat for migratory species that are not migratory shorebird species. The referral guideline specifies that an action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ‘ecologically significant proportion of the population’ of a migratory species. An ecologically significant proportion of the population is defined at a national level as 0.1% of the estimated national population of the species, and at an international level as 1% of the population of the species. The relevant population size and habitat area thresholds for the migratory species known or likely to occur in the Toondah Harbour PDA are summarised in **Table 3.11** below.

Table 3.11. Summary of threshold criteria for the assessment of habitat importance and impact significance for migratory species (excluding migratory shorebirds).

		Population size threshold[1]		Habitat area threshold[2]	
Species	**Common name**	**1%**	**0.1%**	**1%**	**0.1%**
Pandion cristatus	Eastern Osprey	240	24	840 km coastline	84 km coastline
Gelochelidon nilotica	Gull-billed Tern	1,000	100	None specified	None specified
Hydroprogne caspia	Caspian Tern	1000	100	None specified	None specified
Sternula albifrons	Little Tern	1150	115	None specified	None specified
Chlidonias leucopterus	White-winged Black Tern	250-10,000	25-1,000	None specified	None specified
Thallaseus bergii	Crested Tern	No data*	No data*	None specified	None specified
Sterna hirundo	Common Tern	No data*	No data*	None specified	None specified
Hirundapus caudacutus	White-throated Needletail	100	10	None specified	None specified
Cuculus optatus	Oriental Cuckoo	10,000	1,000	250,000 ha	25,000 ha
Rhipidura rufifrons	Rufous Fantail	11,000	1,100	2,600 ha	260 ha

[1] Sources: Wetlands International (2006) and Commonwealth of Australia 2015b).
[2] Areas of important habitat for each species likely to result in a significant impact if affected, as specified in referral guideline (Commonwealth of Australia 2015b).
* While there are no population size data available, these are common, widely distributed species with very large global populations.

Habitat within the Toondah Harbour PDA that is used by migratory species (excluding migratory shorebirds) does not meet the population or habitat area thresholds for recognition as important habitat for any migratory species. Therefore, the Project is unlikely to have a significant impact on any migratory species (excluding migratory shorebirds).

4.0 MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

This section outlines matters of state environmental significance (MSES) with relevance to terrestrial ecology.

4.1 REGULATED VEGETATION

4.1.1 Regional Ecosystems

The Toondah Harbour PDA contains patches of vegetation currently mapped by the Queensland Government as remnant vegetation of the following two regional ecosystems (REs), both of which have a 'least concern' status under the VM Act:

- RE 12.1.2 (Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains); and
- RE 12.1.3 (Mangrove shrubland to low closed forest on marine clay plains and estuaries).

The Queensland Government map of regulated vegetation in the study area is provided in **Appendix 2** and the ground-truthed map of remnant regional ecosystems within the boundaries of the PDA is shown in **Figure 4.1**.

4.1.2 Essential Habitat

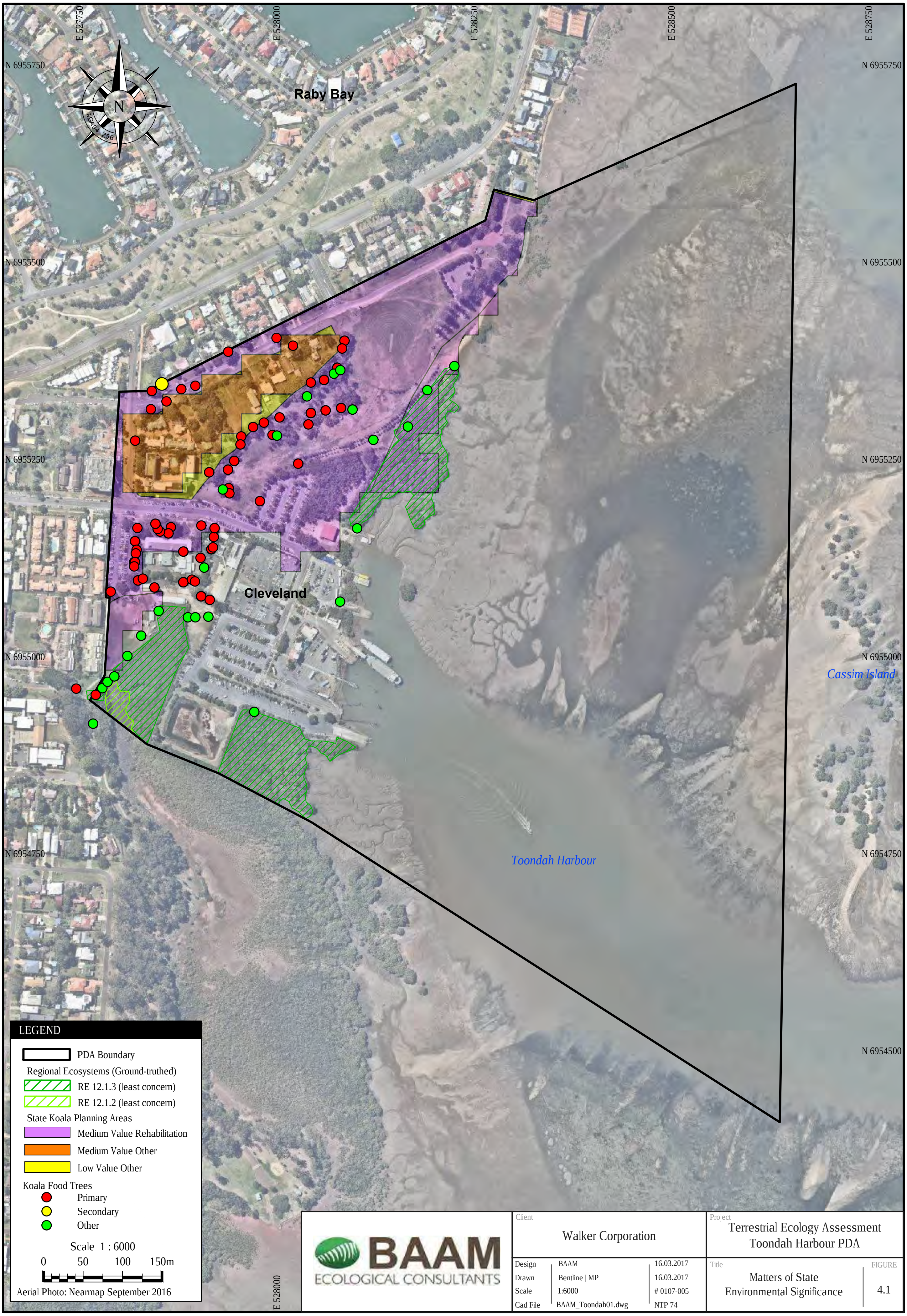
The Queensland Government mapping of regulated vegetation does not identify any essential habitat regulated under the VM Act as occurring within the boundaries of the PDA (see **Appendix 2**).

4.2 THREATENED AND NEAR THREATENED SPECIES

The database searches (**Appendices 1** and **2**) identified a total of 22 terrestrial fauna species and five terrestrial flora species listed as threatened species under the NC Act that may occur within the study area or environs. Two threatened fauna species (both listed vulnerable) were recorded within or immediately adjacent to the study area during field surveys (**Table 4.1**). These two species are dealt with under **Section 3.4** as they are also listed as threatened species under the EPBC Act; however, additional information relevant to Koala is presented in **Section 4.3** below. The remaining 20 fauna species and all five flora species were assessed as unlikely to occur (see **Appendix 3** for details). The study area does not fall within a 'high risk' area of the Queensland Government protected plants flora survey trigger map (see **Appendix 2**); therefore a protected flora survey is not required.

Table 4.1. Terrestrial fauna species listed as threatened species under the NC Act that are known or likely to occur in the study area.

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
Numenius madagascariensis	Eastern Curlew	CE, M	V	**Known.** Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Phascolarctos cinereus (SEQ Bioregion)	Koala (SEQ Bioregion)	V	V	**Known.** Feeds on food trees (*species of Eucalyptus, Corymbia, Lophostemon* and *Melaleuca*) growing in the urban environment within and adjacent to the study area.


E 527750
E 528000
E 528250
E 528500
E 528750
N 6955750
N 6955500
N 6955250
N 6955000
N 6954750
N 6954500
Raby Bay
Cleveland
Cassim Island
Toondah Harbour
LEGEND
PDA Boundary
Regional Ecosystems (Ground-truthed)
RE 12.1.3 (least concern)
RE 12.1.2 (least concern)
State Koala Planning Areas
Medium Value Rehabilitation
Medium Value Other
Low Value Other
Koala Food Trees
Primary
Secondary
Other
Scale 1 : 6000
0 50 100 150m
Aerial Photo: Nearmap September 2016
BAAM
ECOLOGICAL CONSULTANTS
Client
Walker Corporation
Project
Terrestrial Ecology Assessment
Toondah Harbour PDA
Design BAAM 16.03.2017
Drawn Bentline | MP 16.03.2017
Scale 1:6000 # 0107-005
Cad File BAAM_Toondah01.dwg NTP 74
Title
Matters of State
Environmental Significance
FIGURE
4.1

4.3 SOUTH EAST QUEENSLAND KOALA CONSERVATION STATE PLANNING REGULATORY PROVISIONS

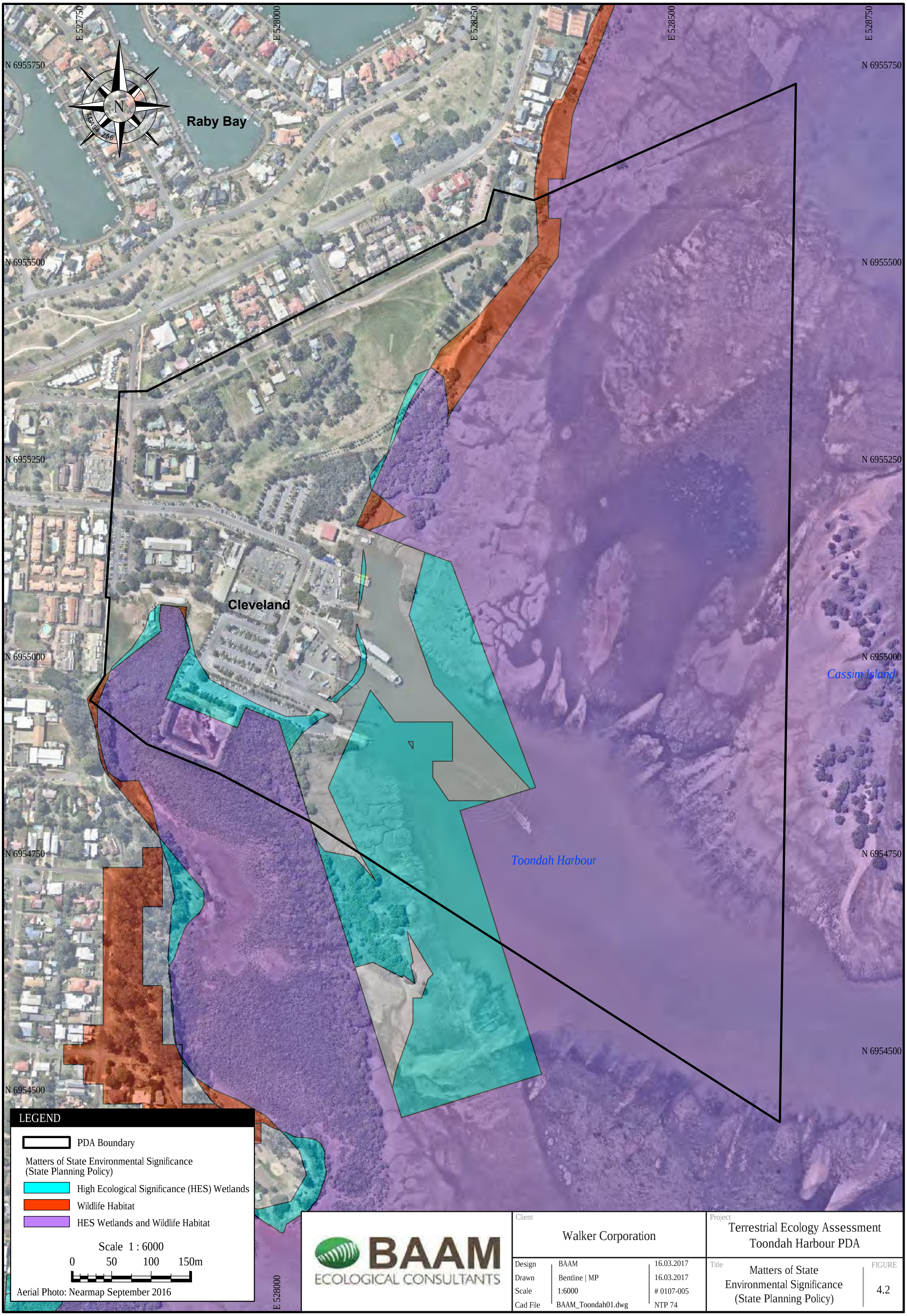
The Toondah Harbour PDA is located within a priority koala assessable development area under the South East Queensland Koala Conservation State Planning Regulatory Provisions (SPRP). For developments subject to particular schedules of the SPRP, clearing of non-juvenile Koala habitat trees within areas mapped 'bushland', 'high value rehabilitation' and 'medium value rehabilitation' requires offsetting in accordance with the Queensland *Environmental Offsets Act 2014* and Queensland Environmental Offsets Policy unless the Project is exempt from the SPRP. A total of 286 non-juvenile Koala habitat trees were recorded within the PDA boundary (**Figure 4.1**); 58 of these trees occur within areas mapped as 'medium value rehabilitation' under the SPRP.

4.4 STATE PLANNING POLICY

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states: *'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset*'. The Queensland Government maps matters of state environmental significance (MSES) of relevance to the SPP to support the implementation of SPP biodiversity policy. The following two MSES are mapped within the Toondah Harbour PDA (see **Figure 4.2**):

- High ecological significance (HES) wetlands on the Map of Referable Wetlands; and
- Wildlife habitat for threatened wildlife and special least concern animals under the NC Act.

The Queensland Government MSES report for the study area is included in **Appendix 2**.



BAAM ECOLOGICAL CONSULTANTS

Client	Project	
Walker Corporation	Terrestrial Ecology Assessment Toondah Harbour PDA	
Design: BAAM 16.03.2017	Title	FIGURE
Drawn: Bentline | MP 16.03.2017	Matters of State Environmental Significance (State Planning Policy)	4.2
Scale: 1:6000 # 0107-005		
Cad File: BAAM_Toondah01.dwg NTP 74		

5.0 POTENTIAL IMPACTS OF THE PROJECT

This section identifies the potential impacts of the Project on matters of national and state environmental significance relevant to terrestrial ecology based on the Project description. As the Project is still at the planning stage of development, potential impacts are identified in general terms. It is understood that the information on potential impacts will be used to inform the ongoing design of the Project, including layout and construction and operational management.

5.1 PROJECT DESCRIPTION

The Walker Group's proposal for the development of the Toondah Harbour PDA includes residential, retail, marina, hotel, port facilities and tourism infrastructure to be developed within the PDA. As a portion of the development is proposed to occur on intertidal lands within the PDA, dredging and land reclamation will be required over intertidal lands.

5.2 POTENTIAL IMPACTS ON MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The potential impacts of the Project on matters of national environmental significance include the following:

- Direct and indirect impacts on a small portion of the Moreton Bay Ramsar wetlands;
- Direct impact on an area of intertidal mudflats and sandflats that is recognised as important feeding habitat for migratory shorebirds, including known feeding habitat for two critically endangered and one vulnerable species;
- Indirect impacts on mudflats and sandflats adjacent to the PDA that are recognised as important feeding habitat for migratory shorebirds, including known and likely feeding habitat for three critically endangered, two endangered and one vulnerable species; indirect impacts relate to reduced food availability for migratory shorebirds in intertidal mudflats and sandflats adjacent to the PDA in the event that altered water quality or hydrodynamics affects benthic invertebrate abundance in intertidal mudflats and sandflats adjacent to the PDA;
- Increased disturbance to migratory shorebirds roosting at three important roost sites for migratory shorebirds located close to the Project, including roosts known to be used by three critically endangered and one vulnerable species (see further detail below); increased disturbance has potential to lead to a substantial reduction in the use of the roost sites by migratory shorebirds;
- Increased disturbance to migratory shorebirds feeding on intertidal mudflats and sandflats adjacent to the PDA in the event that the Project facilitates greater pedestrian access to these areas at low tide, particularly the areas to the east of the Cassim Island mangroves that might be attractive to recreational walkers with dogs;
- Loss of food trees used by several individuals of the vulnerable Koala in an urban area that is not recognised as ‘habitat critical to the survival of Koala’;
- Mortality of Koalas during clearing of Koala habitat trees prior to construction;
- Increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation; and
- Direct or indirect impacts on a small area of the vulnerable Temperate Coastal Saltmarsh threatened ecological community.

Potential direct impacts relate to the clearing of habitat or vegetation for infrastructure, the marina basin or reclamation. The loss of feeding important intertidal feeding habitat for migratory shorebirds, including for threatened species, may lead to a corresponding decrease in the number of migratory shorebirds using the Moreton Bay wetlands proportional to the loss of habitat if migratory shorebird populations in Moreton Bay were currently subject to density-dependent population regulation. However, since migratory shorebird populations using Moreton Bay have undergone substantial declines due to factors outside of Moreton Bay (discussed in detail in **Section 3.5**), the carrying capacity of the Moreton Bay wetlands for supporting migratory shorebirds is likely to be underutilised i.e. migratory shorebirds may not be currently subject to density-dependent population regulation due to the substantial loss of birds from the system. In this case, the loss of a relatively small area of intertidal feeding habitat (approximately 0.17% of the 23,000 ha of intertidal mudflat/sandflat in Moreton Bay) may not lead to a corresponding reduction in the number of migratory shorebirds using Moreton Bay.

Increased disturbance to migratory shorebirds roosting in the mangroves of the Cassim Island roost site may result from:

- presence of built infrastructure and human activities closer to the roost site than at present;
- increased noise, particularly during Project construction and pile driving;
- increased lighting of the roost site at night from Project lighting;
- general Project construction activities;
- increased use of the waters within and adjacent to the roost by kayakers at high tide in the event that the Project provides launching points for kayakers; and
- increased use of the waters within and adjacent to the roost by small recreational boats at high tide resulting from increased recreational boat traffic at Toondah Harbour.

Increased disturbance to migratory shorebirds roosting at the Nandeebie Claypan and Oyster Point roost sites may result from:

- increased pedestrian and cyclist traffic along the public walkway adjacent to the Nandeebie Claypan that increases the risk of people and dogs leaving the walkway to enter the roost site;
- increased recreational use of Oyster Point, where recreational activities already cause substantial disturbance to roosting shorebirds.

5.3 REVIEW OF DISTURBANCE IMPACTS ON SHOREBIRDS

This section reviews published knowledge of disturbance impacts on feeding and roosting shorebirds to inform mitigation and management measures.

5.3.1 Disturbance from recreational activities

During the approach of a disturbance agent, foraging and roosting shorebirds reduce their foraging or resting activity to become more vigilant and will typically begin to walk away from the approach. If the approach continues, the birds will eventually take flight to a new location. Disturbance causes birds to spend energy flying away and to lose feeding time while relocating to different feeding areas, where the increased bird densities may intensify competition from interference and, if of sufficient duration, from prey depletion (Goss-Custard et al. 2006). There is little published information on critical thresholds of disturbance. In France, modelling shows that foraging oystercatcher *Haematopus ostralegus* experience reduced survival and breeding success if they are put to flight more than 1.0-1.5 times per hour in winters with good feeding conditions, or more than 0.2-0.5 times per hour when feeding conditions are poor (Goss-Custard et al. 2006). At Roebuck Bay in Western Australia, Great Knot spent an average of 30 minutes per high tide in alarm flights from disturbance by raptors and humans at the most disturbed roost site, yet still preferred to use this site than an alternative site 25 km away (Rogers et al. 2006c). At the most disturbed roost site in Moreton Bay, Brisbane, up to 400 shorebirds continued to use the roost during spring high tides despite a median number of flights per hour of 0.7, with a total time in flight of less than 5 min (Milton et al. 2011).

Birds taking flight are the most obvious result of disturbance, and different shorebird species have different sensitivities, taking flight at different distances from disturbance agents. Flight initiation distances in response to a variety of disturbance agents are summarised in **Table 5.1**.

Table 5.1 Average flight initiation distance (FID) (and minimum-maximum range) of a variety of migratory shorebird species in response to various disturbance agents, summarised from studies in Australia and elsewhere in the world.

Species	Agent	Bird activity	FID avg (m)	FID range (m)	Ref.*
Australian studies					
Eastern Curlew *Numenius madagascariensis*	Walker	Mixed	126	81-196	1
Whimbrel *N. phaeopus*	Walker	Mixed	90		1
Pacific Golden Plover *Pluvialis dominica*	Walker	Mixed	49	40-60	1
Grey Plover *P. squatarola*	Walker	Mixed	44		1
Latham's Snipe *Gallinago harwickii*	Walker	Mixed	19	9-45	1
Black-tailed Godwit *Limosa limosa*	Walker	Mixed	31	27-35	1
Bar-tailed Godwit *L. lapponica*	Walker	Mixed	60	45-69	1
	Walker	Foraging		18-38	2
Common Sandpiper *Tringa hypoleucos*	Walker	Mixed	43		1
Grey-tailed Tattler *T. brevipes*	Walker	Mixed	23		1
Common Greenshank *T. nebularia*	Walker	Mixed	55	25-145	1
Marsh Sandpiper *T. stagnatilis*	Walker	Mixed	44	20-99	1
Ruddy Turnstone *Arenaria interpres*	Walker	Mixed	30	17-54	1
Sanderling *Caldris alba*	Walker	Mixed	32	22-39	1
Red-necked Stint *C. ruficollis*	Walker	Mixed	19	9-41	1
Pectoral Sandpiper *C. melanotos*	Walker	Mixed	23	16-30	1
Sharp-tailed Sandpiper *C. acuminata*	Walker	Mixed	20	4-44	1
Curlew Sandpiper *C. ferruginea*	Walker	Mixed	25	14-35	1
Shorebirds and terns	Plane	Roosting	170		8
	Boat	Roosting	75		8
	Walker	Roosting	25		8
	Dog	Roosting	30		8
Studies elsewhere					
Eurasian Curlew *N. arquata*	Walker	Foraging		102-196	3
	Walker	Foraging	211	124-299	4
	Walker	Foraging	339	225-550	5
	Walker	Foraging	102-196		3
	Walker	Foraging	88	33-186	9
	Walker	Roosting	213		6
	Helicopter	Roosting	200		6
	Car	Roosting	188		6
	Kayak	Roosting	230		7
	Wind-surfer	Roosting	400		7
Bar-tailed Godwit *L. lapponica*	Walker	Foraging	107	88-127	4
	Walker	Foraging	219	150-225	5
	Walker	Foraging	101-138		3
	Walker	Foraging	45	25-83	9
	Kayak	Roosting	210		7
	Wind-surfer	Roosting	240		7
Grey Plover *P. squatarola*	Walker	Foraging	124	106-142	4
	Walker	Foraging	64	31-85	9
Ruddy Turnstone *Arenaria interpres*	Walker	Foraging	47	31-53	4

Species	Agent	Bird activity	FID avg (m)	FID range (m)	Ref.*
	Walker	Foraging	25	3-87	9

* References: (1) Glover *et al*. 2011; (2) Blumstein *et al*. 2003; (3) Glimmerveen and Went 1984 in Smit and Visser 1993; (4) van der Meer in Smit and Visser 1993; (5) Wolff *et al*. 1982 in Smit and Visser 1993; (6) Blankestijn *et al*. 1986 in Smit and Visser 1993; (7) Koepff and Dietrich 1986 in Smit and Visser 1993; (8) Milton *et al*. 2011; (9) Collop *et al*. 2016.
[1] No significant difference in FID between species.

Larger species such as Eastern Curlew and Whimbrel tend to be more 'flighty', meaning they are more sensitive to disturbance and tend to take flight at greater distances from disturbance agents than most other shorebirds (Smit and Visser 1993, Glover et al. 2011). Joggers and walkers with a leashed dog are more disturbing than a walker alone (Lafferty 2001, Glover et al. 2011), and unleashed dogs are substantially more disturbing (Pfister and Harrington 1992, Kyne 2010, Stigner et al. 2016).

Other more disturbing sources of disturbance are watercraft, particularly jet-skis (Smit and Visser 1993, Collins et al. 2000, Rodgers and Schwikert 2003). Jet-skis are more disturbing that most other watercraft because of their generally faster travelling speeds and sharp turning abilities. At an important shorebird stopover and winter refuge in the southern United States, Red Knots avoided roosts that had high average recreational boat activity within 1,000 m and dowitchers, *Limnodromus griseus* and *L. scolopaceus*, avoided prospective roosts when boat activity within 100 m was high, but disturbance did not appear to be a factor in roost site selection for other species (Peters and Otis 2006).

Shorebird responses to disturbance often depend on the context in which the disturbance takes place. Individuals in larger flocks tend to be more sensitive to disturbance, particularly when they are in large, mixed species flocks, such as occurs at shorebird roosting sites (Rogers *et al*. 2006b, Glover *et al*. 2011). The relationship between flock size and disturbance does not appear to be linear; rather, disturbance levels climbed abruptly if bird numbers exceeded 50-100 (Rogers *et al*. 2006b). Therefore, flight initiation distances for individual species may be larger than those reported in **Table 5.1** when these species are roosting in large, mixed-species flocks.

Shorebirds living in environments that are heavily used by humans and exposed to repetitive, non-lethal disturbance stimuli experience energetic costs associated with their responses to disturbance (West *et al*. 2002, Goss-Custard *et al*. 2006). To reduce these costs, shorebirds are expected to habituate to repetitive stimuli that do not present a direct mortality risk (Deniz *et al*. 2003). Many studies have demonstrated the ability of many shorebird species to habituate to many forms of repetitive disturbance (Smit and Visser 1993, West *et al*. 2002, Baudains and Lloyd 2007), although the process of habituation may require lengthy exposure to repetitive disturbance stimuli (Komenda-Zehnder *et al*. 2003).

5.3.2 Disturbance from noise

Seabirds exhibit alert behaviours to most levels of noise exposure, but begin to take flight in response to noise exposure levels greater than 85 dBA (Brown 1990), consistent with observations that sound levels of 43-87 dBA have limited effects on foraging shorebirds, but sound levels of 84-100 dBA cause most shorebirds in an habituated population to leave the area of disturbance (Smit and Visser 1993). Disturbance reactions are generally stronger when disturbing sounds are combined with visual disturbance (Smit and Visser 1993). Also, intermittent bursts of noise are generally more disturbing than continuous noise; birds are expected to habituate more readily to the latter (Smit and Visser 1993).

5.3.3 Disturbance from lighting

At Roebuck Bay in Western Australia, shorebirds avoid roosting at sites where they are exposed to artificial lighting such as streetlights or traffic; possibly such lighting makes roosting shorebirds too easily detected by predators (Rogers *et al*. 2006c).

5.4 POTENTIAL IMPACTS ON MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

The potential impacts of the Project on matters of state environmental significance include the following:

- direct impact on small areas of remnant regional ecosystems listed as having least concern status under the VM Act;
- loss of food trees used by several individuals of the vulnerable Koala in an urban area, including non-juvenile Koala habitat trees within areas mapped as medium value rehabilitation under the SPRP;
- mortality of Koalas during clearing of Koala habitat trees prior to construction;
- increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation;
- direct and indirect impacts on High ecological significance (HES) wetlands on the Map of Referable Wetlands; and
- direct and indirect impacts on wildlife habitat for threatened and special least concern fauna species.

6.0 POTENTIAL IMPACT MITIGATION AND MANAGEMENT MEASURES

This section outlines a variety of measures that could be implemented to mitigate and manage the potential impacts of the Project on terrestrial ecology matters.

6.1 MEASURES TO MITIGATE POTENTIAL IMPACTS ON MIGRATORY SHOREBIRDS

The direct impact of the Project on loss of feeding habitat for migratory shorebirds can be mitigated by minimising the area of intertidal feeding habitat in the development footprint of the Project design.

Potential impacts of disturbance on migratory shorebirds can be mitigated through the implementation of the following measures recommended by the referral guidelines (Commonwealth of Australia 2015a):

- buffer zones around important areas for migratory shorebirds, particularly important roost sites; ideally there should be no Project activities or public access within the buffer zones;
- construction of appropriate barriers, such as fences around important habitat to restrict access; ideally, there should be no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds;
- landscape and urban design to include sympathetic lighting strategies, vegetation screening and sound attenuation; and
- increased community education through mechanisms such as interpretive signs at access points to shorebird habitats.

6.1.1 Potential impact mitigation for the Cassim Island shorebird roost site

The implementation of a buffer zone around the Cassim Island shorebird roost site will likely be critical to mitigating potential impacts on this important roost site. Based on the information presented in **Section 5.3**, a minimum buffer of approximately 100 m from the outer edge of the roost site boundary would likely be necessary to keep disturbance to roosting Whimbrel to a minimum. Should the outer boundary of the Project footprint extent to the eastern boundary of the PDA, which approaches to within 30 m of the western boundary of the roost site, it is likely that most species would cease roosting along the western edge of the mangroves where most roosting birds were concentrated during the surveys. The displaced birds may then move to other areas of the roost site, including areas more distant from the PDA boundary that they were recorded using during the surveys; these alternative roosting areas would be effectively screened from the Project infrastructure by the western band of mangrove trees. Landscape and urban design along the eastern boundary of the Project opposite the mangroves of the roost site should include sympathetic lighting strategies (to reduce light spill to mangroves and intertidal mudflats), vegetation screening (to minimise visual disturbance) and sound attenuation.

In the event that the Project provides launch points for kayakers, implementation of a buffer exclusion zone, with no public access within 100 m of any of the mangroves of the roost site, would be critical for mitigating disturbance to roosting shorebirds. Effective implementation of such a buffer exclusion zone would require interpretative signage specific to the Cassim Island roost site to be placed at shoreline entry points as well as sufficient resources to regularly enforce the exclusion zone over the long term.

The impact of disturbance from general Project construction activities, particularly activities such as dredging and pile driving, can be mitigated by timing these activities to occur over the winter months May to August when most migratory shorebirds are absent from Moreton Bay.

6.1.2 Potential impact mitigation for the Nandeebie Claypan roost site

The maintenance of tall mangrove vegetation between the north-western edge of the roost site and the Project footprint would assist with screening the roost site from Project infrastructure and construction and operational activities. Construction of a relatively low barrier fence and vegetation screening along the boundary of the public walkway adjoining the Nandeebie Claypan roost site, together with site-specific information signs erected along the barrier fence would help minimise the risk of public and dog access to the Nandeebie Claypan roost site. The suitability of the Nandeebie Claypan roost site for migratory shorebirds could be enhanced though control of mangroves that are slowly encroaching on the roost site, particularly along the eastern boundary of the roost site.

6.1.3 Potential impact mitigation for intertidal mudflat feeding habitats

Public use of the intertidal mudflats within and adjacent to the Toondah Harbour PDA area is currently inhibited by the soft, muddy substrates and loose surface coral rubble that makes walking through these areas unpleasant. This may change in the event that the Project creates sandy beaches on the shoreline perimeter of the Project footprint or permits easier public access to portions of sandflat with a more open, sandy substrate in the vicinity of Cassim Island. This potential impact can be mitigated by adopting a landscape design that minimises the accessibility to the public of areas of sandflat adjacent to the Project.

6.2 MEASURES TO MITIGATE POTENTIAL IMPACTS ON KOALAS

The potential impacts of the Project on Koalas that currently utilise feed trees within the PDA can be mitigated by:

- adopting a landscape and urban design that retains as many of the primary food trees as possible;
- adopting a landscape and urban design that includes a linear strip of public open space to serve as a corridor connecting retained Koala food trees with bushland habitat in Nandeebie Park to the south of the PDA;
- planting additional primary Koala food trees both within the PDA and surrounding areas where possible, to mitigate the likely loss of some Koala food trees within the PDA, noting that it will take years for the plantings to reach a size that they begin to provide food for Koalas;
- including traffic calming designs for roads crossing the open space corridor, and implementing a maximum speed limit of 40 km/hr;
- ensuring that the clearing of any trees during Project construction is performed under the guidance of a licenced fauna spotter; and
- using Koala exclusion fencing to fence off areas that may pose a risk of injury to Koala during construction e.g. deep pits that Koala may fall into.

7.0 REFERENCES

BAAM and frc environmental (2014). Expert advice in ecology (marine and terrestrial) and coastal processes for input to the preparation of a structure plan and development scheme for Toondah Harbour and Weinam Creek Priority Development Areas. Report prepared for Redland City Council.

BAAM (2014). Migratory shorebird assessment, Toondah Harbour and Weinam Creek Priority Development Areas. Report prepared for Walker Corporation.

BAAM (2015). Toondah Harbour and Weinam Creek Priority Development Area migratory shorebird survey results. Technical memorandum prepared for Walker Corporation.

Baker, AJ, González, PM, Piersma, T, Niles, LJ, de Lima Serrano do Nascimento, I, Atkinson, PW, Clark, NA, Minton, CDT, Peck, MK and Aarts, G. (2004). Rapid population decline in red knots: fitness consequences of decreased refuelling rates and late arrival in Delaware Bay. *Proceedings of Royal Society of London B* 271: 875–882.

Baker, M. C. (1979). Morphological correlates of habitat selection in a community of shorebirds (Charadriformes). *Oikos* 33: 121-126.

Bamford, M. J., D. G. Watkins, W. Bancroft, and G. Tischler (2008). Migratory shorebirds of the East Asian-Australasian Flyway; Population Estimates and important Sites. Wetlands International, Oceania.

Barbosa, A., & Moreno, E. (1999). Evolution of foraging strategies in shorebirds: an ecomorphological approach. *The Auk* 712-725.

Baudains, TP and Lloyd, P (2007). Habituation and habitat changes can moderate the impacts of human disturbance on shorebird breeding performance. *Animal Conservation* 10: 400-407.

Birt, P, Markus, N, Collins, L and Hall, L (1998). Urban flying-foxes. *Nature Australia* 26: 54-59.

Blackman, J.G. and Craven, S.A. (1999). Moreton Bay. Pp. 329-332 in Characteristics of important wetlands in Queensland (Eds J.G. Blackman, T.W. Perry, G.I. Ford, S.A. Craven, S.J. Gardiner and R.J. De Lai). Environmental Protection Agency, Queensland.

Blumstein, DT, Anthony, LL, Harcourt, R and Ross, G (2003). Testing a key assumption of wildlife buffer zones: is flight initiation distance a species-specific trait? *Biological Conservation* 110: 97–100.

Brown, A.L. (1990). Measuring the effect of aircraft noise on sea birds. *Environment International* 16: 587–592.

Churchill, S (2008). *Australian bats.* 2nd edn. Allen & Unwin, Crows Nest.

Clemens, R. S., Rogers, D. I., Hansen, B. D., *et al.* (2016). Continental-scale decreases in shorebird populations in Australia. *Emu* 116: 119-135.

Close, D. and Newman, O.M.G. (1984). The decline of the Eastern Curlew in south-eastern Australia. *Emu* 84: 38-40.

Coleman, J. T. and Milton, D. A. (2012). Feeding and roost site fidelity of two migratory shorebirds in Moreton Bay, South-Eastern Queensland, Australia. *The Sunbird* 42: 41-51.

Collins, P, Jessop, R. Weston M A and Taylor. S (2000). Review of impacts on waterbirds and their habitat from jet-skis and hovercraft. Biodiversity Group, Environment Australia.

Collop, C., Stillman, R. A., Garbutt, A., Yates, M. G., Rispin, E., and Yates, T. (2016). Variability in the area, energy and time costs of wintering waders responding to disturbance. *Ibis* 158: 711-725.

Colwell, M.A. (2010). Shorebird ecology, conservation and management. University of California Press, London.

Commonwealth of Australia (2009). EPBC Act Policy Statement 1.1 – Significant Impact Guidelines for Matters of National Environmental Significance. Commonwealth Department of the Environment, Water, Heritage and Arts, Canberra.

Commonwealth of Australia (2014). EPBC Act referral guidelines for the vulnerable koala (combined populations of Queensland, New South Wales and the Australian Capital Territory). Commonwealth Department of the Environment, Canberra.

Commonwealth of Australia (2015a). EPBC Act Policy Statement 3.21: Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species. Commonwealth Department of the Environment, Canberra.

Commonwealth of Australia (2015b). Referral guideline for 14 birds listed as migratory species under the EPBC Act. Commonwealth Department of the Environment, Canberra.

Commonwealth of Australia (2017). Species Profile and Threats Database. Commonwealth Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Crowther, M.S., McAlpine, C.A., Lunney, D., Shannon, I. and Bryant, J.V. (2009). Using broad-scale, community survey data to compare species conservation strategies across regions: a case study of the koala in a set of adjacent catchments. *Ecological Management and Restoration* 10 (Suppl. S1), S88–S96.

Curtis, LK, Dennis, AJ, McDonald, KR, Kyne, PM, Debus, SJS (2012). *Queensland's Threatened Animals*. CSIRO Publishing, Victoria.

Deniz, O, Lorenzo, J and Hernandez, M (2003). A computational mechanism for habituation in perceptual user interfaces. In CIMCA 2003 Proceedings: 846–856. Mohammadian, M. (Ed.). Vienna.

DERM (2012). Koala Coast Koala Population Report 2010. Queensland Department of Environment and Resource Management.

Dique, DS, de Villiers, DL and Preece, HJ (2003a). Evaluation of line-transect sampling for estimating koala abundance. *Wildlife Research* 30: 127-133.

Dique, DS, Thompson, J, Preece, HJ, de Villiers, DL and Carrick, FN (2003b). Dispersal patterns in a regional koala population in south-east Queensland. *Wildlife Research* 30: 281-290.

Dique, DS, Preece, HJ, Thompson, J and Villiers DL (2004). Determining the distribution of a regional koala population in south-east Queensland for conservation management. *Wildlife Research* 31: 109-117.

Donaldson, G.M., Hyslop, C., Morrison, R.I.G., Dickson, H.L. and Davidson, I. (2000). Canadian shorebird conservation plan. Canadian Wildlife Service, Ottowa, Canada.

Driscoll, P.V. (1997). The distribution of waders along the Queensland coastline. Pp 80-122 *in* Shorebird conservation in the Asia-Pacific Region (Ed. P. Straw). Australasian Wader Studies Group of Birds Australia, Melbourne.

Driscoll, P. V., Geering, A., Gynther, I., Harding, S., and Stewart, D. (1993). Monitoring of migratory waders in the Moreton Bay region. Queensland Department of Environment and Heritage, Brisbane.

Duncan, A, Barker, GB and Montgomery, N (1999). *The action plan for Australian bats*. Environment Australia, Canberra.

Durell, S. (2000). Individual feeding specialisation in shorebirds: population consequences and conservation implications. *Biological Reviews* 75: 503-518.

Eby, P. (1991). Seasonal movements of grey-headed flying-foxes, *Pteropus poliocephalus* (Chiroptera: Pteropodidae), from two maternity camps in northern New South Wales. *Wildlife Research* 18: 547-559.

Finn, P. G. (2010). Habitat selection, foraging ecology and conservation of Eastern Curlews on their non-breeding grounds. PhD thesis, Griffith University.

Finn, P. G., Catterall, C. P. and Driscoll, P. V. (2001). The low tide distribution of Eastern Curlew on feeding grounds in Moreton Bay, Queensland. *Stilt* 38: 9-17.

Finn, P. G., Catterall, C. P. and Driscoll, P. V. (2007). Determinants of preferred intertidal feeding habitat for Eastern Curlew: A study at two spatial scales. *Austral Ecology* 32: 131-144.

Finn, P. G., Catterall, C. P. and Driscoll, P. V. (2008). Prey versus substrate as determinants of habitat choice in a feeding shorebird. *Estuarine, Coastal and Shelf Science* 80: 381-390.

Geering, A, Agnew, L and Harding, S (2007). *Shorebirds of Australia*. CSIRO Publishing, Collingwood.

Gill J.A., Norris, K., Potts, P.M., Gunnarsson, T.G., Atkinson, P.W. and Sutherland, W.J. (2001). The buffer effect and large-scale population regulation in migratory birds. *Nature* 412: 436–438.

Glover, HK, Weston, MA, Maguire, GS, Miller, KK and Christie, BA (2011). Towards ecologically meaningful and socially acceptable buffers: response distances of shorebirds in Victoria, Australia, to human disturbance. Landscape and Urban Planning 103: 326–334.

Goss-Custard, JD, Triplet, P, Sueur, F and West, AD (2006). Critical thresholds of disturbance by people and raptors in foraging wading birds. Biological Conservation 127: 88-97.

Hariono, B., Ng, J. and Sutton, R.H. (1993). Lead concentrations in tissues of fruit bats (*Pteropus* sp.) in urban and non-urban areas. *Wildlife Research*, 20: 315-320.

Hasegawa, M. (1995). Habitat utilisation by koalas (*Phascolarctos cinereus*) at Point Halloran, Queensland. M.Sc. Thesis, University of Queensland, Brisbane.

Hume, I.D., and Esson, C. (1993). Nutrients, antinutrients and leaf selection by captive koalas (*Phascolarctos cinereus*). *Australian Journal of Zoology* 41: 379–392.

Komenda-Zehnder, S., Cevallos, M. and Bruderer, B. (2003). Effects of disturbance by aircraft overflight on waterbirds: an experimental approach. Report for the International Bird Strike Committee. http://www.int-birdstrike.org/Warsaw_Papers/IBSC26%20WPLE2.pdf

Kyne, P.M. (2010). A small coastal high-tide roost on North Stradbroke Island, south-eastern Queensland: diversity, seasonality and disturbance of birds. *Australian Field Ornithology* 27: 94-108.

Lafferty, K.D. (2001). Disturbance to wintering western snowy plovers. *Biological Conservation* 101: 315-325.

Lee, K.E., Seddon, J.M., Corley, S., Ellis, W.A.H., Johnston, S.D., de Villiers, D.L., Preece, H.J. and Carrick, F.N. (2010). Genetic variation and structuring in the threatened koala populations of Southeast Queensland reveals a genetically distinct population in the Koala Coast. *Conservation Genetics* 11: 2091-2103.

Lifjeld, J. T. (1984). Prey selection in relation to body size and bill length of five species of waders feeding in the same habitat. *Ornis Scandinavica* 15: 217-226.

Low, T (1995). The animals of Brisbane: A vertebrate status review. Unpublished report prepared for Brisbane City Council.

MacKinnon, J., Verkuil, Y.I. and Murray, N. (2012). IUCN situation analysis on East and Southeast Asian intertidal habitats, with particular reference to the Yellow Sea (including the Bohai Sea). Occasional Paper of the IUCN Species Survival Commission No. 47. IUCN, Gland, Switzerland and Cambridge, UK.

Martin, RW, Handasyde, KA and Krockenberger (2008). Koala. In: S Van Dyck and R Strahan (eds.), The mammals of Australia, 3rd edn. Reed New Holland: Sydney. pp.198–201.

Maxwell, S, Burbidge, AA and Morris, K (1996). *The action plan for Australian marsupials and monotremes.* Wildlife Australia, Canberra.

McApline, C.A., Rhodes, J.R., Peterson, A., Possingham, H.P., Callaghan, J.G., Curran, T., Mitchell, M.E. and Lunney, D. (2007). Planning guidelines for koala conservation and recovery: A guide to best planning practice.

Melville, D. S., Chen, Y., and Ma, Z. (2016). Shorebirds along the Yellow Sea coast of China face an uncertain future - a review of threats. *Emu* 116: 100-110.

Milton, DA, Beck, D, Campbell, V and Harding, SB (2011). Monitoring disturbance of shorebirds and seabirds at Buckley's Hole sandspit in northern Moreton Bay. *The Sunbird* 41: 13-33.

Moore, BD and Foley, WJ (2000). A review of feeding and diet selection in koalas (*Phascolarctos cinereus*). *Australian Journal of Zoology* 48: 317-333.

Moore, B.D., Wallis, I.R., Wood, J.T. and Foley, W.J. (2004). Foliar nutrition, site quality, and temperature influence foliar chemistry of tallowwood (*Eucalyptus microcorys*). *Ecological Monographs* 74: 553–568.

Moores, N., Rogers, D. I., Rogers, K., and Hansbro, P. M. (2016). Reclamation of tidal flats and shorebird declines in Saemangeum and elsewhere in the Republic of Korea. *Emu* 116: 136-146.

Murray, M.J., Clemens, R.S., Phinn, S.R., Possingham, H.P. and Fuller, R.A. (2014). Tracking the rapid loss of tidal wetlands in the Yellow Sea. *Frontiers in Ecology and the Environment* 12: 267–272.

Nebel, S, Porter, JL and Kingsford, RT (2008). Long-term trends of shorebird populations in eastern Australia and impacts of freshwater extraction. *Biological Conservation* 141: 971-980.

Nelson, JE (1965). Movements of Australian flying foxes (Pteropodidae: Megachiroptera). *Australian Journal of Zoology* 13: 53-73.

Pahl, LI, and Hume, ID (1990). Preferences for *Eucalyptus* species of the New England Tablelands and initial development of an artificial diet for Koalas. In: AK Lee, KA Handasyde and GD Sanson (eds.), Biology of the Koala. Surrey Beatty and Sons, Sydney. pp. 123–128.

Peters, KA and Otis, DL (2006). Shorebird roost-site selection at two temporal scales: is human disturbance a factor? *Journal of Applied Ecology* 44: 196-209.

Pfister, C and Harrington, BA (1992). The impact of human disturbance on shorebirds at a migration staging area. *Biological Conservation* 60: 115-126.

Pierce, R. (1999). Regional patterns of migration in the Banded Dotterel (*Charadrius bicinctus bicinctus*). *Notornis* 46:101-122.

Piersma, T., and Baker, A. J. (2000). Life history characteristics and the conservation of migratory shorebirds. *Conservation Biology Series-Cambridge* 2000: 105-124.

Piersma, T., Lok, T., Chen, Y., Hassell, C. J., Yang, H. Y., Boyle, A., ... & Ma, Z. (2016). Simultaneous declines in summer survival of three shorebird species signals a flyway at risk. *Journal of Applied Ecology* 53: 479-490.

Preece, H.J. (2007). Identifying hotspots for threats to koalas using spatial analysis. Pp. 1294-1300 *in* Proceedings of the MODSIM 2007 international congress on modelling and simulation, Modelling and Simulation Society of Australia and New Zealand.

Queensland Government (2015). South East Queensland Koala Conservation State Planning Regulatory Provisions. November 2015.

Rhodes, JR, Ng, CF, de Villiers, DL, Preece, HJ, McAlpine, CA and Possingham, HP (2011). Using integrated population modelling to quantify the implications of multiple threatening processes for a rapidly declining population. *Biological Conservation* 144: 1081-1088.

Roberts, BJ, Caterall, CP, Kanowski, J and Eby, P (2008). A re-evaluation of the northern distributional limit of the grey-headed flying-fox, *Pteropus poliocephalus. Australian Bat Society News* 31: 16-19.

Rodgers Jr, JA and Schwikert. ST (2003). Buffer zone distances to protect foraging and loafing waterbirds from disturbance by airboats in Florida. *Waterbirds* 26: 437–443.

Rogers, D.I. (2003). High-tide roost choice by coastal waders. *Wader Study Group Bulletin* 100: 73-79.

Rogers, D.I., Battley, PF, Piersma, T, van Gils, JA and Rogers KG (2006a). High-tide habitat choice: insights from modelling roost selection by shorebirds around a tropical bay. *Animal Behaviour* 72: 563-575.

Rogers, D.I., Hassell, C. and Lewis, J. (2006b). Shorebird disturbance on the beaches of Roebuck Bay, 2005-2006: Conservation implications and recommendations. A report by Broome Bird Observatory for the WA Department of Conservation and Land Management, NHT and the Shorebird Conservation Project / WWF-Australia.

Rogers, D.I., Piersma, T. and Hassell, C. (2006c). Roost availability may constrain shorebird distribution: Exploring the energetic costs of roosting and disturbance around a tropical bay. *Biological Conservation* 133: 225-235.

Smit, CJ and Visser, GJ (1993). Effects of disturbance on shorebirds: a summary of existing knowledge from the Dutch Wadden Sea and Delta area. *Wader Study Group Bulletin* 68: 6-19.

Stigner, M. G., Beyer, H. L., Klein, C. J., and Fuller, R. A. (2016). Reconciling recreational use and conservation values in a coastal protected area. *Journal of Applied Ecology* 53: 1206-1214.

Threatened Species Scientific Committee (TSSC) (2011). Assessment of the sensitivity of estimates of the trend in the national koala population to uncertainty in estimates of the populations at state level. Threatened Species Scientific Committee.

Threatened Species Scientific Committee (TSSC) (2015). Approved Conservation Advice for *Numenius madagascariensis* (Eastern Curlew). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/847-conservation-advice.pdf. In effect under the EPBC Act from 26-May-2015.

Threatened Species Scientific Committee (TSSC) (2016a). Approved Conservation Advice for *Calidris tenuirostris* (Great Knot). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/862-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Threatened Species Scientific Committee (2016b). Approved Conservation Advice for *Limosa lapponica baueri* (Bar-tailed godwit (western Alaskan)). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/86380-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Threatened Species Scientific Committee (2016c). Approved Conservation Advice for *Calidris canutus* Red knot. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/855-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Threatened Species Scientific Committee (2016d). Approved Conservation Advice for Charadrius mongolus (*Lesser sand plover*). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/879-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Threatened Species Scientific Committee (2016e). *Approved Conservation Advice for* Charadrius leschenaultii *(Greater sand plover)*. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/877-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Tulp, I. and Goeij, P. D. (1994). Evaluating wader habitats in Roebuck Bay (north-western Australia) as a springboard for northbound migration in waders, with a focus on Great Knots. *Emu* 94: 78-95.

Tun, UN (1993). Re-establishment of rehabilitated koalas in the wild and their use of habitat in Sheldon, Redland Shire, southeast Queensland with particular reference to dietary selection. M.Sc. Thesis, University of Queensland, Brisbane.

Watkins, D. (1993). A national plan for wader conservation in Australia. RAOU Report No. 90. Australasian Wader Studies Group, Royal Australasian Ornithologists Union and World Wide Fund for Nature, Melbourne.

West, AD, Goss-Custard, JD, Stillman, RA, Caldow, RWG., Durell, SEA and McGrorty, S (2002). Predicting the impacts of disturbance on shorebird mortality using a behaviour-based model. *Biological Conservation* 106: 319–328.

Wetlands International (2006). Waterbird population estimates, Fourth Edition. Wetlands International, Wageningen, The Netherlands.

Wilson, HB, Kendall, BE, Fuller, RA, Milton, DA and Possingham, HP (2011). Analyzing variability and the rate of decline of migratory shorebirds in Moreton Bay, Australia. *Conservation Biology* 25: 758-766.

Woodward, W, Ellis, WA, Carrick, FN, Tanizaki, M, Bowen, D and Smith, P (2008). Koalas on North Stradbroke Island: diet, tree use and reconstructed landscapes. *Wildlife Research* 35: 606–611.

Yang, H. Y., Chen, B., Barter, M., Piersma, T., Zhou, C. F., Li, F. S., & Zhang, Z. W. (2011). Impacts of tidal land reclamation in Bohai Bay, China: ongoing losses of critical Yellow Sea waterbird staging and wintering sites. *Bird Conservation International* 21: 241-259.

Zhang, X., Hua, N., Ma, Q., Xue, W. J., Feng, X. S., Wu, W., ... and Ma, Z. J. (2011). Diet of great knots (*Calidris tenuirostris*) during spring stopover at Chongming Dongtan, China. *Chinese Birds* 2: 27-32.

Zharikov, Y. and Skilleter, G. A. (2003). Depletion of benthic invertebrates by bar-tailed godwits *Limosa lapponica* in a subtropical estuary. *Marine Ecology Progress Series* 254: 151-162.

APPENDIX 2

Queensland Government database search results

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: All
Records: All
Date: Since 1980
Latitude: -27.528
Longitude: 153.2843
Distance: 1
Email: penn@baamecology.com
Date submitted: Thursday 09 Mar 2017 15:41:18
Date extracted: Thursday 09 Mar 2017 15:50:02

The number of records retrieved = 144

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

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Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Acanthizidae	*Gerygone levigaster*	mangrove gerygone		C		6
animals	birds	Accipitridae	*Elanus axillaris*	black-shouldered kite		C		1
animals	birds	Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle		C		8
animals	birds	Accipitridae	*Pandion cristatus*	eastern osprey		SL		10
animals	birds	Accipitridae	*Aviceda subcristata*	Pacific baza		C		4
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		1
animals	birds	Accipitridae	*Lophoictinia isura*	square-tailed kite		C		1
animals	birds	Accipitridae	*Haliastur indus*	brahminy kite		C		39
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		15
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		1
animals	birds	Anatidae	*Cygnus atratus*	black swan		C		11
animals	birds	Anatidae	*Anas castanea*	chestnut teal		C		10
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		2
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		12
animals	birds	Anseranatidae	*Anseranas semipalmata*	magpie goose		C		1
animals	birds	Ardeidae	*Ardea alba modesta*	eastern great egret		C		66
animals	birds	Ardeidae	*Egretta sacra*	eastern reef egret		C		8
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		23
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		124
animals	birds	Ardeidae	*Nycticorax caledonicus*	nankeen night-heron		C		1
animals	birds	Ardeidae	*Butorides striata*	striated heron		C		13
animals	birds	Ardeidae	*Egretta garzetta*	little egret		C		47
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		3
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		1
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		6
animals	birds	Burhinidae	*Esacus magnirostris*	beach stone-curlew		V		1
animals	birds	Burhinidae	*Burhinus grallarius*	bush stone-curlew		C		6
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		1
animals	birds	Cacatuidae	*Eolophus roseicapilla*	galah		C		1
animals	birds	Cacatuidae	*Calyptorhynchus lathami lathami*	glossy black-cockatoo (eastern)		V		2
animals	birds	Campephagidae	*Coracina tenuirostris*	cicadabird		C		1
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		3
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		100
animals	birds	Charadriidae	*Vanellus miles novaehollandiae*	masked lapwing (southern subspecies)		C		7
animals	birds	Charadriidae	*Charadrius leschenaultii*	greater sand plover		SL	V	2
animals	birds	Charadriidae	*Charadrius ruficapillus*	red-capped plover		C		8
animals	birds	Charadriidae	*Erythrogonys cinctus*	red-kneed dotterel		C		1
animals	birds	Charadriidae	*Charadrius bicinctus*	double-banded plover		SL		6
animals	birds	Charadriidae	*Charadrius mongolus*	lesser sand plover		SL	E	8
animals	birds	Charadriidae	*Pluvialis fulva*	Pacific golden plover		SL		4
animals	birds	Cisticolidae	*Cisticola exilis*	golden-headed cisticola		C		2
animals	birds	Columbidae	*Streptopelia chinensis*	spotted dove	Y			4
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		1
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		2
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		2
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		7
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		5
animals	birds	Falconidae	*Falco peregrinus*	peregrine falcon		C		2
animals	birds	Falconidae	*Falco longipennis*	Australian hobby		C		1
animals	birds	Falconidae	*Falco cenchroides*	nankeen kestrel		C		1
animals	birds	Haematopodidae	*Haematopus longirostris*	Australian pied oystercatcher		C		131
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		2
animals	birds	Halcyonidae	*Todiramphus sordidus*	Torresian kingfisher		C		3
animals	birds	Halcyonidae	*Dacelo novaeguineae*	laughing kookaburra		C		1
animals	birds	Halcyonidae	*Todiramphus macleayii*	forest kingfisher		C		1
animals	birds	Hirundinidae	*Petrochelidon ariel*	fairy martin		C		1
animals	birds	Hirundinidae	*Hirundo neoxena*	welcome swallow		C		6
animals	birds	Laridae	*Sterna hirundo*	common tern		SL		3
animals	birds	Laridae	*Larus dominicanus*	kelp gull		C		1
animals	birds	Laridae	*Thalasseus bergii*	crested tern		SL		14
animals	birds	Laridae	*Hydroprogne caspia*	Caspian tern		SL		88
animals	birds	Laridae	*Chroicocephalus novaehollandiae*	silver gull		C		60
animals	birds	Laridae	*Gelochelidon nilotica*	gull-billed tern		SL		78
animals	birds	Laridae	*Chlidonias leucopterus*	white-winged black tern		SL		1
animals	birds	Laridae	*Thalasseus bengalensis*	lesser crested tern		C		2
animals	birds	Laridae	*Sternula albifrons*	little tern		SL		5
animals	birds	Meliphagidae	*Melithreptus lunatus*	white-naped honeyeater		C		1
animals	birds	Meliphagidae	*Plectorhyncha lanceolata*	striped honeyeater		C		1
animals	birds	Meliphagidae	*Gavicalis fasciogularis*	mangrove honeyeater		C		15
animals	birds	Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater		C		1
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		9
animals	birds	Meliphagidae	*Manorina melanocephala*	noisy miner		C		7
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		4
animals	birds	Monarchidae	*Myiagra rubecula*	leaden flycatcher		C		2
animals	birds	Motacillidae	*Anthus novaeseelandiae*	Australasian pipit		C		2
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		3
animals	birds	Oriolidae	*Sphecotheres vieilloti*	Australasian figbird		C		1
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		1
animals	birds	Passeridae	*Passer domesticus*	house sparrow	Y			5
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		25
animals	birds	Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant		C		10
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		21
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		4
animals	birds	Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant		C		1
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		2
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		2
animals	birds	Psittacidae	*Platycercus adscitus*	pale-headed rosella		C		2
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		4
animals	birds	Psittacidae	*Platycercus eximius*	eastern rosella		C		1
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		110
animals	birds	Recurvirostridae	*Recurvirostra novaehollandiae*	red-necked avocet		C		3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		2
animals	birds	Scolopacidae	*Calidris alba*	sanderling		SL		1
animals	birds	Scolopacidae	*Calidris canutus*	red knot		SL	E	8
animals	birds	Scolopacidae	*Tringa nebularia*	common greenshank		SL		8
animals	birds	Scolopacidae	*Numenius phaeopus*	whimbrel		SL		159
animals	birds	Scolopacidae	*Actitis hypoleucos*	common sandpiper		SL		1
animals	birds	Scolopacidae	*Arenaria interpres*	ruddy turnstone		SL		16
animals	birds	Scolopacidae	*Calidris acuminata*	sharp-tailed sandpiper		SL		5
animals	birds	Scolopacidae	*Tringa stagnatilis*	marsh sandpiper		SL		1
animals	birds	Scolopacidae	*Calidris ferruginea*	curlew sandpiper		SL	CE	12
animals	birds	Scolopacidae	*Calidris ruficollis*	red-necked stint		SL		10
animals	birds	Scolopacidae	*Calidris tenuirostris*	great knot		SL	CE	33
animals	birds	Scolopacidae	*Limosa lapponica baueri*	Western Alaskan bar-tailed godwit		SL	V	219
animals	birds	Scolopacidae	*Numenius madagascariensis*	eastern curlew		V	CE	180
animals	birds	Scolopacidae	*Limosa limosa*	black-tailed godwit		SL		12
animals	birds	Scolopacidae	*Xenus cinereus*	terek sandpiper		SL		22
animals	birds	Scolopacidae	*Tringa brevipes*	grey-tailed tattler		SL		54
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		2
animals	birds	Sturnidae	*Acridotheres tristis*	common myna	Y			1
animals	birds	Sturnidae	*Sturnus vulgaris*	common starling	Y			3
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		139
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		4
animals	birds	Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill		C		1
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		19
animals	birds	Tytonidae	*Tyto delicatula*	eastern barn owl		C		2
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	420
animals	reptiles	Boidae	*Morelia spilota*	carpet python		C		2
animals	reptiles	Scincidae	*Lampropholis delicata*	dark-flecked garden sunskink		C		1
animals	uncertain	Indeterminate	*Indeterminate*	Unknown or Code Pending		C		7
fungi	club fungi	Basidiomycota	*Byssomerulius corium*			C		1/1
fungi	sac fungi	Ramalinaceae	*Ramalina confirmata*			C		1/1
plants	higher dicots	Brassicaceae	*Brassica x juncea*	Indian mustard	Y			1/1
plants	higher dicots	Rubiaceae	*Gynochthodes jasminoides*			C		1/1
protists	brown algae	Phaeophyceae	*Padina australis*			C		1/1
protists	brown algae	Phaeophyceae	*Bachelotia antillarum*			C		1/1
protists	brown algae	Phaeophyceae	*Lobophora variegata*			C		2/2
protists	brown algae	Phaeophyceae	*Sporochnus comosus*			C		1/1
protists	brown algae	Phaeophyceae	*Petalonia fascia*			C		1/1
protists	brown algae	Phaeophyceae	*Spatoglossum macrodontum*			C		1/1
protists	brown algae	Phaeophyceae	*Stypopodium flabelliforme*			C		1/1
protists	brown algae	Phaeophyceae	*Hydroclathrus clathratus*			C		1/1
protists	green algae	Chlorophyceae	*Cladophora*			C		1/1
protists	green algae	Chlorophyceae	*Chaetomorpha*			C		1/1
protists	red algae	Rhodophyceae	*Gracilaria verrucosa*			C		1/1
protists	red algae	Rhodophyceae	*Gracilaria foliifera*			C		1/1
protists	red algae	Rhodophyceae	*Gracilaria compressa*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
protists	red algae	Rhodophyceae	*Hypnea spinella*			C		1/ 1
protists	red algae	Rhodophyceae	*Tolypiocladia glomerulata*			C		1/ 1
protists	red algae	Rhodophyceae	*Herposiphonia*			C		1/ 1
protists	red algae	Rhodophyceae	*Laurencia*			C		1/ 1
protists	red algae	Rhodophyceae	*Gracilaria cylindrica*			C		1/ 1
protists	red algae	Rhodophyceae	*Dasya iyengarii*			C		1/ 1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Regulated Vegetation Management Map

Legend

- Lot and Plan
- Category A area (Vegetation offsets/compliance notices/VDecs)
- Category B area (Remnant vegetation)
- Category C area (High-value regrowth vegetation)
- Category R area (Reef regrowth watercourse vegetation)
- Category X area (Exempt on Freehold, Indigenous and Leasehold land)
- Water
- Area not categorised
- Cadastral line
- Property boundaries shown are provided as a locational aid only

LOCALITY DIAGRAM

N

0 200 400 600 800 1,000 m

This product is projected into:
GDA 1994 MGA Zone 56

Additional information required for the assessment of vegetation values is provided in the accompanying "Vegetation Management Supporting map". For further information go to the web site: www.dnrm.qld.gov.au or contact the Department of Natural Resources and Mines.

Digital data for the regulated vegetation management map is available from the Queensland Spatial Portal at http://www.information.qld.gov.au/

This map is updated on a monthly basis to ensure new PMAVs are included as they are approved.

Queensland Government

Vegetation Management Supporting Map

Legend

- Lot and Plan
- Category A or B area containing endangered regional ecosystems
- Category A or B area containing of concern regional ecosystems
- Category A or B area that is a least concern regional ecosystem
- Category A or B area containing remnant vegetation
- Category A or B area under Section 20AH
  These areas are edged in yellow and filled with the remnant RE Status
- Category C area containing endangered regional ecosystems
- Category C area containing of concern regional ecosystems
- Category C area that is a least concern regional ecosystem
- Category C area containing high value regrowth vegetation
- Category C area under Section 20AI
  These areas are edged in purple and filled with the remnant RE Status
- Non Remnant
- Water
- Wetland on the vegetation management wetlands map
- Essential habitat on the essential habitat map
- Essential habitat species record
- Watercourse on the vegetation management watercourse and drainage feature map (Stream order shown as black number against stream where available)
- Roads
- National Parks, State Forest and other reserves
- Cadastral line
  Property boundaries shown are provided as a locational aid only

Queensland Government

N

0 150 300 450 600 750 m

This product is projected into:
GDA 1994 MGA Zone 56

Labels for Essential Habitat are centred on the area of enquiry.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/- 100 metres.

Disclaimer:
While every care is taken to ensure the accuracy of this product, the Department of Natural Resources and Mines makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.

Additional information may be required for the purposes of land clearing or assessment of a regional ecosystem map or PMAV applications. For further information go to the web site: www.dnrm.qld.gov.au or contact the Department of Natural Resources and Mines.

Digital data for the vegetation management watercourse and drainage feature map, vegetation management wetlands map, essential habitat map and the vegetation management remnant and regional ecosystem map are available from the Queensland Spatial Portal at http://www.information.qld.gov.au/

Vegetation Management Act 1999 - Extract from the essential habitat database

Essential habitat is required for assessment under the:

- State Development Assessment Provisions - Module 8: Native vegetation clearing which sets out the matters of interest to the state for development assessment under the *Sustainable Planning Act 2009*; and
- Self-assessable vegetation clearing codes made under the *Vegetation Management Act 1999*

Essential habitat for one or more of the following species is found on and within 1.1 km of the identified subject lot/s or on and within 2.2 km of an identified coordinate on the accompanying essential habitat map.

This report identifies essential habitat in Category A, B and Category C areas.

The numeric labels on the essential habitat map can be cross referenced with the database below to determine which essential habitat factors might exist for a particular species.

Essential habitat is compiled from a combination of species habitat models and buffered species records.

The Department of Natural Resources and Mines website (http://www.dnrm.qld.gov.au) has more information on how the layer is applied under the State Development Assessment Provisions - Module 8: Native vegetation clearing and the *Vegetation Management Act 1999*.

Regional ecosystem is a mandatory essential habitat factor, unless otherwise stated.

Essential habitat, for protected wildlife, means a category A area, a category B area or category C area shown on the regulated vegetation management map-

1) (a) that has at least 3 essential habitat factors for the protected wildlife that must include any essential habitat factors that are stated as mandatory for the protected wildlife in the essential habitat database; or

2) (b) in which the protected wildlife, at any stage of its life cycle, is located.

Essential habitat identifies endangered or vulnerable native wildlife prescribed under the *Nature Conservation Act 1994*.

Essential habitat in Category A and B (Remnant vegetation species record) areas:1100m Species Information

(no results)

Essential habitat in Category A and B (Remnant vegetation species record) areas:1100m Regional Ecosystems Information

(no results)

Essential habitat in Category A and B (Remnant vegetation) areas:1100m Species Information

(no results)

Essential habitat in Category A and B (Remnant vegetation) areas:1100m Regional Ecosystems Information

(no results)

Essential habitat in Category C (High value regrowth vegetation) areas:1100m Species Information

(no results)

Essential habitat in Category C (High value regrowth vegetation) areas:1100m Regional Ecosystems Information

(no results)

09/03/2017 16:00:41
Longitude: 153.2843 Latitude: -27.528

Protected Plants Flora Survey Trigger Map

Legend

- Coordinates
- High risk area
- Cadastral line
  Property boundaries shown are provided as a locational aid only
- Freeways / motorways / highways
- Secondary roads / streets

N

0 490 980 1,470 1,960 2,450 m

This product is projected into:
GDA 1994 Queensland Albers

This map shows areas where particular provisions of the Nature Conservation Act 1992 apply to the clearing of protected plants.

This map is produced at a scale relevant to the size of the area selected and should be printed as A4 size in portrait orientation.

For further information or assistance with interpretation of this product, please contact the Department of Environment and Heritage Protection at palm@ehp.qld.gov.au

Queensland Government

Department of Environment and Heritage Protection

Environmental Reports

Matters of State Environmental Significance

Area of Interest: Longitude: 153.28432 Latitude: -27.528

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "Central co-ordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: Planning.Support@ehp.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

Assessment Area Details

The following table provides an overview of the area of interest (AOI) with respect to selected topographic and environmental values.

Table 1: Summary table, AOI details

Area of Interest	153.28432,-27.528 with 2 kilometre radius
Size (ha)	1256.6
Local Government(s)	REDLAND CITY
Bioregion(s)	Southeast Queensland
Subregion(s)	Sunshine Coast - Gold Coast Lowlands
Catchment(s)	Logan-Albert, Moreton Bay Islands

Refer to **Map 1** for locality information.

Matters of State Environmental Significance (MSES)

MSES Categories

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states:

'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset.'

The MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The SPP defines matters of state environmental significance as:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992*;

- Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the *Marine Parks Act 2004*;

- Areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008;

- Threatened wildlife under the *Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006;

- Regulated vegetation under the *Vegetation Management Act 1999* that is:

  • Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;

  • Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;

  • Category R areas on the regulated vegetation management map;

  • Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse and drainage feature map;

  • Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map;

- Strategic Environmental Areas under the *Regional Planning Interests Act 2014*;

- Wetlands in a wetland protection area of wetlands of high ecological significance shown on the Map of Referable Wetlands under the Environmental Protection Regulation 2008;

- Wetlands and watercourses in high ecological value waters defined in the Environmental Protection (Water) Policy 2009, schedule 2;

- Legally secured offset areas.

Refer to **Appendix 1** for a description of MSES categories.

MSES Values Present

The MSES values that are present in the area of interest are summarised in the table below:

Table 2: Summary of MSES present within the AOI

MSES Criteria 1 - STATE CONSERVATION AREAS	7.5 ha	0.6%
1.1 Protected Areas	0.0 ha	0.0%
1.2 Marine Parks	7.5 ha	0.6%
1.3 Fish Habitat Areas	0.0 ha	0.0%
MSES Criteria 2 - WETLANDS AND WATERWAYS - area features	687.1 ha	54.7%
MSES Criteria 2 - WETLANDS AND WATERWAYS - linear features	0.2 km	Not applicable
2.1 High Ecological Significance wetlands on the map of Referable Wetlands	687.1 ha	54.7%
2.2 High Ecological Value (HEV) wetlands	73.0 ha	5.8%
2.2 High Ecological Value (HEV) waterways **	0.2 km	Not applicable
2.3 Strategic Environmental Areas (SEA)	0.0 ha	0.0%
MSES Criteria 3 - SPECIES	638.4 ha	50.8%
3.1 Threatened species and Iconic species	638.4 ha	50.8%
MSES Criteria 4 - REGULATED VEGETATION - area features	4.2 ha	0.3%
MSES Criteria 4 - REGULATED VEGETATION - linear features	27.0 km	Not applicable
4.1 Vegetation Management Regional Ecosystems and Remnant Map *	4.2 ha	0.3%
4.2 Vegetation Management Wetland Map *	0.0 ha	0.0%
4.3 Vegetation Management Watercourse Map **	27.0 km	Not applicable
MSES Criteria 5 - OFFSET AREAS	0.0 ha	0.0%
5.1 Legally secured offset areas	0.0 ha	0.0%
Total MSES (criteria 1.1, 1.2, 1.3, 2.1, part of 2.2, 2.3, 3.1, 4.1, 4.2 and 5.1) calculated for area features only	694.4 ha	55.3%

Please note that the area and percent area figures in the table above will not necessarily add up to the "Total MSES" figures due to overlapping values.

**The total extent area of regulated vegetation (Criteria 4.1) may be overestimated due to the presence of dominant and/or subdominant non-regulated regional ecosystems in mixed patches of vegetation, i.e. the total area of mixed vegetated patches is included irrespective of whether the patch consists only partly of endangered, of concern or wetland regional ecosystems.*

***The total linear extent of watercourses may be overestimated in some instances, as both banks (rather than the centreline) of waterbodies and larger watercourses where present are mapped by the State, increasing the extent of linear features.*

Additional Information with Respect to MSES Values Present

Criteria 1 - State Conservation Areas

1.1 Protected Areas

(no results)

1.2 Marine Parks

Marine Park Name	Zone
Moreton Bay Marine Park	Marine National Park Zone

1.3 Fish Habitat Areas

(no results)

Refer to **Map 2 - MSES Criteria 1 - State Conservation Areas** for an overview of the relevant MSES.

Criteria 2 - Wetlands and Waterways

2.1 High Ecological Significance wetlands on the Map of Referable Wetlands

Natural wetlands that are 'High Ecological Significance' (HES) on the Map of Referable Wetlands are present

2.2 High Ecological Value (HEV) wetlands

Natural wetlands that occur in HEV (maintain) freshwater and estuarine areas under the Environmental Protection (water) Policy are present

2.2 High Ecological Value (HEV) waterways

Natural waterways that occur in HEV (maintain) freshwater and estuarine areas under the Environmental Protection (water) Policy are present

2.3 Strategic Environmental Areas

(no results)

Refer to **Map 3 - MSES Criteria 2 - Wetlands and Waterways** for an overview of the relevant MSES.

Criteria 3 - Species

3.1 Threatened species and Iconic species

Threatened and/or iconic species habitat within the AOI (derived from records/essential habitat mapping)

Threatened wildlife and special least concern wildlife	Classification*
Tachyglossus aculeatus	iconic

**NCA E or V - Endangered or Vulnerable status under the NCA; VMA ehab - VMA essential habitat; Iconic - Iconic species.*

To request a species list for an area, or search for a species profile, access Wildlife Online at: https://www.qld.gov.au/environment/plants-animals/species-list/

Koala bushland habitat

Mapped Koala Bushland habitat present

Dugong areas

(no results)

Refer to **Map 4 - MSES Criteria 3 - Species** for an overview of the relevant MSES.

Criteria 4 - Regulated Vegetation

4.1 Endangered and Of Concern regional ecosystems and Category R Regulated Vegetation

Regulated Vegetation Description	Regional Ecosystem Patch	VMA status
rem_oc	12.1.1	O-dom

For further information relating to regional ecosystems in general, go to:
https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/
For a more detailed description of a particular regional ecosystem, access the regional ecosystem search page at:
https://environment.ehp.qld.gov.au/regional-ecosystems/

4.2 Vegetation Management Wetlands

(no results)

Wetlands datasource

Not applicable

4.3 Watercourses shown on the Vegetation Management Watercourse and Drainage Feature Map

A vegetation management watercourse is mapped as present

Watercourses datasource

Vegetation Management Watercourse Map

Refer to **Map 5 - MSES Criteria 4 - Regulated Vegetation** for an overview of the relevant MSES.

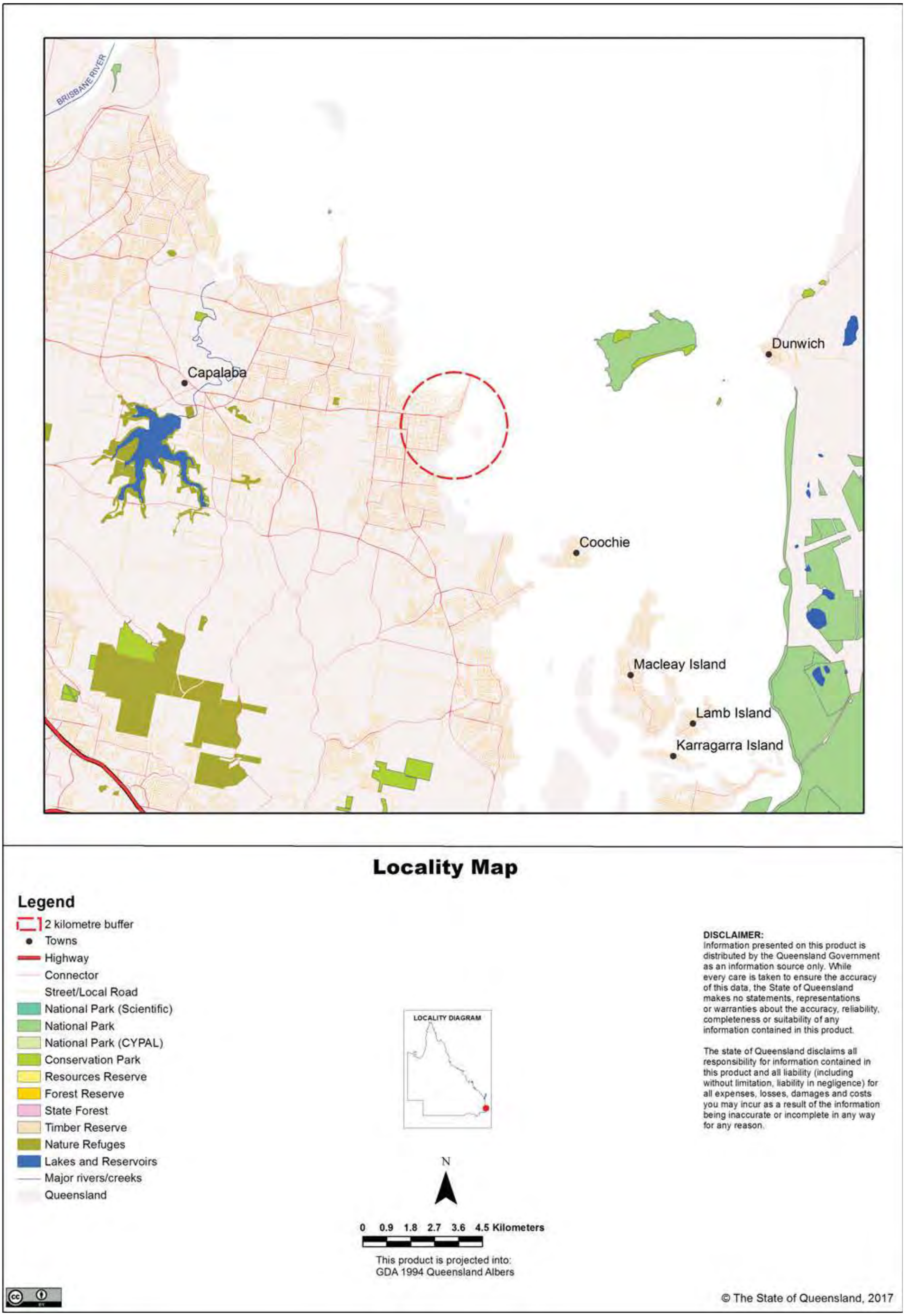
Criteria 5 - Offset Areas

5.1 Legally secured offset areas

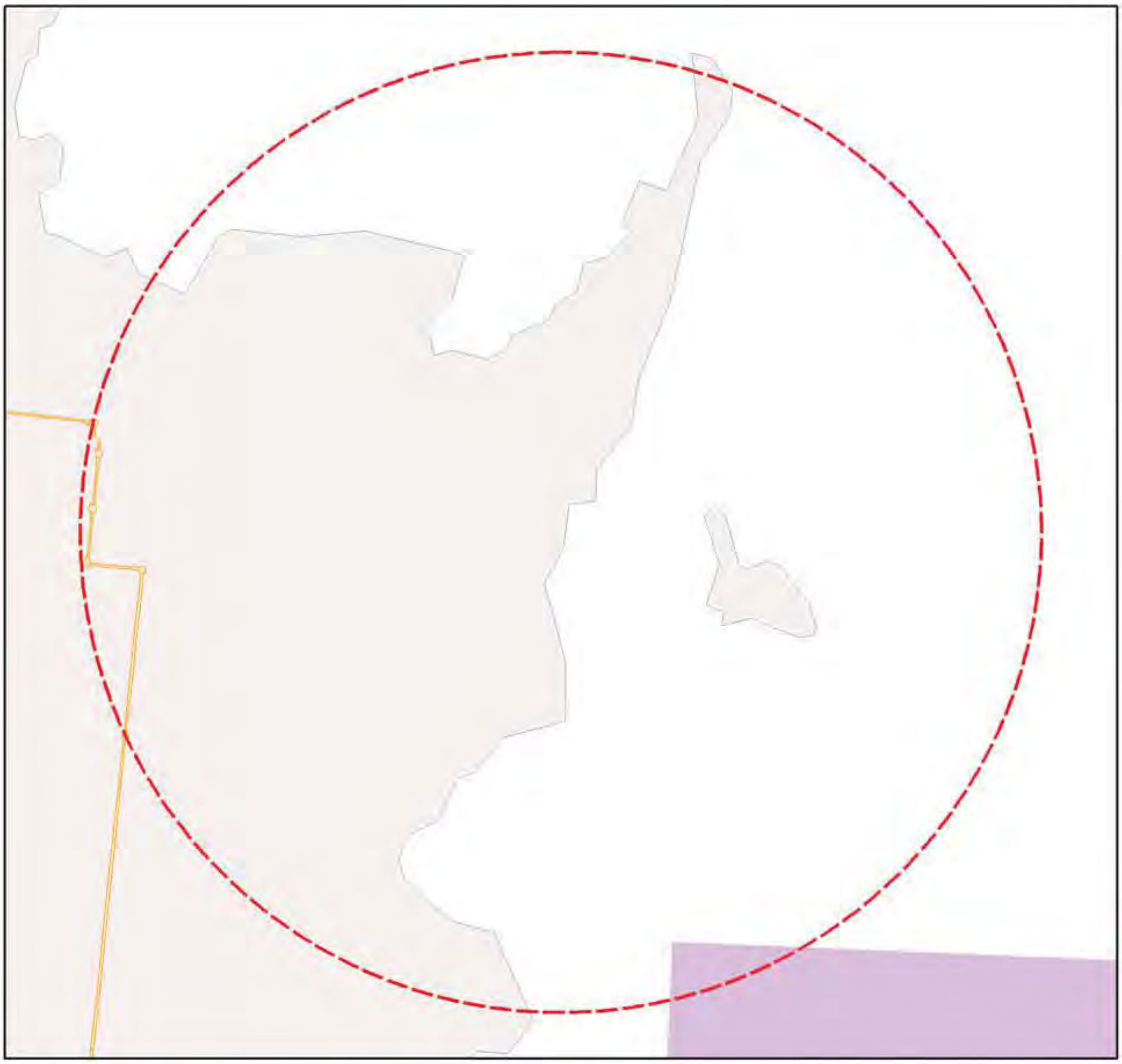
(no results)

Refer to **Map 6 - MSES Criteria 5 - Offset Areas** for an overview of the relevant MSES.

Maps
Map 1 - Location



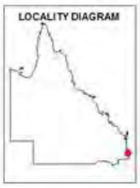
Map 2 - MSES Criteria 1 - State Conservation Areas



MSES Criteria 1- State Conservation Areas

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES Protected area
- MSES Declared fish habitat area
- MSES Marine park

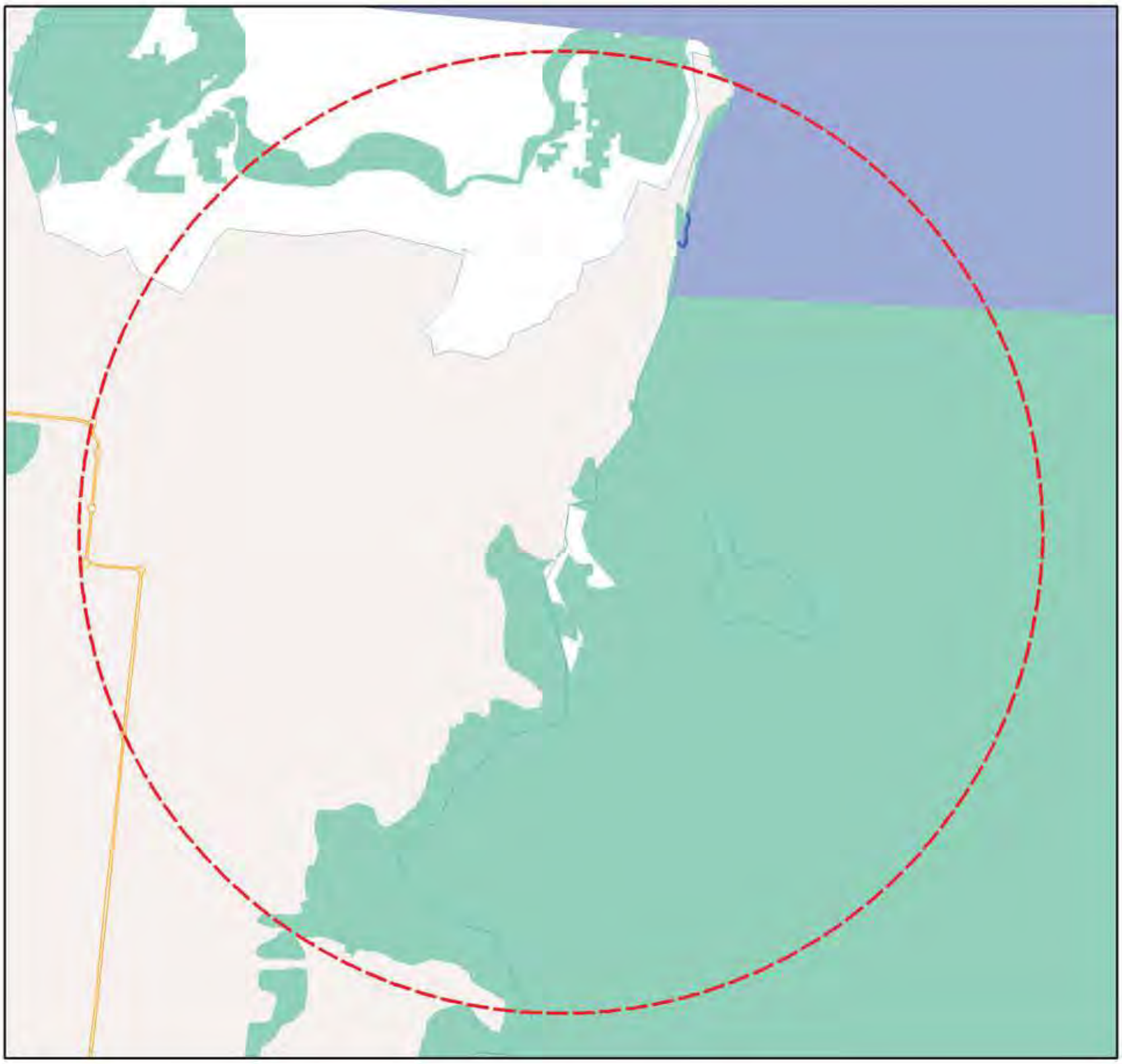


N

0 0.15 0.3 0.45 0.6 0.75 Kilometers

This product is projected into:
GDA 1994 Queensland Albers

Map 3 - MSES Criteria 2 - Wetlands and Waterways



MSES Criteria 2 - Wetlands and Waterways

Area of Interest

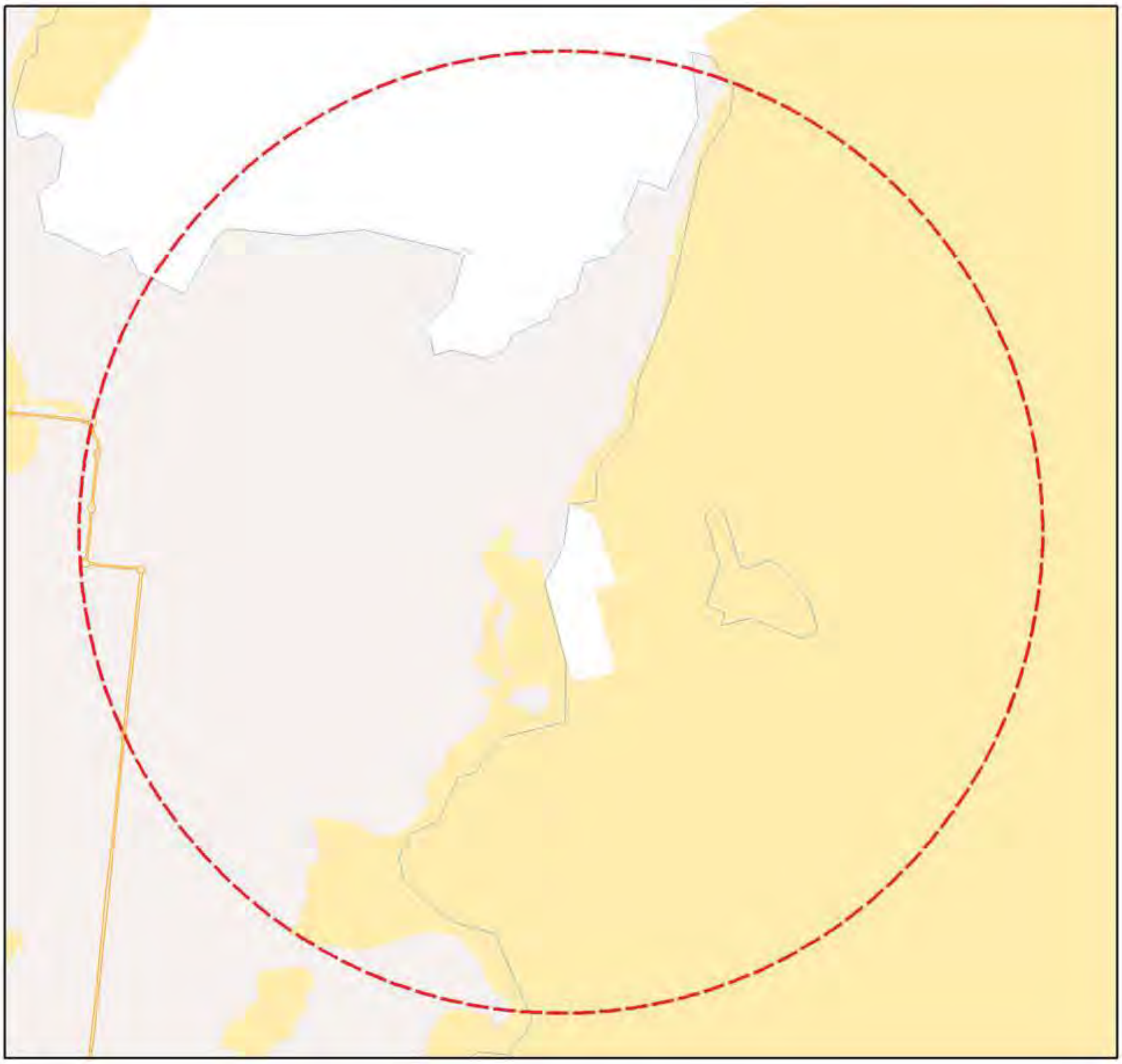
- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES - High ecological value waters (watercourses)
- MSES - Strategic environmental area (designated precinct)
- MSES - High ecological value waters (wetland)
- MSES - High ecological significance wetlands

N

0 0.15 0.3 0.45 0.6 0.75 Kilometers

This product is projected into:
GDA 1994 Queensland Albers

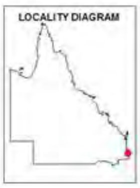
Map 4 - MSES Criteria 3 - Species



MSES Criteria 3 - Species

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES - Wildlife habitat

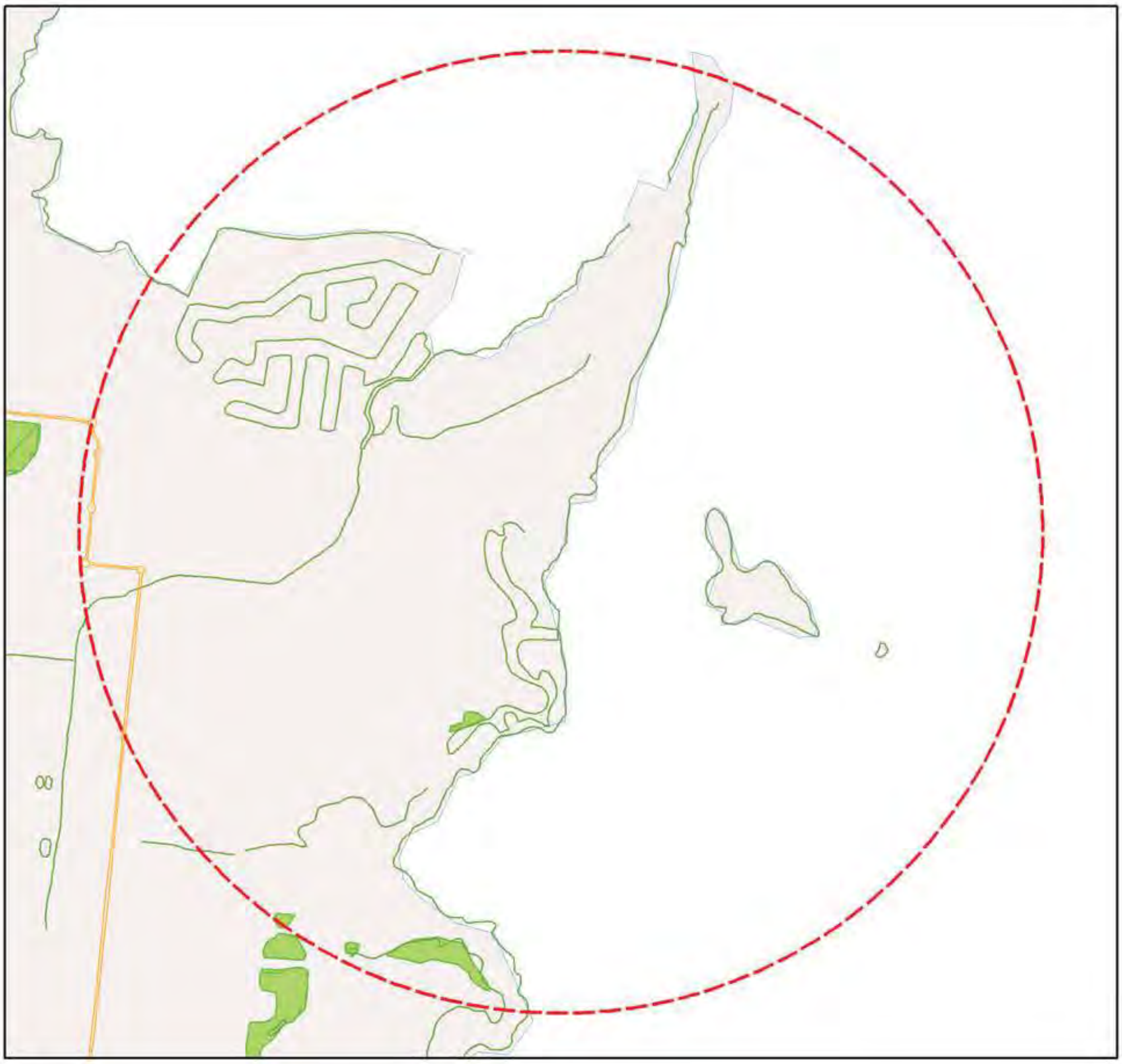


N

0 0.15 0.3 0.45 0.6 0.75 Kilometers

This product is projected into:
GDA 1994 Queensland Albers

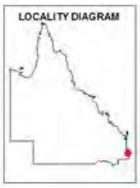
Map 5 - MSES Criteria 4 - Regulated Vegetation



MSES Criteria 4 - Regulated Vegetation

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES - Regulated vegetation (intersecting a watercourse)
- MSES - Regulated vegetation



N

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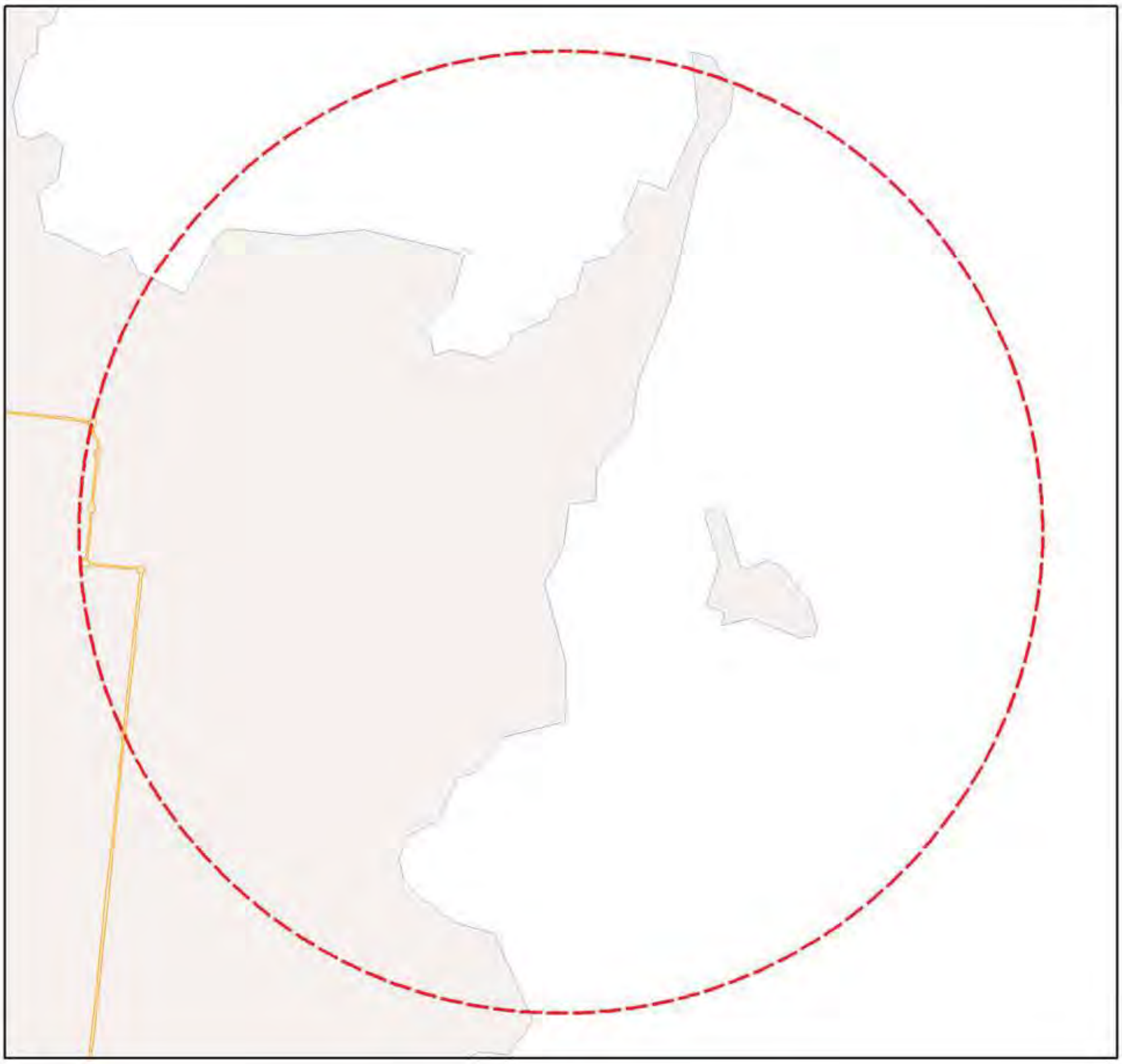
This product is projected into:
GDA 1994 Queensland Albers

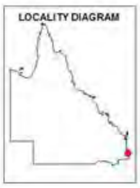
Map 6 - MSES Criteria 5 - Offset Areas



MSES Criteria 5 - Offset Areas

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES - Legally secured offset area



N

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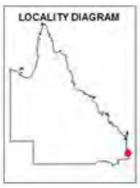
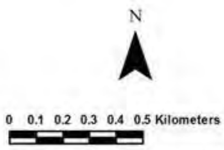
Map 7 - Matters of State Environmental Significance

Matters of State Environmental Significance

Area of Interest

- 2 kilometre buffer
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Matters of State Environmental Significance (watercourses)
- Matters of State Environmental Significance (areas)





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Appendices

Appendix 1 - Matters of State Environmental Significance (MSES) Criteria

Feature Name	Description
1.1 Protected Areas (NCA)	Protected areas under the *Nature Conservation Act 1992*, except coordinated conservation areas.
1.2 Marine Parks (MPA)	The following State marine parks zones under the *Marine Parks Act 2004*: - Marine National Park zone; - Marine Conservation Park zone; - Scientific Research zone; - Preservation zone; - Buffer zone.
1.3 Fish Habitat Areas (FA)	The following areas under the *Fisheries Act 1994* including: All fish habitat areas.
2.1 'High Ecological Significance' wetlands on the Map of Referable Wetlands	All natural wetlands that are 'High Ecological Significance' (HES) on the Map of Referable Wetlands. Exclude: any amendments to the Map of Referable Wetlands.
2.2 High Ecological Value (HEV) wetlands and waterways (EP Act)	Natural wetlands and waterways that occur in HEV (maintain) freshwater and estuarine areas under the Environmental Protection (Water) Policy.
2.3 Strategic Environmental Areas (RPI Act)	Designated precinct areas under the *Regional Planning Interests Act 2014*.
3.1 Threatened species and Iconic species (NCA)	Habitat for: Threatened wildlife under *Nature Conservation Act 1992* including: 'Endangered' and 'Vulnerable' species. Special least concern animals under the *Nature Conservation Act 1992* including: Koala (outside SEQ); Echidna and Platypus.
4.1 Vegetation Management Regional Ecosystem and Remnant Map (VMA)	Include VMA 'Endangered' and 'Of Concern' remnant (Category A and B) and high value regrowth (Category C) REs and Category R (GBR regrowth watercourse) areas from the Regulated Vegetation Management Map.
4.2 Vegetation Management Wetland Map (VMA)	Wetlands that are lakes and swamps shown on the Vegetation Management Wetlands Map.
4.3 Vegetation Management Watercourse and Drainage Feature Map (VMA)	Watercourses shown on the Vegetation Management Watercourse and Drainage Feature Map.
5.1 Legally secured offset areas (VMA, EP Act, SPA, TIA, EA)	Offset areas legally secured under a covenant, conservation agreement or development approval condition.

The Queensland Government's "Method for mapping - matters of state environmental significance for use in land use planning and development assessment" can be downloaded from:

http://www.ehp.qld.gov.au/land/natural-resource/method-mapping-mses.html.

Appendix 2 - Source Data

The datasets listed below are available on request from:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

- Matters of State environmental significance
- Matters of State environmental significance drainage lines
- Boundaries of the Great Barrier Reef Marine Park

Note: MSES mapping is a regional-scale representation of the definition for MSES under the State Planning Policy (SPP). The compiled MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

MSES mapping is not based on new or unique data. The primary mapping product draws data from a number of underlying environment databases and geo-referenced information sources. MSES mapping is a versioned product that is updated generally on a twice-yearly basis to incorporate the changes to underlying data sources. Several components of MSES mapping made for the current version may differ from the current underlying data sources. To ensure accuracy, or proper representation of MSES values, it is strongly recommended that users refer to the underlying data sources and review the current definition of MSES in the State Planning Policy, before applying the MSES mapping.

Underlying data sources used to develop individual releases of complied MSES mapping include, but are not limited to:

- Regulated vegetation including:

- Regulated Regional Ecosystems and Regrowth
- Regulated Essential habitat
- Regulated Wetlands
- Regulated Watercourses and Drainage
- Former Regrowth

- Queensland Wetland Mapping (v3)
- Essential Habitat Mapping
- Protected Areas
- Marine Parks
- Fish Habitat Areas
- Strategic Environmental Areas
- The Map of Referable Wetlands:

- Wetland Protection Areas (HES wetlands in the GBR)
- Wetland Management Areas (contains other HES wetlands)

Datasets reflective of the above matters can be downloaded via the Queensland Spatial Catalogue:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

Appendix 3 - Acronyms and Abbreviations

AOI	- Area of Interest
EHP	- Department of Environment and Heritage Protection
EP Act	- *Environmental Protection Act 1994*
EPP	- Environmental Protection Policy
GDA94	- Geocentric Datum of Australia 1994
GEM	- General Environmental Matters
GIS	- Geographic Information System
MSES	- Matters of State Environmental Significance
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
SPP	- State Planning Policy
VMA	- *Vegetation Management Act 1999*

APPENDIX 3

Conservation significant flora and fauna species identified in the desktop assessment and their likelihood of occurrence in the Toondah Harbour PDA

Conservation significant terrestrial flora and vertebrate fauna species recorded or predicted to occur within a 1 km radius of the Toondah Harbour PDA and their likelihood of occurrence (known, likely, potential or unlikely) within or immediately adjoining the subject site.

Abbreviations: EPBC = status under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth); **NCA** = status under the *Nature Conservation Act 1992* (Queensland); **RCC** = status under the Redland City Council Biodiversity Strategy; **PM** = EPBC Protected Matters Search Tool database search within a 1 km radius of the study area; **WN** = Queensland Government Wildlife Online database records since 1980 within a 1 km radius of the study area; **QWSG** = Queensland Wader Study Group records for Nandeebie Claypan high tide roost site; **BAAM** = Recorded within the study area during surveys conducted by Biodiversity Assessment and Management Pty Ltd; **E** = Endangered; **V** = Vulnerable; **NT** = Near Threatened; **M** = Migratory; **S** = Special Least Concern (Migratory or culturally significant); **LC** = Least Concern; **X** = species occurrence predicted (PM) or recorded; **Y** =Species is associated with mapped vegetation (NEDS).

Likelihood of occurrence categories: Known – the species has been recorded within or immediately adjoining the PDA during surveys (BAAM, QWSG); **Potential to occur** – the species has not been recorded onsite during surveys but there are database records within 1 km of the site, it is known to occur immediately adjacent to the study area or knowledge of the species occurrence suggests it may occur as a regular visitor; **Unlikely to occur** – the species has not been recorded within 1 km of the study site since 1980 or no suitable habitat present and/or the site is outside of the known range of the species.

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
Threatened species known to occur									
Numenius madagascariensis	Eastern Curlew	CE, M	V	x	180	x	x	Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Limosa lapponica baueri	Bar-tailed Godwit (Western Alaskan)	V, M	S	x	219	x	x	Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris tenuirostris	Great Knot	CE, M	S	x	33	x	x	Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris ferruginea	Curlew Sandpiper	CE, M	S	x	12	x		Feeds on intertidal mudflats	**Known**. Feeds on intertidal

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
								and sandflats, roosts on beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark.	mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Phascolarctos cinereus (SEQ Bioregion)	Koala (SEQ Bioregion)	V	V	x	420		x	Forests and woodlands with eucalypt trees, particularly *Eucalyptus* species.	**Known**. Feeds on food trees (*species of Eucalyptus, Corymbia, Lophostemon* and *Melaleuca*) growing in the urban environment within and adjacent to the study area.
Threatened species with potential to occur									
Calidris canutus	Red Knot	E, M	S	x	8			Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	**Potential**. While it has not been recorded within the study area, the species is known to occur within 1 km of the study area and it has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius mongolus	Lesser Sand Plover	E, M	S	x	8			Feeds on intertidal mudflats and sandflats, roosts on beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark.	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius leschenaultii	Greater Sand Plover	V, M	S	x	2			Feeds on intertidal mudflats and sandflats, roosts on	**Potential**. While it has not been recorded within the study area,

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
								beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark.	the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Pteropus poliocephalus	Grey-headed Flying-fox	V	LC	x				Open eucalypt forests, woodlands, melaleuca swamps and banksia woodlands, particularly on more fertile alluvial soils.	**Potential**. While it has not been recorded within the study area, the species is known from the local area and it has potential to be a regular seasonal visitor to feed on flowing trees within the study area.
Threatened species unlikely to occur									
Botaurus poiciloptilus	Australasian Bittern	E	LC	x				Wetlands with tall reeds, sedges, rushes or lignum.	Unlikely – no suitable habitat.
Diomedea antipodensis gibsoni	Gibson's Albatross	V	V	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Diomedea exulans	Wandering Albatross	V, M	V	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Thalassarche cauta cauta	Shy Albatross	V, M	V	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Thalassarche cauta steadi	White-capped Albatross	V, M	V	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Thalassarche eremita	Chatham Albatross	E	LC	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Thalassarche impavida	Campbell Black-browed Albatross	V	LC	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Thalassarche melanophris	Black-browed Albatross	V, M	S	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Thalassarche salvini	Salvin's Albatross	V	LC	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
Macronectes giganteus	Southern Giant-Petrel	E, M	E	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Macronectes halli	Northern Giant-Petrel	V, M	V	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Pterodroma neglecta neglecta	Kermadec Petrel (Western)	V	LC	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Fregetta grallaria grallaria	White-bellied Storm-Petrel (Tasman Sea)	V	LC	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Pachyptila turtur subantarctica	Fairy Prion (southern)	V	LC	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Erythrotriorchis radiatus	Red Goshawk	V	E	x				Woodlands and forests, particularly riverine forests.	Unlikely – no suitable habitat.
Turnix melanogaster	Black-breasted Button-quail	V	V	x				Semi-evergreen vine thicket and low microphyll vine forest; also dry rainforest and coastal scrubs.	Unlikely – no suitable habitat.
Limosa lapponica menzbieri	Bar-tailed Godwit (Northern Siberian)	CE, M	S					Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	Unlikely – not known to migrate down the east coast of Australia.
Rostratula australis	Australian Painted Snipe	E	V	x				Well-vegetated margins of freshwater wetlands.	Unlikely – no suitable habitat.
Geophaps scripta scripta	Squatter Pigeon (southern)	V	V	x				Dry grassy eucalypt woodlands, open forests and scrub	Unlikely – no suitable habitat.
Cyclopsitta diophthalma coxeni	Double-eyed Fig-Parrot (Coxen's)	E, M	E	x				Rainforest with an abundance of large fig trees.	Unlikely – no suitable habitat.
Lathamus discolor	Swift Parrot	E	E	x				Forests and woodlands; feeds on nectar and lerp-insects in foliage	Unlikely – no suitable habitat.
Dasyornis brachypterus	Eastern Bristlebird	E	E	x				In Queensland restricted to scrubs and heaths in mountainous ranges.	Unlikely – no suitable habitat.

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
Anthochaera phrygia	Regent Honeyeater	E, M	E	x				Dry open forest and woodland.	Unlikely – no suitable habitat.
Poephila cincta cincta	Black-throated Finch (Southern subsp)	E	E	x				Grassy woodlands.	Unlikely – no suitable habitat.
Dasyurus maculatus maculatus	Spotted-tailed Quoll (SE Mainland)	E	V	x				Associated with rocky gorges and mountains with rainforests, wet and dry sclerophyll forests, coastal heath, scrub and sometimes Red Gum forests along inland rivers.	Unlikely – no suitable habitat.
Dasyurus hallucatus	Northern Quoll	E	LC	x				Rocky eucalypt woodland and open forest within 200 kilometres of the coast.	Unlikely – no suitable habitat. Within Queensland, it is now largely confined to rocky escarpment country with extensive areas of contiguous remnant vegetation.
Petauroides volans	Greater Glider	V	LC	x				Eucalypt forests and woodlands, favouring forests with a diversity of eucalypt species.	Unlikely – no suitable habitat.
Chalinolobus dwyeri	Large Pied Bat	V	V	x				Associated with sandstone and other rocky escarpments.	Unlikely – no suitable habitat.
Xeromys myoides	False Water-rat	V	V	x				Mangroves and saltmarsh.	Unlikely – not known to occur in the local region.
Delma torquata	Adorned Delma	V	V	x				Open eucalypt forest with a shrub and tussock grass understorey.	Unlikely – no suitable habitat.
Saiphos reticulatus	Three-toed Snake-tooth Skink	V	LC	x				Rainforest, closed forest, wet sclerophyll forest, tall open Blackbutt (*Eucalyptus pilularis*) forest, tall layered open eucalypt forest and closed Brush Box (*Lophostemon*	Unlikely – no suitable habitat.

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
								confertus) forest.	
Phyllodes imperialis smithersi	Pink Underwing Moth	E	LC	x				Undisturbed, subtropical rainforest.	Unlikely – no suitable habitat.
Esacus magnirostris	Beach Stone-curlew		V		1			Open, undisturbed sandy beaches, reefs and lagoons and nearby mudflats and sandflats.	Unlikely – no suitable sandy beach habitat in the vicinity.
Calyptorhynchus lathami lathami	Glossy Black-Cockatoo (eastern)		V		2			Forests and woodlands, preferring habitats dominated by she-oaks (*Allocasuarina* spp. and certain *Casuarina* spp.) in the canopy or middle stratum.	Unlikely – no suitable habitat.
Migratory species known to occur									
Pandion cristatus	Eastern Osprey	M	S		10	x	x	Bays, estuaries, along tidal stretches of large coastal rivers, mangrove swamps, terrestrial wetlands and off-shore islands.	**Known.** Forages for fish over open waters but no nest site occurs in the study area.
Numenius phaeopus	Whimbrel	M	S	x	19	x	x	Feeds on intertidal mudflats and sandflats, roosts on mangrove trees, beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark.	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Xenus cinereus	Terek Sandpiper	M	S	x	9		x	Feeds on intertidal mudflats and sandflats, roosts on mangrove trees, beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark.	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Tringa brevipes	Grey-tailed Tattler	M	S	x	21	x	x	Feeds on intertidal mudflats and sandflats, roosts on mangrove trees, beaches, rocky shores, sandbars,	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
								claypans and saltmarshes near the high tide mark.	sites within and adjacent to the study area.
Arenaria interpres	Ruddy Turnstone	M	S	x	16		x	Feeds on intertidal mudflats and sandflats, roosts on mangrove trees, beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark.	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Calidris ruficollis	Red-necked Stint	M	S	x	10		x	Feeds on intertidal mudflats and sandflats, roosts on beaches, rocky shores, sandbars, claypans and saltmarshes near the high tide mark.	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within (rarely) or adjacent to the study area.
Limosa limosa	Black-tailed Godwit	M	S	x	12	x		Feeds in shallow saltwater and freshwater wetlands, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	**Known**. Recorded rarely at roost sites within and adjacent to the study area.
Pluvialis fulva	Pacific Golden Plover	M	S	x	4	x		Feeds on intertidal mudflats and sandflats, roosts on beaches, rocky shores, sandbars, claypans, saltmarshes and short, open grassy areas near the coast.	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within (rarely) and adjacent to the study area.
Gelochelidon nilotica	Gull-billed Tern	M	S		78	x	x	Coastal bays, lagoons and freshwater wetlands, beaches and mudflats.	**Known**. Feeds over open waters and intertidal mudflats and (maximum 7 birds) rarely roosts at Nandeebie Claypan (maximum 32 roosting birds).
Hydroprogne caspia	Caspian Tern	M	S		88	x	x	Coastal bays, lagoons and wetlands but also inland freshwater wetlands including lakes, reservoirs	**Known**. Feeds over open waters and intertidal mudflats (maximum 2 birds) and rarely roosts at Nandeebie Claypan

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
								and large rivers.	(maximum 14 roosting birds).
Sternula albifrons	Little Tern	M	S	x	5		x	Coastal waters, brackish lakes, saltfields and sewage ponds near the coast; nests on islands and beach sand spits.	**Known**. Feeds over open waters (maximum 1 bird recorded); while it is known to roost at Oyster Point, it was not recorded roosting at Nandeebie Claypan.
Migratory species with potential to occur									
Calidris acuminata	Sharp-tailed Sandpiper	M	S	x	9			Coastal and inland areas, preferring non-tidal fresh or brackish wetlands, or mudflats near river mouths.	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Tringa nebularia	Common Greenshank	M	S		8			Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Tringa stagnatilis	Marsh Sandpiper	M	S	x	1			Feeds in the shallows of brackish and freshwater wetlands.	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
									within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Actitis hypoleucos	Common Sandpiper	M	S	x	1			Mangrove inlets, rocky shores and creeks, channels and dams.	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius bicincutus	Double-banded Plover	M	S	x	6			Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Chlidonias leucopterus	White-winged Black Tern	M	S		1			Large coastal and inland wetlands.	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a rare seasonal visitor, the study area is not important habitat for this

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
									species.
Thallaseus bergii	Crested Tern	M	S		14			Coastal bays and offshore waters, lagoons and wetlands but also inland freshwater wetlands including lakes, reservoirs and large rivers.	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a regular visitor, feeding on fish over open waters, the study area is not important habitat for this species.
Sterna hirundo	Common Tern	M	S		3			Coastal bays, lagoons and wetlands.	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Hirundapus caudacutus	White-throated Needletail	M	S	x				Almost exclusively aerial over a range of habitats, more often over wooded areas. Does not breed in Australia.	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a regular seasonal visitor feeding on insects in the air, the study area is not important habitat for this species.
Cuculus optatus	Oriental Cuckoo	M	S	x				Monsoonal rainforest, vine thickets, wet eucalypt forest or open woodlands (Commonwealth of Australia 2015). Does not	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
								breed in Australia.	may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Rhipidura rufifrons	Rufous Fantail	M	S	x				Breeding migrant to moist habitats with a dense understorey, including mangroves, rainforest, riparian forests and wet eucalypt forests (Commonwealth of Australia 2015).	**Potential**. The species has not been recorded within 1 km of the study area, but suitable mangrove forest habitat occurs in the southern portion of the PDA. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Migratory species unlikely to occur									
Fregata ariel	Lesser Frigatebird	M	S	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Fregata minor	Greater Frigatebird	M	S	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Ardenna carneipes	Flesh-footed Shearwater	M	S	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Calonectris leucomelas	Streaked Shearwater	M	S	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Numenius minutus	Little Curlew	M	S	x				Short, dry grasslands and sedgelands, including artificial areas, and on the grassy edges of freshwater wetlands.	Unlikely – has not been recorded in the local area.
Calidris alba	Sanderling	M	S	x	1			Feeds on sandy coastal beaches, roosts on beaches, rocky shores, claypans and saltmarshes near the high water mark.	Unlikely – no suitable feeding habitat.
Calidris melanotos	Pectoral Sandpiper	M	S	x				Mostly fresh to saline waterbodies, usually coastal but occasionally inland.	Unlikely. The species has not been recorded in the local area and no preferred habitat occurs in the study area.

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
Gallinago hardwickii	Latham's Snipe	M	S	x	1			Shallow freshwater wetlands with emergent grasses and sedges.	Unlikely – no suitable feeding habitat.
Gallinago megala	Swinhoe's Snipe	M	S	x				Edges of reedy swamps and wet grassy ground in northern Australia	Unlikely – no suitable habitat and outside known range.
Gallinago stenura	Pin-tailed Snipe	M	S	x				Boggy wetland edges in north-western Australia	Unlikely – no suitable habitat and outside known range.
Heteroscelus incanus	Wandering Tattler	M	S	x				Rocky coastlines and reefs	Unlikely – no suitable habitat.
Limicola falcinellus	Broad-billed Sandpiper	M	S	x				Feeds on soft muddy substrates of tidal mudflats; roosts at shoreline roost sites.	Unlikely – has not been recorded in the local area and intertidal habitat generally not suitable.
Limnodromus semipalmatus	Asian Dowitcher	M	S	x				Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	Unlikely – has not been recorded in the local area.
Philomachus pugnax	Ruff	M	S	x				Feeds on intertidal mudflats, sandflats and shallows of freshwater wetlands; roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	Unlikely – has not been recorded in the local area.
Tringa glareola	Wood Sandpiper	M	S	x				Margins of freshwater wetlands, occasionally margins of tidal mudflats.	Unlikely – habitat generally not suitable and has not been recorded in the local area.
Pluvialis squatarola	Grey Plover	M	S	x				Feeds on intertidal mudflats and sandflats, roosts on beaches, sandbars, claypans and saltmarshes near the high tide mark.	Unlikely – has not been recorded in the local area.
Charadrius veredus	Oriental Plover	M	S	x				Open grasslands, preferring flat sparsely vegetated inland plains.	Unlikely – no suitable habitat.

Species	Common name	EPBC	NCA	PM	WN	QWSG	BAAM	Preferred habitat	Likelihood of occurrence
Anous stolidus	Common Noddy	M	S	x				Feeds on the open ocean, nests on oceanic islands.	Unlikely – no suitable habitat.
Apus pacificus	Fork-tailed Swift	M	S	x				Almost exclusively aerial over a range of habitats , from inland open plains to wooded areas. Does not breed in Australia.	Unlikely – has not been recorded in the local area.
Symposiarchus trivirgatus	Spectacled Monarch	M	S	x				Breeding migrant to dense vegetation, mainly in rainforest but also in moist forest or wet eucalypt forest.	Unlikely. The species has not been recorded in the local area and no preferred habitat occurs in the study area.
Myiagra cyanoleuca	Satin Flycatcher	M	S	x				Breeding migrant to eucalypt forest and woodlands, at high elevations when breeding.	Unlikely. The species has not been recorded in the local area and no preferred habitat occurs in the study area.
Monarcha melanopsis	Black-faced Monarch	M	S	x				Breeding migrant to wet forest, mainly in rainforest and wet sclerophyll forest, especially in sheltered gullies and slopes with a dense understorey of ferns and shrubs.	Unlikely. The species has not been recorded in the local area and no preferred habitat occurs in the study area.

Conservation significant terrestrial flora species recorded or predicted to occur within a 1 km radius of the Toondah Harbour PDA and their likelihood of occurrence (known, likely, potential or unlikely) within or immediately adjoining the subject site.

Abbreviations: EPBC = status under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth); **NCA** = status under the *Nature Conservation Act 1992* (Queensland); **RCC** = status under the Redland City Council Biodiversity Strategy; **PM** = EPBC Protected Matters Search Tool database search within a 1 km radius of the study area; **WN** = Queensland Department of Environment and Resource Management WildNet database search within a 1 km radius of the study area; **BAAM** = BAAM (2014, 2015) surveys; **E** = Endangered; **V** = Vulnerable; **NT** = Near Threatened; **M** = Migratory; **S** = Special Least Concern (Migratory or culturally significant); **LC** = Least Concern; **Sig** = RCC Significant; **X** = species occurrence predicted (PM or QM).

Species	Common name	EPBC	NCA	PM	WN	BAAM	Habitat characteristics	Likelihood of occurrence
Arthraxon hispidus	Hairy Joint Grass	V	V	X			Edges of rainforest and in wet eucalypt forest, often near creeks or swamps.	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.
Baloghia marmorata	Marbled Balogia			X			Subtropical rainforest/notophyll vine forest and wet sclerophyll forest (brush box woodland) with rainforest understorey between 150 and 550 m above sea level (Commonwealth of Australia 2017).	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.
Bosistoa transversa	Three-leaved Bosistoa			X			Lowland subtropical rainforest up to 300 m above sea level (Commonwealth of Australia 2017).	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.
Corchorus cunninghamii	Native Jute			X			Occurs in the ecotone of wet sclerophyll forest and dry to dry-subtropical rainforest (e.g. araucarian microphyll vine forest),	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.

							and in Hoop Pine (*Araucaria cunninghamii*) plantations. Often occurs on hill crests, exposed slopes, ridges or upper slopes of hilly terrain on south or south-east aspect. It also occurs on sheltered slopes, gullies and on lower slopes, depending on the topographic position of the sclerophyll-rainforest margin (Commonwealth of Australia 2017).	
Cryptocarya foetida	Stinking Laurel	V	V	X			Littoral rainforest on old sand dunes and subtropical rainforests over slate and occasionally on basalt (Commonwealth of Australia 2017).	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.
Cryptostylis hunteriana	Leafless Tongue Orchid	V	LC	X			In south-east Queensland occurs in wet heath on sandy soils (Commonwealth of Australia 2017).	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.
Macadamia integrifolia	Macadamia Nut	V	V	X			Subtropical rainforest, preferring well-drained sites on hill crests, hill slopes, scree slopes, foot slopes and along the edges of hoop pine (*Araucaria cunninghamii*) scrubs and creek beds (SCC	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.

							2006)	
Macadamia tetraphylla	Rough-shelled Bush Nut	V	V	X			Subtropical rainforest and notophyll vine forest in near coastal areas, often on steep slopes, especially at ecotones (TSSC 2008b).	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.
Phaius australis	Lesser Swamp Orchid	E	E	X			Coastal wet heath/sedgeland wetlands, swampy grassland or swampy forest (Commonwealth of Australia 2017).	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.
Phaius bernaysii	Yellow Swamp-orchid	E	E	X			The margins between open forest/woodland and closed sedgeland, along the perimeter of swamps, often in a fairly shady environment in Melaleuca quinquenervia–Eucalyptus robusta open forest in sandy or peaty soil (Commonwealth of Australia 2017).	Unlikely to occur as no suitable habitat is present and the species is currently known to occur only at one location on North Stradbroke Island.
Samadera bidwillii	Quassia	V	V	X			Lowland rainforest or rainforest margins; also open forest and woodland, adjacent to watercourses (Commonwealth of Australia 2017).	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.
Thesium australe	Austral Toadflax	V	V	X			Associated with a range of native grass species, particularly Kangaroo Grass (*Themeda triandra*) in shrubland,	Unlikely to occur as no suitable habitat is present and the species has not been recorded within 1 km of the study area.

							grassland or woodland, often on damp sites (Commonwealth of Australia 2017).	

APPENDIX 4

Migratory shorebird survey data

Table A4.1. Low tide survey data for Toondah Harbour PDA (BAAM 2014, 2015).

Species	Common name	EPBC[1]	NCA[2]	31/10/2014	6/11/2014	26/12/2014	9/01/2015	24/02/2015	19/03/2015	18/06/2015
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S	32	6	33	27	9	30	
Numenius phaeopus	Whimbrel	M	S	6	13	15	19	12	16	
Numenius madagascariensis	Eastern Curlew	CE,M	V	4	2	7	4	4	1	
Tringa brevipes	Grey-tailed Tattler	M	S	88		60	41	55	91	
Calidris tenuirostris	Great Knot	CE,M	S			1				
Calidris ruficollis	Red-necked Stint	M	S					1		
Xenus cinereus	Terek Sandpiper	M	S	7		42		26		
Total migratory shorebirds				137	21	158	91	107	138	0
Haematopus longirostris	Australian Pied Oystercatcher		LC			2	20	43	20	3
Vanellus miles	Masked Lapwing		LC	3			17	4	8	6
Total resident shorebirds				3	0	2	37	47	28	9
Anas castanea	Chestnut Teal		LC			6				4
Threskiornis molucca	Australian White Ibis		LC	13		12	17	69	15	17
Platalea regia	Royal Spoonbill		LC	2		1	1		1	
Butorides striatus	Striated Heron		LC	1		1			1	2
Ardea modesta	Eastern Great Egret		LC	1		2	1	1		
Egretta novaehollandiae	White-faced Heron		LC	16		5	2	1	10	15
Egretta garzetta	Little Egret		LC	1		1		1	2	1
Pelecanus conspicillatus	Australian Pelican		LC	2						
Phalacrocorax melanoleucos	Little Pied Cormorant		LC			4		1	2	2
Phalacrocorax sulcirostris	Little Black Cormorant		LC	4						
Anhinga novaehollandiae	Australasian Darter		LC	1						1

Species	Common name	EPBC[1]	NCA[2]	31/10/2014	6/11/2014	26/12/2014	9/01/2015	24/02/2015	19/03/2015	18/06/2015
Pandion cristatus	Eastern Osprey	M	S					1		
Chroicocephalus novaehollandiae	Silver Gull		LC	3		3	3	10	5	6
Gelochelidon nilotica	Gull-billed Tern	M	S	3		1				4
Hydroprogne caspia	Caspian Tern	M	S			1				2
Sternula albifrons	Little Tern	M	S	1						
Total other waterbirds				48	0	37	24	84	36	54

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: V = vulnerable; S = special least concern (migratory).

Table A4.2. High tide survey data for Nandeebie Claypan roost site (BAAM 2014, 2015).

Species	Common name	EPBC	NCA	30/10/2014	31/10/2014	5/11/2014	6/11/2014	21/11/2014	25/11/2014	26/11/2014	27/11/2014	8/12/2014	9/12/2014	6/01/2015	8/01/2015	16/02/2015	16/02/2015	3/03/2015	20/03/2015	18/06/2015
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S					43							1026	730	932	841		
Numenius phaeopus	Whimbrel	M	S	5			1			103	2	23				124				
Numenius madagascariensis	Eastern Curlew	CE,M	V	14	6		1	6	1	2	2	2	1	1	34	45	2	36		
Calidris tenuirostris	Great Knot	CE,M	S													1	11	5		
Total migratory shorebirds				19	6	0	2	49	1	105	4	25	1	1	1060	900	945	882	0	0
Burhinus grallarius	Bush Stone-Curlew		LC					3	2	2	1		2							
Himantopus himantopus	Black-winged Stilt		LC					29	32	34	30	36	25		7					
Vanellus miles	Masked Lapwing		LC											15		2		2	3	
Total resident shorebirds				0	0	0	0	32	34	36	31	36	27	15	7	2	0	2	3	0
Threskiornis molucca	Australian White Ibis		LC					10	3	2	2		2	10		1		10	2	4

Species	Common name	EPBC	NCA	30/10/2014	31/10/2014	5/11/2014	6/11/2014	21/11/2014	25/11/2014	26/11/2014	27/11/2014	8/12/2014	9/12/2014	6/01/2015	8/01/2015	16/02/2015	16/02/2015	3/03/2015	20/03/2015	18/06/2015
Egretta novaehollandiae	White-faced Heron		LC					17	8	8	11	13	11	2	1				6	30
Egretta garzetta	Little Egret		LC					1											1	
Chroicocephalus novaehollandiae	Silver Gull		LC														4			
Total other waterbirds				0	0	0	0	28	11	10	13	13	13	12	1	1	4	10	9	34

Table A4.3. High tide survey data for Cassim Island roost site (BAAM 2014, 2015).

Species	Common name	EPBC	NCA	6/11/2014	9/01/2015	16/02/2015	19/03/2015	18/06/2015
Numenius phaeopus	Whimbrel	M	S	184	270	160	140	
Tringa brevipes	Grey-tailed Tattler	M	S	215	600	570	460	
Arenaria interpres	Ruddy Turnstone	M	S	10	20	50	26	
Xenus cinereus	Terek Sandpiper	M	S	8	30	30	22	
Butorides striatus	Striated Heron							1
Phalacrocorax melanoleucos	Little Pied Cormorant							1
Phalacrocorax varius	Pied Cormorant							1
Total				**417**	**920**	**810**	**648**	**3**

Table A4.3. Engraved leg flag combinations observed on Bar-tailed Godwits utilising the Nandeebie Claypan roost site (BAAM 2014, 2015).

Flagged leg	Flag colour	Flag combination	Flagged leg	Flag colour	Flag combination	Flagged leg	Flag colour	Flag combination
Right tibia	Green	ADV	Right tibia	Green	BAX	Right tibia	Orange	CHH
Right tibia	Green	ADW	Right tibia	Green	BBA	Right tibia	Green	DZ
Right tibia	Green	ADY	Right tibia	Green	BBD	Right tibia	Green	EH

Flagged leg	Flag colour	Flag combination	Flagged leg	Flag colour	Flag combination	Flagged leg	Flag colour	Flag combination
Right tibia	Green	AKV	Right tibia	Green	BC	Right tibia	Green	EN
Right tibia	Green	AKW	Right tibia	Green	BCB	Right tibia	Green	ET
Right tibia	Green	ALL	Right tibia	Green	BJN	Right tibia	Green	FA
Right tibia	Green	AND	Right tibia	Green	BJP	Right tibia	Green	FJ
Right tibia	Green	ANJ	Right tibia	Green	BKH	Right tibia	Green	FK
Right tibia	Green	ANP	Right tibia	Green	BKM	Right tibia	Green	FL
Right tibia	Green	ANU	Right tibia	Green	BM	Right tibia	Green	FM
Right tibia	Green	ANW	Right tibia	Green	BNZ	Right tibia	Green	FZ
Right tibia	Green	ANX	Right tibia	Green	BPU	Right tibia	Green	HA
Right tibia	Green	APB	Right tibia	Green	BRN	Right tibia	Green	JE
Right tibia	Green	APJ	Right tibia	Green	BRP	Right tibia	Green	JR
Right tibia	Green	APK	Right tibia	Green	BRS	Right tibia	Green	KN
Right tibia	Green	APU	Right tibia	Green	BRT	Right tibia	Green	NC
Right tibia	Green	AXU	Right tibia	Green	BRU	Right tibia	Green	NK
Right tibia	Green	AZS	Right tibia	Green	BRV	Right tibia	Green	NU
Right tibia	Green	AZT	Right tibia	Green	BRX	Right tibia	Green	NV
Right tibia	Green	AZU	Right tibia	Green	BRY	Right tibia	Green	NZ
Right tibia	Green	BAA	Right tibia	Green	BTA	Right tibia	Green	PM
Right tibia	Green	BAE	Right tibia	Green	BTK	Right tibia	Green	PV
Right tibia	Green	BAK	Right tibia	Green	BTL	Right tibia	Green	PX
Right tibia	Green	BAN	Right tibia	Green	BTT	Right tibia	Green	PY
Right tibia	Green	BAP	Right tibia	Green	BTY	Right tibia	Green	RM
Right tibia	Green	BAV	Right tibia	Green	BUD	Right tibia	Green	RP
Right tibia	Green	BAW	Right tibia	Green	BUH	Right tibia	Green	RR
						Right tibia	Green	RY

Table A4.2. Survey times in relation to the tides and weather conditions during the surveys at each of the survey sites.

Site	Date	Tide ht (m)	Tide time	Start time	End time	Cloud [1]	Rain [1]	Wind strength [1]	Disturbance observations	Comments
High tide										
Nandeebie	30/10/2014	2.2	14:20	15:00	15:10	0	0	2	No external disturbance	
Nandeebie	31/10/2014	2.2	15:27	15:25	15:35	1	0	3	No external disturbance	
Nandeebie	5/11/2014	2.3	8:49	8:20	8:30	1	0	1	No external disturbance	
Nandeebie	6/11/2014	2.4	9:05	9:30	9:45	0	0	1	No external disturbance	Whole of pan/saltmarsh flooded. Flock of shorebirds seen flying into pan prior to survey, but these had disappeared by the time the survey was conducted.
Nandeebie	21/11/2014	2.3	8:49	8:10	8:20	4	0	2	No external disturbance	Whole of pan/saltmarsh flooded. Godwits standing in water.
Nandeebie	25/11/2014	2.5	11:35	11:35	11:45	0	0	3	No external disturbance	Whole of pan/saltmarsh flooded.
Nandeebie	26/11/2014	2.4	12:20	12:45	13:10	0	0	3	No external disturbance	Whole of pan/saltmarsh flooded. Whimbrels standing in water, some bathing.
Nandeebie	27/11/2014	2.3	13:10	13:10	13:25	0	0	3	No external disturbance	Most of pan/saltmarsh flooded.
Nandeebie	8/12/2014	2.5	10:50	11:00	11:15	0	0	3	No external disturbance	Whole of pan/saltmarsh flooded.
Nandeebie	9/12/2014	2.4	11:26	11:45	11:55	0	0	2	No external disturbance	Most of pan/saltmarsh flooded.
Nandeebie	6/01/2015	2.5	10:30	10:35	10:45	2	0	5	No external disturbance	Whole of pan/saltmarsh flooded.
Nandeebie	8/01/2015	2.4	11:36	11:10	11:30	3	0	2	No external disturbance	Whole of pan/saltmarsh flooded.
Nandeebie	16/02/2015	2.4	7:37	8:30	9:00	1	0	2	No external disturbance	
Nandeebie	3/03/2015	2.3	8:29	9:00	9:25	1	0	3	No external disturbance	
Nandeebie	20/03/2015	1.6	9:40	9:30	9:40	4	0	1	No external disturbance	
Nandeebie	18/06/2015	1.9	10:48	11:10	11:15	0	0	1	No external disturbance	
Cassim Isl	6/11/2014	2.4	9:05	8:20	9:05	0	0	1	White-bellied Sea-eagle overflight	Sea-Eagle caused most Whimbrel to fly up and circle the mangroves, which facilitated count.
Cassim Isl	9/01/2015	2.3	12:08	11:15	11:45	4	1	3	No external disturbance	Short rain shower during survey did not affect survey
Cassim Isl	16/02/2015	2.4	7:37	7:55	8:20	1	0	2	No external disturbance	

Site	Date	Tide ht (m)	Tide time	Start time	End time	Cloud [1]	Rain [1]	Wind strength [1]	Disturbance observations	Comments
Cassim Isl	19/03/2015	2.6	8:53	10:10	10:45	0	0	3	No external disturbance	
Cassim Isl	18/06/2015	1.9	10:48	11:30	12:10	0	0	1	No external disturbance	
Low tide										
Toondah	31/10/2014	0.6	8:51	9:00	9:40	0	0	3	No external disturbance	Boats active at ferry terminal only; all birds except 7 Terek Sanpiper, 3 ibis & 1 darter north of ferry channel; 1 person at shoreline edge at GJ Walter Park.
Toondah	26/12/2014	0.4	6:30	6:10	7:00	4	0	2	No external disturbance	
Toondah	9/01/2015	0.5	5:46	5:10	5:40	1	0	1	No external disturbance	Birds south of ferry terminal: 4 B-t Godwit, 1 E Curlew, 2 Whimbrel, 42 Terek Sandpiper, 2 A Pied Oystercatcher, 2 Silver Gull
Toondah	24/02/2015	0.6	7:53	8:40	9:00	2	0	4	No external disturbance	Birds south of ferry terminal: 3 whimbrel, 1 Bar-tailed Godwit
Toondah	19/03/2015	0.3	15:33	16:00	16:30	0	0	3	No external disturbance	Birds south of ferry terminal: 26 Terek Sandpiper, 2 Whimbrel, 1 Red-necked Stint; 2 Silver Gull; 1 person at shoreline edge at GJ Walter Park
Toondah	18/06/2015	0.4	16:48	16:20	16:35	1	0	1	No external disturbance	Birds S of ferry terminal: 1 Whimbrel, 1 B-t Godwit, 1 Silver Gull; 2 people at shoreline edge at GJ Walter Park

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Re: Toondah Harbour: Preliminary Turbidity Analyses

This report by letter provides a summary of the turbidity data collected at Toondah Harbour between 9 September 2015 and 22 September 2017.

Summary of the Turbidity Logging Program

Potential impacts of excavation and dredging works on aquatic ecosystems include changes to water quality, and in particular increased suspended sediment in the water column. Increased loads of suspended sediments reduce the amount of light available to key sensitive receptors, such as seagrass and coral, negatively impacting photosynthesis. The distribution of seagrasses in western Moreton Bay is influenced by light availability, with the bottom of the seagrass depth range generally indicating the minimum light requirements.

The objective of the turbidity logging at Toondah Harbour was to provide a long term baseline of turbidity conditions, which can then be used to derive trigger levels for the proposed works. The turbidity data can also be used in the water quality modelling (when correlated with TSS data also collected in late 2015).

Turbidity was logged at three sites (Map 1):

- Logger 1 was located offshore of the PDA boundary (528776.42 m E; 6955817.37 m S): this site was selected to establish a baseline for turbidity in an area that may be impacted by reclamation of the PDA area, and is at the bottom edge of the seagrass.
- Loggers 2 and 3 were located near the Fison Channel (529220.27 m E; 6953925.39 m S; 530487.58 m E; 6954314.20 m S): these sites were selected to provide baseline data for the area that may be impacted by

dredging the channel. Both sites were at the bottom edge of seagrass, and there was also some sparse coral at Site 3.

Loggers were placed in a mounting structure that was secured in the sediment with star pickets (Figure 1). Equipment was clearly labelled with 'frc environmental Pty Ltd' and 'Permit number QS2014/CVL125' and was marked with a floating buoy. Loggers measured turbidity (NTU) generally every 15 minutes. Loggers were serviced approximately every 2 weeks, which involved downloading data, cleaning any biofouling, replacing batteries and calibrating the loggers.

Data logged between 9 September 2015 and 22 September 2017 was cleaned and analysed by Truii (refer to Appendix A). After cleaning there were between 51,542 and 57,275 individual turbidity readings for each of the three loggers.

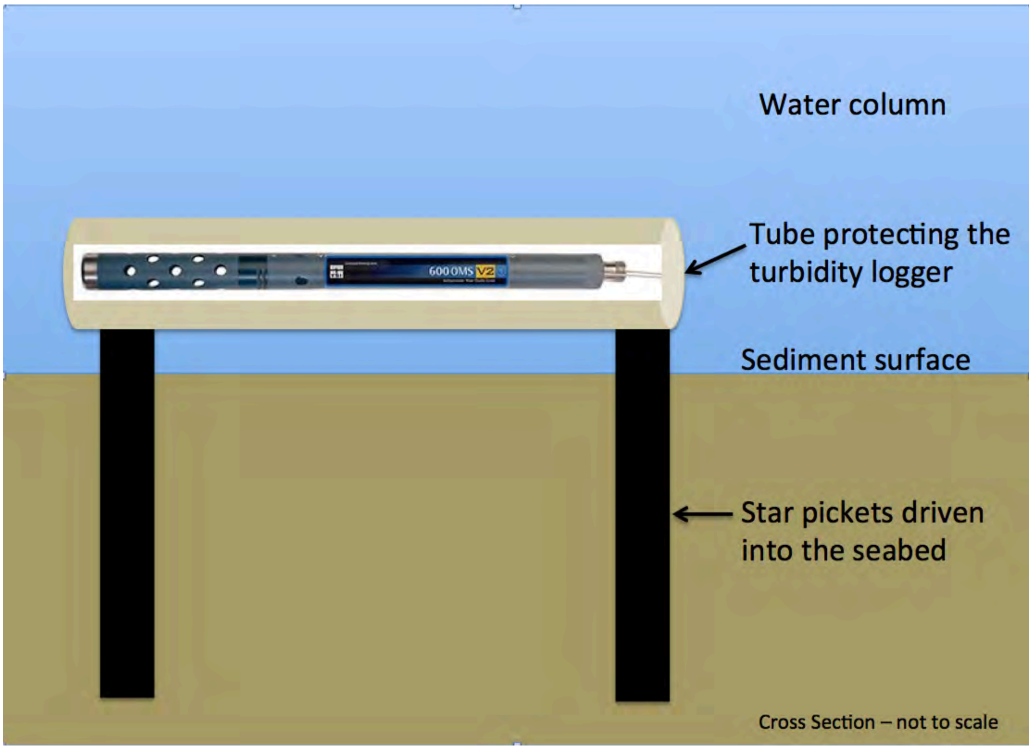

Figure.1 Cross section of turbidity logger placed in Toondah Habour.

Toondah Harbour
Installation and Maintenance of Loggers

Map 1:
Toondah Harbour loggers

LEGEND

Logger

SOURCES

Document Path: Y:\Projects\2015\150803_AEC_Toondah_turbidity\Mapping\Workspaces\150803_Logger_Locations_Sep16.mxd

frc environmental
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deep thinking. science.

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N

SCALE

0 100 200 400 600
Metres

Scale: 1:12,500 @ A3

PROJECTION
Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994

DATE
2016-09-26

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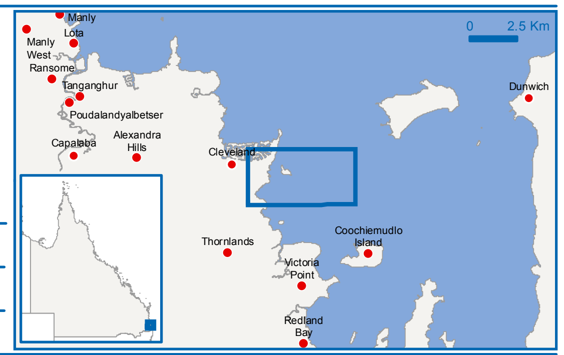

Summary of Data

The mean turbidity over the 24 months of sampling was lower at site 3 (12.6 NTU) than at sites 1 (20.6 NTU) and 2 (30.5 NTU). Overall, turbidity was generally highest during the wetter seasons of late spring and summer at all sites (Appendix A). During the wet season, sediment laden runoff and resuspension of sediments by strong winds can lead to a reduction in water clarity.

Water Quality Objectives

Water quality in Queensland is protected under the *Environmental Protection (Water) Policy 2009 (EPP (Water))* using Water Quality Objectives (WQOs). The *Moreton Bay Environmental Values and Water Quality Objectives (June 2010)* specifies a WQO for the project area (Area C2 on Plan WQ1441) for turbidity of 5 NTU. The median turbidity at all three sites over the 24 months (7.8 NTU to 11.1 NTU) exceeded the WQO. Turbidity at all three sites generally complied with the WQO in winter and exceeded the WQO during late spring and summer. Consequently, it is advisable to set local water quality objectives or trigger levels for this area, before development work starts. The *Queensland Water Quality Guidelines 2009* recommends that trigger levels should be based on data collected preferably over 24 months in order to capture two complete annual cycles. Data has been collected over 24 months at Toondah Harbour and thus can be used to calculate local trigger levels for the development. However, given data is currently still being logged at the three sites, it is advisable to calculate trigger levels on completion of the program when the loggers are removed to incorporate all available data.

Analysis of Data Regarding Ferry Movements

There is a visible increase in turbidity in Fison Channel associated with ferry movements. This has been observed by staff when downloading data from the loggers. Site 2 is located very close to Fison Channel. However there was no obvious relationship detected between ferry passing and turbidity levels at site 2.

Given turbidity levels can be visually seen as a result of the passing ferry, we recommend this is investigated further. This could be done by moving the position of the loggers to specifically target areas likely to be impacted by ferry movements and by recording passing ferries. This will assist in determining the likely impacts of the proposed works (i.e. deepening the channel is likely to reduce turbidity associated with ferry movements).

Consequently identifying the contribution of ferry movement to current turbidity levels will be a key consideration in assessing impacts from the proposed development.

Analysis of Data Regarding Tides, Rainfall and Wind

Typically turbidity in Moreton Bay is highest in the late spring and summer when strong south-east and north-east winds resuspend the sediment and rainfall is more prominent. However, there was no significant relationship between tide, rainfall or wind and turbidity when assessed throughout the 24 month period (Appendix A).

Conclusion

Turbidity is a measurement of water clarity and provides important information on the potential impact of dredge and reclamation works on the marine environment. Higher turbidity indicates reduced light reaching key benthic habitats, such as seagrass and coral.

Turbidity has been logged (approximately every 15 minutes) at three sites near seagrass and / or coral habitat near the proposed development at Toondah Habour over 24 months. The median turbidity over 24 month at all three sites exceeded the WQO, with median values generally compiling with the WQO in winter months and exceeding the WQO in late spring and summer months. During the wet season, sediment laden runoff and resuspension of sediments by strong winds are likely to lead to a reduction in water clarity. Consequently, it is advisable to set local trigger levels for this area before development work starts. Data has been collected over 24 months at Toondah Harbour and thus can be used to calculate local trigger levels in accordance with the *Queensland Water Quality Guidelines 2009* prior to the development.

Given turbidity levels can be visually seen as a result of the passing ferry, we recommend this is investigated to assist in determining the likely impacts of the proposed works, including whether deepening the channel is likely to reduce turbidity associated with ferry movements. This could be done by moving the position of the loggers to specifically target areas likely to be impacted by ferry movements and recording passing ferries.

Seagrass and coral survival and growth is related to the amount of light they receive, in particular the amount of photosynthetically active radiation (PAR). The amount of PAR light they receive is dependent on a number of factors including day length, cloud cover, surface light intensity, water depth, water colour and water clarity. While turbidity gives an indication of the amount of light available to seagrass it does not give an accurate measurement. To ensure the most appropriate minimum light requirements are established for the seagrass and coral habitat adjacent to Toondah Harbour, we recommend PAR is logged in addition to turbidity.

Kelli, if you have any further queries related to this data analyses, please let me know.

Yours sincerely,

Liz West
on behalf of frc environmental

Appendix A Detailed Statistical Analyses

Find the truth in your data

Cleveland Turbidity analysis

Prepared for FRC Environmental

21 October 2017

Dr Nick Marsh

Managing Director

0421 616 087

Nick.marsh@truii.com

1 Executive summary

There where statistically significant associations between all of the potential influencers of turbidity and the turbidity value, however the overall variability in turbidity explained by these parameters is low.

No correlations with predictive power between turbidity and environmental (rainfall, wind speed, tide height) or ferry passing were detected.

2 Background

FRC environmental commissioned Truii Pty Ltd to conduct analysis on three turbidity loggers located in Moreton Bay (near Cleveland). The brief was to investigate the relationship between turbidity levels and environmental factors (rainfall, wind speed and direction and tidal influence) as well as the impact that ferry's may have on turbidity levels. Specifically the turbidity for Logger 2, located near the ferry channel.

The following sections summarise the data collation, cleaning and analysis process. A summary of the data can be viewed at: https://truii.com/viz/PB45Z2 password is frc

3 Input data and preparation

3.1Supplied data - Turbidity

Data from three turbidity loggers was supplied. The turbidity data spans the period 9 September 2015 – 22 September 2017.

The turbidity data was cleaned based on the following procedures

- All negative turbidity values were removed.
- Isolated turbidity spikes above 50NTU were removed, where a spike was defined as exceeding the mean of the preceeding ten samples by a factor of 3 (see Figure 1).
- Specific periods where obvious drift occurred and data removed as noted in table.

Table 1: specific periods where data was removed due to apparent logger drift (extended elevated NTU records)

Start	end	logger	rationale
04 Oct 2015	10 Oct 2015	1	Consistently >500NTU
02/03/2016	12/03/2016	1	Drift period
19/04/2016	27/04/2016	1	Consistently >500NTU
1/9/2016	13/09/2016	1	
23/09/2016	11/10/2016	1	Elevated – doesn't return to baseline
03/11/2016	11/11/2016	1	Elevated – doesn't return to baseline
21/5/2017	1/7/2017	1	Elevated – doesn't return to baseline
22/12/2015	29/12/2015	2	Very high for several days
03/07/2016	15/07/16	2	drift
28/07/16	13/08/16	2	drift
2/3/17	10/4/17	3	Drift
29/6/17	21/7/17	3	drift

Even after the above data cleaning steps there are many very high spikes > 200NTU (especially for logger 2) which may need further investigation.

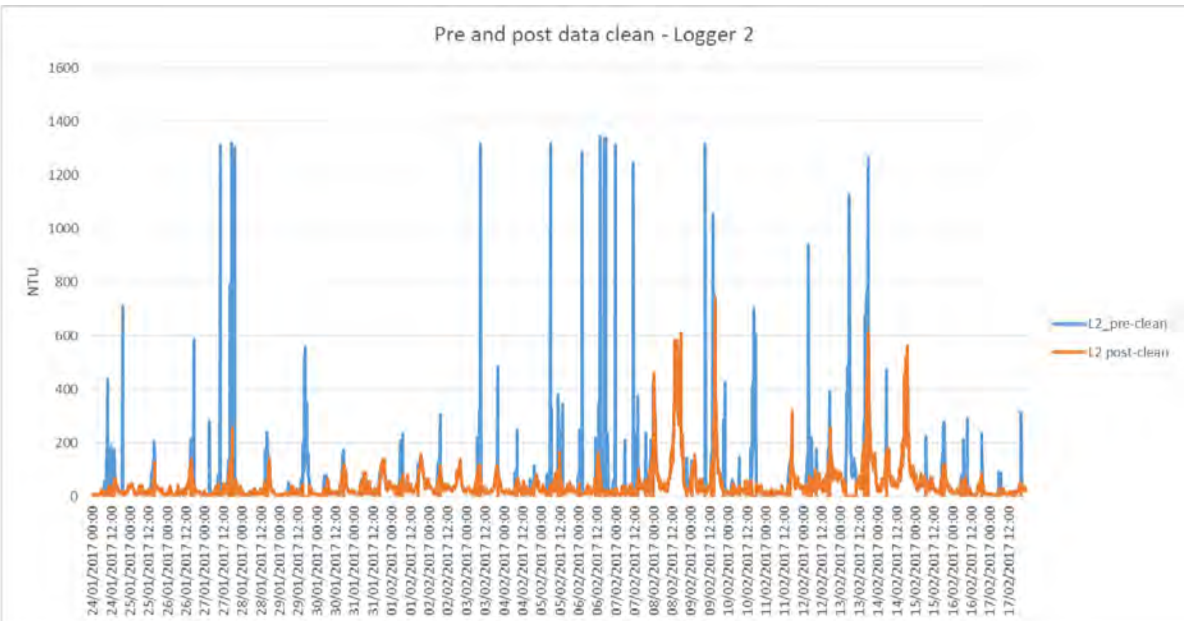

Figure 1: Example of unexplained peak NTU value removal for logger 2.

3.1.1 Turbidity data summary

After cleaning there were 50,000-57,000 individual turbidity samples for each of the three loggers (data summary in Table 3). The long term median turbidity value for the area was approximately

10NTU (Table 2). Logger 2 (near the ferry channel) had a similar median (baseline) but more and higher peaks demonstrated by the 95th percentile of 100NTU.

The coloured cells in Table 3show that there is a consistent temporal pattern across the three loggers (high months are high in all three loggers).

Table 2: long term turbidity values

	Logger1	Logger2	Logger3
Count	51542	57275	55375
Mean	20.6	30.5	12.6
StDev	31.1	81.0	19.5
median	9.7	11.1	7.8
95th%ile	74.9	100.0	40.4
5th%ile	1.2	0.9	0.8

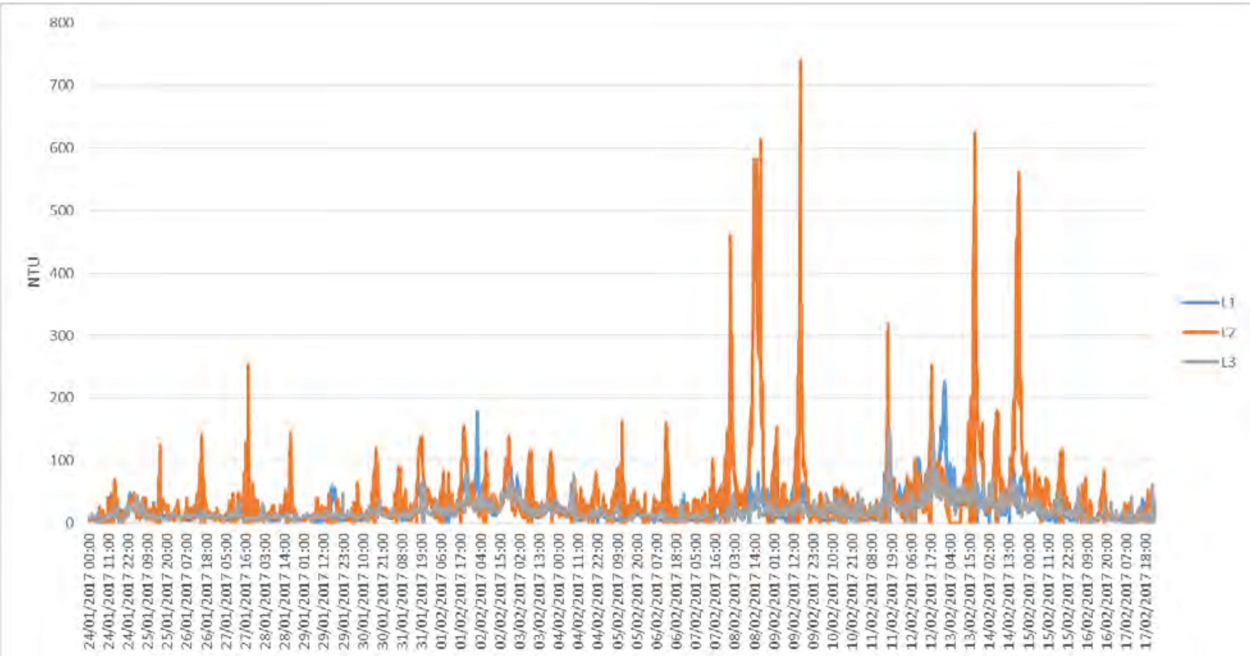

Figure 2: Example month sampling across three turbidity loggers (cleaned data).

Table 3: Cleaned turbidity data summary

Yr	mnth	Logger 1						Logger 2						Logger 3					
		n	Mean	StDev	median	95th%ile	5th%ile	n	Mean	StDev	median	95th%ile	5th%ile	n	Mean	StDev	median	95th%ile	5th%ile
Monthly summary																			
15	9	155	18.6	16.8	14.0	51.3	0.0	651	30.5	19.2	5.6	51.05	0.3	826	5.6	5.0	4.1	12.6	1.8
15	10	2071	21.2	31.0	11.1	69.1	3.5	2503	23.8	29.3	13.5	76.0	1.9	2448	11.2	17.9	6.4	36.2	0.9
15	11	2832	39.1	45.6	22.2	129.4	4.0	2694	39.0	50.4	22.0	137.9	5.5	2838	19.6	16.8	13.8	52.6	4.9
15	12	2857	25.6	34.5	14.8	79.8	4.7	2187	39.0	51.2	23.4	121.4	7.2	2918	16.9	13.4	12	46.2	6.1
16	1	2937	19.5	25.7	10.1	75.6	2.8	2734	20.5	26.8	10.8	69.4	1.7	2826	19.8	24.8	11.9	63.2	4.0
16	2	1555	27.3	23.2	18.1	76.4	5.5	2521	31.4	36.6	18.3	104.9	5	2715	16.1	12.8	12.5	44.9	5.6
16	3	1926	10.4	10.0	6.4	28.6	3.1	2610	11.7	14.6	6.9	37.3	1.4	2495	7.5	5.7	6.1	15.9	2.8
16	4	2067	12.3	10.9	8.6	32.5	3.8	2432	13.1	16.2	7.4	48.7	0.5	1830	4.8	5.0	3.3	14.1	0.9
16	5	1995	7.9	16.2	4.0	20.7	0.6	2882	7.0	11.2	2.9	30.5	0.4	2067	4.2	4.2	2.9	11.5	1.0
16	6	2796	10.2	24.8	3.4	40.0	0.8	2695	16.1	19.7	7.2	54.5	2.3	2850	3.7	6.2	1.6	15.8	0.2
16	7	2826	5.1	13.9	2.1	19.4	0.1	1345	12.0	16.2	4.8	45.2	0.6	2946	1.4	2.1	0.9	4.1	0.2
16	8	2916	5.5	6.1	3.4	18.4	0.6	1652	9.1	12.5	3.9	37.9	1.1	2949	6.8	14.7	2.5	48.2	0.5
16	9	927	31.1	30.9	21.9	96.2	3.2	2699	19.3	23.9	10.8	67.1	3.29	2595	21.0	60.2	5.9	78.4	2.0
16	10	1829	25.4	22.9	19.4	63.9	3.4	2797	18.5	24.6	11.1	58.0	2.4	2884	11.0	11.8	7.8	31.1	2.8
16	11	1889	29.1	39.8	13.0	109.2	2.1	2687	18.1	20.2	11.6	54.4	2.5	2111	14.2	12.5	10.1	41.8	3.6
16	12	2627	44.4	45.9	29.6	133.1	3.3	2474	56.6	70.8	37.7	164.1	1.665	2128	24.0	21.1	19.85	55.7	4.8
17	1	2613	29.7	31.0	19.5	90.7	3.9	2500	53.1	63.6	30.9	190.1	5.9	2602	19.9	14.9	15	48.0	5.9
17	2	2658	28.8	25.9	21.3	79.9	4.0	2332	190.5	300.1	42.4	924.2	8.7	2627	19.6	14.7	15.8	47.6	5.0
17	3	546	16.9	17.8	10.3	51.8	4.1	2643	51.0	106.9	15.8	212.9	2.6	86	15.6	5.5	14.9	25.7	8.3
17	4	2773	20.7	20.6	13.0	56.0	3.9	1759	46.5	64.0	20.4	180.9	1	1766	16.2	10.0	13.6	36.3	6.1
17	5	860	17.5	17.8	11.0	53.6	1.0	2710	12.3	17.1	6.1	48.7	1	2316	10.7	8.0	8.8	26.1	2.3
17	6	60	13.2	11.5	7.4	31.7	1.4	2768	8.6	12.6	3.5	35.3	0.3	2100	10.6	10.1	7.4	31.8	1.4
17	7	2947	7.0	10.9	3.6	27.3	0.7	1801	8.5	13.4	3.2	34.4	0.1	1039	6.9	9.1	4.1	24.4	1.5
17	8	2958	16.5	33.4	7.1	54.7	1.3	2434	9.5	13.5	3.9	38.0	0.2	1911	11.7	13.4	6.8	40.9	1.4

Yr	mnth	Logger 1						Logger 2						Logger 3					
		n	Mean	StDev	median	95th%ile	5th%ile	n	Mean	StDev	median	95th%ile	5th%ile	n	Mean	StDev	median	95th%ile	5th%ile
17	9	1930	29.4	56.5	11.4	121.2	2.4	767	18.1	25.8	9.4	55.6	0.6	1509	7.8	13.9	3	33.4	0.7
Annual Summary																			
15		7915	29.2	38.6	16.1	98.3	3.9	8035	32.2	44.1	18.4	105.7	2.7	9030	15.1	16.0	10.4	46.6	2.2
16		26290	17.7	27.9	7.6	70.3	0.9	29528	19.8	31.9	9.3	70.8	1.1	30396	11.1	22.8	5.6	38.3	0.6
17		17345	20.9	31.2	10.5	69.5	1.6	19714	45.8	127.8	11	182.0	0.6	15956	13.9	13.1	10.2	40.4	1.6

3.2Sourced and derived data

3.2.1 Wind Speed and direction

The wind speed and direction data for the Birsbane airport was sourced from the Bureau of Meterology. The last 14 months of daily summaries only is available (August 2016 – September 2017).

The maximum daily wind speed and direction was disaggregated to apply to all 15 minute time steps for the record. The wind direction was converted to four primary prevailing wind directions (N, E, S, W).

3.2.2 Rainfall

Daily rainfall data for the Brisbane Airport was used for the period august 2016-september 2017. The daily rainfall data for Cleveland (from SILO point drill) was used to represent rainfall from September 2015 – August 2016).

3.2.3 Ferry times

The possible passing of ferry times was based on the ferry timetables for the North Stradbroke Island vehicle ferry and the bay islands vehicle ferry (https://www.stradbrokeferries.com.au/timetables/). The arrival times for the North Stradbroke island vehicle ferry were estimated based on the Dunwich departure times +50 minutes as the advertised travel time.

In order to develop a time series represent when the ferries would pass logger 2 (which is 5 minutes travel time from the ferry terminal) each of the ferry arrival times was reduced by five minutes and each departure time was increased by five minutes. A data set was then created at the same 15minute time intervals as the turbidity logger data. Each record presents a score of potential ferry impact at the site. The scoring schema used was:

Score = 3 if ferry passed within 0-5 minutes of logger sample time

Score = 2 if ferry passed within 5-10 minutes of logger sample time

Score = 1 if ferry passed within 10-15 minutes of logger sample time

Score = 0 if ferry passed logger >15 minutes from sampling time

The ferry impact series takes account of the varying Ferry timetables for different days of the week (mon-thur, Fri, Sat, Sun). the ferry series does not take account of public holiday timetables.

3.2.4 Tidal data

The hourly measured Brisbane bar height (data sourced from https://uhslc.soest.hawaii.edu/data/?fd#uh331). The hourly water levels where linearly interpolated to give an approximate water level at the 15 minute turbidity sampling intervals.

Where low tide was specifically analysed, this has been assessed as the lower 1/3 of water levels across the analysis period.

4 Analysis

The basic approach for the analysis was to determine the impact if any of local ferry traffic on turbidity levels. The turbidity values are high variable through time. The first steps of this anslysis where therefore to identify and remove the effect of rainfall and wind induced wave action from the turbidity data. The residuals (turbidity not due to rainfall and wind) were then considered in terms of the potential contribution to the turbidity from local ferry movements (particularly at low tide).

4.1Effect of rainfall on Turbidity

The first consideration was to look at the effect of large rainfall events on the local turbidity either through major river outflows (multiple day impacts) or local stormwater impacts (single day). The overlay of rainfall timeseries and turbidity data showed no clear relationship (see Figure 3). Similarly a correlation test between rainfall and turbidity showed no significant relationship (slope of best fit not significantly different from zero (@P<0.05).

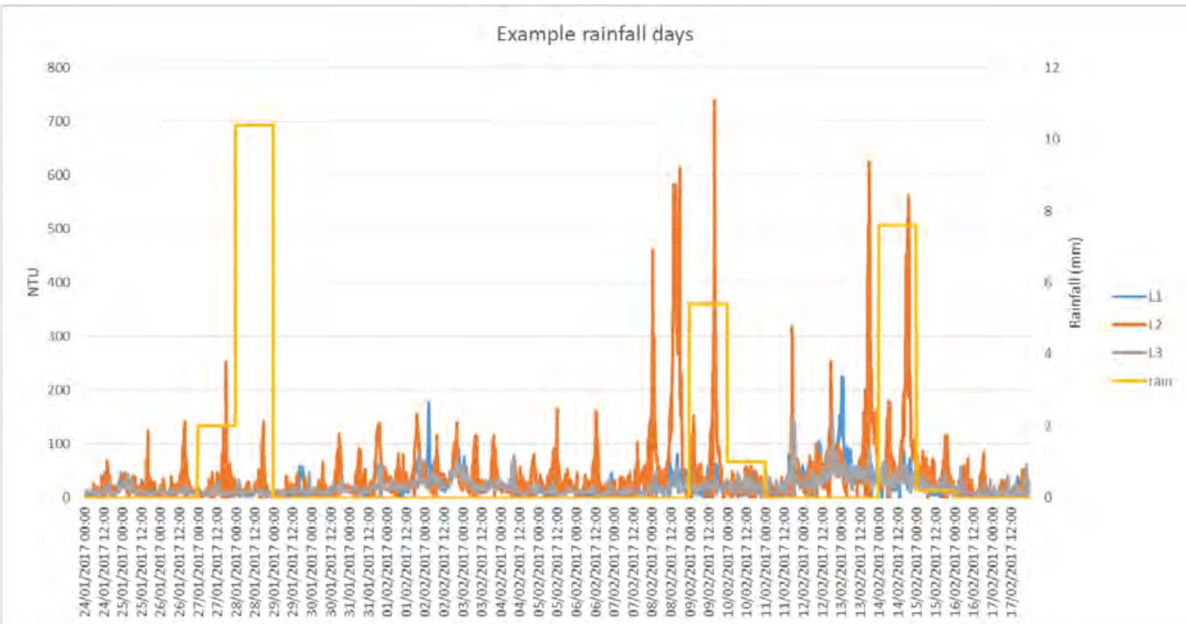

Figure 3: There is no discernible pattern between rainfall and the local turbidity values over the data collection period.

Given the low overall correlation between rainfall and turbidity, rainfall was not considered further in the analysis.

4.2Effect of wind direction

The dominant wind direction was divided into four wind quadrants (N, E, S, W) for the 13 month period of available wind data. For each of the prevailing wind direction subsets of data, the correlation between the speed of the maximum wind gust for the day and the logger2 turbidity values was tested.

Table 4 shows that the relationship between wind speed and turbidity for logger 2 was significant ($P<0.05$) for each quadrant, however the predictive power was very low (low R^2). The exception is the wind from the south which describes around 12% of the variance in turbidity. The reason for this higher correlation with southerlies is because the wind speed range for southerly was lower (max wind gust ~60km/h – compared to a 156km/h gust from the north).

To further explore the influence on wind direction and speed on turbidity, each of the four quadrant datasets was further subset to only include turbidity observations taken in the bottom third of the tide. The hypothesis here is that wind speed and direction is the primary driver of wave action in Moreton Bay. At low tide, the depth to the bay bed on average is reduced, increasing the opportunity for wave derived sediment resuspension during windy days. There was very little difference in the variance in turbidity explained by wind speed for the low tide subset data.

Given the low overall correlation between turbidity and wind the influence of wind direction and speed was not considered further.

Table 4: wind quadrant analysis summary

Wind Quadrant	Number of turbidity samples	Adjusted R2 for correlation	P value
N	12263	0.0264	1.64E-73
E	6277	0.01267	2.26E-19
S	8760	0.1245	1.8E-255
W	3071	0.030778	7.20E-23

4.3Tidal impact

One would expect a greater turbidity value at low tide, simply due to wave action interacting with the bed. Figure 4 shows a regular pattern of turbidity spike in logger 2. However this does not maintain an in-phase association with the tidal cycle. A regression analysis between water level and logger 2 turbidity gives a significant P value ($p<0.05$) however the variance in turbidity explained by water level is very low (R^2 0.011). We further partitioned the data to just look at this relationship for low tide (bottom 1/3 of the tidal cycle). The r2 was slightly improved but still very low (R^2 0.015)

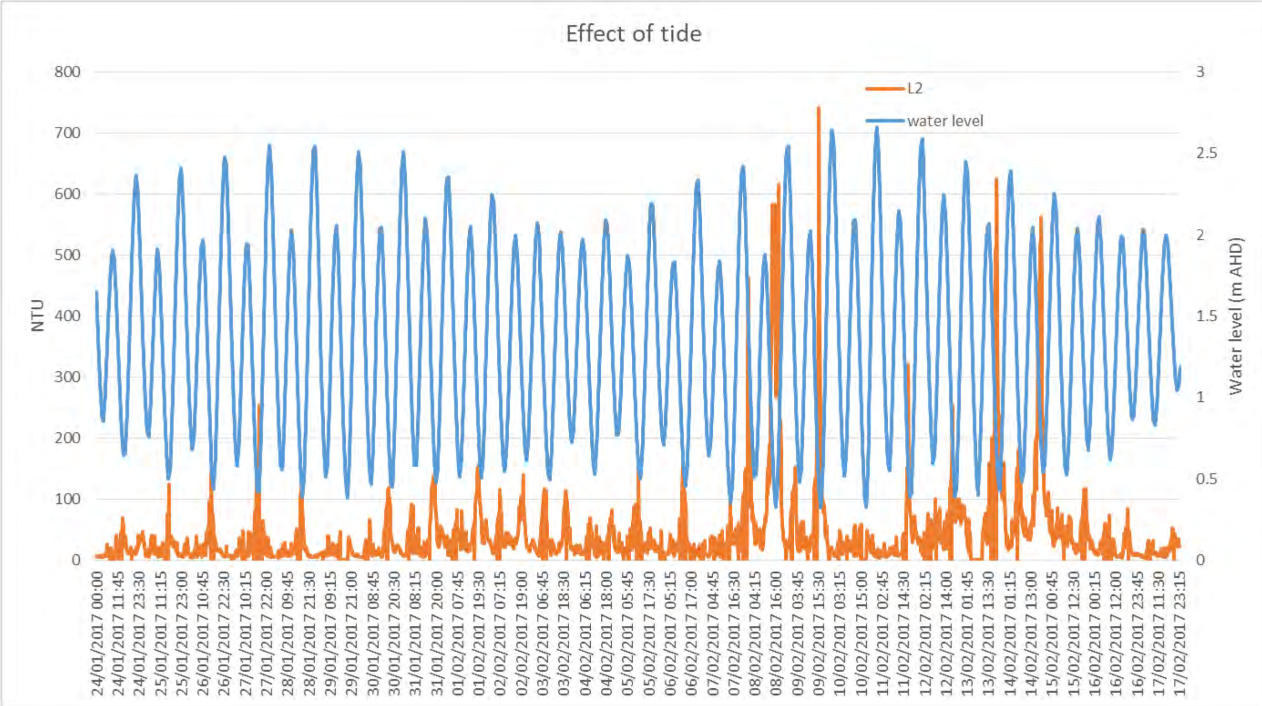

Figure 4: effect of tide on Logger 2 turbidity. Turbidity spikes roughly coincide with low tide, but there are several exceptions.

4.4Ferry impact

Logger 2 is located very close to the main ferry channel. This analysis is to consider how the turbidty values are correlated with the time since ferry passing. The purpose of the analysis is to determine if the ferries are significantly increasing the turbidity. From Figure 5 there is no obvious relationship between ferry passing and turbity levels. This is demonstrated by a correlation check (R^2 0.0015). Even if we only consider the low tide (bottom third of tidal range) then the effect of ferry passing only explains about 0.6% (R^2=0.006) of the variation in turbidity values.

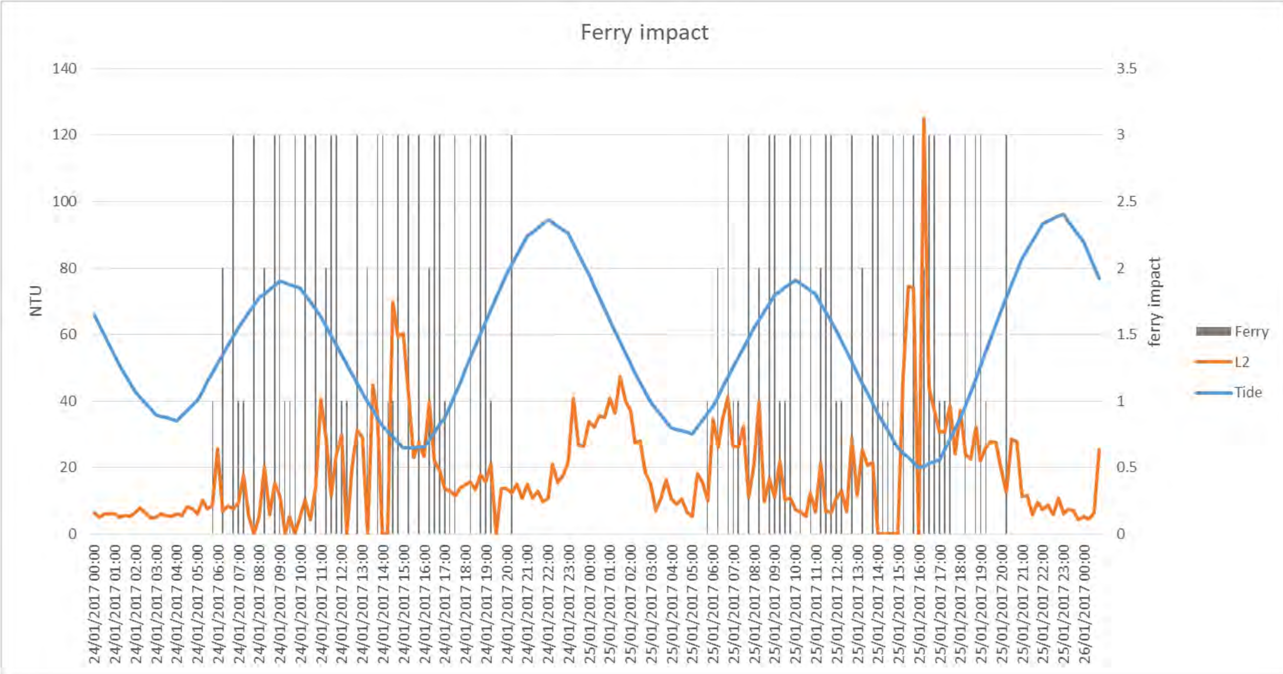

Figure 5: ferry impact (grey bars) shows no correlation with turbity. There appears to be no strong tidal influence.

Australian Government
Department of the Environment and Energy

FOI 180818
Document 12

Notification of
REFERRAL DECISION AND DESIGNATED PROPONENT – controlled action
DECISION ON ASSESSMENT APPROACH – environmental impact statement

Toondah Harbour Development, Queensland (EPBC 2018/8225)

This decision is made under section 75 and section 87 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

proposed action	The development of a mixed use residential, commercial, retail and tourism precinct, including new ferry terminals and a marina at Toondah Harbour south of Brisbane, Queensland, as described in the referral received by the Department on 4 June 2018 [see EPBC Act referral 2018/8225].
decision on proposed action	The proposed action is a controlled action. The project will require assessment and approval under the EPBC Act before it can proceed.
relevant controlling provisions	• Wetlands of international importance (sections 16 & 17B) • Listed threatened species and communities (sections 18 & 18A) • Listed migratory species (sections 20 & 20A)
assessment approach	The project will be assessed by environmental impact statement.
designated proponent	Walker Group Holdings Pty Limited ACN: 001 215 069

Decision-maker

Name and position	James Barker Assistant Secretary Assessments and Governance Branch
Signature	
date of decision	July 2018

Australian Government
Department of the Environment and Energy

EPBC Ref: 2018/8225

Senator the Hon Nigel Scullion
Minister for Indigenous Affairs
Parliament House
CANBERRA ACT 2600

Dear Minister

Decision on referral
Toondah Harbour development, Queensland

This is to advise you of my decision on the referral of the proposed action, to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane.

As a delegate of the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

The information that I have considered indicates that the proposed action is likely to have a significant impact on:

- Wetlands of international importance (sections 16 & 17B)
- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)

This decision only relates to the potential for significant impacts on matters protected by the Australian Government under Chapter 2 of the EPBC Act. Please note that the development of Toondah Harbour was previously referred as EPBC 2017/7939.

I have also decided that the project will need to be assessed by environmental impact statement. A copy of the document recording these decisions is enclosed.

Questions about the referral process or this decision, can be directed to the project manager, s22, by email to s22 @environment.gov.au, or telephone 02 6274 s22

Yours sincerely

James Barker
Assistant Secretary
Assessments and Governance Branch

July 2018

Australian Government
Department of the Environment and Energy

FOI 180818
Document 14

EPBC Ref: 2018/8225

Hon Steven Ciobo MP
Minister for Trade, Tourism and Investment
Parliament House
CANBERRA ACT 2600

Dear Minister

Decision on referral
Toondah Harbour development, Queensland

This is to advise you of my decision on the referral of the proposed action, to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane.

As a delegate of the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

The information that I have considered indicates that the proposed action is likely to have a significant impact on:

- Wetlands of international importance (sections 16 & 17B)
- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)

This decision only relates to the potential for significant impacts on matters protected by the Australian Government under Chapter 2 of the EPBC Act. Please note that the development of Toondah Harbour was previously referred as EPBC 2017/7939.

I have also decided that the project will need to be assessed by environmental impact statement. A copy of the document recording these decisions is enclosed.

Questions about the referral process or this decision, can be directed to the project manager, s22, by email to s22 @environment.gov.au, or telephone 02 6274 s22

Yours sincerely

James Barker
Assistant Secretary
Assessments and Governance Branch

July 2018

EPBC Ref: 2018/8225

Mr s22
Director
Impact Assessment and Operational Support
Department of Environment and Science
GPO Box 2454
BRISBANE QLD 4001

Dear Mr s22

Decision on referral
Toondah Harbour development, Queensland

This is to advise you of my decision on the referral of the proposed action, to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane.

As a delegate of the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

Please note that the development of Toondah Harbour was previously referred as EPBC 2017/7939. I note that the footprint of the proposed development is still substantially within the Moreton Bay Ramsar wetland site and the proposal includes the permanent removal of an area of the wetland though the excavation of a marina and approximately 32 hectares of land reclamation. The ecological character of this wetland is nationally and internationally protected under the Convention on Wetlands of International Importance (the Ramsar Convention).

The information that I have considered indicates that the proposed action is likely to have a significant impact on wetlands of international importance, and nationally listed threatened species and migratory species. I have also decided that the project will need to be assessed by environmental impact statement. A copy of the document recording these decisions is enclosed.

Although I have decided that the proposed action will be assessed under the EPBC Act, I note that significant challenges remain in regard to the approval of this project. In particular, the requirement, under section 138 of the EPBC Act, that when deciding whether or not to approve the taking of an action, the Minister must not act inconsistently with Australia's obligations under the Ramsar Convention. I would expect the more detailed environmental impact assessment process will consider these issues as well as other likely impacts of the proposal.

Questions about the referral process or this decision, can be directed to the project manager, s22, by email to s22 @environment.gov.au, or telephone 02 6274 s22

Yours sincerely

James Barker
Assistant Secretary
Assessments and Governance Branch

July 2018

Australian Government
Department of the Environment and Energy

FOI 180818
Document 16

EPBC Ref: 2018/8225

The Hon Cameron Dick
Minister for State Development, Manufacturing, Infrastructure and Planning
PO Box 15009
CITY EAST QLD 4002

Dear Minister

Decision on referral
Toondah Harbour development, Queensland

This is to advise you of my decision on the referral of the proposed action, to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane.

As a delegate of the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

Please note that the development of Toondah Harbour was previously referred as EPBC 2017/7939. I note that the footprint of the proposed development is still substantially within the Moreton Bay Ramsar wetland site and the proposal includes the permanent removal of an area of the wetland though the excavation of a marina and approximately 32 hectares of land reclamation. The ecological character of this wetland is nationally and internationally protected under the Convention on Wetlands of International Importance (the Ramsar Convention).

The information that I have considered indicates that the proposed action is likely to have a significant impact on wetlands of international importance, and nationally listed threatened species and migratory species. I have also decided that the project will need to be assessed by environmental impact statement. A copy of the document recording these decisions is enclosed.

Although I have decided that the proposed action will be assessed under the EPBC Act, I note that significant challenges remain in regard to the approval of this project. In particular, the requirement, under section 138 of the EPBC Act, that when deciding whether or not to approve the taking of an action, the Minister must not act inconsistently with Australia's obligations under the Ramsar Convention. I would expect the more detailed environmental impact assessment process will consider these issues as well as other likely impacts of the proposal.

I have also written to Queensland Minister for Environment and the Great Barrier Reef, Minister for Science and Minister for the Arts, the Hon Leeanne Enoch MP, to advise her of my decision.

Questions about the referral process or this decision, can be directed to the project manager, s22, by email to s22 @environment.gov.au, or telephone 02 6274 s22

Yours sincerely

James Barker
Assistant Secretary
Assessments and Governance Branch

July 2018

EPBC Ref: 2018/8225

Mr Peter Saba
General Manager – Queensland Developments
Walker Group Holdings Pty Ltd
GPO Box 652
BRISBANE QLD 4000

Dear Mr Saba

Decision on referral
Toondah Harbour development, Queensland

I am writing to advise you of my decision in relation to the Toondah Harbour Development, Queensland (EPBC 2018/8225) proposed by Walker Group Holdings Pty Ltd, which was referred for consideration under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

I note that the footprint of the proposed development is still substantially within the Moreton Bay Ramsar wetland site and includes the permanent removal of an area of the wetland though the excavation of a marina and approximately 32 hectares of land reclamation. The ecological character of this wetland is nationally and internationally protected under the Convention on Wetlands of International Importance (the Ramsar Convention).

I have decided under section 75 of the EPBC Act that the proposed action is a controlled action and, as such, it requires further assessment and a decision about whether approval for it should be given under the EPBC Act. The information that I have considered indicates that the proposed action is likely to have a significant impact on the following matters protected by the EPBC Act:

- Wetlands of international importance (sections 16 & 17B)
- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)

A copy of the document recording this decision is enclosed. Please note that this decision only relates to the potential for significant impacts on matters protected by the Australian Government under Chapter 2 of the EPBC Act.

Although I have decided that the proposed action will be assessed under the EPBC Act, I note that significant challenges remain in regards to the approval of this project. In particular, the requirement, under section 138 of the EPBC Act, that when deciding whether or not to approve the taking of an action, the Minister must not act inconsistently with Australia's obligations under the Ramsar Convention. I would expect the more detailed environmental impact assessment process will consider these issues and other likely impacts of the proposal.

I have also decided that the project will need to be assessed by environmental impact statement. I would expect we will work closely the state to ensure that the EPBC Act and state assessment processes are progressed in a consistent manner as far as possible. We will contact you to discuss the terms of reference for the assessment which reflect this intent.

I note that the Department has been advised by Queensland officials that the proposal may also be assessed under the Queensland *Marine Parks Act 2004.* As this is not a process accredited under the assessment Bilateral Agreement, this assessment will be progressed by the state independently.

Please note, under subsection 520(4A) of the EPBC Act and the *Environment Protection and Biodiversity Conservation Regulations 2000*, your assessment is subject to cost recovery. Please find attached a copy of the fee schedule for your proposal and an invoice for Stage 1. Fees will be payable prior to each stage of the assessment proceeding. Further details on cost recovery are available on the Department's website at: www.environment.gov.au/epbc/cost-recovery.

If you disagree with the fee schedule provided, you may apply under section 514Y of the EPBC Act for reconsideration of the method used to work out the fee. The application for reconsideration must be made within 30 business days of the date of this letter and can only be made once for a fee. Further details regarding the reconsideration process can be found on the Department's website at: www.environment.gov.au/protection/environment-assessments/assessment-and-approval-process/refer-proposed-action.

If you have any questions about the referral process or this decision, please contact the project manager, s22, by email to s22 @environment.gov.au, or telephone 02 6274 s22

Yours sincerely

James Barker
Assistant Secretary
Assessments and Governance Branch

July 2018

Australian Government
Department of the Environment and Energy

EPBC Act Cost Recovery - Fee Schedule

EPBC No: 2018/8225 Date of Fee Schedule: July 10, 2018
Project title: Toondah Harbour
Assessment method: Environmental Impact Statement

Fee Schedule

STAGE FEES	Base fee	PART A Complexity costs (A-L, P)	PART B Complexity costs (MNO)	Total
Stage 1	$4,715	$92,007	$0	$96,722
Stage 2	$5,394	$145,678	$0	$151,072
Stage 3	$7,119	$153,345	$121,010	$281,475
Stage 4	$8,355	$375,697	$121,010	$505,062
TOTAL PROJECT COST	$25,583	$766,729	$242,021	$1,034,333

Notes:

- For assessments by environmental impact statement - If standard guidelines are used under Section 101A(2)(a) of the EPBC Act, the Stage 1 fee will not be applicable.
- For assessments by public environmental report - If standard guidelines are used under Section 96B of the EPBC Act, the Stage 1 fee will not be applicable.
- If no further information is requested under section 95A of the EPBC Act, the Stage 1 and 2 fees will not be applicable.
- The Department advises applicants of the maximum liability for Part B complexity fees at the time of the assessment approach decision, based on the information provided in the referral documentation. Applicants have the opportunity to reduce the Part B complexity fees during the assessment process by improving the quality of information provided to the Department during Stage 2 of the assessment. These Part B complexity fees are confirmed when all the assessment documentation is provided in Stage 2, and are not payable until Stages 3 and 4 of the assessment.

Fee Breakdown

		COMPLEXITY FEE	
	CONTROLLING PROVISIONS		
Part A Fees	A Listed threatened species and ecological communities	Very High	$48,931
	B Listed migratory species	High	$25,615
	C Wetlands of international importance	Very High	$48,931
	D Environment of the Commonwealth marine area	None	$0
	E World heritage properties	None	$0
	F National heritage places	None	$0
	G Nuclear actions	None	$0
	H Great Barrier Reef Marine Park	None	$0
	I Water Resources	None	$0
	J Commonwealth Land/Commonwealth Agency/Commonwealth Heritage Places Overseas	None	$0
	NUMBER OF PROJECT COMPONENTS		
	K Number of project components	High	$51,166
	COORDINATION WITH OTHER LEGISLATION		
	L Coordination with other legislation	Low	$0
Part B Fees:	**ADEQUACY OF INFORMATION AND CLARITY OF PROJECT SCOPE**		
	M Site surveys/Knowledge of environment	Very High	$84,311
	N Management measures (including mitigation and offsets)	Very High	$95,311
	O Project scope	Very High	$62,399
Exceptional circumstances	**EXCEPTIONAL CIRCUMSTANCES**		
	P Exceptional circumstances	True	$592,086
TOTAL COMPLEXITY FEES			$1,008,750
BASE FEE			$25,583
TOTAL FEE			$1,034,333

Potential fees for contingent and post-approval activities (if required)

The Department will notify you if a contingent activity fee is applicable due to an additional statutory step being required under the *Environment Protection and Biodiversity Conservation Act 1999*.

Post-approval fees

Evaluation of new Action Management Plan (per management plan) ($2,690)

Contingent Fees

Request additional information for referral or assessment approach decision ($1,701)
Variation to the proposed action ($1,353)
Reconsideration of the controlled action or assessment approach decision at the applicant's request ($6,577)
Request additional information for approval decision (assessment on referral information, preliminary documentation or bilateral/accredited assessment) ($1,701)
Request additional information for approval decision (assessment by environmental impact statement or public environment report) ($7,476)
Variation of conditions ($2,690)
Variation of an action management plan under conditions of approval ($2,690)
Administrative variation of an action management plan under conditions of approval ($710)
Transfer of approval to new approval holder ($1,967)
Extension to approval expiry date ($2,690)

FOI 180818
Document 19

Australian Government
Department of the Environment and Energy

EPBC Act Cost Recovery - Fee Schedule

EPBC No: 2018/8225

Date of Fee Schedule: July 10, 2018

Project title: Toondah Harbour

Assessment method: Environmental Impact Statement

Fee Schedule

STAGE FEES	Base fee	PART A Complexity costs (A-L, P)	PART B Complexity costs (MNO)	Total
Stage 1	$4,715	$92,007	$0	$96,722
Stage 2	$5,394	$145,678	$0	$151,072
Stage 3	$7,119	$153,345	$121,010	$281,475
Stage 4	$8,355	$375,697	$121,010	$505,062
TOTAL PROJECT COST	$25,583	$766,729	$242,021	$1,034,333

Notes:

- For assessments by environmental impact statement - If standard guidelines are used under Section 101A(2)(a) of the EPBC Act, the Stage 1 fee will not be applicable.
- For assessments by public environmental report - If standard guidelines are used under Section 96B of the EPBC Act, the Stage 1 fee will not be applicable.
- If no further information is requested under section 95A of the EPBC Act, the Stage 1 and 2 fees will not be applicable.
- The Department advises applicants of the maximum liability for Part B complexity fees at the time of the assessment approach decision, based on the information provided in the referral documentation. Applicants have the opportunity to reduce the Part B complexity fees during the assessment process by improving the quality of information provided to the Department during Stage 2 of the assessment. These Part B complexity fees are confirmed when all the assessment documentation is provided in Stage 2, and are not payable until Stages 3 and 4 of the assessment.

Fee Breakdown

			COMPLEXITY	FEE
		CONTROLLING PROVISIONS		
Part A Fees	A	Listed threatened species and ecological communities Management of impacts not well understood	Very High	$48,931
	B	Listed migratory species Management of impacts not well understood	High	$25,615
	C	Wetlands of international importance Management of impacts not well understood	Very High	$48,931
	D	Environment of the Commonwealth marine area Not applicable.	None	$0
	E	World heritage properties Not applicable.	None	$0
	F	National heritage places Not applicable.	None	$0
	G	Nuclear actions Not applicable.	None	$0
	H	Great Barrier Reef Marine Park Not applicable.	None	$0
	I	Water Resources Not applicable.	None	$0
	J	Commonwealth Land/Commonwealth Agency/Commonwealth Heritage Places Overseas Not applicable.	None	$0
		NUMBER OF PROJECT COMPONENTS		
	K	Number of project components Dredging of Fison Channel Construction of marina Construction of residential/commercial buildings	High	$51,166
		COORDINATION WITH OTHER LEGISLATION		

			COMPLEXITY	FEE
	L	Coordination with other legislation	Low	$0
		ADEQUACY OF INFORMATION AND CLARITY OF PROJECT SCOPE		
Part B Fees:	M	Site surveys/Knowledge of environment Preliminary surveys have been undertaken.	Very High	$84,311
	N	Management measures (including mitigation and offsets) Management of impacts not understood, untested and technical review may be required.	Very High	$95,311
	O	Project scope Although no alternatives have been provided, it is likely that the design and scope of the project will change through the assessment period.	Very High	$62,399
		EXCEPTIONAL CIRCUMSTANCES		
Exceptional circumstances	P	Exceptional circumstances The impacts to wetlands of international importance and migratory shorebirds will be very hard to mitigate or offset	True	$592,086
TOTAL COMPLEXITY FEES				$1,008,750
BASE FEE				$25,583
TOTAL FEE				$1,034,333

Potential fees for contingent and post-approval activities (if required)

The Department will notify you if a contingent activity fee is applicable due to an additional statutory step being required under the *Environment Protection and Biodiversity Conservation Act 1999*.

Post-approval fees

Evaluation of new Action Management Plan (per management plan) ($2,690)

Contingent Fees

Request additional information for referral or assessment approach decision ($1,701)

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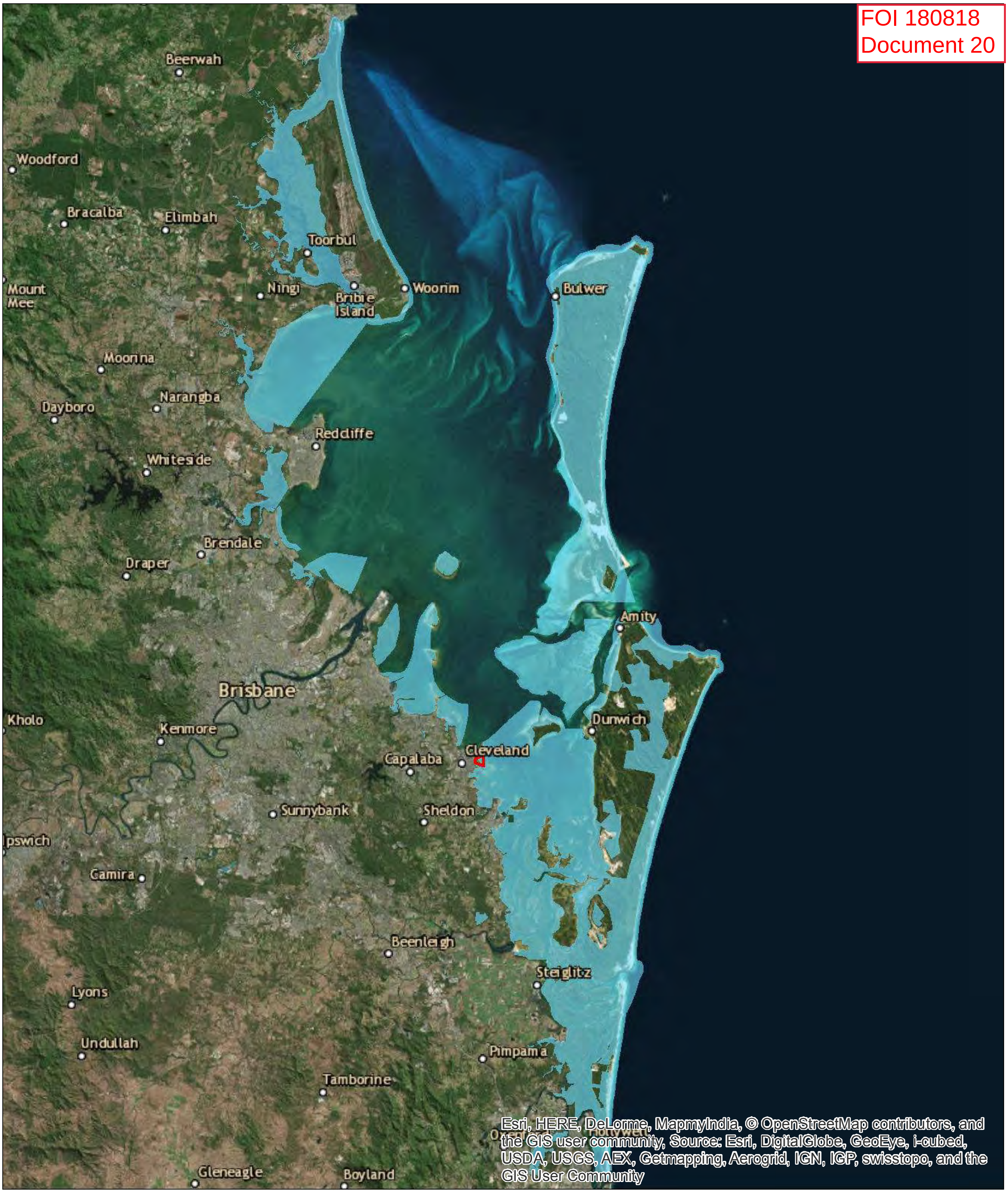

Legend

PDA - Toondah Harbour

Moreton Bay RAMSAR wetland

Figure 1 *Site Context*

File ref. 8444 E Site Context A
Date *20/04/2017*
Project *Toondah Harbour*

0 5 10 20 *Kilometers*

N

Scale (A4): 1:575,379 [GDA 1994 MGA Z56]

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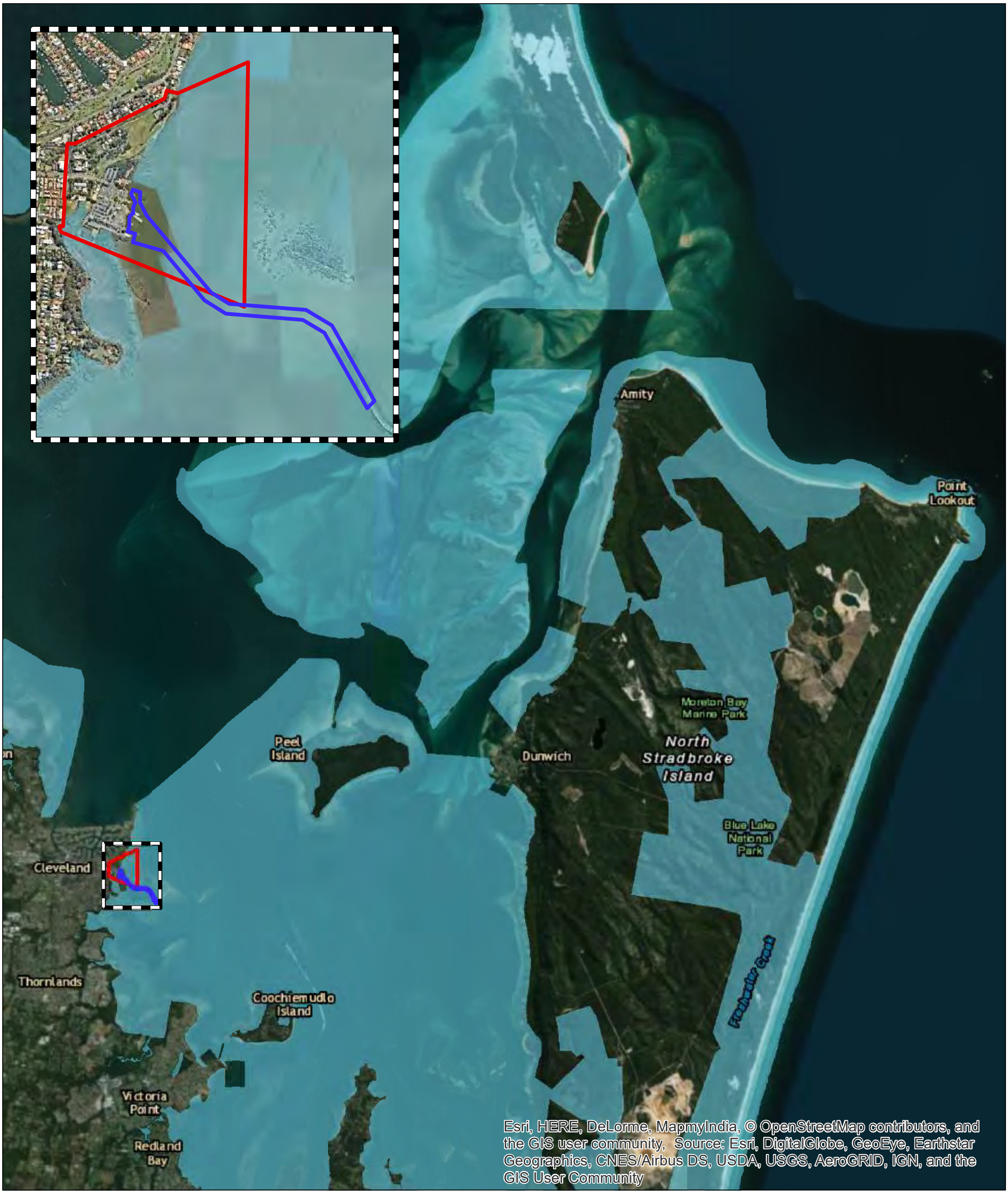
Layer Sources QLD GIS Layers (QLD Gov. Information Service 2014)



Legend

PDA - Toondah Harbour

Approved dredge area

Moreton Bay RAMSAR wetland

Figure 1a *Site Context*

File ref. *8444_E_01_Context_approved_DA_A*
Date *4/05/2018*
Project *Toondah Harbour*

0 1 2 3 4 5 6 *km*

Scale (A4): 1:160,000 [GDA 1994 MGA Z56]

N

walker

saunders havill group

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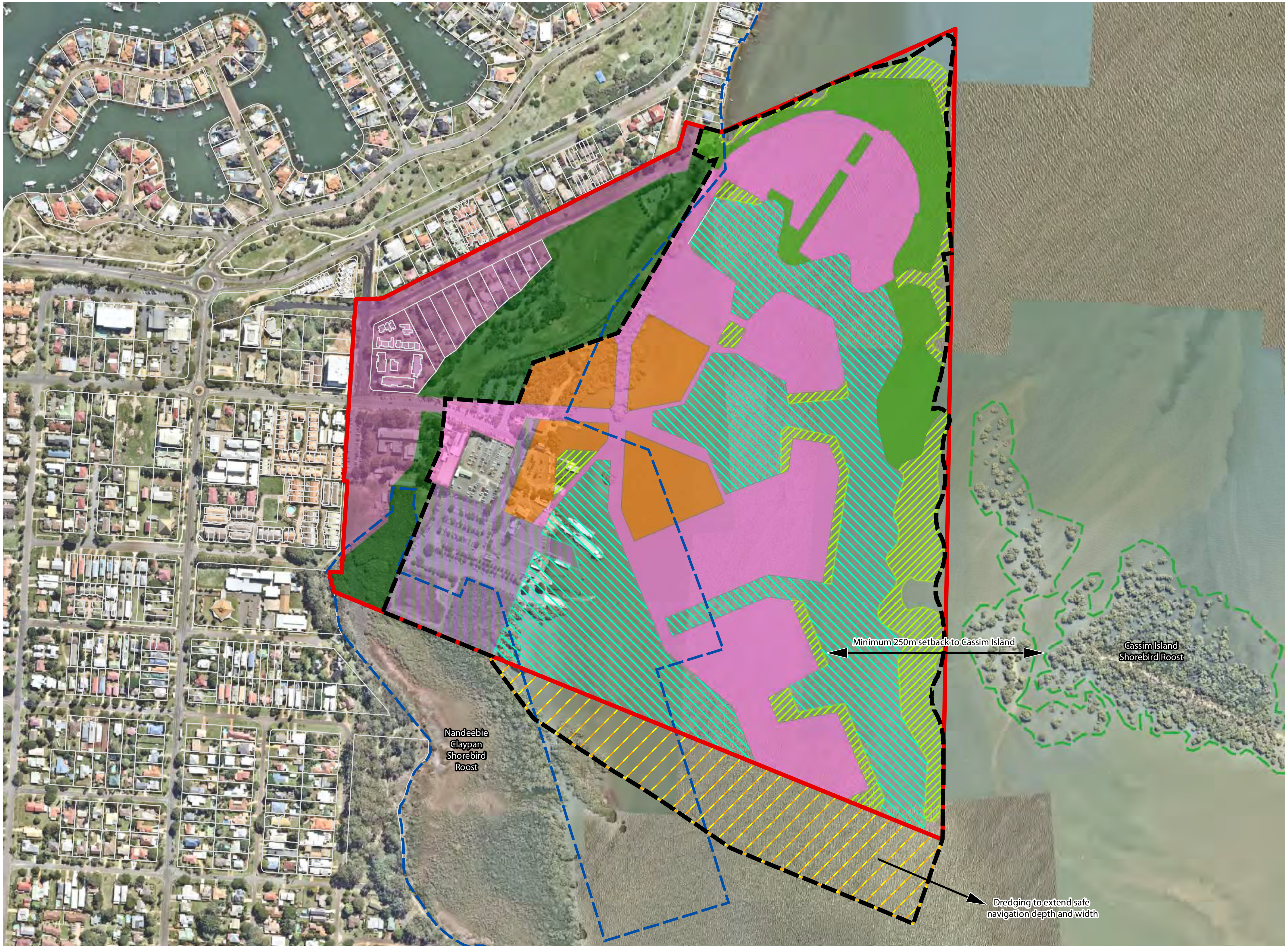
Layer Sources QLD GIS Layers (QLD Gov. Information Service 2018)

2. MASTER PLAN - BROAD LAND USES



NOTES
This plan was prepared as a desktop assessment tool.
The information on this plan is not suitable for any other purpose.
Property dimensions, areas, numbers of lots and contours and other physical features shown have been compiled from existing information and may not have been verified by field survey. These may need verification if the development application is approved and development proceeds, and may change when a full survey is undertaken or in order to comply with development approval conditions. No reliance should be placed on the information on this plan for detailed design or for any financial dealings involving the land. Saunders Havill Group therefore disclaims any liability for any loss or damage whatsoever or howsoever incurred, arising from any party using or relying upon this plan for any purpose other than as a document prepared for the sole purpose of accompanying a development application and which may be subject to alteration beyond the control of the Saunders Havill Group. Unless a development approval states otherwise, this is not an approved plan.

Layer Sources
Qld State Cadastre and Mapping layers © State of Queensland (Department of Natural Resources and Mines) 2018. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//
Aerial Imagery © Nearmap, 2017

* This note is an integral part of this plan/data. Reproduction of this plan or any part of it without this note being included in full will render the information shown on such reproduction invalid and not suitable for use.

Legend

- Toondah Harbour PDA
- Referral Area
- Indicative Entrance Channel
- QLD DCDB
- Ramsar Wetland Boundary
- Mangroves

Broad Land Uses

- Mixed use centre
- Urban uses & wetlands (including walkways, pocket parks & communal spaces)
- Existing Infrastructure and Buildings
- Wetland Retention and Rehabilitation
- Open Space
- Retained Open Space & Intertidal Communities
- Upgraded Harbour
- Waterways

Issue	Date	Description	Drawn	Checked
A	14/03/2018	Preliminary	MC	SM
F	30/05/2018	Lodgement	MC	SM

0 25 50 100 150 200 m

Transverse Mercator | GDA 1994 | Zone 56 | 1:5,500 @ A3

saunders havill group

walker

TOONDAH HARBOUR, CLEVELAND

ADDRESS/RPD: TOONDAH HARBOUR PDA 30/05/2018 8444_01_broad_land_uses_F

A part of BMT in Energy and Environment

FOI 180818
Document 21

BMT WBM

"Where will our knowledge take you?"

Moreton Bay
Ecological Character Description

Final Report

December 2008

Queensland Government
Environmental Protection Agency

Ecological Character Description – Moreton Bay Ramsar Site

FINAL REPORT

Offices

Brisbane
Denver
Karratha
Melbourne
Newcastle
Perth
Sydney
Vancouver

Prepared For:	Queensland Environmental Protection Agency
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

DOCUMENT CONTROL SHEET

BMT WBM Pty Ltd BMT WBM Pty Ltd Level 11, 490 Upper Edward Street Brisbane 4000 Queensland Australia PO Box 203 Spring Hill 4004 Tel: +61 7 3831 6744 Fax: + 61 7 3832 3627 ABN 54 010 830 421 www.wbmpl.com.au	**Document :** R.B17004.001.03 **Project Manager :** Greg Fisk **Client :** Queensland Environmental Protection Agency **Client Contact:** s22 **Client Reference**

Title :	Ecological Character Description – Moreton Bay Ramsar Site
Author :	Greg Fisk, Darren Richardson, s47F , s47F , s47F , s47F r, s47F
Synopsis :	This report comprises the Ecological Character Description (ECD) for the Moreton Bay Ramsar site. Prepared in accordance with the draft National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands, the report identifies the critical services, components and processes of the site and identifies limits of acceptable change, knowledge gaps and monitoring requirements in relation to these critical elements.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	30 May 2008		ABM		GWF
1	14 July 2008		DLR		GWF
2	24 October 2008		DLR		GWF
3	12 December 2008		DLR		GWF

DISTRIBUTION

DESTINATION	REVISION			
	0	1	2	3
Queensland EPA	1 (1 Electronic)	1 (1 Electronic)	1 (1 Electronic)	1 (1 Electronic)
BMT WBM File	-	1	1	1
BMT WBM Library	PDF	PDF	PDF	PDF

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ACKNOWLEDGEMENTS

This report was prepared by BMT WBM Pty Ltd with expert input from Austecology Pty Ltd (fauna) and Converge Heritage + Community Pty Ltd (cultural heritage) under contract to the Queensland Environmental Protection Agency (EPA). The consultant project team wish to express their thanks to EPA's project manager, Gay Deacon and members of the Inter-Governmental Steering Group formed for the project for their assistance and guidance. We would also like to recognise and thank the members of the Knowledge Management Committee convened for the project and the scientists of the Healthy Waterways Scientific Expert Panel (SEP) whom provided invaluable advice and guidance about the identification of critical wetland processes, habitat and species limits of acceptable change, information gaps and monitoring priorities. Appendix A contains a list of members of these committees.

Photos that appear in the Report are supplied by BMT WBM or the Queensland Environmental Protection Agency unless otherwise noted. Figures that have been reproduced (without modification) from other sources have been referenced accordingly.

Disclaimer: In undertaking this work the authors have made every effort to ensure the accuracy of the information used. Any conclusions drawn or recommendations made in the report are done in good faith and take no responsibility for how this information and report are used subsequently by others. Note also that the views expressed, and recommendations provided in this report are those of the report authors and do not necessarily reflect those of the persons or organisations that have contributed their views or other materials.

Use of terms and information sources: All definitions and terms used in this report were correct at the time of production in October 2008. The version of the *Draft National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* used in preparing this ECD was dated January 2008.

Within this report, the conservation status of a species may be described as *endangered, vulnerable, rare, migratory, near threatened* or *least concern wildlife*. These terms are used in accordance with the provisions of the Queensland *Nature Conservation Act 1992* (NC Act) and its regulations and amendments, and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Threatened is a common term used to collectively describe *Endangered* and *Vulnerable* species.

The terms *shorebirds* and *waders* are generic terms used to describe both resident and migratory species from the following families: Scolopacidae; Burhinidae; Haematopodidae; Recurvirostridae; Charadriidae; and Glareolidae.

The term waterbird refers to waterbird species found predominantly on freshwater ecosystems in Australia from the six major orders Anseriformes (ducks, geese and Black Swan), Podicipediformes (grebes), Pelecaniformes (Australian Pelican and cormorants), Ciconiiformes (herons, ibis, spoonbills and bitterns), Gruiformes (cranes, rails, crakes and gallinules), and Charadriiformes (waders and terns) (after Kingsford & Norman 2002).

Citation: When finalised, this report can be cited as follows:

BMT WBM. (2008). Ecological Character Description of the Moreton Bay Ramsar Site. Prepared for the Queensland Environmental Protection Agency. Brisbane.

LIST OF ABBREVIATIONS:

ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
CAMBA:	China-Australia Migratory Bird Agreement
CEA	Community, Education and Awareness
CFISH	Commercial Fisheries Information System
CPUE	Catch per unit effort
CRL	Consolidated Rutile Limited
DEWHA	Department of Environment, Water, Heritage and the Arts
DPI&F:	Queensland Department of Primary Industries and Fisheries
EAC:	East Australian Current
ECD:	Ecological Character Description
EFO	Environmental Flow Objective
EHMP:	Ecosystem Health Monitoring Program
EPA:	Queensland Environmental Protection Agency
EPBC:	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FHA	Fish Habitat Area
GAP	Global Action on Peatlands
GBRMPA	Great Barrier Reef Marine Park Authority
GCCC	Gold Coast City Council
HAT:	Highest Astronomical Tide
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IUCN	International Union for Conservation of Nature
JAMBA:	Japan-Australia Migratory Bird Agreement
KMC:	Knowledge Management Committee
LAT:	Lowest Astronomical Tide
LAC:	Limit(s) of Acceptable Change
LTMP, CFISH, RFISH	Long Term Monitoring Program
MARPOL	International Convention for the Prevention of Pollution from Ships
MBSIA EMS	Moreton Bay Seafood Industry Association Environmental Management Sytstem
MHWS:	Mean High Water Springs
MNP	Marine National Park
NCA:	Queensland *Nature Conservation Act 1992*
NCR:	Queensland *Nature Conservation (Wildlife) Regulations 2006*
NES	National Environmental Significance
NRM:	Natural Resource Management
NSW NPWS	New South Wales National Parks and Wildlife Service
OUM	Office of Urban Management
ORV	Off road vehilces
PIFU	Planning and Information Forecasting Unit
QPW:	Queensland Parks and Wildlife (part of the Queensland EPA)
QWSG	Queensland Wader Study Group
RCC	Regional Coordination Committee
RE:	Regional Ecosystem
REDD:	Regional Ecosystem Description Database
RFISH	Recreational Fishing Information System
RIS:	Ramsar Information Sheet
ROKAMBA:	Republic of Korea- Australia Migratory Bird Agreement
ROP	Resource Operation Plan
SDR	Seagrass Depth Range
SEP	Scientific Expert Panel
SEQ	Southeast Queensland
SEQ HWP	Southeast Queensland Healthy Waterways Partnership

SEQROC	South East Queensland Regional Organisation of Councils
SEQTOLSMA	South East Queensland Traditional Owners Land and Sea Management Alliance
SGAP	Scoety for Growing Australian Plants
sp.:	Species (singular)
spp.:	Species (plural)
TSSC	Threatened Species Scientific Commuttee
UQ	University of Queensland
WASO	Water Allocation and Security Objective
WRP:	Water Resource Plan prepared under the *Queensland Water Act 2000*

1 EXECUTIVE SUMMARY

The Moreton Bay wetland aggregation is one of 65 wetland areas in Australia that have been listed as a wetland of international importance under the *Convention on Wetlands of International Importance especially as Waterfowl Habitat* or, as it is more commonly referred to, the Ramsar Convention (the Convention). Moreton Bay was listed as a Ramsar site under the Convention in 1993 in recognition of its outstanding coastal wetland values and features.

This report provides the first version of the Ecological Character Description (ECD) for the Moreton Bay Ramsar site. The report has been prepared in accordance with the *Draft National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (January 2008) hereafter referred to as the National Framework.

Following the methodology set out in the National Framework, Table 1-1 summarises the critical services/benefits provided by the Moreton Bay Ramsar site and the underlying critical ecosystem components and processes nominated by this ECD. The critical wetland services/benefits nominated were based on the attributes of the site as identified in the Ramsar Nomination Criteria as well as identifying critical cultural and provisioning services provided by the site in terms of human use. Together, these critical wetland components and processes provide the basis for the identified services/benefits to continue to be provided by the wetland in the future.

As part of this study, the digital Moreton Bay Ramsar site boundary has been updated in accordance with the Mapping Specifications and Guidelines promulgated under the Ramsar Convention by the Australian Government. The Moreton Bay Ramsar boundary is largely confined to nearshore estuarine waters within the Bay and extends over tidal lands that are State-owned or under aligned tenures where the long term management intent for the area is consistent or complementary with the objectives of the Ramsar Convention. In general terms, the site includes the waters and tidal wetlands of Pumicestone Passage, selective areas of the Western Bay, large areas of the Southern Bay including the Broadwater, and the banks and shoals of the Eastern Bay including the ocean beaches and marine areas immediately offshore from the barrier islands. Freshwater and transitional wetland areas within the boundaries of the site are found on the sand islands of Bribie, Moreton, North Stradbroke and South Stradbroke Islands.

A key feature of the Moreton Bay Ramsar site is its large size, the diversity of wetland habitats present within it and the connectivity between wetland habitat types in areas such as Pumicestone Passage and the Southern Bay which have complex mosaics of tidal flats, saltmarsh, mangroves and seagrass assemblages. While many wetlands such as mangroves and saltmarsh are well represented across the >1100 km^2 site, other wetland habitat features have much more localised distribution such as the peatlands of Eighteen Mile Swamp on North Stradbroke Island, the dune lakes and freshwater springs and streams on the sand islands, and coral reef communities in and around Peel Island.

Despite being situated at the doorstep of a growing major capital city, there are several important reference habitats within the site that are representative of the bioregion and remain in a near natural state. The six important reference habitat areas include seagrass and shoals, tidal flats, mangroves and saltmarsh, inshore coral communities, freshwater wetlands and ocean beaches and foredunes.

The ECD defines endangered and vulnerable wetland species associated with the site as critical ecosystem (or supporting) services. These include marine fauna such as turtles and dugong, two nationally-threatened freshwater fish species (Oxleyan pygmy perch and honey blue-eye), several wetland-dependant avifauna species, and selected wetland dependant non-avian species such as water mouse, Illidge's ant blue butterfly and acid frogs that are of high conservation value at National and/or International levels. Endangered wetland vegetation communities and flora species have also been identified on the Bay islands as a critical service/benefit.

In addition to these species, important populations (that address the 1% criterion within the Ramsar Nomination Criteria) are identified in relation to migratory and resident shorebird species.

Cultural and provisioning services/benefits identified as being significant in the context of the Ramsar site include commercially and recreationally important fisheries, the significance of the site to indigenous people, and the site's importance and use for research and education and for tourism and recreational uses.

The ten (10) critical services/benefits outlined in the ECD are underpinned by a range of wetland ecosystem processes and components. Key processes identified in the study include broad and local scale hydrodynamics and coastal processes, hydrology (particularly as it relates to groundwater interaction on the Bay islands and freshwater inflows into the Pumicestone, Western Bay and Southern Bay regions), water and sediment quality, energy and nutrient dynamics (primary productivity, nutrient and carbon cycling), climate, geomorphology and a range of biological processes (such as growth, reproduction, and feeding).

Critical ecosystem components include the 22 different wetland types identified in the Ramsar site (using the Ramsar wetland classification typology) which support its noteworthy wetland flora and fauna.

The study has sought to define the natural variability and limits of acceptable change for the critical services/benefits, components and processes identified in the ECD as they relate to the site's Nomination Criteria. A summary of the limits of acceptable change (LACs) is shown in Tables 1-2 to 1-4 which should be read together in assessing any changes to the ecological character of the site. Critical habitat types within the Ramsar area as well as specific wetland species of conservation significance (and the various wetland processes that underpin them) are the focus of the limits of acceptable change. As outlined in the tables, where there are insufficient data to set a limit of acceptable change with confidence, interim limits of acceptable change are supplied with a view to triggering management investigation and action to assess if a change to ecological character has or may occur.

The study has found that while there have been observable changes to the condition of wetland habitats in some areas of the site since nomination in 1993, these changes are not perceived by the study team or the advisory committees consulted as part of the study as representing a loss to any of the ten critical services/benefits that define ecological character.

Public awareness and management responses to impacts that have occurred in the 15 year period since nomination have been considerable. Significant investment has been made toward improvement of point-source water quality, intensive environmental monitoring and the preparation and implementation of many plans and strategies that ultimately aim to conserve environmental values of the Bay in a way that is consistent with the wise use paradigm of the Ramsar Convention

Recent or continuing impacts that are notable in the context of the site and may affect future ecological character are identified as disturbance/reduction in habitat quality for migratory shorebirds, decreasing water quality in the Southern and Western Bay areas, seagrass loss in Deception Bay and the Southern Bay (and its potential affect on fisheries, dugong and turtle populations) and increasing incidence and intensity of *Lyngbya* algal blooms.

Closely related to the discussion on impacts, a range of threatening processes and activities have been identified in the ECD based on a review of literature sources, the opinions and views of the advisory committees for the project and the expert opinion of the study team. While not exhaustive, key threats that have the potential to influence ecological character have been identified and assessed in terms of the future risk. Where possible this risk has also been assessed against the perceived effectiveness of the regulatory/management regime, with the risk of the threat to ecological character reduced where the regime is seen as effective or improving.

Key threat issues identified are (in no particular order of importance):

- Harmful interactions with wetland species;
- Sustainability of fishing and harvesting;
- Sediment and nutrient input into the Bay from point and non-point sources;
- Groundwater extraction;
- Urban encroachment into the Ramsar boundary and adjacent wetland areas;
- Significant changes to wetland ecosystem processes from major infrastructure/development projects;
- Oil spills or other large scale marine pollution incident; and
- Impact on coastal wetlands from climate-change induced sea level rise and related threats.

Information gaps, monitoring recommendations and recommendations in relation to communication education and awareness messages are also identified in the ECD. Thematic information gaps identified as being most important for future monitoring for the site include:

- Additional research and monitoring expenditure to establish an ecological character baseline for the near-natural representative habitats, particularly those more localised habitats within the Ramsar site such as the freshwater wallum habitats of the Bay islands, the Eastern Bay coral reefs and peatlands such as Eighteen Mile Swamp;
- The need for better information and data sets about the presence and natural history of critical wetland species and their habitat including for example, surveys of vulnerable and endangered plant species on the Bay islands, aquatic species such as Oxleyan pygmy perch and more systematic surveys of important avifauna species and populations;

- Better information and understanding about the natural variability of critical wetland fauna populations and key attributes and controls on those populations (including whether or not any non-avian fauna species meet the 1% population requirement in Ramsar Nomination Criterion 9);
- The ecological character thresholds of particular habitats and communities to changes in key attributes/controls such as water quality and hydrology need additional investigation. Noting that any interim limits of acceptable change stated in the ECD should be revised as improved information becomes available;
- Resilience of habitats, community structure and key species to acute or prolonged impacts from water quality degradation such as nutrient enrichment, increased levels of salinity and sedimentation/turbidity (eg. similar to the approach in ANZECC for toxicants); and
- Consultation and involvement of traditional owners of the Moreton Bay Ramsar site if a greater understanding of historic and contemporary wetland values of the site to indigenous people is to be obtained and appreciated.

Monitoring needs and recommendations presented in the ECD relate broadly to obtaining data to assess future changes to ecological character (as defined by the Nomination Criteria for the site) and corresponding critical services/benefits as they relate to wetland habitats, species and populations and the cultural services discussed above. Principally, these monitoring recommendations relate to:

- Broad-scale observation/monitoring to ensure each wetland type outlined in the ECD continues to be represented across the site;
- Wetland habitat extent monitoring (noting that a precursor to being able to do this will be to establish a better correlation between EPA wetland mapping and the Ramsar Classification System);
- Habitat condition monitoring (principally in the form of monitoring underlying wetland ecosystem processes such as water quality and hydrological process or surrogate biological indicators such as crab burrow density);
- More targeted surveys of the threatened flora and fauna species (perhaps on a five year or ten year basis) to assess presence/absence or population changes of noteworthy species or communities; and
- More regular counts of roosting and feeding shorebirds with a particular emphasis on those species that meet the 1% population criteria.

In making recommendations for future monitoring of the Ramsar site, the information gaps and monitoring needs identified in the ECD were also considered in the broader context of the Southeast Queensland Healthy Waterways Partnership's Ecosystem Health Monitoring Program (EHMP) and the monitoring program being implemented to assess the effect of proposed re-zoning of the Moreton Bay Marine Park by the Queensland EPA.

To ensure close alignment between these initiatives, a special sub-group of the Southeast Queensland Healthy Waterways Partnership Scientific Expert Panel (SEP) met several times with the consultant study team and the Knowledge Management Committee to workshop and discuss synergies and commonality between the existing and proposed monitoring programmes (refer Appendix A). A separate report outlining the outcomes of these discussions has been produced by BMT WBM (2008b) as part of the ECD project.

While specific priorities and methodologies for monitoring were not sought to be developed through the workshop process, the information collected provides a basis for the next phase of monitoring and sampling design under EHMP and other monitoring regimes that is cognisant of the important/significant habitats and species, key attributes and associated stressors and threats affecting the Moreton Bay Ramsar site.

Finally, in terms of communication, education and awareness messages, the critical elements of the Ramsar site nominated in this ECD that are perhaps not being fully articulated include:

- The importance of freshwater wallum and peatland wetland habitats on the Bay islands and adjacent to Pumicestone Passage and the unique aquatic fauna that exists in these areas such the Oxleyan pygmy perch, water mouse and acid frogs. This also includes the associated critical wetland flora and communities identified in this report (noting that significant work is needed by to better identify and survey the extent and values of these endangered and vulnerable communities and species);
- In keeping with the wise use paradigm of the Ramsar Convention, promotion of the diversity of sustainable wetland-based tourism and recreational values of the Ramsar site;
- The current state of fisheries resources and the need for continued conservation of fish habitat;
- The use and significance of the site to Indigenous people; and
- The importance of Moreton Bay for migratory shorebirds.

Table 1-1 Critical Services Summary

Critical Service/Benefit	Underlying Critical Components	Underlying Critical Processes
S1. The Moreton Bay Ramsar site contains a **diversity** of wetland habitat types that are **representative** of a major coastal wetland aggregation and in many areas show a high degree of **connectivity** between habitat types **S2.** Moreton Bay Ramsar site contains several critical **wetland habitat types**. For reporting purposes, reference sites have been selected within these critical habitat types that are in a **near natural state** and are **representative** of the habitat type within the broader biogeographic region **S3.** Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered **marine/aquatic fauna** **S4.** Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered **wetland-dependent terrestrial fauna** species **S5.** Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered **wetland flora** species and endangered and of concern **wetland regional ecosystems** **S6.** Moreton Bay Ramsar site supports significant **populations** (more than 20 000 in total and over 1% of the population size of particular populations) of **migratory and resident shorebirds** **S7.** The tidal fish habitats and fish and invertebrate populations of the Moreton Bay Ramsar site support valuable **recreational and commercial fishing** activities **S8.** Moreton Bay Ramsar site has important **cultural values and significance** to indigenous peoples **S9.** Moreton Bay Ramsar site is an important site for **research and education** **S10.** Moreton Bay Ramsar site provides and supports significant **tourism and recreational uses** in the region	**Wetland habitats,** including six near-natural reference habitats as follows (links to S2): • S2A Seagrass and shoals in the Eastern Banks area • S2B Tidal flats and associated estuarine assemblages within Pumicestone Passage • S2C Mangroves and saltmarsh in the Southern Bay • S2D Coral communities of the Eastern Bay • S2E Freshwater wallum and peatland habitats on the Bay islands • S2F Ocean beaches and foredunes on Moreton Island **Wetland-dependant fauna and flora species**, including: • Marine: dugongs, green and loggerhead turtles (link to S3) • Aquatic: Oxleyan pygmy perch and honey blue eye (link to S3) • Wetland-dependant terrestrial fauna species: Little tern, beach stone-curlew, Illidge's ant blue butterfly, Australian painted snipe, acid frogs, water mouse, Australasian bittern (link to S4) • Wetland-dependant terrestrial flora species: Vulnerable and Endangered flora species including swamp orchids, knotweed and swamp daisy (links to S5) Noteworthy **flora communities** within the Ramsar site that are endangered or of concern regional ecosystems (links to S5) Noteworthy **populations** of migratory and resident shorebirds (links to S6) **Fisheries** of recreational and commercial significance and their habitats (links to S7)	**Physical Coastal Processes.** Hydrodynamic controls on habitats through tides, currents, erosion and accretion **Hydrology.** Patterns of tidal inundation and freshwater flows to wetland systems **Groundwater.** For those wetlands influenced by groundwater interaction, the level of the groundwater table and groundwater quality **Energy and Nutrient Dynamics.** Primary productivity and the natural functioning of carbon and nutrient cycling processes **Biological Processes.** Important biological processes such as growth, reproduction, recruitment, migration and dispersal **Water Quality.** Water quality that provides aquatic ecosystem values within wetland habitats **Climate.** Patterns of temperature, rainfall and evaporation **Geomorphology**. Key geomorphologic/ topographic features of the site

Table 1-2 Summary of Limits of Acceptable Change

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	Criterion 1 is based on the site containing at least one particularly notable wetland habitat type, and this wetland type is maintained in natural or near-natural condition. **Wetland Types and Extent** The ECD/RIS list twenty-two (22) wetland types within the site (using the Ramsar Classification Methodology). An unacceptable change will have occurred if it can be demonstrated that one or more of these wetland types have been lost. **Wetland Condition** A change in natural or near-natural condition at one of the six (6) reference sites[1] or more broadly across that habitat type at a whole-of-site scale are defined as follows**:** • **Seagrass meadow** cover and extent has declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (Eastern Bay) or has resulted in measurable changes to the local population status of dugongs and green turtles, or fisheries stocks (all seagrass areas); • **Unvegetated intertidal flats** and associated microphytobenthos and marine fauna community structure has changed to such levels that it in the medium to long-term (>5 years), can no longer be considered to be in pristine or near-pristine condition (Pumicestone Passage) or has resulted in measurable changes to avifauna populations or fisheries stocks (all tidal flat areas); • **Mangrove and saltmarsh** habitat extent and community structure has changed to such levels that in the medium to long-term (>5 years), it can no longer be considered to be in pristine or near-pristine condition (Southern Bay) or has resulted in measurable changes to avifauna populations or fisheries stocks (all mangrove and saltmarsh areas); • **Coral community** and reef habitat structure has changed to such levels that in the medium to long-term (>5 years), it can no longer be considered to be in pristine or near-pristine condition (Eastern Bay coral communities) or has resulted in measurable changes to the extent or condition of the habitat (eg. coral dominated reefs algal dominated); • **Freshwater wallum** wetland **/peatland** habitat conditions have declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (North Stradbroke or Moreton Islands) or has resulted in measurable changes to the local population status of	**Habitat Extent** At a local scale, >10% change in habitat extent, relative to natural background variability, such that it results in measurable impacts at sub-km spatial scales, and causes measurable, medium-term (>2 to 5 years) flow-on effects to key species, communities or habitat at this spatial scale. **Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4

[1] These representative habitat types and locations have been selected on the basis of their role in ecosystem functioning across the site and are important habitats for threatened species, communities and populations that are relevant to other Criteria in the table.

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	threatened flora and fauna species or communities (see Criterion 2 below); • **Ocean beach and foredune** habitat conditions have declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (Moreton Island) or has resulted in measurable changes to the local population status of avifauna or nesting usage by avifauna and marine turtles (all ocean beaches and foredune areas).	
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	Criterion 2 is based on the site containing at least one vulnerable or endangered species or threatened ecological community. The ECD/RIS lists several species/communities within the site that meet this criterion which include: • Marine Species - dugongs, green and loggerhead turtles • Freshwater Fish - Oxleyan pygmy perch and honey blue eye • Avifauna - little tern, beach stone-curlew, painted snipe, Australasian bittern • Wetland-dependant non-avian fauna - Illidge's ant blue butterfly, acid frogs and water mouse • Nationally Endangered wetland flora species including several swamp orchids, knotweed and swamp daisy An unacceptable change will have occurred if it can be demonstrated that one or more of these threatened species or threatened communities is lost within the site. In particular, a change to character would be demonstrated if the following were to occur: • The wetland becomes unsuitable as habitat for one or more threatened species or community listed in this ECD; or • Threatened animal and plant species identified in the ECD no longer occur at the site.	**Species/Populations** Detectable decline in local abundance/population of the key species. See Wetland Species Ecosystem Process Indicators – Table 4-5
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	Criterion 3 is based on the site containing a large proportion of species that are not well represented in the wider region. An unacceptable change will have occurred if it can be demonstrated that there has been a reduction in the number of species occurring within the site, and that this has resulted in a loss in biodiversity within the bio-region. In this context, a change to character would be demonstrated if the following were to occur: • Habitats have become unsuitable for wetland flora or fauna species or populations listed in the critical services of this ECD (see Criterion 2) • Noteworthy animal and plant species identified in the ECD are no longer present (see Criterion 2) • Populations of noteworthy species (see Criterion 2 above) no longer recorded in previous abundances (i.e. possible loss of genetic diversity)	**Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4 **Species/Populations** See Wetland Species Ecosystem Process Indicators – Table 4-5

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	• Overall vertebrate fauna biodiversity is measurably and significantly reduced	
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	Criterion 4 is based on the site representing critical refugia for any species, and the site maintaining critical life-cycle processes for any species. An unacceptable change will have occurred if it can be demonstrated that the site no longer provides a refugia function for important flora and fauna species (see Criterion 2) or if critical life-cycle processes are no longer being supported. The following are considered to represent the key critical life-cycle functions in the Moreton Bay Ramsar site - • Feeding and nesting habitat for green and loggerhead turtles that could impact the local population • Feeding and breeding habitat for dugong that could impact the local population • Refuge habitat for freshwater fish of conservation significance that could impact the local population • Roosting habitat for migratory waterbirds that could impact the local population • Critical overwintering habitat and a flyway staging area (both northern and southern migration routes) for migratory waterbirds	**Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4 **Species/Populations** See Wetland Species Ecosystem Process Indicators – Table 4-5
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.	The site no longer supports the required abundance of waterbirds under this Criterion	That the total number of waterbirds at the site always exceeds 20,000 individuals Greater than 10% reduction in over a 10 year period of numbers of bar-tailed godwit, Eastern curlew, or Pacific golden plover which are surrogates for assessing shorebird abundance generally.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	The site no longer supports the 1% of individuals of populations for the key species in the ECD which are: • bar-tailed godwit • whimbrel • Eastern curlew • terek sandpiper • grey-tailed tattler • curlew sandpiper	Greater than 20% reduction in any three year period over five years for any of the eight migratory shorebird species (which exceed the 1% threshold).

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	• pied oystercatcher • Pacific golden plover • lesser sand plover	
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	Long term impacts on the sustainability of populations of important commercial and recreational species that occur within the site (or in adjacent areas of the Bay) including: • bream, flathead, whiting, luderick, mullet, tailor, mackerel, sharks, baitfish, eels, pink snapper and other key finfish species; • king, tiger, endeavour, banana, greasyback and school prawns; • blue swimmer, mud, red spot, spanner and coral crabs and Callianasid shrimp (yabbies); • squid, cuttlefish, gastropods, rock oysters, bivalves and *beche-de-mer*.	A long-term loss of fish/shellfish stocks, which results in the reduction in the sustainability of key Bay fisheries, should be considered a trigger for assessing potential changes to ecological character.
Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	Medium to long-term (>5 years) reduction in the extent or condition of wetlands or other areas and a corresponding measurable impact on important spawning, nursery or migration pathways for fisheries.	At a local scale, >10% change in habitat extent, relative to natural background variability, such that it results in measurable impacts at sub-km spatial scales, and causes measurable, medium-term (>2 to 5 years) flow-on effects to key species, life-stages, communities or habitat at this spatial scale. In assessing this interim LAC, attention should be given to assessing changes in the extent of mangroves, saltmarsh, seagrass and tidal flat environments, which represent key nursery habitats to many commercially important species within the site.

Table 1-3 Summary of Limits of Acceptable Change – Critical Habitats

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Seagrass	See 'Natural Variability' column	See below Turbidity/light	Variable across site. Refer to EHMP data.	n/d	*H. ovalis*: H1. Min. light requirement = 16% SI [P,Q] H2. Duration = >30 days at 0% SI [P,S] *Z. muelleri*: H3. Duration = >30 days at 5% SI [P,Q] H4. Critical thresholds = >30% SI [Q,R,]; 0.9 Kd (m^{-1}) [P,R]; 10 mg/L [P,R] H5. If site values exceed levels in H1 to H4, use default baseline turbidity values at seagrass sites as default trigger values (see SDR sites below) [J]	S1, S2, S3, S6, S8
		Seagrass depth limit/range (SDR)		n/d	Medium term (>5 years) median SDR value should not fall below the following interim default SDR values [N]: H6. Pumicestone Passage HEV = -0.8 m	
					H7. Pumicestone Passage SMD = -1.2 m	
					H8. Deception Bay North SMD = -3m	
					H9. Waterloo Bay HEV = -1.9m	
					H10. Central Bay HEV/ SMD = -2.2m	
					H11. Eastern Bay HEV = -3.5m	
					H12. Eastern Bay SMD = -2.2m	
					H13. Southern Bay HEV/ SMD = -1.3m	
		Long-term change in tidal hydraulics and sedimentation patterns (short to medium term)	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008)[A].	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H14. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background [B].	
Unvegetated tidal flats	Pumicestone Passage, Waterloo Bay, Bramble Bay, Eastern Banks.	Freshwater flows	Waterway-specific & highly variable over time. Baseline hydraulic conditions as per 'Existing-case' scenarios in Moreton WRP.	n/d Quantitative environmental flow requirements of key local species and habitats unknown	H15. As a minimum, compliance with EFOs outlined in Moreton WRP for Nodes A-E	S1, S2, S3, S4, S6, S8

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		Tidal hydraulics & sedimentation patterns (short to medium term)	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008) [A].	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H16. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background [B]	
		Long term (>50 years) changes to tidal inundation and sediment dynamics patterns & processes due to sea level rise	-0.22 mm/year change over last 26 years of data collection [C]	n/d Impacts dependent on sedimentation rate relative to sea level rise	H17. A change in frequency, duration & magnitude of tidal inundation between: • MHW and MSL; • MSL and MLW • MLW and LAT • Such that it results in >10% change (above background) in the extent of unvegetated habitat at these levels, and results in [B].	
		Spionidae and Capitellidae worm densities, and sediment TOC, as indicators of organic enrichment	Highly variable in space and time	n/d	Using methods as per ANZECC, assess whether the following are exceeded: H18. Interim high range – Capitellidae or Spionidae densities >1000 individuals per m^2 H19. Interim low range – n/d	
		Crab burrow densities. This is a potential non-destructive, rapid assessment technique for assessing potential changes in crab abundances, which may be linked to changes in ecosystem condition [U]			n/d. H20. There is a need to investigate (i) whether robust and cost-effective methods can be developed, and if so (ii) proceed to establish threshold criteria based on sampling of appropriate indicator species at a range of references sites.	
Mangroves and Saltmarsh	Southern Bay Pumicestone Passage Western Bay	Freshwater flows	H21. As a minimum, compliance with EFOs outlined in Moreton WRP for Nodes A-E (see also H15) plus nodes outlined in Logan WRP (Note G) and Gold Coast (Note A) WRPs. This should be assessed using SunWater IQQM models.			S1, S2, S7, S8
		Tidal hydraulics	H22. Refer to unvegetated flats, i.e. H16			
		Tidal inundation patterns	H23. Refer to unvegetated flats, i.e. H17			
		Crab burrow densities	n/d	n/d	H24. n/d. Refer to H20	
		Mangrove die-back extent	n/d	n/d	H25. n/d. There is a need to map the	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		and hypersaline areas			distribution and extent of mangrove die-back (aerial photography & ground-truthing) to establish existing conditions. Monitoring should be undertaken on a 5 year basis. H26. Salinity should not be > 40-50 g/L (low tide) to reduce the risk of impacts to mangrove health[V]. H27. Where ambient salinity exceeds levels in H26, & mangroves and saltmarsh are demonstrated to be in good condition, derive local trigger values based on ambient/background data. [J]	
Coral Communities (Eastern Bay)	Central and Eastern Bay – Myora, Peel Island, etc	Turbidity	<1, 1, 1 NTU [E]	n/d. Tolerance limits of most local species are largely unknown.	H28. Long-term (>5 day) average turbidity should not exceed >3 NTU [H] H29. Use default baseline conditions at coral reef sites as default interim trigger values for turbidity & other attributes [J]	S1, S2, S3, S8
		pH	8.2, 8.3, 8.4 [E]			
		TN	100, 120, 160 μg/L [E]			
		TP	5, 9, 12 μg/L [E]			
		Water temperature	12.5° to 32°C (Reef flat); 16 to 28°C (Moreton Bay surface waters [F]			
		Sedimentation rates ($mg/cm^2/day$) [G]	Peel Is = 2 to 32 Myora = 5.9 to 16.1	n/d Tolerance limits are: • highly species-specific. • not available for local species • dependent on duration & frequency of exposure to sedimentation Available baseline sedimentation data has limited temporal coverage (1 year).	H30. Sedimentation should not exceed background variability and lead to measurable impacts to coral communities [K]	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		Coral bleaching frequency & extent	n/d Incidence of coral bleaching is not reported in EHMP.	n/d	H31. The frequency & duration of bleaching events should not increase to such levels where measurable impacts to coral communities occur [K]	
		Reef community structure (cover of numerically dominant taxa)	Site specific, and variable in time for some macrophyte species. Refer to EHMP (2006) data for a description of baseline conditions.	n/d	H32. >5% loss in hard and/or soft coral cover > background temporal variability [L]	
Wallum freshwater wetlands	Bay Islands Pumicestone Passage	Groundwater hydrology	Waterway-specific & highly variable over time. Baseline hydraulic conditions as per 'Existing-case' scenarios in Logan WRP (& underlying modelling).	n/d	H33. As a minimum, compliance with EFOs outlined in future draft Logan WRP (North Stradbroke Island) [M] H34. No changes in water levels at Blue Lake, or the Blue Lake Overflow discharge channel, such that a detectable community or ecosystem change occurs [B]	S1, S2, S4, S5, S7
		Invertebrates	20th percentile: Taxa richness = 12 PET richness = 2 SIGNAL = 3.32	n/d	H35. No change in water quality or invertebrate biotic indices, outside the bounds of natural variability. Note that water quality and biotic indices show great change among different waterbodies, hence there is a need to derive local trigger values based on ambient/background data. [J]	
		pH [I]	Blue L. = 4.9 to 5.2 Brown L. = 4.6 to 5.0			
		EC (μS/cm) [I]	Blue L. = 90 Brown L.= 90			
		Secchi (m) [I]	Blue L. = 4.9 to 6.9 Brown L. = 0.7			
		DO (% saturation) [I]	Blue L. = 86 to 95 Brown L. = 90 to 99			
		Chlorophyll a (μg/L) [I]	Blue L. = 0.6 to 2.4 Brown L. = 14			
		TP (μg/L) [I]	Blue L. = 2 to 6 Brown L. = 15			
		Water Temp (deg C) [I]	Blue L. = 19 to 26			

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Brown L. = 19 to 26			
		Turbidity (NTU) [I]	Blue L. = <1 to 1			
			Brown L. = 9			
		Ammonia (μg/L) [I]	Blue L. = 2 to 7			
			Brown L. = 9			
		Total N (μg/L) [I]	Blue L. = 90 to 130			
			Brown L. = 500			
		NOX (μg/L) [I]	Blue L. = 6 to 37			
			Brown L. = 3			
Ocean beaches and foredunes	High-energy beaches and foredunes of Bribie, Moreton and North and South Stradbroke Islands	Long-term change in tidal hydraulics and sedimentation patterns (short to medium term) leading to change in beach morphology	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008)[A] or long term aerial photograph analysis.	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H36. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater, relative to background [B].	S1, S2, S3, S4, S7
		Groundwater inflows	Highly site-specific. Groundwater flows bring nutrients into the beach system and into the swash zone and control invertebrate and nearshore phytoplankton communities	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H37. No measurable medium term (>5 years) change to groundwater supply/flows into beach systems relative to background [B].	
		Density of *Pipis* or other indicator species linked to changes in ecosystem condition	Highly variable in space and time	n/d	H38. There is a need to establish threshold criteria based on sampling of appropriate indicator species at a range of references sites. Refer to H20.	

Table 1-4 Summary of Limits of Acceptable Change – Critical Species

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Oxleyan pygmy perch	Bay Islands, Pumicestone Passage	No long-term reduction in population densities of Oxleyan pygmy perch in waterbodies, outside the range of natural variability. No reduction in the total number of waterbodies inhabited by Oxleyan pygmy perch within the site.	pH	4.2 to 7.2 [A]	n/d No experimental determination of physiological tolerances All information on habitat preferences based on environmental conditions in which this species has been recorded	H39. Long term average should not >6.5 H40. If above this value, adopt 20th, 50th & 80th percentile values of reference site conditions in which population has been recorded. The 75th confidence limit should not be > these values.	S1, S2, S3
			Dissolved Oxygen	> 2 mg/L [B]		H41. Long-term median should not be <5 mg/L. If above this value, then adopt percentile values described in H40	
			Turbidity	Clear, tannin stained waters (1 to 300 NTU) [A, B]		H42. Long-term median should not > 1 NTU. If above this value, then adopt percentile values described in H40	
			EC/Salinity	<330 μS/cm [A]		H43. Long term average should not exceed 300 μS/cm. If above this value, then adopt percentile values described in H40	
			Water levels	0.2[A, B] to 5[C] m, depending on water body characteristics. Mean weighted depth of captures = 0.63 m [A], whereas OPP Recovery Plan indicates most OPP captures in 0.3 to 0.4 m depth range [F].		H44. n/d. Trigger value may vary depending on particular requirements and local habitat conditions, i.e. avoidance of competition with eastern Gambusia or maintenance of fish passage. Local trigger values therefore need to be developed, although water depths <0.2 m unlikely to allow maintenance of OPP populations. H45. Drying. Where adjoining permanent refugia is absent, drying of a known habitat will cause local extinction at the site.	
			Groundwater hydrology	Low flow <0.3 m/sec [A]		H46. Flow <0.1 m/second. If >, then If above this value, then adopt percentile values described in H40	
			Emergent macrophyte cover and undercut banks	60-80% emergent macrophyte cover (typically sedges), undercut banks, woody debris & root masses.		H47. >50% reduction in emergent vegetation cover, above background variability, such that it results in such that it results in a measurable, short-term (1-5 years) flow-on effects to OPP populations and/or key ecosystem functions.	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Eastern Gambusia in freshwater reaches of Little Canalpin Ck.**	Absent in freshwater reaches, but found in lower estuarine/brackish environs	n/d	H48. Presence of Eastern Gambusia in Little Canalpin Creek represents a trigger for further investigation of viability of this sub-population.	
			Oxleyan pygmy perch abundance	This species has low population densities, hence empirical limits are difficult to set. On North Stradbroke Is., average CPUE is typically 0-0.6 individuals/trap /hour*.	n/d	H49. No fish recorded during >5 sampling events, using various combinations of sampling methods (e.g. box traps, electro-fishing and seine netting), should trigger further investigations of whether waterbody continues to provide suitable OPP habitat, and the identification of drivers for change.	
Honey blue-eye	Pumicestone Passage	No long-term reduction in population densities of honey blue-eye in waterbodies, outside the range of natural variability. No reduction in the total number of waterbodies inhabited by honey blue-eye within the site.	pH	4.4 to 6.8 ^{A}	n/d No experimental determination of physiological tolerances All information on habitat preferences based on environmental conditions in which this species has been recorded	H50. Long term median should not be >6.5, or if above this value: H51. Adopt 20th, 50th & 80th percentile values of reference site conditions as described in H40	S1, S2, S3
			Dissolved Oxygen	> 6.8 mg/L ^{A}		H52. Long-term median should not be <5 mg/L. H53. If background above this value, then adopt percentile values described in H40	
			Turbidity	Clear, tannin stained waters (<17 NTU) ^{A}		H54. Long-term median should not > 1 NTU. H55. If background above this value, then adopt percentile values described in H40	
			EC/Salinity	<900 µS/cm ^{A}		H56. Long term median should not exceed 700 µS/cm. H57. If background above this value, then adopt percentile values described in H40	
			Water levels	n/d		H58. n/d. Trigger value may vary depending on particular requirements, i.e. avoidance of competition with eastern Gambusia or maintenance of fish passage. Local trigger values need to be developed. H59. Drying. Where adjoining permanent refugia is absent, drying of a known habitat will cause local extinction at the site.	
			Groundwater hydrology	Low flow <0.3 m/sec ^{A}		H60. Median flow velocity <0.1 m/second. H61. If background above H22, then adopt percentile values using approach described in H40	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Emergent macrophyte cover and undercut banks	High aquatic plant cover, typically sedges [A]		H62. >50% reduction in emergent vegetation cover, above background variability, such that it results in such that it results in a measurable, short-term (1-5 years) flow-on effects to Honey Blue-eye populations and/or key ecosystem functions..	
			Honey blue-eye abundance	This species typically has low population densities [A], hence empirical limits are difficult to set.	n/d	H63. No fish recorded during >5 sampling events, using various combinations of sampling methods (e.g. box traps, electro-fishing and seine netting), should trigger further investigations of whether waterbody continues to provide suitable habitat, and the identification of drivers for change.	
Dugong	Eastern Bay Pumicestone Passage Southern Bay	Detectable decline in local abundance of dugong outside the range of natural variability	Turbidity, nutrients and chlorophyll *a*	Refer to seagrass indicators in Habitat Table 4-4			S1, S2, S3, S9
			Seagrass depth limit (and extent)	Refer to seagrass in Habitat Table 4-4			
			Dugong population densities	503 ± 63 (S.E) (July) to 1019 ± 166 (S.E) (December) individuals in 1995 (Lanyon 2003) [D]. Recent population modelling suggests local population size of ~970 ±75 animals [E].	n/d	H64. A decline in dugong abundance to <800 individuals for 2-3 successive years may represent a trigger for further investigation. Note however that these figures should be considered as indicative only, as there is insufficient available information on the population dynamics and genetics of dugongs to develop a reliable interim trigger value.	
Marine Turtles: green turtle loggerhead turtle	Eastern Bay Pumicestone Passage Southern Bay	Detectable decline in green and loggerhead turtles outside the range of natural variability	Turbidity, nutrients & chlorophyll *a*	Refer to seagrass indicators in Habitat Table 4-4			S1, S2, S3, S9
			Seagrass depth limit (and extent)	Refer to seagrass in Habitat Table 4-4			
			Green and loggerhead turtle population dynamics & breeding readiness	n/d	n/d	H65. n/d. Insufficient available information on the population dynamics, growth rates and breeding readiness of turtles to develop a reliable interim trigger value.	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Wallum Acid Frogs	Wallum habitats on Bay Islands and Pumicestone Passage	Significant population declines outside the range of natural variability in either of the four acid frog species	Water quality: • non-turbid • tannin-stained • oligotrophic (low nutrient) • naturally acidic	pH 3.0-5.5 as derived from dissolved organic acids leached from humus).	n/d	H66. Significant decline in the numbers of the four acid frog species for important populations on North Stradbroke and Moreton Islands.	S4
			Absence of predatory fish	n/d	n/d	H67. Presence of Eastern Gambusia may represent a threat to local populations	S4
			Wallum wetland vegetation	n/d	n/d	H68. Greater than 5% reduction over five years of wallum wetland vegetation cover.	S4
			Ground water hydrology and freshwater flows	n/d	n/d	H69. No long-term change in groundwater hydrology such that it causes alterations to water quality, water levels and wetland flora and fauna, outside the bounds of natural variation.	S4
Beach stone-curlew	Outer Bay islands, Pumicestone Passage, mangrove habitats of southern Moreton Bay.	Significant declines in key habitat areas	Mangroves and associated intertidal flats (roost and feeding); sandy beaches (feeding), foredunes (breeding sites)	n/d	n/d	H70. Lack of observation of beach stone-curlew in any three year period over five years within the following areas: Pumicestone Passage (Toorbul north to Bells Creek); Bulwer to North Point (Cape Moreton); Cape Cliff (Cape Moreton) to Eagers Creek; Little Sandhills to Mirapool Lagoon; Amity to Point Lookout; Peel Island; Jumpinpin (includes southern end tip of North Stradbroke Island and associated mangrove islands); western side of South Stradbroke Island.	S4
Water mouse	Pumicestone Passage, North Stradbroke Island, Southern Moreton Bay (e.g. Steiglitz, Jacobs Well, Pimpama River Conservation Area, Coomera River, & South Stradbroke Island).	Significant declines in the usage of nests and the diversity of nest types used.	Relatively large areas of intertidal flats in association with mangroves (feeding), marine intertidal invertebrate prey, supralittoral wetlands, including salt marsh and sedgelands (nesting sites)	n/d	n/d	H71. Greater than 20% reduction in the number of active/recently active water mouse nests or greater than 15% reduction in usage of any one of the diversity of nest types used (following Van Dyck and Gynther 2003) over five years for important populations associated with North Stradbroke Island, southern Moreton Bay (e.g. Macleay Island, Coomera & Pimpama Rivers, South Stradbroke Island) and Pumicestone Passage (e.g. Bribie Island, Donnybrook).	S4
			Tidal conditions	n/d	n/d	H72. Any detectable long-term change to tidal regimes at spatial scales >5 km.	S4

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Australian painted snipe	Freshwater swamps of outer Bay islands (e.g. 18 Mile Swamp).	Lack of records for any 10 year period.	Densely vegetated permanent of seasonal wetlands	n/d	n/d	H73. Loss of more than 20% of the extent of vegetated freshwater wetland habitat.	S4
Australasian Bittern	Freshwater swamps of outer Bay islands (e.g. 18 Mile Swamp).	Lack of records for any 10 year period.	Densely vegetated permanent of seasonal wetlands	n/d	n/d	H74. Loss of more than 20% of the extent of vegetated freshwater wetland habitat.	S4
Little Tern	Open waters of Bay, Caloundra sandbanks, beaches & sand spits of outer Bay islands, South Stradbroke Island.	Significant decline in abundance, outside the range of natural variability.	Nearshore and offshore open waters and rivers; water quality sufficient to support abundance of surface active baitfish; high-tide roost sites.	n/d	n/d	H75. Significant decline in the numbers of Little Tern, outside the range of natural variability, over five years as determined at key roost sites (e.g. northern Pumicestone Passage; South Stradbroke Island).	S4
Illidge's ant blue butterfly	Mangrove communities of Redland Bay, Hays Inlet, Fisherman Islands, outer Bay islands, and Coomera Island	Lack of records for any three year period.	Large areas of mangroves with mature trees bearing senescing limbs and dead branchlets which support the *Crematogaster* sp. ant; also adjacent supralittoral forests.	n/d	n/d	H76. Greater than 10% reduction over five years of mangrove cover and associated intertidal habitats.	S4
Migratory Shorebirds	Intertidal sand/mud flats, rocky shores and mangrove communities throughout the site, intertidal areas of coarse rubble associated with	Decline in shorebird abundance and species diversity.	Diversity and abundance of epi/infauna of the intertidal flats; diversity of disturbance-free high tide roost spatially	n/d	n/d	H77. Greater than 10% reduction over five years of any one of the following components – mangrove cover and associated intertidal habitats; and supralittoral salt marsh habitats. H78. Any detectable long-term change to tidal regimes at spatial scales >5 km. H79. No long-term reduction in water quality and ecosystem condition in the estuarine sections of	S6

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
	central bay islands (Mud, St. Helena and Green islands) and western shores (Wellington Point and Redcliffe Peninsula), high tide roost sites throughout the site (natural and artificial).		proximate to suitable feeding grounds.			each major catchment area (as determined through the EHMP). H80. Greater than 10% reduction in over a 10 year period of numbers of bar-tailed godwit, Eastern curlew, or Pacific golden plover which are surrogates for assessing shorebird abundance generally. H81. Greater than 20% reduction in the in any three year period over five years for any of the eight migratory shorebird species (which exceed the 1% threshold).	
Threatened Flora Communities: Endangered and Of Concern Regional Ecosystems	Bribie Island, Moreton Island, Southern Moreton Bay Islands, Southern Bay	Detectable decline in extent of Regional Ecosystems. Loss of sensitive plant species and change to alternate community type. (Loss of dependent fauna).	Groundwater hydrology	Waterway-specific and variable over time.	n/d Quantitative groundwater requirements of ecosystems unknown.	H82. No significant reductions in water table depth, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. H83. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
			Fire regimes	Variable over time and between different vegetation types.	n/d Specific fire regime requirements of ecosystems unknown.	H84. No significant changes in fire frequency or intensity, relative to background variability, such that it results in such that it results in a measurable, medium-term (>5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. No significant changes in fire frequency or intensity such that ecological integrity of ecosystems is not maintained. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Geomorphology: • Erosion • Sedimentation • Soil type	Erosion and sedimentation variable over time. Soil type not variable over relevant time scale.		H85. No significant changes in erosion or sedimentation processes, or changes to soil characteristics, relative to background variability, such that it results in such that it results in a measurable, medium-term (>2 to 5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
Vulnerable and Endangered wetland plants: *O. hygrophila* *P. elatior* *P. australis* *P. bernaysii* *P. tancarvilleae*	Bay Islands: swamps, lakes and waterways	Detectable decline in local abundances of plant species.	Groundwater hydrology	Waterway-specific and variable over time.	n/d Quantitative groundwater requirements of flora species unknown.	H86. No significant reductions in water table depth, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
			Water Quality: • Toxicants • Nutrients • Turbidity • Salinity, pH	Waterway-specific and variable over time.	n/d No experimental determination of flora species water quality tolerances.	H87. No change in water quality indices outside bounds of natural variability. Adopt 20th, 50th & 80th percentile values of reference site conditions in which population has been recorded. The 75th confidence limit should not be > these values. Specific limits cannot be quantified with current knowledge – but as an interim trigger, species should continue to exist at current conservation status.	S5

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Freshwater flows and inundation	Waterway-specific and variable over time.	n/d No quantification of frequency, duration and extent of freshwater inundation requirements for flora species.	H88. No significant reductions in flow regimes, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, species should continue to exist at current conservation status.	S5
			Geomorphology: • Erosion • Sedimentation • Soil type	Erosion and sedimentation variable over time. Soil type not variable over relevant time scale.	n/d No quantification of geomorphologic requirements of flora species.	H89. No significant changes in erosion or sedimentation processes, or changes to soil characteristics, relative to background variability, such that it results in such that it results in a measurable, medium-term (>2 to 5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	

2 INTRODUCTION

This Section provides general information about the Ecological Character Description (ECD) process and the Moreton Bay Ramsar site.

2.1 Background to the Study

The Moreton Bay wetland aggregation is one of 65 wetland areas in Australia that have been listed as a wetland of international importance under the *Convention on Wetlands of International Importance especially as Waterfowl Habitat* or, as it is more commonly referred to, the Ramsar Convention (the Convention). Moreton Bay was listed as a Ramsar site under the Convention in 1993 in recognition of its outstanding coastal wetland values and features.

The Convention sets out the need for contracting parties to conserve and promote wise use of wetland resources. In this context, an assessment of ecological character of each listed wetland is a key concept under the Ramsar Convention.

Under Resolution IX.1 Annex A: 2005, the ecological character of a wetland is defined as:

> *The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.*

The definition indicates that ecological character has a temporal component, generally using the date of listing under the Convention as the point for measuring ecological change over time. As such, the description of ecological character should identify a wetland's key elements and provide an assessment point for the monitoring and evaluation of the site as well as guide policy and management, acknowledging the inherent dynamic nature of wetland systems over time.

This report provides the Ecological Character Description (ECD) for the Moreton Bay Ramsar site. In parallel with the preparation of the ECD, the Ramsar Information Sheet (RIS) for the site is being updated and the associated Ramsar maps and digital GIS boundaries of the site have been reviewed and documented in a separate report (refer BMT WBM 2008d). Additional reports have also been prepared that are companion documents to this ECD. These include:

- A report reviewing and documenting management actions relevant to the critical services/benefits, components and processes of the ECD (refer BMT WBM 2008a);
- A report documenting the discussions and outcomes of the expert panel review process for the ECD undertaken with members of the Scientific Expert Panel of the Southeast Queensland Healthy Waterways Partnership (refer BMT WBM 2008b)
- A report reviewing and documenting the relevant wetland management goals and indicators relevant to the services/benefits, components and processes of the ECD (refer BMT WBM 2008c).

These reports have been prepared over a period of ten months by the consultant study team led by BMT WBM Pty Ltd under contract with the Queensland Environmental Protection Agency (EPA). This has occurred with input from the EPA Project Management Team for the study, a Project

Steering Committee made up of officials from the Australian Government Department of Environment, Water, Heritage and the Arts (DEWHA) and Queensland Government agencies, and a Knowledge Management Committee (KMC) comprising Government and non-Government individuals with expertise and/or local research experience working within the Ramsar site. As outlined above, parts of the ECD were also subject to review and discussion as part of a workshop process with scientists from the Southeast Queensland Healthy Waterways Partnership Scientific Expert Panel (SEP). Appendix A contains a list of the representatives of each of these committees and workshop processes and provides a summary of meeting dates.

2.2 Scope and Purpose of this Study

The *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands January 2008* (hereafter referred to as the National Framework), provides a comprehensive approach to preparation of ECD studies in Australia taking into account the obligations of the Convention, domestic legislative requirements under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and best practice approaches in other jurisdictions. Refer to Section 3.2.7 for a description of the policy and legilslative framework governing the site.

Figure 2-1 shows the key steps of the ECD process from the National Framework document.

Based on the National Framework document, the key purposes of undertaking an ECD are as follows:

- Contribute to meeting the obligations of the Convention and EPBC Act for the site;
- Through a review of existing information, data and literature, supplement the description of ecological character in the Ramsar Information Sheet (RIS) for the wetland;
- Quantify, where possible, the natural variation and/or limits of acceptable change to the ecological character of the site such that it can be measured over time including as part of assessments under the EPBC Act and other impact assessment legislation at a State and local level; and
- Identify information and knowledge gaps that will assist in measuring changes to ecological character over time and prioritise future monitoring and management planning for the site.

As such, the key audiences for this document are expected to be:

- The Queensland Environmental Protection Agency as the site manager;
- Other Queensland Government Agencies (and local government) that make decisions that could affect the ecological character of the site;
- The regional natural resource management (NRM) body constituted for the area;
- The Department of Environment, Water, Heritage and the Arts in terms of decision-making under the EPBC Act; and
- Other sectors of the community with a scientific or general interest in the Moreton Bay Ramsar site.

It is understood that this ECD (including updated Ramsar Map and updated Ramsar Information Sheet) submitted by the consultant team to the EPA will be assessed as part of a whole-of-Government process. If acceptable, the ECD will then be forwarded to the Australian Government Department of Environment, Water, Heritage and the Arts (DEWHA) for consideration.

If endorsed by DEWHA, the document will then be forwarded to the Ramsar Secretariat and formally registered in the context of a supporting document under the Ramsar Convention.

Ecological Character Description

1. Introduction to the description
Site details, purpose of the description and relevant legislation

↓

2. Describe the site
Site location, climate, maps and images, tenure, wetland criteria and types

↓

3. Identify and describe the critical components, processes and services
3.1 Identify all possible components, processes and benefits
3.2 Of these, identify the critical components, processes and benefits responsible for determining the ecological character of the site
3.3 Describe each of the critical components, processes and benefits

↓

4. Develop a conceptual model for the wetland
Depict the critical components and processes of the wetland (e.g. hydrology, biogeochemical processes, biota and vegetation, and their relationships)

↓

5. Set limits of acceptable change
Determine limits of acceptable change for critical components, processes and services of the site

↓

6. Identify threats to the ecological character of the site
use information from Steps 3-5 and other information to identify the actual or likely threats to the site

↓

7. Describe changes to ecological character
Describe any changes to the ecological character of the site since the time of listing; include information on the current condition of the site

↓

8. Summarise the knowledge gaps
Use information from Steps 3-7 to identify the knowledge gaps

↓

9. Identify site monitoring needs
Use information from Steps 3-8 to identify monitoring needs

↓

10. Identify communication and education messages
Identify any communication and education message highlighted during the development of the description

↓

11. Compile the description of the ecological character

12. Prepare or update the Ramsar Information Sheet
Submit as a companion document to the ecological character description

Figure 2-1 Key Steps in Preparing an Ecological Character Description

(Source: National Framework document, Jan 2008)

2.3 Key Terminology

Wetland ecosystem processes, components and wetland services/benefits are core terminology used in the National Framework document for defining ecological character. The sections below outline the definitions and meanings of those terms used generally throughout the report. Specific definitions of these and other commonly used terms are contained in the Glossary in Section 9.

2.3.1 Wetland Processes

Wetland ecosystem processes are defined as the dynamic forces within the ecosystem between organisms, populations and the non-living environment. Interactions can be physical, chemical or biological. Examples include:

- Climate – rainfall, temperature, evaporation
- Hydrology – water balance, flooding and inundation regime
- Geomorphology and physical processes – topography, soils, sedimentation processes, erosion
- Energy and nutrient dynamics – primary production, decomposition, carbon cycle
- Biological Processes such as:
  - (a) Biological maintenance – reproduction, migration, dispersal, pollination
  - (b) Species interactions – competition, predation, succession, disease, infestation

2.3.2 Wetland Components

Wetland ecosystem components are the physical, chemical and biological parts or features of a wetland. Examples include:

- Physical form – wetland type, geomorphology
- Wetland soils – profiles, permeability, physico-chemical properties
- Water quality – physico-chemical properties such as salinity or pH
- Biota – flora, fauna and habitats

It is noted in the National Framework that some components may be viewed as both wetland components and wetland processes (eg. geomorphology, water quality).

2.3.3 Wetland Services/Benefits

The terms benefits and services are defined within the Millennium Ecosystem Assessment (2005) and adopted as part of the National Framework document in the context of the 'benefits that people receive from ecosystems'.

However, the National Framework notes that wetland ecosystem services and benefits are based on or underpinned by wetland components and processes and can be both of direct benefit to humans (eg. food for humans or livestock) or of indirect benefit (eg. wetland provides habitat for biota which contribute to biodiversity). In this context, benefits and services can also be short term or long term.

The National Framework breaks down wetland services/benefits into four categories. The categories and examples of services/benefits in each category are listed below:

- Provisioning services – products obtained from wetlands such as water or food
- Regulating services – water quality regulation, flood regulation and other natural functions
- Cultural services – relating to education, recreation, tourism, cultural heritage and similar values
- Supporting services – biodiversity and other ecosystem services

Figure 2-2 from the National Framework document shows a generic conceptual model of the interaction between ecosystem processes, components and services/benefits for a wetland. In general terms, the model shows how wetland ecosystem processes interact with wetland components to generate a range of wetland services/benefits. These services/benefits can be broadly applicable to all wetlands ecosystems (such as primary productivity) or specific to a given site (eg. breeding habitat for an important avifauna species or population).

2.4 Report Structure

The report has been structured largely in accordance with the key steps outlined in the National Framework and as shown in Figure 2.1. Sections 4 and 5 provide an essentially non-technical ecological description. Readers requiring more detailed information (including key citations) of ecological character (and associated limits of acceptable change) are referred to section 7 of the ECD report.

Table 2-1 Key Steps in Preparing an Ecological Character Description and Relevant Report Sections

Framework step	Report section
Introduction to ECD	2; 3.2.7
Describe Site	3
Identify and describe critical components, processes and services	4
Develop a conceptual model for the wetland	7
Set limits of acceptable change	4.3; 7
Identify threats to the ecological character of the site	5.2
Describe changes to ecological character	5.1
Summarise knowledge gaps	6.1
Identify site monitoring needs	6.2
Identify communication and education messages	6.3
Compile the description of the ecological character	7

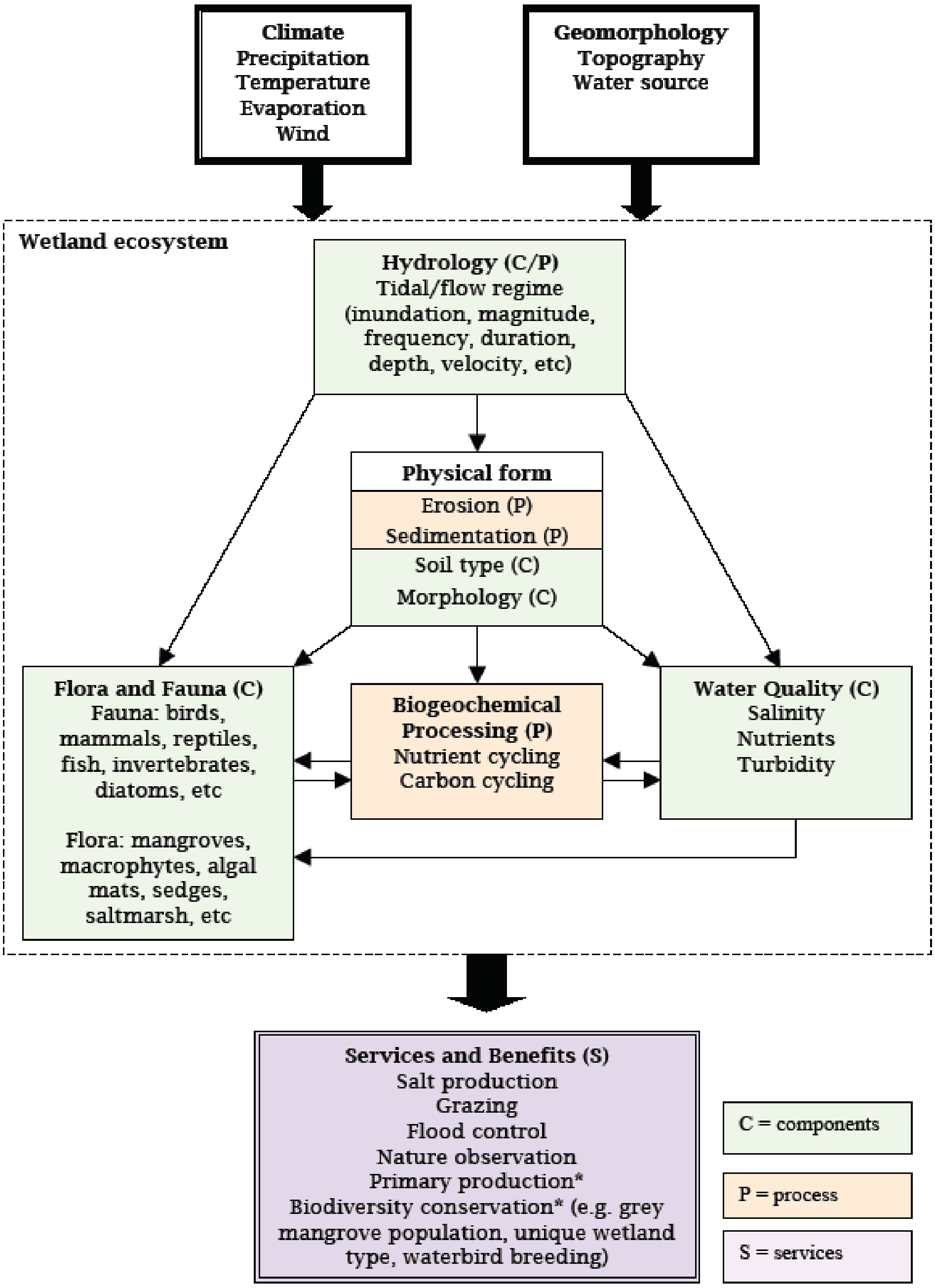


Figure 2-2 Generic conceptual model showing interactions between wetland ecosystem processes, components and services/benefits

(Source: National Framework document Jan 2008)

3 SITE CONTEXT

This Section of the report provides an overview and description of the Moreton Bay Ramsar site. The wetland habitat components of the site, the wetland processes that influence those habitats and the nomination criteria for which the site has been declared under the Convention are discussed.

These components, processes and criteria are important considerations in the selection of the critical components, processes and wetland benefits/services that make up the basis of the ECD, addressed in Sections 4 - 6 of the Report.

3.1 Site Details – Summary

Summary details of the site for the purposes of the ECD are provided in Table 3-1.

Table 3-1 Details of the Moreton Bay Ramsar site

Ramsar Site Name	Moreton Bay Ramsar site
Area	Total Area: 120 525 ha
Date of Listing	1993
Dates Used for Description	1993 (time of listing)
Justification for Date of Description	See above
Original Description Date	This is the first ECD undertaken for the site. As part of this project, the Ramsar Information Sheet (last updated in 1999) has also be updated and re-issued.
Compiler's Name	BMT WBM Pty Ltd with expert input from Austecology Pty Ltd and Converge Heritage + Community Pty Ltd under contract with the Queensland Environmental Protection Agency.
Ramsar Information Sheet	Last updated 1999 (by the Queensland EPA). Updated as part of current ECD by BMT WBM (2008).
Management Plan	There is no single plan relevant to the Ramsar site (refer Appendix B). Instead, a number of statutory management plans apply over broader areas of Moreton Bay and Southeast Queensland for which the boundaries of the Moreton Bay Ramsar site are a subset. The two primary management plans relevant to the Ramsar site are: • *Marine Park (Moreton Bay) Zoning Plan 1997* (currently under review) • *South-east Queensland Regional Coastal Management Plan (2006)* Other statutory plans/mechanisms relevant to the Ramsar site include: • National Park and other protected area management plans • The SEQ Regional Plan (2005-2026)

Ramsar Site Name	Moreton Bay Ramsar site
	• Environmental Values and Water Quality Objectives under the *Environmental Protection (Water) Policy 1997* • Fisheries Management Plans (East Coast Trawl and Coral Reef Finfish) and Fish Habitat Areas declared under the *Fisheries Act 1994* • *Water Resource (Logan Basin) Plan 2007* • *Water Resource (Moreton) Plan 2007* • *Water Resource (Gold Coast) Plan 2006* • Local Government Planning Schemes These statutory documents are supported by several key non-statutory natural resource management plans and strategies. The most notable relevant to the Ramsar site include: • The Healthy Waterways Strategy 2007-2012 • The SEQ Catchments Natural Resource Management Plan, *The Future in Balance* (2004) (currently under review) • EPA Shorebird Management Strategy 2005
Management Authority	The Ramsar site predominantly includes Queensland waters. Land areas above high water mark within the Ramsar site are largely State-owned lands managed by various State agencies and local governments as trustees of reserves and similar tenured land. There are some areas of leasehold and freehold land in the Western Bay area of the site. The Queensland Environmental Protection Agency (EPA) is the lead agency for planning and management of wetlands in Queensland noting that other Departments also play a crucial role in the management of wetland resources such as the Department of Primary Industries and Fisheries and the Department of Natural Resources and Water. EPA is considered as the nominal 'site manager' for the Moreton Bay Ramsar site.

3.2 Description of the Site

Section 3.2 and its subsections provide the general description of the site. This section is set out as follows:

- Section 3.2.1 – Describes the Ramsar site boundary
- Section 3.2.2 – Provides an overview of the wetland habitats present within the site
- Section 3.2.3 – Provides an overview of broad and local wetland processes that underpin and influence the site
- Section 3.2.4 – Provides an overview of the uses and tenure of land within and surrounding the site

- Section 3.2.5 – Provides an overview of the natural and cultural values of the site
- Section 3.2.6 – Provides an overview and summary of the policy framework for the site particularly in terms of relevant International, Commonwealth, State and regional plans and strategies

3.2.1 The Ramsar Site Boundary

Moreton Bay is located roughly mid-way along the east coast of Australia from 27 – 28 degrees latitude, placing it about 400 km south of the Tropic of Capricorn. A locality map of the Bay (with the Ramsar site boundary overlain) is shown in Figure 3-1.[2]

The broad study area for this ECD includes the Bay, its sand barrier islands and adjoining catchment areas. The Bay and its catchment areas are a component of the broader Southeast Queensland Region (or SEQ region as referred in this Report) which extends north to the Sunshine Coast (generally to northern boundary of the Sunshine Coast Regional Council), south across the Gold Coast and its hinterland to the border with New South Wales, and west to the Great Dividing Range.

Guidelines under the Ramsar Convention favour the use international or national biogeographic regions in the context of interpretation of Ramsar Nomination criteria and other aspects of the Convention. In this context, the Interim Marine and Coastal Regionalisation for Australia (IMCRA-version 4 - June 2006) have been adopted. Under this classification system, Moreton Bay lies within the Tweed-Moreton (TM) marine and coastal bioregion. From a terrestrial biogeographic perspective, the site is situated in the SEQ bioregion, based on the Interim Biogeographical Regionalisation for Australia (IBRA- version 6.1 – October 2008).

References within the report to the planning area or project area refer to those areas that are included within the nominated boundaries of the Moreton Bay Ramsar site (hereafter referred to as the Ramsar site or simply, 'the site').

As shown in Figure 3-1, the boundaries of the Ramsar site are essentially a series of discontinuous polygons that are generally limited to nearshore estuarine areas to a depth of roughly 6m below LAT (consistent with the definition of wetlands within the Convention). However, the boundary also extends selectively over State-controlled lands or similar above the high water mark in some locations including most notably, the Bay islands.

In addition, the site excludes major rivers such as the Brisbane and the Logan and in many cases does not extend up the smaller adjoining estuaries and creeks to their full tidal extent.

Specific observations about the site boundaries (moving from North to South) are as follows:

- The site includes the waters and tributaries of Pumicestone Passage;
- The site only includes selected intertidal and subtidal areas of the Western Bay;
- The site includes the Southern Bay and sandy channels of the Broadwater region;

[2] Minor modifications to the site boundary have been made as part of the current study and are documented as part of a separate mapping report (refer BMT WBM 2008d).

- The site excludes deeper marine areas and sand banks within the Central and Northern Bay;
- The site includes the ocean beach habitats of all the main sand islands and adjacent marine areas to a distance of approximately 50 m;
- The site includes all of Moreton Island, but has limited coverage on North and South Stradbroke Islands, Bribie Island and the Southern Bay Islands.

The discontinuous nature of the site is significant as most important wetland species identified in the nomination criteria for the site (refer RIS 1999 and outlined in this ECD in later sections), such as migratory shorebirds, turtles and dugong are highly mobile both within the site and across much larger habitat ranges.

Thus, while the approach within the ECD has been to identify those species and habitats that are most salient to the areas contained within the boundaries of the site (eg. core habitat), it is accepted that many of these species will only use the areas within the site from time to time. Likewise, threats and controls on these species and habitats may also be occurring outside the boundaries of the site, and as such, maintenance of ecological character can be highly reliant on other conservation and management regimes.

Figures 3-2 to 3-5 provide a 'snapshot' of the wetland habitat types, noteworthy flora and fauna that occur in the broader Moreton Bay region, water quality, coastal resource and marine park zoning, water resource planning and other planning information about the areas within the Ramsar site boundaries that will be described in the sections below. Given the size and diversity of wetland environments present in the Ramsar site, the site has been delineated into four areas for reporting purposes:

- Area 1 – Bribie Island and Pumicestone Passage
- Area 2 – Western Bay
- Area 3 – Moreton Island and Eastern Banks
- Area 4 – Stradbroke Islands and Southern Bay.

For all snap-shot descriptions note that:

- The term RE refers to regional ecosystems. Regional ecosystems are defined by Sattler and Williams (1999) as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
- Water quality condition codes are taken from Environmental Health Monitoring Program (EHMP). Refer to Section 3.2.3.4 for background to these codes.

Title:

Moreton Bay Locality Map

Figure: 3-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 10 20km

Approx. Scale

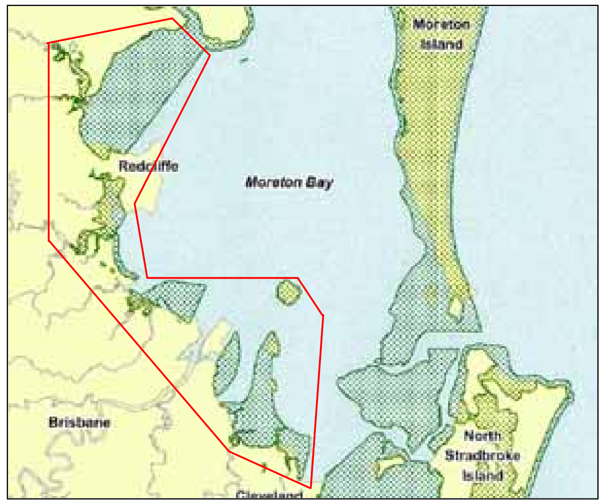
BMT WBM

www.wbmpl.com.au

Filepath : I:\B17004_I_BRH Moreton Bay Ramsar Site GWF\DRG\ECO_011_080530_Locality_Map.wor

AREA 2: WESTERN BAY

Location



Protected / Conservation Areas

Endangered Wetland REs

-

Of concern Wetland REs

12.1.1 - *Casuarina glauca* open forest on margins of marine clay plains

12.3.11 – Eucalypt open forest on alluvial plains

Areas of Significance (Source: EPA Coastal Plan)

Significant coastal dunes (<1% area covered)

Declared Fish Habitat Area (~10% area covered)

Area of special interest for whales and dolphins

Seagrass (~20% area covered)

Critical shorebird habitat (<5% area covered)

Shorebird habitat (~35% area covered)

Wetlands (significant and coastal) (~90% area covered)

National Parks and Conservation Parks:

St Helena NP

Beachmere CP

King Island CP

Marine Parks (Source: Draft Marine Parks (Moreton Bay) Zoning Plan 2008)

Marine National Park Zone (~30% area covered)

Conservation Park Zone (~20% area covered)

Habitat Protection Zone (~40% area covered)

General Use Zone (~10% area covered)

Ramsar Nomination Criteria

1 2 ✓ 3 ✓ 4 ✓ 5 (✓) 6 (✓) 7 (✓) 8 (✓) 9

✓ indicates within project area; (✓) indicates within entire Ramsar site

Ramsar Wetland types

Estuarine, based on RE
Estuarine, based on water body
Lacustrine, based on RE
Lacustrine, based on water body
Marine, based on water body
Palustrine, based on RE
Palustrine, based on water body
Riverine, based on RE
Riverine, based on water body

Source: EPA Wetland Mapping

	Marine / Coastal Wetlands	Regional example
	A – Permanent shallow marine waters (<6m)	
✓	B – Marine subtidal aquatic beds (kelp, seagrass)	
✓	C – Coral reefs	
	D – Rocky marine shores, sea cliffs	
✓	E – Sand, shingle or pebble shores; sandbars; dunes	
✓	F – Estuarine waters	
✓	G – Intertidal mud, sand or salt flats	
✓	H – Intertidal marshes, including saltmarshes	RE12.1.2
✓	I – Intertidal forested wetlands, including mangroves	REs 12.1.3, 12.1.1
	J – Coastal brackish / saline lagoons	
	K – Coastal freshwater lagoons	
	Inland Wetlands	
✓	M – Permanent rivers / streams / creeks	
✓	N – Seasonal / intermittent rivers / streams / creeks	
	O – Permanent freshwater lakes	
✓	Tp – Permanent freshwater marshes / pools	RE 12.2.15
✓	Ts – Seasonal / intermittent freshwater marshes / pools	RE 12.2.15
	U – Non-forested peatlands	
	W – Shrub-dominated wetlands; shrub swamps	
✓	Xf – Freshwater, tree-dominated wetlands and swamps	REs 12.3.5, 12.3.6
	Xp – Forested peatlands; peatswamp forests	
	Y – Freshwater Springs	
	Man-made Wetlands	
✓	9 - Canals, drainage channels and ditches	Dowse Lagoon

Note: Based on EPA wetland codes; Only wetland types present within Moreton Bay are listed here

Noteworthy Flora and Fauna likely to occur (Status NCA, EPBC respectively)

Terrestrial flora: *Acacia attenuata* (V,V), Hairy-joint Grass (V,V), Marbled Baloghia (V,V), Heart-leaved Bosistoa (V,V), Three-leaved Bosistoa (V,V), Leafless Tongue-orchid (V,V), Macadamia Nut (V,V), Small-fruited Queensland Nut (V,V), Lesser Swamp-orchid (E,E), Minute Orchid (V,V), *Acacia baueri* subsp. *baueri* (V,-), Toadflax (V,V), *Corchorus cunninghamii* (E,E), *Cupaniopsis shirleyana* (V,V), *Gossia gonoclada* (E,E)

Aquatic flora: Frogbit (V), *Maundia triglochinoides* (V,-)

Birds: Coxen's Fig Parrot (E,E), Ground Parrot (V,-), Paradise Parrot (PE,EX), Swift parrot (E,E), Glossy Black Cockatoo (V,-), Squatter pigeon (V,V), Powerful Owl (V,-), Red Goshawk (E,V), Southern Giant-petrel (E,E), Northern Giant Petrel (V,V), Kermadec Petrel (-,V), Australian Painted Snipe (-,V), Campbell Albatross (-,V), Black-breasted Button Quail (V,V), Regent Honeyeater (E,E), Little Tern (E,-), Beach Stone-curlew (V,-), Red-tailed Tropic Bird (V,-),

Amphibians: Wallum Sedgefrog (V,V), Southern Barred Frog (E,E), Wallum Rocketfrog (V,-), Wallum Froglet (V,-), Tusked Frog (V,-)

Mammals (terrestrial): Large-eared Pied Bat (-,V), Grey-headed Flying Fox (-,V), Long-nosed Potoroo (-,V), Water Mouse (V,V), Koala (V,-), Spotted-tailed Quoll (V,E)

Reptiles: Loggerhead Turtle (E,E), Green Turtle (V,V), Three-toed Snake-tooth Skink (R,V), Leatherback Turtle (E,V), Pacific Ridley (E,V)

Insects: Illidge's Ant Blue (V,-), Australian Fritillary (E,-), Richmond Birdwing (V,-)

Mammals (aquatic): Southern Right Whale (R,E), Humpback Whale (R,V), Dugong (V,-)

Sharks: Grey Nurse Shark (E,CE), Great White Shark (-,V), Green Sawfish (-,V), Whale Shark (-,V)

Fish: Oxleyan Pygmy Perch (V,E)

Source: Wildlife online & EPBC online searches. Note that these searches indicate species that are likely – not necessarily known - to occur within the area. Critical wetland species known within the project area have been identified in the report.

Water Quality

Unit	Area	2007	2006	2005	2004
Freshwater	Caboolture Catchment	C+	B-	B-	C-
	Pine Catchment	D+	C	C	D
	Lower Brisbane Catchment	F	F	D-	F
	Redlands Catchment	F	F	F	D
Estuarine	Caboolture Estuary	D	D	D+	C-
	Pine Estuary	C-	D	D	D+
	Brisbane Estuary	D+	D-	D-	D-
	Cabbage Tree Estuary	F	F	D-	D-
	Tingalpa Estuary	D+	D	D	D-
	Epraprah Estuary	D	D	C-	NG
Marine	Deception Bay	D	C-	D+	C+
	Bramble Bay	D+	D+	D+	D
	Waterloo Bay	B+	B-	B-	B

Source: Ecosystem Health Monitoring Program (Healthy Waterways)

Water Resource Outcomes (Source: Water Resource (Moreton) Plan 2007)

Estuarine reaches: Minimise changes to brackish habitats

Moreton Bay and Pumicestone Channel: Minimise changes to the natural movement and delivery of sediment, and the delivery of freshwater, natural nutrients and organic matter

Boondall Wetlands: Provide freshwater flows to maintain long-term inflow patterns and ecological functions

Figure 3-3 Snapshot of Western Bay

AREA 3: MORETON ISLAND AND EASTERN BANKS

Location

Protected / Conservation Areas

Endangered Wetland REs

-

Of concern Wetland REs

12.3.8 – Swamps with *Cyperus* spp., *Schoenoplectus* spp.

Areas of Significance (Source: EPA Coastal Plan)

Significant coastal dunes (100% area covered)

Declared Fish Habitat Area (~80% area covered)

Area of special interest for whales and dolphins

Seagrass (~80% area covered)

Critical shorebird habitat (<5% area covered)

Shorebird habitat (~65% area covered)

Wetlands (significant and coastal) (~40% area covered)

National Parks and Conservation Parks:

Moreton Island NP

Marine Parks (Source: Draft Marine Parks (Moreton Bay) Zoning Plan 2008)

Marine National Park Zone (~45% area covered)

Conservation Park Zone (~15% area covered)

Habitat Protection Zone (~40% area covered)

Ramsar Nomination Criteria

1✓ 2✓ 3✓ 4✓ 5(✓) 6(✓) 7(✓) 8(✓) 9

✓ indicates within project area; (✓) indicates within entire Ramsar site

Ramsar Wetland types

Estuarine, based on RE

Estuarine, based on water body

Lacustrine, based on RE

Lacustrine, based on water body

Marine, based on water body

Palustrine, based on RE

Palustrine, based on water body

Riverine, based on RE

Riverine, based on water body

Source: EPA Wetland Mapping

	Marine / Coastal Wetlands	Regional example
✓	A – Permanent shallow marine waters (<6m)	
✓	B – Marine subtidal aquatic beds (kelp, seagrass)	
✓	C – Coral reefs	
✓	D – Rocky marine shores, sea cliffs	Cape Moreton
✓	E – Sand, shingle or pebble shores; sandbars; dunes	
✓	F – Estuarine waters	
✓	G – Intertidal mud, sand or salt flats	
✓	H – Intertidal marshes, including saltmarshes	RE12.1.2
✓	I – Intertidal forested wetlands, including mangroves	REs 12.1.3, 12.1.1
	J – Coastal brackish / saline lagoons	
✓	K – Coastal freshwater lagoons	
	Inland Wetlands	
✓	M – Permanent rivers / streams / creeks	Spitfire Creek
✓	N – Seasonal / intermittent rivers / streams / creeks	
✓	O – Permanent freshwater lakes	Lake Jabiru
✓	Tp – Permanent freshwater marshes / pools	RE 12.2.15
✓	Ts – Seasonal / intermittent freshwater marshes / pools	RE 12.2.15
	U – Non-forested peatlands	
	W – Shrub-dominated wetlands; shrub swamps	
✓	Xf – Freshwater, tree-dominated wetlands and swamps	RE 12.2.5
	Xp – Forested peatlands; peatswamp forests	
	Y – Freshwater springs	
	Man-made Wetlands	
	9 - Canals, drainage channels and ditches	

Note: Based on EPA wetland codes; Only wetland types present within Moreton Bay are listed here

Noteworthy Flora and Fauna likely to occur (Status NCA, EPBC respectively)

Terrestrial flora: Marbled Baloghia (V,V), Lesser Swamp-orchid (E,E), Minute Orchid (V,V), *Acacia baueri* subsp. *baueri* (V,-), Swamp Orchid (E,E), Ball Nut (V,V)

Aquatic flora: N/A

Birds: Swift Parrot (E,E), Glossy Black Cockatoo (V,-), Tristan Albatross (-,E), Campbell Albatross (-,V), Southern Giant-petrel (E,E), Northern Giant Petrel (-,V), Kermadec Petrel (-,V), Australian Painted Snipe (-,V), Black-breasted Button Quail (V,V), Regent Honeyeater (E,E), Little Tern (E,-), Beach Stone-curlew (V,-), Red-tailed Tropic Bird (V,-)

Amphibians: Wallum Sedgefrog (V,V), Wallum Rocketfrog (V,-), Wallum Froglet (V,-)

Mammals (terrestrial): Long-nosed Potoroo (-,V), Grey-headed Flying Fox (-,V), Water Mouse (V,V)

Reptiles: Loggerhead Turtle (E,E), Green Turtle (V,V), Leatherback Turtle (E,V), Pacific Ridley (E,V), Three-toed Snake-tooth Skink (R,V),

Insects: Illidge's Ant Blue (V,-)

Mammals (aquatic): Blue Whale (R,E), Southern Right Whale (R,E), Humpback Whale (V,V), Dugong (V,-)

Sharks: Grey Nurse Shark (E,CE), Great White Shark (-,V), Green Sawfish (-,V), Whale Shark (-,V)

Fish: Oxleyan Pygmy Perch (V,E)

Source: Wildlife online & EPBC online searches. Note that these searches indicate species that are likely – not necessarily known - to occur within the area. Critical wetland species known within the project area have been identified in the report.

Water Quality

Unit	Area	2007	2006	2005	2004
Freshwater	-	-	-	-	-
Estuarine	-	-	-	-	-
Marine	Eastern Bay	A-	A	A	A
	Eastern Banks	A	A	A	A

Source: Ecosystem Health Monitoring Program (Healthy Waterways)

Water Resource Outcomes

Moreton Bay and Pumicestone Channel: Minimise changes to the natural movement and delivery of sediment, and the delivery of freshwater, natural nutrients and organic matter

(Source: Water Resource (Moreton) Plan 2007)

Figure 3-4 Snapshot of Moreton Island and Eastern Banks

AREA 4: STRADBROKE ISLANDS AND SOUTHERN BAY

Location

Protected / Conservation Areas

Endangered Wetland REs

-

Of concern Wetland REs

12.1.1 - *Casuarina glauca* open forest on margins of marine clay plains

12.3.11 – Eucalypt open forest on alluvial plains

Areas of Significance (Source: EPA Coastal Plan)

Significant coastal dunes (~60% area covered)

Declared Fish Habitat Area (~25% area covered)

Area of special interest for whales and dolphins

Seagrass (~10% area covered)

Critical shorebird habitat (<1% area covered)

Shorebird habitat (~70% area covered)

Wetlands (significant and coastal) (~65% area covered)

National Parks and Conservation Parks:

Blue Lake NP

Bird Island CP, Cobby Cobby Island CP, Coomera Island CP, Goat Island CP, Kangaroo Island CP, Myora CP, S. Stradbroke Island CP, South Stradbroke Island CP2, Woogoompah Island CP

Marine Parks (Source: Draft Marine Parks (Moreton Bay) Zoning Plan 2008)

Marine National Park Zone (~25% area covered)

Conservation Park Zone (~20% area covered)

Habitat Protection Zone (~55% area covered)

Ramsar Nomination Criteria

1☑ 2☑ 3☑ 4☑ 5(☑) 6(☑) 7(☑) 8(☑) 9

☑ indicates within project area; (☑) indicates within entire Ramsar site

Ramsar Wetland types

Estuarine, based on RE
Estuarine, based on water body
Lacustrine, based on RE
Lacustrine, based on water body
Marine, based on water body
Palustrine, based on RE
Palustrine, based on water body
Riverine, based on RE
Riverine, based on water body

Source: EPA Wetland Mapping

	Marine / Coastal Wetlands	Regional example
☑	A – Permanent shallow marine waters (<6m)	
☑	B – Marine subtidal aquatic beds (kelp, seagrass)	
☑	C – Coral reefs	Peel Island
☑	D – Rocky marine shores, sea cliffs	Point Lookout
☑	E – Sand, shingle or pebble shores; sandbars; dunes	
☑	F – Estuarine waters	Nerang Estuary
☑	G – Intertidal mud, sand or salt flats	
☑	H – Intertidal marshes, including saltmarshes	RE 12.1.2
☑	I – Intertidal forested wetlands, including mangroves	REs 12.1.3, 12.1.1
☑	J – Coastal brackish / saline lagoons	Lake Coombabah
☑	K – Coastal freshwater lagoons	
	Inland Wetlands	
☑	M – Permanent rivers / streams / creeks	Little Canalpin Creek
☑	N – Seasonal / intermittent rivers / streams / creeks	
☑	O – Permanent freshwater lakes	Brown Lake
☑	Tp – Permanent freshwater marshes / pools	RE 12.2.15
☑	Ts – Seasonal / intermittent freshwater marshes / pools	RE 12.2.15
☑	U – Non-forested peatlands	18 Mile Swamp
☑	W – Shrub-dominated wetlands; shrub swamps	RE 12.2.12
☑	Xf – Freshwater, tree-dominated wetlands and swamps	REs 12.2.5, 12.2.7, 12.3.5
☑	Xp – Forested peatlands; peatswamp forests	18 Mile Swamp
☑	Y – Freshwater springs	Myora Springs
	Man-made Wetlands	
☑	9 - Canals, drainage channels and ditches	Couran Cove

Note: Based on EPA wetland codes; Only wetland types present within Moreton Bay are listed here

Noteworthy Flora and Fauna likely to occur (Status NCA, EPBC respectively)

Terrestrial flora: *Acacia attenuata* (V,V), Marbled Baloghia (V,V), Heart-leaved Bosistoa (V,V), Three-leaved Bosistoa (V,V), Native Jute (E,E), Stinking Cryptocaria (V,V), Leafless Tongue-orchid (V,V), Macadamia Nut (V,V), Small-fruited Queensland Nut (V,V), Swamp Daisy (E,E), Swamp Orchid (E,E), Lesser Swamp Orchid (E,E), Yellow Swamp Orchid (E,E), Minute Orchid (V,V), *Thelypteris confluens* (V,-), *Acacia baueri* subsp. *baueri* (V,-), Toadflax (V,V), Shiny-leaved Coondoo (E,E)

Aquatic flora: Frogbit (-,V), *Persicaria elatior* (V,E)

Birds: Coxen's Fig Parrot (E,E), Swift parrot (E,E), Glossy Black Cockatoo (V,-), Glossy Black Cockatoo eastern (V,-), Powerful Owl (V,-), Red Goshawk (E,V), Tristan Albatross (-,E), Campbell Albatross (-,V), Southern Giant-petrel (E,E), Northern Giant Petrel (V,V), Black-throated Finch (V,E), Kermadec Petrel (-,V), Australian Painted Snipe (-,V), Black-breasted Button Quail (V,V), Regent Honeyeater (E,E), Beach Stone-curlew (V,-), Little Tern (E,-), Red-tailed Tropic Bird (V,-),

Amphibians: Wallum Sedgefrog (V,V), Southern Barred Frog (E,E), Wallum Rocketfrog (V,-), Wallum Froglet (V,-), Tusked Frog (V,-)

Mammals (terrestrial): Large-eared Pied Bat (-,V), Spotted-tail Quoll (V,E), Brush-tailed Rock Wallaby (-,V), Long-nosed Potoroo (-,V), Grey-headed Flying Fox (-,V), Water Mouse (V,V), Koala (V,-)

Reptiles: Loggerhead Turtle (E,E), Green Turtle (V,V), Leatherback Turtle (E,V), Flatback Turtle (V,V), Hawksbill Turtle (V,V), Pacific Ridley (E,V), Three-toed Snake-tooth Skink (R,V), *Ophioscincus truncatus* (R,-)

Insects: Illidge's Ant Blue (V,-), Richmond Birdwing (V,-)

Mammals (aquatic): Blue Whale (-,E), Southern Right Whale (-,E), Humpback Whale (V,V), Dugong (V,-)

Sharks: Grey Nurse Shark (E,CE), Great White Shark (-,V), Green Sawfish (-,V), Whale Shark (-,V)

Fish: Oxleyan Pygmy Perch (V,E)

Source: Wildlife online & EPBC online searches. Note that these searches indicate species that are likely – not necessarily known - to occur within the area. Critical wetland species known within the project area have been identified in the report.

Water Quality

Unit	Area	2007	2006	2005	2004
Freshwater	Logan Catchment	D	D+	D	C
	Pimpama/Coomera Catchment	B-	C+	B+	C
	Nerang Catchment	A-	C+	B+	A-
Estuarine	Logan Estuary	D-	F	D-	D
	Pimpama Estuary	C+	C	C	C
	Coomera Estuary	B	A-	B+	B
	Nerang Estuary	B	B	B	B
Marine	Southern Bay	B-	D	D+	C
	Broadwater	B+	B-	C-	C-

Source: Ecosystem Health Monitoring Program (Healthy Waterways)

Water Resource Outcomes

Estuarine reaches: Minimise changes to brackish habitats

Moreton Bay and Pumicestone Channel: Minimise changes to the natural movement and delivery of sediment, and the delivery of freshwater, natural nutrients and organic matter

(Source: Water Resource (Moreton) Plan 2007; Water Resource (Gold Coast) Plan 2006)

Figure 3-5 Snapshot of Stradbroke Islands and Southern Bay

3.2.2 Overview of Wetland Types

In seeking to characterise the types of wetlands within the boundaries of the Moreton Bay Ramsar site, it is important to recognise that the site has a high level of habitat diversity, ranging from perched freshwater lakes and sedge swamps, to intertidal mudflats and mangroves to sub-tidal seagrass habitats. For this report, the Ramsar Classification System for Wetland Types (approved by Recommendation 4.7 and amended by Resolutions VI.5 and VII.11 of the Conference of the Contracting Parties) is used.

As shown in the area 'snapshots' above, detailed mapping of wetlands within the region has been undertaken by the Queensland EPA as part of a State-wide mapping programme under the Queensland Wetlands Programme. The EPA mapping method uses a combination of Queensland Regional Ecosystem (RE) vegetation mapping and water body mapping (interpreted from satellite imagery) to classify wetlands into broad categories of marine, estuarine, riverine, lacustrine and palustrine types. Although there are broad overlaps between the EPA classification and the Ramsar classification systems (lacustrine ~ lake, palustrine ~ marshes/pools, riverine ~ river channel), these systems have limited analogies due to the finer-scale of wetland categorization under the Ramsar typology which provides up to 12 marine/coastal wetland types, up to 20 inland wetland types and up to 10 human-made wetland types.

To assist in this regard, the EPA has developed and made available for the study a draft cross-referencing table that assigns particular RE types with Ramsar habitat classification types. Using this table and the EPA mapping supplied, the presence of Ramsar wetland types within the Moreton Bay Ramsar site has been refined and the following habitat types are seen as being represented:

- 11 marine/coastal wetland types;
- 10 inland wetland types; and
- 1 man-made wetland type

Further description and examples of these types is contained in the sections below.

3.2.2.1 *Marine/Coastal Wetland Types (11)*

Photos of estuarine and marine wetland environments in the Moreton Bay region (Source: EPA and BMT WBM photo library)

Type A: Permanent shallow marine waters

This wetland type incorporates marine waters that are less than six metres deep at low tide, including sea bays and straits. Within the Moreton Bay Ramsar site, shallow marine waters are located along the length of the offshore islands on the seaward boundary.

Type B: Marine subtidal aquatic beds

This wetland type is represented within the Moreton Bay Ramsar site by seagrasses that form meadows in quiet, clear, shallow waters. These seagrass beds provide food and habitat for turtles, dugong, and commercially and recreationally important fish and invertebrate populations in Moreton Bay. Within the Ramsar site, seagrass beds cover an area of 24,078 hectares and are predominantly located in Pumicestone Passage, the Eastern Banks and Southern Moreton Bay.

Type C: Coral reefs

Moreton Bay is close to the southern limit of reef-building corals. Within the Ramsar site, coral reef communities occur around Peel, St Helena, Mud and Green Islands, and from Wellington Point to Raby Bay. The presence of coral communities are limited in the Western Bay (around Mud and St Helena Island) as a result of historical coral limestone extraction which has since ceased. In total, 1,152 hectares of coral reef are present within the Ramsar site. Of particular importance is the area on the northern side of Peel Island and Myora reef in the Eastern Bay.

Type D: Rocky marine shores

This wetland type is characterised by exposed rocky marine shores, including rocky offshore islands and sea cliffs. Rocky shores provide habitats for a wide range of algae, marine invertebrates and fish species. Approximately 200 hectares of rocky shores are present within the Ramsar site, with representative examples including the rocky headlands of Point Lookout on North Stradbroke Island and Cape Moreton on Moreton Island, as well as rocky shores inside the bay such as Toorbul Point at the entrance to Pumicestone Passage.

Type E: Sand, shingle or pebble shores

This wetland type includes sand bars, spits and sandy islets, as well as dune systems and humid dune slacks. Within the Moreton Bay Ramsar site, approximately 3,000 hectares of sandy shores are present, typically located along the eastern shorelines of the Bay Islands.

Type F: Estuarine waters

This wetland type includes permanent water of estuaries and estuarine systems of deltas. Due to the protection provided by the large offshore islands, estuarine waters are widespread within the Moreton Bay Ramsar site from Pumicestone Passage to the Southern Bay.

Type G: Intertidal mud, sand or salt flats

This wetland type encompasses habitats comprised of alluvial deposits of sand and mud that accumulate on intertidal flats. Many invertebrate species inhabit these intertidal flats, and at low tides they are an important feeding ground for waders. Intertidal flats are widespread within the Moreton Bay Ramsar site, covering an area in excess of 5,000 hectares. Specific locations including Pumicestone Passage, the Western Bay, the Southern Bay and the landward shores of North Stradbroke Island.

Type H: Intertidal marshes

This wetland type is represented in the Ramsar site by saltpan vegetation on marine clay plains, as well as saline or brackish sedgelands. There is approximately 2,522 hectares of saltmarsh / saltpan complexes within the Moreton Bay region (Duke *et al*. 2003), of which approximately 85% is contained within the Ramsar site. Characteristic vegetation communities are *Sporobolus virginicus* grasslands, and samphire herblands dominated by *Sarcocornia* species and *Suaeda australis*. Saltmarsh typically occurs in the upper-intertidal zone as a band along the landward edge of the mangrove zone. Protected intertidal marshes within Moreton Bay include Bribie Island National Park, Coombabah Lake Conservation Park and Southern Moreton Bay Island National Park.

Type I: Intertidal forested wetlands

This wetland type is represented in the Ramsar site by mangrove shrublands to low closed forest on marine clay plains and estuaries, as well as tidal freshwater swamp forests such as those primarily composed of *Casuarina glauca*. Mangrove forests occupy an area of approximately 15,300 hectares in Moreton Bay (Duke and Pederson 2003), of which approximately 85% is contained within the Ramsar site. Mangroves are important roosting and sheltering sites for a variety of shorebirds, and provide nursery grounds for fish and a diversity of invertebrate fauna. Protected intertidal forested wetlands within the Ramsar site include Bribie Island National Park, Buckleys Hole Conservation Park, Coombabah Lake Conservation Park, Moreton Island National Park and Southern Moreton Bay Islands National Park.

Type J: Coastal brackish/saline lagoons

This wetland type consists of brackish to saline lagoons with at least one relatively narrow connection to the ocean. It is represented within the Moreton Bay Ramsar site by Lake Coombabah, covering 222 hectares.

Type K: Coastal freshwater lagoons

This wetland type includes freshwater lagoons. Although not listed in the current RIS, this wetland type is represented within the Moreton Bay Ramsar site by various freshwater lagoons on the Bay islands such as Ibis Lagoon and Black Snake Lagoon on North Stradbroke Island.

3.2.2.2 Inland Wetland Types (10)

Photos of freshwater and transitional wetland environments in the Moreton Bay region (Source: BMT WBM photo library)

Type L: Permanent inland deltas

While listed in the current RIS (1999), this wetland type is not considered to be present in the Ramsar site.

Type M: Permanent rivers / streams / creeks

This wetland type incorporates permanent rivers, streams and creeks. Within the Moreton Bay Ramsar site, freshwater creeks include Spitfire Creek on Moreton Island and Little Canalpin Creek on North Stradbroke Island.

Type N: Seasonal rivers / streams / creeks

This wetland type incorporates seasonal rivers, streams and creeks. This wetland type was not included in the current RIS, but is believed to be represented within Moreton Bay in the context of ephemeral freshwater and semi-tidal creeks and streams in the Pumicestone Passage area.

Type O: Permanent freshwater lakes

Permanent freshwater bodies over 8 hectares in area are included in this wetland type. Representative examples within the Moreton Bay Ramsar site include Blue Lake on North Stradbroke Island, and Lake Jabiru on Moreton Island.

Type Q: Permanent saline / brackish / alkaline lakes

While listed in the current RIS (1999), this wetland type is not considered to be present in the Ramsar site.

Type Tp: Permanent freshwater marshes / pools

This wetland type includes ponds < 8 hectares in area, as well as marshes and swamps on inorganic soils with emergent vegetation that is waterlogged for at least most of the growing season. Vegetation communities in this category include palustrine wetlands such as freshwater swamps with *Cyperus*, *Schoenoplectus* and *Eleocharis* species, or coastal sedgelands with *Baumea* and *Juncus* species. Within the Moreton Bay Ramsar site, protected areas of this wetland type include Moreton Island National Park, Blue Lake National Park and Bribie Island National Park.

Type Ts: Seasonal / intermittent freshwater marshes / pools on inorganic soils

This wetland type includes sloughs, potholes and seasonally flooded meadows. Vegetation communities associated with this wetland type are typically sedge marshes, comparable in species composition to vegetation communities of the permanent freshwater marshes / pools (Type Tp). Protected areas of this wetland type include Blue Lake National Park and Bribie Island National Park.

Type U: Non-forested peatlands

This wetland type includes shrub or open bogs, and swamps. Although not currently included in the current RIS, this wetland type is represented within the Ramsar site by Eighteen Mile Swamp on North Stradbroke Island, one of the largest of its type in Queensland.

Type W: Shrub-dominated wetlands

This wetland type includes shrub swamps and shrub-dominated freshwater marshes. It is represented within the Moreton Bay Ramsar site by seasonally waterlogged closed heathland that covers a total area of 130 hectares. Flora composing these palustrine wetlands characteristically includes *Banksia*, *Epacris* and *Leptospermum* species. Protected shrub-dominated wetlands within the Ramsar site are located in Bribie Island National Park.

Type Xf: Freshwater tree-dominated wetlands

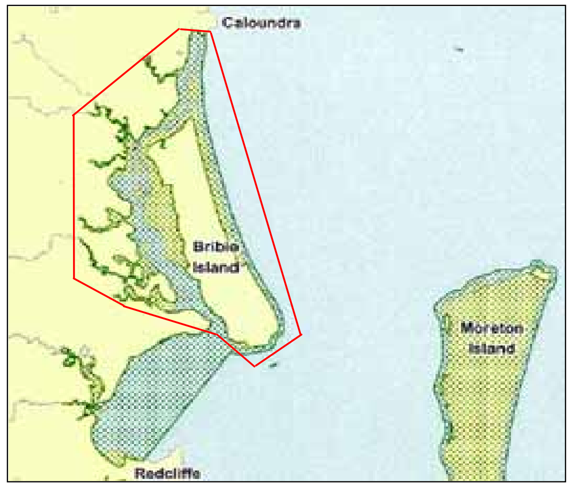
This wetland type includes freshwater swamp forests, seasonally flooded forests and wooded swamps on inorganic soils. It is represented in Moreton Bay by palustrine open forests dominated by *Melaleuca quinquenervia*, covering a total area of 8,596 hectares within the Ramsar site. The understorey varies in composition depending on the duration of water logging, and may include ferns, grasses, sedges and/or shrubs. Protected areas of freshwater tree-dominated wetlands include Bribie Island National Park, Coombabah Lake Conservation Park, Southern Moreton Bay Islands National Park, Buckley's Hole Conservation Park, Blue Lake National Park and Moreton Island National Park.

Type Xp: Forested peatlands

This wetland type incorporates peat swamp forests. Forested peatlands are present within Eighteen Mile Swamp on North Stradbroke Island. As outlined in the Ramsar Guidelines for Global Action on Peatlands (GAP), peatlands are increasingly being recognised as an important wetland resource at the global level through their role in contributing to global biodiversity, as an important carbon sink and through the retention of paleo-environmental information about previous landscapes and climate states.

AREA 1: BRIBIE ISLAND AND PUMICESTONE PASSAGE

Location



Protected / Conservation Areas

Endangered Wetland REs

12.3.1 – Riverine notophyll vine forest on alluvial plains

Of concern Wetland REs

12.1.1 - *Casuarina glauca* open forest on margins of marine clay plains

12.3.4 - *Melaleuca quinquenervia, Eucalyptus robusta* open forest; on or near coastal alluvial plains

12.3.11 – Eucalypt open forest on alluvial plains

Areas of Significance (Source: EPA Coastal Plan)

Significant coastal dunes (~30% area covered)

Declared Fish Habitat Area (~65% area covered)

Area of special interest for whales and dolphins

Seagrass (~15% area covered)

Critical shorebird habitat (~1% area covered)

Shorebird habitat (~40% area covered)

Wetlands (significant and coastal) (~95% area covered)

National Parks and Conservation Parks:

Bribie Island NP

Buckley's Hole CP

Marine Parks (Source: Draft Marine Parks (Moreton Bay) Zoning Plan 2008)

Marine National Park Zone (~10% area covered)

Conservation Park Zone (~55% area covered)

Habitat Protection Zone (~35% area covered)

Ramsar Nomination Criteria

1⊾ 2⊾ 3⊾ 4⊾ 5(⊾) 6(⊾) 7(⊾) 8(⊾) 9

⊾ indicates within project area; (⊾) indicates within entire Ramsar site

Ramsar Wetland types

Estuarine, based on RE

Estuarine, based on water body

Lacustrine, based on RE

Lacustrine, based on water body

Marine, based on water body

Palustrine, based on RE

Palustrine, based on water body

Riverine, based on RE

Riverine, based on water body

Source: EPA Wetland Mapping

	Marine / Coastal Wetlands	Regional example
⊾	A – Permanent shallow marine waters (<6m)	
⊾	B – Marine subtidal aquatic beds (kelp, seagrass)	
	C – Coral reefs	
⊾	D – Rocky marine shores, sea cliffs	Toorbul Point
⊾	E – Sand, shingle or pebble shores; sandbars; dunes	
⊾	F – Estuarine waters	
⊾	G – Intertidal mud, sand or salt flats	
⊾	H – Intertidal marshes, including saltmarshes	RE 12.1.2
⊾	I – Intertidal forested wetlands, including mangroves	REs 12.1.3, 12.1.1
	J – Coastal brackish / saline lagoons	
⊾	K – Coastal freshwater lagoons	
	Inland Wetlands	
⊾	M – Permanent rivers / streams / creeks	
⊾	N – Seasonal / intermittent rivers / streams / creeks	
	O – Permanent freshwater lakes	
⊾	Tp – Permanent freshwater marshes / pools	RE 12.2.15
⊾	Ts – Seasonal / intermittent freshwater marshes / pools	RE 12.2.15
	U – Non-forested peatlands	
⊾	W – Shrub-dominated wetlands; shrub swamps	RE 12.2.12
⊾	Xf – Freshwater, tree-dominated wetlands and swamps	REs 12.2.7, 12.3.4, 12.3.5, 12.3.6
	Xp – Forested peatlands; peatswamp forests	
	Y – Freshwater Springs	
	Man-made Wetlands	
⊾	9 - Canals, drainage channels and ditches	Skipper Canal

Note: Based on EPA wetland codes; Only wetland types present within Moreton Bay are listed here

Noteworthy Flora and Fauna likely to occur (Status NCA, EPBC respectively)

Terrestrial flora: *Acacia attenuata* (V,V), Heart-leaved Bosistoa (V,V), Three-leaved Bosistoa (V,V), Miniature Moss-orchid (V,V), Swamp Stringybark (E,E), Small-fruited Queensland Nut (V,V), Lesser Swamp-orchid (E,E), Yellow Swamp Orchid (E,E), *Prasophyllum wallum* (V,V), Minute Orchid (V,V), *Acacia baueri* subsp. *baueri* (V,-), Stinking Cryptocaria (V,V), *Macrozamia pauli-guilielmi* (E,E)

Aquatic flora: *Maundia triglochinoides* (V,-),

Birds: Coxen's Fig Parrot (E,E), Paradise Parrot (PE,EX), Swift parrot (E,E), Glossy Black Cockatoo (V,-), Squatter pigeon (V,V), Powerful Owl (V,-), Plumed Frogmouth (V,-), Red Goshawk (E,V), Southern Giant Petrel (E,E), Northern Giant Petrel (V,V), Kermadec Petrel (-,V), Australian Painted Snipe (-,V), Campbell Albatross (-,V), Beach Stone-curlew (V,-), Little Tern (E,-), Southern Emu-wren (V,-), Black-breasted Button Quail (V,V), Regent Honeyeater (E,E)

Amphibians: Wallum Sedgefrog (V,V), Southern Barred Frog (E,E), Wallum Rocketfrog (V,-), Wallum Froglet (V,-), Tusked Frog (V,-)

Mammals (terrestrial): Large-eared Pied Bat (-,V), Eastern Long-eared Bat (V,V), Grey-headed Flying Fox (-,V), Long-nosed Potoroo (-,V), Water Mouse (V,V), Spotted-tailed Quoll (V,E)

Reptiles: Loggerhead Turtle (E,E), Green Turtle (V,V), Leatherback Turtle (E,V), Hawksbill Turtle (V,V), Pacific Ridley (E,V), Three-toed Snake-tooth Skink (R,V)

Mammals (aquatic): Southern Right Whale (R,E), Humpback Whale (R,V)

Sharks: Grey Nurse Shark (E,CE), Great White Shark (-,V), Green Sawfish (-,V), Whale Shark (-,V)

Fish: Oxleyan Pygmy Perch (V,E), Honey Blue-eye (V,V)

Source: Wildlife Online & EPBC online searches. Note that these searches indicate species that are likely – not necessarily known - to occur within the area. Critical wetland species known within the project area have been identified in the report.

Water Quality

Unit	Area	2007	2006	2005	2004
Freshwater	Pumicestone Catchment	C-	C-	C+	C
Estuarine	-	-	-	-	-
Marine	Pumicestone Passage	B-	B	C+	B

Source: Ecosystem Health Monitoring Program (Healthy Waterways)

Water Resource Outcomes

Estuarine reaches: Minimise changes to brackish habitats

Moreton Bay and Pumicestone Channel: Minimise changes to the natural movement and delivery of sediment, and the delivery of freshwater, natural nutrients and organic matter

(Source: Water Resource (Moreton) Plan 2007)

Figure 3-2 Snapshot of Bribie Island and Pumicestone Passage

Type Y: Freshwater springs

This wetland type includes freshwater springs and oases. Freshwater springs are a feature of North Stradbroke Island where the watertable and natural land surface intersect such that a freshwater spring develops as a result of groundwater seepage. This wetland type is closely associated with Type M, as a number of streams and creeks on North Stradbroke Island are spring-fed. Within the Moreton Bay Ramsar site, an example of this wetland type is Myora Springs.

3.2.2.3 Man-made Wetland Types (1)

Type 9: Canals, drainage channels and ditches

The Ramsar boundary along the Western Bay includes waterbodies and features that are remnant wetland or drainage channels that are now heavily modified and largely artificial in nature. Examples include the entrance at Skipper Canal on Bribie Island, the entrance channel to the canal and harbour area at Couran Cove on South Stradbroke Island and parts of Dowse Lagoon in Sandgate, covering a total of 9 hectares within the Ramsar site.

3.2.3 Overview of Wetland Processes

Wetland habitat components within the site, as identified in the section above, are influenced by a range of both broad-scale and localised wetland ecosystem processes. These processes include physical processes, chemical processes, biological processes, geologic processes and combinations thereof.

This section provides an overview of the key wetland processes occurring within and external to the Ramsar site.

3.2.3.1 Regional Climate and Hydraulic Processes

The climate and oceanographic current patterns affecting Moreton Bay are influenced by both tropical and temperature features.

The East Australian Current (EAC) typically produces a flow of warm low-nutrient waters from the Coral Sea past Moreton Bay which has a number of effects as outlined in Abal *et al.* (2005) including:

- Transport of tropical larvae;
- Maintenance of relatively consistent water temperatures; and
- Low frequency of upwelling events.

In summer, the average maximum air temperature is about 28º – 29º C and the minimum ranges from 19º to 20º C. The average maximum temperature in winter is about 20º – 21º C and the minimum average ranges from 9º to 10º C.

Winds from the south-east are the prevailing summer winds with low pressure systems bringing rain to the region generally in summer and early autumn. The tropical influences in the summer months lead to heavy, periodic rainfall that causes significant runoff and occasional floods, with considerable silt, mud and sand washed down into the Bay during large events.

Fronts move from west to east in the winter months, generally bringing cool and dry conditions. Winds during winter months generally prevail from a southwest to northwest direction.

The site is occasionally subject to the effects of tropical cyclones which originate in the Coral Sea and may travel as far south as Moreton Bay before (usually) weakening into a low pressure system or rain depression as they cross the coast.

Median annual rainfall in the region is reported as being some 1500 mm with high variability within and among years. Rainfall in dry years is roughly less than half of the rainfall in wet years (Abal *et al.* 2005). Rainfall is also spatially variable, with coastal catchments receiving greater rainfall than western (inland) catchments in the region. This occurs, in part, as a result of on-shore winds and adiabatic cooling as clouds rise over the coastal ranges causing precipitation to form.

The wind climate of Moreton Bay is driven by the synoptic winds and diurnal pattern of sea and land breezes. The sea and land breeze effect is very pronounced in the inshore areas of the site, while greater winds speeds are recorded at more exposed areas such as Cape Moreton.

The dominant processes affecting water levels in the Bay region relate to:

- Astronomical tides;
- Storm surges associated with cyclones and low pressure systems;
- Wind stresses (and generation of local ‘sea’ waves as discussed above); and
- Potential sea level rise associated with climate change.

From a hydraulic perspective, Moreton Bay is a semi-enclosed waterbody with ocean connections *via*:

- the sand channels of the Northern Entrance Tidal Delta between Bribie and Moreton Islands;
- the South Passage entrance between Moreton and North Stradbroke Islands; and
- an (indirect) connection through the Gold Coast Broadwater system which has a connection to the ocean at Jumpinpin and the Gold Coast Seaway.

The ocean tide penetrates into the system through these separate entrances and is significantly amplified as it moves through the Bay. Tidal currents vary from 0.2 ms^{-1} in the shallow western region to 1.0 ms^{-1} in the deep channels to the north-east. Studies have shown that the Moreton Bay tidal incursion extends southward to the Southern Bay area to the vicinity of the southern end of Russell Island. South from this point, the Bay tides interact with the inflow from Jumpinpin and the Broadwater in a complex way. This complexity results from the natural geomorphology of the area and also the influence of the constructed Gold Coast seaway, which has caused tides in the Broadwater to be only slightly less than those in the ocean (Crimp 1992).

The Central Bay region is shallower in the western and southern areas and deeper (exceeding 20 m) in the eastern parts. This pattern is disturbed by the intrusion of coastal sands which are aggregating along the banks in both the Northern Entrance Tidal Delta as well as in the vicinity of South Passage.

Several streams enter the Bay from the mainland coastal plan including the Brisbane, Caboolture, Pine, Pimpama, Coomera and Logan Rivers and other small creeks and estuaries. Waterways connecting to the Bay are tidal for part of their length with larger waterways such as the Brisbane River exhibiting tidal extent as far as 70 km upstream from the mouth. However, as previously discussed, the major rivers are not included in the boundaries of the Ramsar site.

While the tidal rivers flowing into the Broadwater contribute a significant proportion to the tidal volume of water within that part of the overall system, the contribution of the streams entering Moreton Bay proper is small compared to the total tidal prism of the Bay (Crimp 1992). However, the nutrient and sediment input from these waterways can have significant effects on water quality and associated habitats as discussed in the water quality section below.

The mainland shoreline and Bay waters are largely sheltered from ocean (swell) waves by the outer Bay islands. As a result, wind 'sea' waves dominate swell waves and will develop quickly with the onset of winds, but also diminish quickly as winds ease (Crimp 1992).

Alternatively, the eastern shorelines of the Bay islands are strongly affected by oceanic wind and wave processes, which have caused the formation of high energy sandy beaches and rocky headlands as discussed in the geology section below.

3.2.3.2 Geology and Geomorphology

Stephens (in Crimp 1992) provides an insight to the geological formation of the Bay, which is one dominated by sea level change over geologic time scales. This has led to the laying of a series of sedimentary landscapes that regulate many present day geomorphologic processes.

During the low sea level phases of the Pleistocene ice ages, the present Bay formed as a terrestrial plain traversed by stream valleys of the ancestral Brisbane and Pine Rivers. Sea levels began to rise about 17 000 years Before Present (BP) peaking at the end of the post glacial marine transgression about 6 500 years ago.

As such, the present landscape of the Bay as a marine area has existed for only about 6 500 years during which time a great deal of sedimentation and changes to the morphological features of habitats have occurred. As a result of coastal progradation, the Bay is bordered by extensive estuarine flats and mangrove swamps along its western and southern shores.

Coastal headlands and most of the islands of Moreton Bay are formed of Tertiary age basalts and freshwater shales, Mesozoic age sandstones and Palaeozoic age metamorphic rocks with laterite soils developed at the surface.

The islands themselves are essentially drowned sand dune island barriers anchored by the rocky headlands that formed by wave and wind action during several cycles of sea level change. The resultant landscape on the islands consists of coastal swamps and beach ridges and a wide array of freshwater features such as perched and window lakes, streams and springs.

The modern sedimentation pattern within the Bay itself reflects long term sedimentation patterns since the last major sea level rise and shows the Bay is essentially filling from three sides:

- fluvial sand and mud from the Brisbane River (calculated by Stephens in Crimp 1992 at a supply of about 175 000 tonnes/year averaged over the past 6 500 years);
- marine sand from the South Passage (calculated at a supply of about 200 000 m^3/year over the past 7 000 years); and
- marine sand from the Northern Passage Tidal Delta (calculated at a supply of about 600 000 m^3/year over the past 6 500 years).

The central, deeper area of the Bay remains a non-depositional area.

Figure 3-6 shows a recent satellite image of the Bay produced by SEQ Catchments and partner organisations. This figure illustrates the depositional environments of the Northern Entrance and Southern Passage as well as the Brisbane River Delta, the complex bathymetry and hydrology of the Southern Bay and the relatively static, deeper areas within the Central Bay.

Moreton Bay is situated close to the southernmost limit of reef-building corals. Coral reefs formed in shallower areas of the Bay (along the margins of the large islands and between Mud and Peel islands) around 6 500 to 4 000 years BP in locations when conditions were suitable for growth. Since this time there has been little coral reef development. Some of these nearhsore reefs have since been degraded as a result of increased sediment and nutrient runoff following clearing of the catchment and urbanisation of the region over the past 150 years and from coral limestone mining.

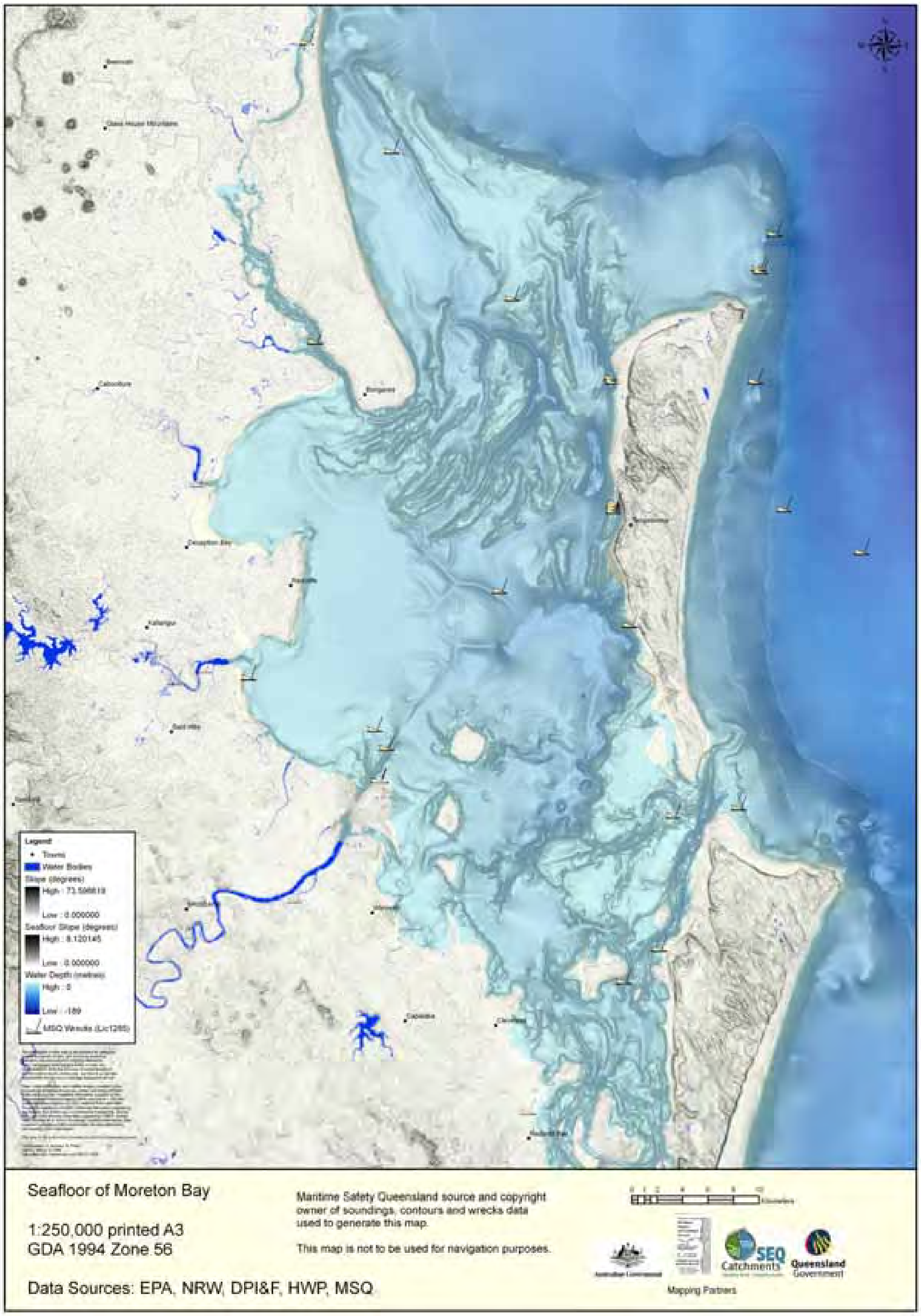


Figure 3-6 Bathymetry of Moreton Bay

Source www.seqcatchments.com.au

3.2.3.3 Freshwater Flows

Coastal catchments between the Lamington Plateau in the south, extending north along the Great Dividing Range to the D'Aguilar Range drain into Moreton Bay. The combined catchment area draining to Moreton Bay is almost 22,000 km^2. Moreton Bay also receives smaller freshwater contributions from run-off from the barrier islands (Bribie, Moreton and North and South Stradbroke) and directly from rainfall.

The northern reach of Moreton Bay comprises Pumicestone Passage, which separates Bribie Island from the mainland. The mainland catchment area draining to Pumicestone Passage consists of a series of sub-catchments which are collectively identified in the Moreton Water Resource Plan as Pumicestone Creeks (State of Queensland 2007). The Western Bay area receives inflows from a series of catchments, the most northerly of which discharges to Deception Bay from the Caboolture River. South from Deception Bay, the Pine River and Cabbage Tree Creek discharge into Bramble Bay. The Brisbane River (which includes drainage from the Upper Brisbane, Stanley, Lockyer and Bremer River subcatchments) enters Moreton Bay between Bramble Bay and Waterloo Bay and the Redlands subcatchments also flow into Waterloo Bay. Further south and the Logan, Pimpama and Coomera Rivers drain to the Southern Bay and Gold Coast Broadwater areas.

Freshwater flows to Moreton Bay are characterised by limited inflow for most of the year with episodic, large-volume floods, which typically occur over summer and autumn months. These high flow events usually contribute to increased productivity of Western Bay environments at a time when shorebirds are most abundant in the area.

The implications of freshwater flows for locally occurring wetlands are largely dependent on the type of wetland, the quantity and quality of flow and/or the wetlands location relative to the freshwater influence. In general terms, freshwater dependent wetlands, such as those in and adjacent to freshwater reaches of watercourses, are those most influenced by freshwater flow patterns. The distribution of mangrove and saltmarsh wetlands are influenced mostly by physiographic features and tidal inundation, however their species composition can be determined by prevailing salinity regimes. Mudflats and seagrass beds can be affected by settlement of freshwater-borne sediments in brackish/saline environments – the former in an advantageous sense from accretion, the latter in a deleterious sense from potential smothering and loss of seagrass beds. Excessive nutrient inputs from freshwater in-flows from point and non-point sources can also impact on seagrass beds as is evidenced by the loss of seagrass from Bramble Bay and Southern Deception Bay and a few sites in Pumicestone Passage and southern Moreton Bay.

Freshwater flows to Moreton Bay have altered over time with development of both land and water resources. Urbanisation of the catchments of the Bay have resulted in significant increases in impervious surfaces, as natural surfaces such as grassland and forested areas are replaced by concrete. These surfaces increase the flow of urban pollutants (including sediment) into nearshore habitats causing altered nutrient sources, eutrophication, and other impacts that affect habitat quality (Young *et al.* 2006).

Over recent years in particular the demand for freshwater has challenged supply and a process of water allocation is being developed. Water Resource Plans (WRPs) provide a strategic framework for the management of water resources within a nominated area by specifying Environmental Flow Objectives (EFOs) and Water Allocation and Security Objectives (WASOs) that are intended to achieve, amongst other things, desired ecological outcomes. Recently developed regional WRPs are being implemented through Resource Operation Plans (ROPs) – currently being established - which will establish detailed water resource management rules for achieving the aspirational EFOs and WASOs set out in the WRPs, as well as a monitoring framework for assessing plan performance. These plans, when implemented, will further influence freshwater flows to Moreton Bay.

3.2.3.4 Water and Sediment Quality

The following water and sediment quality description has segregated the Ramsar site into the four broad areas previously introduced. Water quality condition in this section utilises monitoring information collected as part of the Southeast Queensland Healthy Waterways Partnership Ecosystem Health Monitoring Program (EHMP). The EHMP Annual Report Card provides an overall water quality rating for each area of the Bay, assessed against water quality guidelines (based on benmarks derived from reference data) for several key physio-chemical and biological parameters. Monitoring ratings range from A (excellent – reference conditions) to F (fail – poor water quality, major ecosystem impairment). Detail on the EHMP program and the methods used to derive scorecard values are provided in EHMP technical reports (EHMP 2006).

Bribie Island and Pumicestone Passage

Pumicestone Passage can be broken into three sub-areas when water and sediment quality issues are considered, with these sub-areas largely being controlled by the interplay between catchment inflows and tidal flushing. The northern and southern sections of Pumicestone Passage are well flushed by tidal processes and as such typically exhibit high to moderate water quality, especially so in the case of the southern section. The central sections of Pumicestone Passage, located around 'The Skids', have poorer water quality due to lower rates of tidal flushing (this is an area where tidal inflows from the north and south ends of the Passage meet, creating an area with lowered rates of net water exchange). Pumicestone Passage in recent years has been ascribed EHMP report card ratings of between C^+ and B for estuarine areas and C^- to C^+ for freshwater areas.

There is little readily available, recent sediment grain size distruibution data for this area. Given tidal and catchment influences, it is expected that sediments within the northern and southern sections will be largely marine in nature, progressing to finer, more organic sediments in the central section. The presence of substantially deposits of acid sulfate soils within the catchment will almost certainly be reflected in the quality of sediments within the Passage.

In regard to wetland ecosystem processes in Pumicestone Passage, for most of the areas, natural or quasi-natural conditions still exist, though catchment land use change and large scale infrastructure development (eg. road/rail/water supply) pressures still exist. In general, intertidal wetlands above mean sea level in and adjacent to the Passage (eg. mangroves, tidal flats, saltmarsh) are strongly affected by hydrologic conditions whereby water quality is a more salient issue for sub-tidal vegetation and seagrass beds in the Passage which are undoubtedly under moderate stress.

For waters adjoining the eastern coastline of Bribie Island, water and sediment qualities will be high due to the absence of pollutant sources (e.g. point source discharges or major catchment inflows) and the high rates of tidal flows and net exchange of water.

Western Bay

The Western Bay can also be broken into three sub-areas when water and sediment quality issues are considered, with these largely being controlled by the interplay between point and diffuse (catchment) inflows and tidal processes. These sub-areas are Deception Bay, Bramble Bay and Waterloo Bay, and the respective estuarine/freshwater areas contiguous with these bays.

Bramble Bay exhibits the poorest water and sediment quality of these sub-areas, primarily due to the high rates of pollutant loading (both continual inflows of wastewater and intermittent, though high, inflows of catchment sourced pollutants), with a similar situation for the estuaries connected to Bramble Bay. EHMP report card ratings for Bramble Bay in recent years have ranged between D and D^+ while the Brisbane, Pine and Cabbage Tree Creek estuaries have respectively had D^- to D^+, D to C^- and F to D^- grades.

Deception Bay also exhibits poor water quality, for reasons similar to Bramble Bay, though in the case of Deception Bay the per-unit-area rate of diffuse and point source loading is somewhat lower. Consequent EHMP ratings in Deception Bay have been D to C^+ and for the Caboolture Estuary C^- to B^-.

Waterloo Bay is the portion of the western part of Moreton Bay with the highest water quality, primarily due to high rates of tidal flushing/water exchange caused by its close proximity to South Passage and also as there are low rates of point/diffuse pollutant loadings in this area. Waterloo Bay EHMP report cards in recent years have ranged between B- and B+. The estuaries entering Waterloo Bay exhibit poorer water quality due to their small size and proportionally higher rates of wastewater loads. In recent years, these estuaries have exhibited EHMP report card ratings of D- to D+ (Tingalpa Estuary) and D to C- (Eprapah Estuary).

In regard to wetland 'functioning', similar comments in regard to vegetation 'above' mean sea level as made for Pumicestone Passage apply, with the exception of there being far greater levels of disturbance due to anthropogenic effects. For the subtidal/seagrass areas, there are sub-area specific comments which can be made, as follows:

Deception Bay – the key factors affecting subtidal wetlands in this area are water quality related, specifically excessive nutrients and commensurate nuisance algal blooms (specifically the blue green cyanobacteria *Lyngbya*). There may well be a strong causative link between continually elevated phosphorus levels (due to regional pressures) and episodic loadings of iron (due to local pressures) and these lyngbya blooms. There have been major losses of seagrass from southern Deception Bay since declaration of the Ramsar site in 1993.

Bramble Bay – this area has seen almost the total loss of sub-tidal seagrass, undoubtedly due to excessive nutrient and sediment loads from point source and catchment loads.

Waterloo Bay – subtidal wetlands in this area are likely to be functioning in a robust manner due to the generally acceptable water quality levels.

Sediments in all of these bays and estuaries, especially Bramble and Deception Bay, are known (Dennison and Abal 1999) to be fine (silts and clays) and in most areas are highly organic. These sediments will undoubtedly comprise a major reservoir of carbon and nutrients and will be contributing to ongoing surface water quality degradation.

Moreton Island and Eastern Banks

The marine sections of this area exhibit reference/near-reference water quality conditions, as evidenced by EHMP report card ratings for recent years never falling below A-. As could be expected, this high water quality can be attributed to very high rates of tidal flow/exchange and very low rates of pollutant input. As a consequence of this, subtidal wetlands (seagrass) are found extensively and to some of the greatest depths in the entire Moreton Bay region, highlighting the unique nature of this area.

Marine sediments in this area are known (Dennison and Abal 1999) to be mostly fine to medium sand, that are mostly marine in origin. The relatively 'clean' nature of these sediments will be assisting in maintaining high water quality levels in the overlying water column.

The physio-chemical characteristics of freshwater lakes, creeks and marshes on Moreton Island vary among waterbodies. In common with other dune island wetland systems, these waterbodies typically have low nutrient concentrations (although some perched lakes can have high nitrogen concentrations at low water levels), low pH and electrical conductivity. Waterbodies with a peat substrate typically have low water transparency due to high concentrations of dissolved organic carbon (tannins, linols etc.), whereas waterbodies that are a predominantly fed by the regional water-table typically have clearer waters.

Stradbroke Islands and Southern Moreton Bay

Water quality in the marine sections of the Southern Bay is highly variable in space (i.e. strong east-west and to a lesser extent north-south gradients in water quality) and in time (i.e. strong influence of pulsed flood events).

The Southern Bay and the Gold Coast Broadwater had EHMP report card ratings respectively ranging from D to B- and C- to B+. In an estuarine context, EHMP report card ratings ranged from: heavily impacted (Logan/Albert, EHMP report cards F to D- in recent years), moderately impacted (Pimpama, EHMP report cards C+ to C in recent years) and slightly impacted (Coomera and Nerang, EHMP report cards respectively ranging between B and A- and constantly at a B level in recent years).

As evidenced by environmental monitoring work conducted after recent (2008) heavy flooding in the area, and previous reporting by Dennison and Abal (1999), this is a highly dynamic area in regard to water quality and wetland vegetation. The area is regularly affected by flood events which have seen the loss, and subsequent recovery of, subtidal seagrass beds.

There have also been losses of major areas of mangroves (not due to flooding) and subsequent colonization of former saltmarsh areas as a result of urban development (including on the Southern Bay islands), from sand mining activities and from natural hazards (in the case of hail damage at Cobby Cobby Island). In combination there are major concerns that the various existing processes affecting both water quality and wetland vegetation in this area, when combined with anticipated major population growth/land use change in the catchment could see (water quality driven) consistent and permanent reductions in the extent and health of wetland vegetation in this area.

Sediments in this area will range from sandy/marine in nature throughout much of Southern Moreton Bay and the Gold Coast Broadwater to highly organic silts and muds in the estuaries and less dynamic reaches of Southern Moreton Bay and the Broadwater. As per previous comments, where the sediments are fine and organic, they are highly likely to be contributing to degradation in overlying water quality levels.

Water quality conditions in freshwater environments on North Stradbroke Island are similar to that described for Moreton Island (see discussion above).

3.2.3.5 Marine and Estuarine Nutrient Cycling

Nutrient cycling in and around the wetlands of the Moreton Bay Ramsar site plays a key role, both in regard to functions within the wetlands, and to feedback processes between the wetlands and their proximate areas and the water quality within and overlying (in the case of seagrass beds) them. Nowhere in the region is this more important than in the heavily disturbed/impacted wetland areas of Bramble and Deception Bays. Detailed scientific studies of sediment quality and nutrient cycling processes in these areas (as reported in Dennison and Abal 1999) have indicated that natural denitrification processes in marine sediments are unable to reduce the rates of organic loading of benthic zones (due to a combination of point and diffuse carbon sources). Recent and ongoing efforts to reduce sewage carbon and nutrient loads to the region are being implemented to reduce these impacts.

Outside the above discussion on nutrient cycling which is essentially specific to Bramble and Deception Bays, nutrient budgeting work reported in Dennison and Abal (1999) highlights the following:

- The carbon budget of Moreton Bay is dominated by marine plants, predominantly phytoplankton in the water column. Mangroves and seagrasses constitute smaller sources of primary production in Moreton Bay (see Table 3-2);
- Nitrogen fixing and recycling within wetlands is small in comparison to point and diffuse sources; and phosphorus recycling is also small in comparison to point and diffuse sources.

3.2.3.6 Groundwater Resources

Groundwater (as reported in Dennison and Abal 1999) is not a major inflow or nutrient source to Moreton Bay as a whole and, as such, is likely to be having minimal overall impact on wetland functioning.

There are several, more localised, exceptions in this regard, which are noteworthy, as follows:

- The freshwater wetlands of Bribie Island and the western border of Pumicestone Passage, which will be heavily influenced by groundwater;
- The freshwater wetlands of Moreton Island and North Stradbroke Island, which will also be heavily influenced by groundwater; and
- The seagrass beds in and around Amity and Pelican Banks to the west of South Passage. There would appear to be a strong causative link between the dissolved iron content of groundwater upwellings in these areas and occasional occurrences of *Lyngbya* growth on the seagrass.

Recent studies undertaken by the Department of Natural Resources and Water on North Stradbroke Island (Marshall *et al.* 2006) have sought to identify and examine the groundwater dependent ecosystems, species and communities of the Island. This has been done particularly to formulate potential ecological consequences associated with groundwater extraction. However, the study found that it is not currently possible to evaluate the likelihood or magnitude of changes as a result of increased groundwater extraction in the absence of better hydrological and ecological understanding.

3.2.3.7 Biological Processes

Ecosystem functions are maintained and regulated by numerous, often interacting biological processes. While it is not possible to list and describe each of the biological processes operating within the Ramsar site, the following processes are thought to represent the most important controls operating over broad spatial scales (i.e. either whole of site, or key habitats within the site).

Primary Productivity

Primary productivity, which is the rate at which vegetative matter is produced within a habitat, is ultimately controlled by the availability of light, nutrients, temperature and salinity in estuaries. Preliminary primary productivity estimates for estuarine waters within Moreton Bay (Abal *et al.* 1998) suggest that phytoplankton contributes ~67.9% of primary productivity within the bay. The remaining one third is thought to be generated by seagrass (~16.8%) and mangroves (~15.3%). The high proportion of primary productivity by phytoplankton is a reflection of the large area of this group, whereas on productivity/area basis, seagrasses and mangroves are far more productive (Table 3-2).

The contribution of benthic micro-algae (microphytobenthos) and saltmarsh to primary productivity within the Bay has not been examined to date. In the context of the Ramsar site, which occurs in water depths below 6m and is therefore largely in the euphotic zone, it is likely that benthic microalgae are also important primary producers at this scale (Alongi 1990). Saltmarsh is also a contributor to total primary productivity in the Bay and can be highly productive on a unit area basis (Saenger *et al.* 1977; King 1981; Clarke and Jacoby 1994; Mazumder 2004).

Table 3-2 Primary productivity estimates of seagrasses, mangroves and phytoplankton in Moreton Bay (Abal *et al.* 1998)

Group	Area (ha)	Primary productivity (tonnes C/day)	% Contribution
Seagrasses	25000	105	16.8
Mangroves	13604	96	15.3
Phytoplankton	140000	424	67.9

Patterns in aquatic primary productivity in freshwater wetlands are thought to vary among wetland types. Water-table window lakes such as Blue Lake and Blue Lagoon, which having very low turbidity and colour (transparency), are nutrient poor ecosystems that are considered to be oligotrophic (Bayly 1964; Bowling 1988; Arthington *et al.* 1989; Outridge *et al*. 1989). However given the limited extent of aquatic macrophytes in these lakes compared to the total area of potential microalgae habitat, it possible that phytoplankton and benthic microalgae contribute a high proportion of total primary productivity within these lakes.

Macrophyte cover on perched lakes varies greatly among lakes, and can vary within lakes over time. For example, in 2000, Black Snake Lagoon on North Stradbroke Island had a large open water: littoral macrophyte area ratio, but due to low transparency resulting from high concentrations of tannins, is unlikely to have high microalgae productivity. Ibis Lagoon on North Stradbroke Island, a relatively permanent waterbody with high water transparency, had moderate cover of emergent macrophytes, and a high cover of benthic microalgae (periphyton). Ephemeral perched waterbodies (e.g. Mungaree Lagoon) and palustrine wetlands can have 100% aquatic macrophyte cover (WBM 2002c), and therefore primary productivity is likely be dominated by this component.

Carbon Cycling by Bacteria

As vegetative and animal matter begins to senesce and die, microbes invade the tissues and transform the organic material into more bio-available forms of carbon. While microalgae, and to a lesser extent mangroves and seagrasses, are responsible for primary productivity within estuarine and marine waters of the site, microbial breakdown is a key pathway for plant material entering the food-web in these ecosystems (Alongi 1990). This is especially true for marine macrophytes (seagrass, mangroves, saltmarsh), which with few notable exceptions (e.g. dugongs, some fish) are generally not directly grazed, but instead enter food-webs following microbial conversion of organic matter (Day *et al*. 1989). Carbon flows in sand island freshwater wetlands are not well known and require further investigation, although peatlands (such as Eighteen Mile Swamp on North Stradbroke Island) are exceedingly recognised as important sinks for carbon as actively accumulate organic matter.

In the context of energy flows through the ecosystem, some energy is lost during microbial respiration, some is leached as dissolved organic mater into the water, some is incorporated into microbial biomass, and some may be transformed to other organic compounds not incorporated in microbial cells. Of particular importance to higher trophic levels (i.e. consumers) is the conversion of detrital material into bacterial biomass, which is then in a bio-available form for animals (Day *et al.* 1989). Microbes also affect energy flow by using dissolved organic matter, which is largely unavailable to other estuarine community components (Day 1967; Nybakken 1982; Day *et al.* 1989).

Carbon cycling is intimately linked with nutrient cycling (see section above) and primary productivity. Note that autotrophic bacteria are primary producers, and also contribute to carbon cycling and nutrient flux.

Zooplankton Grazing

Grazing of phytoplankton by zooplankton is an important link in the chain of nutrient flux and energy flow in the coastal and estuarine waters of Moreton Bay (Greenwood 1998). Zooplankton has the following key roles in estuarine ecosystems:

- Transfer of energy through the food web, by transferring organic compounds derived from phytoplankton to higher trophic levels (secondary consumers), including species of direct economic significance;
- Regulation of community structure (species composition, abundance, biomass) of phytoplankton communities. In Moreton Bay, microzooplankters were responsible in one study for the majority of herbivorous grazing (ciliates in the <64μm fraction) (Dennison 1999). In this study, it was demonstrated that zooplankton grazers could account from between 10 and 100% of the total phytoplankton productivity and biomass per day. Therefore, grazing may partially control water quality at local scales.

It is also notable that the planktonic phase forms part of the life-cycle of most benthic and marine demersal fauna (meroplankton), including most species of direct fisheries significance.

While there is a relatively good information base describing estuarine marine zooplankton communities in Moreton Bay, comparatively little is known about the relationships between nutrient levels, phytoplankton dynamics and zooplankton composition, grazing and production, within different parts of the system (Greenwood 1998). No studies have examined zooplankton productivity and dynamics within dune island wetlands, although it is known that communities are depauperate and contain species that are restricted to humic, coastal waterbodies (Bayly 1964; Bensink and Burton 1975; Timms 1982; WBM 2002a,b).

Bioturbation in Estuarine Sediments

Bioturbation, a bottom-up process where biological activity (burrowing) disturbs the ocean floor, can be critical to the structural organisation of soft sediment communities. The main bioturbators include polychaete worms, burrowing crabs (particularly in mangroves) and other crustaceans (e.g. ghost nippers), rays, fish, dugongs and turtles.

Bioturbation results in the mixing of sediment layers. This mixing assists in the oxygenation of the sediment, increases rates of organic decomposition, and affects nutrient cycling processes (Day *et al*. 1989). Furthermore, bioturbation can breakdown micro-topographical features of the bed such as ripples and cross-bedding, which were demonstrated by Stephenson and Sadacharan (1983) to have an important role in structuring soft-sediment communities in Moreton Bay. Bioturbation has a strong influence on many aspects of benthic ecology including:

- physical properties of sediments;
- sediment-water biogeochemical processes, including nutrient cycling;
- seagrass productivity;
- mangrove ecosystem functioning; and

- benthic fauna community interactions, including predation, competition etc.

<u>Other Fauna Interactions</u>

Competition, predation, and disturbance all have an influence on freshwater and estuarine/marine community functioning. The influence of these processes on communities can vary across a range of spatial and temporal scales. Critical fauna interactions in the context of this ECD will be identified in the discussion of specific critical services in Section 7.

In general terms, the following fauna interactions are thought to be important in regulating community structure and ecosystem processes:

- Marine and Estuarine Fish - It is generally thought that populations of most fish species are regulated by non-equilibrium processes (i.e. predation, recruitment limitation) rather than density-dependent processes such as competition. While there is a large body of work examining populations controls and processes for reef fish (Hixon 1998; Levin 1998), with few exceptions there is comparatively little information describing the ultimate population controls for estuarine and coastal fish species. Since most fish species are part of an open population, the process/es that ultimately control populations can vary across multiple spatial scales, and may operate both within and external to the Ramsar site.

- Benthic macroinvertebrates – Numerous studies have examined the roles of competition, predation, larval supply, food supply and disturbance in structure in soft-sediment benthic macroinvertebrate communities. The relative importance of these processes can vary across a range of spatial and temporal scales (Seitz 1998). Of particular note, in parts of Moreton Bay it is known that a cyclic seasonal (spring) recruitment pulse occurs for many species of macroinvertebrate (Stephenson *et al*. 1978; Stephenson 1980a-c). Although not examined within empirical experimental frameworks, predation has been suggested to lead to major temporal changes in invertebrate prey abundance within Moreton Bay (Stephenson 1980b).

- Freshwater fish and decapod crustaceans – Unlike marine and estuarine fish populations, it is generally thought that many freshwater fish species (and some decapod crustacean species) on dune island wetlands form relatively discrete, closed populations (Page *et al.* 2006; Page and Hughes 2007). Biological processes operating at local (within-wetland) spatial scales may therefore be very important controls on these populations. With the notable exception of Oxleyan pygmy perch (Arthington 1996), few studies to date have examined the population ecology of these species.

3.2.4 Uses and Tenure

3.2.4.1 Uses

Urban Development

Southeast Queensland is one of the fastest growing regions in Australia with over 2.5 million people and a population that is increasing by just under 3% per annum. The latest Queensland Government projections by the Planning and Information Forecasting Unit (PIFU) estimate the current population of the Region at 30 June 2006 was 2.8 million people and is expected by 2011 to grow to between 3.0 and 3.1 million people. By 2026, this is expected to increase again to between 3.6 and 4.3 million people.

Urban and suburban developments are concentrated on the Brisbane River corridor and are rapidly expanding into areas along the North and South coast. There continues to be increasing pressure and demand for development of coastal and foreshore areas for residential and associated commercial development that can displace more appropriate coastal dependant uses.

Fishing and Collecting

The Moreton Bay region supports one of the most productive fisheries in Queensland, representing just under three percent of the Queensland coastline while annually producing about 20 percent of Queensland's commercial seafood catch by weight (RIS 1999). Vessels operating within the Moreton Bay Marine Park are reported to have landed approximately $24.1 million gross value of product each year during the three year period ending June 2006 (EPA 2007a).

The Bay is also a popular recreational fishing area. A variety of species are targeted, including yellowfin bream, whiting, tailor, flathead, Black bream, mackerel, snapper and mullet. Eight species of prawn and four species of crab are commercially important, with mud and blue swimmer crabs also being of recreational importance.

Commercial collection of fish and invertebrates for aquarium purposes occurs within the Bay as well as offshore reefs outside of the Ramsar site. Bait collection, food gathering and viewing of coral and aquarium fish species are popular recreational pursuits. Commercial oyster beds operated by licensed oyster growers, commercial baitworm and shell collection also occurs.

The boundaries of the Ramsar site are similar to those of the current Moreton Bay Marine Park excluding deeper areas in the Central Bay. Information presented within the Queensland Government document, *Have Your Say: Moreton Bay Marine Park* (2006) reports that on average 410 commercial fishing licences accessed the Marine Park annually from June 2003 to June 2006. In terms of the value of the fisheries, the report states that these vessels landed approximately $24.1 million gross value of product (that is the wharf price paid to commercial fishers) each year during this period (Queensland Government 2006).

Recreation and Tourism

The Bay is an important and well utilised area for recreational boating and water related activities, offering opportunities for a wide range of water-based recreation including fishing, sailing, power boating, water skiing, parasailing, jetskiing, sailboarding, scuba diving, bird watching, marine study and snorkelling. The southern area of the bay receives the heaviest boating use for most activities because of its sheltered waters and proximity to many boat launching facilities. Policies administered under the marine park zoning plan and Southeast Queensland regional coastal management plan closely regulate the construction of tidal canals and boat harbours including placement of private moorings and jetties in largely undeveloped natural waterways.

The three barrier islands (Moreton, North and South Stradbroke) have unspoilt beaches, topographic diversity within the dunal system and largely undisturbed natural scenery, forest and wetlands.

Sea and Air Port Facilities

The Port of Brisbane is the fastest growing capital city port on the east coast with the capability to handle a wide variety of cargoes. The Port has expanded significantly since the listing of the Ramsar site with the construction of the 230 ha Future Port Expansion reclamation area which extends from Fisherman Islands at the mouth of the Brisbane River into the Waterloo Bay. Maintenance dredging occurs within the shipping channels of the Bay as well as operational areas of the Port and Brisbane River (berths, swing basin, shipping channel) with the dredged material/spoil placed in the reclamation area.

Across the Brisbane River, the Brisbane Airport is Australia's fastest growing passenger airport with a $2.5 billion capital works programme over the next 10 years. These works involve upgrading road transport into the Airport, the expansion of the domestic and international terminals and the development of a New Parallel Runway (which was approved with conditions under the EPBC Act in August 2006) on the Brisbane Airport federal lease. The footprint of the New Runway (with the exception of proposed approach lighting) is situated outside of the boundaries of the Ramsar site in the Western Bay.

Sand Mining and Extraction

Silica and heavy mineral sands are extracted primarily from North Stradbroke Island, under commercial sand mining leases and relevant environmental authorities.

Marine sand is extracted for the construction industry in the northern bay banks near Spitfire Channel and Middle Banks. These sources are highly valued in a regional sense due to the diminishing resources available from mainland streams and terrestrial areas. A long term (20 year) Sand Extraction Strategy (underpinned by the Moreton Bay Sand Extraction Study 2001-2005) regulates the extraction of sand from the Bay for the construction industry and major infrastructure projects at the Port and Airport as outlined above.

Water Extraction

Redland Shire Council's mainland water supply is supplemented by water extracted from an unconfined aquifer on North Stradbroke Island in the vicinity of 18 Mile Swamp (Herring Lagoon).

In response to long term drought and significant water shortages in the region, large-scale groundwater extraction from North Stradbroke Island and Bribie Island is being investigated by the Queensland Water Commission as part of the SEQ Water Supply Strategy.

Marina and Boat Harbours

Several of the Bay's marinas and harbours provide bases for the transport operations which service surrounding locations and the bay islands, servicing commercial, recreational and residential demands.

3.2.4.2 Tenure

Moreton Bay lies within Queensland waters. Most of the land adjoining the Bay consists of land under the control of the Queensland Government, but there are substantial areas of privately owned land along the western shore from Pumicestone Passage to the Southern Bay and Broadwater. In some cases, the property boundaries of this leasehold and freehold land extend to the high water mark (measured at mean high water springs(MHWS)).

Each of the Bay islands has different settlement patterns which can be summarised as follows:

- Moreton Island - several very small townships, a large tourist resort and the remainder of land held as protected area;
- North Stradbroke Island – three primary townships, large mining leases, protected areas and a range of other tenures;
- South Stradbroke Island - largely protected area and other State land tenures with a large tourist resort and several isolated settlements;
- Bribie Island - several large townships on the southern section and a range of reserves and protected areas in the undeveloped northern section.

As described previously, the declared boundaries of the Moreton Bay Ramsar site are predominantly Queensland State waters (unallocated State land) to a depth of 6m below lowest astronomic tide or following the boundaries of other declared regulatory zones in marine areas such as Fish Habitat Areas under the *Fisheries Act 1994*.

Land areas above high water mark included within the Ramsar site are also largely State-owned lands managed by various State agencies or by local governments as trustees of reserves and similar tenured land. This includes national parks, conservation parks, reserves, undeveloped esplanades and unallocated State land. Areas of freehold land in the Ramsar site are controlled by local government (Brisbane City Council in the case of the Boondall wetlands). Leasehold above and below high water mark is also largely excluded.

3.2.5 Noteworthy Flora and Fauna

The freshwater, estuarine and marine wetland habitats of Moreton Bay Ramsar site support a range of noteworthy flora and fauna species and important populations. In this context, it is recognised that there are a range of migratory species (many of which are of conservation significance such as cetaceans and sharks) that may also use habitat within the boundaries of the site from time to time. However, the focus of this ECD is on those species and populations that use the areas within the site as core habitat. Further discussion on this point is contained in Section 4 of the report.

A summary of these key species and populations are as follows:

- Moreton Bay supports a high abundance of shorebirds (Bamford *et al.* 2008). During the summer months, Moreton Bay habitats support over 3500 resident and between 40,000 to 50,000 migratory shorebirds (Thompson 1990a; Driscoll 1993; Watkins 1993; Driscoll 1997). This equates to approximately 10% of maximum number of shorebirds migrating to Queensland over the summer period (Driscoll 1993; Watkins 1993; Driscoll 1997);

- Moreton Bay also supports a high diversity of shorebirds. Ten resident and 32 migratory shorebird species are regularly recorded in Moreton Bay (Thomson 1990);

- Moreton Bay supports significant numbers of individual shorebird species (Watkins 1993; Driscoll 1997; and Bamford *et al.* 2008), including bar-tailed godwit *Limosa lapponica*, whimbrel *Numenius phaeopus*, eastern curlew *Numenius madagascariensis*, terek sandpiper *Xenus cinereus*, grey-tailed tattler *Heteroscelus brevipes*, curlew sandpiper *Calidris ferruginea,* pied oystercatcher *Haematopus longirostris*, Pacific golden plover *Pluvialis fulva*, and lesser sand plover *Charadrius mongolus*;

- Moreton Bay represents the southern limit of the dugong's (*Dugong dugon*) Australian distribution (Lanyon and Morrice 1997) and currently contains one of the largest populations of dugongs on the east coast of Australia (Marsh *et al.* 1996);

- Six species of marine turtle are known to use Moreton Bay as a feeding area. Two of these species - the green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) - have resident populations in Moreton Bay within the nearshore marine areas that are within the boundaries of the Ramsar site;

- Two nationally threatened 'wallum' habitat associated fish species occur within the Moreton Bay Ramsar site: Oxleyan pygmy perch (*Nannoperca oxleyana*) and honey blue-eye (*Pseudomugil mellis*);

- Moreton Bay supports populations of ten threatened wetland-dependant fauna species. These are: Illidge's ant blue butterfly *Acrodipsas illidgei,* wallum froglet *Crinia tinnula*, wallum rocketfrog *Litoria freycineti* and wallum sedgefrog *L. olongburensis*, beach stone-curlew *Esacus neglectus*, water mouse *Xeromys myoides,* Cooloola sedgefrog *Litoria cooloolensis*, Australian painted snipe *Rostratula australis,* little tern *Sterna albifrons* and Australasian bittern *Botaurus poiciloptilus*; and

- Numerous endangered and vulnerable flora species are known to occur within the Moreton Bay region, including five nationally-listed species that are wetland-dependent. Particularly noteworthy species include the endangered swamp daisy (*Olearia hygrophila*) that is endemic to North Stradbroke Island, known only from two locations on the island; and three endangered swamp orchid species (*Phaius australis, P. bernaysii* and *P. tancarvilleae*) that are rarely seen on mainland but are more frequently encountered on the bay islands (SGAP 2005).

3.2.6 Cultural Values

Indigenous

Moreton Bay was an important area for Indigenous people in the past as well as remaining so today (Fesl and Davies 2004). On many of the islands, in particular North Stradbroke Island, there is evidence of Aboriginal presence going back 20 000 years.

There are numerous archaeological site types that have been located within the broader wetland area in and around Moreton Bay and the Bay islands. These include:

- Stone Artefact Scatters
- Shell Middens
- Burials
- Scarred Trees
- Quarries
- Axe Grinding Grooves
- Stone Arrangements
- Burial Grounds

As outlined in the geological processes section above, the entire area of Moreton Bay was exposed as a dry, flat plain during the last glacial maximum in the Pleistocene period. The floodplain would have been regularly traversed by indigenous people of that time on their way to the Bay islands which as a result of low sea levels in the region would have comprised the mainland coast. This Pleistocene landscape and the potential for indigenous artefacts to be preserved within it are discussed by Hall (1999) and the Moreton Bay Sand Extraction Study.

Historic

The shoreline of Moreton Bay was the first area in the Brisbane region to be settled by Europeans. Coochiemudlo Island was the site of the first landing by Matthew Flinders during his exploration of Moreton Bay and the Brisbane River. St Helena Island which was used as a prison and quarantine station at different periods was the first historical area in Queensland to be reserved as a National Park solely because of its historic ruins. Other areas settled by Europeans include Peel Island, used first as a quarantine station and then as a leper colony, Dunwich and Amity Point on North Stradbroke Island and Redcliffe on the mainland which was the site initially chosen for the penal colony before it was moved up the Brisbane River (RIS 1999).

Tourism and Recreational Values

Tourism and recreational values of the Moreton Bay Ramsar site predominantly relate to nature-based activities available within the Moreton Bay region. The Ramsar site includes important terrestrial and aquatic environments for tourism and recreational activities including boating, diving, spear fishing, line fishing, snorkelling, swimming, surfing, shorebird, turtle, dolphin, dugong and whale watching, bushwalking, camping, four wheel driving and sand tobogganing. In addition to the activities available, the high aesthetic and wilderness values, and indigenous and European values (discussed above) attract people to the area.

The proximity of the Moreton Bay Ramsar site to Queensland's capital city, Brisbane, highlights the importance of the site for regional residents and visitors, both for tourism and recreational purposes, and conservation and wise use of the area (i.e. management of impacts from tourism and recreation). The Bay supports a significant economic contribution from tourism and recreational activities with an estimated $500 million spent by visitors to the Moreton Bay and islands region in 2006, further contributing an estimated 5,500 jobs (EPA 2007a).

Education and Research Activities

The Bay and its flora and fauna have been, and continue to be, well studied. Queensland University, CSIRO and the Department of Primary Industries and Fisheries have research stations in the Moreton Bay region (although outside the boundaries of the Ramsar site). Other universities and colleges use Moreton Bay for research and education.

Numerous research programs and projects have been undertaken with respect to the Bay's habitats and important species that are documented in Section 8, References. In terms of recent research activities undertaken by State agencies, of particular note are the EPA's Queensland Turtle Conservation Project (see Limpus *et al*. 2006), recent studies of groundwater ecosystems on the Bay islands by the Department of Natural Resources and Water (see Marshall *et al.* 2006) and various research projects on Bay fisheries by the Department of Primary Industries and Fisheries.

The Brisbane City Council manages and operates the Boondall Wetlands Environment Centre on the Boondall Wetlands Reserve in western Moreton Bay which offers a range of displays and activities on the environmental and cultural heritage of the reserve for park visitors and organised groups. The mangrove boardwalk at Wynnum North is also a significant educational resource.

The Queensland Department of Education runs environmental education centres at Nudgee Beach, Moreton Bay (at Wynnum) and Jacobs Well for educating children on coastal and environmental matters. The Environmental Protection Agency has educational facilities on St Helena and Moreton Islands.

The Bay's resources and key components such as water quality are also extensively monitored. Under the Healthy Waterways Partnership, following design and input from stakeholders, the Ecosystem Health Monitoring Programme for estuarine and marine waters was implemented in 2000. The water quality and biological information obtained from this monthly monitoring program continues to the present day, allowing Bay resource managers and stakeholders to evaluate the ecosystem and community benefits of investment in protection and conservation measures. The EHMP forms the basis for the annual Report Card for the Bay which rates each of the Bay's major water bodies, rivers and catchment streams.

Other monitoring activities include extensive work by volunteers such as wader bird observations collected by the Queensland Wader Study Group and the Seagrass Watch programme undertaken by conservation groups in the region.

3.2.7 Policy Framework Governing the Site

The size and significance of the Moreton Bay Ramsar site is such that it is subject to a wide array of statutory and non-statutory plans and strategies that aim to manage its resources and values. A summary of the most relevant laws, plans and strategies at all relevant levels of Government is included below:

International

In addition to the Ramsar Convention itself, many of the values of the site that are salient to its listing as a Wetland of International Importance are also relevant to international obligations under other conventions and agreements. Some of the key instruments are:

- JAMBA - the Agreement between the Government of Australia and the Government of Japan for the protection of migratory birds in danger of extinction and their environment 1974.
- CAMBA - the Agreement between the Government of Australia and the Government of China for the protection of migratory birds in danger of extinction and their environment 1986.
- ROKAMBA – the Agreement between the Government of Australia and the Government of the Republic of Korea for the protection of migratory birds and their environment 2006.
- The Convention on the Conservation of Migratory species of Wild Animals (the Bonn Convention);
- The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)

National

At the National level, the Australian Government through the Department of Environment, Water, Heritage and the Arts (DEWHA) has provided guidance with respect both preparing and using ecological character descriptions. In this context, the ECD of a wetland provides a reference for the following planning and management activities:

- development and implementation of a management plan designed to maintain the ecological character of the Ramsar site;
- the design of a monitoring program to detect change in ecological character;
- assistance in reporting to the Australian Government and the Ramsar Convention about any changes in the ecological character of Ramsar sites; and
- Environmental impact assessment of the likely impact on ecological character of proposed actions, including that required under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In relation to the last point, Ramsar sites are a key component of the matters of National Environmental Significance (NES) under which assessment and approval of controlled actions under the EPBC Act must be obtained. In practice, this is undertaken through the referral of a development proposal by a proponent to the Minister administering the Act for a determination about the likelihood of impacts to a matter of NES. For development that may affect the Moreton Bay Ramsar site, the potential for changes to the ecological character of the site (as outlined in this ECD) plays a key role in the Minister's determination of the appropriate assessment process used under the Act as well as the decision to approve a development proposal and any conditions imposed under the controlled action approval.

Of note in the context of the current study, the Moreton Bay Ramsar site is identified as generating the high number of referrals under the Act for consideration by the Minister. This is a likely reflection of the size of the site as well as the large locally resident population that is rapidly urbanising surrounding areas.

State and SEQ Region

There is a plethora of legislation, policies, plans and strategies that apply directly and indirectly to the conservation and wise use of the Moreton Bay Ramsar site. At the State level, legislation such as the *Integrated Planning Act 1997*, *Environmental Protection Act 1994, Fisheries Act 1994, Nature Conservation Act 1992, Coastal Protection and Management Act 1995, Water Act 2000, Vegetation Management Act 1999, Aboriginal Cultural Heritage Act 2003, Queensland Heritage Act 1992,* and their respective regulations, are applied throughout the Ramsar site. Further, the *Marine Parks Act 2004, Nature Conservation Act 1992* and *Recreation Areas Management Act 2006* are applicable in areas within the Ramsar site designated under these Acts for protection and management (e.g. as a Marine Park, National Park, Conservation Park or Recreation Area). A more substantive discussion of the applicability of these statutes to the Ramsar site is contained in BMT WBM (2008a).

Within South East Queensland (SEQ) there are additional statutory and non-statutory plans and strategies relevant to the region. Some of these plans also apply specifically to Moreton Bay. No legislation, policies, plans or strategies specifically apply to, or manage the Moreton Bay Ramsar site, although many apply to the management of aspects influencing the Ramsar values and ecological character of the site. The most relevant plans and strategies applicable to the conservation and wise use of the Ramsar site, Ramsar values and aspects of the ecological character of the site include the following:

Statutory plans, strategies and areas

- *Marine Park (Moreton Bay) Zoning Plan 1997*;
- Southeast Queensland Regional Coastal Management Plan 2006 prepared under the *Coastal Protection and Management Act 1995*;
- Protected Area Management Plans (for national parks, conservation parks and other protected areas in the region);
- Environmental Values and Water Quality Objectives under the *Environmental Protection (Water) Policy 1997*;
- *South East Queensland Regional Plan 2005*;
- Fisheries Management Plans including the East Coast Trawl and Coral Reef Fin Fish fisheries;

- Declared Fish Habitat Areas (FHAs) under the *Fisheries Act 1994*;
- Water Resource Plans prepared under the *Water Act 2000*; and
- Local Government Planning Schemes prepared under the *Integrated Planning Act 1997*.

Non-statutory plans

- SEQ Healthy Waterways Strategy – Moreton Bay Action Plan
- The Future in Balance - SEQ Catchments
- Shorebird Management Strategy – Moreton Bay

A more detailed summary and discussion of these plans, strategies and areas is contained in Appendix B.

3.3 Ramsar Nomination Criteria

Each site nominated under the Ramsar Convention must address some or all of the Ramsar Nomination Criteria established within the text of the Convention and amended from time to time by the Conference of Parties.

Since the Moreton Bay Ramsar site was nominated in 1993, the Nomination Criteria under the Ramsar Convention have been modified. Table 3-3 presents a comparison between the pre-1999 (as listed in the current RIS and Nomination Documentation) and the post-1999 Ramsar Nomination Criteria for identifying Wetlands of International Importance (as outlined in the Convention and National Framework document).

In the table, Nomination Criteria listed on the current Ramsar Information Sheet for Moreton Bay are underlined and italicised; noting that the Moreton Bay Ramsar site currently supports criteria 1, 2, 3, 4, 5, and 6 under the 'new' (eg. post-1999) criteria.

Criteria 7, 8 and 9 listed in Table 3-3 (which relate to criteria about fishes and wetland-dependant non-avian fauna) did not exist at the time of the nomination of the Moreton Bay Ramsar site in 1993 and as such have been evaluated in the context of the current ECD study.

The evaluation has been undertaken using the guidance and other supporting information for interpretation of the Nomination Criteria provided within the *Ramsar Handbook 14*, *Designating Ramsar sites* within the Ramsar Handbooks for the Wise Use of Wetlands 3rd Edition (published by the Ramsar Secretariat).

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Table 3-3 Comparison of current and pre-1999 Ramsar nomination criteria

Notes: Underlined and italicised text indicates pre-1999 nomination criteria for the Moreton Bay Ramsar site

'New' Criteria	Pre-1999 Criteria
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	1(a) it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region *1(b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region* *1(c) it is a particularly good representative example of a wetland which plays a substantial hydrological, biological or ecological role in the natural functioning of an major river basin or coastal system, especially where it is located in a trans-border position* 1(d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	*2(a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species.*
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	*2(b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna* 2(d) it is of special value for one or more endemic plant or animal species or communities *3(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity.*
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	*2(c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle.*
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.	*3(a) it regularly supports 20,000 waterfowl.*
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	*3(c) where data on populations are available, it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterfowl.*
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	4(a) it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	4(b) it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Criterion 9: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.	None.

3.3.1 Justification for Listing – Criteria (1 – 6)

The justification for the listing of the Moreton Bay Ramsar site is made by a number of supporting statements in the current RIS (updated 1999) that relate back to the Nomination Criteria listed above. These have been reviewed and updated as part of the current ECD study and include the following:

Criterion 1

Ramsar Nomination Criterion 1 states: *A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.*

Moreton Bay is one of the largest estuarine bays in Australia enclosed by a barrier island of vegetated sand dunes.

Moreton Bay plays a substantial role in the natural functioning of a major coastal system through its protection from oceanic swells providing habitat for wetland development, receiving and channelling the flow of all rivers and creeks east of the Great Dividing Range from the McPherson Range in the south to the north of the D'Aguilar Range.

In the absence of appropriate mapping, a detailed assessment of the distribution and extent of various Ramsar wetland types is not possible at this stage (see Section 3.2.2). However, based on available information and the expert knowledge of the study team, it is known that the Moreton Bay Ramsar site contains a wide diversity of Ramsar wetland types (with up to twenty-two types represented) including several that are considered rare within the bioregion. Of particular note are the following three wetland types, all of which occur in freshwater environments, typically on sand barrier islands:

- Unforested peatland (Type U). Eighteen Mile Swamp on North Stradbroke Island contains a mosaic of unforested peatland (Type U) and forested peatland (mainly Melaleuca) (Type Xp). This wetland type is thought to be mainly resticted to offshore sand barrier islands within the biogeographic region;
- Forested peatlands (Type Xp) – see above;
- Permanent freshwater lakes (Type O). Several large, permanent freshwater lakes occur on Moreton (e.g. Lake Jabiru) and North Strabroke Island (e.g. Blue Lake, Ibis Lagoon). While Fraser Island also contains good examples of representative freshwater lakes within the biogeographic region, this habitat type is poorly represented in mainland areas within the bioregion.

Criterion 2

Ramsar Nomination Criterion 2 states: *A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.*

Numerous nationally and internationally threatended species occur within the site. Moreton Bay supports appreciable numbers of the nationally vulnerable green turtle *Chelonia mydas* and the endangered loggerhead turtle *Caretta caretta*. Wallum wetland habitats within the site provide habitat for the endangered Oxleyan pygmy perch *Nannoperca oxleyana*, and the vulnerable honey blue-eye *Pseudomugil mellis*, and is ranked among the top ten habitats of the IUCN listed dugong in Queensland.

Moreton Bay also supports a range of nationally threatened wetland-dependant fauna species including the wallum sedgefrog *Litoria olongburensis*, water mouse *Xeromys myoides,* and Australian painted snipe *Rostratula australis.* The internationally threatened (IUCN listed) Illidge's ant blue butterfly *Acrodipsas illidgei* also occurs in the site.

Numerous nationally vulnerable and endangered plant species exist within the Ramsar site, five of which are wetland-dependent species.

It should be noted that several other internationally and nationally marine species have been recorded in Moreton Bay, but are considered as either vagrants or do not have core habitats within the site. This includes for example whales and shark species that prefer more oceanic waters. Furthermore, hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*) and flatback (*Natator depressus*) turtles are seasonal visitors to the region, or do not have high abundances within site (Limpus *et al.* 2006). These species are therefore not considered as critical elements in the context of this ECD.

A range of state listed threatended species also occur within the site. Consistent with the National Framework, only national and international threatened species are to be considered under this nomination criteria. However, many State listed threatened species are considered as critical services in this ECD in the context of other Ramsar nomination criteria, particularly Criterion 3 (in the context of maintaining biodiversity valuyes at a regional scale), and Criteria 4-6.

The terrestrial fauna species list data sets for the South-east Queensland Bioregion and Moreton Bay presented in Appendix D were interrogated to provide a summary of threatened species for Moreton Bay. Table 3-4 provides a full listing of threatened species (wetland-dependent or otherwise). Of these species, the wetland-dependant species of conservation significance are regarded as providing critical ecosystem services in the context of the ECD.

Table 3-4 List of threatened terrestrial fauna species known to occur in the Moreton Bay region and their primary habitat types

Family	Scientific Name	Common Name	NCA	EPBCA	IUCN	Habitat Types (see footnote below for codes)
Pteropodidae	*Pteropus poliocephalus*	grey-headed flying-fox	C	V	V	Not wetland-dependent taxa - Open forests, wet sclerophyll forests, closed forests wherever flowering trees occur.
Muridae	*Xeromys myoides*	false water-rat	V	V	V	H & I
Myobatrachidae	*Adelotus brevis*	tusked frog	V		Near Threatened	M, N, O, Tp,Xf, & 9
Myobatrachidae	*Crinia tinnula*	wallum froglet	V		V	K, O, Tp, U, W, Xf, Xp, & 9
Hylidae	*Litoria olongburensis*	wallum sedgefrog	V	V	V	K, O, Tp, Ts, & Xp

Family	Scientific Name	Common Name	NCA	EPBCA	IUCN	Habitat Types (see footnote below for codes)
Hylidae	*Litoria cooloolensis*	Cooloola sedgefrog	R		E	O & Tp
Hylidae	*Litoria freycineti*	wallum rocketfrog	V		V	O, Tp, Ts, & Xp
Ardeidae	*Botaurus poiciloptilus*	Australasian Bittern			E	Tp & Xp
Turnicidae	*Turnix melanogaster*	black-breasted button-quail	V	V	V	Not wetland-dependent taxa - dry closed forests (esp. semi-evergreen vine thickets) & softwood scrubs.
Rostratulidae	*Rostratula australis*	Australian painted snipe	V	V		H, J, K, Tp, Ts & Xp
Burhinidae	*Esacus neglectus*	beach stone-curlew	V		Near Threatened	E, G, H, K, Tp, Ts,
Laridae	*Sterna albifrons*	little tern	E		Least Concern	A, E, & F
Lycaenidae	*Acrodipsas illidgei*	Illidge's ant blue butterfly	V		E	I & Xp

Where applicable, habitat types in Table 3-4 follow those listed under the current Ramsar Information Sheet (1999) for Moreton Bay, i.e.:

<u>Coastal Marine Wetland Types (11)</u>

Type A: Permanent shallow marine waters

Type B: Marine subtidal aquatic beds (seagrass beds)

Type C: Coral reefs

Type D: Rocky marine shores

Type E: Sand, shingle or pebble shores

Type F: Estuarine waters (permanent water of estuaries and estuarine systems of deltas)

Type G: Intertidal mud, sand or salt flats

Type H: Intertidal marshes (saltpan vegetation on marine clay plains, as well as saline or brackish sedgelands)

Type I: Intertidal forested wetlands

Type J: Coastal brackish/saline lagoons

Type K: Coastal freshwater lagoons (freshwater delta lagoons)

<u>Inland Wetland Types (9)</u>

Type L: Permanent inland deltas

Type M: Permanent rivers / streams / creeks

Type N: Seasonal rivers / streams / creeks

Type O: Permanent freshwater lakes (Permanent freshwater bodies over 8ha in area)

Type Q: Permanent saline / brackish / alkaline lakes

Type Tp: Permanent freshwater marshes / pools

Type Ts: Seasonal / intermittent freshwater marshes / pools on inorganic soils

Type U: Non-forested peatlands (Eighteen Mile Swamp)

Type W: Shrub-dominated wetlands (Bribie Island National Park)

Type Xf: Freshwater tree-dominated wetlands (open forests dominated by *Melaleuca quinquenervia*)

Type Xp: Forested peatlands (Eighteen Mile Swamp)

<u>Man-made Wetland Types (1)</u>

Type 9: Canals, drainage channels and ditches

Criterion 3

Ramsar Nomination Criterion 3 states: *A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.*

The Moreton Bay Ramsar site contains high biodiversity values at a bioregional scale. The site has a high level of habitat diversity (and associated species richness) at a bioregional scale, and includes most wetland types found in the bioregion. The site is thought to provide a refuge and source of propoagules for marine species within and external to bioregion. The site has the following biodiversity values for key wetland species groups:

- Moreton Bay supports ~275 species of macroalgae, which represents ~40% of the macroalgae species reported in Queensland (Phillips 1998). A large proportion of these species occur in the site, although this figure does include reef areas outside the boundaries of the site. Overall, tropical/subtropical species predominate (~64% of species), and several of which have their southernmost distribution limit in the Bay. The warmer waters within the Bay relative to oceanic water temperatures may provide refugia for tropical species. Temperate species represent ~15% of the species, although few species have their northern-most distribution limit in the Bay (Phillips 1998).

- The site contains seven species of seagrass (Abal *et al.* 1998), which includes all five species recorded in the bioregion by Coles *et al*. (1989), as well as *Halophila decipens*. Moreton Bay, like Hervey Bay to the north, provides optimal habitat conditions for seagrass species (i.e. large interdal babnks, high water clarity, relatively sheltered areas etc). Consequently, the site has a larger number of seagrass species compared to most riverine estuaries in the bioregion, which are typically comprised of one to three species (typically *Zostera muelleri*, together with *Halophila ovalis* and sometimes other species).

- The site supports seven species of mangrove (Abal *et al.* 1998). This represents 50% of the total number of mangrove species recorded in the south-east Queensland region (Duke 2006). The site represents the southernmost distribution limit of *Lumnitzera racemosa*. Six of the seven species recorded in Moreton Bay have been recorded in northern NSW (Duke 2006), and it is possible that the site provides a source of propagules to other areas within the bioregion.

- The site supports a rich terrestrial flora assemblage, with for example, 824 native plant species recorded from North Stradbroke Island alone (Queensland Herbarium 2005). Some flora species are thought to be restricted to the site, and therefore contribute to bioregional biodiversity.

- Moreton Bay supports ~3,225 species of marine invertebrates, although this figure also includes records from offshore reef sites outside the site (Davie and Hooper 1998). No comprehensive account of marine invertebrate diversity is available for the bioregion, although Davie and Hooper (1998) argue that the Bay:
  - has a wide diversity of habitats and constituent species in a relatively small area.
  - has many species that appear to be endemic (or undescribed);

- o lies on a biogeographic overlap zone and provides "…a refuga for both temperate and tropical species, some of which are apparently not found in neighbouring regions."

- Moreton Bay supports ~750 marine fish species (Johnson 1999). Comparisons with other estuaries is complicated by patterns in habitat selectivity and differences in habitat types. Shoalwater Bay, which has similar habitat types as Moreton Bay, contains ~413 species of estuarine and marine fish (Johnson 1999). Most other estuaries in the bioregion, which typically have less complex habitat and are generally smaller in area, would generally have lower species richness than Moreton Bay.

- The freshwater invertebrate and fish fauna of the site are compartiavely less well known. The sand barrier islands contain wallum/humic specialists (e.g. Oxlyan pymgmy perch *Nannopera oxleyana*; the zooplankter *Calamoecia tasmanica*, the dragonfly *Petalura gigantea* etc.) as well as species that have more generalist habitat requirements (Arthington and Watson 1982; Arthington 1996). The wallum/humic specialists are found in a small number of waterbodies within the bioregion, hence their presence at the site contributes greatly to bioregional biodiversity values.

- All six marine turtle species known to occur in Australian waters have been recorded in Moreton Bay (Limpus *et al.* 2006). With the exception of Hervey Bay, no other estuaries in the bioregion are known to contain this level of biodiversity.

- At least 42 species of shorebirds use intertidal habitats in the Bay, including 32 migratory species listed by JAMBA, CAMBA and ROKAMBA.

- The site contains approximately 59% of the total number of number mammal, reptile, amphibian and bird species known to occur in the SEQ bioregion (see Table 3-5). Refer to Appendix D for species lists.

Table 3-5 Number of terrestrial fauna species in the SEQ Bioregion and in Moreton Bay

Taxa	**SEQ Species Richness**	**Moreton Bay species Richness (% of SEQ species)**
Mammals	91	45 (49%)
Reptiles	151	52 (34%)
Frogs	49	26 (53%)
Birds*	403	290 (72%)
Total	**694**	**413 (59%)**

* excludes oceanic species that do not use habitats found in the site (e.g. petrels, albatross, skuas, some terns, jaegers, tropibirds etc.)

<u>Criterion 4</u>

Ramsar Nomination Criterion 4 states: *A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.*

The Ramsar site provides habitat for a range of important wetland and aquatic fauna at a critical life stage. This includes the following:

- The site is an important wintering area for migratory shorebirds.
- The site is an important breeding (nesting) area for a number of waterbirds and shorebirds. Key waterbird and shorebird species are listed in Appendix D.
- The site is an important feeding area for green and loggerhead turtles.
- The site is an important feeding and breeding area for dugong.
- The site has the most significant concentration of young and mature loggerhead turtles in Australia.
- The site represents important nursery grounds for a range of marine fish, prawns and crabs, many of which are of commercial significance.

<u>Criterion 5</u>

Ramsar nomination Criterion 5 states*: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.*

Moreton Bay can support more than 40,000 migratory shorebirds during the non-breeding season (Austral summer).

Table 3-6 is a summary of the total number of shorebird species known to occur in the South-east Queensland Bioregion and Moreton Bay (refer to Appendx D for a detailed list of species). This table shows that ten resident and 32 migratory shorebird species are regularly recorded in Moreton Bay (Thomson 1990; EPA 2005b). Note that the term shorebird is a generic term used to describe both resident and migratory species from the following families: Scolopacidae; Burhinidae; Haematopodidae; Recurvirostridae; Racanidae; Charadriidae; and Glareolidae.

Table 3-6 Number of shorebird species in the SEQ Bioregion and in Moreton Bay

Category	SEQ Species Richness	Moreton Bay Species Richness
INBM – International non-breeding migrant	34	34
BR – breeding resident	12	12
ANBR – Australian non-breeding resident	3	1
PBR – possible breeding resident (though no breeding records to date)	1	1
Total Species Richness	**50**	**48**
V - Vagrant	8	6

Criterion 6

Ramsar Nomination Criterion 6 states*: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.*

A total of 57 of the 66 waterbirds known from the SEQ bioregion have been recorded in Moreton Bay (see Appendix D for species list). Note that the term waterbird refers to those species found predominantly on freshwater ecosystems in Australia from the six major orders Anseriformes (ducks, geese and Black Swan), Podicipediformes (grebes), Pelecaniformes (Australian Pelican and cormorants), Ciconiiformes (herons, ibis, spoonbills and bitterns), Gruiformes (cranes, rails, crakes and gallinules), and Charadriiformes (waders and terns) (after Kingsford & Norman 2002).

The 1% species population threshold is exceeded for the following avifauna species: bar-tailed godwit *Limosa lapponica*, whimbrel *Numenius phaeopus*, Eastern curlew *Numenius madagascariensis*, terek sandpiper *Xenus cinereus*, grey-tailed tattler *Heteroscelus brevipes*, curlew sandpiper *Calidris ferruginea,* pied oystercatcher *Haematopus longirostris*, Pacific golden plover *Pluvialis fulva*, and Lesser sand plover *Charadrius mongolus* (see data in Bamford *et al.* 2008).

3.3.2 Justification for Listing – Criteria (7 - 9)

As part of the current study, it is recommended that criteria 7 and 8 are also supported by the Moreton Bay Ramsar site and should be included in the revision of the RIS.

While it is likely that Moreton Bay supports more than 1% of the individuals in a biogeographic population of several non-avian species (eg. Criterion 9), there is insufficient published data about populations across the biogeographic region to verify this (a stated requirement in the Ramsar Nomination Guidelines). On this basis, justification for inclusion of the site on the basis of Criterion 9 has not been recommended at this time but is discussed below for future consideration.

Criterion 7

Ramsar Nomination Criterion 7 states*: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages,* *species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.*

Moreton Bay contains an appreciable diversity of fish with ~750 fish species represented and over 3000 species of free living marine invertebrates (Johnson 1999).

Situated within the Moreton Tweed Marine Bioregion (IMCRA), Moreton Bay lies within a transition zone that supports both temperate and tropical fish and crustacean species. High levels of biodiversity are also supported by the unique geography and diversity of habitat types found within the site that include both nutrient-rich inshore components (made up of intertidal and shallow estuarine habitats) and more oligotrophic offshore components (made up of sandy beaches, channels, banks and bars).

Moreton Bay contains assemblages of fish that are representative of the marine and terrestrial bioregions, with at least one species with a restricted geographic distribution having core populations within the site (including Oxleyan Pygmy Perch).

Criterion 8

Ramsar Nomination Criterion 8 states*: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.*

Moreton Bay provides important habitats, feeding areas, dispersal and migratory pathways, and spawning sites for numerous fish species of direct and indirect fisheries significance. These fish have important fisheries resource values both within and external to the site.

Key fish species of significance include flat tailed mullet, sea mullet, fantail mullet, sand flathead, dusky flathead, tailor, spotted mackerel, golden lined whiting, eels, diver whiting, yellow finned bream and tarwhine. Significant nektobenthic crustacean species include banana, king, endeavour, tiger, school and greasy back prawns; mud, blue swimmer, red-spot, spanner and coral crabs; and Callianisidae shrimps. Other species of commercial significance include bait worms, squid, cuttlefish, rock oysters and beche-de-mer.

Many of the fish and crustacean species listed above spend their juvenile stages in shallow nearshore waters of the site, particularly around mangroves and seagrass habitats. These species also spawn in inshore waters, particularly near the surf zone and in sandy channels within the boundaries of the Ramsar site.

Criterion 9

Ramsar Nomination Criterion 9 states: *A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.*

Criterion 9 relates to non-avian wetland taxa including, *inter alia*, mammals, reptiles, amphibians, fish and aquatic macro-invertebrates. Some of the key non-avian wetland species within Moreton Bay that are appropriate to consider in the context of Criterion 9 would include:

- acid frogs (wallum froglet, wallum rocketfrog, wallum sedgefrog, Cooloola sedgefrog);
- water mouse;
- Illidge's ant blue butterfly;
- dugong;
- green and loggerhead turtles;
- Oxleyan pygmy perch; and
- honey blue-eye.

Furthermore, Davie and Hooper (1998) note that at least 27 marine macroinverebrate species are known only to occur in Moreton Bay. These species may be either locally endemic species (i.e. restricted to the Bay) that are either relics from more widespread habitats that have been restricted to the Moreton Bay area, or are species that may occur elsewhere outside the site but have so far remained undetected due to limited sampling effort.

In interpreting the application of Criterion 9 to these species, Ramsar Handbook 14 indicates that reliable population size limits from published sources must be included in the justification for the application of the Criterion.

Investigation of survey data for these species as part of the current study has shown such data is largely incomplete and forms an information gap. On this basis, there is not definitive data from which to determine the applicability of the Criterion. However, it is noted that expert opinion provided by various researchers to the study team as part of the study supports the view that the criterion is met by several of the species listed above. This is documented for particular species within sections 7.3 and 7.4 of this report.

4 SUMMARY OF CRITICAL SERVICES, COMPONENTS AND PROCESSES

4.1 Introduction

Section 4 of the report summarises the *critical* services/benefits, components and processes that make up the ecological character of the Ramsar site and provides the limits of acceptable change to those critical elements. The Section is set out as follows:

- Section 4.1 outlines the methodology used in the selection of the critical services/benefits, components and processes for the site;
- Section 4.2 summarises the nominated critical services and underlying critical components and processes of the Ramsar site; and
- Section 4.3 provides a summary of the limits of acceptable change developed for the site including the methodology used to derive them.

More detailed information about the critical services is presented in Section 7 of the report which provides a more complete discussion of each critical service/benefit and its underlying wetland ecosystem components and processes.

4.1.1 Methodology – Information Collation and Review Stage

The first step in ECD preparation outlined the National Framework document is to identify the wetland services/benefits, wetland components and wetland processes present in the Ramsar site. These key terms are defined in Section 2 of the Report and the Glossary (refer Section 9). This was initiated by undertaking a process of information collation and literature review.

As part of the information collation phase, literature and existing data relevant to the study area (whole-of-bay and catchment scale) and site were collated and reviewed. Relevant existing information was sourced from the following:

- Published scientific papers;
- Database records (EPBC, Wildnet, etc.);
- Mapping products supplied by the EPA (RE data, wetland mapping);
- Management plans, strategies and other policy documents;
- EIS and other applied studies that involved assessment of Ramsar values;

- Academic theses; and
- Grey literature from internet searches and other sources of data

Many articles, information and data sets were obtained from the EPA project team and by following up suggestions and recommendations about sources of information from the Project Steering Group and Knowledge Management Committees.

Each article of information was collated to a cursory level sufficient to determine its relevance to the study. The collected information was then reviewed to prioritise and identify information of direct relevance to the ECD.

As part of the information collation phase, key information gaps were identified on the basis of these reviews and further information was sought from the Knowledge Management Committee as part of its first meeting.

Key experts in relevant fields were also contacted and interviewed as part of the study as outlined in Section 9 and in Appendix A.

4.1.2 Methodology – Selection of Critical Services

Following the information collation and review phase, the study team collectively identified the potential services/benefits of the wetland. This process was based primarily upon a review of the literature and professional opinion. Wetland benefits/services were identified first as a means of facilitating the identification of the more generic wetland processes and wetland specific components (eg. wetland types and noteworthy flora and fauna species) that underpin these services.

Using the categories and list of services/benefits from the National Framework as a guide, it was apparent that the Moreton Bay Ramsar site provides a broad spectrum of services/benefits. This included: provisioning services such as provision of food in the form of fisheries and fresh water supply (through groundwater extraction), regulatory services such as erosion protection and climate regulation, cultural services such as recreational and tourism, cultural heritage, education and research and supporting ecosystem services such as biodiversity and the presence of endangered and vulnerable species.

Likewise, given the scope, areal extent and diversity of wetland environments present within the Moreton Bay Ramsar site, all wetland ecosystem processes from the National Framework were seen as occurring within the site, including a broad range of hydrological, climatic, geomorphologic, physico-chemical, biogeochemical and biological processes. It was noted that while each of these processes play a part in underpinning normal wetland functioning, many of these factors such as coastal hydrodynamics and climate operate at both regional scales and local scales.

As outlined in Section 3, a range of wetland habitat types are known to be present within the site boundaries including those designated within the coastal/marine, inland and man-made wetland categories under the Ramsar classification scheme. Within these systems, a rich diversity of wildlife exists from all the major groups of organisms (from planktonic organisms to vertebrates) which make up the key components of the wetland.

With the full range of ecosystem services/benefits, components and processes represented, there was a need to identify the most important or *critical* in the context of the Ramsar site, and the supporting critical components and processes that contribute to delivery of those services.

Following the methodology within the National Framework, the assignment of a given wetland process, component or service as *critical* was guided by the following considerations:

- The service or underlying component/process is important for supporting one or more of the Ramsar Nomination criteria under which the site was listed (refer Section 3.3); or
- The service or component/process is an important determinant of the uniqueness of the site; or
- The service or component/process may be subject to change in short to medium time frames (<100 years) and/or the change will cause potentially significant consequences (eg. change the ecological character).

To supplement these criteria, it was decided as part of the ECD process that additional consideration would be given to:

- Suggestions or recommendations regarding critical services, components or processes by Knowledge Management Committee/SEP experts (particularly where such information was documented in scientific literature) – refer Appendix A; and
- For cultural services, reference to Ramsar's 9th Conference, Resolution IX.21 – "Taking into account the cultural values of wetlands" – which identified the following cultural characteristics as relevant in the designation of Ramsar sites:

  i) Sites which provide a model of wetland wise use, demonstrating the application of traditional knowledge and methods of management and use that maintain the ecological character of the wetland;

  ii) Sites which have exceptional cultural traditions or records of former civilizations that have influenced the ecological character of the wetland;

  iii) Sites where the ecological character of the wetland depends on the interaction with local communities or indigenous peoples;

iv) Sites where relevant non-material values such as sacred sites are present and their existence is strongly linked with the maintenance of the ecological character of the wetland.

Following this internal prioritisation process, a list of draft critical services/benefits and underpinning components and processes was developed by the study team. Ecosystem components (such as habitats, species and populations) and ecosystem processes (such as hydrology) were identified as critical where such features or processes were seen as underpinning one or more nominated critical services.

The Nomination Criteria for the site were used as the primary consideration in selecting the draft critical services/benefits (principally relating to the wetland's ecological values) along with the selection of several cultural services such as site's fisheries values, the significance of the site to indigenous peoples, as well as the education and research and tourism and recreational values of the site. Evaluation of other ECD documents undertaken for large estuaries, such as the draft ECD prepared for the Great Sandy Straits and the ECD for the Coorong Lakes region in South Australia were also considered as part of the nomination process.

Using the draft list of critical services/benefits, the study team conducted a one day workshop with the Knowledge Management Committee (KMC). The primary purpose of the first KMC meeting was to undertake a parallel validation process of the study team's critical service selections with the committee of experts using a workshop to identify the key habitats of the site. This process served to confirm the identification of the critical services as well as to identify additional services, components or processes that were perceived to have been overlooked.

In general there were minimal changes to the draft critical services that were presented to the Knowledge Management Committee and the critical services/benefits presented in Section 4.2. However, the Committee provided significant assistance to the study team in identifying the key linkages between the services and the key wetland ecosystem components and processes and were able to provide guidance about the processes and components most important to maintenance of the service.

4.1.3 Methodology – Selection of Critical Flora and Fauna Species

The critical services/benefits presented in Section 4.2 are underpinned by the identification of several critical flora and fauna species that relate to the Nomination Criteria for the site and serve as *de-facto* indicator species for the purpose of assessing ecological character.

<u>Flora</u>

In nominating particular wetland **flora** species/communities for consideration under the critical services, the following considerations were applied –

1. Species must occur in aquatic environments (eg. macrophytes) or are otherwise considered to be wetland species; and

2. Species are listed as threatened (ie. vulnerable or endangered) at the National (threatened under EPBC Act) and/or International (i.e. IUCN) level; or

3. Communities that are classified as wetlands and designated as Endangered under the EPBC Act were considered.

Fauna

In nominating particular **fauna** species/groups for consideration under the critical services, the following considerations were applied –

1. Species must occur in aquatic or marine environments or are otherwise considered to be wetland-dependant terrestrial species (refer Glossary in Section 9 for definitions of these terms). It is acknowleged that many other terrestrial fauna (and flora) species also occur in the site that, while important to the maintaince of biodiversity values of the site, are not necessarily key wetland elements. Key threatened terrestrial species are listed in Appendix D of the ECD, and have also been considered in the context of the nomination criteria (Criterion 2 and 3). However, due to a lack of dependence on the wetland values of the site, none of these terrestrial species are viewed as critical elements in the context of this ECD report; and

2. Species should be either:

    a. designated as threatened (eg. endangered or vulnerable) at a national scale (listed as threatened under the EPBC Act) or international scale (i.e. threatened under IUCN Red List); and/or

    b. Particularly noteworthy or critical from a regional biodiversity perspective (i.e. refer to Criteria 3 or 7). This includes species that are perceived by the authors to be iconic to the site, and must also be designated as threatened under Queensland legislation (i.e. endangered or vulnerable at a State scale). In the context of this report, the key species considered here are beach stone curlew and little tern.

3. Given the boundaries of the Ramsar site are largely confined to near-shore areas, emphasis has been placed on species that use the site as core habitat, have significant population numbers and spend a large proportion of their life cycle within the site boundaries. This excludes vagrant species such as whales, sharks and some marine turtles (hawksbill, olive ridley, leatherback) that may only occur in the Ramsar site infrequently.

Based on the above, in general terms, species that are listed as migratory or marine species under the EPBC Act or listed as 'rare' under national or state species lists have not been nominated as key species under the ECD unless they otherwise meet the above criteria.

4.1.4 Methodology – Selection of Representative Habitat Types

The Moreton Bay Ramsar site contains marine, estuarine, palustrine, lacustrine and terrestrial biotopes. Several of these wetland habitats are considered, either individually or collectively, to represent particularly outstanding examples of near-natural 'reference' areas within the biogeographic region. This is important in the context of Service 2 (refer Section 4.2).

While it is acknowledged that there are numerous examples of such habitat areas within the site, for reporting purposes the study team identified six key wetland representative areas. These are:

a. Seagrass and shoals in the Eastern Banks area;

b. Intertidal flats and estuarine assemblages in the Pumicestone Passage area;

c. Mangroves and saltmarsh associated with the islands in the Southern Bay;

d. Coral communities of the Eastern Bay;

e. Freshwater wetlands (including wallum and peatlands) of Moreton and North Stradbroke Islands;

f. Ocean beaches and foredunes on Moreton Island

These wetland areas were selected on the basis that they:

- are in natural or near-natural condition (relevant to Ramsar Nomination Criterion 1);
- contain representative examples of the key habitats within the site;
- contain excellent representative examples of various wetland habitat types within the biogeographic region;
- support many or all of the ten (10) critical wetland services nominated by the ECD; and
- contain wetland habitats of recognised high conservation significance, as prescribed under legislation (protect areas) and State plans (i.e. Queensland State Coastal Plan).

The representative wetland habitat areas provide specific areas within the broader site for assessing limits of acceptable change and provide priority sites for future monitoring and research.

Further information about the representative habitat types are contained in Section 7.2 of the report.

4.2 Overview of Critical Services/Benefits

A graphic and summary table listing the critical wetland services/benefits, components and processes for the Moreton Bay Ramsar site are shown in Figure 4-1 and Table 4-1 respectively.

As outlined above, the ten (10) critical services/benefits have been developed principally through identification of key services/benefits that relate back to the key Ramsar Nomination Criteria for the Moreton Bay Ramsar site but also include several cultural and provisioning services that are seen as particularly important or noteworthy in the context of the benefits derived from the site.

In many cases there is a direct relationship between the critical services and wetland habitat types (such as seagrass meadows or mangrove swamps) or noteworthy fauna (endangered and vulnerable flora or fauna). In this way, many of these habitats and species are effective surrogate measures for maintenance of the wetland service and broader ecological character of the wetland.

Critical processes have been selected on the basis of their importance in underpinning the critical services/benefits and in considering the wetland habitat and noteworthy flora and fauna that make up the critical components.

It should be noted that the box model shown in Figure 4-1 does not seek to prioritise or provide any hierarchy to the processes, components and services presented; its role is simply to show the approach to categorisation of the critical elements in accordance with the guidance in the National Framework document.

The interaction of wetland services/benefits, processes and components is shown in Figure 4-2. As shown in the figure, there are three broad processes identified (climate, geomorphology and regional-scale hydrodynamic and hydrological processes) that together have shaped the topography, tidal flushing regime and other important aspects of the site. At the local habitat scale, there is a mix of physical and chemical processes as well as biological processes that control the wetland habitats and associated biota.

The interaction of the wetland components with the wetland processes yields a range of wetland benefits and services (shown in the yellow box in Figure 4-2) that are supporting (ecosystem services) and cultural (relevant to providing a social or economic benefit to humans).

Within the cultural services, two services – related to fisheries and indigenous significance – also have a provisioning aspect e.g. humans are taking and using direct products from the wetland.

Conceptual models have also been prepared for the six representative habitat types and can be found in Section 7.2 of the report. These models demonstrate the interaction between the wetland services, components and processes at a habitat scale.

Semi-quantitative and qualitative descriptions are provided of the critical components, processes and services of the site. While acknowledging that quantitative descriptions may provide more detailed information, it was the view of the study team that such an approach was not justified given most environmental parameters show great variation across a wide range of spatial (measured in meters to 100's of kilometres) and temporal (diel, diurnal, daily, seasonal, inter-annual) scales, and it is therefore often difficult to provide meaningful empirical data without fully explaining the context of this variability. Furthermore, with few exceptions, quantitative data are typically unavailable for most species and environmental parameters, which could lead to biases towards those attributes that are more easily or intensively studied. Consequently, the reader is referred to the original data sources (cited in this report) that have been used to describe the critical components, processes and services.

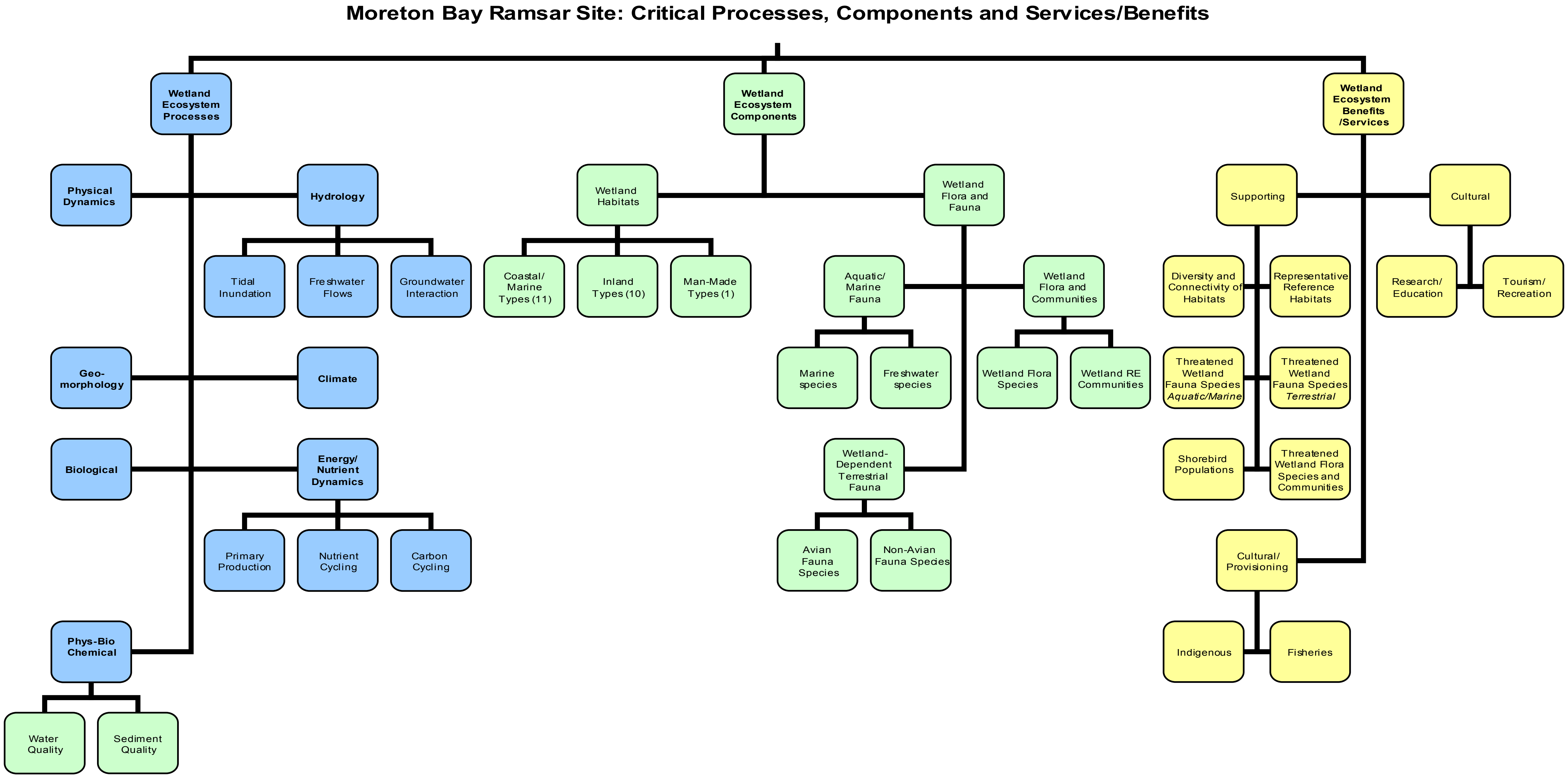

Figure 4-1 Graphical Depiction of Critical Services/Benefits, Components and Processes

Table 4-1 Summary of Critical Services/Benefits, Components and Processes

Critical Service/Benefit	Nomination Criteria and Service Type	Underlying Critical Components	Underlying Critical Processes[3]
S1. Moreton Bay Ramsar site contains a **diversity** of wetland habitat types that are **representative** of a major coastal wetland aggregation and in many areas show a high degree of **connectivity** between habitat types.	Criterion 1 *Supporting*	Across the site there are 22 Ramsar Wetland types represented Of these: • 11 are classified as coastal/marine • 10 are classified as inland waters • 1 is classified as man-made Several habitat types are highly localised (eg. rare) in the context of the bioregion and within the site itself including Type U – non-forested peatlands and Type O – permanent freshwater lakes.	Broad-scale processes including: • **Physical Coastal Processes.** Hydrodynamic controls on habitats through tides, currents, erosion and accretion • **Hydrology.** Patterns of tidal inundation and freshwater flows to wetland systems • **Groundwater.** For those wetlands influenced by groundwater interaction, the level and quality of the groundwater table • **Energy and Nutrient Dynamics.** Primary productivity and the natural functioning of carbon and nutrient cycling processes • **Biological Processes.** Important biological processes such as growth, reproduction, recruitment, migration and dispersal • **Water Quality.** Water quality that provides aquatic ecosystem values within wetland habitats • **Climate.** Patterns of temperature, rainfall and evaporation • **Geomorphology**. Key geomorphologic/topographic features of the site

Critical Service/Benefit	Nomination Criteria and Service Type	Critical Habitat Component (Reference site in parenthesis)	Underlying Critical Processes
S2. Moreton Bay Ramsar site contains several critical **wetland habitat types**.	Criterion 1 *Supporting*	S2A Seagrass and shoals (Eastern Banks Area)	• **Physical Coastal Processes**. Natural coastal processes and hydrodynamics such as current, waves, erosion and accretion (eg. hydrodynamic controls on the topography of the habitat) • **Water Quality**. Particularly, light penetration, salinity, turbidity, suspended solids, and nutrients • **Energy and Nutrient Dynamics.** Primary productivity and the functioning of carbon and nutrient cycling processes • **Biological Processes**. Biological processes that maintain and control habitat condition, including plant growth and reproduction, and grazing

[3] Note that while there are many ecosystem processes that apply, the dot points listed are those considered to be the most important/critical to the maintenance of the critical components and critical service/benefit

Reference sites have been selected within these critical habitat types that are **in a near natural state** and are **representative** of the habitat type within the broader biogeographic region.		S2B Tidal Flats and estuarine assemblages (Pumicestone Passage)	• **Hydrology.** Natural patterns of tidal inundation and freshwater flows • **Physical Coastal Processes**. Natural coastal processes and availability of habitat (eg. accretion and erosion of key intertidal habitats), as well as tidal and current velocity • **Water and Sediment Quality**. Particularly, suspended solids, nutrients, toxicants, and salinity • **Biological processes**. Biological processes that maintain and control habitat condition, including grazing, plant growth and reproduction.
		S2C Mangroves and saltmarsh (Southern Bay)	• **Hydrology.** Natural patterns of tidal inundation and freshwater flows to wetland systems • **Energy and Nutrient Dynamics.** Primary productivity and the functioning of carbon and nutrient cycling processes • **Physical Coastal Processes**. Natural coastal processes and availability of habitat (eg. accretion and erosion of key intertidal habitats), as well as tidal and current velocity • **Biological Processes**. Biological processes that maintain and control habitat condition, including grazing, plant growth and reproduction. • **Sea level rise**. Controls on mangrove colonisation into saltmarsh areas in response to sea level rises.
		S2D Coral Communities (Eastern Bay)	• **Physical Coastal Processes**. Natural coastal processes and hydrodynamics such as current, waves, erosion and accretion (eg. hydrodynamic controls on the topography/morphology of the habitat such as depth) • **Water Quality.** Particularly light penetration, salinity, turbidity, temperature, suspended solids, nutrients, and toxicants • **Energy and Nutrient Dynamics.** Primary productivity and the functioning of carbon and nutrient cycling processes are maintained • **Biological Processes**. Maintenance of essential biological processes that maintain and control habitat condition, including grazing, and plant growth and reproduction. and predation
		S2E Wallum and peatland freshwater wetlands (Bay Islands)	• **Water Quality.** Particularly pH, nutrients and dissolved oxygen • **Groundwater.** Water depth and groundwater interaction in lakes, bogs and creeks and groundwater interactions with surface water • **Climate.** Precipitation and evaporation rates will determine supply and water levels in these environments • **Geomorphology.** Topography of these features (eg. depth) is critical to their long term condition. • **Fire Regime.** Natural fire regime can control extent and condition in relation to these island wetlands
		S2F Ocean Beaches and foredunes (Moreton Island)	• **Physical Coastal Processes**. Natural coastal processes and hydrodynamics such as current, waves, erosion and accretion (eg. hydrodynamic controls on the morphology of the habitat) • **Wind-Driven Processes.** Particularly as it affects fine sediment erosion and deposition processes. • **Biological Processes**. Structural habitat and vegetation cover particularly in dune areas will affect nesting habitat.

Critical Service/Benefit	Nomination Criteria and Service Type	Underlying Critical Components		Underlying Critical Processes
		Key Wetland Habitat	Noteworthy Flora and Fauna Species	
S3. Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered marine/aquatic fauna	Criterion 2 Criterion 4 *Supporting*	Seagrass, reefs, nearshore open waters and rivers, offshore coastal environments	Dugongs, green, loggerhead, turtles	See S1 and S2A above
		Dune lakes and creeks on sand islands Wallum habitats adjacent to Pumicestone Passage	Oxleyan pygmy perch Honey blue-eye (mainland only)	See S1 and S2E above
S4. Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered wetland–dependant terrestrial fauna species	Criterion 2 Criterion 4 *Supporting*	Flats (sand, mud, and bars) Sandy Beaches Mangroves and Saltmarsh	Little tern Beach stone-curlew Water mouse Illidge's ant blue butterfly	See S1 and See 2B above
		Wallum habitats adjacent to Pumicestone Passage and on the sand islands	Wallum sedgefrog; wallum rocketfrog; wallum froglet; Cooloola sedgefrog; Australian painted snipe Australasian bittern	See S1 and S2E above
S5. Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered wetland flora species and endangered and of concern wetland regional ecosystems	Criterion 2 Criterion 4 *Supporting*	Key Ramsar wetland types for wetland flora and communities include: • Intertidal forested wetlands (Type I) • Permanent streams and creeks (Type M) • Freshwater marshes and pools (Types Tp and Ts) • Freshwater tree-dominated wetlands (Type Xf).	Several vulnerable and endangered wetland flora species have been identified within the Ramsar site. These include: • Swamp Daisy • Knotweed • Lesser Swamp Orchid • Yellow Swamp Orchid • Swamp Orchid	See S1 and S2E above plus: • **Geomorphology.** Stabilisation of substrate (vegetation cover, maintenance of natural sand/sediment transport patterns) important for retention of soils • **Biological processes.** Growth, reproduction and maintenance for population viability of key plant species and communities
S6. Moreton Bay Ramsar site supports significant populations (more than 20 000 in total and over 1% of the population size of particular populations of shorebirds	Criterion 3, 5, 6 *Supporting*	Intertidal flats (sand, mud, and bars) +/- Seagrass beds Sandy Beaches Coral rubble on islands (Eastern Bay) Sparsely vegetation salt marsh and freshwater marshes (Western Bay)	Migratory Waterbirds (>20 000 and up to 50 000) Species exceeding the 1% criterion are as follows: bar-tailed godwit, whimbrel, Eastern curlew, terek sandpiper, grey-tailed tattler, curlew sandpiper, pied oystercatcher, Pacific	Broad-Scale Processes – See S1 See S2A, S2B, S2C, S2F as key shorebird habitat areas

		Underlying Critical Components		
			golden plover, and lesser sand plover.	

Critical Service/Benefit	Nomination Criteria and Service Type	Underlying Critical Components		Underlying Critical Processes
		Key Wetland Habitat	Noteworthy Flora and Fauna Species	
S7. The tidal fish habitats and fish and invertebrate populations of the Moreton Bay Ramsar site support valuable recreational and commercial fishing activities	Criterion 7 and 8 *Cultural and Provisioning*	Mangroves Saltmarsh Intertidal flats Supratidal channels and flats Seagrass and algal beds Coral and Rocky Reefs Shallow surf bars and banks Open expanses of shallow oceanic waters	Bream, flathead, whiting, luderick, mullet, tailor, mackerel, sharks, baitfish, eels, and pink snapper finfish King, tiger, endeavour, banana, greasyback and school prawns Blue swimmer, mud, red spot, spanner and coral crabs and Callianasid shrimp (yabbies) Squid, cuttlefish, gastropods, rock oysters, bivalves and beche-de-mer.	Broad-Scale Processes – See S1 See S2 for important fish habitats (eg. nursery, spawning, etc.)
S8. Moreton Bay Ramsar site has important cultural values and significance to indigenous peoples	Ramsar Cultural Criteria *Cultural and Provisioning*	All ~ acknowledging many traditional owner groups in the SEQ region will have close association/regularly use wetland resources within particular areas such as the Bay Islands and Southern Bay region.	Culturally important species (eg. wetland fauna species with spiritual importance and/or targeted as part of traditional fishing and hunting activities; wetland flora species with particular traditional food or medicinal significance)	Broad-Scale Processes – See S1
S9. Moreton Bay Ramsar site is an important site for research and education	N/A *Cultural*	All ~ noting that several of the key habitat types identified above have been subject to long term research and education activities	All ~ noting that several of the noteworthy species of conservation significance identified above have been subject to long term research and education activities	Broad-Scale Processes – See S1
S10. The Moreton Bay Ramsar site provides and supports significant tourism and recreational uses in the Region	N/A *Cultural*	All ~ With specific importance placed on: • Marine and estuarine waters; • Sandy beaches and dunes; and • Freshwater lakes	All ~ noting that some species of specific tourism interest such as whales that while associated with the Bay, rarely occur within the Ramsar site.	Broad-Scale Processes – See S1

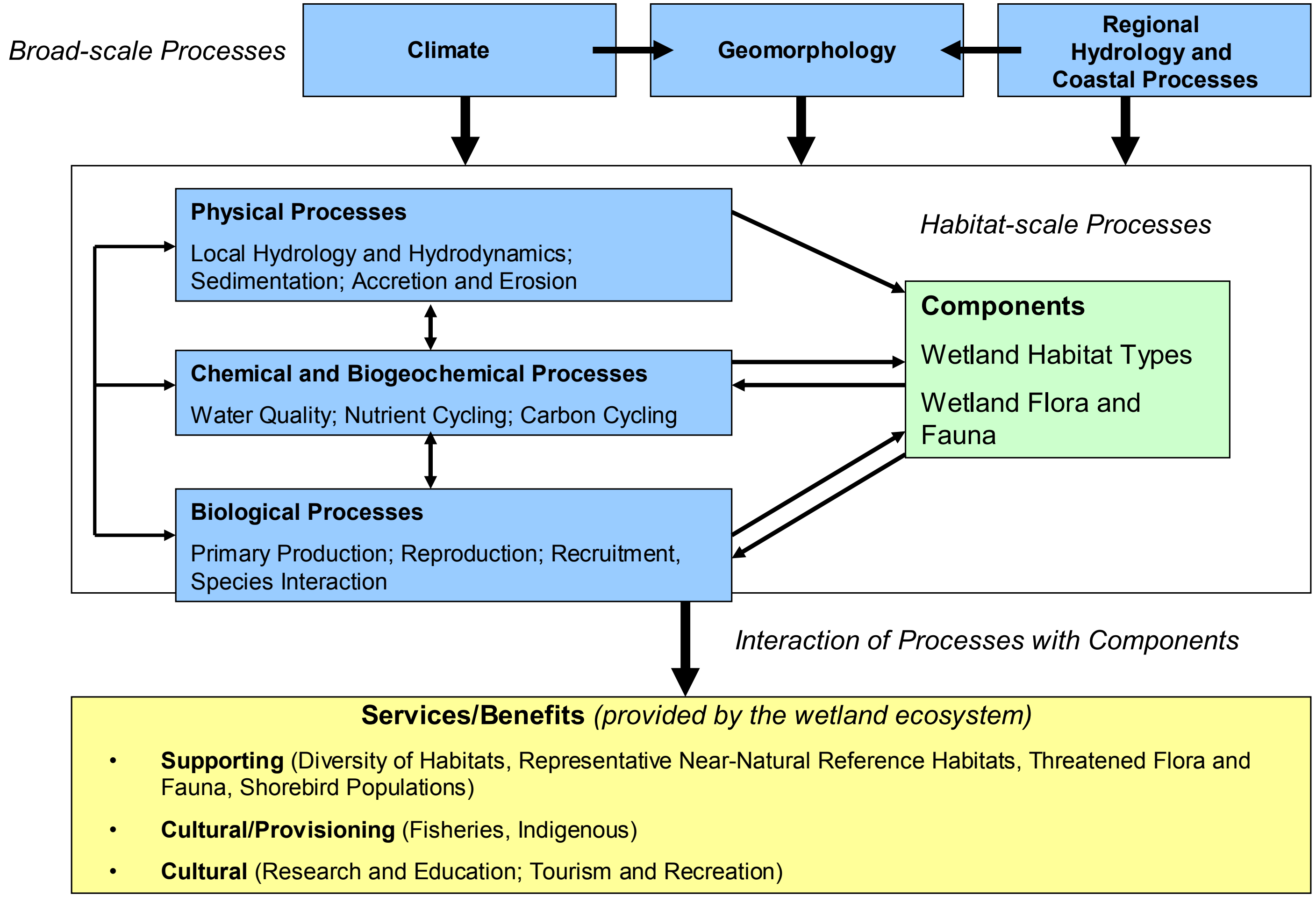

Figure 4-2 Conceptual Model Showing Interaction of Critical Elements

4.3 Overview of Limits of Acceptable Change

A key requirement of the ECD is to define the limits of acceptable change (LACs) for the critical services/benefits, components and processes of the wetland.

The approach taken for the identification of LAC's for Moreton Bay has been to outline the following:

- to align the limits of acceptable change defined under this ECD with the Ramsar Nomination Criteria under which the site has been listed under the Convention;
- to provide a qualitative description of what characterises an unacceptable change to ecological character under the relevant nomination criterion based on the critical services, components and processes;
- to identify 'interim' limits of acceptable change - where there is insufficient data to set a limit of acceptable change with confidence - based on current knowledge, data and published research about underlying critical components (habitats and species) and underlying critical processes (wetland ecosystem processes such as water quality, hydrological processes and similar).

This approach is described graphically in Figure 4-3.

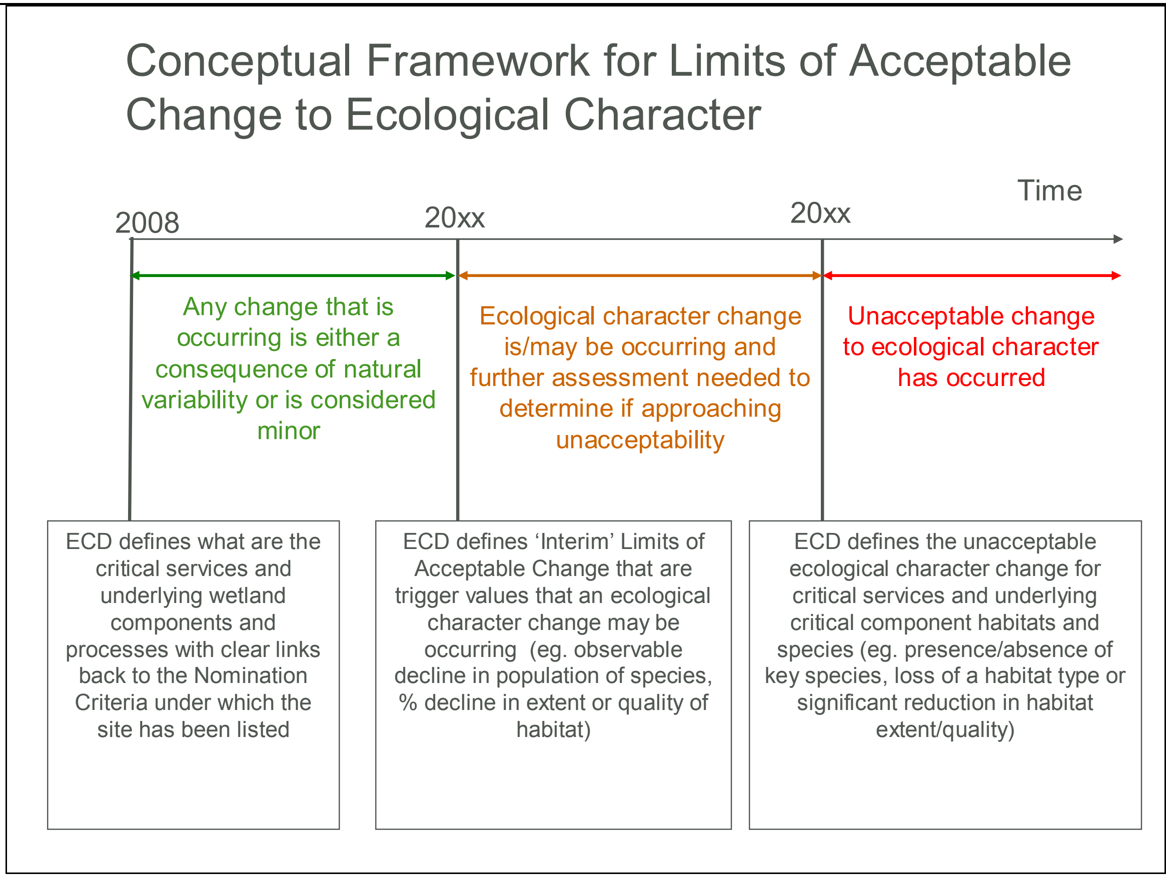

Figure 4-3 Conceptual Framework for Limits of Acceptable Change to Ecological Character

Consistent with the above, in general terms, LAC's outlined in this ECD should be interpreted and applied as follows:

- An unacceptable change to ecological character will have been deemed to occur where one (or more) of the Ramsar Nomination Criteria under which the site has been nominated no longer apply or where limits of acceptable change have been exceeded (see dot point below);
- Limits of acceptable change listed in the ECD that have a direct relationship back to ecological character include for example: the continued presence or absence of particular vulnerable or endangered species listed in the ECD, the reduction below a minimum population number for key

species, or a reduction in the overall abundance of populations or groups such as the requirement for at least 20 000 over-wintering avifauna under Ramsar Criterion 5;

- In most cases though, there will be one or more indicators of *potential* change to ecological character based on a key attribute, control or stressor on a habitat, species or population which serve as 'interim' limits of acceptable change. Observation or exceedance of an interim limit of acceptable change does not necessarily represent a significant change to ecological character of the site is occurring. Instead, exceedance of the interim limits of acceptable change provides a management trigger for further evaluation to determine if the change is characteristic of an unacceptable change or alternatively, to further evaluate if the change is the likely consequence of the broad natural variability of the site.

Interim limits of acceptable change also provide guidance to whether or not an action is or is likely to have a 'significant impact' on the ecological character of the Ramsar site in the context of EPBC Act assessments. Using the criteria presented in EPBC Act Policy Statement 1.1 – *Significant Impact Guidelines* (DEWHA 2006) particular issues addressed in the 'interim limits' of the ECD that are relevant to EPBC assessments include:

- identification of changes to wetland extent that may affect ecological character;
- identification of changes to the hydrological regime of the wetland that may affect ecological character;
- identification of the key habitats and lifecycles of important wetland flora and fauna within the site;
- identification of changes to water quality of the wetland that may affect ecological character; and
- presence of invasive species that may be harmful to ecological character

In this context, section 4.3.2 provides the limits of acceptable change identified for the Moreton Bay Ramsar site, preceded by the methodology used to derive them in section 4.3.1.

4.3.1 Derivation of Limits of Acceptable Change

Almost all Limits of Acceptable Change (LAC) outlined in this report are considered as interim limits, in recognition of the lack of empirical data describing ecological responses of biota to key regulating processes or controls. Wherever possible, the LAC have been based on existing benchmarks or guideline values used in other programs that have the key aim of protecting environmental values of relevance to this ECD. The following provides a rationale for the LAC for the selected critical components, services and processes.

Water Quality Indicators

By default, sub-regional guideline values outlined in Queensland Water Quality Guidelines (EPA 2006) have been adopted as interim LAC. The methodology to be followed to assess compliance should also be consistent with the approach outlined in EPA (2006) guidelines for assessing compliance in HEV areas.

It is recognised that there are available data describing the tolerance limits of some of the critical species identified in this ECD. These are:

- seagrasses (*Zostera muelleri, Halophila ovalis*), based on published critical threshold values including (but not limited to) values summarised by Erftemeijer and Lewis (2006);
- corals. This is based on studies in GBR, which demonstrate a threshold value that may lead to light limitation, and hence sub-lethal photo-physiological stress for *Symbiodinium* hosted by *Pocillopora damicornis* (Cooper *et al.* 2008). However, it should be noted that this species is not common in Moreton Bay (Johnson and Neil 1998a), and case studies for local species are lacking.
- reference data at which key aquatic species have been recorded (i.e. Oxleyan pygmy perch, honey blue-eye, wallum froglets etc.). While this may not necessarily represent the actual tolerance limits of these data, water quality conditions approaching or beyond the range should trigger management action to determine the causes and consequences of these changes.

Flow Regimes

By default, the mandatory Environmental Flow Objectives (EFOs) outlined in Water Resource Plans (WRP), as prescribed under the Queensland *Water Act 2000*, have been adopted here as the interim LAC. Within the context of water resource planning, mandatory EFOs are defined as flow objectives for the protection of the health of natural ecosystems for the achievement of ecological outcomes. These EFOs have therefore been developed to protect downstream ecosystem values, which is consistent with the wise use paradigm of Ramsar wetlands.

In this ECD, where freshwater flows are known or likely to represent a key controlling process for a particular ecosystems service, mandatory EFOs have been adopted as default interim triggers. Where mandatory EFOs are not met as a result of water resource activities, then further consideration needs to given to whether measurable impacts are known or are likely to occur to the service, and management actions may need to be implemented to mitigate these impacts.

According to the WRP, mandatory EFOs must be met at a number of critical sites, or nodes, within the river system. Several of these nodes occur within or directly adjacent to the Ramsar site, and have been adopted here to determine potential impacts to the site. These are listed in Table 4-2 below. Note that on 26 July 2007, the Minister for Natural Resources and Water announced his intention to amend the Logan Basin WRP to include water in a watercourse, lake, wetland, subartesian aquifer or spring in the Southern Moreton Bay Islands area. The revised Logan Basin WRP is likely to include additional EFOs of direct relevance to this ECD, particularly as it relates to water resources on North Stradbroke Island. It is recommended that the revised WRP be reviewed to assess implications of this ECD.

Table 4-2 Nodes and Mandatory EFOs adopted as interim LAC

Water Resource Plan	Mandatory EFO	Node	Node Location
Water Resource (Moreton) Plan 2007	See Schedule 7 of WRP	A	Pumicestone Creeks at end of system (AMTD 0.0km)
		B	Caboolture River at end of system (AMTD 0.0km)
		C	Pine River at end of system (AMTD 0.0km)
		E	Brisbane River end of system (AMTD 0.0km)
Water Resource (Logan Basin) Plan 2007	See Schedule 5 of WRP	G	Logan River at AMTD 0.0km
Water Resource (Gold Coast) Plan 2006	See Schedule 5 of WRP	A	Coomera River at end of system (AMTD 0.0km)
		N/A	Pimpama River

Given the current absence of EFOs for North Stradbroke Island wetland habitats, several interim trigger values were established. These interim trigger values were specifically used to protect habitat of threatened fish species, i.e. Oxleyan pygmy perch (OPP) *Nannoperca oxleyana*. Because this species forms genetically discrete populations with no interchange over the last few millennia, populations could become locally extinct if its waterbody completely dries and there is no adjoining refugia. This is a particular risk for the Little Canalpin Creek, given the small size of this waterway. Complete drying of a known habitat would result in local extinction of a genetically distinct population, and is considered to represent a change to ecological character (specifically the intent of criterion 9). Based on baseline monitoring undertaken in Little Canalpin Creek, it is known that OPP can occur in waters ~0.2 m water depth, and this may represent a useful start to developing a LAC for this location. It is known that deeper waters are used by OPP at other locations, and for this reason there is a need to develop site-specific LACs for this parameter.

It is also known that OPP prefers relatively quiescent waters, hence an increase in flow velocities above background may also result in impacts to this species. There are insufficient data to assess specific tolerances of OPP to increased flow velocities. OPP has been recorded in water velocities up to between 0.21 to 0.3 m/second (Pusey *et al.* 2004), which Cotterell (1998) suggests is likely to allow passage of all species of native fishes. It is recommended as in interim measure that flow velocities >0.1 m/second represent a preliminary trigger for management action. There is also a need to collect baseline data to determine reference conditions, and on the basis of this information, refining this interim LAC.

Tidal Hydraulics

Background/reference values for various tidal hydraulics indicators should form the basis of this LAC. If values fall outside these reference values (i.e. conditions outside background variability), there may be a change to species, communities or habitats, which may in exceptional circumstances lead to a change in ecological character, as defined by the ten (10) critical services/benefits outlined in this ECD.

It is very difficult to provide a complete list of LAC for tidal hydraulics indicators, as these values will vary from place to place, as well as over time in response in changes in tidal phase and meteorological conditions. It is also noted that while a change in conditions may occur as a result of a particular activity, these changes may not necessarily be ecologically meaningful, or lead to changes to ecological character.

In the interim, it is recommended that:

- The Moreton Bay Partnership Hydraulic Model (or its future replacement) be used to establish background/reference hydraulic (and associated sediment dynamics) conditions (based on a 2008 model configuration) of the site;
- Modelling be used to assess the potential hydraulic impacts of the development under consideration;
- There should be no measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background such that it results in a measurable, medium-term (>2 to 5 years) flow-on effects to key species, communities or habitat at this spatial scale.

In this context, it is strongly advised that there is a need to further refine these limits before they are applied in assessing impacts to ecological character.

Flora and Habitat Extent

It is difficult to set LACs for changes in habitat extent for several reasons:

- The area of some habitat types is variable over time, hence it is difficult to determine ‘baseline’ conditions for these habitats;

- Empirical relationships between habitat extent and flora and fauna abundance/ richness etc. have not been established, hence it is not generally possible at this stage to make quantitative predictions of the responses of most key species to habitat changes;
- It is known that different habitat patches with similar size and structural characteristics can have different fauna habitat values. For example, studies elsewhere demonstrate that particular patches of seagrass can contain more diverse or abundant fish assemblages than nearby, structurally similar patches. The reasons for why different habitat patches are more or less valuable to fauna are not well understood, which further hinders the development of generalised habitat area : fauna assemblage models;
- At the whole-of-site scale, habitat loss associated with a particular development proposal is often small relative to the total available area of habitat. Therefore, at a whole-of-site scale, habitat loss is often a result of incremental or cumulative changes associated with multiple developments.

There is however a need to establish interim LACs describing changes in habitat extent which, if triggered, will lead to a management response. There are two components required to derive a LAC:

1. there is a need to develop a numerical habitat-extent based trigger value;
2. there is a need to consider whether the changes in extent are ecologically meaningful in the context of the critical services/benefits.

In terms of the first component, consistent with approaches used elsewhere, interim LACs are based on the total area of habitat lost relative to a particular benchmark (i.e. percentage of the total extent of habitat lost). Studies elsewhere usually set habitat loss LACs of 0% to 10%, depending on the known perceived values of the habitat. Based on this, the following trigger values have been developed for this ECD:

- In the context of vegetated and unvegetated marine habitats, there should not be a >10% change in marine habitat extent, relative to the total area of available habitat within Moreton Bay, and also relative to natural background temporal variability, in the medium term (>2-5 years);
- For intertidal habitats, there should not be a >10% change in the total area of unvegetated habitat and the extent of habitat within the following tidal zones: Mean High Water (MHW) and Mean Sea Level (MSL); MSL and Mean Low Water (MLW); and MLW and Lowest Astronomical Tide (LAT), in the medium term (>2-5 years);
- For critical terrestrial and aquatic habitats for threatened species, >5-10% change in extent (outside the bounds of natural variability) should trigger management action.

In terms of the second component, there is also a need to take into account natural temporal variability in habitat extent, and if changes in extent are ecologically meaningful in the context of the key services. For the purpose of this assessment, two spatial scales have been delineated: (i) Regional scale, and (ii) local (measured in kilometres) scales. The regional scale considers the impacts of a habitat loss to the overall population size and conservation status of particular species. The local scale considers the significance of impacts within the site.

At broad (regional or greater) spatial scales, there should be no net change in extent and condition of a particular habitat type, relative to natural background temporal variability, such that it results in a measurable, medium-term (>2 to 5 years) flow-on effect to the declared population status (as defined under Commonwealth or State legislation) of threatened species or communities. This means that there should be no change in habitat extent such that it results in species or communities having a revised conservation status under legislation (i.e. downgrade of conservation status from rare to vulnerable, or vulnerable to endangered etc.).

It is also recognised that there is a need to establish a more conservative interim LAC to capture local scale level impacts (i.e. impacts to values within the site). It is recognised that the definition of "local-scale" may vary depending on the distribution and home-range of different species. However, for the purposes of this assessment, local scale change is defined as a change in a particular pattern or process that is measurable at spatial scales of kilometres. For example, a change in a community measure (e.g. the abundance of a plant or an animal, the diversity etc.), that is either predicted (in the context of an impact assessment study) or measured (in the context of monitoring) 1.2 km from a particular project area would be considered unacceptable. In contrast, where community structure is within the range of background variability <600 m from a particular project area, this is not considered as an unacceptable change (unless the change is measurable at the greater than regional scale discussed above, i.e. change in conservation status).

It is important to note that for most habitat types, natural temporal variability in the extent of habitats is not well known. This is a key information gap that needs attention.

Threatened and Significant Fauna Abundance

As an interim measure and based on standardised sampling methodology and effort, it is suggested that the following represent triggers for management intervention:

- Significant decline in the numbers of the four acid frog species for important populations on North Stradbroke and Moreton Islands;
- Significant decline in the numbers of little tern over five years as determined at key roost sites (e.g. northern Pumicestone Passage; South Stradbroke Island);
- Lack of observation of Beach stone-curlew in any three year period over five years within the following areas: Pumicestone Passage (Toorbul north to Bells Creek); Bulwer to North Point (Cape Moreton); Cape Cliff (Cape Moreton) to Eagers Creek; Little Sandhills to Mirapool Lagoon; Amity to

Point Lookout; Peel Island; Jumpinpin (includes southern end tip of North Stradbroke Island and associated mangrove islands); western side of South Stradbroke Island;

- Greater than 20% reduction in the number of active/recently active water mouse nests or greater than 15% reduction in usage of any one of the diversity of nest types used (following Van Dyck and Gynther 2003) over five years for important populations associated with North Stradbroke Island, southern Moreton Bay (e.g. Macleay Island, Coomera & Pimpama Rivers, South Stradbroke Island) and Pumicestone Passage (e.g. Bribie Island, Donnybrook); and

- Loss or otherwise significant reductions in the known populations of Oxleyan pygmy perch and Honey blue-eye.

Habitat Condition Indicators

For habitat condition, interim LAC used in the study are as follows:

- Sedimentation on coral reefs. Sedimentation should not exceed background variability and lead to measurable impacts to coral communities.

- Emergent macrophyte cover. Oxleyan pygmy perch and honey blue-eye are both found in structurally complex habitat, with bank undercutting and/or 60-80% aquatic plant cover (typically sedges). Should this habitat feature be lost then impacts to fish could occur. An interim limit of >50% cover of emergent macrophytes has been set. It is recognised that some sites may have naturally lower emergent macrophyte cover, but still represent an important habitat. In such cases, adopt: 20^{th}, 50^{th} & 80^{th} percentile values of reference site conditions in which population has been recorded. The 75^{th} confidence limit should not be less than these values.

Ecosystem Condition Biological Indicators

Several condition indicators based on fauna provide a basis for defining the following interim LAC:

- Seagrass depth range (SDR). SDR guideline values outlined in the Queensland Water Quality Guidelines (EPA 2006) for various sub-areas within the Bay have been adopted.

- Coral community structure. The EHMP has adopted coral community structure as a measure of ecosystem condition. Coral community structure is also directly relevant to Service 2 and to a lesser extent service 1 in this ECD. A change in coral community structure, such that key processes, functions and attributes are lost or modified, would be considered an unacceptable change.

- Coral bleaching. Coral bleaching occurs when hard coral reject their symbiotic zooxanthellae, which typically occurs under stressful conditions. An increase incidence in bleaching (above background variability), such that it results in significant long-term coral mortality, would be considered an unacceptable change in the context of changes to Services 1 and 2. There is a need to collect further reference data to assess this LAC.

- Crab burrow densities. Counts of crab burrows is a potential non-destructive, rapid assessment technique for assessing potential changes in crab abundances, which may be linked to changes in ecosystem condition. Crabs also represent an important food resource for fish and some wader birds, and represent keystone species in mangrove forests. There is a need to develop methods and limits of acceptable change for this indicator.

- Spionidae and Capitellidae worm abundance. These taxa may increase in abundance in response to organic enrichment, or decrease in abundance in response to increase toxicant loads. Polychaete abundances can also exert an influence on waterbird abundance. High range and low range limits are therefore proposed. The high range is based on ANZECC/ ARMCANZ (2000) value of >1000 individuals per m^2. A low range guideline would need to be developed. This method and LAC should be further developed based on *Method 8 Density of Capitellid Worms* in ANZECC/ARMCANZ (2000).

- Eastern Gambusia abundance. Eastern Gambusia represents a pressure of native fish and frogs. The presence of Eastern Gambusia in critical habitat of sensitive species should be a matter of management concern. In the context of this ECD presence of Eastern Gambusia in Little Canalpin Creek would represent a trigger for management concern given the limited area of this habitat, and the absence of refugia (i.e. deeper waters) for OPP to avoid interactions with Eastern Gambusia.

4.3.2 Summary of Limits of Acceptable Change

Table 4-3 below lists the Nomination Criteria for the Moreton Bay Ramsar site (column 1), qualitative indicators that describe unacceptable changes to ecological character (column 2) and more detailed indicators that have been developed as ‘interim’ limits of acceptable change to indicate that ecological change for the criteria may be affected or occuring (column 3). As mentioned previously, these ‘interim’ limits of acceptable change in column 3 have been developed to assist the site manager to identify potentially significant changes to ecological character on the site prior to an unacceptable change occurring.

In this context, observation or exceedance of an interim limit of acceptable change (column 3) does not necessarily represent a change to ecological character of the site. Instead, exceedance of the interim indicator provides a management trigger for further evaluation to determine if the change is characteristic of an unacceptable change to ecological character or alternatively, to further evaluate if the change is the likely consequence of the broad natural variability of the site.

Table 4-4 and 4-5 underpin Table 4-3 and are specific to the identification of natural variability and limits of acceptable change for particular critical wetland habitats and species nominated within the critical services/benefits of the ECD. Specifically, these tables outline the key attributes (eg. wetland ecosystem processes) that underpin the ecological condition of these habitats and species which are fundamental to the maintenance of critical services and overall ecological character of the site. Cross-references are supplied in the table, particularly to show where a particular habitat or species has relevance to one or more of the ten (10) critical services. The detailed discussion of critical services within Section 7 of the report provides further information to support these tables.

Limits of acceptable change have not been identified for the broader cultural and provisioning services identified in the ECD such as fisheries values (S7), indigenous significance (S8), research and education (S9) and tourism and recreational uses (S10). This is generally due to a lack of quantitative or comparable data sets. Also, in general, the extent to which these cultural services continue over time will depend on the maintenance of the other critical services and underlying ecosystem components and processes.

Notwithstanding, qualitative analysis of the key threats, information gaps and monitoring needs concerning these cultural services (and their maintenance) are identified and discussed in Section 7 as part of the detailed description.

Table 4-3 Summary of Limits of Acceptable Change

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	Criterion 1 is based on the site containing at least one particularly notable wetland habitat type, and this wetland type is maintained in natural or near-natural condition. **Wetland Types and Extent** The ECD/RIS list twenty-two (22) wetland types within the site (using the Ramsar Classification Methodology). An unacceptable change will have occurred if it can be demonstrated that one or more of these wetland types have been lost. **Wetland Condition** A change in natural or near-natural condition at one of the six (6) reference sites[4] or more broadly across that habitat type at a whole-of-site scale are defined as follows: • **Seagrass meadow** cover and extent has declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (Eastern Bay) or has resulted in	**Habitat Extent** At a local scale, >10% change in habitat extent, relative to natural background variability, such that it results in measurable impacts at sub-km spatial scales, and causes measurable, medium-term (>2 to 5 years) flow-on effects to key species, communities or habitat at this spatial scale. **Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4

[4] These representative habitat types and locations have been selected on the basis of their role in ecosystem functioning across the site and are important habitats for threatened species, communities and populations that are relevant to other Criteria in the table.

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	measurable changes to the local population status of dugongs and green turtles, or fisheries stocks (all seagrass areas); • **Unvegetated intertidal flats** and associated microphytobenthos and marine fauna community structure has changed to such levels that it in the medium to long-term (>5 years), can no longer be considered to be in pristine or near-pristine condition (Pumicestone Passage) or has resulted in measurable changes to avifauna populations or fisheries stocks (all tidal flat areas); • **Mangrove and saltmarsh** habitat extent and community structure has changed to such levels that in the medium to long-term (>5 years), it can no longer be considered to be in pristine or near-pristine condition (Southern Bay) or has resulted in measurable changes to avifauna populations or fisheries stocks (all mangrove and saltmarsh areas); • **Coral community** and reef habitat structure has changed to such levels that in the medium to long-term (>5 years), it can no longer be considered to be in pristine or near-pristine condition (Eastern Bay coral communities) or has resulted in measurable changes to the extent or condition of the habitat (eg. coral dominated reefs algal dominated); • **Freshwater wallum** wetland **/peatland** habitat conditions have declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (North Stradbroke or Moreton Islands) or has resulted in measurable changes to the local population status of threatened flora and fauna species or communities (see Criterion 2 below); • **Ocean beach and foredune** habitat conditions have declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (Moreton Island) or has resulted in measurable changes to the local population status of avifauna or nesting usage by avifauna and marine turtles (all ocean beaches and foredune areas).	
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	Criterion 2 is based on the site containing at least one vulnerable or endangered species or threatened ecological community. The ECD/RIS lists several species/communities within the site that meet this criterion which include: • Marine Species - dugongs, green and loggerhead turtles • Freshwater Fish - Oxleyan pygmy perch and honey blue eye • Avifauna - little tern, beach stone-curlew, painted snipe, Australasian bittern • Wetland-dependant non-avian fauna - Illidge's ant blue butterfly, acid frogs and water mouse • Nationally Endangered wetland flora species including several swamp orchids, knotweed and swamp daisy An unacceptable change will have occurred if it can be demonstrated that one or more of these threatened species or threatened communities is lost within the site.	**Species/Populations** Detectable decline in local abundance/population of the key species. See Wetland Species Ecosystem Process Indicators – Table 4-5

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	In particular, a change to character would be demonstrated if the following were to occur: • The wetland becomes unsuitable as habitat for one or more threatened species or community listed in this ECD; or • Threatened animal and plant species identified in the ECD no longer occur at the site.	
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	Criterion 3 is based on the site containing a large proportion of species that are not well represented in the wider region. An unacceptable change will have occurred if it can be demonstrated that there has been a reduction in the number of species occurring within the site, and that this has resulted in a loss in biodiversity within the bio-region. In this context, a change to character would be demonstrated if the following were to occur: • Habitats have become unsuitable for wetland flora or fauna species or populations listed in the critical services of this ECD (see Criterion 2) • Noteworthy animal and plant species identified in the ECD are no longer present (see Criterion 2) • Populations of noteworthy species (see Criterion 2 above) no longer recorded in previous abundances (i.e. possible loss of genetic diversity) • Overall vertebrate fauna biodiversity is measurably and significantly reduced	**Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4 **Species/Populations** See Wetland Species Ecosystem Process Indicators – Table 4-5
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	Criterion 4 is based on the site representing critical refugia for any species, and the site maintaining critical life-cycle processes for any species. An unacceptable change will have occurred if it can be demonstrated that the site no longer provides a refugia function for important flora and fauna species (see Criterion 2) or if critical life-cycle processes are no longer being supported. The following are considered to represent the key critical life-cycle functions in the Moreton Bay Ramsar site - • Feeding and nesting habitat for green and loggerhead turtles that could impact the local population • Feeding and breeding habitat for dugong that could impact the local population • Refuge habitat for freshwater fish of conservation significance that could impact the local population • Roosting habitat for migratory waterbirds that could impact the local population • Critical overwintering habitat and a flyway staging area (both northern and southern migration routes) for migratory waterbirds	**Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4 **Species/Populations** See Wetland Species Ecosystem Process Indicators – Table 4-5
Criterion 5: A wetland should be considered internationally	An unacceptable change will have occurred if the site no longer supports the required abundance of waterbirds under this Criterion	That the total number of waterbirds at the site always exceeds 20,000 individuals

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
important if it regularly supports 20,000 or more waterbirds.		Greater than 10% reduction in over a 10 year period of numbers of bar-tailed godwit, Eastern curlew, or Pacific golden plover which are surrogates for assessing shorebird abundance generally.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	An unacceptable change will have occurred if the site no longer supports the 1% of individuals of populations for the key species in the ECD which are: • bar-tailed godwit • whimbrel • Eastern curlew • terek sandpiper • grey-tailed tattler • curlew sandpiper • pied oystercatcher • Pacific golden plover • lesser sand plover	Greater than 20% reduction in any three year period over five years for any of the eight migratory shorebird species (which exceed the 1% threshold).
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	Long term impacts on the sustainability of populations of important commercial and recreational species that occur within the site (or in adjacent areas of the Bay) including: • bream, flathead, whiting, luderick, mullet, tailor, mackerel, sharks, baitfish, eels, pink snapper and other key finfish species; • king, tiger, endeavour, banana, greasyback and school prawns; • blue swimmer, mud, red spot, spanner and coral crabs and Callianasid shrimp (yabbies); • squid, cuttlefish, gastropods, rock oysters, bivalves and *beche-de-mer*.	A long-term loss of fish/shellfish stocks, which results in the reduction in the sustainability of key Bay fisheries, should be considered a trigger for assessing potential changes to ecological character.
Criterion 8: A wetland should be considered internationally	Medium to long-term (>5 years) reduction in the extent or condition of wetlands or other areas and a corresponding measurable impact on important spawning, nursery or migration pathways	At a local scale, >10% change in habitat extent, relative to natural background

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	for fisheries.	variability, such that it results in measurable impacts at sub-km spatial scales, and causes measurable, medium-term (>2 to 5 years) flow-on effects to key species, life-stages, communities or habitat at this spatial scale. In assessing this interim LAC, attention should be given to assessing changes in the extent of mangroves, saltmarsh, seagrass and tidal flat environments, which represent key nursery habitats to many commercially important species within the site.

Table 4-4 Summary of Natural Variability and LAC – Critical Habitats

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Seagrass	See 'Natural Variability' column	See below Turbidity/light	Variable across site. Refer to EHMP data.	n/d	*H. ovalis*: H90. Min. light requirement = 16% SI [P,Q] H91. Duration = >30 days at 0% SI [P,S] *Z. muelleri*: H92. Duration = >30 days at 5% SI [P,Q] H93. Critical thresholds = >30% SI [Q,R,]; 0.9 Kd (m^{-1}) [P,R]; 10 mg/L [P,R] H94. If site values exceed levels in H1 to H4, use default baseline turbidity values at seagrass sites as default trigger values (see SDR sites below) [J]	S1, S2, S3, S6, S8
		Seagrass depth limit/range (SDR)		n/d	Medium term (>5 years) median SDR value should not fall below the following interim default SDR values [N]: H95. Pumicestone Passage HEV = -0.8 m	
					H96. Pumicestone Passage SMD = -1.2 m	
					H97. Deception Bay North SMD = -3m	
					H98. Waterloo Bay HEV = -1.9m	
					H99. Central Bay HEV/ SMD = -2.2m	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
					H100. Eastern Bay HEV = -3.5m H101. Eastern Bay SMD = -2.2m H102. Southern Bay HEV/ SMD = -1.3m	
		Long-term change in tidal hydraulics and sedimentation patterns (short to medium term)	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008)[A].	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H103. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background [B].	
Unvegetated tidal flats	Pumicestone Passage, Waterloo Bay, Bramble Bay, Eastern Banks.	Freshwater flows	Waterway-specific & highly variable over time. Baseline hydraulic conditions as per 'Existing-case' scenarios in Moreton WRP.	n/d Quantitative environmental flow requirements of key local species and habitats unknown	H104. As a minimum, compliance with EFOs outlined in Moreton WRP for Nodes A-E	S1, S2, S3, S4, S6, S8
		Tidal hydraulics & sedimentation patterns (short to medium term)	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008) [A].	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H105. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background [B]	
		Long term (>50 years) changes to tidal inundation and sediment dynamics patterns & processes due to sea level rise	-0.22 mm/year change over last 26 years of data collection [C]	n/d Impacts dependent on sedimentation rate relative to sea level rise	H106. A change in frequency, duration & magnitude of tidal inundation between: • MHW and MSL; • MSL and MLW • MLW and LAT • Such that it results in >10% change (above background) in the extent of unvegetated habitat at these levels, and results in [B].	
		Spionidae and Capitellidae worm densities, and sediment TOC, as indicators of organic enrichment	Highly variable in space and time	n/d	Using methods as per ANZECC, assess whether the following are exceeded: H107. Interim high range – Capitellidae or Spionidae densities >1000 individuals per m^2 H108. Interim low range – n/d	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		Crab burrow densities. This is a potential non-destructive, rapid assessment technique for assessing potential changes in crab abundances, which may be linked to changes in ecosystem condition [U]			n/d. H109. There is a need to investigate (i) whether robust and cost-effective methods can be developed, and if so (ii) proceed to establish threshold criteria based on sampling of appropriate indicator species at a range of references sites.	
Mangroves and Saltmarsh	Southern Bay Pumicestone Passage Western Bay	Freshwater flows	H110. As a minimum, compliance with EFOs outlined in Moreton WRP for Nodes A-E (see also H15) plus nodes outlined in Logan WRP (Note G) and Gold Coast (Note A) WRPs. This should be assessed using SunWater IQQM models.			S1, S2, S7, S8
		Tidal hydraulics	H111. Refer to unvegetated flats, i.e. H16			
		Tidal inundation patterns	H112. Refer to unvegetated flats, i.e. H17			
		Crab burrow densities	n/d	n/d	H113. n/d. Refer to H20	
		Mangrove die-back extent and hypersaline areas	n/d	n/d	H114. n/d. There is a need to map the distribution and extent of mangrove die-back (aerial photography & ground-truthing) to establish existing conditions. Monitoring should be undertaken on a 5 year basis. H115. Salinity should not be > 40-50 g/L (low tide) to reduce the risk of impacts to mangrove health[V]. H116. Where ambient salinity exceeds levels in H26, & mangroves and saltmarsh are demonstrated to be in good condition, derive local trigger values based on ambient/background data. [J]	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Coral Communities (Eastern Bay)	Central and Eastern Bay – Myora, Peel Island, etc	Turbidity	<1, 1, 1 NTU [E]	n/d. Tolerance limits of most local species are largely unknown.	H117. Long-term (>5 day) average turbidity should not exceed >3 NTU [H] H118. Use default baseline conditions at coral reef sites as default interim trigger values for turbidity & other attributes [J]	S1, S2, S3, S8
		pH	8.2, 8.3, 8.4 [E]			
		TN	100, 120, 160 μg/L [E]			
		TP	5, 9, 12 μg/L [E]			
		Water temperature	12.5° to 32°C (Reef flat); 16 to 28°C (Moreton Bay surface waters [F]			
		Sedimentation rates (mg/cm^2/day) [G]	Peel Is = 2 to 32 Myora = 5.9 to 16.1	n/d Tolerance limits are: • highly species-specific. • not available for local species • dependent on duration & frequency of exposure to sedimentation Available baseline sedimentation data has limited temporal coverage (1 year).	H119. Sedimentation should not exceed background variability and lead to measurable impacts to coral communities [K]	
		Coral bleaching frequency & extent	n/d Incidence of coral bleaching is not reported in EHMP.	n/d	H120. The frequency & duration of bleaching events should not increase to such levels where measurable impacts to coral communities occur [K]	
		Reef community structure (cover of numerically dominant taxa)	Site specific, and variable in time for some macrophyte species. Refer to EHMP (2006) data for a description of baseline conditions.	n/d	H121. >5% loss in hard and/or soft coral cover > background temporal variability [L]	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Wallum freshwater wetlands	Bay Islands Pumicestone Passage	Groundwater hydrology	Waterway-specific & highly variable over time. Baseline hydraulic conditions as per 'Existing-case' scenarios in Logan WRP (& underlying modelling).	n/d	H122. As a minimum, compliance with EFOs outlined in future draft Logan WRP (North Stradbroke Island) [M] H123. No changes in water levels at Blue Lake, or the Blue Lake Overflow discharge channel, such that a detectable community or ecosystem change occurs [B]	S1, S2, S4, S5, S7
		Invertebrates	20^{th} percentile: Taxa richness = 12 PET richness = 2 SIGNAL = 3.32	n/d	H124. No change in water quality or invertebrate biotic indices, outside the bounds of natural variability. Note that water quality and biotic indices show great change among different waterbodies, hence there is a need to derive local trigger values based on ambient/background data. [J]	
		pH [I]	Blue L. = 4.9 to 5.2 Brown L. = 4.6 to 5.0			
		EC (µS/cm) [I]	Blue L. = 90 Brown L.= 90			
		Secchi (m) [I]	Blue L. = 4.9 to 6.9 Brown L. = 0.7			
		DO (% saturation) [I]	Blue L. = 86 to 95 Brown L. = 90 to 99			
		Chlorophyll a (µg/L) [I]	Blue L. = 0.6 to 2.4 Brown L. = 14			
		TP (µg/L) [I]	Blue L. = 2 to 6 Brown L. = 15			
		Water Temp (deg C) [I]	Blue L. = 19 to 26 Brown L. = 19 to 26			
		Turbidity (NTU) [I]	Blue L. = <1 to 1 Brown L. = 9			
		Ammonia (µg/L) [I]	Blue L. = 2 to 7 Brown L. = 9			
		Total N (µg/L) [I]	Blue L. = 90 to 130 Brown L. = 500			
		NOX (µg/L) [I]	Blue L. = 6 to 37 Brown L. = 3			
Ocean beaches and foredunes	High-energy beaches and foredunes of Bribie, Moreton and North and South Stradbroke Islands	Long-term change in tidal hydraulics and sedimentation patterns (short to medium term) leading to change in beach morphology	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008)[A] or long term aerial photograph analysis.	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H125. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater, relative to background [B].	S1, S2, S3, S4, S7

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		Groundwater inflows	Highly site-specific. Groundwater flows bring nutrients into the beach system and into the swash zone and control invertebrate and nearshore phytoplankton communities	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H126. No measurable medium term (>5 years) change to groundwater supply/flows into beach systems relative to background [B].	
		Density of *Pipis* or other indicator species linked to changes in ecosystem condition	Highly variable in space and time	n/d	H127. There is a need to establish threshold criteria based on sampling of appropriate indicator species at a range of references sites. Refer to H20.	

Table 4-5 Summary of Natural Variability and LAC – Critical Species

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Oxleyan pygmy perch	Bay Islands, Pumicestone Passage	No long-term reduction in population densities of Oxleyan pygmy perch in waterbodies, outside the range of natural variability. No reduction in the total number of waterbodies inhabited by Oxleyan pygmy perch within the site.	pH	4.2 to 7.2 [A]	n/d No experimental determination of physiological tolerances All information on habitat preferences based on environmental conditions in which this species has been recorded	H128. Long term average should not >6.5 H129. If above this value, adopt 20th, 50th & 80th percentile values of reference site conditions in which population has been recorded. The 75th confidence limit should not be > these values.	S1, S2, S3
			Dissolved Oxygen	> 2 mg/L [B]		H130. Long-term median should not be <5 mg/L. If above this value, then adopt percentile values described in H40	
			Turbidity	Clear, tannin stained waters (1 to 300 NTU) [A, B]		H131. Long-term median should not > 1 NTU. If above this value, then adopt percentile values described in H40	
			EC/Salinity	<330 µS/cm [A]		H132. Long term average should not exceed 300 µS/cm. If above this value, then adopt percentile values described in H40	
			Water levels	0.2[A, B] to 5[C] m, depending on water body characteristics. Mean weighted depth of captures = 0.63 m [A], whereas OPP Recovery Plan indicates most OPP captures in 0.3 to 0.4 m depth range [F].		H133. n/d. Trigger value may vary depending on particular requirements and local habitat conditions, i.e. avoidance of competition with eastern Gambusia or maintenance of fish passage. Local trigger values therefore need to be developed, although water depths <0.2 m unlikely to allow maintenance of OPP populations. H134. Drying. Where adjoining permanent refugia is absent, drying of a known habitat will cause local extinction at the site.	
			Groundwater hydrology	Low flow <0.3 m/sec [A]		H135. Flow <0.1 m/second. If >, then If above this value, then adopt percentile values described in H40	
			Emergent macrophyte cover and undercut banks	60-80% emergent macrophyte cover (typically sedges), undercut banks, woody debris & root masses.		H136. >50% reduction in emergent vegetation cover, above background variability, such that it results in such that it results in a measurable, short-term (1-5 years) flow-on effects to OPP populations and/or key ecosystem functions.	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Eastern Gambusia in freshwater reaches of Little Canalpin Ck.**	Absent in freshwater reaches, but found in lower estuarine/brackish environs	n/d	H137. Presence of Eastern Gambusia in Little Canalpin Creek represents a trigger for further investigation of viability of this sub-population.	
			Oxleyan pygmy perch abundance	This species has low population densities, hence empirical limits are difficult to set. On North Stradbroke Is., average CPUE is typically 0-0.6 individuals/trap /hour*.	n/d	H138. No fish recorded during >5 sampling events, using various combinations of sampling methods (e.g. box traps, electro-fishing and seine netting), should trigger further investigations of whether waterbody continues to provide suitable OPP habitat, and the identification of drivers for change.	
Honey blue-eye	Pumicestone Passage	No long-term reduction in population densities of honey blue-eye in waterbodies, outside the range of natural variability. No reduction in the total number of waterbodies inhabited by honey blue-eye within the site.	pH	4.4 to 6.8 [A]	n/d No experimental determination of physiological tolerances All information on habitat preferences based on environmental conditions in which this species has been recorded	H139. Long term median should not be >6.5, or if above this value: H140. Adopt 20th, 50th & 80th percentile values of reference site conditions as described in H40	S1, S2, S3
			Dissolved Oxygen	> 6.8 mg/L [A]		H141. Long-term median should not be <5 mg/L. H142. If background above this value, then adopt percentile values described in H40	
			Turbidity	Clear, tannin stained waters (<17 NTU) [A]		H143. Long-term median should not > 1 NTU. H144. If background above this value, then adopt percentile values described in H40	
			EC/Salinity	<900 µS/cm [A]		H145. Long term median should not exceed 700 µS/cm. H146. If background above this value, then adopt percentile values described in H40	
			Water levels	n/d		H147. n/d. Trigger value may vary depending on particular requirements, i.e. avoidance of competition with eastern Gambusia or maintenance of fish passage. Local trigger values need to be developed. H148. Drying. Where adjoining permanent refugia is absent, drying of a known habitat will cause local extinction at the site.	
			Groundwater hydrology	Low flow <0.3 m/sec [A]		H149. Median flow velocity <0.1 m/second. H150. If background above H22, then adopt percentile values using approach described in H40	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Emergent macrophyte cover and undercut banks	High aquatic plant cover, typically sedges [A]		H151. >50% reduction in emergent vegetation cover, above background variability, such that it results in such that it results in a measurable, short-term (1-5 years) flow-on effects to Honey Blue-eye populations and/or key ecosystem functions..	
			Honey blue-eye abundance	This species typically has low population densities [A], hence empirical limits are difficult to set.	n/d	H152. No fish recorded during >5 sampling events, using various combinations of sampling methods (e.g. box traps, electro-fishing and seine netting), should trigger further investigations of whether waterbody continues to provide suitable habitat, and the identification of drivers for change.	
Dugong	Eastern Bay Pumicestone Passage Southern Bay	Detectable decline in local abundance of dugong outside the range of natural variability	Turbidity, nutrients and chlorophyll *a*	Refer to seagrass indicators in Habitat Table 4-4			S1, S2, S3, S9
			Seagrass depth limit (and extent)	Refer to seagrass in Habitat Table 4-4			
			Dugong population densities	503 ± 63 (S.E) (July) to 1019 ± 166 (S.E) (December) individuals in 1995 (Lanyon 2003) [D]. Recent population modelling suggests local population size of ~970 ±75 animals [E].	n/d	H153. A decline in dugong abundance to <800 individuals for 2-3 successive years may represent a trigger for further investigation. Note however that these figures should be considered as indicative only, as there is insufficient available information on the population dynamics and genetics of dugongs to develop a reliable interim trigger value.	
Marine Turtles: green turtle loggerhead turtle	Eastern Bay Pumicestone Passage Southern Bay	Detectable decline in green and loggerhead turtles outside the range of natural variability	Turbidity, nutrients & chlorophyll *a*	Refer to seagrass indicators in Habitat Table 4-4			S1, S2, S3, S9
			Seagrass depth limit (and extent)	Refer to seagrass in Habitat Table 4-4			
			Green and loggerhead turtle population dynamics & breeding readiness	n/d	n/d	H154. n/d. Insufficient available information on the population dynamics, growth rates and breeding readiness of turtles to develop a reliable interim trigger value.	

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Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Wallum Acid Frogs	Wallum habitats on Bay Islands and Pumicestone Passage	Significant population declines outside the range of natural variability in either of the four acid frog species	Water quality: • non-turbid • tannin-stained • oligotrophic (low nutrient) • naturally acidic	pH 3.0-5.5 as derived from dissolved organic acids leached from humus).	n/d	H155. Significant decline in the numbers of the four acid frog species for important populations on North Stradbroke and Moreton Islands.	S4
			Absence of predatory fish	n/d	n/d	H156. Presence of Eastern Gambusia may represent a threat to local populations	S4
			Wallum wetland vegetation	n/d	n/d	H157. Greater than 5% reduction over five years of wallum wetland vegetation cover.	S4
			Ground water hydrology and freshwater flows	n/d	n/d	H158. No long-term change in groundwater hydrology such that it causes alterations to water quality, water levels and wetland flora and fauna, outside the bounds of natural variation.	S4
Beach stone-curlew	Outer Bay islands, Pumicestone Passage, mangrove habitats of southern Moreton Bay.	Significant declines in key habitat areas	Mangroves and associated intertidal flats (roost and feeding); sandy beaches (feeding), foredunes (breeding sites)	n/d	n/d	H159. Lack of observation of beach stone-curlew in any three year period over five years within the following areas: Pumicestone Passage (Toorbul north to Bells Creek); Bulwer to North Point (Cape Moreton); Cape Cliff (Cape Moreton) to Eagers Creek; Little Sandhills to Mirapool Lagoon; Amity to Point Lookout; Peel Island; Jumpinpin (includes southern end tip of North Stradbroke Island and associated mangrove islands); western side of South Stradbroke Island.	S4
Water mouse	Pumicestone Passage, North Stradbroke Island, Southern Moreton Bay (e.g. Steiglitz, Jacobs Well, Pimpama River Conservation Area, Coomera River, & South Stradbroke Island).	Significant declines in the usage of nests and the diversity of nest types used.	Relatively large areas of intertidal flats in association with mangroves (feeding), marine intertidal invertebrate prey, supralittoral wetlands, including salt marsh and sedgelands (nesting sites)	n/d	n/d	H160. Greater than 20% reduction in the number of active/recently active water mouse nests or greater than 15% reduction in usage of any one of the diversity of nest types used (following Van Dyck and Gynther 2003) over five years for important populations associated with North Stradbroke Island, southern Moreton Bay (e.g. Macleay Island, Coomera & Pimpama Rivers, South Stradbroke Island) and Pumicestone Passage (e.g. Bribie Island, Donnybrook).	S4
			Tidal conditions	n/d	n/d	H161. Any detectable long-term change to tidal regimes at spatial scales >5 km.	S4
Australian painted	Freshwater swamps	Lack of	Densely	n/d	n/d	H162. Loss of more than 20% of the extent of	S4

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
snipe	of outer Bay islands (e.g. 18 Mile Swamp).	records for any 10 year period.	vegetated permanent of seasonal wetlands			vegetated freshwater wetland habitat.	
Australasian Bittern	Freshwater swamps of outer Bay islands (e.g. 18 Mile Swamp).	Lack of records for any 10 year period.	Densely vegetated permanent of seasonal wetlands	n/d	n/d	H163. Loss of more than 20% of the extent of vegetated freshwater wetland habitat.	S4
Little Tern	Open waters of Bay, Caloundra sandbanks, beaches & sand spits of outer Bay islands, South Stradbroke Island.	Significant decline in abundance, outside the range of natural variability.	Nearshore and offshore open waters and rivers; water quality sufficient to support abundance of surface active baitfish; high-tide roost sites.	n/d	n/d	H164. Significant decline in the numbers of Little Tern, outside the range of natural variability, over five years as determined at key roost sites (e.g. northern Pumicestone Passage; South Stradbroke Island).	S4
Illidge's ant blue butterfly	Mangrove communities of Redland Bay, Hays Inlet, Fisherman Islands, outer Bay islands, and Coomera Island	Lack of records for any three year period.	Large areas of mangroves with mature trees bearing senescing limbs and dead branchlets which support the *Crematogaster* sp. ant; also adjacent supralittoral forests.	n/d	n/d	H165. Greater than 10% reduction over five years of mangrove cover and associated intertidal habitats.	S4
Migratory Shorebirds	Intertidal sand/mud flats, rocky shores and mangrove communities throughout the site, intertidal areas of coarse rubble associated with central bay islands	Decline in shorebird abundance and species diversity.	Diversity and abundance of epi/infauna of the intertidal flats; diversity of disturbance-free high tide roost spatially proximate to	n/d	n/d	H166. Greater than 10% reduction over five years of any one of the following components – mangrove cover and associated intertidal habitats; and supralittoral salt marsh habitats. H167. Any detectable long-term change to tidal regimes at spatial scales >5 km. H168. No long-term reduction in water quality and ecosystem condition in the estuarine sections of each major catchment area (as determined through	S6

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
	(Mud, St. Helena and Green islands) and western shores (Wellington Point and Redcliffe Peninsula), high tide roost sites throughout the site (natural and artificial).		suitable feeding grounds.			the EHMP). H169. Greater than 10% reduction in over a 10 year period of numbers of bar-tailed godwit, Eastern curlew, or Pacific golden plover which are surrogates for assessing shorebird abundance generally. H170. Greater than 20% reduction in the in any three year period over five years for any of the eight migratory shorebird species (which exceed the 1% threshold).	
Threatened Flora Communities: Endangered and Of Concern Regional Ecosystems	Bribie Island, Moreton Island, Southern Moreton Bay Islands, Southern Bay	Detectable decline in extent of Regional Ecosystems. Loss of sensitive plant species and change to alternate community type. (Loss of dependent fauna).	Groundwater hydrology	Waterway-specific and variable over time.	n/d Quantitative groundwater requirements of ecosystems unknown.	H171. No significant reductions in water table depth, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. H172. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
			Fire regimes	Variable over time and between different vegetation types.	n/d Specific fire regime requirements of ecosystems unknown.	H173. No significant changes in fire frequency or intensity, relative to background variability, such that it results in such that it results in a measurable, medium-term (>5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. No significant changes in fire frequency or intensity such that ecological integrity of ecosystems is not maintained. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Geomorphology: • Erosion • Sedimentation • Soil type	Erosion and sedimentation variable over time. Soil type not variable over relevant time scale.		H174. No significant changes in erosion or sedimentation processes, or changes to soil characteristics, relative to background variability, such that it results in such that it results in a measurable, medium-term (>2 to 5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
Vulnerable and Endangered wetland plants: *A. baueri* *M. triglochinoides* *O. hygrophila* *P. elatior* *P. australis* *P. bernaysii* *P. tancarvilleae* *T. confluens*	Bay Islands: swamps, lakes and waterways	Detectable decline in local abundances of plant species.	Groundwater hydrology	Waterway-specific and variable over time.	n/d Quantitative groundwater requirements of flora species unknown.	H175. No significant reductions in water table depth, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
			Water Quality: • Toxicants • Nutrients • Turbidity • Salinity, pH	Waterway-specific and variable over time.	n/d No experimental determination of flora species water quality tolerances.	H176. No change in water quality indices outside bounds of natural variability. Adopt 20th, 50th & 80th percentile values of reference site conditions in which population has been recorded. The 75th confidence limit should not be > these values. Specific limits cannot be quantified with current knowledge – but as an interim trigger, species should continue to exist at current conservation status.	S5

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Freshwater flows and inundation	Waterway-specific and variable over time.	n/d No quantification of frequency, duration and extent of freshwater inundation requirements for flora species.	H177. No significant reductions in flow regimes, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, species should continue to exist at current conservation status.	S5
			Geomorphology: • Erosion • Sedimentation • Soil type	Erosion and sedimentation variable over time. Soil type not variable over relevant time scale.	n/d No quantification of geomorphologic requirements of flora species.	H178. No significant changes in erosion or sedimentation processes, or changes to soil characteristics, relative to background variability, such that it results in such that it results in a measurable, medium-term (>2 to 5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	

5 CHANGES TO ECOLOGICAL CHARACTER AND THREATS

5.1 Changes to Ecological Character

5.1.1 Changes/Impacts Observed Since Nomination

The National Framework requires ECD studies to assess the extent to which the ecological character of the wetland has changed, with a specific point of reference or baseline from the date of nomination into the Ramsar List of Wetlands of International Importance.

Following a review of scientific literature and planning documents relevant to the Moreton Bay Ramsar site, the study team engaged the Steering Committee and Knowledge Management Committee members about their views regarding potential changes to ecological character that have occurred since listing of the site in 1993. In particular, the study team sought advice about impacts to those aspects of the site nominated as critical services/benefits and underlying components and processes as outlined in the previous sections of this report.

In general terms, the literature reviewed and experts have not identified any significant or overarching changes during this fifteen year period but recognise that a number of long term threats are having an incremental and cumulative effect on ecological character. Likewise, no views were expressed from the information sources reviewed or from the committee members to merit consideration that the ecological character of the site had significantly diminished with respect to the critical services/benefits outlined in this study.

Some of the issues that were raised in the context of perceived impacts and potential changes to ecological character of the Ramsar site were as follows (not reported in any order):

- Increased occurrence and severity of *Lyngbya* blooms in southern Deception Bay and the Eastern Banks;
- Localised die-off of seagrass communities in Deception Bay (resulting from increased turbidity caused by fine sediment re-suspension) and in the Broadwater (resulting from changes to hydrodynamics and habitat modification as a result of the construction of the Gold Coast Seaway opening) and in some cases, the corresponding replacement of these habitats with macroalgal communities (eg. *Caulerpa* sp.). Abal *et al.* (2005) provides a quantitative measure of change to seagrass abundance for the whole Bay (not just the Ramsar site), noting that there have been significant declines in abundance of seagrass over time measured in a time frame between 1987 and 1997/2000, with a net change of - 2219 ha in the Northern area of the Bay and - 84 ha in the Southern area (note that these figures account for seagrass additions);
- Localised die-back of mangrove communities (eg. Southern Bay, Brisbane River delta area) from a range of natural and potentially anthropogenic causes;
- Loss/reduction of saltmarsh areas since 2003 (estimated 2500 ha) due to a combination of development pressure and sea level rise leading to subsequent colonisation of saltmarsh areas by mangroves in the Western and Southern Bay areas (Hegerl and Tarte, pers. comm. 2008);
- Observed fluctuations in dugong and turtle populations suspected to be from a range of natural and anthropogenic causes;

- Observed decreases in the number of visiting migratory waterbirds (noting that this is likely related to a variety of off-site circumstances such as changes to extent of habitat and condition of habitats throughout the Flyway);
- Increased pressure on wetland values through increased visitation and use of the site (such as the bay island National Parks);
- Groundwater extraction for domestic water supply and associated impacts on Eighteen Mile Swamp on North Stradbroke Island (including the increased susceptibility of the peatlands to irreversible impacts from fire);
- Wetland habitat modification (principally of adjacent wetland areas outside the site) and direct fishing effort resulting in impacts on commercial and recreational fisheries (see threats section below); and
- Changes in the location and an overall reduction in the quality of shorebird roosting sites in the Western and Southern Bay (principally mainland habitats) as a result of habitat loss, modification and increases in frequency of disturbance.

From this list of impacts observed over the period from 1993 - 2008, the following six impacts are seen as having the greatest significance in the context of the critical services/benefits and therefore, implications for future ecological character:

Use and quality of habitat for migratory waterbirds

While difficult to quantify without more complete data sets, there is a general view by professional and amateur ornithologists and regular observers that there have been observed decreases in the number of visiting migratory waterbirds to the site (R. Jaensch, pers. comm.. 2008). As outlined above, this is likely to be the result of multiple stressors off and on site. Off-site impacts that are likely contributing to this decline are the quality and availability of habitat in other nations along the Australasian Flyway as well as the condition of Australia's inland wetland habitats. See Nebel *et al.* (2008) for a discussion on long term survey results which show a consistent declines in waterbird abundance. On-site changes in the location and an overall reduction in the quality of bird roosting sites in the Western and Southern Bay (principally mainland habitats) as a result of habitat loss, modification and increases in frequency of disturbance are also likely contributing factors.

Seagrass loss in Deception Bay and Southern Bay

Large-scale seagrass dieback in southern and eastern Deception Bay in recent years has resulted in the loss of a significant area of *Zostera* as well as sub-tidal *Halophila* species preferred by dugong and turtles as a food resource. Losses of seagrass abundance have also occurred in the southern Broadwater, Peel Island and areas around Coochiemudlo Island. The impacts of this habitat loss on local populations of dugong and turtle species and on broader fishery productivity are poorly understood. However, it would be reasonable to suggest that the loss has put additional pressure on other suitable dugong and turtle feeding areas within the Bay and could have lead to changes in fish and prawn recruitment success and possibly productivity. Further investigations are required to determine whether this could be considered to represent a change to ecological character.

Lyngbya

As outlined in the 2007 Healthy Waterways Action Plan for Algal Blooms, the toxic marine cyanobacterium *Lyngbya majuscula* has formed large (10 km^2 in Deception Bay), persistent and annually recurring blooms in Moreton Bay since around 1998. While historical research suggests blooms have occurred in the region for at least the last 100 years, there has been an increase in intensity and frequency of lyngbya blooms since the mid 1990's, with blooms occurring each summer across several locations within Moreton Bay, including Deception Bay in the Western Bay and on the Eastern Banks.

Results from the SEQ Healthy Waterway Partnership's Lyngbya Research and Management Program 2005-2007 identify that the key environmental factors for lyngbya growth in Deception Bay are a combination of increases in bioavailable nutrients (including iron, phosphorus, nitrogen and dissolved organics) and suitable light, salinity and temperature regimes. Specifically, the research has found that the disturbance and subsequent oxidation of Acid Sulfate Soils is of concern, as it leads to the release of nutrients such as iron. The cause of lyngbya blooms in the Eastern Banks region is less understood although the natural infiltration of nutrient-rich groundwater from the islands into surface waters are postulated as a likely trigger during favourable climatic conditions.

Lyngbya can impact on Ramsar values through the smothering of seagrass beds by dense blooms which has been found to lower the density and extent of seagrass in the affected areas. Likewise, high density blooms of lyngbya covering mangrove mudflats have been linked to malformation and mortality of mangrove seedlings. Harmful algal blooms of cyanobacteria species (including lyngbya) may also release toxins that cause illness or even mortality of marine fauna. Lyngbya can have an equally significant economic impact on wetland tourism and recreational activities in the Bay during summer bloom periods making coastal waters unfit for primary contact and beaches unuseable.

Water quality in the Western Bay

As mentioned in Section 3, the rates of organic loading of benthic zones (due to a combination of point and diffuse carbon sources) in the Western Bay are at greatest threat from continued poor water quality with the process of denitrification in the sediments 'poised' to turn off. If this were to occur, there would be potentially very serious consequences, as water column nutrient levels would increase. This would in turn encourage greater water column primary productivity, which would further affect subtidal vegetation in the Ramsar wetlands, and a potentially continual cycle of ecosystem decay could be initiated. It should be noted that recent and ongoing efforts to reduce sewage carbon and nutrient loads to the region may assist in reducing the potential for this scenario to develop.

Water quality in the Southern Bay

In terms of long term trends in water quality, the Healthy Waterways Strategy indicates that the area within the Bay of most concern is the steadily decreasing grade of the Southern Bay area; in 2002 it rated as "good", however by 2006 it had declined to "poor". This decline is linked with the increasingly poor water quality in the Logan and Albert River estuaries. While the most recent Report Card has seen an improvement in grade back to a B-, this is reported as being due, in part, to the application of less stringent water quality guidelines to the area. Future urban expansion adjacent to the Southern Bay is indicative that much greater pressure on the water quality (and associated wetland values such as seagrass) in this region is likely in coming years.

5.1.2 Management Responses Since Listing

It is important in the context of Moreton Bay to highlight that the impacts discussed in the previous section (and those that pre-date Ramsar listing) signalled a significant public appreciation of environmental threats to the Bay. This fuelled the impetus for significant Government investment in planning, management and monitoring of the Bay over the past two decades.

The early 1990's saw the genesis of a number of major planning and management regimes relevant to the Bay and its resources. Some of the key responses during this early period included:

- Declaration of the Bay as a marine park under the Queensland *Marine Parks Act 1982* and promulgation of the Moreton Bay Strategic Plan 1993 by the then Department of Environment and Heritage (note that the marine park would be zoned several years later in 1997);
- Alignment of the Moreton Bay Water Quality Study and Brisbane River Management Group activities toward the formation of the Healthy Waterways Partnership and significant investment and improvement in wastewater discharges by local authorities;
- The prohibition and removal of commercial fishing activities from Pumicestone Passage by the then Queensland Department of Primary Industries/Queensland Fisheries Management Authority; and
- Increased emphasis and funding to improve rural land management through integrated catchment management by the then Department of Natural Resources and Department of Primary Industries.

By the 2000's, the management response to the conservation and sustainable management of the Bay saw further progress. Significant investments were made in water quality monitoring (EHMP), urban wastewater treatment and stormwater management, improved rural land management and preparation of numerous statutory land use plans and strategies recognising the Bay's environmental values by State Government, local governments and the regional NRM bodies (many of which still apply and are outlined in this report). This was underpinned by significant investment in projects by the community through funding programs like Coastcare and Coast and Clean Seas as well as investment by the private sector to both monitor and improve environmental practices.

Discussions with Committee members also highlighted some perceived positive effects on ecological character as a result of mitigation schemes and works. Particular examples include creation of shorebird habitat at Boondall through placement of dredge spoil, rehabilitation of mangroves at the Kerkins Levee site in Pimpama, and saltmarsh restoration at both Hays Inlet and Bulimba Creek (J Beumer, pers. comm. 2008).

Despite the significant investment to date and demonstrable improvement in ecosystem health in some localised areas, there is recognition by stakeholders that more broad scale improvement of highly modified aquatic ecosystems will be a long term process in the Bay and its waterways. Further, the maintenance of current values (by stopping the further decline of these systems) will continue to be challenging given the economic and infrastructure growth the region is experiencing.

5.2 Overview of Threats

A range of threats have been identified in the summary tables for the critical services/benefits contained in Section 7 of this report. In analysing this list, a number of common threats to ecological character can be derived.

In general, threats can be categorised between threats occurring *within* the boundaries of Ramsar site and those that are occurring *outside* the site boundaries that because of their scale or intensity can have an adverse impact on ecological character.

This categorisation is important given the nature of the boundaries of the site which are essentially a series of discontinuous polygons that are limited to nearshore estuarine areas and extend selectively over State controlled lands or similar above the high water mark. In addition, the site excludes major rivers such as the Brisbane and the Logan and in most cases does not extend up the smaller adjoining estuaries and creeks to their full tidal extent.

It is also important to recognise that many important wetland species identified in the critical services/benefits (birds, some fish, turtles, and dugong) are highly mobile both within the site and across much larger habitat ranges. As such there is an inherent difficulty in using a management regime like the Ramsar Convention to effectively manage threats and impacts to such fauna.

For this reason, most management regimes (including the EPBC Act) tend to focus on regulating activities that will or may have an impact on the values of the site without necessarily occurring within the boundaries of the site or involving direct disturbance.

Through the expert panel process undertaken with the Scientific Expert Panel (refer Appendix A), threats and stressors at a habitat-scale and species-scale within the estuarine and marine areas of Moreton Bay were developed. Table 5-1 provides a summary of the outputs of these discussions focussing on those habitats and species relevant to the Ramsar site.

Table 5-1 Threats and Stressors on Key Habitats and Species

Habitat Type	Stressors/Threats *(note that the items are not listed in any order of priority)*
Seagrass meadows	Anchoring/propeller damage; Fishing (bait collection); Algal Growth (*caulerpa* and *lyngbya*); Dredging; Fishing (trawling); Water pollution (run-off); Climate change
Mangroves and Saltmarsh	Direct clearing or filling; Water pollution (nutrients and hydrocarbons); Adjacent works (eg. urban development); Off road vehicle driving (tyre tracks); Climate change; Algal growth/weed infestation
Tidal flats	Fishing (netting); Fishing (bait collection); Direct clearing or filling; Adjacent works (ie. dredging, urban development); Climate change; Water pollution (nutrients)
Rocky shores	Fishing (bait collection); Recreational use and collection (trampling); Climate change; Water pollution (run-off and sedimentation)
Ocean beaches and foredunes	Fishing (line and netting); Fishing (bait collection); Works (extraction, structures, nourishment projects); Human use (off road vehicle driving); Introduced predators; Climate change; Water pollution (nutrients)
Inshore coral communities	Fishing (line and netting); Anchoring; Aquarium fish collection; Human use (recreational and tourism diving); Dredging and placement of spoil; Water pollution (land based runoff); Climate change; Water pollution (vessel based); Algal growth
Inshore mud (sub-tidal areas with predominantly muddy substrate)	Dredging and placement of spoil; Fishing (trawling); Water pollution (plumes and runoff; Changes to fluvial flow regime
Inshore sand (sub-tidal channels, banks and bars with predominantly sandy substrate)	Works (sand extraction; dredging; training river mouths); Fishing (netting, line, trawling and crabbing)
Wallum freshwater habitats (including peat swamps)	Urban development; Fire regimes; Introduced species and weeds; Groundwater extraction; Climate Change; Water pollution (run-off).
Species Type	**Stressors/Threats (not listed in any order of priority)**
Dugong	Harassment; Fishing (traditional hunting); Boat strike; By-catch and entanglement; Water pollution; Climate change;
Marine turtles	Rubbish and plastic ingestion; Fishing (traditional hunting); By-catch and entanglement; Boat strike; Introduced predators (particularly for nesting); Water pollution; Climate Change; Off road vehicle driving; Algal blooms (*lyngbya*)

Shorebirds	Human disturbance (visual and noise and habitat modification); Introduced and native predators; Climate change
Little tern	Human disturbance (visual and noise, habitat modification and direct mortality from beach driving); Introduced and native predators; Climate change; Line fishing (impact on food source)
Water mouse	Human disturbance (habitat modification); Introduced and native predators
Illidge's ant blue butterfly	Human disturbance (habitat modification in mangrove areas)
Acid frogs	Habitat loss and fragmentation; Altered hydrological regimes (water diversion); Water pollution; Weed and mosquito control; Introduced predators (Eastern Gambusia); Fire regimes; Climate Change
Painted snipe and Australasian bittern	Habitat modification (drainage of wetlands); Altered hydrological regimes (water diversion); clearance of wetland vegetation (particularly dense sedge) and overgrazing
Oxleyan pygmy perch and honey blue-eye	Human disturbance (habitat modification); Water pollution; Groundwater extraction; Introduced predators (Eastern Gambusia); Algal blooms

Given the diverse range and varying magnitude of threats and stressors at a habitat or species scale, further analysis was needed in order to identify the most prominent threats to the Ramsar site, particularly at the whole of site scale.

Accordingly, the study team sought to identify and group threats into categories considering the following criteria:

- The degree of salience or relevance to the nominated critical services, components and processes in the ECD;
- The propensity of the threat to affect a broad area;
- The propensity of the threat to impact the site cumulatively over time.

In this context, threats were considered both in terms of stressors or threats occurring within the boundaries of the site and those that were external to the site boundaries.

The key threats derived from this analysis are set out in section 5.2.1 – 5.2.8 and are summarised into the following categories:

- Harmful interaction with wetland species;
- Sustainability of fishing and harvesting;
- Sediment and nutrient input into the Bay from point and non-point sources;
- Groundwater extraction;

- Urban encroachment into the Ramsar boundary and adjacent wetland areas;
- Significant changes to wetland ecosystem processes from major infrastructure/development projects;
- Oil spills or other large scale marine pollution incident;
- Altered fire regimes; and
- Impact on coastal wetlands from climate-change induced sea level rise and related threats.

In characterising the nine (9) key threats identified above, a qualitative risk assessment matrix has been used to assist in assignment and prioritisation of risk. This involves assessing the likelihood and severity of potential impacts based on a range of threat categories. Description and assignment of risk levels using this framework is summarised in Tables 5-2 to 5-6 below.

As part of this risk assessment it is also important in a highly managed environment like Moreton Bay to consider the effectiveness of National, State and local laws and policies to regulate and reduce risks to wetland values from threatening processes. Thus, the final residual risk for each threat has been presented with this regulatory/management adjustment.

Table 5-2 Spatial Application of Impact Categories

Spatial Application of Impact
Broad Scale - Impacts will occur at a Whole-of-Ramsar -site scale, with marked impacts to populations/sub-populations of key flora and fauna listed in the critical services
Regional Scale – Impacts will occur beyond the local scale (eg. potentially across several habitat types) with some impacts to populations/sub-populations of key flora and fauna listed in the critical services
Local Scale – Impacts will be at an individual habitat or community scale (eg. within a habitat type) but will not have any measurable effect on population or subpopulations of key flora and fauna listed in the critical services
Individual Scale – Impacts will be at an individual species level and will not affect population or subpopulations of key flora and fauna listed in the critical services

Table 5-3 Duration of Impact Categories

Duration/Irreversibility of Impact
Permanent or otherwise Long Term and Irreversible
Medium Term Impact
Short Term Impact

Notes:
- ***Permanent/Long Term** = Recovery of habitat or population measured in decades or irreversible*
- ***Medium Term** = Recovery of habitat or population measured in years*
- ***Short Term =** Recovery of habitat or population measured in days to months*

Table 5-4 Impact Risk Category Table

Impact Risk Category	
High	Irreversible Impacts at the Broad Scale or Regional Scale Medium Term Impact at the Broad Scale
Medium	Irreversible Impact at a Local Scale Medium Term Impacts at the Regional Scale Short Term impact at a Broad Scale
Low	Irreversible Impact at the Individual Scale Medium Term Impact at a Local scale Short Term impact at a Regional Scale
Very Low	Medium Term Impact at the Individual Scale Short Term Impact at a Local Scale

Table 5-5 Likelihood that the Impact could lead to a significant/marked change to Ecological Character

Likelihood that impact to ecological character will occur from the threat	High Impact Level	Medium Impact Level	Low Impact Level	Very Low Impact Level
Likely or Certain	4 – High Risk	4 – High Risk	3 – Medium Risk	2 – Low Risk
Possible	4 – High Risk	3 – Medium Risk	2 – Low Risk	1 – Very Low Risk
Not Likely	3 – Medium Risk	2 – Low Risk	1 – Very Low Risk	1 – Very Low Risk

Notes:

- ***Likely/Certain** indicates that a significant or marked change to ecological character (eg. one or more limits of acceptable change have been compromised) is likely or certain to occur from a particularly threatening process*
- ***Possible** indicates that while change could occur to a Ramsar value or Service, this change may not necessarily be one that represents a significant or marked change to ecological character (eg. limits of acceptable change have not been compromised)*
- ***Not Likely** indicates that a change could occur but this change is not seen as having any material impact on ecological character (eg. change does not compromise limits of acceptable change)*

Table 5-6 Management Regime Adjustment to Residual Risk

Perceived Effectiveness of Management Regime (eg. application of EPBC, State laws, Local laws) to reduce risk of threat having significant/marked change to ecological character	
Highly Effective	Reduce Risk Rating by One – Two Rankings
Effective	Reduce Risk Rating by One Ranking
Somewhat Effective	Unmitigated Risk becomes residual risk

Notes:

- ***Highly Effective** is indicative that there is an existing regulatory or management regime in place for the threat and implementation is comprehensive and effective.*
- ***Effective** is indicative that there is an existing regulatory or management regime in place for the threat and implementation is considered to be effective but is likely limited by extent, jurisdiction, resources or a similar issue.*
- ***Somewhat Effective** is indicative that there may not be a regulatory or management regime in place for the threat or otherwise that the existing regime is considered to be somewhat ineffective.*

5.2.1 Harmful Interactions with Wetland Species

Growing population in the region has led to increased usage and access within, across and through the various wetland habitats of the Ramsar site for a range of commercial and non-commercial activities.

These activities present a further threat to critical wetland services/benefits and ecological character. Human presence and use of wetland habitats can have indirect impacts on the quality of the habitat for important wetland species, particularly where such disturbance is occurring at a critical or sensitive life stage (eg. nesting). While isolated incidents are unlikely to result in marked or observable changes to ecological character in the short term, the cumulative impacts of these activities on particular habitats or on the populations of important species are perhaps of greater concern.

Specific threats within this category include:

- Beach driving and other human usage resulting in on-going disturbance to shorebird nesting, roosting and feeding areas;
- Disturbance to shorebirds (roosting and breeding) that can occur as a direct result of human recreational activities including: 4WD vehicles on beaches (Moreton and North/South Stradbroke Islands); boating/kite surfing/jet skin around feeding and roost sites (e.g. Days gutter, Amity banks, Jumpinpin, Caloundra sand banks), pedestrian activity (with or without companion animals) through or in close proximity to shorebird roost sites;
- Localised wetland habitat degradation through trampling of reed beds in areas with high levels of human visitation (e.g. Blue Lake – North Stradbroke Island; Blue Lagoon - Moreton Island), which has the potential to impact seriously on local acid frog populations;
- Interaction between important marine fauna and commercial and recreational fishing activities including provision of food resources from by-catch; and
- Increase potential for boat strike/disturbance of dugongs and turtles through increased commercial shipping, major dredging activities and recreational boating activities (including jet-skis).

Management of these threats in a manner consistent with the objectives of the Ramsar Convention (eg. so as to maintain ecological character) is reliant on the application of legislative powers and management measures by the various State Government agencies and Local Governments as well as those industries directly involved. Funding and resources to undertake planning, day to day management and enforcement functions are key management challenges in the context of these activities.

Threat: Harmful Interactions with Wetland Species	Risk Level
Threats under this category include beach driving, by-catch, boat strike and similar and their likelihood to cause a significant/marked change to ecological character	Beach Driving – Low and Possible– 3
	By-Catch – Low and Possible – 2
	Boat Strike – Low and Possible - 2
	Others – Low and Possible - 2
Critical Services of the ECD relevant to this threat	S2a and 2f, S3, S4, S6, S7
Overall Unmitigated risk	Risk Level 2 – Low Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	A range of regulatory regimes apply. However, these threats generally relate to day to day management activities and are difficult to enforce. Education programs and similar have been implemented with some success.
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.2 Sustainability of Fishing and Harvesting

The Queensland Department of Primary Industries and Fisheries (DPI&F) manages the state's fisheries resources. DPI&F, through the *Fisheries Act 1994*, has implemented a range of programs and strategies that aim to manage fisheries in a sustainable manner. This includes gear/vessel restrictions, fish size limits, area and seasonal closures, and bag limits for recreational fish species. For most species, there are no overall total quotas (total allowable catch). Note that revised limits are to come into force in 2008/2009.

There are several key fisheries of relevance to the Moreton Bay Ramsar site (Table 5-7). The key fisheries of relevance to the site are the East Coast Otter Trawl, Inshore Finfish, Rocky Reef, Mud Crab, Blue Swimmer Crab, Spanner Crab and Beche-de-mer fisheries. Most of these fisheries are accredited under the EPBC Act, in line with the *Guidelines for the Ecologically Sustainable Management of Fisheries* (Department of the Environment and Water Resources 2007).

In addition to the above strategies, there are a range of monitoring programs in place to assess potential impacts of the fishery and the effectiveness of fisheries management arrangements. Monitoring activities include reviews of commercial logbook data, recreational fishery diaries, boat ramp surveys, and a range of fisheries dependent and independent sampling programs. Stock assessments for Queensland fisheries resources are also undertaken on a 3 yearly basis (e.g. Tanimoto *et al.* 2006; O'Neil and Leigh 2006; Allen *et al.* 2006). It should be noted however that in general terms, it is difficult to quantify trends in the abundance of most fisheries species based on available information, and impacts of fisheries activities, at local spatial scales.

Annual status reports are prepared by DPI&F for each major fishery, which considers fisheries management arrangements, trends in long-term catch and effort data, and an assessment of the sustainability of the fishery based on catch-effort data (see Table 5-7). The status of the fishery is examined on a state-wide and regional basis, and in most cases, does not consider finer spatial scale trends (i.e. site specific data for Moreton Bay). The broad spatial scale of monitoring (and associated reporting) is appropriate in the context of fisheries management, as few fish stocks are likely to be restricted to local geographic area (such as Moreton Bay, or sites with the Bay). However, this approach does prevent an understanding of trends in the relative abundance of key fisheries in time at spatial scales relevant to the ECD.

Table 5-7 Status of key fisheries operating within Moreton Bay

Fishery	Status	Source
Inshore finfish	Potential issues regarding sustainability of fishery for some shark species. No other issues raised, although data are of insufficient resolution to determine any issues at a regional scale.	DPI&F (2007b)
East coast trawl fishery	Major changes in catch, effort and overall harvest over time, reflecting changes in fisheries management arrangements. Insufficient data at this stage to assess status of key resources.	DPI&F (2007g)
Rocky reef fishery	The Rocky Reef Fin Fish Fishery is under review following concerns from the commercial, recreational and charter fishing sectors about the sustainability of rocky reef fish stocks.	DPI&F (2007f)
Mud crab	Relatively stable Catch Per Unit Effort (CPUE) at both the State and East Coast Regional scales (2001-2006). No fisheries independent data from the Long Term Monitoring Program (LTMP) presented in this report to validate these trends. LTMP data, which provides fishery-independent relative abundance (CPUE) data (DPI&F 2006), shows that the Moreton Bay region had highly variable mud crab abundance over time (2000-2005), unlike the other areas in the State. The reasons for this are unclear.	DPI&F (2007d, 2006)
Blue swimmer crab	Commercial CPUE within Moreton Bay has remained relatively stable from 1999 onwards, excluding a peak in 2001. The lowest reported catch occurred in 2005 & 2006, and was thought to be linked to a decline in the number of days fished, together with a possible reduction crab numbers due to drought conditions. RFISH surveys conducted in 2002 & 2005 indicate that the recreational harvest has remained fairly stable over this period.	DPI&F (2007e)
Spanner crab	Trend of increasing CPUE in the south coast (Managed Area A) region between 1990 and 1997. Independent estimates from DPI&F's Long Term Monitoring Program (LTMP) from 2000-2003 also support the suggestion of an increase in spanner crab abundance.	DPI&F (2007a)
Beche-de-mer	Static CPUE in 2003-2005, decline in distribution and abundance in 2006. Given that a small proportion of population is harvested, DPI&F argues that reduction is unlikely a fishery effect.	DPI&F (2007c)

This mix of zoning and fishery management tools (administered through the Fisheries Act) aim to ensure fisheries are managed in an ecologically sustainable manner. The Moreton Bay Zoning Plan prepared under the Queensland *Marine Parks Act 2004* also regulates fishing activities in the Bay by restricting the type of fishing that can be undertaken in different zonal areas. Based on the draft zoning map released in 2008 by the Queensland Government, increased regulation of commercial and recreational fishing is also likely to occur through proposed amendments to the zoning plan.

Threat: **Sustainability of fishing and harvesting**	Risk Level
Threats from fishing activities and their likelihood to cause a significant/marked change to ecological character	Medium and Possible
Critical Services of the ECD relevant to this threat	S7
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective (and improving) – Reduce Risk Level by One
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.3 Water Quality Inputs

Considerable investment has been made over the past 15 years to improve point source discharges from regional sewage treatment plants, noting that the improvement and upgrade of existing facilities remains a priority as populations grow. However, it is diffuse sources of pollution that constitute the largest threat to long term ecosystem health in the Bay.

As part of the SEQ Healthy Waterways Strategy 2007-2012, the SEQ Healthy Waterways Partnership has identified the need to set sustainable load targets to assess whether or not waterways of the Bay will meet water quality objectives and protect environmental values. Scenario modelling has been undertaken as part of the development of the Strategy to predict the impact of population growth and subsequent land use change on annual pollutant loads. With a 'business as usual' approach, the Strategy predicts that by 2026, there will be a 14% increase in Nitrogen, 21% increase in Phosphorous and 17% increase in Total Suspended Solids loads to Moreton Bay. This increase is broken down between increases from point sources, diffuse urban, diffuse rural and diffuse natural sources of these nutrients and sediments of which land based sources of pollution represent the greatest threat to long term ecosystem health. As mentioned in the impacts section previously, two areas of the Ramsar site of particular concern in terms of future water quality include Bramble Bay in the Western Bay region and the Southern Bay area. Lyngbya blooms remain an important indicator of the water quality of run off in the Western Bay area.

The investigation and implementation of new water infrastructure in the region in the form of reverse osmosis wastewater recycling and desalination plants present a new point source threat, generally involving the discharge of concentrated pollutants (generally high salinity and high nutrients) associated with the purification process. However, all new wastewater recycling and desalination projects are likely to trigger State and possible Commonwealth assessment under relevant environmental impact legislation, further reducing their potential to cause unacceptable impacts to Ramsar values. Where reverse osmosis technology is being used to treat existing STP discharges such as is proposed at Luggage Point, there may be a net improvement in water quality from the current discharge accepting that a range of positive and negative impacts would need to be assessed (eg. loss of flows into the system, different concentration/proportions of nutrients, increased salinity, etc.).

Threat: Diffuse-sources of water pollution	Risk Level
Threats from diffuse sources of pollution	High and Possible
Critical Services of the ECD relevant to this threat	All, possibly excluding S4, S5, S7 and S9
Overall Unmitigated risk	Risk Level 4 – High Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective (and improving) – Reduce Risk Level by One
Residual Risk Rating	Risk Level 3 – Medium Risk

Threat: Point-source of water pollution	Risk Level
Threats from point sources of pollution	Medium and Possible
Critical Services of the ECD relevant to this threat	All, possibly excluding S4, S5 and S9
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective (and improving) – Reduce Risk Level by Two
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.4 Groundwater Extraction

Groundwater extraction in the Moreton Bay region principally occurs on North Stradbroke Island with several bores located in and around the three major townships and extraction from Herring Lagoon near 18 Mile Swamp. These bores are operated by Redlands Shire Council to service both on- and off- island potable water supply. Other bores on the island provide water for industrial use by Consolidated Rutile Limited in its sand mining operations, though almost all of this water is recycled back to the aquifer through the mining processes.

More significant groundwater extraction from the Bay Islands has recently been investigated by the Queensland Government and local governments as part of the SEQ Regional Water Supply Strategy on North Stradbroke Island and Bribie Island.

The Eastern Pipeline Inter-Connector project investigated the feasibility of extracting groundwater from North Stradbroke Island and water from Leslie Harrison Dam, for the purpose of supplying water to Logan City Council. Extensive hydrological models of groundwater on the island were developed and continue to be refined and analysed by local and State Government in the context of the potential impacts of the project on Blue Lake and other wetlands on the island. However, the Queensland Premier, the Hon. Anna Bligh MP stated in October 2007 that,

> *'the Environmental Impact Study on the Eastern Pipeline Inter-connector Project {will} not proceed until alternatives are explored. I am determined to ensure that every piece of infrastructure we build is not only built on time and on budget, but is environmentally sustainable.'* (from www.qwc.qld.gov.au)

Investigations to extract up to 10 ML/day from the groundwater resources of Bribie Island continue with that project (as of March 2008) moving to construction of test and monitoring bores, construction of associated pipeline infrastructure and water treatment facilities (Moreton Bay Regional Council 2008 Progress Report from www.qwc.qld.gov.au).

As has been the case with the major proposals to date, new water extraction proposals will likely be subject to environmental impact assessment processes at the State and Commonwealth level.

Redland Shire Council's mainland water supply is supplemented by water extracted from an unconfined aquifer on North Stradbroke Island in the vicinity of 18 Mile Swamp (Herring Lagoon). The extent to which this water extraction has affected the peatlands of the Swamp has not been extensively studied or quantified although it is noted that the extraction is regulated, has been previously assessed and is operating under lawful permit. The greatest potential impact identified as part of the literature search and as part of discussions with Knowledge Committee Members relates to the effect the reduction in the groundwater table has on the wetness of upper layers of the peatland, and the increased susceptibility of the wetland to irreversible impacts from fire.

Threat: Groundwater Extraction	Risk Level
Threats from groundwater extraction	Medium and Possible
Critical Services of the ECD relevant to this threat	S1, S2e, S3, S4, S5
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective – Reduce Risk Level by One
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.5 Habitat Loss Due to Urban Encroachment

The development of urban areas, often with minimal buffer areas to coastal wetlands, can result in disturbance to shorebird feeding and roosting habitat and degradation of aquatic habitat through uncontrolled recreational access, contaminated stormwater and litter.

Given that the Ramsar site is generally over state land and waters, the risks from urban expansion causing direct habitat loss within the boundaries is unlikely. However, removal or degradation of coastal wetlands situated outside the Ramsar site can result in indirect, cumulative loss of overall fish habitat values that can affect fisheries values (refer Service 7) and other important wetland fauna and populations that rely on overall ecosystem health.

The effect of urban encroachment is particularly noteworthy for transitionary wetland habitats such as *Melaleuca* and *Casuarina* swamps and supratidal saltmarsh areas that provide fish habitat as well as other wetland services (eg. habitat for water mouse and other species listed in Service 4). These habitats are afforded less protection than intertidal marine plants under Queensland legislation and often are not of sufficient size to be mapped as remnant under the Vegetation Management Act (thus avoiding protection under that Act). Saltmarsh habitats are particularly at risk given the additional impact of climate change which will make these habitats more susceptible to mangrove intrusion as sea levels rise. In many areas, the natural succession of saltmarsh areas landward in response to rising sea levels will be blocked or otherwise inhibited by existing coastal development.

The placement of human populations close to wetlands also places pressure on wetland resources through day to day management issues. Managing the introduction of increased domestic pets and feral animals into wetland ecosystems including within the foreshores of the Ramsar site is a particular issue in the Western and Southern Bay areas where a large proportion of the population accesses the foreshore.

Likewise, the encroachment of urban areas in close proximity to wetlands increases the risk of fire and the need for implementation of fire management strategies (such as controlled burns, etc.) that while reducing risks to human populations, can have acute temporary and potentially long term impacts on wetland flora and fauna.

Threat: Urban Encroachment	Risk Level
Threats from urban encroachment	Low and Likely
Critical Services of the ECD relevant to this threat	S1, S4, S6, S7, S8, S10
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective – Reduce Risk Level by One
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.6 Major Infrastructure Projects

Large-scale projects can affect the hydrologic, hydrodynamic or water quality conditions of the Bay and associated Ramsar site at broader spatial scales. Examples of major projects that have previously been undertaken or proposed in the context of Moreton Bay include:

- reclamation or capital dredging of tidal areas;
- large-scale placement of contaminated dredge material;
- construction and operation of major water desalination facilities;
- construction and operation of major dams on rivers and streams that input into Moreton Bay; and
- sea cage or other intensive aquaculture facilities.

While potentially causing more significant impacts, the likelihood that these projects will affect the ecological character of the Ramsar site is reduced by the regulatory processes and environmental impact assessment processes that would be needed prior to approval and operation. In this regard, any project that could cause impacts to the Ramsar site (and ecological character) would generally need to be considered to be in the National or State interest.

Threat: Major Infrastructure	Risk Level
Threats from major infrastructure	High and Possible
Critical Services of the ECD relevant to this threat	All
Overall Unmitigated risk	Risk Level 4 – High Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective – Reduce Risk Level by One
Residual Risk Rating	Risk Level 3 – Medium Risk

5.2.7 Oil Spills and Other Incidents

The Port of Brisbane and associated heavy industrial uses of the Australia Trade Coast lie at the doorstep of the Ramsar site. Oil spills are a potential risk to the marine environment associated with the shipping industry and on-shore petrochemical industries, with national and local plans formulated to respond rapidly to clean up spills and minimise impacts.

In March 2003, almost 2000 tonnes of light crude oil seeped from a ruptured pipeline at Lytton near the mouth of the River. This spill was controlled through a multi-agency effort such that impacts on the Ramsar site and Bay environment were largely avoided except at highly localised scales.

Introduction of exotic organisms through ballast water or on the hulls of foreign ships are a further potential threat to the Ramsar site, acknowledging that the Port of Brisbane and related agencies (AQIS, etc) implement strict controls to manage the translocation of potentially harmful organisms.

Threat: Oil Spill or other incident	Risk Level
Threats from oil spill or other incident	Medium and Possible
Critical Services of the ECD relevant to this threat	All, possibly excluding S4, S5 and S9
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective – Reduce Risk Level by One
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.8 Altered Fire Regimes

Changes in land-use over time have led to modified natural fire regimes, and continue to alter fire regimes. Furthermore, predicted changes in climate are also likely to result in changes to fire regimes. Altered fire regimes threaten vegetation communities as regeneration processes are directly impacted, and often controlled, by fire. Consequently, fires experienced at inappropriate (too high or too low) frequencies, intensities or seasonality may lead to substantial changes in community composition and/or structure. Alterations to fire regimes threaten terrestrial vegetation communities within the site, with wallum freshwater habitats including peat swamps notably susceptible. In turn, threats may be exerted on fauna species that are dependent on these habitats, with the acid frogs of particular importance.

While management activities of protected vegetation communities may incorporate controlled burning, the possibility to reduce risks associated with altered fire regimes is limited by the lack of knowledge regarding specific fire requirements of vegetation communities and species.

Threat: Fire Regimes	Risk Level
Threats from climate change	Medium and Possible
Critical Services of the ECD relevant to this threat	S1, S2e, S4 and S5
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Somewhat Effective
Residual Risk Rating	Risk Level 3 – Medium Risk

5.2.9 Climate Change

The potential impacts of climate change on the natural values of the Moreton Bay Ramsar site and the natural capacity of the system to cope with the change will vary depending on the nature of the impact as well as the location and type of wetland habitat.

In the context of current trends, recent projections of sea level rise have been made by the National Tidal Centre (as reported in the 2007 Queensland State of the Environment Report) as 1.2mm/yr.

Potential impacts of climate change on coastal ecosystems are summarised in Voice *et al.* (2006). The most salient potential threats to the Moreton Bay Ramsar site include:

- Sea level rise and shoreline erosion (noting that the response to this may be the proliferation of works to armour the foreshore and further impact on natural values);
- Changes in wind and wave climate causing changes in local erosion rates;
- Increased coastal flooding and saltwater intrusion by higher mean sea levels;
- Changes to freshwater flows regimes caused by changes in rainfall and runoff rates that can affect the condition of wetland environments such as mangroves and saltmarsh;
- Progressive inland migration of coastal ecosystems likely leading to increased pressure on saltmarsh communities from mangrove colonisation (noting in many areas there are physical barriers to such migration as a result of the presence of coastal development);
- The possibility of coral reef bleaching from increased sea temperature and coral degradation through water acidification; and
- Increased frequency/intensity of coastal storms and increased damage to coastal property.

Estuaries like Moreton Bay are considered as being particularly susceptible to climate change given their propensity to multiple stressors of which climate change becomes an additional or exacerbating factor.

Climate change impacts on the cultural values of the Ramsar site are also noteworthy. Many of the natural assets of the site important for tourism and recreation such as coral reefs, sandy beaches, fisheries and flora and fauna in protected areas will also be adversely affected by climate change leading to more direct and measurable economic flow-on effects should they be perceived as being altered or degraded.

Currently, there is significant investment and adaptation to climate change being implemented across a broad spectrum of planning and management activities by resource managers. As such, the assessment of the local risks of climate change within the region and the management response to climate change is expected to improve over time.

Threat: Climate Change	**Risk Level**
Threats from climate change	Medium and Possible
Critical Services of the ECD relevant to this threat	All
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Somewhat Effective (improving) – No change at present
Residual Risk Rating	Risk Level 3 – Medium Risk

6 INFORMATION GAPS, MONITORING AND EDUCATION

6.1 Information Gaps

The ECD preparation process promotes the identification of information gaps about the Ramsar site that are principally derived through interrogation of the nominated ecosystem services, components and processes and associated understanding of natural variability and limits of acceptable change.

This section summarises the key information gaps identified from the detailed description of ecological character provided in Section 7 for each critical service/benefit and reflects the discussions and outcomes of the SEP expert panel process in relation to key habitats and species within Moreton Bay (refer Appendix A).

6.1.1 Summary of Information Gaps

In general, data and information gaps have been identified in this ECD in two ways:

1) In relation to the natural variability and limits of acceptable change for critical wetland habitats and species (as outlined in the summary tables in Section 4) particularly for those attributes/controls where no data (*nd*) is stipulated; and

2) In the context of the discussion of each of the ten (10) critical services/benefits (refer Section 7).

<u>Service 1: Diversity of Habitats</u>

- The lack of a definitive baseline for assessment of changes in spatial extent of habitats over time is a significant information gap in the context of setting limits of acceptable change and assessing ecological character changes over time.
- In this context, there needs to be further alignment between the Ramsar Wetland Classification System and EPA's wetland mapping methodology such that more exact spatial data can be obtained or developed about the extent of relevant wetland types. Steps include -
    - Greater identification, description and mapping of the Ramsar wetland types at a local spatial scale;
    - Identification of how the Ramsar typology can be nested within the EPA's standard mapping methodology either as particular REs (for wetland types with vegetation) or as sub-categories within the broader classification set (eg. palustrine, lacustrine, riverine, estuarine and marine).

<u>Service 2: Representative Habitats</u>

- Noting the above inconsistencies in mapping techniques prevent direct comparisons between existing data-sets over time, for each of the representative habitats more systematic information is required on background variability in wetland habitat extent, condition and linkages to controlling or impacting processes.

- As outlined in section 4.3.1, there is a broad information gap around the issue of pontenial changes to ecological character as a result of changes to habitat extent or species populations. While response curves to particular stressors in particular habitats may be able to be developed, broader limits of change (such as acceptable habitat loss as a percentage of the total habitat area present in the Bay) are difficult to apply holistically at a habitat or species population scale.

- Key areas for further assessment for each of the representative habitats include:

  - For Eastern Banks and other seagrass habitats – extent of habitat (both in terms of areal extent and depth limits for key species); gross productivity (in terms of biomass and density); and community composition and structure (in terms of presence/abundance of dugong and turtle as well as commercially and recreationally important fisheries)

  - For Pumicestone Passage and other tidal flats habitats – extent of habitat (areal); habitat condition measured through Total Organic Carbon in the sediments; and community composition and structure using indicators such as polychaete density, abundance of benthic microalgae, and crab burrow density

  - For the Southern Bay and other mangrove and saltmarsh habitats– extent of habitat (areal); extent or trends in dieback; community composition and structure in terms of ratio of mangroves to saltmarsh over time; presence/abundance of commercially and recreationally important fish species.

  - For Coral Communities – Habitat condition (in terms of the recruitment and fecundity of coral species); extent of bleaching or other mortality; and community composition/structure (such as the relative abundance of coral versus macroalgae, the ratio of massive to branching corals and individual coral populations over time).

  - For Bay Island Wallum habitats, as outlined in Marshall *et al.* 2006 -

    i. Further development of groundwater modelling techniques to take into account ecological assets and impacts from potential changes to groundwater levels

    ii. Implementation of real time aquifer, surface water and ecological monitoring to confirm the thresholds critical to ecological assets are not exceeded

    iii. Targeted research on the nature of groundwater dependency of wetland ecosystems, species and communities

  - For Ocean Beach and Foredune Habitats - More systematic survey of key species (birds and turtle) populations over time including usage and quality of nesting sites; further research of the impact of ORV usage on sandy beach invertebrate communities; long term changes to beach morphology.

<u>Service 3: Aquatic/marine fauna</u>

Marine Species

- Present-day and historical marine vegetation mapping done at relevant spatial scale (minimum 1:25,000) and temporal (at least every 5 years, preferably with analysis of seasonal changes).

- Information on factors controlling temporal changes in seagrass.

- Natural variability in dugongs and green and loggerhead turtles and factors controlling these changes.
- Sustainability of dugongs, green turtles and loggerhead turtles given existing pressures and management arrangements.
- Health/condition status of turtles, and identification of factors causing disease.

Freshwater Species

- Environmental flow requirements of wallum fish species.
- Impacts of introduced species on wallum fish species.
- Up-to-date assessment of the distribution, population status and site-specific threats to wallum-habitat fish species, including an assessment of any changes of population status.

Service 4: Wetland-dependant terrestrial fauna

- Natural population variability for all species and factors controlling these changes.
- Sustainability of beach stone-curlew pairs (and breeding success) (particularly related to impacts of recreational activities) and water mouse populations (in relation to development or degradation of habitat adjoining the site).
- Extent of populations of acid frogs and water mouse outside/adjoining study area boundaries.
- Systematic information to assess background variability in wetland community structure and linkages to controlling processes; environmental flow requirements of acid frogs; impacts of introduced species (on acid frogs, beach stone-curlew, and little tern) and congeneric competitors (to acid frogs).
- Locations and sustainability of little tern nesting sites (primarily in southern parts of site). Longer-term variability in patterns of usage of little tern roost sites.
- The need for monitoring and survey data collected for shorebirds is collated in a consistent manner, with data held in relevant databases that can be accessed to inform decision-making.

Service 5: Wetland-dependant terrestrial flora and communities

- Systematic surveys of flora and mapping of significant species is lacking.
- Research to understand groundwater dependencies for communities and species is very limited.
- Research to identify species tolerance to salinity and desiccation is lacking.

Service 6: Shorebird Populations

- Indices/trends for shorebird abundance and diversity over time, patterns of roost and feeding habitat usage, particularly in terms of the proportion of shorebird aggregate feeding outside the Ramsar site boundaries.

- Natural population variability for all species and factors controlling these changes.
- Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh.
- Information on natural population variability of invertebrate prey and factors controlling temporal changes.
- Current distribution and categorisation of roost habitats (e.g. size, level of disturbance, position in relation to HAT and feeding grounds) within and adjacent to study area boundaries.

Service 7: Fisheries

- Present-day and historical marine vegetation mapping done at relevant spatial scale (minimum 1:25,000) and temporal (at least every 5 years, preferably with analysis of seasonal changes).
- Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh.
- Natural variability in fish and shellfish stocks, and factors controlling these changes.
- Specific environmental flow requirements of estuarine vegetation and fisheries species.
- Sustainability of current recreational and commercial fisheries management practices.
- Values and functions of proposed no-take ‘green zones’ in the future Marine Park Zoning Plan.
- Estimates of the abundance of key fisheries species over time at a local (Moreton Bay) spatial scale.
- Impacts of fisheries activities on abundances in Moreton Bay.
- Assessment of impacts of climate change on commercially and recreationally important fish stocks such as changes to migration patterns and initiation of critical life stage processes.

Service 8: Indigenous

- While some values and resources have been identified, further articulation of the values and cultural significance of the site are seen as only able to be set and measured through consultation with Traditional Owners.

Service 9: Research and Education

- A range of science priorities for Moreton Bay have been identified as part of the 2007-2012 Healthy Waterways Strategy (Moreton Bay Action Plan component). In addition to these priorities, the information gaps and monitoring recommendations of this ECD are seen as essential for monitoring the ecological character of the Ramsar site.

Service 10: Tourism and Recreational Uses

- Reliable visitor statistics, including tourist expenditure and other economic contributions.
- Carrying capacity of the Ramsar site for activities and locations.

- The importance placed on the Ramsar site and values by visitors when undertaking tourism and recreational activities and experiences.

6.1.2 Priority Information and Data Gaps

In analysing this expansive list, the following thematic information gaps are identified as priority areas:

- Additional research and monitoring expenditure to establish an ecological character baseline for the near-natural representative habitats, particularly those more localised habitats within the Ramsar site such as the freshwater wallum habitats of the Bay islands, the Eastern Bay coral reefs and peatlands such as Eighteen Mile Swamp;
- The need for better information and data sets about the presence and natural history of critical wetland species and their habitat including for example, surveys of vulnerable and endangered plant species on the Bay islands, aquatic species such as Oxleyan pygmy perch and more systematic surveys of important avifauna species and populations;
- Better information and understanding about the natural variability of critical wetland fauna populations and key attributes and controls on those populations (including whether or not any non-avian fauna species meet the 1% population requirement in Ramsar Nomination Criterion 9);
- The ecological character thresholds of particular habitats and communities to changes in key attributes/controls such as water quality and hydrology need additional investigation. Noting that any interim limits of acceptable change stated in the ECD should be revised as improved information becomes available;
- Resilience of habitats, community structure and key species to acute or prolonged impacts from water quality degradation such as nutrient enrichment, increased levels of salinity and sedimentation/turbidity (eg. similar to the approach in ANZECC for toxicants); and
- Consultation and involvement of traditional owners of the Moreton Bay Ramsar site if a greater understanding of historic and contemporary wetland values of the site to indigenous people is to be obtained and appreciated.

6.2 Monitoring Needs

6.2.1 Summary of Monitoring Needs

A broad range of monitoring recommendations are provided in this ECD based on the information gaps and monitoring recommendations provided under each critical service and critical process summary table.

Similar to the above section on data and information gaps, monitoring needs can be derived from the ECD in two primary areas:

1. In relation to the natural variability and limits of acceptable change as they relate to the Ramsar Nomination Criteria and underlying critical wetland habitats and species of the site

particularly for those attributes/controls where no data (*nd*) is stipulated and an interim limit of acceptable change is presented; and

2. In the context of the detailed discussion of each of the ten (10) critical services/benefits (refer Section 7 of the report).

Limits of Acceptable Change

Some level of monitoring will be needed to assess the suitability of interim limits of acceptable change (versus natural variability) and to assess if unacceptable changes as outlined in the summary table for LAC (refer Table 4-3) are being approached or are occurring. Principally, this monitoring will need to relate to:

- Broad-scale observation/monitoring to ensure each wetland type outlined in the ECD continues to be represented across the site;
- Wetland habitat extent monitoring (noting that a precursor to being able to do this will be to establish a better correlation between EPA wetland mapping and the Ramsar Classification System);
- Habitat condition monitoring (principally in the form of monitoring underlying wetland ecosystem processes such as water quality and hydrological process or surrogate biological indicators such as crab burrow density);
- More targeted surveys of the threatened flora and fauna species (perhaps on a five year or ten year basis) to assess presence/absence or population changes of noteworthy species or communities; and
- More regular counts of roosting and feeding shorebirds with a particular emphasis on those species that meet the 1% population criteria.

In the context of assessing whether or not ecological character is being maintained, the following monitoring objectives and measures are recommended in Table 6-1.

Table 6-1 Monitoring Changes to Ecological Character

Basis of Monitoring	Objectives of Monitoring	Indicator/Measure	Frequency	Priority
Nomination Criterion 1	Ensure current diversity of wetland types are maintained	Establish reference sites for each Ramsar wetland type and record observations about extent and condition	Annually	High
	Monitor extent of Ramsar wetland types (all)	Correlate and map Ramsar wetland types within broader EPA mapping product Establish baseline extent for each habitat type based on the revised mapping Re-map at regular intervals and assess extent and determine if changes are part of natural variability or represent anthropogenic change	Undertake as part of planned updates of EPA wetland mapping	Medium
	Monitor extent and condition of key habitats including reference habitats	Establish reference sites for each key habitat type (eg. seagrass, tidal flats, etc) and monitor extent and condition – refer Table of LACs for key habitat attributes (refer Table 4-4) Continue and augment EHMP monitoring for water quality and seagrass habitat extent with consideration of additional sampling locations and indicators based on this ECD	Monthly - Annually Monthly	Medium - High High
Nomination Criterion 2	Determine presence/absence of threatened wetland species	Undertake more detailed surveys of species and communities within the Ramsar site Assess presence/absence with consideration of relevant LAC	Species specific – generally studies will need be undertaken every 5 – 10 years and may need to be undertaken over	High

Basis of Monitoring	Objectives of Monitoring	Indicator/Measure	Frequency	Priority
			several seasons	
	Assess condition/change to populations	Undertake more detailed surveys of species populations and communities within the Ramsar site Assess any changes to population (eg. breeding success, mortality rates, health etc.) and any applicable underlying wetland processes (eg. water quality of key habitats – refer relevant species-based LACs in Table 4-5)	See above	Medium
Nomination Criterion 3	Loss of biodiversity	Utilise indicator/measures from Criteria1 and 2	See above	Medium
Nomination Criterion 4	Use of the site as refugia habitat	Survey and monitor the following key refugia functions: 1) Feeding habitat for green and loggerhead turtles 2) Feeding and breeding habitat for dugong 3) Refuge habitat for freshwater fish of conservation significance 4) Roosting habitat for migratory shorebirds 5) Critical overwintering habitat and flyway staging area (both northern and southern migration routes) for migratory shorebirds	Specific monitoring programs for each refugia function to be developed – monitoring to occur during key usage periods	High
Nomination Criterion 5	Use of the site by at least 20 000 waterbirds	Ensure regular surveys of waterbird usage of the site during key visitation periods Use of surrogate species (bar-tailed godwit, Eastern curlew and Pacific golden plover) for overall abundance	Undertake annual counts of waterbird usage of the site	High
Nomination	The site supports	Undertake more detailed surveys of	Specific	High

Basis of Monitoring	Objectives of Monitoring	Indicator/Measure	Frequency	Priority
Criterion 6	the 1% of individuals of populations for the key avifauna species in the ECD	1% candidate species of avifauna listed in the ECD	monitoring programs for each species to be developed	
Nomination Criterion 7	Long term impacts on the sustainability of populations of important commercial and recreational fishery species that occur within the site	Continue to fund and implement monitoring of fisheries by the Department of Primary Industries and Fisheries (eg. CFISH [Commercial Fisheries Information System] and RFISH [Recreational Fishing Information System].	As per current programs	Medium
Nomination Criterion 8	Assess reduction in the extent or condition of wetlands or other areas and a corresponding measurable impact on important spawning, nursery or migration pathways for fisheries	Identify reference sites for key spawning, nursery and migration pathways within the Ramsar site In assessing the interim LAC, attention should be given to assessing changes in the extent of mangroves, saltmarsh, seagrass and tidal flat environments, which represent key nursery habitats to many commercially important species within the site	Medium to long term (>5 years)	Medium

Critical Services/Benefits

In addition to undertaking monitoring to assess potential changes to ecological character as discussed above, a summary of more specific monitoring needs identified under each critical service (as summarised in Section 7) is contained below. In most cases, these recommendations provide additional detail and context to the information already presented above in Table 6-1.

Service 1: Diversity of Habitats

While preliminary work has been done in this ECD, assignment of more detailed definitions and provision of spatial data for each of the wetland types in the Ramsar site (using the Ramsar Classification System) is needed such that a baseline for each wetland type represented in the site can be monitored over time. This needs to be closely aligned to the Queensland Wetlands Mapping Project.

Service 2: Representative Habitats

2a (Eastern Banks) Examination of long-term changes in seagrass based on aerial photograph interpretation and review of existing information.

2a (Eastern Banks) Additional EHMP/Seagrass Watch monitoring sites in representative areas subject to different wind/wave regimes.

2b (Pumicestone Passage) Examination of long-term changes in extent of tidal flats based on aerial photograph interpretation and review of existing information.

2c (Southern Bay) Examination of long-term changes in mangroves and saltmarsh based on aerial photograph interpretation and review of existing information.

2d (Coral Reefs) Additional EHMP monitoring sites in representative areas subject to different wind/waves regimes.

2d (Coral Reefs) Monitoring of coral growth (individual colonies) over time.

2e (Freshwater wetlands on Bay Islands) Additional EHMP monitoring sites in representative sites within North Stradbroke Island and Moreton Island.

2e (Freshwater wetlands on Bay Islands) Development of locally specific ecosystem condition objectives. Additional measures recommended by Marshall *et al.* (2006) related to assessing changes to ecological assets as a result of future water extraction include -

- Further development of groundwater modelling
- Implementation of real time aquifer, surface water and ecological monitoring to confirm the thresholds critical to ecological assets are not exceeded
- Targeted research on the nature of groundwater dependency.

2f (Moreton Island Ocean Beach) Examination of long-term changes in habitat extent using aerial photograph interpretation and review of existing information.

2f (Moreton Island Ocean Beach) Schlacher *et al.* (2008) also recommends research into the implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity and the effects of cumulative impacts from multiple stressors and disturbances on the structure, function, and recovery dynamics of sandy beach ecosystems.

<u>Service 3: Aquatic/marine fauna</u>

Fauna population monitoring at appropriate spatial and temporal scales.

Marine vegetation monitoring.

Continuation and expansion of EHMP to monitor key species identified in the ECD.

<u>Service 4: Wetland-dependant terrestrial fauna</u>

Acid frogs - Identify key populations and for those populations, monitor presence/absence, breeding evidence (tadpoles and metamorphs), and maintenance of parapatry (speciation) between acid frog congener species during optimum breeding conditions until markers/trends of population variability are evident. Quarterly monitor water quality for key population sites (salinity, pH range 3-5, dissolved oxygen, nitrate levels (maintain <0.7 mg/L) and other toxicants (e.g. monomeric Aluminium and surfactants)). Assess impacts of fire on habitat of key frog populations from fires.

Beach stone-curlew – Monitor habitat usage and breeding success at key habitat sites (bi-annual).

Little tern – Identify locations and sustainability of Little Tern nesting sites (primarily in southern parts of site) (yearly). Monitor abundance and pattern of usage at key roosts within northern Pumicestone Passage and northern sector of South Stradbroke Island (annual).

Water mouse – Identify full extent of water mouse habitat within and outside the site and monitor nest activity and diversity of nest types as surrogate for species distribution and abundance (annual and during breeding period).

Continuation and expansion of EHMP to monitor key species identified in the ECD

<u>Service 5: Wetland flora and communities</u>

Systematic flora surveys would quantify the representation of wetland communities and species of conservation significance within the Ramsar site. This would assist in prioritising targeted areas for conservation and management actions, and in specifying limits of acceptable change more accurately (i.e. in terms of percentage area for RE’s or population numbers for species).

<u>Service 6: Shorebird populations</u>

Early and late summer monitoring events at key roost sites and feeding grounds (to be conducted annually) to target bar-tailed godwit, Eastern curlew and Pacific golden plover (species which currently exceed the 1% threshold and which may provide useful surrogate for numbers of other shorebirds using the site and of habitat usage).

Annual audit of roost sites (condition and use).

Monitor habitat usage and breeding success (bi-annual) of pied oystercatcher (key resident species) on outer bay islands.

<u>Service 7: Fisheries</u>

Fish stock monitoring based on DPI&F state-wide LTMP, CFISH (Commercial Fisheries Information System) and RFISH (Recreational Fishing Information System) programmes.

Marine vegetation monitoring.

Continuation and expansion of EHMP to monitor key commercial and recreational species identified in the ECD.

Service 8: Indigenous

No specific monitoring needs for this Service were recorded.

Service 9: Research and Education

No specific monitoring needs for this Service were recorded.

Service 10: Tourism and Recreational Uses

Reliable visitor statistics, including tourist expenditure and other economic contributions.

Number of visitors participating in each activity/location and the resultant environmental impacts and potential indicators for monitoring.

Importance/awareness of Ramsar site and values for visitors.

6.2.2 Monitoring Alignment

In making recommendations for future monitoring of the Ramsar site, the information gaps and monitoring needs identified in the ECD were also considered in the broader context of the Southeast Queensland Healthy Waterways Partnership's Ecosystem Health Monitoring Program (EHMP) and the monitoring program being implemented to assess the effect of proposed re-zoning of the Moreton Bay Marine Park by the Queensland EPA.

To ensure close alignment between these initiatives, a special sub-group of the Southeast Queensland Healthy Waterways Partnership Scientific Expert Panel (SEP) met several times with the consultant study team and the Knowledge Management Committee to workshop and discuss synergies and commonality between the existing and proposed monitoring programmes (refer Appendix A). A separate report outlining the outcomes of these discussions has been produced by BMT WBM (2008b) as part of the ECD project and is summarised here.

To facilitate the determination of monitoring priorities and identify possible efficiencies, there were two key hypothesis questions posed to the workshop project group for discussion:

1. What species/habitats/processes are salient to all three programs (eg. Ramsar, Marine Park and EHMP) and should be monitored in order to most cost effectively assess if health/character is being maintained (or improved by management interventions)?

2. What is the most effective and efficient sampling design in the context of overall information needs for management?

Key indicators seen by the group as relevant to the Moreton Bay Ramsar site (as well as the other two programs) are outlined below:

In relation to **habitats**, the following indicators were identified as high priorities:

- Areal extent of seagrass meadows (though use of the light penetration and depth surrogate is seen as most appropriate);

- Gross production of seagrass meadows;
- Presence abundance of key species in seagrass meadows (particularly dugong and green turtles);
- Areal extent of mangroves and saltmarsh;
- Ratio of mangroves to saltmarsh;
- Abundance and diversity of key species within mangrove and saltmarsh habitats;
- Areal extent of dieback of mangroves and saltmarsh and changes over time;
- Areal extent of tidal flats;
- A range of indicators presented relevant to inshore coral communities;
- Bird nesting/feeding usage (including birds of prey) in ocean beaches and foredunes; and
- Abundance/diversity of benthic invertebrates across several habitat types (ocean beaches and foredunes, tidal flats and inshore mud and sand habitats).

In relation to **species**, the following indicators were identified as high priorities:

- Monitoring indicators related to dugong;
- Monitoring indicators related to marine turtles (green and loggerhead);
- Monitoring indicators related to migratory and resident shorebird species including little tern; and
- Monitoring indicators related to water mouse.

Key **ecosystem processes** identified as critical across a range of wetland habitat types included:

- Hydrodynamic controls including sedimentation and inundation patterns;
- Water quality; and
- Biogeochemical processes.

Key **stressors and threats** identified to habitats and species in Moreton Bay were:

- For habitats - Dredging/placement of dredge spoil and related marine works, various forms of fishing, water pollution and climate change were the most common stressor/threats listed.
- For species – Climate change, habitat modification, and by-catch/entanglement were the most common stressor/threats listed.

While specific priorities and methodologies for monitoring were not sought to be developed through the workshop process, the information presented in the analyses above provides a basis for the next phase of monitoring and sampling design under EHMP and other monitoring regimes that is cognisant of the important/significant habitats and species, key attributes and associated stressors and threats affecting the Moreton Bay Ramsar site.

6.3 Communication, Education and Awareness Messages

6.3.1 Existing CEA Messages

This section reviews the key communication, education and awareness messages (CEA) related to the Moreton Bay Ramsar site and identifies perceived gaps.

The role of the Healthy Waterways Partnership over the past decade in raising public awareness about the environmental values of the Bay has been significant. These communication and education messages include many of the values and services identified by the ECD as being critical such as:

- The ecosystem values of wetland to important fauna such as birds, turtles and dugong;
- The impacts of human uses and activities on Bay water quality and amenity; and
- The use of best practice measures and water quality technology to manage runoff.

The Annual Ecosystem Health Monitoring Programme Report Card produced by the Healthy Waterways Partnership remains a powerful tool to convey the current condition of waterways to the public and to elected officials that is now being pursued in a number of other areas and jurisdictions such as the Port Curtis area in Central Queensland and as part of the Great Barrier Reef Water Quality Protection Plan.

The Report Card provides a snapshot of both current information as well as trend information over time across a broad area of the Bay. Of note in the context of the current study is the predominant emphasis on physico-chemical parameters in the estuarine and marine Report Card. The inclusion of more biotic indicators in the form of key habitats and key fauna would better align the Estuarine and Marine Components with similar indicators used in the Freshwater Components of Western Catchments as well as recognise key fauna and habitat values important to the Bay's Ramsar designation.

Community education and monitoring programs also remains a key facet of NRM investment programmes in the region such as the long running 'Seagrass Watch' and emerging complementary programmes for mangrove and saltmarsh.

Educational facilities such as the Boondall Wetland Centre and Nudgee Beach Environmental Education Centre located in the Western Bay utilise the resources, values and threats to the Bay as key components of their curriculum and activities.

6.3.2 Gaps

As identified in Section 3 of the report, the Moreton Bay Ramsar site is recognised in a wide array of plans and strategies for the Bay and region. As site manager, the EPA has a number of brochures and information sheets about the site that are available to the public.

A general observation about CEA messages for Moreton Bay is the sense of overlap regarding planning instruments and which Government authorities are involved in management. As such, alignment under a common banner (such as the Healthy Waterways Partnership) and the promotion of consistent messages about conservation and management of the Bay are a continuing priority for resource managers, recognising that there will always be a wide range of plans and legislation that apply and these instrument need to be implemented in a coherent and integrated way.

To this end, in parallel with the ECD project, a Conceptual Framework for the ecological health and character of Moreton Bay has been developed as an outcome of the SEP workshop process that seeks to align the management and monitoring goals of this ECD, the Healthy Waterways Strategy and the Moreton Bay Marine Park Zoning Plan. The Framework (documented in BMT WBM 2008b) is a useful first step in trying to look at the Bay's habitats and species more holistically and to recognise where and how the various planning and regulatory instruments under the three conservation/management initiatives can be better aligned.

More specific areas or issues where the critical elements of the Ramsar site nominated in this ECD are perhaps not being fully articulated in the context of current CEA messages include:

- The importance of freshwater wallum and peatland wetland habitats on the Bay islands and adjacent to Pumicestone Passage and the unique aquatic fauna that exists in these areas such the Oxleyan pygmy perch, water mouse and acid frogs. This also includes the associated critical wetland flora and communities identified in this report (noting that significant work is needed by to better identify and survey the extent and values of these endangered and vulnerable communities and species);
- In keeping with the wise use paradigm of the Ramsar Convention, promotion of the diversity of sustainable wetland-based tourism and recreational values of the Ramsar site;
- The current state of fisheries resources and the need for continued conservation of fish habitat;
- The use and significance of the site to Indigenous people; and
- The importance of Moreton Bay for migratory shorebirds.

Each of these items is discussed below:

Freshwater wetlands and associated systems

The relative isolation and near-naturalness of the freshwater wetland habitats found on the Bay islands remain, at least anecdotally, a scarce-known resource outside of SEQ, although recent investigations as part of the Queensland Water Commission groundwater resource development on North Stradbroke Island has raised the profile of the values and threats to a greater audience. It is likely that the public is aware many of the larger more prominent water bodies such as Blue Lake are within protected areas but less knowledge that a diversity of freshwater wetland environments made up of dune lakes, palustrine depressions, and creeks and streams are within the boundaries of the Ramsar site.

Peatlands such as Eighteen Mile Swamp are also of growing importance at a global scale with Ramsar Contracting Parties calling for further cooperation on their conservation through a global action plan to conserve their unique biodiversity, paleo-geologic significance and their role as a major storehouse for carbon.

Sustainable Tourism

If Moreton Bay is to be differentiated as a sustainable tourism destination, Whitmore and De Lacy (2005) as part of their report on Sustainable Tourism in Moreton Bay identify the need for and recommend the establishment of a 'destination management committee of stakeholders' to develop Moreton Bay as a sustainable, 'Platinum Plus' Destination. This is underpinned by a range of recommendations to conduct tourism future modelling and visioning for the Bay, ensuring environmental sustainability through industry compliance and certification programmes and investigating a 'Tourism in Protected Areas" initiative between Tourism Queensland and Queensland Parks and Wildlife. Acknowledging the impacts that increased tourism and recreational use of the Bay can bring, sustainable tourism and recreational use of the Bay remains a critical part of its cultural services and promotion of this industry is seen as an important driving economic force in the future for continued conservation efforts within and external to the Ramsar site. In this context, nomination of the site as a Ramsar wetland should be heavily embraced as part of any future promotional push.

Fisheries and Fish Habitat

As discussed in the critical services section, there is a strong social (eg. cultural) as well as economic value associated with the fisheries of the Bay which is shared by commercial fishers, recreational fishers and indigenous fishers. It is likely that all of these groups embrace the notion that fisheries and fishing effort should be ecologically sustainable such that there are sufficient fish resources to support commercial, recreational and indigenous fishing activity now and in the future with some degree of intergenerational equity (eg. the fisheries of commercial, recreational or indigenous significance are maintained over time for the use and enjoyment of future generations).

In this context there have been improvements in the management of fisheries by the industry (such as the Moreton Bay Seafood Industry Association Environmnetal Management System (EMS) initiative and promotion of sustainable practices such as biodegradable bait bags by the recreational fishing industry as well as through the involvement and recognition of fisheries management practices by indigenous people in traditional fishing activities and Government regulatory and management responses to conserve fish habitat and fish populations.

Maintaining this critical service over time will depend on building upon the positive initiatives of these various groups with a vested interest in maintaining the health of the Bay and its fisheries over time.

Indigenous Values and Significance

As outlined in the Cultural Heritage Report by Converge Heritage and Community prepared as part of the ECD contained in Appendix C, the Ramsar site is likely to hold significant cultural values to the relevant Traditional Owner group/s that use the site. These values may include physical and non-physical cultural heritage areas and objects, oral knowledge, such as stories, animals and plants, and the natural environment itself;

Traditional Owners are already taking an active role in managing Ramsar areas as part of their management of the wider Moreton Bay area, and they would likely wish to increase this role if offered the opportunity. The Traditional Owners have already formed an encompassing organization (SEQTOLSMA) which may prove to be a vehicle through which consultation and planning for the future could be organized. However, only through consultation with the individual Traditional Owner groups could this be ascertained.

<u>Migratory Shorebirds</u>

As demonstrated throughout this ECD, the assemblage of diverse habitats of the Bay makes it one of Eastern Australia's most significant coastal ecosystems. This diversity of habitat types present in the Bay and within the boundaries of the Ramsar site (sheltered estuary versus active systems such as beaches and sandy channels) in close proximity are especially important for migratory species that use the Bay such as birds and turtles that will utilise different habitats within the Bay for feeding versus roosting/breeding/nesting.

Despite its proximity to one of Australia's fastest growing regions, Moreton Bay continues to be one of Australia's top 12 shorebird habitats and is in the top three in Queensland (EPA 2005b). Likewise, the site is a critically important stop along the East Asian-Australasian Flyway and many species that utilise Moreton Bay are recognised in the bilateral agreements for shorebird conservation between Australia and Japan, China and the Republic of Korea.

These values and obligations justify continued promotion and investment in effective education and communication activities with respect to shorebirds and shorebird habitats. To this end, a range of community education actions are already outlined in the EPA Shorebird Management Strategy and should continue to be implemented.

7 DETAILED ECOLOGICAL CHARACTER DESCRIPTION

Sections 4 – 6 of this report summarises the ten (10) nominated critical services/benefits of the Moreton Bay Ramsar site and provides information about the underpinning ecosystem components and processes, natural variability and limits of acceptable change, threats, information gaps and monitoring needs and recommendations associated with the ecological character of the site.

The broader, more detailed assessment of the critical elements of the Ramsar site on which the summary sections were based is presented in this section. The information is presented through a combination of text and tabular information using a standard template prepared for each nominated service/benefit. The standard reporting template is shown in Table 7-1.

Table 7-1 Reporting Template for Critical Services

Summary Table	Critical Service # and Name
Reason for inclusion	Relates back to the Ramsar Nomination Criteria or similar justification for selection as a critical service
Type of Service	From the National Framework document, list if the service relates to a supporting, cultural, regulatory, provisioning service or combination thereof
Description of Service	Quantified description of the service (using literature sources or similar)
Spatial application (if relevant)	Whether or not the element applies to a specific component of the site (such as a wetland type) a locality (such as one of the bay islands) or to the site as a whole
Critical component habitat types underpinning the service (if applicable)	If applicable, lists the key or noteworthy wetland types underpinning the wetland service/benefit
Critical component species that underpin the service (if applicable)	If applicable, lists the noteworthy or indicator species (such as species of conservation significance) underpinning the wetland service/benefit
Critical wetland processes underpinning the service	Lists the key wetland ecosystem processes underpinning the wetland service/benefit
Natural variability (if relevant)	Describes the natural variability of the relevant service and its underlying components/processes if known
Principal threats	Lists the key threats to the service or its underlying components or processes
Data quality underpinning this critical service	List the level of confidence in the data or information used in defining the limit (see below)
Information gaps	Cognisant of the information provided in the rows above, this section lists out the information gaps for the critical service and any underlying components and processes
Recommended monitoring	Based on the information gaps, this section sets out proposed monitoring to be carried out in relation to the critical elements

As outlined in the methodology in Section 4, following the assignment of the critical processes, components and services of the wetland, information and data gaps related to these critical elements were analysed. As part of this task, an assessment of the quality/value of the main information and data sources was undertaken using the definitions described in Table 7-2. These definitions are used in the ECD, particularly with respect to describing natural variability and the limits of acceptable change, to identify the basis on which the suggested measures have been developed and to provide a qualitative degree of confidence about the accuracy of the proposed measure.

Table 7-2 Data Quality/Quantity Review Definitions

Level Code	Description
1	Data are current, have been collected using a robust sampling design (adequate replication in time and space) and are likely to be accurate.
2	Data have been collected with respect to the research issue but there are one or more of the following limitations in the data: ➢ Limited sampling effort in time (e.g. does not consider inter-annual or seasonal variations); ➢ Limited sampling effort in space (e.g. inadequate replication at different spatial scales, or mismatch in spatial scale with issue under investigation); ➢ Potential/likely inaccuracies in collected data (e.g. due to methods of data collection, reporting etc.); ➢ Data are not current (e.g. significant changes in environmental conditions since survey undertaken).
3	Semi-quantitative assessment based on general scientific principles and limited data
4	Best scientific judgement or wholly qualitative assessment

Using the approach set out above, sections 7.1 to 7.10 outline the detailed description of the ten (10) critical services/benefits identified.

7.1 Service 1 ~ Diversity, Representativeness and Connectivity

Photos showing various wetland habitats in Moreton Bay (Source: EPA photo library)

The wetland types of the Moreton Bay Ramsar site are extremely diverse, ranging from perched freshwater lakes and sedge swamps, to intertidal mudflats and mangroves and sub-tidal seagrasses, to oceanic, high-energy beaches. An overview of the twenty-two (22) Ramsar wetland types present in the boundaries of the site and some examples of these wetlands are cited in Section 3 of this report.

As outlined previously, the study team sought to divide the Ramsar site into four geographic areas that shared common components and processes. As identified previously, the key areas used for reporting were: a) Bribie Island and Pumicestone Passage; b) Western Bay; c) Moreton Island and Eastern Banks; and d) Stradbroke Islands and the Southern Bay.

As part of this sub-regional analysis, the Ramsar wetland types were identified and listed for each of these areas in order to identify any trends in terms of the abundance and representativeness of different habitat types across the broader area. From this analysis, the following characterisation of the site in terms of the diversity of wetland habitat types can be made:

- A number of wetland habitats types are **common** across the breadth of the site (all four areas) and therefore best represented. These include: Type B (marine sub-tidal aquatic beds), Type D (rocky marine shores),Type E (sand, shingle or pebble bars; sandbars and dunes), Type F (estuarine waters), Type G (intertidal mud, sand or salt flats), Type H (intertidal marshes including saltmarsh), Type I (intertidal forested wetlands including mangroves), Type M (permanent rivers, creeks and streams), Type N (seasonal/intermittent rivers, creeks and streams) Type Tp (permanent freshwater marshes), Type Ts (seasonal/intermittent freshwater marshes) and Type Xf (freshwater, tree-dominated wetlands and swamps).

- Wetland habitats that are **well represented** in 3 of the 4 areas include: Type A (permanent shallow marine waters), Type J (coastal brackish/saline lagoons), and Type K (coastal freshwater lagoons) all of which are absent in the Western Bay.

- Wetland habitat that are **localised** (occurring in 2 or less of the areas) include: Type C (coral reefs) which are present in the Southern and Eastern Bay only; Type O (permanent freshwater lakes) which are present on the offshore sand islands, Type W (shrub dominated wetlands) characteristic of RE 12.2.12 which have been mapped by the Queensland Herbarium in the Bribie/Pumicestone and Southern Bay areas, and Type Y (freshwater springs) which generally are associated with freshwater habitats on the outer sand islands.

- Wetland habitat that are **highly localised** (occurring in 1 area only) include Type U (non-forested peatlands) of which 18 Mile Swamp on North Stradbroke Island is the site's most notable example.

In general there is a much greater diversity of wetland types present on the Bay islands than elsewhere within the boundaries of the site, in part due to the complexity of dune, freshwater wallum and peatland, and transitional terrestrial habitats present in those locations as well as the array of traditional estuarine wetland communities such as mangroves, saltmarsh and sand and mud flats in intertidal areas

In a number of areas within the Ramsar site, there is also a high degree of connectivity between the terrestrial, intertidal and subtidal habitat types. For example, the southern part of Pumicestone Passage contains a complex mosaic of mangroves, seagrass, unvegetated shoals and deeper waters in close proximity to each other. This combination and diversity of habitat types may represent potentially important nursery habitat for many fish (Laegdsgaard and Johnson 1995; Tibbetts and Connolly 1998) and prawn (Young 1978) species of commercial significance. Similar comments have been made with regard to the relationship between saltmarsh, mangrove and seagrass in the Southern Bay.

In this context, there is an emerging view that fish and nektobenthic crustacean community structure in mangroves and unvegetated habitats is influenced by their proximity to seagrass beds (e.g. Jelbart 2004, Olds 2002). Some documented examples of the beneficial interaction between wetland habitats illustrating this connectively include:

Despite being devoid of seagrass, Melville and Connolly (2003) demonstrated that organic matter, particularly from seagrasses, was important as the base of food webs for fish species of commercial significance on adjacent unvegetated mudflats in Moreton Bay.

Studies by Olds (2002) in Moreton Bay and Jelbart (2004) in central NSW both found that seagrass beds (particularly dense beds – Olds 2002) in close proximity to mangroves tend to contain more abundant nekton assemblages than seagrass remote from mangroves. Both studies also found that the suite of species inhabiting seagrass varied with distance from mangroves.

Given the size and complexity of habitats present in the Ramsar site, while there is a range of local scale relevant processes, it is the broad scale processes that are seen as important to maintaining the overall diversity of habitat types. These include:

- Physical Coastal Processes. Natural (equilibrium) hydrodynamic controls on habitats through tides, currents, erosion and accretion;
- Hydrology. Natural patterns of tidal inundation and freshwater flows to wetland systems;
- Groundwater. For those wetlands influenced by groundwater interaction, the groundwater table;

- Energy and Nutrient Dynamics. Primary productivity and the proper functioning of carbon and nutrient cycling processes;
- Water Quality. Water quality that provides aquatic ecosystem values within wetland habitats;
- Climate. Patterns of temperature, rainfall and evaporation; and
- Geomorphology. Key geomorphologic/topographic features of the site

Table 7-3 Critical Service 1

Summary Table	**Critical Service (S1)**
Reason for Inclusion	The diversity of habitats as a critical service is underpinned by Ramsar Nomination Criterion 1.
Type of Service	Supporting
Description of Service (quantify if possible)	Using the Ramsar wetland type classification system, the Moreton Bay Ramsar site contains 22 different types of wetlands in the coastal/marine, inland wetland and man-made categories. The different types represented and examples of each are listed in Section 3 of the report.
Spatial Application (if relevant)	Section 3 lists the wetland types present in the site.
Critical habitat components underpinning this service	All habitat types, noting that based on a broad qualitative assessment of wetland types across the site, wetlands of the following types are less widespread/common than other wetland types represented on the site: • Type C (coral reefs); • Type O (permanent freshwater lakes); • Type W (shrub dominated wetlands); • Type U (non forested peatlands); • Type Y (freshwater springs).
Critical species underpinning this service	Not applicable; this service relates primarily to habitat. Other services address particular species and populations.
Critical processes underpinning this service	Broad-scale wetland processes as listed above; noting that individual wetland habitats will be influenced by a range of local/site specific processes.
Natural Variability (if relevant)	The geomorphology and biotic components of the wetland habitats of the Bay have formed over thousands of years, in a sedimentary environment that is characterised by major fluctuations in sea level. Near natural and representative environments that remain in the Bay (refer Service 2 below) are indicative that there is natural stability in the system that will retain these habitats in the long term in the absence of anthropogenic influences. Notwithstanding, wetland environments can show significant seasonal/local variation depending on key drivers such as rainfall, hydrological inputs, nutrients, and sedimentation. Particular habitats will be more susceptible to temporary disturbance (be it natural or of anthropogenic origin) than others. For example, seagrass, coral reefs, dune lakes and similar environments are highly dependant on stable water quality conditions whereas mangroves and saltmarsh communities can be highly resilient to water quality impacts but are more susceptible to changes to hydrology and inundation patterns.
Principal threats	Key threats to the overall diversity of habitats present in the site include: • Major changes to the Bay hydrodynamics in terms of coastal processes and other

Summary Table	Critical Service (S1)
	hydrodynamic controls on habitat • Major changes to the Bay hydrology in terms of freshwater flows and inputs from rivers and streams • Long term and significant changes to water quality – particularly the assimilative capacity of the western and southern bay to carry out essential nutrient cycling processes and the broadening of catchment-based water quality impacts into the central and eastern bay • Localised die-back and other impacts particularly if the wetland type is one of the less widespread types in the Ramsar site (refer list above) • Inadequate buffers between human settlement and wetland areas and associated edge effects • Changes to the groundwater table and groundwater interaction with surface water in freshwater lakes and creeks on the sand islands including increased susceptibility to fire (particular impact for peatlands) • Climate change and exacerbation of current mangrove intrusion into traditional saltmarsh habitats as a result of sea level rise
Data quality underpinning this critical service	Level 3 – The wetland habitat types identified and analysed as part of this Service rely on the interpretation of a number of sources of information including the EPA wetland mapping data layer (which is itself based on a combination of RE and waterbody data).
Information gaps	There needs to be further guidance about the identification of the Ramsar wetland types such that more exact spatial data can be obtained or developed. This should be compatible where possible with State mapping methodologies such as that employed by the EPA. In the meantime, the EPA dataset (using RE types as surrogates for vegetated Ramsar wetland types) provides a baseline for measuring the extent of various wetland types across the site.
Recommended monitoring	Assignment of more detailed definitions and provision of spatial data for each of the wetland types in the Ramsar site such that a baseline extent for each wetland type represented in the site can be monitored over time (and natural variation analysed).

7.2 Service 2 ~ Near-Natural Wetland Habitat Reference Sites

As discussed in Service 1, the Moreton Bay Ramsar site contains a range of marine, estuarine, palustrine, lacustrine and terrestrial biotopes.

Among the 22 wetland types listed as being represented, several key wetland habitat types are seen as most critical to the ecological character of the site based on the range of wetland services/benefits supported. These include for example, core habitat for threatened flora and fauna species (refer Services 3, 4 and 5), supporting important populations of shorebirds (Service 6), and supporting cultural values such as fisheries habitat and productivity, indigenous significance, education and research values and tourism and recreation values (refer Services 7-10).

The six key habitats identified and are as follows:

a. Seagrass and sandy shoals

b. Unvegetated intertidal flats (and associated adjacent estuarine assemblages)

c. Mangrove and saltmarsh communities

d. Coral communities

e. Freshwater wetlands (including both wallum and peatlands)

f. Ocean beaches and foredunes

Several of these wetland habitats are considered, either individually or collectively, to represent particularly outstanding examples of near-natural 'reference' areas within the biogeographic region. It is acknowledged that there are numerous examples of such habitat areas within the site, however for reporting purposes six key reference sites have been identified as follows:

- Seagrass and shoals - Eastern Banks area
- Intertidal flats and estuarine assemblages - Pumicestone Passage
- Mangrove and saltmarsh communities - Southern Bay
- Coral communities - Eastern Bay
- Freshwater wetlands (including wallum and peatlands) - Moreton and North Stradbroke Islands
- Ocean beaches and foredunes - Moreton Island

These representative areas were selected on the basis that they:

- are in natural or near-natural condition based on existing ecosystem health and other monitoring data;
- contain representative examples of key habitats within the site;

- contain excellent representative examples of various wetland habitat types within the IMCRA and IBRA biogeographic regions; and
- contain wetland habitats of recognised high conservation significance, as prescribed under legislation (protect areas) and State management plans (i.e. State Coastal Plan).

Table 7-4 provides summary information on these points underpinning the six reference sites.

A more detailed description of each of the six habitat types and the selected reference site are contained in the sections below.

Table 7-4 Ramsar wetland types, ecosystem condition ratings and statutory conservation values in each representative wetland area

Attribute	(A) Eastern Banks seagrass & shoals	(B) Pumicestone Passage intertidal flats	(C) Southern Bay mangroves and saltmarsh	(D) Eastern Bay coral communities	(E) Moreton & North Stradbroke Is. freshwater wetlands	(F) Moreton Island ocean beaches and foredunes
Ramsar wetland types	B, E, F, G, H, I	B, D, E, F, G, H, I	B, D, E, F, G, H, I	B, C, F	M, N, O, Tp, Ts, W, Xf, Xp, U, Y	A, D , E
Ecosystem Condition[5]	• 'A to A-' (Excellent) • Excellent water quality • Intact natural habitats present; deep & stable seagrass & healthy and diverse coral in some parts • *Lyngbya* present	• 'B to C+' (Good) • Fair water quality, with generally poorer water quality in the northern reaches • Intact & stable natural habitats with extensive mangrove forests & stable seagrass meadows • *Lyngbya* present	• 'B- to D' (Good) • Fair to poor water quality, strongly influenced by floods • Shallow & unstable seagrass meadows in main channel closest to the coast but expansive meadows in Canaipa Passage • *Lyngbya* present	• Note – Following is for Eastern Bay, which includes reef areas. • ' A to A-' (Excellent) • Excellent water quality • Intact natural habitats remain; deep & stable seagrass and healthy & diverse coral in some parts • *Lyngbya* present	• No EHMP monitoring data	• No EHMP data. Based on adjacent habitats, excellent water quality expected throughout. • Intact natural habitats present including presence & usage by endangered & vulnerable shorebirds • Principle impact from Off Road Vehicle Usage
Statutory Conservation Zones						
High Ecological Value area[6]	E1B	PLE1, PLE1, PME1	Part – S1, B1	C1 (also incl. Waterloo Bay)	M1 (All Moreton Island) ST1A, ST1B (Part of North Stradbroke Is.)	E1C (coastal waters along northern Moreton Island & northern coastline of North Stradbroke Island)
Marine National Park (Draft)	Part – MNP14; MNP20	MNP02; MNP01	Part – MNP27; MNP26; MNP28; MNP29; MNP30	Part – MNP22	N/A	MNP05-07; MNP 16
National Park	N/A	N/A (adjacent to Bribie Island NP)	Southern Moreton Bay Islands NP	N/A (adjacent to Teerk Roo Ra (Peel Island) National Park)	Moreton Is. NP Blue Lake NP	Moreton Island National Park
Fish Habitat Area (FHA) [7]	Moreton Banks FHA; Amity-Myora Banks FHA	Pumicestone Channel FHA	Pimpama FHA; Coomera FHA; Jumpinpin-Broadwater FHA	Peel Island FHA; Amity-Myora Banks FHA	N/A	N/A
State Coastal Plan	State Significance (natural resources) – Significant Coastal Wetlands; Coastal Biodiversity	State Significance (natural resources) – Significant Coastal Wetlands; Significant Coastal Dunes; Coastal Biodiversity	State Significance (natural resources) – Significant Coastal Wetlands; Coastal Biodiversity	State Significance (natural resources) – Significant Coastal Wetlands; Coastal Biodiversity	State Significance (natural resources) – Significant Coastal Wetlands; Significant Coastal Dunes; Protected Areas etc.; Coastal Biodiversity	State Significance (natural resources) – Significant coastal dunes, wetlands; and coastal biodiversity

[5] Based on EHMP reporting – EHMP (2007) Report Card.
[6] Sub-zones outlined in plans within Schedule 1 of EPP Water - Moreton Bay, North Stradbroke, South Stradbroke, Moreton and Moreton Bay Islands Environmental Values and Water Quality Objectives published by the department in March 2007; Pumicestone Passage Environmental Values and Water Quality Objectives published by the department in March 2007
[7] See discussion in Beumer *et al*.. (1997). Declared Fish Habitat Areas in Queensland. Brisbane, DPI Fisheries.

A. Eastern Banks Seagrass and Shoals

Photo of *H. Ovalis* (Source: EPA photo library)

This area is located on the tidal delta west of South Passage, which extends from Moreton Island and North Stradbroke Island west and south west almost to Peel Island. The Eastern Banks area encompasses Coonungai, Boolong, Pelican, Chain, Maroom, Warragamba Banks; South Passage; Rous and Rainbow Channels; and the various gutters and passages within the shoal complex. Maxwell (1970) describes this area as *"…a large, complex system of banks and ridges separated by channels and re-entrants of 2-3 fathoms (~ 3.6 to 5.5 m) depth. It is flanked on the east and west by deeper water."*

These banks provide large areas of potential and actual seagrass habitat. Seagrass mapping undertaken by EHMP in 2004 indicates that the seagrass meaadows within this area represented the largest contiguous/semi-contiguous seagrass meadow in Moreton Bay. Most of the seagrass is comprised mainly of *Zostera muelleri, Halophila ovalis* and *H. spinulosa*. This seagrass provides an important food resource for green turtles and dugongs (Poiner *et al.* 1989; Marsh 1990; Abal *et al.* 1998; Dennison 2001).

Carruthers *et al.* (2002) proposed a number of generalised models of key seagrass processes and controls that vary across various biotopes, namely estuary, coastal, deepwater or reef. The wider eastern and northern Moreton Bay area supports potential coastal and deepwater seagrass habitat. In general terms, coastal habitats can be both intertidal and subtidal (depth <15m) and are primarily controlled by physical disturbance by waves and currents, while light availability is typically the dominant control on deepwater seagrass habitat (depth >15m) (Carruthers *et al.* 2002).

Seagrass distribution and extent is generally thought to be controlled by the following key processes (Edgar 2001; Carruthers *et al.* 2002):

- Physical Coastal Processes (waves and currents). Turbulent wave action and currents can result in physical disturbance of seagrass. Shallow, exposed banks tend to be exposed to greater wave turbulence (particularly during storms) than deeper, sheltered waters, and seagrass beds in shallow waters can be more patchy and comprised of species such as *Halophila ovalis*, which is capable of rapid re-colonisation (Rasheed 2004). The maintenance of suitable substrates for seagrass is also dependent on the maintenance of existing hydraulic and wave processes, and associated sediment transport regimes.

- Water Quality. Water quality conditions, particularly water clarity and concentrations of nutrients, also regulate seagrass distribution and extent (Young and Kirkman 1975; Dennison *et al.* 1993; Abal and Dennison 1996; Udy and Dennison 1998). Some species of *Halophila* are able to survive in areas with 5% surface light (Udy and Levy 2005). The Eastern Bay has low ambient turbidity and nutrient concentrations, reflecting the high degree of tidal flushing and limited influence of riverine discharges (EHMP 2006). This high water clarity allows seagrass to occur in deeper waters than in the more turbid southern and western Moreton Bay, with *Zostera* extending to 3 m (Seagrass Watch unpublished data) and *Halophila spinulosa* and *H. ovalis* occurring at water depths of 12 m (Dr James Udy unpublished data). In a recent survey (BMT WBM unpublished data) in northern Moreton Bay *H. ovalis* was found at depths of approximately 14m and 20m.

- Energy and Nutrient Dynamics. This section of the study area has characteristically low rates of phytoplankton productivity, reflecting the low nutrient status of waters. Seagrass represents a key primary producer in this area.

- Grazing. Grazing by dugongs and green turtles also has a major influence on seagrass communities, by altering species composition, distribution and sediment nutrient cycling processes (Perry 1997; Aragones and Marsh 2000). Grazing of benthic invertebrates by loggerhead turtles (Preen 1996) and fish (including rays) also results in the disturbance of bed sediments, altering sediment-nutrient patterns and processes. Grazing results in increased sediment aeration, burial of detritus, and increased sulfate reduction and nitrogen fixation (Perry 1997). Areas grazed by dugongs typically can also have lower shoot biomass but higher productivity than ungrazed areas (Perry 1997). Given the high densities of dugong and turtles within the Amity/Eastern Banks area (Lanyon 1997), grazing is likely to be a significant control on ecosystem functioning in this area.

- Other Biological Processes. A wide range of biological processes are important to the maintenance of ecosystem functions and values, including growth and reproduction, use of the site as a nursery habitat, recruitment, feeding and predation. No studies to date have assessed the relative importance of these processes in regulating marine flora and fauna communities within this section of the site (see Section 3 of the report for a general discussion).

Together with limited ongoing anthropogenic disturbances, these and other patterns and processes together maintain extensive, 'healthy' seagrass meadows within the Eastern Banks area. Table 7-5 summarises the key attributes of this critical service.

The primary value of this feature for shorebirds is linked to the intertidal exposure of sandbanks which roost opportunities in close proximity to large areas of feeding intertidal habitat on the south-western side of Moreton Island and those along the north-western side of North Stradbroke Island. The relatively large feeding grounds, which include exposed seagrass, may be particularly important for species such as Eastern Curlew, Bar-tailed Godwit and Grey-tailed Tattler.

A conceptual model of this key reference habitat is shown in Figure 7-1.

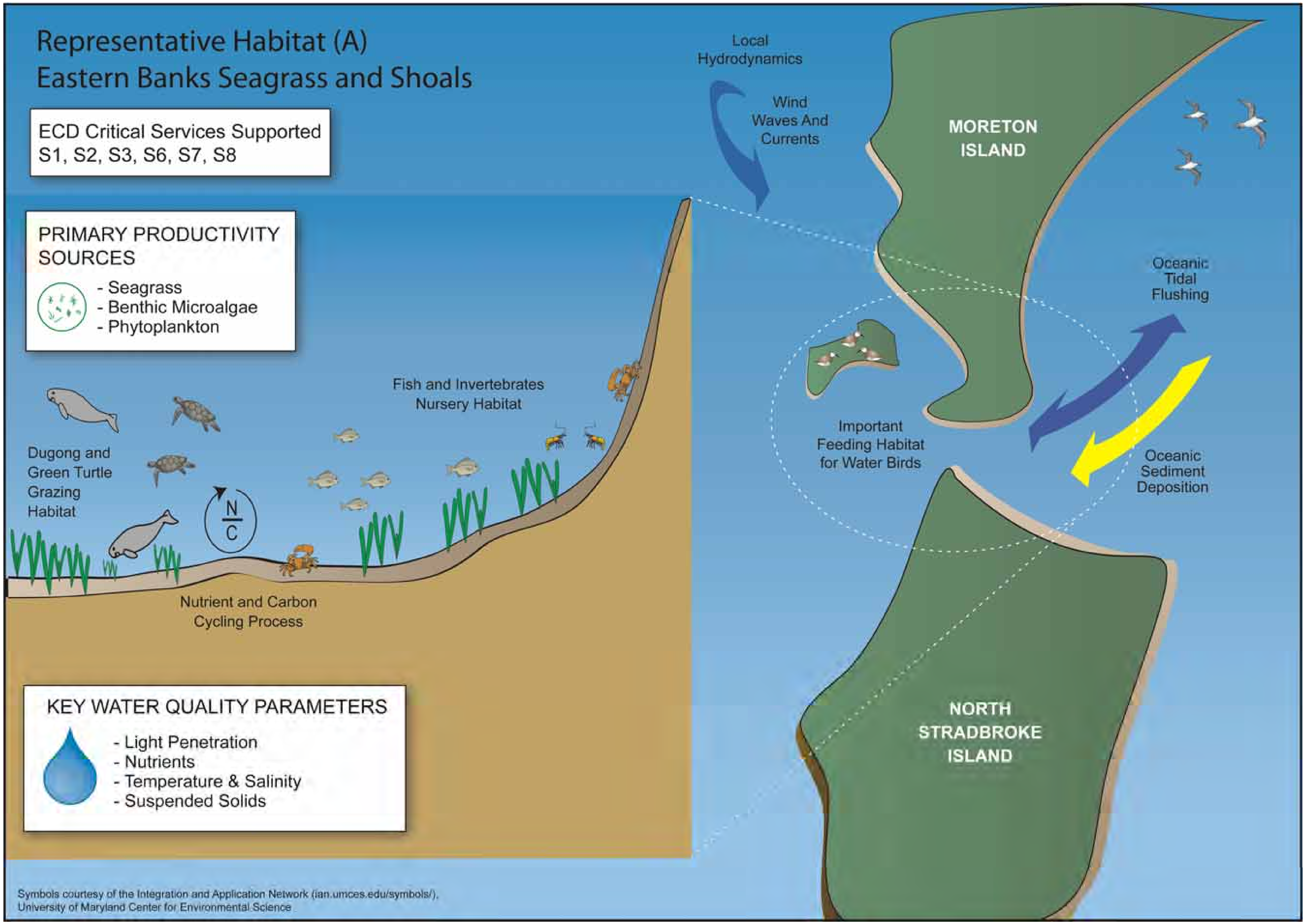


Figure 7-1 Conceptual Model of Eastern Banks

Table 7-5 Critical Service 2A - Eastern Banks Seagrass & Shoals

Summary Table	**Critical Service (S2A)**
Reason for Inclusion	Representative near-natural reference site for shoals and coastal/deepwater seagrass. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Eastern Banks area in eastern Moreton Bay
Critical habitat components underpinning this service	Seagrass; shoals
Critical species underpinning this service	See S3 (dugongs, turtles)
Critical processes underpinning this service	• Currents and waves • Turbidity and water quality • Nutrient cycling • Grazing • Other biological processes (growth, reproduction, nursery habitat, predation, feeding, recruitment)
Natural Variability (if relevant)	Seagrass – No major changes in distribution, extent and structure are known to have occurred in the last 5 years. Long-term changes unknown. Possible cyclic, seasonal changes in distribution and extent due to seasonal changes in wind patterns. Episodic catastrophic storms may also lead to short-term reductions in seagrass cover.
Principal threats	Activities that alter water quality, particularly nutrients, algal biomass and turbidity.
Data quality underpinning this critical service	Level 1-2 - based on Seagrass Watch cover data, seagrass mapping data (EHMP 2004; (Hyland *et al.* 1989); SDR data (EHMP monitoring)
Information gaps	More systematic information is required on background variability in wetland habitat extent and linkages to controlling processes. Note inconsistencies in mapping techniques prevent direct comparisons between existing data-sets, and therefore long-term changes in seagrass.
Recommended monitoring	Examination of long-term changes in seagrass based on aerial photograph interpretation and review of existing information Additional EHMP/Seagrass Watch monitoring sites in representative areas subject to different wind/waves regimes.

B. Pumicestone Passage Tidal Flats and associated Estuarine Wetland Assemblages

Photo of intertidal flats in the vicinity of Pumicestone Passage (Source: BMT WBM photo library)

Pumicestone Passage is a narrow passage-type estuary that separates the mainland and Bribie Island and contains a wide diversity of estuarine wetland habitat types that are generally considered to be in 'good' condition. Pumicestone Passage is a relatively shallow waterbody (<2 m deep at Mean Sea Level for >80% of its area, QDEH 1993), which supports shallow sub-tidal sandy channels, intertidal flats (both with and without seagrass), and fringing mangrove, saltmarsh and freshwater/brackish wetland communities. It is one of four major passage-type estuaries in Queensland (Queensland Department of Environment and Heritage 1993).

The distribution, extent and configuration of structural habitats present in the Passage are ultimately controlled by geomorphologic processes operating over a range of time scales. Contemporary hydraulic (i.e. tidal forces, groundwater and pulsed stream flow events) and sedimentary processes also interact to regulate local conditions, for example:

- sedimentary processes that configure creek and channel mouth deltas. There is a tendency for sediment deposition at the mouth of tributary creeks during the dry season and scouring during flood events. Sand bar formation processes and patterns at the entrances of the Passage are a function of entrance morphology, tidal and freshwater discharge velocities and oceanic swell patterns near the mouths (Queensland Department of Environment and Heritage 1993). An extensive sand bar occurs at the northern entrance (near Caloundra) due to low tidal discharge, exposure to oceanic swell and shallow depths. The southern entrance does not contain an extensive bar system due to stronger tidal currents, its greater width and depth, and protection from swells;

- sedimentary processes that configure the extent and distribution of shoals and channels, and sediment characteristics. Sediment loading on the Passage is a function of oceanic process (tidal inflows and waves), which dominate at the entrances of the Passage, and tributary discharges. The entrances are comprised predominantly of fine to coarse sands, which are predominantly of marine origin, whereas finer silts and clays derived from fluvial sources dominate further up the estuary (Queensland DEH 1993);

- the frequency and extent of tidal inundation, which together with the competing influence of freshwater inflows, controls the extent and distribution of littoral wetland components (i.e. mangroves, saltmarsh, freshwater wetlands, seagrass, benthic algae etc.);
- tidal flushing and associated water quality characteristics of estuarine waters. The average nett tidal flow in the passage is in a northerly direction, although currents also run in a southerly direction, discharging into Deception Bay (WBM 2005). Residence/flushing (E-folding) times within the passage are estimated to be in the order of days at the south end, and up to 4 to 6 weeks through the middle sections of the Passage (WBM 2005). Tidal exchange at the northern entrance is curtailed by the oceanic sand bar at the mouth of the Passage (Queensland Department of Environment and Heritage 1993); and
- biogeochemical cycles within sediments and overlying waters.

The physico-chemical characteristics of waters (water quality), which are in part controlled by hydraulic processes, is a key control on wetland ecology. EHMP (2007) noted that water quality within the Passage was degraded in places, with generally poorer quality water (higher nutrients and turbidity) in the northern and central reaches compared with the southern reaches. Several small creeks discharge into the Passage, which are known to contain high levels of nitrogen, sediments and tannins, and are considered to be of ‘fair’ quality (EHMP 2007).

Turbidity is a particularly important control, particularly in terms of regulating the depth distribution and extent of seagrass, macroalgae and micro-phytobenthos. Less well known are the direct physiological and behavioural effects of turbidity on aquatic fauna (e.g. fish larvae behaviour to turbid waters, reduced predation success, interference of feeding efficiencies of filter feeders etc.). Turbidity within western Moreton Bay, and most likely Pumicestone Passage, is controlled by re-suspension of sediments by waves and currents, pulses of turbid freshwater inflows, and to a lesser extent, phytoplankton biomass.

Nutrients also represent a stressor, with slightly elevated TN, TP and chlorophyll *a* concentrations recorded within the Passage. Nutrient loading regimes are linked to transportation, deposition and resuspension of particulate material. Nutrient sources include Deception Bay, which is the receiving waters for the Caboolture River and other sources, stormwater runoff from the adjacent catchment, oceanic inputs, groundwater inflows, sediment fluxes and a range of point sources including wastewater treatment plants, gravel washing plants etc.

Important biogenic habitat components include littoral freshwater wetlands, saltmarsh, mangroves, seagrass and microalgae. The 2007 EHMP report card (EHMP 2007) describes Pumicestone Passage as containing *‘intact and stable natural habitats throughout with extensive mangrove forests and stable seagrass meadows’.* The degree of ‘stability’ in seagrass and mangroves over longer timescales (timescales measured in 10’s of years) than assessed by EHMP has not been quantified and requires further investigation.

In terms of spatial distribution of seagrass, the most recent broad scale data comes from EHMP 2004, which was derived from a survey conducted in Autumn 2002 *Zostera muelleri (=capricorni)* was the most abundant and widespread species, followed by *Halophila ovalis.* In the southern region of the Passage *Halophila spinulosa* was recorded, together with a small meadow of *Cymodocea serrulata*. The total area of seagrass within the Passage was ~1200ha, with the most extensive meadows located at Tripcony Bight and the south-western intertidal areas of the Passage. Seagrass cover was low (sparse cover of *H. ovalis*) in the area north of Tripcony Bight, possibly reflecting poorer water clarity. The average maximum seagrass depth was approximately 1m. To the south of Pumicestone Passage in Deception Bay there has been an almost complete loss of seagrass in the last decade (Abal *et al.* 1998), as a result of high turbidity and *Lyngbya* blooms (EHMP 2007).

As discussed in Critical Service 3 (see next section), the deeper water in southern Pumicestone Passage is thought to be an important year-round dugong habitat (Lanyon 1997; Lanyon *et al.* 2005). Grazing by dugongs is likely to influence seagrass communities, in much the same way as discussed above for the Eastern Banks. In terms of maintenance of reference habitat values, the other most notable biological processes are likely to be growth and reproduction of littoral vegetation (mangroves, saltmarsh, freshwater wetlands), seagrasses, phytoplankton and benthic microalgae.

The extensive tidal flats in the Pumicestone area also represent important estuarine wetland habitats for waterbirds and other important wetland fauna as described in Critical Services 4 and 6.

A conceptual model for this critical habitat is shown in Figure 7-2. Table 7-6 summarises the key attributes of this critical service.

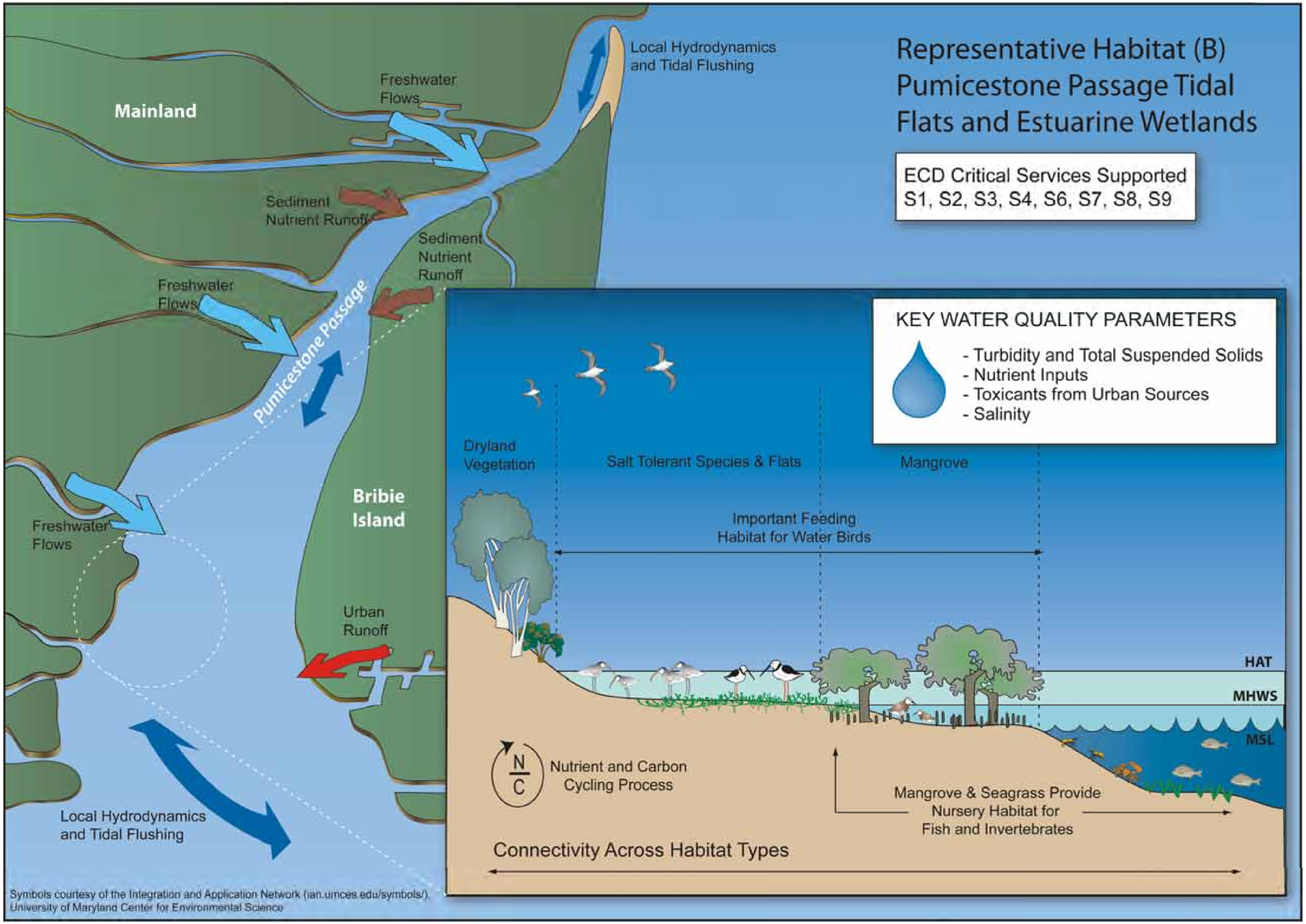
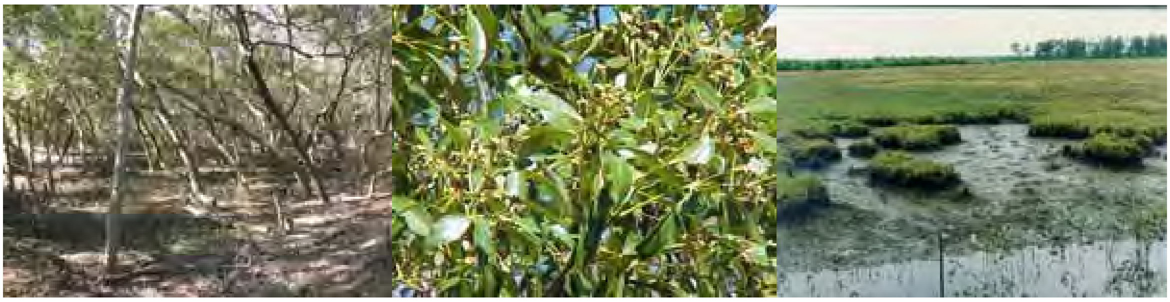


Figure 7-2 Conceptual Model of Pumicestone Passage Flats and Estuarine Wetland Assemblages

Table 7-6 Critical Service 2B - Pumicestone Passage Tidal Flats and Estuarine Wetland Assemblages

Summary Table	Critical Service (S2B)
Reason for Inclusion	Representative near-natural reference site for nearshore tidal flats and adjacent vegetated habitats such as seagrass. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Pumicestone Passage is located in north-western Moreton Bay
Critical habitat components underpinning this service	Intertidal flats and shoals; seagrass
Critical species underpinning this service	See S3 (dugongs, turtles), S4 (wetland dependant terrestrial fauna) and S6 (shorebirds)
Critical processes underpinning this service	Currents and natural coastal processes Hydrology/freshwater flows Water and sediment quality (turbidity and nutrient cycling) Other biological processes (growth and reproduction of marginal freshwater assemblages, mangroves, saltmarsh, seagrasses and algae)
Natural Variability (if relevant)	Flats and Shoals – No data available to assess changes in distribution and extent Seagrass – Based on EHMP data, no major changes in distribution, extent and structure of seagrass communities are known to have occurred in the last 5-10 years. Long-term changes unknown. Possible cyclic, seasonal changes in distribution and extent due to seasonal changes in wind patterns and freshwater flows. Episodic catastrophic storms may also lead to short-term reductions in seagrass cover.
Principal threats	Land use activities that alter water quality, particularly nutrients, algal biomass and turbidity.
Data quality underpinning this critical service	Level 1-2 - semi-quantitative based on Seagrass Watch data, seagrass mapping data (EHMP 2004; (Hyland *et al.* 1989).
Information gaps	More systematic information is required on background variability in seagrass habitat extent and linkages to controlling processes. See notes for Eastern Banks (Table 7-5)
Recommended monitoring	Examination of long-term changes in seagrass based on aerial photograph interpretation and review of existing information Examination of long-term changes in tidal flat extent (particularly in terms of impacts from sea level rise)

C. Southern Bay Mangroves and Saltmarsh



Photos of grey mangrove/saltmarsh environments in the Moreton Bay region (Source: BMT WBM photo library)

Southern Moreton Bay is bounded in the east by the dune-island barriers of North and South Stradbroke Islands, and low-lying fluvial dominated coastal plain and mangrove islands to the west. The central and eastern sections of southern Moreton Bay contain a complex network of mangroves and saltmarsh on low-lying silt and sand islands interspersed by tidal channels. These features represent important estuarine wetland habitats for wader birds and species of direct fisheries significance.

The geomorphologic processes that maintain mangrove-colonised islands in the Southern Bay vary spatially, and over a range of time scales (geological to years) (Lockhart *et al.* 1998). Fluvial deposits from the Logan River, together with some inputs of marine sands, have formed a bayhead delta with a series of associated islands. These islands have been colonised by mangroves, which have increased in extent in recent decades (Lockhart *et al.* 1998). The relict Jumpinpin flood-tide delta to the south also contains a series of mangrove-colonised mud and sand islands. The relict delta has a marine origin, whereas fluvial deposits in this area are predominantly restricted to the mouths of the Logan, Coomera and Pimpama Rivers (Lockhart *et al.* 1998). These fluvial-dominated river mouth environments also contain large areas of mangroves.

Hydraulic processes (tides, waves and freshwater flows) control, and are controlled by, geomorphologic processes and patterns. These patterns are described in Section 3. The distribution of mangroves and saltmarshes is ultimately determined by patterns of tidal inundation. Since the opening of the Jumpinpin Bar in 1898, tidal levels within the Southern Bay are relatively similar to those experienced in the ocean. An increase in sea levels would be expected to result in a retreat in the seaward extent of mangroves, and possible loss of mangroves on low-lying islands if sedimentation rates are lower than the rate of rise.

Mapping of mangroves based on aerial photography from 1944, 1987 and 1997 indicated that the mangrove areas associated with the Coomera and Pimpama Rivers have been markedly influenced by agricultural practices and changes to hydraulic regimes (WBM 2001). Approximately 1043 hectares of mangroves were mapped in the Coomera/Pimpama Rivers region in 1944, compared to 1241 hectares in 1997. Increases in mangrove area have occurred mostly on Coomera and Woogoompah Islands, with a general movement of mangroves landward. The trend of mangroves becoming established in more landward regions is probably related to alterations in the tidal regime of the region associated with the opening of the Jumpinpin Bar. Davie (pers. comm. in WBM 2001) notes that mangroves have been, and are presently, replacing saltmarsh and paperbark communities and that an equilibrium has apparently not occurred.

Mangrove losses in the area since 1944 totalled 60 hectares, and were all recorded between 1987 and 1997. All losses were associated with clearing, with the largest loss recorded in the upper Pimpama River (49 hectares). No data are available to assess changes in saltmarsh extent in this area.

In Moreton Bay in general, there has been a loss of saltmarsh vegetation of ~3051 ha between 1974 and 2002, most of which has been due to filling and reclamation works (Centre for Marine Studies 2006).

Mangroves and saltmarshes are not particularly sensitive to water quality modifications, although changes in the supply of suspended sediments can affect depositional patterns and habitat availability for mangroves.

The freshwater flow requirements of mangroves are not well understood. Freshwater pulses are thought to represent a source of sediment (and nutrients) required to maintain mangrove and saltmarsh habitat. In response to physiological tolerances and species interactions, freshwater inputs can also influence vertical 'zonation' patterns of saltmarsh species and may also control horizontal zonation patterns of mangroves (ie. replacement of *Avicennia* by *Aegiceras* in upstream areas).

A reduction in freshwater flows can also lead to higher ambient salinities in rivers, possibly leading to the upstream expansion of mangroves in rivers that do not have a tidal barrage, and possible loss of saltmarsh.

Figure 7-3 shows a conceptual model of this critical reference habitat. Table 7-7 summarises the key attributes of this critical service.

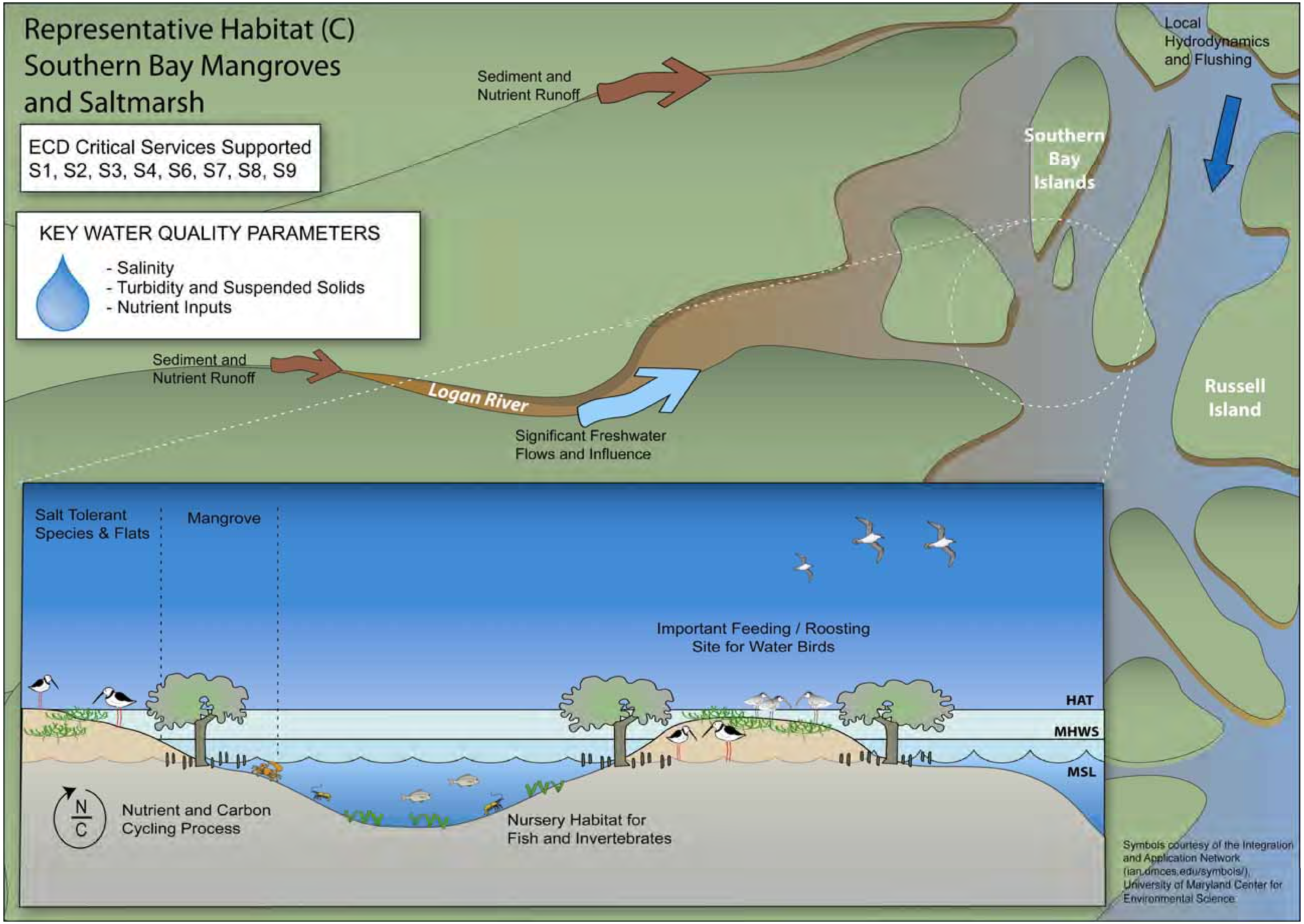


Figure 7-3 Conceptual Model of Southern Bay Mangroves and Saltmarsh

Table 7-7 Critical Service 2C - Southern Bay Mangroves and Saltmarsh

Summary Table	Critical Service (S2C)
Reason for Inclusion	Representative near-natural reference site for mangroves and saltmarsh communities. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Southern Moreton Bay
Critical habitat components underpinning this service	Mainland littoral habitats, mangrove-colonised islands
Critical species underpinning this service	Mangrove and saltmarsh species
Critical processes underpinning this service	Tidal hydraulics – currents, waves and sea level rise Freshwater flows – Source and delivery of sediment Physical (geomorphologic) coastal processes that maintain mangrove islands Energy and nutrient dynamics Other biological processes (growth, reproduction, recruitment, and possibly competition?)
Natural Variability (if relevant)	Mangrove losses reported following storms No studies have examined broad-scale changes in mangrove extent across the Southern Moreton Bay area. Large increases in mangrove extent were recorded in the Pimpama and Coomera catchments associated with changed agricultural practices and tidal inundation patterns over the last 60 years (WBM 2001). Landward increases in mangrove extent have resulted in the loss of saltmarsh in many areas within the Pimpama and Coomera catchments. Overall, there has been a large reduction in saltmarsh over the last 50 years as outlined in the text above in the Southern Moreton Bay area from a range of natural and anthropogenic factors.
Principal threats	Mangroves/saltmarsh - Clearing; reclamation and filling; and sea-level rise; Competition between species types. The combination of sea level rise with limited coastal land area for saltmarsh migration places these habitats at particular risk.
Data quality underpinning this critical service	Level 1-3 (Dowling 1986; Hyland and Butler 1989; WBM 2001; EPA 2005a)
Information gaps	More systematic information is required on background variability in mangrove and saltmarsh habitat extent and linkages to controlling processes.
Recommended monitoring	Examination of long-term changes in mangroves and saltmarsh based on aerial photograph interpretation and review of existing information

D. Eastern Bay Coral Reef Communities

Photo of typical coral reef flat in Central Moreton Bay (Source: BMT WBM photo library)

Coral communities occur on relict carbonate (coral) reefs throughout the Moreton Bay. The coral communities of Eastern Moreton Bay, namely northwest Peel Island, Goat Island, Bird Island, Myora Reef and Lazaret Gutter, are considered to be in near natural condition.

Living corals form a thin veneer over predominantly unconsolidated Holocene carbonate deposits that are interspersed patches of soft sediment and seagrass. The seaward edge of hard corals is delineated by the edge of hard substrate (Harrison *et al.* 1991), which typically occurs in water depths <3 m (Lovell 1975). The upper limit of corals typically occurs in the upper subtidal zone, but may occasionally extend into the lower intertidal zone (Johnson and Neil 1998b).

Tidal exchange through South Passage, and then Rainbow and Rous channels, dominates flow movement around the Peel Island reefs. Tidal flows maintain relatively clear, nutrient poor waters at these reefs (EHMP 2007), which is essential to the maintenance of corals and many other reef species. Oceanic exchange through South Passage is also thought to be important in the dispersal of larvae among reefs (Harrison *et al.* 1998), but is not thought to have a major influence of sea surface temperatures in the Bay (Johnson and Neil 1998a,b). The wide variability in sea surface temperatures within the Bay (compared to oceanic waters) is thought to prevent the colonisation of many coral species found in the wider region (Johnson and Neil 1998a,b).

Peel Island receives limited fluvial sediment inputs and has lower proportion of fine sediment material compared to Western Bay reefs (Johnson and Neil 1998a,b). However, re-suspension of fine sediments by wind, particularly during the summer months, can increase turbidity and sedimentation rates at these reef sites (Johnson and Neil 1998a,b). Major flood events, which result in reduced salinity and high turbidity, can also result in coral mortality on these reefs. However, floods are not thought to be a major determinant of spatial patterns in coral community structure within the Bay (Johnson and Neil 1998a,b).

Reef communities in this section of the Bay are numerically dominated by bare substrate, hard coral. Macroalgae cover is relatively low, in contrast to reef communities in the Western Bay (Harrison *et al.*

1991; Harrison *et al.* 1995; EHMP 2006). The actual controls on reef community structure have not been examined to date. However, grazing (e.g. by sea urchins), inter-species competition and possibly nutrient availability, could have a strong influence on these spatial patterns of macroalgae and other reef components. In order to develop LAC, further work is required to assess the proximal controls of reef communities, and the spatial and temporal scales at which that these controls operate.

Figure 7-4 shows a conceptual model of this critical reference habitat. Table 7-8 summarises the key attributes of this critical service.

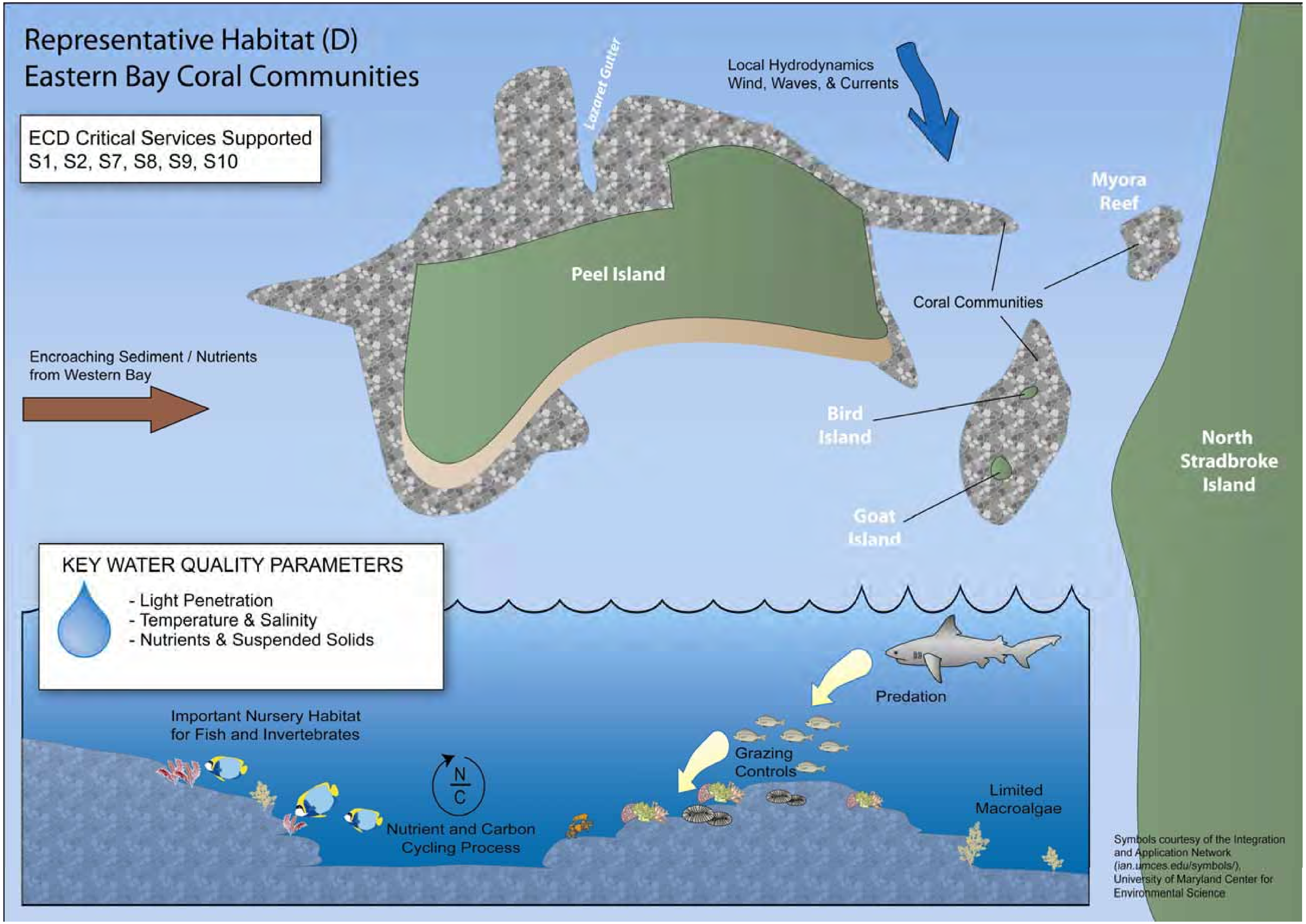


Figure 7-4 Conceptual Model of Coral Reef Communities

Table 7-8 Critical Service 2D - Eastern Bay Coral Reef Communities

Summary Table	**Critical Service (S2D)**
Reason for Inclusion	Representative near-natural reference site for coral reef communities. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Eastern Moreton Bay, including northwest Peel Island, Goat Island, Bird Island, Myora Reef and Lazaret Gutter
Critical habitat components underpinning this service	Coral reef
Critical species underpinning this service	Coral reef associated flora and fauna
Critical processes underpinning this service	Physical Coastal Processes (Currents and waves) Water quality (particularly turbidity and nutrients, but also toxicants, salinity and nutrient cycling processes) Grazing Other biological processes
Natural Variability (if relevant)	No major changes in distribution, extent and structure are known to have occurred in the last 5-10 years. Long-term changes unknown. Possible cyclic, seasonal changes in distribution and extent due to seasonal changes in wind patterns. Episodic catastrophic storms may also lead to short-term reductions in some reef flora and fauna.
Principal threats	Activities that alter water quality, particularly nutrients, algal biomass and turbidity.
Data quality underpinning this critical element	Level 1-2 - based on EHMP monitoring data and previous reef surveys (Harrison *et al*. 1991; Harrison *et al*. 1995)
Information gaps	More systematic information is required to assess background variability in coral reef community structure and linkages to controlling processes.
Recommended monitoring	Additional EHMP monitoring sites in representative areas subject to different wind/waves regimes. Monitoring of coral growth (individual colonies) over time.

E. Freshwater Wetlands of North Stradbroke and Moreton Islands

Photo of Blue Lake overflow creek on North Stradbroke Island (Source: BMT WBM photo library)

The Moreton Bay Ramsar site includes several near natural freshwater wetlands on Moreton and North Stradbroke Islands. A list of wetland types and key representative examples of each type are provided in Table 7-9. Several wetland habitat types are represented, as described below. Table 7-10 summarises the key attributes of this critical service.

Lacustrine wetlands (lakes)

These include both perched lakes and water table window lakes.

Perched lakes are fed by seepage from a perched aquifer system that has formed above relatively shallow sand layers, has a low permeability and which lie above the regional water-table. These waterbodies typically have distinctive water quality characteristics including (Kalf 1998):

- brown coloured water and associated with this, a shallow euphotic zone;
- low dissolved oxygen levels near the lake bed;
- low pH resulting from accumulation of humic material in the water;
- low to moderate concentrations of bio-available nutrients (dystrophic conditions); and
- variable water levels depending on the amount of rainfall, evaporation and seepage through the perching layer.

Perched lakes are the most common lake type on both islands.

Water-table window lakes form between dunes in depressions that extend at or below the upper surface of the regional water-table. Water quality and hydraulic characteristics typical of water-table window lakes include (Kalf 1998):

- high water clarity;
- low electrical conductivity, dominated by sodium and chloride ions;
- high transparency;
- slightly acidic pH;
- low nutrient concentration and productivity (oligotrophic conditions), with low levels of organic matter; and
- relatively constant water levels.

Blue Lake on North Stradbroke Island and Blue Lagoon on Moreton Island are examples of water table window lakes. Note that recent hydraulic and environmental investigations by DNRW suggest that Blue Lake is not entirely fed by regional water table, but instead is partially perched above the regional aquifer.

Palustrine (marshes and freshwater peat swamps)

Palustrine wetlands are natural low-lying areas from which groundwater emerges above the ground surface level. Hydrology, morphology and water quality processes may vary greatly among wetlands. Some palustrine wetlands, such as Eighteen Mile Swamp and most wetlands on the northern and western sides of North Stradbroke Island, are predominantly fed by the regional groundwater table, and therefore have water quality and hydrological characteristics that are similar to water table window lakes. Palustrine wetlands that are contiguous with nearby perched lakes are often fed by the local groundwater table of the perched lake. From a hydrological perspective, these wetlands are analogous to perched lakes, but are typically shallower and have a higher vegetation cover than lakes (e.g. sections of Ibis Lagoon, Mugaree and Jaragill Lagoons on North Stradbroke Island).

Freshwater Creeks

There are three basic types of creeks and drainages on Moreton and North Stradbroke Island:

- Coastal drainages, which are drainages with a defined channel that discharge directly into the sea. The largest of these watercourses on North Stradbroke Island is Freshwater Creek, which discharges through Eighteen Mile Swamp and ultimately to Swan Lagoon at the southern end of the island. On the western side of North Stradbroke Island, Laycock (1975) noted that stream flows occur to the north of Dunwich in Aranarawai Creek, Cooroon Cooroonpah Creek, Campebah Creek, Myora Springs, Yerrol Creek, and One Mile Creek. Similarly to the south of Dunwich stream flows occur to Canalpin Creek, Little Canalpin Creek and several other smaller, unnamed creeks.
- Coastal seeps are groundwater expressions that do not have a defined channel which discharge directly into the sea. Several seeps occur on the west coast of North Stradbroke Island, such as those associated with the Canalpin Swamp system.

- Internal drainages. These are creeks and drainages that flow into and out of wetlands and lakes. The most notable example on North Stradbroke Island is the Blue Lake Overflow. Several other internal drainages are also associated with perched lakes and palustrine wetlands.

Important Wetland Controls

Geomorphologic processes (and associated aeolian and to a lesser extent hydraulic processes), mostly operating over geological timescales, control such factors as landform and waterbody configuration, elevation and drainage patterns (Benussi 1975; Heidecker 1984). This in turn controls patterns in connectivity and among waterbodies, and associated with this patterns in the genetic exchange, generic diversity, species composition, and species richness of waterbodies (Page *et al*. 2006). For example, the presence of a high sand ridge separating the eastern and western sides of North Stradbroke Island, together with a higher degree of interconnectivity between waterbodies on the east side of the island (i.e. Eighteen Mile Swamp complex), are thought to explain differences in fish populations and communities between these areas.

- Climate, rainfall and groundwater hydrology. These wetlands are groundwater dependent ecosystems. The key processes and patterns that control wetland hydrological characteristics are rainfall (and hence regional climate), evaporation, infiltration, groundwater flows, and in some creeks (e.g. Blue Lake Overflow, Little Canalpin Creek, Spitfire Creek), surface expression of groundwater. All freshwater waterbodies are fed by groundwater exfiltration, with the degree of influence of the regional versus the local groundwater table dependent on whether the waterbody is 'perched' above the regional groundwater table (Laycock 1975; Lee-Manwar *et al.* 1980; James 1984). Eighteen Mile Swamp on North Stradbroke Island and Blue Lagoon on Moreton Island represent surface water expressions of the regional groundwater table, although local perched waterbodies may also exist. Blue Lake is also fed by the regional watertable, but in contrast to previous views (Lee-Manwar *et al.* 1980), also has its own perched layer, and is therefore considered a semi-perched lake (DNRW unpublished data).

- Water chemistry. The physico-chemical properties of waters are controlled mainly by soil properties, rainfall, groundwater processes and surface-groundwater interactions. *In-situ* cycling of nutrients is also important in perched lakes with a bed comprised of humic material, whereas interactions between tidal processes and freshwater flows influence the water quality characteristics of many coastal seeps, creeks and palustrine wetlands. These properties exert a strong influence on resident aquatic fauna and flora communities and key ecosystem patterns and processes. In particular:

- Clear, dystrophic[8] waters that characterise water-table window lakes and palustrine wetlands have flora and fauna communities that are distinctly different from those found in tannin-stained, humic perched lake systems (Bayly 1964; Bensink and Burton 1975; Arthington 1984);

- Water chemistry, particularly low pH, humic waters, provide habitats for several species that are uniquely adapted to such conditions e.g. Oxleyan pygmy perch (Arthington 1996), the zooplankter *Calamoecia tasmanica* (Timms 1982), several dragonfly (Arthington and Watson 1982) and caddisfly species (Neboiss 1978), and 'acid' frogs (Ingram and Corben 1975).

[8] tannin stained, humic

- Rainfall patterns and groundwater flows have a profound influence on dissolved oxygen concentrations of certain creeks (e.g. Little Canalpin Creek) and wetlands. Rainfall and groundwater processes also control concentrations of dissolved and particulate iron, which can influence habitat structure in some areas due to the creation of a layer of iron 'flocs' on the lake bed.

- Fire regimes. Fire regimes play an important role in the life cycle of many plant species, and consequently exert a strong influence on wetland vegetation (e.g. Gill 1981). Reproductive mechanisms of vegetation that are dependent on fire include promotion of germination, triggering of seed release and stimulation of flowering, as well as promotion of vegetative sprouting; while key processes include the influence of fire over nutrient availability and opening up of the canopy. Changes to fire regimes over time, primarily post European-settlement, may result in changes in vegetation community structure (see Fensham 1997; Watson 2001), although the extent to which modified fire regimes have altered the community structure of Bay island wetlands has not been comprehensively addressed. Fire is a particularly acute threat to peatland wetlands as these systems either cannot or are extremely slow to regenerate following a fire event. The risk of fire is exacerbated during periods of lowered groundwater levels.

- Soil types, including the age of underlying sand deposits, also directly control wetland vegetation communities. Smaller scale heterogeneities arise from variations in topography and elevation, the layering of new soil horizons and the mosaic of past and contemporary fire regimes (Westman 1975). Many of these controlling elements are interrelated. For example, soils in gullies are often deeper and richer in nutrients when compared to soils along slopes.

Wetland habitats of both islands are largely undisturbed. Past sand mining activities have resulted in localised, but long-term modifications to the landscape (and waterbodies) of several wetlands. This includes the creation of a Lacustrine system (i.e. Keyholes and Yarraman Lakes) within the Eighteen Mile Swamp complex, which are located outside the boundaries of the Ramsar site. Water extraction also occurs from the Eighteen Mile Swamp system to supplement the Redland Shire water supply, as well as to supply water for sand mining operations on the island.

Figure 7-5 shows a conceptual model of these freshwater wetland reference habitats. Table 7-10 contains a summary of the critical service attributes.

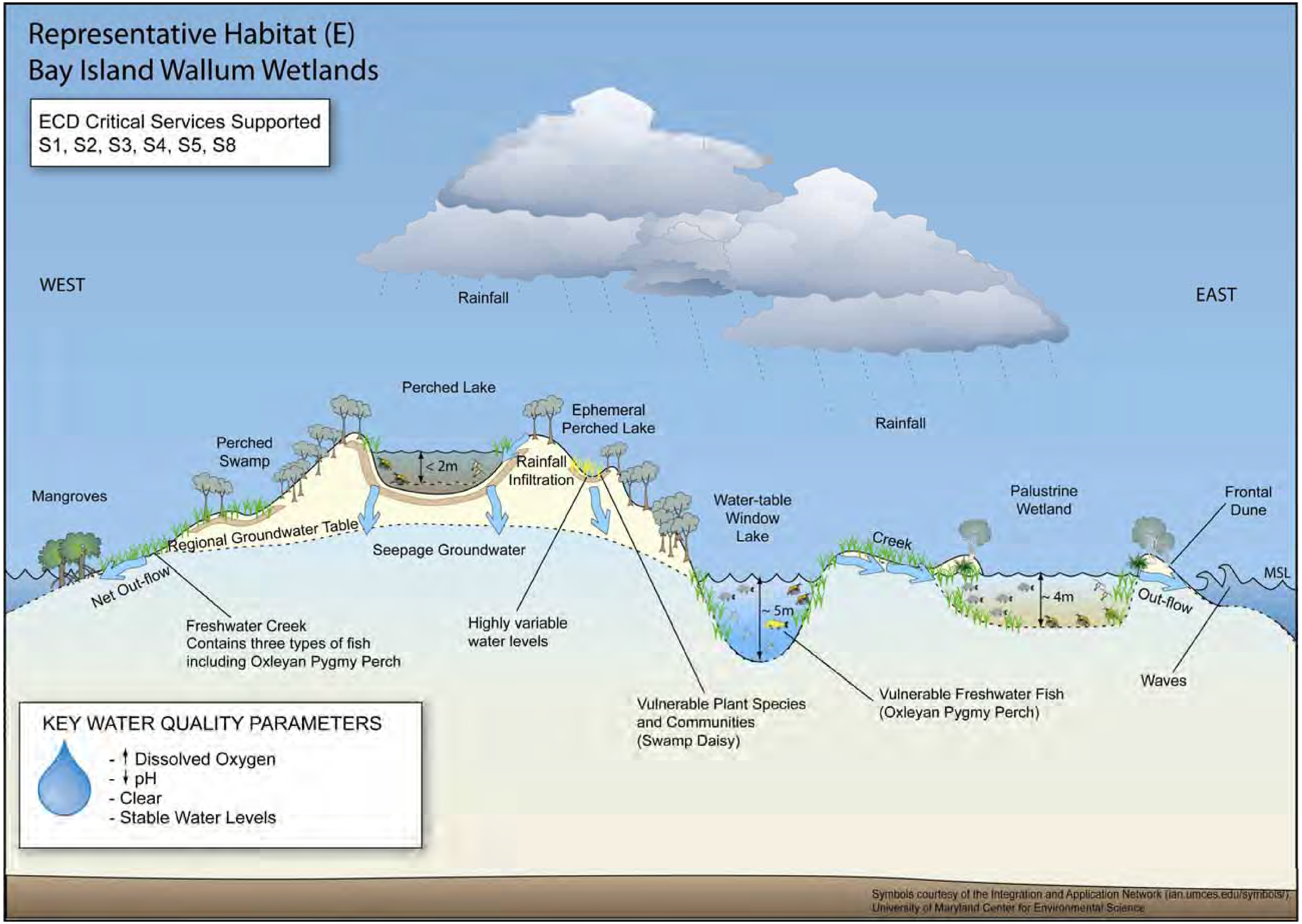


Figure 7-5 Conceptual Model of Bay Island Wallum

Table 7-9 Key examples of freshwater wetland types

Major wetland type (EPA)	Wetland sub-type	Ramsar types	Notable examples:	
			Moreton Is.	**N. Stradbroke Is.**
Lacustrine	Perched lakes	K – Coastal freshwater lagoon O – Permanent f/w lakes (>8ha) P – Seasonal f/w lakes (>8 ha) Also found in association with: M – Permanent creeks N – Intermittent creeks Tp – Permanent f/w marshes/ pools on inorganic soils Ts – Intermittent marshes/ pools on inorganic soils U – Non-forested peatlands W – Shrub-dominated wetlands Xf – F/w, tree-dominated wetlands Xp – Forested peatlands Y – Freshwater springs	Jabiru Lake; Mirapool Lagoon; Honeyeater Lake	Welsby; Tortoise; Blaksley; Shag; Black Snake; Ibis; Tea Tree; Native Companion; Duck; and South Lagoons
	Water table window lakes	O and K, also associated with M, N, Tp, Ts, U, Xf, Xp, Y	Blue Lagoon	Blue Lake
Freshwater Creeks	Coastal drainages	M, N. Also see types cross-referenced above	Eagers, Craven's & Spitfire, Ben-Ewa Creeks; Drainages associated with Jabiru Swamp	Freshwater Creek (Eighteen Mile Swamp); North-western drainages: Aranarawai, Cooroon Cooroonpah, Campebah Creek, Yerrol, One Mile Creeks; Myora Springs. South-western drainages: Little Canalpin & Canalpin Creek, Creeks; numerous small, unnamed creeks.

Major wetland type (EPA)	Wetland sub-type	Ramsar types	Notable examples: Moreton Is.	Notable examples: N. Stradbroke Is.
	Coastal seeps	Y. Also see types cross-referenced above	Unnamed seeps associated with major swamp systems	
	Internal drainages	M, N. Also see types cross-referenced above	Cowan; Shrapnel; Monash Gullys	Blue Lake Overflow and unnamed inflow drainages; Unnamed drainages at Brown Lake.
Palustrine	Peat marshes, fed by either perched lakes, regional watertable or freshwater creeks	M, N, Tp, Ts, U, W, Xf, Xp, Y	Bulwer (Comboyuro to Cowan Cowan); Eagers and Jabiru Swamps	Eighteen Mile; Flinders Beach; Amity; Kounpee; Canalpin; Little Canalpin; Horseshoe Swamps
	Groundwater dependent woodlands, forests & shrublands. Includes Casuarina woodland; Woodland/open forest of Casuarina equisetifolia; Livistona/Melaleuca forest; Open-forest/ woodland of Melaleuca quinquenervia; Notophyll vine forest	W, Xf, Xp. Also see types cross-referenced above	Associated with major waterbodies listed above.	

Table 7-10 Critical Service 2E – Freshwater Wetlands of Moreton and North Stradbroke Islands

Summary Table	Critical Service (S2E)
Reason for Inclusion	Representative near-natural reference site for freshwater wetlands. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Moreton Island and North Stradbroke Island
Critical habitat components underpinning this service	Peat swamp, window water-table lakes, perched lakes, freshwater creeks
Critical species underpinning this service	Wetland vegetation associated flora and fauna. Vulnerable species including Oxleyan Pygmy Perch (refer Service 3) and Swamp Orchid (refer Service 5).
Critical processes underpinning this service	Geomorphic processes (predominantly aeolian and marine) Groundwater hydrology Water quality Fire regimes Energy and nutrient dynamics (including soil and sediment nutrient processes)
Natural Variability (if relevant)	Vegetation communities show a high degree of variability over multiple spatial and temporal scales Water levels usually stable in Blue Lake, but show marked variability in many other wetlands (WBM 2002a;b)
Principal threats	Extraction of groundwater, water quality modifications, fire
Data quality underpinning this critical service	Level 2 – North Stradbroke Island EHMP monitoring data with limited spatial and temporal context Quantitative baseline flora and fauna survey results are available for parts of North Stradbroke Island, most of which is not current (Arthington 1984; Arthington 1996; WBM 2002a;b; WBM 2003) Level 3-4 – Moreton Island Very few baseline data describing aquatic flora, fauna and their habitats at Moreton Island
Information gaps	More systematic information is required to assess background variability in wetland community structure and linkages to controlling processes.
Recommended monitoring	Additional EHMP monitoring sites in representative sites within North Stradbroke Island and Moreton Island Development of locally specific ecosystem condition objectives.

F. Ocean Beaches and Foredunes of Moreton Island

Photo of Moreton Island beach coastline (Source: EPA photo library)

Ocean beaches within the Moreton Bay Ramsar site occur along the eastern coastlines of Bribie Island, Moreton Island, North Stradbroke and South Stradbroke Islands. These beaches can generally be characterized as dissipative in nature, with high waves >2 m, fine sand and the presence of offshore bars.

In looking at the Ramsar site as a whole, the ocean beaches of the planning area are quite distinct from the estuarine habitat assemblages of the Bay both in terms of geomorphologic form and function. In particular, the composition, diversity, and abundance of fauna communities on beaches are likely to be more strongly controlled by physical factors (e.g. wave climates, sediment properties) than by the biological interactions.

The intertidal zone of ocean beaches is dominated by wave action causing the sand to be in a constant state of disturbance. The coastal processes cause organic nutrients to continually re-suspend, meaning there is limited food available, particularly compared to more sheltered estuarine areas. While the environment limits the presence of larger invertebrates, beach ecosystems can contain significant species diversity when smaller invertebrate forms (i.e. the interstitial micro- and meiofauna) are included in surveys. Beaches also provide unique ecological services, such as filtration of large volumes of seawater, not covered by any other ecosystem (Schlacher *et al.* 2008).

Above the active surf zone, macrobenthic organisms are a key structural and functional component of sandy beach ecosystems, with benthic invertebrates playing roles in both the cycling of nutrients and as serving as prey species for larger crustaceans, fish and birds. Foredunes situated landward of the active surf zone provide important habitat for range of fauna species including nesting by shorebirds and marine turtles and roosting by coastal birds of prey.

Of the beach environments of the Ramsar site, the ocean beach environments of Moreton Island are seen as the most representative and near natural of the site which is supported by a long term conservation management regime over the site as a national park. The ocean beach of the island provides critical habitats (nesting, roosting and foraging sites) for migratory and resident birds of

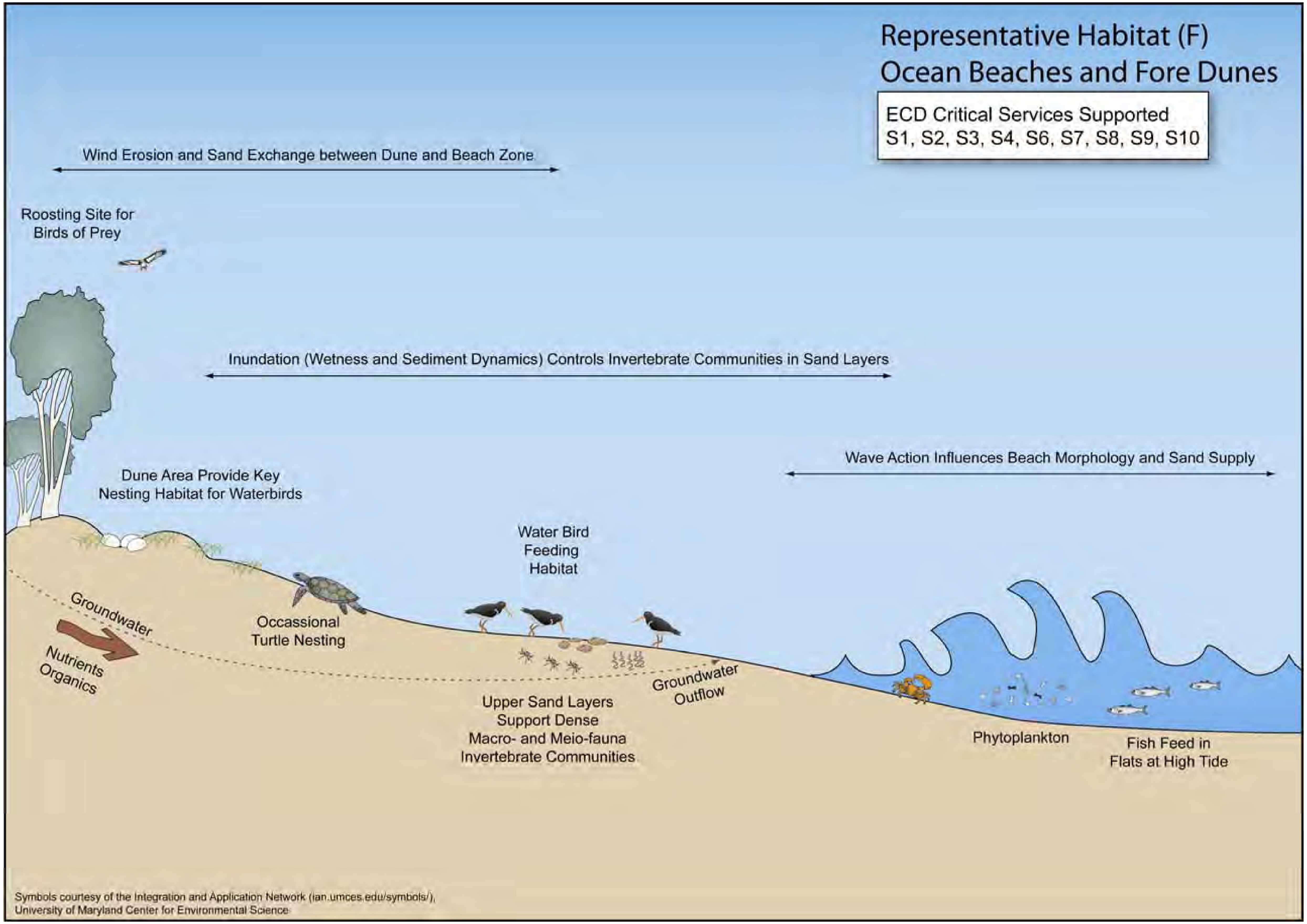


Figure 7-6 Conceptual Model of Moreton Island Ocean Beaches and Foredunes

Table 7-11 Critical Service 2F – Ocean Beaches and Foredunes of Moreton Island

Summary Table	Critical Service (S2F)
Reason for Inclusion	While there a number of ocean beaches represented in the site, the ocean beaches of Moreton Island have been selected as a representative near-natural reference site, underpinned by Ramsar Criteria 1.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Moreton Island ocean beaches and foredunes
Critical habitat components underpinning this service	Sandy Beach, Dune systems, Marine Waters
Critical species underpinning this service	See S3 (turtles), S4 (principally little tern and other avifauna), S7 (shorebirds)
Critical processes underpinning this service	Waves and current and their effect on sediment deposition and shoreline morphology including erosion and accretion Changes to tidal regimes/tidal drainage patterns Sediment stability, compactness and structure (eg. most animals surviving within upper sand layers) Wind erosion (stabilisation)
Natural Variability (if relevant)	Seasonal changes in distribution and extent of the habitat due to coastal processes. Episodic catastrophic storms may also lead to short-term reductions in available habitat.
Principal threats	Activities that disturb or otherwise reduce the quality of habitat for important fauna (nesting and feeding birds and turtles) Crushing of invertebrate species and communities from sediment disruption (principally by Off Road Vehicles) Removal and damage to dune vegetation (reducing habitat quality and increasing susceptibility to wind erosion)
Data quality underpinning this critical service	Level 3-4: There is emerging research into the impact of ORV on sandy beach ecosystems that demonstrates the diversity and abundance of species within beach ecosystems are adversely affected by ORV use compared to control sites.
Information gaps	• More systematic survey of key species (birds and turtle) populations over time including usage and quality of nesting sites • Further research of the impact of ORV usage on sandy beach invertebrate communities.
Recommended monitoring	• Examination of long-term changes in habitat extent using aerial photograph interpretation and review of existing information • Schalcher *et al.* (2007) also recommends research into the implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity. Effects of cumulative impacts from multiple stressors and disturbances on the structure, function, and recovery dynamics of sandy beach ecosystems are also recommended.

conservation significance and to a lesser extent turtles (noting the ocean beaches of South Stradbroke Island are recognised as being more significant for turtle nesting). The prominent bird species include the pied oystercatcher (*Haematopus longirostis*), the little tern (*Sterna albifrons*) and the beach stone-curlew (*Esacus neglectus*) with the beach and adjoining dune areas important breeding and chick rearing areas with close access to marine feeding zones. Mirapool Lagoon in the southeastern corner of Moreton Island and Heath Island area on the Island's northern coast are recognised vital feeding and roosting site for waders in both the National Park and Marine Park Zoning Plans (EPA 2007b).

The principal impacts to wetland values that occur in ocean beach environments are from off-road vehicle usage. Research on the impacts on wetland fauna from beach driving have traditionally focused on disturbance to rare and vulnerable species such as birds and turtles, particularly in the context of disturbance to breeding activities and nests. However, recent research on the impacts of off road vehicles (ORV) on beach ecosystems by Schlacher *et al.* (2008) demonstrated that macrobenthic assemblages on heavy traffic ORV beaches contained significantly fewer species at much reduced abundances than beaches without vehicles present. This was particularly marked in the upper and middle part of the beach where vehicle usage is highest. As identified above, these species provide an important prey source for a range of higher order vertebrates (such as shorebirds and birds of prey) that are of direct relevance to the Ramsar site.

Figure 7-6 shows a conceptual model of this critical reference habitat. Table 7-11 summarises the key attributes of this critical service.

7.3 Service 3 ~ Marine / Aquatic Fauna

Photos of marine turtle, dugong and Oxleyan pygmy perch (Source: BMT WBM photo library)

For the purposes of this assessment, species of conservation significance are considered to be those that are listed as endangered or vulnerable under National (EPBC Act 1999) or state (Nature Conservation (Wildlife) Regulation 2006) legislation. The definition has also been extended to include marine mammal and reptile species that are protected under the EPBC Act 1999.

Dugongs

Dugongs have a global IUCN listing of “vulnerable to extinction” (IUCN 1996) and the Queensland dugong population is considered as “vulnerable” under the Queensland *Nature Conservation (Wildlife) Regulation 2006*.

Moreton Bay represents the southern limit of the dugong’s Australian distribution (Lanyon and Morrice 1997) and currently contains one of the largest populations of dugongs on the east coast of Australia (Marsh *et al.* 1996). A study estimated the Moreton Bay dugong population to be comprised of approximately 500 individuals (Great Barrier Reef Marine Park Authority (GBRMPA) 2003) compared with an estimated population of 503 ± 63 (S.E) (July) to 1019 ± 166 (S.E) (December) individuals in 1995 (Lanyon 2003). However as noted by GBRMPA (2003), there were differences in sampling techniques, which preclude direct comparisons between the two studies. Recent population modelling estimates that the Moreton Bay dugong ‘population’ is ~970 ±75 animals (Dr Janet Lanyon, pers. comm. 2008). It should be noted, however that this figure should be considered as indicative only, subject to further investigations. A range of studies are either underway or are planned to gain a more detailed appreciation of dugong movement patterns (within and external to the site), population dynamics, genetics and ecology within the site (Dr Janet Lanyon, pers. comm. 2008).

Dugongs are believed to move in and out of Moreton Bay in ranging movement patterns, but principally through the South Passage and not the northern delta region (Lanyon and Morrice, 1997). There is uncertainty regarding the movement patterns of dugongs within and external to the site (Dr Janet Lanyon, pers. comm. 2008). Dugong densities appear to be concentrated around the extensive seagrass beds associated with the Moreton Banks area (located 10-12 km to the south) in the Eastern Bay (Lanyon and Morrice, 1997), with relatively few individuals sighted in other portions of Moreton Bay. However, areas containing dugong foraging habitat (i.e. seagrass areas) have been recognised as far north as Tangalooma Point on the west coast of Moreton Island. The importance of the Moreton/Eastern Banks area to this species has been recognised by the Environmental Protection Agency in the *Marine Parks (Moreton Bay) Zoning Plan 1997*, with the area designated as a Conservation Zone and the implementation of “go slow zones” in areas such as Moreton Banks.

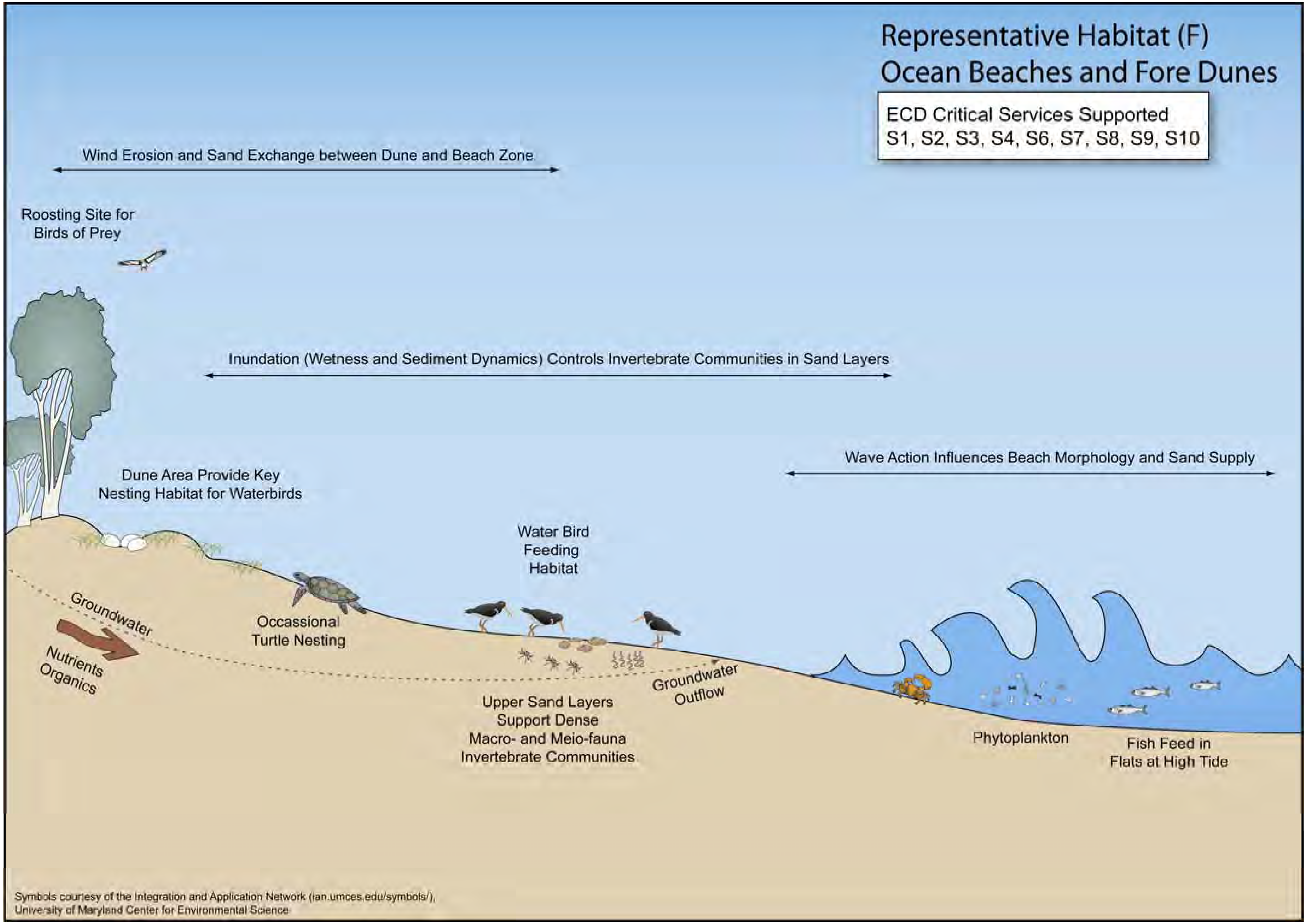


Figure 7-6 Conceptual Model of Moreton Island Ocean Beaches and Foredunes

Table 7-11 Critical Service 2F – Ocean Beaches and Foredunes of Moreton Island

Summary Table	Critical Service (S2F)
Reason for Inclusion	While there a number of ocean beaches represented in the site, the ocean beaches of Moreton Island have been selected as a representative near-natural reference site, underpinned by Ramsar Criteria 1.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Moreton Island ocean beaches and foredunes
Critical habitat components underpinning this service	Sandy Beach, Dune systems, Marine Waters
Critical species underpinning this service	See S3 (turtles), S4 (principally little tern and other avifauna), S7 (shorebirds)
Critical processes underpinning this service	Waves and current and their effect on sediment deposition and shoreline morphology including erosion and accretion Changes to tidal regimes/tidal drainage patterns Sediment stability, compactness and structure (eg. most animals surviving within upper sand layers) Wind erosion (stabilisation)
Natural Variability (if relevant)	Seasonal changes in distribution and extent of the habitat due to coastal processes. Episodic catastrophic storms may also lead to short-term reductions in available habitat.
Principal threats	Activities that disturb or otherwise reduce the quality of habitat for important fauna (nesting and feeding birds and turtles) Crushing of invertebrate species and communities from sediment disruption (principally by Off Road Vehicles) Removal and damage to dune vegetation (reducing habitat quality and increasing susceptibility to wind erosion)
Data quality underpinning this critical service	Level 3-4: There is emerging research into the impact of ORV on sandy beach ecosystems that demonstrates the diversity and abundance of species within beach ecosystems are adversely affected by ORV use compared to control sites.
Information gaps	• More systematic survey of key species (birds and turtle) populations over time including usage and quality of nesting sites • Further research of the impact of ORV usage on sandy beach invertebrate communities.
Recommended monitoring	• Examination of long-term changes in habitat extent using aerial photograph interpretation and review of existing information • Schalcher *et al.* (2007) also recommends research into the implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity. Effects of cumulative impacts from multiple stressors and disturbances on the structure, function, and recovery dynamics of sandy beach ecosystems are also recommended.

Dugongs are principally herbivores and have been shown to be highly selective feeders, preferring certain species of seagrass to others. Preen (1995b) reported dugongs showing a preference for grazing on seagrass from the genus *Halophila*, three species of which (*H. ovalis, H. spinulosa* and *H. decipiens*) are found in Moreton Bay. This is despite the dominance in biomass of another species of seagrass (*Zostera*) in the region. Dugongs in Moreton Bay are also reported to feed deliberately on invertebrates such as ascidians. This omnivory is thought to be a response to nutritional stress caused by seasonality in abundance of seagrasses in Moreton Bay (Preen 1995a).

Marine Turtles

Six species of marine turtle are known to use Moreton Bay as a feeding area. Two of these species – the green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles, have relatively high abundances within the site, while the hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*) and flatback (*Natator depressus*) turtles are seasonal visitors to the region, or do not have high abundances within site (Limpus *et al.* 2006). For this reason, emphasis in this critical service (and the ECD as a whole) is on the two most common species.

Moreton Bay is not an important turtle breeding area, with most turtles in the Bay believed to have originated from rookeries on the central and north Queensland coast and Islands. Loggerhead turtles nest at low densities on the local sand islands of Bribie, Moreton, and North and South Stradbroke.

The distribution and abundance patterns of turtles within Moreton Bay are thought to be greatly influenced by the availability of suitable food resources. Green turtles in Moreton Bay feed directly on seagrasses and algae (Brand-Gardner *et al.* 1999) with most concentrated numbers of these fauna (c.f. dugongs) also centred on the important foraging areas at Moreton/Eastern Banks. By comparison, loggerhead turtles are carnivorous, and feed on jellyfish, crustaceans, echinoderms, and bivalve molluscs from seagrasses and reef areas (Limpus *et al.* 1994).

'Population' estimates of turtles in Moreton Bay in 1995 range from 800 and 900 individuals (Lanyon 1997). However, the authors acknowledge that this is likely to be an underestimate due to bias inherent in the survey methodology. It should also be noted that the term 'local population' is a misnomer, given the large home range of these species. The number of green turtles is consistently higher in the Eastern and Southern Bay than elsewhere due to the presence of extensive (seagrass) foraging areas (Limpus *et al.* 2006). With the exception of green turtles, there is a paucity in data to describe key or preferred foraging habitats for the remaining marine turtles in Moreton Bay, possibly due to the lower resident numbers of these species.

Marine turtles are protected under the *Nature Conservation Act 1992*, with the loggerhead listed as Endangered, and the green turtle listed as Vulnerable. The green and loggerhead are also listed as threatened under the EPBC Act 1999.

Oxleyan pygmy perch and honey blue-eye

Two nationally threatened 'wallum-habitat' associated fish species occur within the Moreton Bay Ramsar site: Oxleyan Pygmy Perch (*Nannoperca oxleyana*) and Honey Blue-eye (*Pseudomugil mellis*). Both species are listed as Vulnerable under *Nature Conservation (Wildlife) Regulation 2006*, and Endangered under the IUCN red list. Under the Commonwealth's *Environmental Protection and*

Table 7-7 Critical Service 2C - Southern Bay Mangroves and Saltmarsh

Summary Table	Critical Service (S2C)
Reason for Inclusion	Representative near-natural reference site for mangroves and saltmarsh communities. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Southern Moreton Bay
Critical habitat components underpinning this service	Mainland littoral habitats, mangrove-colonised islands
Critical species underpinning this service	Mangrove and saltmarsh species
Critical processes underpinning this service	Tidal hydraulics – currents, waves and sea level rise Freshwater flows – Source and delivery of sediment Physical (geomorphologic) coastal processes that maintain mangrove islands Energy and nutrient dynamics Other biological processes (growth, reproduction, recruitment, and possibly competition?)
Natural Variability (if relevant)	Mangrove losses reported following storms No studies have examined broad-scale changes in mangrove extent across the Southern Moreton Bay area. Large increases in mangrove extent were recorded in the Pimpama and Coomera catchments associated with changed agricultural practices and tidal inundation patterns over the last 60 years (WBM 2001). Landward increases in mangrove extent have resulted in the loss of saltmarsh in many areas within the Pimpama and Coomera catchments. Overall, there has been a large reduction in saltmarsh over the last 50 years as outlined in the text above in the Southern Moreton Bay area from a range of natural and anthropogenic factors.
Principal threats	Mangroves/saltmarsh - Clearing; reclamation and filling; and sea-level rise; Competition between species types. The combination of sea level rise with limited coastal land area for saltmarsh migration places these habitats at particular risk.
Data quality underpinning this critical service	Level 1-3 (Dowling 1986; Hyland and Butler 1989; WBM 2001; EPA 2005a)
Information gaps	More systematic information is required on background variability in mangrove and saltmarsh habitat extent and linkages to controlling processes.
Recommended monitoring	Examination of long-term changes in mangroves and saltmarsh based on aerial photograph interpretation and review of existing information

Biodiversity Conservation (EPBC) Act 1999, Oxleyan pygmy perch is listed as Endangered, whereas honey blue-eye is listed as Vulnerable.

Table 7-12 lists localities where Oxleyan pygmy perch and honey blue-eye have previously been recorded, and the habitat attributes of the sites in which these species were recorded. There are several mainland and island waterbodies within the Ramsar site in which Oxleyan pygmy perch has been recorded. Honey blue-eye by contrast has not been recorded on the Moreton Bay islands, but has been recorded in several waterways that discharge into Pumicestone Passage.

Honey blue-eye and Oxleyan pygmy perch are both typically found in the coastal lowland "wallum" ecosystem and are often found in the same waterways (Arthington and Marshall 1993; Arthington 1996). Both species are thought to be restricted to acidic (pH 4.4 - 6.8) freshwater lakes, pools and small streams with dense, aquatic vegetation (such as emergent sedges and submerged sedges), along the margins (Allen and Ivantsoff 1982; Arthington and Marshall 1993; Arthington 1996; Kuiter *et al.* 1996; Pusey *et al.* 2004). Both species are found in clear and tannin-stained waters (Arthington and Marshall 1993) with sandy or muddy bottoms (Allen 1989), typically where there is little or no flow (Arthington and Marshall 1993; Arthington 1996). Oxleyan pygmy perch are restricted to freshwaters (Arthington 1996, Pusey *et al.* 2004), whereas honey blue-eye occurs in slightly brackish and freshwater environments (Semple 1991).

Both species are considered as nationally threatened. In response, recovery plans have been prepared for both species which provide basic life history and population distribution information, identify key threats and recommendations for management of the species and their habitats (Arthington and Marshall 1993; Arthington 1996).

It should be noted that the mainland waterbodies that Oxleyan pygmy perch and honey blue-eye have been recorded are, in most cases, brackish reaches within the Moreton Bay Ramsar site. Within the context of the Ramsar site boundaries, these mainland waterbodies are therefore unlikely to represent critical habitat for these essentially freshwater species.

Table 7-13 provides the summary of key attributes related to this critical service.

Table 7-12 Localities Known to Support Oxleyan Pygmy Perch and Honey Blue-eye and Habitat Conditions

	Oxleyan Pygmy Perch	**Honey Blue-eye**
Mainland Localities	Searys Ck, Carland Ck, Noosa River & tributaries, Coondoo/Tiana Ck, **Mellum Ck**, trib of Blue Gum Ck, **Burpengary Ck**, Marcus Ck [D], Coochin Creek [E]	Big Tuan Ck, Lake Cooloola, Noosa River, Marcus Ck, Scrubby Ck, Kangaroo Ck, Schnapper Ck, Carland Ck, **Mellum Ck**, **Tibrogargan Ck** [D]
Island Localities	**Spitfire Ck** and **Jabiru Ck** (Moreton Island) [A]; **Bribie Island** [A]; **Eighteen Mile Swamp** [G]; **Blue Lake** [H]; **Blue Lake Overflow** [G]; **Little Canalpin Ck** [F]	-
Localities not recorded by Arthington (1996); Arthington and Marshall (1993)	Waraba Ck, Tibrogargan Ck, Coonowrin Ck, Coochin Ck, Obi Obi Ck; Mooloola R., Tingalpa Ck, Currumbin Ck [D]	Seary Ck, Lake freshwater, Kin Kin Ck, Castaways Ck, Obi Obi Ck, Mooloola River, Coochin Ck, Coonowrin Ck, Waraba Ck, Tingalpa Ck, Currumbin Ck [D]; North and South Stradbroke, Bribie, Moreton Islands
Water Quality[A,B]	pH 4.2 to 7.2 Conductivity <330 μS/cm DO > 2 mg/L Clear, tannin stained waters	pH 4.4 to 6.8 Conductivity <900 μS/cm DO > 6.8 mg/L Clear, tannin stained waters
Habitat	Wallum habitat, often with Melaleuca Structurally complex habitats: • 60-80% aquatic plant cover (typically sedges) • Undercut banks • Leaf litter or fallen timber	Wallum habitat High aquatic plant cover, typically sedges Low flow environments (<0.3 m/sec)

A = Pusey, *et al.* (2004); B = EPBC database; C = Arthington (1996); D = Arthington and Marshall (1993); E = unpublished AGFA records; F = WBM (2002a); G = WBM (2002a); H = BMT WBM (2007); **Bold** – waterbodies located in, or have a direct connection to, the Ramsar site

Table 7-13 Critical Service 3

Summary Table	Critical Service (S3)
Reason for Inclusion	Key services provided by the site in regards to threatened fauna complies with Ramsar Nomination Criteria 2 in that the site supports vulnerable fauna and Ramsar Nomination Criteria 4 in respect to provision of critical refuge.
Type of Service	Supporting – Nationally threatened species, contributes to biodiversity
Description of Service (quantify if possible)	The site supports records of, and habitat suitable for, threatened aquatic fauna species. Dugong, two species of marine turtle, and two 'wallum-habitat' fish species are identified as critical elements.
Spatial Application (if relevant)	This service applies to the whole site. Refer to text for important localities and habitats for these species.
Critical habitat components underpinning this service	Seagrass (dugongs and green turtles), reefs (loggerhead turtles), wallum freshwater wetland habitats (Oxleyan pygmy perch, honey blue-eye).
Critical species underpinning this service	**Food** Freshwater littoral and pelagic micro- and macro-invertebrates - Oxleyan pygmy perch, honey blue-eye Seagrass (*Halophila* species and *Halodule uninervis*) - Dugongs and green turtles Soft sediment epifauna and infauna – Loggerhead turtles Reef biota (algae, sponges, soft coral) – Loggerhead turtles Jellyfish – Loggerhead turtles **Habitat** Emergent macrophytes - Oxleyan pygmy perch, honey blue-eye
Critical processes underpinning this service	Maintenance of biophysical habitat extent, diversity and interconnectivity Maintenance of tidal and wave regimes that drives biophysical habitat patterns and processes Maintenance of water quality conditions, particularly with respect to its influence on estuarine vegetation communities (i.e. seagrass, algae etc.) Maintenance of groundwater and surface flow regimes to wallum wetland habitats
Natural Variability (if relevant)	Patterns in abundances of all fauna species are known to vary across a range of spatial and temporal scales.
Principal threats	Habitat loss due to development - Oxleyan pygmy perch, honey blue-eye Water quality degradation - Oxleyan pygmy perch, honey blue-eye, dugong, green turtle Fishing (by-catch) – Turtles Boat strike (including jetskis) – Dugongs, turtles Water extraction – Wallum wetland fish species Disease, possibly linked to *Lyngyba* – Turtles Entanglement and ingestion of marine debris – Turtles Toxicants – Turtles, possibly other marine fauna.
Data quality underpinning this critical service	Service – Level 2-3 (population survey data outdated, insufficient scale) Components – Level 2 (outdated, insufficient scale) Processes – Level 1-2 (water quality); 2 (freshwater flows); 2 (tidal data)
Information gaps	**Marine** Present-day and historical marine vegetation mapping done at relevant spatial scale (minimum 1:25,000) and temporal (at least every 5 years, preferably with analysis of seasonal changes);

Summary Table	Critical Service (S3)
	Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh; Natural variability in dugongs and turtles, and factors controlling these changes; Sustainability of dugongs and turtles given existing pressures and management arrangements; and Health/condition status of turtles, and identification of factors causing disease. **Freshwater** Environmental flow requirements of wallum fish species Impacts of introduced species on wallum fish species Up-to-date assessment of the distribution, population status and site-specific threats to wallum-habitat fish species, including an assessment of any changes of population status.
Recommended monitoring	Fauna population monitoring at an appropriate spatial and temporal scales Marine vegetation monitoring Continuation and expansion of EHMP to include key habitats

7.4 Service 4 ~ Wetland-Dependant Terrestrial Fauna

Photos of little tern (*Ray Viljoen*), beach stone-curlew (*Ray Viljoen*) and water mouse (*Bruce Cowell*)

There are records for nine threatened wetland-dependant terrestrial fauna within the Moreton Bay Ramsar site. These are: Illidge's ant blue butterfly *Acrodipsas illidgei,* wallum froglet *Crinia tinnula*, wallum rocketfrog *Litoria freycineti*, wallum sedgefrog *L. olongburensis*, beach stone-curlew *Esacus neglectus*, water mouse *Xeromys myoides,* Cooloola sedgefrog *Litoria cooloolensis*, Australian painted snipe *Rostratula australis,* little tern *Sterna albifrons*. A tenth, the Australasian bittern *Botaurus poiciloptilus*, has not been recorded currently for the site but could be present due to suitable habitat. The following provides a profile of ecological characteristics, habitat usage in Moreton Bay, and potential threatening process for each of the species.

Illidge's Ant Blue Butterfly

Illidge's ant blue butterfly *Acrodipsas illidgei* is listed as Endangered under the IUCN Red List, and is also listed as *Vulnerable* at a State scale under the provisions of the NCA.

Illidge's ant blue butterfly appears to be restricted to a small number of coastal localities from the Mary River Heads, south-eastern Queensland to Brunswick Heads, northern New South Wales (Sampson 1993; Sands and New 2002). Whilst single specimens have been recorded in non-coastal environments (Toowoomba - Lane 1991 and Braby 2000; and near Leyburn - Sands and Sands 2005), there is insufficient information relating to these records to add to the knowledge of the butterfly's ecology (D. Sands, pers. comm. 2008).

Site localities within Moreton Bay are: Hayes Inlet (1974; DeBaar in Sands and New 2002); Southport (Samson 1989); Redland Bay (Hagan 1980); Coomera Island (1999; Breitfuss and Dale 2004); and Fisherman's Islands (D. Sands, pers. comm. 2008).

Large and undisturbed mangal communities are considered to be the primary habitat for this butterfly. The vast majority of known habitats all characterised by the presence of well-spaced, mature mangrove trees bearing senescing limbs and dead branchlets which support the *Crematogaster* sp. ant (prey of Illidge's ant blue larvae). In these habitats, tree phenology and architecture appears to be important (D. Sands, pers. comm. 2008).

Adults of the Illidge's ant blue feed on the nectar of flowers (e.g. eucalypts, mangroves, *Parsonsia* spp.) (D. Sands, pers. comm. 2008). After mating, females deposit their eggs singly or in small groups at the edge of hollows in dead twigs or under bark of old trees of *Avicennia marina* when occupied by a common Black ant (*Crematogaster* sp.; *laeviceps* group) (Smales and Ledward 1942; Samson 1989).

Detection of Illidge's ant blue butterfly is highly problematic, even for highly experienced personnel, as the density of adults is very low and the butterfly has the propensity to remain settled on the upper branches of mangroves and flies infrequently (D. Sands, pers. comm. 2008). It is quite likely that new habitats will eventually be discovered if persistent searches of other potential habitats are undertaken, particularly on the islands of Moreton Bay (D. Sands, pers. comm. 2008). It is highly probable that Moreton Bay supports in excess of 1% of the population of Illidge's ant blue (D. Sands, pers. comm. 2008) but a lack of definitive data about the bioregional population limits its application.

Acid Frogs

For the purposes of this report, wallum or acid frogs (after Ingram and Corben 1975) include wallum froglet *Crinia tinnula*, wallum rocketfrog *Litoria freycineti*, wallum sedgefrog *L. olongburensis*¸ and Cooloola sedgefrog *Litoria cooloolensis*. The wallum froglet, wallum rocketfrog, wallum sedgefrog are listed as *Vulnerable* under the provisions of the NCA. The wallum sedgefrog is the only species listed nationally as *Vulnerable* under the EPBCA. All four species are listed as threatened by the World Conservation Union (IUCN 2006).

Wallum froglets *Crinia tinnula* occur primarily in heathland, paperbark (*Melaleuca*) swamps and sedge swamps in areas of sandy soil which support waters that are typically tannin-stained, highly acidic (i.e. <5.5 pH) and non-turbid (Cogger 2000; Straughan and Main 1966; Ingram and Corben 1975; Meyer *et al.* 2006). Other habitats include adjoining eucalypt forest and woodland in areas of sandy soil overlaying clay and sandstone (Hines *et al.* 1999). Waterbodies used for breeding are typically oligotrophic (low nutrient), naturally acidic (pH 3.0-5.5 as derived from dissolved organic acids leached from humus), and free of predatory fish (Hines *et al.* 1999). Primary breeding habitat is associated with shallow ephemeral swamps and soaks, though also known to breed in artificial habitats such as dams and flooded ditches (Hines *et al.* 1999; Anstis 2002).

In Queensland, the frogs are restricted to the coastal lowlands and offshore islands ("wallum" landscapes of Coaldrake 1961) of the south-east (Czechura 1995; Meyer *et al.* 2006). Site localities within Moreton Bay include Bribie, Moreton and North Stradbroke Islands (both public and private land tenure) (Neilson 2000; Greenloaning Biostudies 2000; EPA 2008b). National Parks on all three islands are listed as supporting important populations of wallum froglet (Meyer *et al.* 2006). Other localities include wallum habitats adjoining Pumicestone Passage and several small islands within the southern sector of Moreton Bay (EPA 2008b).

Wallum sedgefrogs *Litoria olongburensis* are known from a variety of ephemeral and semi-permanent, low-nutrient, well-vegetated swamps of coastal wallum (Liem and Ingram 1977; Emhann 1997; Hines *et. al.* 1999). Within these habitats, areas of sedges, reeds, grasses and/or Bungwell fern (*Blechnum indicum*) which are inundated with shallow acid, low-nutrient waters (e.g. up to 1.5m in depth) are regarded as important breeding habitat attributes (Liem and Ingram 1977; Hines *et. al.* 1999; Meyer *et al.* 2006; DEWHA 2008a). Wallum sedgefrogs are typically more common in and around ephemeral acid swamps, though also known to occur along slow-flowing creeks and acid lakes in wallum landscapes (Liem and Ingram 1977; Ehmann 1997; DEWHA 2008a). Aquatic sites at the base of sedges area also important microhabitats for amplexus and egg laying (Ehmann 1997;

Meyer *et al.* 2006). Fish are largely absent from habitat occupied by the species (E. Meyer pers. comm. 2002 in DEWHA 2008a).

The wallum sedgefrog is primarily restricted to the coastal lowlands of south-east Queensland and north-east New South Wales (Tyler 1997; Meyer *et al.*. 2006). The main localities for wallum sedgefrog within the study area are similar to the wallum froglet, on Bribie, Moreton and North Stradbroke Islands (both public and private land tenure) (EPA 2008b). National Parks on all three islands are listed as supporting important populations of wallum sedgefrog (Meyer *et al.* 2006). Other localities include fragmented wallum habitats adjacent Pumicestone Passage (mainland) (EPA 2008b).

The wallum rocketfrog *Litoria freycineti* is a ground dwelling species associated with coastal wet heath, though also occurs around sedge swamps, slow moving streams, perched lakes and within nearby *Melaleuca* and *Banksia* woodlands on sandstone and sandy soils (Ingram and Corben 1975; Hines *et al.* 1999; Meyer *et al.* 2006). The wallum rocketfrog breeds after rain in spring and summer in ephemeral swamps and pools and males call from wet ground near water, amidst sedges and eggs are laid in shallow water (Straughan and Main1966; Anstis, 2002; Barker *et al.* 1995; Meyer *et al.* 2006).

The wallum rocketfrog occurs in lowland coastal south-east Queensland and eastern New South Wales from Fraser Island south to Jervis Bay (Hines *et al.* 1999; Meyer *et al.* 2006). The main localities for wallum rocketfrog within the study area are similar to those of wallum froglets and wallum sedgefrogs as already discussed.

The Cooloola sedgefrog is typically more abundant around perched lakes with emergent sedges and reeds (Ehmann, 1997; Meyer *et al.* 2006). The lakes in which *L. cooloolensis* breeds are typically oligotrophic and acidic (pH<5.5). (Ehmann, 1997; James 1996; Meyer 2004; Meyer *et al.* 2006). As with the wallum sedgefrog, there are a small number of records of Cooloola sedgefrogs breeding in disturbed habitat and have also been recorded from dams within disturbed habitat, though, whether these sites provide suitable breeding habitat is unknown (Meyer *et al.* 2006).

The Cooloola sedgefrog is known only from Fraser Island and the Cooloola sandmasses, with a disjunct population on North Stradbroke Island (Hines *et al.* 1999; Meyer *et al.* 2006). On North Stradbroke Island, most sites are on leased or unallocated state land (Meyer *et al.* 2006). Monitoring suggests that populations on leased land are stable, though numbers are known to have declined dramatically following the introduction of the *Gambusia holbrooki* in 2002 (Neilson 2000; E. Meyer unpub. data; in Meyer *et al.* 2006). Site records include Brown Lake; Blue Lake, Ibis Central and Ibis West Lagoons within mining leases, Duck Lagoon, Native Companion Lagoon, Welsby Lagoon, Shag Lagoon, Tortoise Lagoon, Lake Kounpee, Lake Yarraman, Spanner Lake, Swallow Lagoon, Eighteen Mile Swamp, Yarraman Swamp, Flinders Swamp, Kounpee Swamp and Creaking Tree Swamp (Ingram and Corben 1975; Neilson 2000; Queensland Museum 2008; Meyer *et al.* 2006; EPA 2008b).

The Moreton Bay Area (including Bribie, Moreton and North Stradbroke Islands) provides important habitat for all three wallum-dependent acid frog species. Given the extent of wallum habitat within Moreton Bay, the study area is likely to support significantly more than 1% of the total population of each of these species (E. Meyer, pers. comm. 2008). In the case of the wallum sedgefrog, this figure could well exceed 10% (E. Meyer, pers. comm. 2008). However, specific data to support the Nomination Criteria have not been collected.

Given the importance of the Moreton Bay Area for acid frogs, the loss of habitat (in particular that of the wallum sedgefrog) should not exceed 5% of the area occupied by these species. In addition, water quality within areas of suitable habitat must be maintained at current levels (or better). Of particular importance in this regard is the maintenance of acidic and oligotrophic conditions in areas of breeding habitat (i.e., wallum swamps and lakes). Wallum swamp and lake waters should therefore remain acidic (within the pH range 3-5) while nitrate levels should not exceed 0.7 mg/L (E. Meyer, pers. comm. 2008). Levels of other toxicants including monomeric Aluminium and surfactants must also remain low. Also important, in terms of habitat suitability, is the maintenance of parapatry between acid frog and congeneric sibling species (i.e., the beeping froglet *Crinia parinsignifera*, common sedgefrog *Litoria fallax* and striped rocketfrog *Litoria nasuta*) in undisturbed wallum habitat.

Beach Stone-Curlew

Beach stone-curlew *Esacus neglectus* is listed as *Vulnerable* under the provisions of the NCA.

Beach stone-curlews occur exclusively within coastal environments using a variety of sheltered and open beaches (sandy, muddy or rocky), often around mouths of rivers and beaches associated with mangroves (Marchant and Higgins 1993). Beach stone-curlews forage within exposed intertidal areas and feed predominately on crabs and other marine invertebrates (Clancy 1986; Marchant and Higgins 1993).

Beach stone-curlews characteristically roost amongst mangroves, grassy treed areas within foredunes, or where there is suitable vegetation cover above the high tide mark (Clancy 1986; Geering *et al.* 2007). Nest sites are typically located landward side of sandy beaches, often within low foredunes in the same area year after year (September to November) (Marchant and Higgins 1993). This species is mainly nocturnal or crepuscular[9] and adult birds appear to be sedentary (Marchant and Higgins 1993; Geering *et al.* 2007). Beach stone-curlews feed predominately on crabs and other marine invertebrates in the intertidal zone (Clancy 1986; Marchant and Higgins 1993).

Beach stone-curlews are distributed along coastal environments throughout Eastern and Northern Australia, from the Manning River in New South Wales to Onslow in Western Australia (Marchant and Higgins 1993). The species was considered to be 'not common' on North Stradbroke Island by Vernon and Martin (1975) and more recently, rare in Moreton Bay and restricted mainly to outer islands with extensive areas of mangroves or long sandy beaches (Agnew and Stewart 1998).

The main localities for beach stone-curlew within the study area include Bribie, Moreton and North Stradbroke Islands (EPA 2008b). Other site records derive from Fisherman Islands, Peel Island, Southport Spit, South Stradbroke Island, and Pumicestone Passage (GCCC 2008; EPA 2008b).

Whilst beach stone-curlews can still be found in coastal locations where human activity is relatively high, the lack of young birds in such areas suggests that reproduction is being affected by human disturbance (Freeman 2003). Breeding success may also be significantly reduced from predation by cats, dogs and feral pigs and disturbance resulting form recreation activities (e.g. beach-combing,

[9] Active at dawn and/or dusk

dog-walking, boating and 4WD vehicles (Roberts 1957; Garnett 1992; Marchant and Higgins 1993; Garnett and Crowley 2000).

Water Mouse

The water mouse *Xeromys myoides* is listed as *Vulnerable* under the provisions of the NCA and EPBC Act (where it is listed as false water rat).

The water mouse has been recorded in coastal saltmarsh, mangrove and adjacent freshwater wetland habitats in the Queensland, Northern Territory and New Guinea. In Queensland, the water mouse has been recorded on the mainland from the Proserpine region, at Mackay, an area south of Gladstone, and from south-east Queensland between Hervey Bay and the Coomera River (50km south-east of Brisbane) (EPA 2008b). Non-mainland sites include Fraser Island, Bribie Island, North Stradbroke Island and South Stradbroke Island (EPA 2008b).

The species has been recorded in various coastal and freshwater vegetation assemblages. In southeast Queensland (including Moreton Bay), these include sedgeland (an often well defined zone to about 1m and composed mainly *Juncus* and *Baumea* spp.), chenopod shrubland (including succulents and dwarf shrubs growing on soils that dry out and crack between inundations), *Sporobolus virginicus* grassland (marine couch meadows found closest to the extreme high water spring tide mark and associated with freshwater drainage), and mangrove communities (with variation in structural type and complexity and comprising of one or more mangrove species) (Van Dyck and Gynther 2003; EPA 2008b).

The water mouse is likely to require relatively large areas of intertidal flats where it forages by following tidal waters to the low water mark and forage until advancing waters inundate the mangrove community (Van Dyck 1997). The diet of the water mouse largely comprises marine intertidal crustaceans, pulmonate snails, marine gastropods and other invertebrates (Van Dyck 1997; Gynther and Janetzki 2008).

The water mouse is probably entirely nocturnal, sheltering during the day and between tidal cycles in constructed nesting mounds adjacent to foraging habitat. Nesting structures recorded in south-east Queensland include:

- free-standing termitarium-like mounds (often in sedgeland and *Sporobolus* grassland, though also in mangroves),
- excavated nests within supralittoral banks (often built amongst peat and roots in bank), and
- mounds built against tree bases (often surrounding a natural cavity within living or dead trees and within the mangrove zone or at/near marine/terrestrial boundary) (Van Dyck and Gynther 2003).

Nests often occupy naturally elevated ground and utilise the bases of fallen trees or logs for consolidation of the nest structure (Van Dyck 1997; Van Dyck and Durbidge 1992; Van Dyck and Gynther 2003). Once constructed, nests are continuously added to, with the larger mounds or nests having potential to provide significant historical information about populations and habitats over time (Van Dyck 1997).

EPA (2008b) identifies that in south-east Queensland, high density water mouse populations occur within the Great Sandy Strait (including Tin Can Bay), Pumicestone Passage and southern Moreton Bay (including the western shores of North and South Stradbroke Islands). A large percentage of the water mouse population in the Moreton Bay area occurs in intertidal habitats within the Moreton Bay Ramsar site (EPA 2008b). Within Moreton Bay, the species has been recorded at the following locations: Pumicestone Passage (Gallagher Point, White Patch, Bukllock Creek CP, Donnybrook), North Stradbroke Island (Amity, Chiggil Chiggil, Rainbow Channel, Canalpin Creek, Myora Springs, Two Mile, Deanbilla, Stockyard), Steiglitz, Jacobs Well, Pimpama River Conservation Area, Coomera River, South Stradbroke Island (Van Dyck 1997; Van Dyck and Gynther 2003; GCCC 2008; EPA 2008b). Habitats along the western side of North Stradbroke Island and those within the southern part of the bay (Macleay Island to Coomera) appears to be a stronghold for the water mouse.

The water mouse is a relatively recent discovery to science, so no known reduction in historical range can be accurately compared to current distribution estimates (EPA 2008b). It is highly probable that Moreton Bay supports in excess of 1% of the population of Water Mouse (I. Gynther, pers. comm.. 2008).

Australian Painted Snipe

Australian painted snipe *Rostratula australis* is listed as *Vulnerable* under the provisions of the NCA and EPBC Act.

The Australian painted snipe is a secretive, crepuscular species that occurs on well vegetated shallow, permanent or seasonal wetlands, usually freshwater but occasionally brackish (Marchant and Higgins 1993; Geering *et al.* 2007). This species is has also been recorded in the following habitats: inundated grasslands, saltmarsh, dams, rice crops, sewage farms and bore drains (Marchant and Higgins 1993; Geering *et al.* 2007). Australian painted snipes require dense vegetation cover for roosts (often tall grass) and forage on soft muds and in shallow water for seeds and invertebrates, including crustaceans and molluscs invertebrates (Marchant and Higgins 1993; Geering *et al.* 2007). Occurrence is erratic and unpredictable (often in response to local rainfall), seldom remaining long in any locality (Marchant and Higgins 1993; Geering *et al.* 2007).

Australian painted snipes have a patchy distribution throughout Australia, with most records being in the south-east (Marchant and Higgins 1993) and within its range, inland swamps with temporary water regimes are considered a stronghold (Geering *et al.* 2007). Records are erratic, the species being absent from areas in some years and common in others. Nests are located on the ground in swamps and grassland and nesting in Queensland mainly occurs during and after the wet season, e.g. December to May (Marchant and Higgins 1993; R. Jaensch, pers. comm..2008). A breeding stronghold occurs within the Murray-Darling region, though breeding recorded throughout eastern and northern Australia (Marchant and Higgins 1993; Geering *et al.* 2007).

Within the study area, this species has been recorded from North Stradbroke Island and mainly freshwater and brackish wetlands (e.g. Eighteen Mile Swamp - Vernon and Martin 1975; Black Snake Lagoon - Lewis Environmental Consultants 1995; Lytton, Luggage Point and Nudgee wetlands EPA 2008b).

Little Tern

The little tern *Sterna albifrons* is listed as *Endangered* under the provisions of the NCA.

Little terns inhabit sheltered coastal environments of estuaries, river mouths, inlets and harbours, particularly those which support sand spits and exposed sandbanks (Higgins and Davies 1996). Little terns feed singly or in small groups on fish taken from the water surface, although often roosting in large flocks on beaches or sand spits with other terns (Smith 1990; Higgins and Davies 1996). Nesting is colonial (often traditional sites) with preferred nesting habitat characterised by sandy substrate on flat or gently sloping topography, usually within 150m of water, preferably between the high tide mark and littoral vegetation (Smith 1990; Higgins and Davies 1996). An abundance of shells, small pebbles & sparse clumping vegetation cover may be critical factors in breeding success (Smith 1990).

Internationally, the little tern has a wide but patchy distribution in Europe, Africa, Asia and Australia (Higgins and Davies 1996). The subspecies *Sterna albifrons sinensis* (Little Tern (western Pacific)) is the only form of the species that occurs in Australia (TSSC 2007). There appears to be three separate populations of subspecies *sinensis* in Australia: a Northern Australian population (it is unclear whether the breeding birds are sedentary, migratory or both); an Asian population (non-breeding spring-summer migrants to Australia); and a South-eastern Australian population (spring-summer breeding migrants to southern Australia, including south-eastern Queensland (north to Bundaberg)) (NSW NPWS 2003; TSSC 2007). The small size of the south-east Australian breeding population is likely to be masked by the presence of relatively large numbers of migrants from breeding sites in Asia in summer (Garnett 1992).

At least two populations are likely to occur in south-east Queensland (both Asian and Australian breeding populations), though birds can not be distinguished from each other (Agnew and Stewart 1998). Within inshore and offshore waters of North Stradbroke Island, little terns were considered a common summer migrant, being most numerous March to May (Smyth and Corben 1984). Within Moreton Bay, little terns are considered common, particularly in summer when migrant birds are present (Agnew and Stewart 1998).

The south-eastern Australia breeding population is estimated to be around 1,000 breeding birds, and based on 1998 data, 62 birds bred in Queensland (TSSC 2007). Garnett and Crowley (2000) reported 40 known breeding colonies in Queensland, though only 27 known to have been used recently.

Significant counts of little terns have been recorded in the northernmost section of Pumicestone Passage. On sandbanks near the Caloundra bar, counts of greater than 11,000 birds, principally *Sterna albifrons sinensis*, have been recorded (Chan and Dening 2007). The north-eastern beaches and sand spit of the South Stradbroke Island are also support important roost sites (Sonnenburg 2006; Searle 2006).

Australasian Bittern

Australasian bittern *Botaurus poiciloptilus* is listed as is listed as *Endangered* (IUCN 2007).

The Australasian bittern inhabits terrestrial and estuarine wetlands, though preferring permanent freshwater wetlands which support a combination of tall, dense vegetation (e.g. bullrushes *Typha* spp. and spikerushes (*Eloacharis* spp.) and short dense vegetation including sedges, rushes and reeds (Marchant and Higgins 1990; Garnett and Crowley 2000). This shy and cryptic bird, roosts, feeds and breeds within dense vegetation cover (Marchant and Higgins 1990). Garnett and Crowley (2000) considered that their comparatively specialised habitat requirements, this species may be more sensitive to overall habitat loss than are many wetland species.

The Australian population is estimated to be around 2,500 birds, most of which are in the Murray Darling basin and adjacent coastal areas (Garnett and Crowley 2000; IUCN 2007). Whilst there are no current records for the site, birds may possibly occur within large densely vegetated wallum swamps of Moreton and North Stradbroke Islands which appear potentially suitable. The combination of the species' cryptic habits and the difficulty of accessing and surveying favoured habitats means that this species is may have been overlooked by general fauna surveys of potential habitat.

Table 7-14 outlines a summary of the key attributes of the critical service.

Table 7-14 Critical Service 4

Summary Table	Critical Service (S4)
Reason for Inclusion	Key services provided by the site in regards to threatened fauna comply with the Ramsar Nomination Criteria 2, in that the site supports endangered and vulnerable fauna, Criteria 4, in respect to support for animal species at critical life stages in their life cycles.
Type of Service	Supporting – threatened fauna species.
Description of Service (quantify if possible)	The site supports records of, and habitat suitable for, nine threatened wetland-dependant terrestrial fauna as outlined in the text. A tenth species, the Australasian bittern has not been recorded currently but may utilise the site due to suitable habitat.
Spatial Application (if relevant)	This service applies to the whole site, though important localities and habitats are the outer sand islands (Bribie, Moreton and North Stradbroke Islands), estuarine environments of Pumicestone Passage and southern Moreton Bay, and inshore waters. Refer to species accounts for important localities.
Critical habitat components underpinning this service	• Mangrove forests and associated intertidal areas (Illidge's ant blue butterfly, beach stone-curlew and water mouse) • Freshwater and wallum wetland habitats (acid frogs, water mouse, Australasian bittern and Australian painted snipe) • Nearshore and offshore open waters and rivers (little tern) • Supralittoral wetlands, including salt marsh and sedgelands (water mouse and Australian painted snipe) and adjacent forest (Illidge's ant blue butterfly and beach stone-curlew) • High tide roost sites, including open beaches (beach stone-curlew and little tern).
Critical species underpinning this service	Food - crustaceans and molluscs invertebrates of freshwater/brackish wetlands (Australian Painted Snipe), invertebrates of freshwater wetlands (acid frogs), intertidal crustaceans, pulmonate snails, marine gastropods and other invertebrates (water mouse, beach stone-curlew), nectar of flowers, including mangroves, eucalypts, *Parsonsia* spp. (Illidge's ant blue butterfly), small surface active schooling fish (little tern). Habitat - mangroves supporting *Crematogaster* sp. Ant (Illidge's ant blue butterfly); shallow wallum wetlands (permanent or ephemeral) which support highly acidic, non-turbid, oligotrophic waters (acid frogs); shallow wallum wetlands with emergent macrophytes (wallum sedgefrog); broad intertidal areas within mangrove forests (beach stone-curlew, water mouse); and densely vegetated wetlands (Australian painted snipe).
Critical processes underpinning this service	Maintaining the service over time is most dependant on the following: • Water Quality. In regards to all three wallum-dependent acid frog species - maintenance of water quality of island wetlands (esp. pH, nutrients and dissolved oxygen). In regards to little tern - maintenance of water quality (light, salinity, turbidity, suspended solids, nutrients). • Hydrology (freshwater wetlands). In regards to all three wallum-dependent acid frog species - maintenance of the water table (water depth and groundwater interaction in lakes, swamps and creeks) and groundwater interactions with surface water. "Perched" wetland systems are dependent of direct rainfall recharge and sub-surface infiltration from surrounding dunal systems.

Summary Table	Critical Service (S4)
	• Hydrology (tidally influenced wetlands). In regards to beach stone-curlew and water mouse – maintenance of natural patterns of tidal inundation and freshwater flows to intertidal and supralittoral wetland systems. • Climate. In regards to all three wallum-dependent acid frog species - precipitation and evaporation rates will determine supply and water levels in terrestrial wetland environments. The level of rainfall is important in terms of the high dune system supply which subsequently links into the permanent lakes and swamps. • Fire Regime. In regards to all wallum-dependent acid frog species - natural fire regime in relation to island wetlands is maintained. • Biological/Biophysical Processes. In regards to Illidge's ant blue butterfly, all three wallum-dependent acid frog species, beach stone-curlew, Australian painted snipe and water mouse - maintenance natural vegetation patterns, extent, health, and interconnectivity is critical to their long term condition. In regards to all threatened taxa - maintenance of key biological processes occurring at the site such as growth, reproduction, recruitment, feeding and predation.
Natural Variability (if relevant)	Patterns in abundances of all fauna species are thought to vary across a range of spatial and temporal scales. There are significant constraints to assessment of Illidge's ant blue butterfly, Australian painted snipe and water mouse due to their highly cryptic nature. Potentially the most detailed data set relates to migratory shorebirds, though such data is not currently in a form which enables detailed analysis. Population data for the remaining species is not comprehensive.
Principal threats	Habitat loss, fragmentation and degradation due to development (all species), water quality degradation (all species), changes to freshwater inflows to wallum wetlands (acid frogs), groundwater extraction (acid frogs, Australasian bittern, and Australian painted snipe).
Data quality underpinning this critical service	Service – Level 2-3 (population survey data outdated, insufficient scale). Components – Level 2 (outdated, insufficient scale). Processes – Level 1-2 (water quality); 2 (freshwater flows); 2 (tidal data).
Information gaps	• Natural population variability for all species and factors controlling these changes. • Sustainability of beach stone-curlew pairs (and breeding success) (particularly related to impacts of recreational activities) and water mouse populations (in relation to development or degradation of habitat adjoining the site). • Extent of populations of acid frogs and water mouse outside/adjoining study area boundaries. • Systematic information to assess background variability in wetland community structure and linkages to controlling processes; environmental flow requirements of acid frogs; impacts of introduced species (acid frogs, beach stone-curlew, little tern) and congeneric competitors (to acid frogs). • Locations and sustainability of little tern nesting sites (primarily in southern parts of site). Longer-term variability in patterns of usage of little tern roost sites.
Recommended monitoring	Acid frogs - Identify key populations and for those populations, monitor presence/absence, breeding evidence (tadpoles and metamorphs), and maintenance of parapatry between acid frog and congeneric sibling species during optimum breeding conditions until markers/trends of population variability are evident. Quarterly monitor water quality for key population sites (salinity, pH range 3-5, dissolved oxygen, nitrate levels (maintain <0.7 mg/L) and other toxicants (e.g. monomeric Aluminium and surfactants)). Assess impacts of fire on habitat of key frog populations from fires. Beach stone-curlew – Monitor habitat usage and breeding activity within key habitat areas (annual). Little tern – Identify locations and sustainability of nesting sites (primarily in southern parts of site) (yearly). Monitor abundance and pattern of usage at key roosts within northern Pumicestone Passage and northern sector of South Stradbroke Island (annual). Water mouse – Identify full extent habitat within and outside the site and monitor nest activity and diversity of nest types as surrogate for species distribution and abundance (annual and during breeding period).

7.5 Service 5 ~ Wetland Flora Communities and Species

Photos of Swamp Orchid (© Shane Ruming), Freshwater wetland North Stradbroke Island (Source: BMT WBM Photo Library) and Lesser Swamp Orchid (© Shane Ruming)

The Moreton Bay Ramsar site supports a diverse array of vegetation communities. While none of the wetland communities present within the site are listed nationally, one and four wetland RE's present are listed at the State-level as Endangered and Of Concern respectively (EPA 2007c, 2008a; refer Table 7-15). The Endangered wetland RE is riverine gallery rainforest (RE 12.3.1), and is represented in Bribie Island National Park. One Of Concern wetland RE is estuarine open forest (RE 12.1.1), and is represented in Bribie Island National Park and in the southern Bay. The three remaining Of Concern RE's are all palustrine in nature, including two open forest wetlands (RE's 12.3.4 and 12.3.11) and one sedgeland swamp (RE 12.3.8). These wetlands are predominantly located on the Bay islands.

Numerous endangered and vulnerable flora species are known to occur within Moreton Bay; including five nationally-listed species that are wetland-dependent (refer Table 7-16). Particularly noteworthy species include the endangered swamp daisy (*Olearia hygrophila*) that is endemic to North Stradbroke Island, known only from two locations on the island; and three endangered swamp orchid species (*Phaius australis, P. bernaysii* and *P. tancarvilleae*) that are rarely seen on the mainland but are more frequently encountered on the Bay islands (SGAP 2005).

Categories of critical processes underlying this service were identified as hydrologic (tidal regime; freshwater inundation regime; groundwater), geomorphologic (age of the underlying sand deposits; sedimentation; erosion) and biologic (reproduction). Variations in processes within these three categories have the potential to substantially alter the flora of Moreton Bay. For example, hydrologic changes such as variation in water quality may impact flora species that are sensitive to nutrient levels, and changes in the depth of the water table may significantly impact the survival of wetland flora; geomorphologic changes may impact flora communities due to changes in substrates; and changes to reproductive processes may significantly impact the persistence of species over time.

Currently, flora communities and species of conservation significance are under threat from a range of processes, principally invasion by exotic weed species and changes to hydrology and water quality. Additional threats on a more localised scale include damage to vegetation by feral animals such as pigs and goats, inappropriate fire regimes and destruction of plants by recreational activities (QPWS 2007).

Knowledge of the biology and ecology of important plant species, such as *O. hygrophila*, is extremely limited (Bostock and Thomas 1992). In particular, research has neglected, been unable to definitively address groundwater dependencies for communities and species in Moreton Bay, or understand species tolerance to salinity and desiccation (refer Marshall et. al. 2006 in relation to recent studies of groundwater dependant ecosystems on North Stradbroke Island).

Quantifying specific limits of acceptable change should - at a minimum - aim to maintain the biodiversity and integrity of natural ecosystems, and ensure that Endangered and Vulnerable flora communities and species within the site persist into the future. Further, species of significance should maintain their current conservation status (i.e. not be upgraded from Rare to Vulnerable, Vulnerable to Endangered, Endangered to Critically Endangered). In order to more precisely quantify limits of acceptable change through the estimation of thresholds, it is necessary to address various shortcomings in the current knowledge. This includes conducting systematic flora surveys and mapping significant flora. This would assist in specifying acceptable percentages regarding reductions in spatial extent for vegetation communities or in population numbers for flora species. Additionally, systematic surveys and mapping would assist in prioritising targeted areas for conservation and management actions, as well as monitoring strategies. Research on aspects such as groundwater dependency, tolerance to desiccation and reproductive dynamics would enable the development of relatively accurate predictions of future extents of vegetation communities and viability of populations.

Table 7-17 contains a summary of the key attributes of this critical service.

Table 7-15 Threatened wetland ecological communities occurring within the Moreton Bay Ramsar site

RE	Status*	Description	Protected areas
12.3.1	Endangered	Gallery rainforest (notophyll vine forest) on alluvial plains	Bribie Island NP
12.1.1	Of concern	*Casuarina glauca* (Swamp Oak) open forest on margins of marine clay plains; may also include *Melaleuca quinquenervia* (Broadleaved Paperbark) and/or mangroves	Bribie Island NP, Broadwater CP, Southern Moreton Bay Islands CP, Coombabah CP
12.3.4	Of concern	*Melaleuca quinquenervia, Eucalyptus robusta* (Swamp Mahogany) open forest on or near coastal alluvial plains	Bribie Island NP
12.3.8	Of concern	Freshwater swamps with *Cyperus* spp. and *Schoenoplectus* spp.; associated with floodplains	Moreton Island NP
12.3.11	Of concern	Open forest to woodland of *Eucalyptus siderophloia* (Grey Ironbark), *E. tereticornis* (Queensland Blue Gum) and *Corymbia intermedia* (Pink Bloodwood) on alluvial plains	Bribie Island NP

*Conservation status under the *Vegetation Management Act 1999*

Table 7-16 Nationally Endangered wetland flora species occurring within the Moreton Bay Ramsar site

Scientific name	Common name	EPBC*	NCA*
Olearia hygrophila	Swamp Daisy	E	E
Persicaria elatior	Knotweed	E	V
Phaius australis	Lesser Swamp Orchid	E	E
Phaius bernaysii	Yellow Swamp Orchid	E	E
Phaius tancarvilleae	Swamp Orchid	E	E

*EPBC = *Environment Protection and Biodiversity Conservation Act 1999*

NCA = *Nature Conservation Act 1992*

E = Endangered

V = Vulnerable

Table 7-17 Critical Service 5

Summary Table	Critical Service (S5)
Reason for Inclusion	• Supports Vulnerable or Endangered species (Criterion 2). • Supports a plant species at a critical stage of its life cycle (Criterion 4).
Type of Service	Supporting
Description of Service (quantify if possible)	Supports one Endangered and four Of Concern wetland RE's, as well as five nationally Endangered wetland plant species.
Spatial Application (if relevant)	Applicable to various habitats across the site as a whole, but predominantly the Bay islands.
Critical habitat components underpinning this service	With respect to the Ramsar Wetland Types, the following are the key habitat types for the critical flora species and communities: intertidal forested wetlands (Type I), permanent streams and creeks (Type M), freshwater marshes and pools (Types Tp and Ts) and freshwater tree-dominated wetlands (Type Xf).
Critical species underpinning this service	*Acacia baueri* subs. *baueri, Maundia triglochinoides, Olearia hygrophila, Persicaria elatior, Phaius australis, Phaius bernaysii, Phaius tancarvillea* and *Thelypteris confluens*.
Critical processes underpinning this service	• Hydrologic: tidal regime, freshwater inundation regime, groundwater • Geomorphologic: sedimentation, soil erosion • Biologic: reproduction
Natural Variability (if relevant)	Communities and species will continue to exist under normal hydrological regimes, geomorphologic processes and climatic conditions.
Principal threats	• Weed invasion • Changes to hydrology and water quality
Data quality underpinning this critical service	• Flora communities: Level 2, quantitative based on current RE mapping (EPA 2008a) and a range of general papers and studies. • Flora species: Level 3, semi-quantitative based on online species searches (as opposed to systematic surveys) and a range of non-specific papers and studies.
Information gaps	• Systematic surveys of flora and mapping of significant species is lacking. • Research to understand groundwater dependencies for communities and species is very limited. • Research to identify species tolerance to salinity and desiccation is lacking.
Recommended monitoring	Systematic flora surveys would quantify the representation of wetland communities and species of conservation significance within the Ramsar site. This would assist in prioritising targeted areas for conservation and management actions, and in specifying limits of acceptable change more accurately (i.e. in terms of percentage area for RE's or population numbers for species).

7.6 Service 6 ~ Shorebird Populations

Photos of various shorebird species (source: BMT WBM Photo Library)

The significance of Moreton Bay, including Pumicestone Passage, as a site of national and international significance for migratory shorebirds has been widely described (Thompson 1990a; Driscoll 1993; Watkins 1993; Hulsman *et al.* 1993; Driscoll 1997; Bamford and Watkins 2003; EPA 2005b; Geering *et al.* 2008; Bamford *et al.* 2008). Moreton Bay is also significant for a large waterbird population (Nichols and Maher 1999).

Moreton Bay supports a high abundance of shorebirds. During the summer months, Moreton Bay habitats support over 3500 resident and between 40,000 to 50,000 migratory shorebirds (Thompson 1990a; Driscoll 1993; Watkins 1993; Driscoll 1997; EPA 2005b). This equates to approximately 10% of maximum number of shorebirds migrating to Queensland over the summer period (Driscoll 1993; Watkins 1993; Driscoll 1997).

Moreton Bay also supports a high diversity of shorebirds. Ten resident and 32 migratory shorebird species are regularly recorded in Moreton Bay (Thomson 1990; EPA 2005b). Nationally, 18 species are considered resident, at least 36 migratory shorebird species are regularly recorded, and a further 21 are considered vagrant species (occasionally recorded-less than five records annually) in Australia (Priest *et al.* 2002; Birds Australia 2008).

Moreton Bay supports significant numbers of individual waterbird species, e.g. Eastern curlew *Numenius madagascariensis* (3000 to 5000 birds, approximating 20% percent of the species' population) and grey-tailed tattler *Tringa brevipes* (>10,000 birds, approximating 50% percent of the species' population) (Driscoll 1997; Finn *et al.* 2002; EPA 2005b). Bamford *et al.* (2008) considers Moreton Bay to be the third most significant site for Eastern curlew within the East Asian–Australasian Flyway.

Existing data demonstrates that the 1% species population threshold has been exceeded for the following species: bar-tailed godwit *Limosa lapponica*, whimbrel *Numenius phaeopus*, Eastern curlew *Numenius madagascariensis*, terek sandpiper *Xenus cinereus*, grey-tailed tattler *Heteroscelus brevipes*, curlew sandpiper *Calidris ferruginea,* pied oystercatcher *Haematopus longirostris*, Pacific golden plover *Pluvialis fulva*, and lesser sand plover *Charadrius mongolus* (Lane 1987; Thomson 1993; Driscoll 1997; Finn *et al.* 2002; QWSG 2008 unpublished data; Geering *et al.* 2007; Birds Australia 2008; Bamford *et al.* 2008).

In respect of migratory shorebirds, four main roost types and key habitat types have been identified (Thompson 1990a and 1992). These are:

- Open sandy islands or beaches – Moreton, Bribie and North Stradbroke Islands. Only two similar roosts known on, or adjacent to, the western side of Moreton Bay. These types of roosts are used by most species.

- Salt and clay pans - within and adjacent to mangrove communities. Birds may find cover under mangrove trees or shelter within clumps of samphire and sedge. These roosts are used by most species.

- Inland freshwater marshes - restricted to the western side of the Bay and used by some species at all stages of the tidal cycle.

- Mangroves - the preferred roosting sites for grey-tailed tattler, whimbrel, and terek sandpiper, though often used by other also used by others less frequently, e.g. curlew sandpiper and common greenshank *Calidris nebularia*.

112 roost sites have been identified in Moreton Bay, though only 15 are considered to be suitable roosts above the highest astronomical tide (HAT) (Lawler 1995; Miller 1997; Nichols and Maher 1999). A significant number of these roosts are considered threatened by development and by their definition beyond the boundary of the marine park (Nichols and Maher 1999; EPA 2005b). The largest roost sites occur at the Port of Brisbane and Manly Boat Harbour (adjacent to western side of Ramsar site), Mirapool on Moreton Island, and within Pumicestone Passage (i.e. Toorbul) (Driscoll 1997). In response to loss of more natural roost sites, there are a variety of sites where shorebirds are using artificial structures and substrates. Notable amongst these sites, are the purpose built roosts, i.e Kakadu Beach (Bribie Island), Empire Point (near Raby Bay) and at the Port of Brisbane (Fisherman Islands, Brisbane River mouth).

Shorebird feeding habitat varies throughout Moreton Bay, with the primary differences relate to intertidal substrate type, i.e. being predominately finer, muddier sediment associated with the western side of the bay in contrast to the sandier sediment along shores on the eastern side of the bay. Notable, though of limited extent, are smaller areas of coarse coral and rock rubble around the islands of central Moreton Bay (Mud, St. Helena and Green islands), Wellington Point and Redcliffe Peninsula These feeding substrate differences influence the relative numbers and shorebird species which occur throughout the bay (Driscoll 1997). Feeding substrates along the western side of the bay exhibit greater levels of variation as they are influenced to a greater extent by human influence (e.g. sewage outfalls, direct stormwater discharges, sediment, etc.) (Thomson 1990 and 1992; Driscoll 1997).

The expansive flats at the southern end of Moreton Island and the western side of North Stradbroke Island to Russell Island hold the highest concentrations of waders anywhere in the Bay (Driscoll 1997). Whilst areas of intertidal flats adjoining the outer islands are less common than those adjoining mainland areas, they are the preferred habitat of several species (e.g. Eastern curlew, bar-tailed godwit *Limosa lapponica*) and support a higher proportion of adult birds for some species (Thomson 1990b; Finn 2008).

Major feeding areas within the western side of the bay include: Pumicestone Passage (i.e. Tripcony Bight and between Donnybrook and Toorbul), Deception Bay, Hays Inlet and shoreline between Nudgee south to Redland Bay (Driscoll 1997). Within the southern part of the bay, feeding habitat is characterised by relatively narrow intertidal flats associated with an extensive network of channels and waders occur in much lower densities (Driscoll 1997).

Threats to shorebirds and their habitats in Moreton Bay include:

- Water pollution – includes any pollution (point and/or diffuse source) which might negatively impact on invertebrate prey populations, e.g. sediment inputs which can smother intertidal substrates, increases water turbidity leading to reductions in epibenthic algae and seagrass; organic nutrient inputs (e.g. sewage discharge, urban nutrient runoff) leading to eutrophication (resulting in excessive macro-algal growth) and alteration of intertidal invertebrate species composition; and episodic pollution events such as oil spills (particularly relevant to habitats adjacent to Brisbane River mouth). It should be noted that some polychaete worms and bivalve molluscs have benefited from nutrient enrichment, which in turn has provided food to support greater densities of curlew sandpiper and great knot, but other species such as grey-tailed tattler, which prefer to forage in areas of seagrass, have declined dramatically (e.g. Bramble Bay and Luggage Point; see Thomson 1993; Harding and Wilson 2008).

- Alterations to hydrodynamics – permanent changes to tidal regimes (current speed and direction) can impact on current velocity (increases and decreases) which in turn affect intertidal and roost habitats (through changes in erosion and deposition rates).

- Roost habitat loss – Whilst the form and location of many roost sites are subject to natural changes over time (e.g. Eastern banks), Moreton Bay has previously experienced an unquantified but considerable loss of habitat as a result development of the coastal zone (e.g. marina and canal developments, and reclamation for industrial lands) (EPA 2005b). Whilst a large proportion of roost sites are currently within protected land tenure, there are sites which occur on privately owned lands which are not subject to the same level of protection.

- Human associated disturbance – In southeast Queensland, management of anthropogenic disturbances is regarded as a key issue for shorebird conservation management, particularly at high tide roost sites (Nichols and Maher 1999). Shorebirds are particularly vulnerable to disturbance from direct impacts at nesting areas to indirect impacts on food sources and at roost sites, and activity can impact on shorebirds more than 200m away (Thompson 1992). Disturbance to shorebirds (generated human activity and by companion animals) can result from poor separation between coastal recreational activities and/or urban development and roost sites (e.g. Mirapool, Manly Boat Harbour). Disturbance to both migratory and resident shorebirds (roosting and breeding) can occur as a direct result of human activities, e.g. recreational activities such as 4WD vehicles on beaches (Moreton and North Stradbroke Islands) and boating around feeding and roost sites (e.g. Days gutter, Amity banks). For resident shorebirds, this disturbance and also lead to reduced breeding success through nest destruction or abandonment, or succumbing to predators associated with humans, such as dogs, black rats *Rattus rattus*, silver gulls *Larus novaehollandiae* or ravens *Corvus* spp. (Priest *et al.* 2002). Nests of a variety of resident shorebirds (e.g. pied oystercatcher and red-capped plover) are frequently disturbed by vehicles on ocean beaches in south-east Queensland (EPA 2005b). As many of these species occur at low densities in an essentially linear habitat, local extinctions could easily become regional ones (Garnett and Crowley 2000; EPA 2005b).

Table 7-18 Critical Service 6

Summary Table	**Critical Service (S6)**
Reason for Inclusion	Key services provided by the site in regards to migratory shorebirds complies with Ramsar Nomination Criteria 3, 4 and 5 in regards to shorebird abundance and diversity, provision of over-wintering and flyway staging habitat, and Criteria 6, in regards to exceeding the 1% species population threshold for nine shorebird species.
Type of Service	Supporting – migratory shorebirds
Description of Service (quantify if possible)	The site supports: • high shorebird diversity and represents almost 90% of the migratory shorebird species regularly occurring in Australia and approximately 55% shorebird species resident in Australia. • high shorebird abundance with a variety of counts (individually &/or collectively) which provide evidence that in excess of 20,000 shorebirds occur within habitats of the site each year. Population counts for the site equate to approximately 10% of maximum number of shorebirds migrating to Queensland over the summer period. • nine shorebird species (eight migratory and one resident species) for which the 1% species population threshold is exceeded. • critical overwintering habitat and a flyway staging area (both northern and southern migration routes) for migratory shorebirds.
Spatial Application (if relevant)	Intertidal sand/mud flats, rocky shores and mangrove communities throughout the site, intertidal areas of coarse rubble associated with central bay islands (Mud, St. Helena and Green islands) and western shores (Wellington Point and Redcliffe Peninsula), high tide roost sites throughout the site (natural and artificial).
Critical habitat components underpinning this service	Expansive intertidal flats; a diversity of feeding substrates (e.g. soft muds and sands, substrates supporting seagrass, coral and rock rubble); and a diversity of disturbance-free high tide roost sites (e.g. above and below HAT, clay pans, saltmarsh, exposed sand banks, mangroves, rocky shores) which are spatially proximate to suitable feeding grounds.
Critical species underpinning this service	Food - A diversity and abundance of epi/infauna of the intertidal flats, e.g. polychaete worms, bivalve molluscs, and crustacea. Habitat – Mangroves (roost sites and nutrient inputs to associated intertidal areas); seagrass associated with intertidal areas (preferred feeding habitat for Grey-tailed Tattler; often supports a richer prey base for shorebirds generally).
Critical processes underpinning this service	• Tidal influences - maintenance of natural patterns of tidal inundation. Tidal inundation influences intertidal feeding habitat characteristics, i.e. overall extent, bioproductivity and daily availability to shorebirds. Tidal and wave regimes influence the biophysical processes in the development and maintenance of feeding and roost habitats. • Freshwater flow regimes – Pine, Brisbane, Pimpama and Coomera Rivers contribute the bulk of fluvial sediment to the western side of the bay. These sediments influence intertidal habitat suitability for shorebirds with comparatively higher influence on intertidal areas adjacent to and nearby river mouths. • Biological Processes - Primary and secondary bioproductivity of seagrass, algae and micro- and macro-invertebrates within intertidal habitats are crucial processes in supporting adequate shorebird food requirements. • Water quality – Required for maintenance of high primary and secondary bioproductivity on intertidal feeding areas.
Natural Variability (if relevant)	76% of the shorebirds regularly occurring within the site are migratory, though a small proportion remains in the bay during the non-breeding period (austral winter). The populations of migratory species fluctuate seasonally and the reasons for such changes are not well understood. Fluctuations may be influenced by local factors and/or influenced by external factors (impacts to breeding habitat and sites essential for migration within the East Asian-Australasian Flyway). Declines in shorebirds abundance and species composition have been recorded within the site (e.g. Fisherman Islands; Driscoll 1996 and 1998), though the sampling periods have been relatively short and do not provide conclusive evidence as to any particular factor, i.e. links to habitat loss and/or habitat alterations and/or an overall decline in the bay's shorebird population. Whilst local databases are data rich, data is not currently in a form which can be readily analysed.
Principal threats	• Water quality degradation – Point and/or diffuse source pollution which negatively impacts on epibenthic algae, seagrass, and invertebrate prey populations. This includes: sediment, organic nutrient inputs (e.g. sewage discharge, urban nutrient runoff), toxins (including persistent herbicides and biocides), and episodic pollution

Summary Table	Critical Service (S6)
	events such as oil spills. • Alterations to hydrodynamics – Changes to tidal regimes (current velocity and direction) which influence changes in erosion and deposition patterns, particularly in relation to establishment and maintenance of intertidal habitats. • Anthropogenic disturbances - Disturbance to shorebirds on feeding grounds and at roost sites generated human activity and companion animals. • Roost habitat loss – Whilst a large proportion of roost sites are currently within protected land tenure, there are sites which occur on privately owned lands which are vulnerable and not subject to the same level of protection. In addition, there is an imperative to maintain a suitable geographic spread of a combination of non-HAT and HAT roost sites which are spatially proximate to suitable feeding grounds. • External factors - Loss of roost and feeding habitat and birds within the Flyway.
Data quality underpinning this critical service	Service – Level 2-3 (potential inaccuracies in collected data, limited capacity to interrogate data). Components – Level 2 (outdated, insufficient scale). Processes – Level 1-2 (water quality); 2 (tidal data).
Information gaps	• Indices/trends for shorebird abundance and diversity over time, patterns of roost and feeding habitat usage. • Natural population variability for all species and factors controlling these changes. • The proportion of the site's shorebird population which is associated with feeding and roosting outside the Ramsar site boundary. • Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh. • Information on natural population variability of invertebrate prey and factors controlling temporal changes. • Current distribution and categorisation of roost habitats (e.g. size, level of disturbance, position in relation to HAT and feeding grounds) within and adjacent to study area boundaries. • Data on shorebird numbers and changes in populations within other parts of the Flyway.
Recommended monitoring	• Early and late summer monitoring events at key roost sites and feeding grounds (to be conducted annually) to target bar-tailed godwit, Eastern curlew and Pacific golden plover (species which currently exceed the 1% threshold and which may provide useful surrogate for numbers of other shorebirds using the site and of habitat usage). • Annual audit of roost sites (condition and use). • Monitor habitat usage and breeding activity (annual) within key habitat areas on outer bay islands

7.7 Service 7 ~ Fisheries

Photos sourced from BMT WBM Photo Library

The Moreton Bay Ramsar site supports high fisheries resource values, including:

- Provision of shelter and food resources for fish, crustaceans (crabs, prawns) and other shellfish (including oysters) of high commercial and recreational fisheries value;
- High value commercial and recreational fishing industries;
- Indigenous cultural values (noting that these values are addressed as part of Service 8 and are not addressed further below).

Habitats

The site supports a wide diversity of habitats utilised by species of direct fisheries values, including mangroves, saltmarsh, seagrass, unvegetated sand and mud flats, estuarine creeks, offshore channels and reef environments. In general terms, fisheries productivity of an estuary is thought to be a function of its geomorphic conditions, which is a function of the degree of infilling (e.g. Roy *et al*. 2001; Saintilan 2004). From an estuary geomorphology perspective, Moreton Bay is classified as a wave-dominated estuary that is comprised of four types of depositional environment or estuary zones (Rochford 1951; Roy *et al*. 2001):

- **Marine tidal delta**, which extends along the Eastern Bay. The geomorphology of this zone is dominated by wave action and is well flushed by marine waters. Structural habitat complexity is lower than found in fluvial delta environments in Western Moreton Bay, but nonetheless, this zone contains significant fish habitat resources in the form of seagrass beds (i.e. Amity Banks) and 'unvegetated' sandy banks;
- **Central mud basin**, which includes deeper areas between the marine tidal deltas of Eastern Moreton Bay, and fluvial delta environments of Western Moreton Bay. This zone is not well represented in the Ramsar site;
- **Fluvial delta**. The central western foreshore of Moreton Bay contains numerous fluvial deltas associated with the rivers and creek systems draining the Moreton Bay catchment. Southern Moreton Bay is dominated by fluvial deltas of the Logan, Coomera and Pimpama Rivers. Fluvial

delta zones typically contain the most complex physical settings and habitat types of the four estuary zones, including mud flats, mangroves, saltmarsh, seagrass, and creek channels;

- **Riverine channel and alluvial plain**. This zone is situated in areas where the alluvial plains are intersected by the river channel. This zone typically has limited structural habitat complexity, and has highly variable salinities that are a function of tidal flows and river discharges. This habitat zone type is not well represented within the Moreton Bay Ramsar site, the possible exception being upstream sections of the Coomera River.

At broad spatial scales (regional), the fluvial delta environments of Western and Southern Moreton Bay can be considered to represent structurally complex environments compared to other three estuary zones in the broader Moreton Bay region. These nearshore environments also have relatively high species richness of macroinvertebrates and fish compared to other environments in the Bay (e.g. Stephenson *et al.* 1970; Davie and Hooper 1998).

The western side of Moreton Bay contains a range of mangrove-lined creeks and rivers (and associated saltmarsh communities) of varying complexity and size, several of which are protected as Fish Habitat Areas. From north to south, the major tidal creeks and rivers within the site include Caboolture River, Burpengary Creek, Hays Inlet, Pine River, Cabbage Tree Creek, Nundah Creek, Nudgee Creek, Jubilee Creek, Brisbane River and Boggy Creek, Crab Creek, Tingalpa Creek, Eprapah Creek; Logan-Albert River; Pimpama River and Coomera River. By contrast, the sand islands that form the eastern edge of Moreton Bay do not contain rivers or major creek systems.

The mangroves, saltmarsh and tidal channels found on these fluvial delta environments and creek environments provide important fisheries habitat and foraging areas. For example, saltmarsh communities within the study site are inundated tidally during high water spring events, and are known from case-studies elsewhere to provide functional habitats and foraging areas for a range of fish (typically small-bodied non-commercial species) and nektobenthic crustaceans (including Penaeid prawns and non-commercial crab species) of indirect and direct fisheries value (e.g. Morton *et al.* 1987; Mousalli and Connolly 1998, Muzumder *et al.* 2006). Intertidal environments provide shelter and/or foraging areas for fish and nektobenthos during high tide, whereas adjacent sub-tidal creek channel environments provide low tide refugia and feeding areas (Crowley and Tibbetts in Tibbetts and Connolly 1998)[10].

Extensive seagrass meadows occur within the site. Within nearshore areas, the most extensive meadows occur (from north to south) at Pumicestone Passage, adjacent to Fisherman Islands south of the Brisbane River mouth, Wynnum, Cleveland, and shoal environments throughout southern Moreton Bay. These meadows are strongly influenced by light limitation due to turbidity (Abal and Dennison 1996; Abal *et al.*. 1998). Extensive seagrass beds also occur along the western edge of Moreton Island, most notably the Eastern Banks marine delta complex and around Peel Island.

Recent studies have examined the importance of mangroves, seagrasses and saltmarsh as autotrophic nutritional sources for fish in adjacent unvegetated environments (Melville and Connolly 2003, Guest and Connolly 2004, Melville and Connolly 2005). Despite being devoid of seagrass, Melville and Connolly (2003) demonstrated that organic matter, particularly from seagrasses, was important as the base of food webs for fish species of commercial significance on adjacent

[10] The authors also note however that conditions (possibly stochastic) encountered during movements may increase feeding opportunities and reduce predation rate.

unvegetated mudflats in Moreton Bay. Benthic microalgae also contributed a relatively high proportion of the nutrition of the species examined.

There are few empirical data describing the values of the Ramsar sites' reefs as a fisheries habitat. Advice from DPI Fisheries (Brad Zeller, pers. comm. 2008) indicates that several species of direct fisheries value utilise these reefs, most notably pink snapper at Peel Island.

Hydraulic Habitats and Flows

Flows of fresh water can have important effects on the physical and biological characteristics of estuaries and nearshore waters (Loneragan and Bunn 1999). River discharges provide nutrients and organic matter to estuaries, contributing to their high production (Loneragan and Bunn 1999).

It is known that many important life-history aspects of estuarine fish and crustaceans appear to be linked to flows (including migratory patterns, spawning, and movements of fish between different habitat types). However, globally, there is very little information on actual flow requirements of estuarine fish (Gillanders and Kingsford 1992; Loneragan and Bunn 1999; Connolly *et al.*. 2006).

Based on the analyses of commercial catch data and total flows in the Logan River estuary, Loneragan and Bunn (1999) demonstrated an increase in production of some fisheries with increased flow. They found that total (annual) flows explained 69% of total (annual) flathead catch in the estuary, and that this relationship was statistically significant. Loneragan and Bunn (1999) also found a positive link between freshwater discharge in the Logan River and fisheries production in the Logan River estuary, largely based on commercial catch data of prawns (bay, king, school, greasy, tiger and banana) and crabs (mud crabs and blue swimmer crabs). This is due, in part, to nutrients and organic matter being transported to the estuary during flows (Loneragan and Bunn 1999).

Key Species

Estuarine fish communities can show enormous variation over a range of spatial and temporal scales. This has been demonstrated even at small spatial and temporal scales for estuarine fish communities in the area (Stephenson 1980c; Sumpton and Greenwood 1990; Quinn 1992; Laegdsgaard and Johnson 1995; Tibbetts and Connolly 1998; Loneragan and Bunn 1999). Because of this, it is very difficult to make generalisations regarding the processes that control patterns in community structure.

Numerous estuarine fish species commonly occur in the site that are of value to commercial and/or recreational fishers, including but not limited to those listed in Table 7-19.

Key fish species of commercial and recreational significance within the site include snub-nosed garfish, river garfish, flat tailed mullet, sea mullet, fantail mullet, sand flathead, dusky flathead, tailor, spotted mackerel, golden lined whiting, eels, diver whiting, yellow finned bream and tarwhine. Numerous nektobenthic crustacean species of recreational and commercial interest also occur in the site, including banana, king, endeavour, tiger, school and greasy back prawns; mud, blue swimmer, red-spot, spanner and coral crabs; and Callianisidae shrimps. Other species of commercial significance include bait worms, squid, cuttlefish, rock oysters and beche-de-mer.

Fish and shellfish use different habitat types during different stages of their ontogenetic development (Table 7-19). Most require a combination of estuarine habitats to complete their life-cycle. For example, juvenile mullet are commonly found in freshwater reaches of tidal creeks and around shoals, whereas adults are typically more common in riverine channel habitats. Other species only occupy estuaries during their juvenile phase, such as king prawns, snapper and tarwhine, whereas other species, such as Australian bass, migrate from their primary freshwater habitat into the estuary to spawn. Species such as school prawns, luderick, yellowfin bream, flathead and whiting spend most of their life-cycle in estuaries, only moving to nearshore areas to spawn (Kailola *et al.*. 1993). These estuary residents are among the most important species from a commercial and/or recreational fisheries perspective.

Table 7-19 shows that important fisheries species commonly found within the Ramsar site are not found exclusively in any one habitat type during any part of their life-cycle. Rather, these species have relatively plastic habitat requirements, and are typically found in a variety of habitat types. Banana prawns were the only habitat specialists recorded in the study site, and are typically found in mangrove during their juvenile stages (Staples *et al.*. 1985). In general terms, most of the species listed in the table below spend their juvenile stages in shallow nearshore waters, particularly around seagrass and mangroves, whereas most species tend to spawn in inshore waters, particularly near the surf zone. Adults of most species tend to occur across a variety of habitats.

Table 7-19 Key fisheries species present in the Moreton Bay Ramsar site, and their primary habitats at different stages of their life-cycle (Data: Kailola *et al.*. 1993)

Species	Estuary					Coastal/Oceanic		
	Mangroves*	Seagrass*	Shoals*	Channels and Mud basin*	Freshwater*	Inshore*	Offshore	Reef/seawall*
TELEOSTI								
Long-finned eel					Juv., Ad.		Spw.	
Dusky flathead	Juv., Ad.	Spw.,Juv., Ad.	Spw., Juv., Ad.,	Ad., Juv.		Spw.		
Sand whiting	Juv., Ad.	Juv., Ad.	Juv., Ad.	Juv., Ad.		Spw.	Spw., Ad.	
Diver whiting		Juv. Ad		Ad.		Spw.		
Tailor		Juv., Ad.	Juv., Ad.	Juv.,Ad.		Spw., Juv., Ad.		
Yellowfin bream	Juv., Ad.	Juv., Ad.	Juv., Ad.			Spw., Ad.		Ad.
Mulloway	Ad.	Juv., Ad	Juv. Ad	Juv., Ad.		Ad. Spw.		
Luderick	Juv. Ad.	Juv. Ad.	Ad.	Ad.		Ad. Spw.	Ad.	Ad.
Sea mullet	Juv. Ad.	Juv.	Juv.	Juv., Ad.	Juv.	Spw.	Spw.	
Flat-tail mullet	Juv. Ad.	Ad.	Ad.	Ad.	Spw.	Ad.	Ad.	
Tiger mullet	Juv. Ad.	Ad.	Ad.	Ad.	Spw.	Ad.	Ad.	
CRUSTACEA								
Blue swimmer crab	Juv., Ad.	Juv., Ad.	Juv., Ad.	Ad.		Ad., Spw.	Ad.	
Mud crab	Juv., Ad.	Juv.	Juv.				Spw.	
King prawn	Juv.	Juv.	Juv.	Juv.		Ad.	Ad., Spw.	
Greasyback prawn	Juv.	Juv.	Juv., Ad.	Juv., Ad.		Spw.		
School prawn		Juv.	Juv., Ad.	Juv., Ad.			Spw.	
Banana prawn	Juv., Ad.	Ad.	Juv., Ad.	Ad.		Ad., Spw		

Note: Juv. = Juvenile, Ad. = Adult, Spw. = Spawning; * denotes habitat type found in the Ramsar site

Fishing Activities

Commercial fisheries in Moreton Bay include inshore and ocean beach net, otter and beam trawl, crab (pot), line and several collection based fisheries (i.e. bait worm, aquarium and development *beche-de-mer* collection). Commercial harvest methods occur within the Moreton Bay Ramsar site: gill, seine, fixed netting; beam trawling, otter trawling; line fishing; crab potting; pearl and rock oyster culture; and the above mentioned collection based fishing methods. Recreational fishing methods include line fishing; bait collecting; cast netting; crabbing; limited prawn netting and spear fishing. Limited charter (line) fishing occurs within the site, being mostly situated in offshore areas outside the site. Indigenous fishing is considered in Service 9 below.

Within the broader Moreton Bay Marine Park, commercial vessels landed approximately $24.1 million gross value of product (GVP) annually in the three year period ending 30 June 2006 (Environmental Protection Agency 2007). Over this same period, approximately 410 commercial fishing licenses were assessed annually in the Marine Park (Environmental Protection Agency 2007). Note that the Marine Park includes large areas outside the Ramsar site. Williams (2002) found that the total Moreton Bay catch represented ~12% of the State's total catch in the period 1988-2000.

Within the broad South East Queensland region, recreational fishing was reported to have generated $194 million in related expenditure annually in 2000-2001 (Environmental Protection Agency 2007). There are insufficient data to assess the current status of fish catch and effort with the site, and its impacts on fish stocks.

Access is a key control on fishing activities. The term access includes physical access constraints (which can vary over time in response to weather conditions, seasonal factors etc.), and regulatory constraints associated with fisheries management regulations (i.e. closed areas, seasonal closures, gear limitations etc.). Social factors also have a major influence on fishing activities, including disposable income, time constraints, holiday periods etc.

Table 7-20 Critical Service 7

Summary Table	Critical Service (S7)
Reason for Inclusion	Meets Ramsar criteria 3, 4 and 8
Type of Service	Supporting – Biodiversity and ecosystem functioning Cultural – Indigenous cultural values and tourism Provisioning – Food for indigenous, recreational and commercial fisheries
Description of Service (quantify if possible)	The site provides important habitat for species of direct economic significance, as well as regionally important fisheries.
Spatial Application (if relevant)	Whole of site. Most fish stocks do not reside exclusively within the site, hence factors external to the site are likely to control stock sizes.
Critical habitat components underpinning this service	Mangroves; Saltmarsh; Intertidal flats; Supratidal channels and flats; Seagrass and algal beds; Coral and Rocky Reefs; Shallow surf bars and banks; Open expanses of shallow oceanic waters
Critical species underpinning this service	Seagrass, mangroves, saltmarsh (habitats) Harvested species including: • Finfish - Bream, flathead, whiting, luderick, mullet, tailor, mackerel, sharks, baitfish, eels, and pink snapper • Prawns - King, tiger, endeavour, banana, greasyback and school prawns • Other decapod crustacea - Blue swimmer, mud, red spot, spanner and coral crabs and callianasid shrimp (yabbies) • Others - Squid, cuttlefish, gastropods, rock oysters, bivalves and beche-de-mer.
Critical processes underpinning this service	Maintenance of biophysical habitat extent, diversity and interconnectivity Maintenance of freshwater flow regimes Maintenance of tidal and wave regimes that drives biophysical habitats patterns and

Summary Table	Critical Service (S7)
	processes Maintenance of water quality conditions, particularly with respect to its influence on estuarine vegetation communities (i.e. seagrass, algae etc.)
Natural Variability (if relevant)	Patterns in fish and shellfish community structure may vary across a range of spatial and temporal scales. Fisheries productivity (catch) varies in response to this and other factors (i.e. regulations, weather conditions etc).
Principal threats	Over-harvesting Incremental habitat loss due to human population growth Water use and modifications to freshwater flow regimes Water quality degradation Lyngbya blooms
Data quality underpinning this critical service	Service – Level 3 (fish catch data) Components – Level 2 (outdated, insufficient scale) Processes – Level 1-2 (water quality); 2 (freshwater flows); 2 (tidal data)
Information gaps	Present-day and historical marine vegetation mapping done at relevant spatial scale (minimum 1:25,000) and temporal (at least every 5 years, preferably with analysis of seasonal changes); Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh; Natural variability in fish and shellfish stocks, and factors controlling these changes; Specific environmental flow requirements of estuarine vegetation and fisheries species; Priority areas for habitat rehabilitation and possible offsets areas; Sustainability of current recreational and commercial fisheries management practices Values and functions of proposed no-take ‘green zones’ in the future Marine Park Zoning
Recommended monitoring	Fish stock monitoring based on DPI&F state-wide LTMP, CFISH (Commercial Fisheries Information System) and RFISH (Recreational Fishing Information System) programmes

7.8 Service 8 ~ Indigenous Cultural Significance

BMT WBM commissioned Converge Heritage + Community Pty Ltd (previously trading as ARCHAEO Cultural Heritage Services Pty Ltd) to conduct a desktop assessment of indigenous cultural values associated with the Moreton Bay Ramsar areas. This assessment forms part of the ECD with the full report prepared by Converge Heritage + Community contained in Appendix C.

As identified in Section 3 of this report, Resolution IX.21 of the Ramsar Convention, entitled “Taking into account the cultural values of wetlands” was adopted at Ramsar’s ninth conference. This important change to global policy statements of the Ramsar Convention provides a strong mandate for taking into consideration the indigenous cultural values of the Moreton Bay Ramsar areas in the current study.

The scope of the cultural heritage assessment undertaken as part of the ECD is limited to being desktop, and will be based only on documentation that is already in the public arena. Specifically, consultation with indigenous groups is not part of the scope. This assessment provides:

- Contextual information;
- A discussion of the relationship between indigenous groups and land;
- A summary of available information about cultural connections with Ramsar areas;
- Case studies that demonstrate that significant cultural values may be associated with Moreton Bay Ramsar areas;
- Available information on how cultural values are being sustained; and
- An assessment of the limits of acceptable change if cultural values in Ramsar areas are to be protected and managed.

As outlined in Section 3 (refer section on cultural resources) and Appendix C, while environmental, ethnographic and archaeological evidence may indicate the richness of the Moreton Bay environment during the past 6,000 or so years that would have been an important and sustaining resource for Aboriginal groups, these observations only give partial insights into the relationship between those Aboriginal groups and the land in which they lived and indeed continue to live. Often, the ethnographic reports provide a commentary on what the observer has found interesting, thus emphasizing a perspective that tends to focus on resources, rather than placing on the public record, an understanding of the complex cultural and social network that existed, and continues to exist amongst Aboriginal people of Southeast Queensland.

Approximately one third of Queensland’s Aboriginal and Torres Strait Islander population lives in Southeast Queensland (South East Queensland Regional Plan 2005). Many of these people have moved to the region. As contemporary residents, these people are often referred to as “historically associated”, and may be regarded as stakeholders in the region similar to the non-indigenous population. In contrast, those Aboriginal people who are descendants of ancestors who lived in Southeast Queensland before non-indigenous settlement identify as Traditional Owners. Each of these groups is an important stakeholder in the community of Southeast Queensland, but Traditional

Owners have additional and different aspirations to non-indigenous and historically associated indigenous stakeholders. Through their lineage, Traditional Owners inherit responsibilities under traditional law and custom to manage their land (often referred to as country), as well as a connection to country that is a cultural and spiritual relationship. This is best summed up in the words of Southeast Queensland's Traditional Owners:

> *As the current Aboriginal Traditional Owners in South East Queensland we have inherited a responsibility to look after our country. This responsibility has been handed to us by our ancestors, whose spirits continue to guide our decisions. We in turn have a responsibility to manage our country to the best of our abilities and to teach our youth the values and skills and provide them with the knowledge that they will need to manage our country with and after us….*
>
> *Cultural resources are all the tangible and intangible things in our land and sea country that are essential to our wellbeing: land, water, plants and animals (biodiversity), coastal and marine things, the air (atmosphere), and community. As Aboriginal people, we have such a deep and integral connection and set of relationships with these 'natural' elements that we consider them as cultural entities., Our identity as well as our cultural, spiritual and material wellbeing is entwined with the country and its health; without strong and healthy country, our people cannot be strong and healthy (SEQTOLSMA 2008: 8)*

In the absence of consultation as part of this ECD study, two important points should be made. Firstly, the statements of SEQTOLSMA would suggest that those Traditional Owners relevant to the Ramsar areas of Moreton Bay will have strong views on what will be considered their country or cultural resource, and will wish to take part in management decisions. Secondly, a further consideration is that the Traditional Owners relevant to Ramsar areas may have valuable historical knowledge of what these areas were like in the past, and what management strategies would be preferred. These points are best demonstrated through some case studies that are provided below:

Case Study 1 – Blue Lake, North Stradbroke Island

In 2007, consideration was given by the Queensland Government to the potential to harvest fresh water from aquifers on North Stradbroke Island for the water grid being developed across Southeast Queensland. Consultation was commenced with the Minjerribah Moorgumpin Elders in Council, the Aboriginal Cultural Heritage Body for North Stradbroke Island. During initial consultation, the Elders expressed deep concern about the project, as it potentially could impact directly on water levels in Blue Lake, a natural freshwater lake on the island. The Elders were particularly worried about such impacts because of the high levels of cultural significance associated with the lake. What constitutes the lake's cultural significance cannot be reported here, without consultation with and the permission of the Elders. Suffice to say that the Elders were extremely relieved when the project was abandoned because of general public concern.

This case study illuminates Traditional Owners' responsibilities and connection with country. Other people in the North Stradbroke community were concerned about the environmental impact of water harvesting on Blue Lake, a known and much appreciated natural part of the island. But the Traditional Owners' concerns were amplified by their cultural connection to the lake which is a significant Aboriginal area in the meaning of the *Aboriginal Cultural Heritage Act 2003* (ACH) Act.

Case Study 2 – Traditional Hunting Guidelines

An excellent example of on-going traditional responsibilities and customs working today is provided by the Quandamooka people.

The Quandamooka people of the Moreton Bay area are continuing their ages old traditional hunting, which provides an important part of their diet. Working with the Queensland Environmental Protection Agency (EPA), the Quandamooka people have developed Traditional Hunting Guidelines to ensure that hunting practices are sustainable. With the new zoning plan in Moreton Bay Marine Park the Quandamooka people are looking to progress the Traditional Hunting Guidelines into a Traditional Use of Marine Resources Agreement (TUMRA) which will be the new best practice. Quandamooka people have demonstrated their commitment to making the Agreement work through six years of sound management since the establishment of the traditional Hunting Guidelines (SEQTOLSMA 2008: 13).

Case Study 3 – Native Title's Rights and Interests

Whether or not native title is relevant from the perspective of land tenure in the Ramsar areas of Southeast Queensland is not a discussion for this assessment. Rather, the point being made is that the rights and interests detailed in the various native title claims in the Moreton Bay area give an indication of Traditional Owners' perspectives about their traditional responsibilities and rights. While the native title process may result in these claimed rights and interests only being relevant where native title has not been extinguished, from the Traditional Owners' perspectives, it is likely that they would prefer these rights and interests to be relevant in all of their country.

Consistent in the native title rights and interests claimed in all of the claim applications that cover parts of the Ramsar areas are the following themes:

- Access to enter and remain on lands and waters;
- Use and enjoy land and waters, including traditional hunting and gathering;
- Protection and management of the resources of lands and waters;
- Capacity to exercise customary rights and discharge traditional responsibilities;
- Recognition as Traditional Owners

The themes enunciated by the claimed rights and interests show that there is no differentiation between land and water – both are country – and all country requires protection and management.

Case Study 4 – SEQTOLSMA

The Moreton Bay region is home for a number of Traditional Owner groups as listed in Appendix C. These include the Kabi Kabi families, Jagera and Turrbal families, Quandamooka (Ngugi, Noonucle, Gorenpul) families, Yugambeh (eight groups) and Ngarang-Wal/Kombumeri families.

Other Traditional Owner groups include the Jinibara and Mulinjarlie families, but these groups are sub-coastal and may not necessarily have Ramsar areas in their traditional countries.

In 2005, representatives of all but two of these groups commenced negotiations about forming a body “to establish more comprehensive and meaningful Traditional Owner involvement and ownership in improving the condition of the region’s natural resources”, and “to promote more comprehensive and effective engagement of Traditional Owners in cultural (natural) resource management” (SEQTOLSMA 2008, p. iv). The outcome is the development of an on-going body of Traditional Owner representatives who have now developed a plan, called OUR PLAN, for the future (SEQTOLSMA 2008). Actions relevant to Ramsar areas that have been nominated by OUR PLAN include: the development of a Memorandum of Agreement with SEQ Catchments; developing alliances and partnerships at all levels of government and with the wider community; and becoming fully engaged in planning, decision-making and delivery of on-ground works (SEQTOLSMA 2008: 26).

The foundation of SEQTOLSMA is an important initiative that has the capacity to provide a central body with which consultation and management planning can be developed. SEQTOLSMA does not reduce the responsibilities of Traditional Owners, and recognizes that within the organization, certain Traditional Owners speak for parts (their country) of Southeast Queensland. In regard to the Ramsar areas of Moreton Bay, no one Traditional Owner will speak for them all; rather specific areas will be associated with certain groups, as shown discussed in Appendix C. In large part, this arrangement also reflects the requirements of the Queensland *Aboriginal Cultural Heritage Act 2003* in regard to cultural heritage decision-making by Aboriginal Parties.

Taking these arrangements into account, SEQTOLSMA offers an opportunity for the development of overarching management planning for Ramsar areas, with the additional capacity for relevant Traditional Owners to have input into those areas that are within their countries.

While there has been little to no assessment to date that is available in the public record about the indigenous cultural values of the Ramsar area in Moreton Bay, hints are provided by the initiatives detailed in the case studies above. These case studies also underline that the Traditional Owners of Southeast Queensland are continuing their traditional responsibilities.

In the absence of guidance from Traditional Owners on this matter, it is reasonable to predict the following:

- Each of the Ramsar areas (eg. areas within the broader site boundaries) will hold significant cultural values to the relevant Traditional Owner group/s. These values may include physical and non-physical cultural heritage areas and objects, oral knowledge, such as stories, animals and plants, and the natural environment itself;

- The values of each of the Ramsar areas may be different to the others, e.g., the environmental, spiritual and cultural nature of Pumicestone Passage may have been different to those of North Stradbroke Island, and thus require differences in traditional management;

- Traditional Owners are already taking an active role in managing Ramsar areas as part of their management of the wider Moreton Bay area, and that they will wish to increase this role if offered the opportunity; and

- The Traditional Owners have already formed an encompassing organization (SEQTOLSMA) which may prove to be a vehicle through which consultation and planning for the future could be organized. Only through consultation with the individual Traditional Owner groups could this be ascertained.

A summary table has not been prepared for this service based on the discussion outlined above. Further articulation of the values and cultural significance of the site are seen as only able to be set and measured through consultation with Traditional Owners. Limits of acceptable change will only become apparent, if indeed they do, after a detailed understanding about cultural values and how they are being sustained is achieved.

7.9 Service 9 ~ Research and Education

Boondall Bird Hide and field survey photos sourced from www.nudgeebheec.eq.edu.au
Field photo (far right) BMT WBM Photo Library

The size and accessibility of the Bay (being situated at the doorstep of a capital city) makes it an ideal resource for research and education activities.

The Bay and its flora and fauna have been, and continue to be, the subject of numerous scientific studies and investigations by leading academics in Australia and around the world. As demonstrated by this ECD, the Bay provides a wide range of issues and habitats for natural science and social science researchers and industry research activities.

Queensland University, CSIRO and the Department of Primary Industries and Fisheries have research stations in the Moreton Bay region (although situated outside the boundaries of the Ramsar site). Many other research institutions use Moreton Bay for research and education.

Major studies and investigations have been undertaken by the Queensland Environmental Protection Agency with respect to the coastal wetlands (as part of the SEQ Coastal Wetlands Study) in the region. A range of other studies have also been undertaken to support various plans and strategies such as survey and mapping of rocky intertidal areas, shorebird roosting sites, seagrass areas and offshore reef mapping.

In terms of recent research activities undertaken by State agencies, of particular note are the EPA's Queensland Turtle Conservation Project (see Limpus *et al.*. 2006), recent studies of groundwater ecosystems on the Bay islands by the Department of Natural Resources and Water (see Marshall *et al.*. 2006) and various research projects on Bay fisheries by the Department of Primary Industries and Fisheries.

Well-documented environmental impact studies of the Bay's habitats, fauna and hydrology provide an insight into the natural variability present within the systems of the Bay as well as their resilience to change. These documents build upon the significant knowledge provided by the research and scientific community, often augmenting these studies with the collection of data and analysis at more localised scales.

The wetlands of Moreton Bay are also an integral component of a number of environmental education facilities in the region. Some examples include the following:

- Boondall Wetlands lies on the western edge of Moreton Bay between Nudgee Beach, Boondall and Shorncliffe and includes more than 1000 hectares of tidal flats, mangroves, saltmarshes, melaleuca wetlands, grasslands, open forests and woodlands. Brisbane City Council manages and operates the Boondall Wetlands Environment Centre which offers a range of displays and activities on the environmental and cultural heritage of the reserve for park visitors and organised groups. The mangrove boardwalk at Wynnum North is also a significant educational resource.

- The Department of Education (Education Queensland) operates environmental education centres at Nudgee Beach, Moreton Bay (at Wynnum) and Jacobs Well for educating children on coastal and environmental matters. The Bay is an important environmental and historical education resource for these centres. The Environmental Protection Agency also has educational facilities on St Helena and Moreton Islands.

The third component of this service relates to environmental monitoring activities. Since 2000, the Healthy Waterways Partnership's Ecosystem Health Monitoring Program (EHMP) has undertaken monthly monitoring of over 250 estuarine and marine sites including sites throughout Moreton Bay. Data are collected for a range of water quality and biological parameters. The results of this monitoring are reported annually via the Ecosystem Health Report Card and Technical Report (EHMP 2007).

Monitoring being undertaken under the auspices of the EHMP is augmented by strong and long-standing volunteer monitoring programmes in Moreton Bay. Two examples include:

- *Wader Birds.* The Queensland Wader Study Group (QWSG) is a special interest group within Birds Queensland. It was formed to further research on both migratory and resident waders (shorebirds) in Queensland, and to work for their conservation. The QWSG undertakes regular counts of waders around Moreton Bay that provides a measure of the abundance of the birds and provides the long term population trend data used in planning and management.

- *Seagrass.* Seagrass Watch is an initiative that uses trained volunteers to help monitor seagrass meadows along the Queensland coast. Originally developed by the Queensland Department of Primary Industries and Fisheries, Seagrass Watch has now spread to neighbouring countries in Asia and the Pacific. Seagrass Watch has been operating for a number of years in the Bay, undertaken by conservation groups and their volunteers using funding from the Natural Heritage Trust (NHT) and other sources. There are current plans to extend this programme to also include Mangrove Watch and Saltmarsh Watch components.

Over the next five years, science priorities relating to Moreton Bay have been identified as part of the Healthy Waterways Strategy 2007-2012. These priorities are to:

- understand processes in receiving waters (freshwater, storages, estuaries and Moreton Bay);

- understand challenges specific to coastal and beach ecosystems (e.g. coastal algal blooms, population growth in coastal areas);

- understand movement, cycling and transformations of nutrients and toxicants and look at relative importance of inputs versus remobilisation to focus management actions;

- understand "cause and effect" relationships between management actions, Water Quality Objectives and Environmental Values; and

- understand climate change implications for water quality, ecosystem health, and efficacy of management actions.

While the maintenance of all the critical components and processes outlined above are important, those that underpin maintaining the diversity of wetland habitats present in the site and key representative habitats (Services 1 and 2), the maintenance of important species (Service 3,4,5) and the maintenance of significant shorebird populations (Service 6) are seen as most critical to supporting the research and education service outlined here.

Table 7-21 Critical Service 9

Summary Table	Critical Service (S9)
Reason for Inclusion	Moreton Bay's location, condition and conservation significance make it a vitally important resource in the context of research and education. In addition to countless studies by the academic community, the Bay and its wetlands are important components of environmental education programmes and facilities in the Region and the subject of millions of dollars of funding from State and local government for environmental monitoring under EHMP over the past 8 years.
Type of Service	Cultural
Description of Service (quantify if possible)	Key aspects of this Service recognise the importance of the site for: Research activities by universities, colleges and science organisations such as CSIRO Environmental Education Facilities and Curricula (Boondall, Nudgee, etc) Environmental Monitoring (EHMP and volunteer monitoring programmes by the Queensland Wader Study Group and community conservation groups).
Spatial Application (if relevant)	This service applies to the whole site.
Critical habitat components underpinning this service	While many habitats have been studied, research undertaken with respect to seagrass, mangroves and saltmarsh is especially noteworthy.
Critical species underpinning this service	While many species and habitats have been studied, the research undertaken on turtles and shorebirds in Moreton Bay is especially noteworthy.
Critical processes underpinning this service	Broad-Scale Processes as outlined in Critical Service 1 and Critical Service 2.
Natural Variability (if relevant)	Not Applicable.
Principal threats	Not Applicable. Moreton Bay has been an important site for research and education activities over the past 30 years and continues to be so. The global and national emphasis on climate change and related impacts to coastal areas is seen as a driving force for research and education over the next 5 – 10 years and will likely dominate the focus of future studies involving the Bay and its resources. However it is expected that long term monitoring and research programmes relating to water quality, habitat quality and important species/populations in the Bay will continue.
Data quality underpinning this critical element	Not Applicable
Information gaps	A range of science priorities for Moreton Bay have been identified as part of the 2007-2012 Healthy Waterways Strategy (Moreton Bay Action Plan component). In addition to these priorities, the information gaps and monitoring recommendations of this ECD are seen as essential for monitoring the ecological character of the Ramsar site.
Recommended monitoring	No specific recommendations. However, developing a system or database to record previous and current research and monitoring data related to key wetland assets of the site remains a priority. In particular, improved management of data from shorebird counts and surveys is a high priority.

7.10 Service 10 ~ Tourism and Recreational Uses

Photos supplied from the EPA Photo Library

Tourism and recreation in Moreton Bay is largely built upon the attraction of the area's natural assets, with activities undertaken in the area being predominantly nature-based. No data are available on visitation to, and activities undertaken specifically within the Ramsar site, but a recent study estimates the annual visitation to Moreton Bay at 1,666,805, inclusive of domestic overnight and day-trip and international visitors (refer Table 7-22 below). The source of these visitors is 24% domestic overnight, 74% domestic day-trip and 2% international visitors, with the peak months of tourist activity in the school holiday periods of December/January, April and September. For the purposes of the ECD, it is acceptable to assume that the majority of visitors will use an area within the Ramsar boundary at some point during their visit, either undertaking activities or passing through the site.

Table 7-22 Estimates for visitor arrivals using Bureau of Tourism Research (grouped for 1999-2002)

	Domestic Overnight*	Domestic Day-trip*	International Visitors*	Total Visitation*
Caboolture	131,000	408,500	5,158	544,658
Redcliffe	33,000	268,500	5,217	306,717
Brisbane	75,250	236,250	17,823	329,323
Redland	158,750	318,250	11,257	488,257
Total Moreton Bay	**397,000**	**1,231,000**	**38,805**	**1,666,805**

*All figures are the average per year over 4 years.
Source: Adapted from Whitemore and De Lacy (2005). Note that the area covered is larger than the Moreton Bay Ramsar site.

The high percentage of visitation by domestic day-trip visitors indicates that most visitors are from the local region (Brisbane and SEQ generally) (Table 7-22). The proximity of the Moreton Bay Ramsar site to Brisbane signifies an important consideration for management of the site as the regional population continues to increase. It also denotes a significant economic contribution to the region, providing an estimated 18,000 jobs through tourism within Moreton Bay electorates[11] (Whitmore and De Lacy 2005), with 5,500 jobs within the Moreton Bay and islands area (EPA 2007a). Expenditure from visitation to the Moreton Bay and islands region is estimated at approximately $500 million annually (based on 2006 data; EPA 2007a).

While the wide variety of tourism and recreational activities undertaken within the Moreton Bay Ramsar site are predominantly nature-based, occurring in both terrestrial and aquatic environments, there are specific components and processes that impact on the quality of the experience, and which continue to attract visitors and return visitors to the region. Further, many activities are primarily

[11] Note this figure is for a larger area than the Moreton Bay Ramsar site.

undertaken in specific environments (e.g. four wheel driving on the eastern sandy beaches of Bribie, Moreton and North Stradbroke Islands, canoeing/kayaking in inshore areas) indicating that some ecosystem components and process may be more important for tourism and recreation in particular locations within the Ramsar site. Activities and supporting ecosystem components and processes are described in Table 7-23.

Table 7-23 Underlying services, components and processes for the wetland service (tourism and recreation) in the Moreton Bay Ramsar site

Activity	Ecosystem Components	Ecosystem Processes
Boating / sailing / canoeing / kayaking	Pleasant weather conditions Good water quality	Climate Water quality
Diving / snorkeling	Good water quality Pleasant weather conditions Rich and diverse marine fauna Healthy wetland habitats	Water quality Climate Flora / fauna Biological maintenance
Recreational Spear fishing / Line fishing	Abundant target fish species	Flora / fauna Biological maintenance Species interaction
Swimming / surfing / surf-lifesaving	Good water quality Pleasant weather conditions	Water quality Climate
Wildlife-watching	Rich and diverse wildlife Near pristine wetland habitats	Climate Biogeochemical and nutrient cycling Water quality Flora / fauna Biological maintenance Species interaction
Bush walking / Camping / Picnics	Range of wetland types Rich and diverse wildlife Pleasant weather conditions Near pristine wetland habitats Cultural heritage items and places	Climate Biogeochemical and nutrient cycling Geomorphology Water quality Flora / fauna Biological maintenance Species interaction
Four wheel driving / Sand toboganning	Pleasant weather conditions Relevant wetland types (predominantly sandy beaches)	Climate Geomorphology

The high level of nature-based activities within the Moreton Bay Ramsar site is supported by the bulk of the site being situated within National Parks, Conservation Parks, Recreation Areas or Marine Park. These areas are managed under State legislation, and management and zoning plans which aim to conserve and manage the areas in a predominantly natural state.

Limits of acceptable change for tourism-related critical services are reported to “relate to thresholds that significantly reduce tourism economic activity” (e.g. loss of beaches, reduction in reef size, perceived adverse changes to ‘eco-values’) (Voice *et al.* 2006). That is, if tourism and recreational activities impact on other critical services (e.g. aquatic wetland fauna of conservation significance), the subsequent degradation or change in these critical services is likely to cause a change in tourism and recreation within the Ramsar site.

Table 7-24 Critical Service 10

Summary Table	Critical Service (S10)
Reason for Inclusion	Uniqueness - diversity of activities and experiences in a range of locations, close to major city/capital city (e.g. "Moreton Bay is the only place in the world where you can see dugong within view of a city skyline." (Whitmore and De Lacy 2005).
Type of Service	Cultural
Description of Service (quantify if possible)	Predominantly nature-based tourism and recreational activities undertaken in a range of wetland environments. The annual visitation to Moreton Bay is approximately 1,666,805.
Spatial Application (if relevant)	Whole Ramsar site, though certain activities are focused in specific environments within the site (e.g. four wheel driving on sandy beaches).
Critical habitat components underpinning this service	All – variety of activities undertaken in different environments. Predominant habitats used are beaches, marine waters, estuarine waters, freshwater lakes, sand dunes and intertidal flats.
Critical species underpinning this service	Fauna - all, although predominately megafauna and wader birds. Flora – all.
Critical processes underpinning this service	Refer Table 7-23.
Natural Variability (if relevant)	Limits of acceptable change for components and processes elsewhere in the ECD. Combination of climate, maintenance of habitat quality, quality and supply of tourism/recreation product (e.g. supply, management of industry, disposable income, cost of activities)
Principal threats	Impacts from tourism and recreational activities to other critical services. Subsequent impacts to tourism and recreational activities from degraded critical services.
Data quality underpinning this critical service	No reliable visitor statistics, including tourist expenditure and other economic contributions (Whitmore and De Lacy 2005). Importance of Ramsar values to tourism and recreational experiences.
Information gaps	Reliable visitor statistics, including tourist expenditure and other economic contributions. Carrying capacity of the Ramsar site for activities and locations. The importance placed on the Ramsar site and values by visitors when undertaking tourism and recreational activities and experiences.
Recommended monitoring	Reliable visitor statistics, including tourist expenditure and other economic contributions. Number of visitors participating in each activity/location and the resultant environmental impacts and potential indicators for monitoring. Importance/awareness of Ramsar site and values for visitors.

8 REFERENCES

Abal, E.G., Dennison, W.C. (1996) Seagrass depth range and water quality in southern Moreton Bay, Queensland, Australia. Marine and Freshwater Research 47, 763-771.

Abal, E.G., Dennison, W.C., O'Donohue, M.H. (1998) Seagrasses and Mangroves in Moreton Bay. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland: Brisbane. pp. 269-278.

Abal, E.G., Bunn S.E., Dennison W.C. (eds.) (2005) Healthy Waterways Healthy Catchments: Making the Connection in Southeast Queensland Australia. Moreton Bay Waterways and Catchment Partnership. Brisbane. 240 pp.

Agnew, L.R, Stewart, D. (1998) Birds of Moreton Bay. In; Ryan, M. (ed.). Wild Guide to Moreton Bay-Wildlife and Habitats of a Beautiful Australian Coast - Noosa to the Tweed, Queensland Museum. pp 319-353.

Allen, G.R. (1989) Freshwater Fishes of Australia. T.F.H. Publications, Inc.: Brookvale, N.S.W.

Allen, G.R., Ivantsoff, W. (1982) *Pseudomugil mellis*, le Honey Blue-eye, une nouvelle espèce de poisson Arc-en-ciel (Melanotaeniidae) d'Australie orientale. Rev. fr. Aquariol. 9, 83-86.

Allen M., Sumpton, W., O'Neill, M. F., Courtney, T., Pine, B. (2006) Stock reduction analysis for assessment of the Pink Snapper Fishery. June 2006. DPI&F, Brisbane. pp. 51.

Alongi, D.M. (1990) The ecology of tropical soft-bottom benthic ecosystems. Oceanography and Marine Biology Annual Review 28, 381-496.

Anstis, M. (2002) Tadpoles of South-eastern Australia. Reed New Holland, Sydney, NSW.

ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Aragones, L., Marsh, H. (2000) Impact of dugong grazing and turtle cropping on tropical seagrass communities. Pacific Conservation Biology 5, 277-288.

Arthington, A.H. (1984) Freshwater fish of North Stradbroke, Moreton, and Fraser Islands. In Coleman, R.J, Covacevish, J., Davie, P. (eds.) Focus on Stradbroke. Boolarong Publications: Brisbane, pp. 279-282.

Arthington, A.H. (1996) Recovery Plan for the Oxleyan Pygmy Perch, *Nannoperca oxleyana*. Prepared by Griffith University for Australian Nature Conservation Agency, Canberra, Brisbane.

Arthington, A.H., Marshall, C.J. (1993) Distribution, ecology and conservation of Honey Blue-eye, *Pseudomugil mellis*, in south-eastern Queensland. Volume 1. Prepared by Griffith University for Australian Nature Conservation Agency, Canberra, Brisbane.

Arthington, A.H., Miller, G.J., Outridge, P.M. (1989) Water quality, phosphorous budgets and management dune lakes used for recreation in Queensland (Australia). Water Science Technology 21, 111-118.

Arthington, A.H., Watson, J.A.L. (1982) Dragonflies (Odonta) of coastal sanddune fresh waters of south-eastern Queensland and north-eastern New South Wales. Australian Journal of Marine and Freshwater Research 33, 77-88.

Bamford, M., Watkins, D. (2003) Population Estimates and Important Sites for Shorebirds in the East Asian-Australasian Flyway. In Straw, P. (ed.) Status and Conservation of shorebirds in the East Asian-Australasian Flyway. Proceeding of the Australian Shorebirds Conference, December 2003, Canberra. Wetlands International Global Series 18, International Wader studies 17, Canberra.

Bamford, M., Watkins, D., Bancroft, W., Tischler, G., Wahl, J. (2008) Migratory Shorebirds of the East Asian - Australasian Flyway; Population Estimates and Internationally Important Sites. Wetlands Interanational - Oceania. Canberra, Australia

Barker, J., Grigg, G.C., Tyler, M.J. (1995) A Field Guide to Australian Frogs. Surrey Beatty and Sons, Chipping Norton, NSW.

Bayly, I.A.E. (1964) Chemical and biological studies on some acidic lakes of east Australian coastal lowlands. Australian Journal of Marine and Freshwater Research 15, 56-72.

Bensink, A.H.A., Burton, H. (1975) North Stradbroke Island, a place for freshwater invertebrates. Proceedings of the Royal Society of Queensland 86, 29-45.

Benussi, G. (1975) Genesis of North Stradbroke Island. Proceedings of the Royal Society of Queensland 86, 3-8.

Beumer, J., Carseldine, L., Zeller, B. (1997) Declared Fish Habitat Areas in Queensland. DPI Fisheries, ISBN 0 7242 6697 6, ISSN 1326-6985, Brisbane.

Birds Australia (2008) Shorebirds 2020 Project. Data analysed by Wetlands International-Oceania for Birds Australia. http://www.shorebirds.org.au/shorebirdsites/national_sites/qld.html

BMT WBM (2008a) Management Actions – Final Report. Brisbane.

BMT WBM (2008b) Towards Understanding the Ecological Health and Character of Moreton Bay. Prepared by BMT WBM on behalf of the SEQ Healthy Waterways Partnership Scientific Expert Panel and Queensland Environmental Protection Agency. Final Report – Version 1. Brisbane.

BMT WBM (2008c) Goals and Indicators for the Moreton Bay ECD. Final Report. Brisbane.

BMT WBM (2008d) Update of the Digital Boundary and Mapping. Final Report. Brisbane.

Bowling, L.C. (1988) Optical properties, nutrients and phytoplankton of freshwater coastal dune lakes in south-east Queensland. Australian Journal of Marine and Freshwater Research 39, 805-815.

Bostock, P.D., Thomas, M.B. (1992) Status of Rare Plant Species of Myora Swamp North Stradbroke Island. Prepared for Stradbroke Island Management Organisation by Queensland Herbarium, Department of Environment and Heritage, December 1992.

Braby, M.F. (2000) Butterflies of Australia, their identification, biology and distribution. CSIRO, Melbourne.

Brand-Gardner, S.J., Lanyon, J.M., Limpus, C.J. (1999) Diet selection by immature green turtles, Chelonia mydas, in subtropical Moreton Bay, South East Queensland. Australian Journal of Zoology 47, 181-191.

Breitfuss, M.J., Dale, P.E.R. (2004) The endangered Illidge's Ant Blue Butterfly, Acrodipsas illidgei, from an intertidal habitat managed for mosquito control. Journal of the American Mosquito Control Association 20, 91-93.

Carruthers, T.J.B., Dennison, W.C., Longstaff, B.J., Waycott, M., Abal, E.G., McKenzie, L.J., Lee Long, W. J. (2002) Seagrass habitats of northeast Australia: models of key processes and controls. Bulletin of Marine Science of the Gulf and Caribbean 71, 1153-1169.

Centre for Marine Studies (2006) Moreton Bay Saltmarsh. University of Queensland, Brisbane.

Chan, K., Dening, J. (2007) Use of sandbanks by terns in Queensland, Australia: a priority for conservation in a popular recreational waterway. Biodiversity and Conservation 16, 447–464.

Clancy, G.P. (1986) Observations of nesting Beach Thick-knees *Burhinus neglectus* at Red Rock, New South Wales. Corella 10,114-118.

Clarke, P.J., Jacoby, C.A. (1994) Biomass and above-ground productivity of salt-marsh plants in South-eastern Australia. Australian Journal of Marine and Freshwater Research 45, 1521-1528.

Coaldrake, J.E. (1961) The ecosystem of the coastal lowlands ("Wallum") of southern Queensland. CSIRO Australian Bulletin, 283.

Cogger, H. (2000) Reptiles and Amphibians of Australia. 6th Edition. Reed Books, Chatswood, NSW.

Coles, R.G., Poiner, I.R., Kirkman, H. (1989) Regional studies-seagrasses of north-eastern Australia. In Larkum, A.W.D., McComb, A.J., Shepherd, S.A. (eds.) Biology of Seagrasses. Elsevier: Amsterdam. pp. 261-78.

Connolly, R., Udy, J., McAlister, T. (2006) Appendix K (Estuarine and Southern Moreton Bay). In Brizga, S. (ed.) Logan Basin Draft Water Resource Plan. Ecological Investogations Report: Volume IIb. Natural Resources, Mines and Water: Brisbane. pp. 72.

Cooper, T. F., Ridd, P.V., Ulstrup, K. (2008) Temporal dynamics in coral bioindicators for water quality on coastal coral reefs of the Great Barrier Reef. Marine and Freshwater Research 59, 703-716.

Crimp, O. (ed.) (1992) Moreton Bay in the Balance. Australian Littoral Society and the Australian Marine Science Consortium. Brisbane. pp. 127.

Czechura, G. (1995) Frogs. In Ryan, M. (ed.), Wildlife of Greater Brisbane. Queensland Museum, Brisbane. pp. 143-164.

Davie, P.J.F., Hooper, J.N.A. (1998) Patterns of biodiversity in marine invertebrate and fish communities of Moreton Bay. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland: Brisbane. pp. 331-346.

Day, J.H. (1967) A monograph on the polychaeta of southern Africa - Part I Errantia. Trustees of the British Museum (Natural History) - London, viii-374.

Day, J.W., Hall, C.A.S., Kemp, W.M., Yanez-Arancibia, A. (1989) Estuarine Ecology. John Wiley & Sons: New York.

Dennison, B. (2001) Moreton Bay Seagrasses. University of Queensland, Marine Botany.

Dennison, W.C. (1999) Moreton Bay Study. A scientific basis for the healthy waterways campaign. In. Abal, E.G. (ed.) South-East Queensland Regional Water Quality Managment Strategy: Brisbane.

Dennison, W.C., Abal E.G. (1999) Moreton Bay Study: a Scientific Basis for the Healthy Warterways Campaign. South East Queensland Regional Water Quality Management Strategy, Brisbane.

Dennison, W.C., Orth, R.J., Moore, K.A., Stevenson, J.C., Carter, V., Kollar, S., Bergstrom, P.W., Batuik, R.A. (1993) Assessing water quality with submersed aquatic vegetation. BioScience 43, 86-94.

Department of Environment and Heritage (1993) Pumicestone Passage, its catchment and Bribie Island. Draft Integrated Management Strategy – Summary paper. November 1993.

Department of the Environment and Water Resources (2007) Guidelines for the Ecologically Sustainable Management of Fisheries. September 2007. Department of the Environment and Water Resources, Canberra.

DEWHA (2006) EPBC Act Policy Statement 1.1 Significant Impact Guidelines. May 2006

DEWHA (2008a) *Litoria olongburensis* in Species Profile and Threats Database, Department of the Environment, Water, Heritage and the Arts, Canberra. Sourced from: http://www.environment.gov.au/sprat on 26 May 2008.

DEWHA (2008b) National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands. Module 2 of the National Guidelines for Ramsar wetlands - Implementing the Ramsar Convention in Australia.

Dowling, R.M. (1986) The mangrove vegetation of Moreton Bay. Queensland Botany Bulletin No. 6.

DPI&F (2006) Annual status report - Queensland Mud Crab Fishery 2006. Queensland Department of Primary Industries and Fisheries, Brisbane.

DPI&F (2007a) Annual status report 2007 - Queensland Spanner Crab Fishery. Queensland Department of Primary Industries and Fisheries, Brisbane.

DPI&F (2007b) Annual status report - East Coast Inshore Fin Fish Fishery 2007. Queensland Department of Primary Industries and Fisheries, Brisbane.

DPI&F (2007c) Annual status report - Moreton Bay Beche-de-mer Fishery 2007. Queensland Department of Primary Industries and Fisheries, Brisbane.

DPI&F (2007d) Annual status report - Queensland Mud Crab Fishery 2007. Queensland Department of Primary Industries and Fisheries, Brisbane.

DPI&F (2007e) Annual status report Blue Swimmer Crab Fishery 2007. Queensland Department of Primary Industries and Fisheries, Brisbane.

DPI&F (2007f) Annual status report Rocky Reef Fishery 2007. Queensland Department of Primary Industries and Fisheries, Brisbane.

DPI&F (2007g) Annual status report East Coast Otter Trawl and Beam Trawl Fisheries. Queensland Department of Primary Industries and Fisheries, Brisbane.

Driscoll, P.V. (1993) Monitoring of Bird Populations in the Environs of Fisherman Islands: 1992-1993. An unpublished report prepared for the Port of Brisbane Authority.

Driscoll, P.V. (1996) Bird Populations of Fisherman Islands: Monitoring and Assessment of Changes 1995-1996. An unpublished report prepared for the Port of Brisbane Corporation.

Driscoll, P.V. (1997) The Distribution of Waders along the Queensland Coastline. In: Straw, P. (ed.) Shorebird Conservation in the Asia Pacific Region. Based on papers presented at a symposium held on 16-17 March in Brisbane, Australia. Melbourne. AWSG of Birds Australia.

Driscoll, P.V. (1998) Further Assessment of Bird Numbers, Movement and Habitat Conditions in the Environs of Fisherman Islands. An unpublished report prepared for the Port of Brisbane Corporation.

Duke, N.C., Lawn, P., Roelfsema, C.M., Phinn, S., Zahmel, K.N., Pedersen, D., Harris, C., Steggles, N., Tack, C. (2003) Assessing historical change in coastal environments. Port Curtis, Fitzroy River Estuary and Moreton Bay regions. Final Report to the CRC for Coastal Zone Estuary & Waterway Management. Historical Coastlines Project, Marine Botany Group, Centre for Marine Studies, University of Queensland, Brisbane.

Duke, N., Pederson, D. (2003) Moreton Bay Mangroves. Centre for Marine Studies, University of Queensland. June 2003.

Duke, N. (2006) Australia's Mangroves. University of Queensland, Brisbane. pp 200.

Edgar, G.J. (2001) Australian Marine Habitats in Temperate Waters. Reed New Holland Publishers: Sydney.

Ehmann, H. (1997) Threatened Frogs of New South Wales: Habitats, Status and Conservation. Frog and Tadpole Study Group of New South Wales Inc. Sydney, NSW.

EHMP (2006) EHMP 2005-2006 Annual Technical Report. South East Queensland Healthy Waterways Partnership, Brisbane.

EHMP (2007) EHMP 2007 Report Card. South East Queensland Healthy Waterways Partnership, Brisbane.

EPA (2005a) Moreton Bay Sand Extraction Study – Summary of Findings, Brisbane, April 2005.

EPA (2005b) Shorebird Management Strategy – Moreton Bay. June 2005.

EPA (2006) South East Queensland Regional Coastal Management Plan, Brisbane, August 2006.

EPA (2007a) Have Your Say Moreton Bay Marine Park - Draft Zoning Plan Including Regulatory Impact Statement and Draft Public Benefit Test. Queensland Environmental Protection Agency, Brisbane.

EPA (2007b) Moreton Island National Park, Cape Moreton Conservation Park and Moreton Island Recreation Area and Management Plan, Brisbane, April 2007.

EPA (2007c) Regional Ecosystem Description Database (REDD). Version 5.2 Updated November 2007. Database maintained by Queensland Herbarium, Environmental Protection Agency, Brisbane.

EPA (2008a) Copy of the certified regional ecosystem map for the purpose of the Vegetation Management Act 1999. Online RE Maps, Environmental Protection Agency, Brisbane. [URL: http://www.epa.qld.gov.au/REMAP] Accessed on 13 May 2008.

EPA (2008b) National recovery plan for the water mouse (false water-rat) *Xeromys myoides*. Report to Department of the Environment and Water Resources, Canberra. Environmental Protection Agency, Brisbane.

Erftemeijer, P.L.A.; Lewis III, R.R. (2006) Environmental impacts of dredging on seagrasses: a review. Marine Pollution Bulletin 52, 1553-1572.

Fensham, R.J. (1997) Aboriginal fire regimes in Queensland, Australia: analysis of the explorers' record. Journal of Biogeography 24, 11-22.

Fesl, E. Davies, S. (2004) Moreton Bay Sand Extraction Environmental Study: Indigenous Traditional Owner Cultural Heritage Investigation. Consultancy Report undertaken for the Queensland Government as part of the Moreton Bay Sand Extraction Study.

Finn, P.G. (2008) Feeding ecology and habitat selection – Chapter 4. In Geering, A., Agnew, L., and Harding, S. (eds.) Shorebirds of Australia. CSIRO Publishing, Collingwood.

Finn, P.G., Driscoll, P.V., Catterall, C.P. (2002) Eastern curlew numbers at high-tide roost versus low-tide feeding grounds: a comparison at three spatial scales. Royal Australasian Ornithologists Union, Emu, 2002 (102).

Freeman, A.N.D. (2003) The distribution of Beach stone-curlews and their response to disturbance on far north Queensland's Wet Tropical Coast. *Emu* 103, 369-372.

Garnett, S. (1992) Threatened and Extinct Birds of Australia. Royal Australasian Ornithologists Union, Moonee Ponds.

Garnett, S.T., Crowley, G.M. (2000) The Action Plan for Australian Birds. Environment Australia, Canberra.

GBRMPA (2003) The status of dugongs on the Great Barrier Reef and the southern coast of Queensland. In Reef Research Information Sheet. Great Barrier Reef Marine Park Authority, Townsville.

GCCC (2008). Gold Coast City Council's Nature Conservation Database. Accessed via http://www.goldcoastflorafauna.com.au/.

Geering, A., Agnew, L., Harding, S. (2007) Shorebirds of Australia. CSIRO Publishing, Collingwood.

Gill, A.M. (1981) Adaptive responses of Australian vascular plant species to fire. In Gill, A.M., Groves, R.H., Nolbe I.R. (eds.) Fire and the Australian Biota. Australian Academy of Science, Canberra. pp 243-272.

Gillanders, B. M., Kingsford, M.J. (1992) Abundance patterns of *Achoerodus viridus* (Pisces: Labridae) on estuarine and exposed rocky reefs: Possible linkages. In Battershill, C.N., Schiel, D.R., Jones, G.P., Creese, R.G., MacDiarmid, A.B. (eds) Proceedings of the Second International Temperate Reef Symposium. Auckland. NIWA Marine, Wellington. pp. 93-98.

Greenloaning Biostudies (2000) Ibis Lagoon Frog Surveys, Environmental Response Report. Greenloaning Biostudies Pty Ltd. Unpublished report for Consolidated Rutile Limited.

Greenwood, J.G. (1998) Zooplankton of Moreton Bay: The hidden processors. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. Brisbane. School of Marine Science, University of Queensland: Brisbane. pp. 347-364.

Guest, M.A., Connolly, R.M. (2004) Fine-scale movement and assimilation of carbon in saltmarsh and mangrove habitat by resident animals. *Aquatic Ecology* 38, 599-609.

Gynther, I.C., Janetzki, H. (2008) Water mouse *Xeromys myoides*. In Van Dyck, S., Strahan, R. (eds) The Mammals of Australia (3rd ed.). Reed New Holland, Sydney, NSW. pp 664-666

Hagen, C. E. (1980) Recent records of *Acrodipsas illidgei* (Waterhouse and Lyell) (Lepidoptera: Lycaenidae) from the Brisbane area, Queensland. Australian Entomological Magazine 7, 39.

Hall, J. (1999) The impact of sea level rise on the archaeological record of the Moreton region, southeast Queensland. In: Hal, J., McNiven, I.J. (eds.). Australian Coastal Archaeology. Department of Archaeology and Natural History, Canberra. pp 169-184

Harding, S., Wilson, J. (2008) Threats to shorebirds and conservation actions – Chapter 7. In Geering, A., Agnew, L., Harding, S. (eds.) Shorebirds of Australia. CSIRO Publishing, Collingwood.

Harrison, P.L., Harriott, V.J., Banks, S.A., Holmes, N.J. (1998) The Corals Communities of Flinders Reef and Myora Reef in the Moreton Bay Marine Park, Queensland, Australia. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland: Brisbane. pp. 525-536.

Harrison, P.L., Holmes, N.J., Banks, S.A., Hariott, V.J. (1995) Biological Conservation Values of Flinders Reef and Myora Reef - Moreton Bay Marine Park. Centre for Coastal Management, Lismore.

Harrison, P., Holmes, N., Saenger, P. (1991) A Survey of the Scleractinian Coral Communities and other Benthic Communities around Green Island, Wellington Point-Empire Point, and Peel Island in Moreton May, Queensland. Centre for Coastal Management.

Heidecker, E.J. (1984) The morphostructural framework of Moreton Bay and Stradbroke Island. In Coleman, R.J., Covacevich, J., Davie, P. (eds.) Focus on Stradbroke. Boolarong Publications: Brisbane. pp. 136-145.

Higgins, T.J., Davies, S.J.J.F. (1996). Handbook of Australian, New Zealand and Antarctic Birds. Volume 3. Snipe and Pigeons. Oxford University Press, South Melbourne.

Hines, H., Mahoney, M., McDonald, K. (1999) An assessment of frog declines in wet subtropical Australia. In Campbell, A. (ed.) Declines and Disappearances of Australian Frogs. Environment Australia, Canberra.

Hixon, M.A. (1998) Population dynamics of coral-reef fishes: Controversial concepts and hypotheses. Austral Ecology 23, 192-201

Hulsman, K., Thompson, J.J., Tarte, D. (1993) Coastal zone issues. In Catterall, C.P., Driscoll, P., Hulsman, K., Muir, D., Taplin, A. (eds.) Birds and Their Habitats: Current Knowledge and Conservation Priorities in Queensland. Queensland Ornithological Society: Brisbane. pp. 187-90.

Hyland, S.J., Butler, C.T. (1989) The Distribution and Modification of Mangroves and Saltmarsh - Claypans in Southern Queensland. Queensland Department of Primary Industries Information Series QI89004, Brisbane.

Hyland, S.J., Courtney, A.J., Butler, C.T. (1989) Distribution of Seagrass in the Moreton Region from Coolangatta to Noosa. Queensland Department of Primary Industries Information Series Q189010.

Ingram, G.J., Corben, C.J. (1975) The frog fauna of North Stradbroke Island, with comments on the 'acid' frogs of the wallum. Proceedings of the Royal Society of Queensland 86, 49-54.

IUCN (1996) IUCN Red List of Threatened Species. International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland.

IUCN (2006) IUCN Red List of Threatened Species. International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland.

IUCN (2007) IUCN Red List of Threatened Species. International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland.

James, C. (1996) Conservation genetics of island and mainland populations of the sedge frogs *Litoria cooloolensis* and *Litoria olongburensis*. Unpublished report for the Queensland Department of Environment and Heritage.

James, P.M. (1984) Perched lakes and water table windows. In Coleman, R.J., Covacevich, J., Davie, P. (eds.) Focus on Stradbroke. Boolarong Publications: Brisbane. pp. 146-146.

Jelbart, J.E. (2004) The influence of seascape spatial features on the fish and macroinvertebrates in seagrass beds. PhD thesis thesis, University of Western Sydney.

Johnson, J.W. (1999) Annotated Checklist of the fishes of Moreton Bay, Queensland, Australia. Memoirs of the Queensland Museum 43, 709-762.

Johnson, P.R., Neil, D.T. (1998a) The corals of Moreton Bay: Living with extremes. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland, Brisbane. pp. 525-536.

Johnson, P.R., Neil, D.T. (1998b) Susceptibility to flooding of two dominant coral taxa in Moreton Bay. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland: Brisbane. pp. 597-604.

Kailola, P.J., Williams, M.J., Stewart, P.C., Reichelt, R.E., McNee, A., Grieve, C. (1993) Australian Fisheries Resources. Bureau of Resource Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Developement Corporation: Canberra.

Kalf, F. (1998) Impacts of proposed sand extraction processing and replacement on groundwater hydrology Yarraman Prokect. Kalft and Associated. Prepared for Consolidated Rutile Limited.

King, R.J. (1981) Mangrove and saltmarsh plants. In Clayton, M.N., King, R.J., (eds.) Marine Botany: an Australian Perspective. Longman Cheshire: Melbourne. pp. 308-328.

Kuiter, R.H., Humphries, P.A., Arthington, A.H. (1996) Family Nannopercidae, Pygmy perches. In McDowell, R.M. (ed.) Freshwater Fishes of South-Eastern Australia. Reed Books: Chatswood, NSW. pp. 169-175.

Laegdsgaard, P., Johnson, C.R. (1995) Mangrove habitats as nurseries: unique assemblages of juvenile fish in subtropical mangroves in eastern Australia. Marine Ecology Progress Series 126, 67-81.

Lane, B.A. (1987) Shorebirds in Australia. Nelson Publishers, Melbourne.

Lane, D.A. (1991) A new distribution record for *Acrodipsas illidgei* (Waterhouse and Lyell) (Lepidoptera: Lycaenidae). Australian Entomological Magazine 18, 83-84.

Lanyon, J.M. (1997) The distribution and abundance of dugongs in Moreton Bay, south-east Queensland.

Lanyon, J.M. (2003) Distribution and abundance of dugongs in Moreton Bay, Queensland, Australia. Wildlife Research 30, 397-409.

Lanyon, J.,M., Johns, T.B., Sneath, H.L. (2005) Year-round presence of dugongs in Pumicestone Passage, south-east Queensland, examined in relation to water temperature and seagrass distribution. Wildlife Research 32, 361-368

Lanyon, J.M., Morrice, M.G. (1997) The Distribution and Abundance of Dugongs in Moreton Bay, South East Queensland. Report prepared for the Queensland Department of Environment and Heritage, Brisbane.

Lawler, W. (1995) Wader Roost Construction In Moreton Bay: A Feasibility Study into the Construction of Migratory Wader (Shorebird) High Tide Roosts in Moreton Bay, Qld, using Raby Bay as a Case Study. An unpublished report for the Queensland Department of Lands

Laycock, J.W. (1975) Hydrogeology of North Stradbroke Island. Proceedings of the Royal Society of Queensland 86, 15-19.

Lee-Manwar, G., Arthington, A.H., Timms, B.V. (1980) Comparative studies of Brown Lake, Tortoise Lagoon and Blue Lake, North Stradbroke Island, Queensland. I. Morphometry and origin of the lakes. Proceedings of the Royal Society of Queensland 91, 53-60.

Levin, P.S. (1998) The significance of variable and density-independent post-recruitment mortality in local population of reef fishes. Australian Journal of Ecology 23, 246-251.

Lewis Environmental Consultants (1995) Ibis-Alpha Mining Operation North Stradbroke Island: Flora and fauna survey of four areas.' Lewis Environmental Consultants. Unpublished report for Consolidated Rutile Limited.

Liem, D.S., Ingram, G.J. (1977) Two new species of frogs (Anura: Myobatrachidae, Pelodryadidaoe) from Queensland and New South Wales. Victorian Naturalist 94, 255-262.

Limpus, C.J., Couper, P., Read, M.A. (1994) The loggerhead turtle *Caretta caretta* in Queensland: Population strucutre in a warm temperate feeding area.

Limpus, C.J., Limpus, D.J, Draper, R. (2006) Queensland Turtle Conservation Project: Monitoring marine turtle population dynamics in Moreton Bay Marine Park, 2005-2006. Environmental Protection Agency: Brisbane.

Lockhart, D.A., Lang, S.C., Allen, G.P. (1998) Sedimentation and coastal evolution of Southern Moreton Bay. In: Tibbetts, I.R., Hall, N.J.., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland, Brisbane. pp. 93–106.

Loneragan, N.R., Bunn, S.E. (1999) River flows and estuarine ecosystems: Implications for coastal fisheries from a review and a case study of the Logan River, southeast Queensland. Australian Journal of Ecology 24, 431-440.

Lovell, E.R. (1975) The reef building corals (Coelenterata: Scleractinia) of Moreton Bay, Queensland: their distribution and ecology. MSc Thesis, University of Queensland.

Marchant, S., Higgins, P.J. (eds.) (1993) Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings. Oxford University Press, Melbourne.

Marsh, H. (1990) The distribution and abundance of dugongs in southern Queensland waters: implications for management. James Cook University.

Marsh, H., Corkeron, P., Lawler, I., Lanyon, J., Preen, A. (1996) The Status of the Dugong in the Southern Great Barrier Reef Marine Park. Great Barrier Reef Marine Park Authority, Research Publication No. 41.

Marshall, J, McGregor, G., Negus, P. (2006) Assessment of North Stradbroke Island Groundwater Dependent Ecosystems. Natural Resources and Water. pp. 43.

Maxwell (1970) The sedimentary framework of Moreton Bay, Queensland. Australian Journal of Marine and Freshwater Research 21, 71-88.

Mazumder, D. (2004) Contribution of saltmarsh to temperate estuarine fish and southeast Australia.

Melville, A.J., Connolly, R.M. (2003) Spatial analysis of stable isotope data to determine primary sources of nutrition for fish. *Oecologia* 136, 499–507.

Melville, A.J., Connolly, R.M. (2005) Food webs supporting fish over subtropical mudflats are based on transported organic matter not in situ microalgae. Marine Biology 148, 363–371.

Meyer, E.A. (2004) Acid adaptation and mechanisms for softwater acid tolerance in larvae of anuran species native to the 'wallum' of east Australia. Unpublished PhD thesis. University of Queensland, St Lucia.

Meyer, E., Hero, J-M., Shoo, L., Lewis, B. (2006). Recovery plan for the wallum sedgefrog and other wallum-dependent frog species 2005-2009. Report to Department of Environment and Heritage, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Miller, G. (1997) Wader Site Data Collection and Survey Project for South-east Queensland. Brisbane, unpublished report for the Queensland Department of Environment.

Morton, R.M., Pollack, B.R., Beumer, J.P. (1987) The occurrence and diet of fishes in a tidal inlet to a saltmarsh in southern Moreton Bay, Queensland. Australian Journal of Ecology 12, 217-237.

Mousalli, A., Connolly, R. (1998) Fish use of the inudated waters of a subtropical saltmarsh-mangrove complex in southeast Queensland. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland, Brisbane. pp. 471-472.

Nebel, S., Porter, J.L, Kingsford, R.T. (2008) Long-term trends of shorebird populations in eastern Australia and impacts of freshwater extraction. Biological Conservation 141, 971–980.

Neboiss, A. (1978) A review of caddis flies from three coastal islands of south-eastern Queensland (Insecta : Trichoptera). Australian Journal of Marine and Freshwater Research 29, 825-843.

Neilson, K (2000) Ecology and distribution of frogs on North Stradbroke Island. Honours Thesis, Faculty of Environmental Sciences, Griffith University, Nathan, Brisbane.

Nichols, P. and Maher, M. and Associates (1999). Migratory Shorebird Roost and Feeding Sites in Moreton Bay Marine Park.

NRM SEQ (2004) Integrated Natural Resource Management Plan for South East Queensland – The Future In Balance, December 2004.

NSW NPWS (2003). Little Tern (*Sterna albifrons*) Recovery Plan. NSW NPWS, Hurstville.

Nybakken, J.W. (1982) Marine Biology: an Ecological Approach. Harper & Row Publishers: New York.

Olds, A. (2002) Utilisation by prawns of seagrass beds at different distances from mangrove forests. Honours thesis, University of Queensland.

O'Neill, M.F., Leigh, G.M. (2006) East Coast Trawl Fishery fishing power and catch rates. June 2006. DPI&F, Brisbane. pp. 185.

OUM (2005) South East Queensland Regional Plan 2005 – 2026. Prepared in partnership with the South East Queensland Regional Organisation of Councils (SEQROC) and in consultation with South East Queensland Regional Coordination Committee (RCC), Queensland Department of Local Government, Planning, Sport and Recreation, Brisbane.

Outridge, P.M., Arthington, A.H., Miller, G.J. (1989) Limnology of naturally acidic, oligotrophic dune lakes in subtropical Australia, including chlorophyll - phosphorus relationships. Hydrobiologia 179, 39-51.

Page, T.J., Hughes, J.M. (2007) Phylogeographic structure in an Australian freshwater shrimp largely pre-dates the geological origins of its landscape. Heredity 98, 222-231.

Page, T.J., Ponniah, M., Sharma, S., Hughes, J.M. (2006) Genetic distinctness of aquatic species on North Strabroke Island: inferred from mitochondrial DNA sequence data from five freshwater species (*Caridina* spp., *Rhadinocentrus ornatus*, *Nannoperca oxleyana* and *Macrobrachium tolmerum*). In Marshall, J., McGregor, G., Negus, P. (eds.) Assessment of North Strabroke Island Groundwater Dependent Ecosystems. Potential responsses to proposed increases in groundwater extraction. Aquatic Ecosystems Technical Report No. 59. Queensland Natural Resources and Water: Brisbane. pp. 51.

Perry, C. (1997) Microbial processes in seagrass sediments. University of Queensland.

Phillips J. (1998) Macro-algae of Moreton Bay: species diversity, habitat specificity and biogeography. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland, Brisbane. pp. 279-290.

Poiner, I.A., Conacher, D.J., Staples, D.J., Moriarty, D.J.W. (1989) Seagrasses - Why are they important? In Crimp, O.N. (eds.) Moreton Bay in the Balance. Australian Littoral Society/Australian Marine Science Consortium. pp. 41-53.Preen, A. (1995a) Diet of dugongs: are they omnivores? Journal of Mammalogy 76, 163-171.

Preen, A. (1995b) Impacts of dugong foraging on seagrass habitats: observational and experimental evidence for cultivation grazing. Marine Ecology Progress Series 124, 201-213.

Preen, A.R. (1996) Infaunal mining: A novel foraging method of Loggerhead Turtles. Journal of Herpetology 30, 94-96.

Priest, B., Straw, P., Weston, M. (2002). Shorebird Conservation in Australia. Supplement to Wingspan, vol.12, no 4 December 2002.

Pusey, B., Kennard, M., Arthington, A. (2004) Freshwater Fishes of North-Eastern Australia. CSIRO Publishing: Collingwood.

QPWS (1999a) Carbrook Wetlands Conservation Park, Serpentine Creek Conservation Park Management Plan, Brisbane. November 1999.

QPWS (1999b) King Island Conservation Park Management Plan. Brisbane, November 1999.

Queensland Department of Environment and Heritage (1993) Pumicestone Passage, its Catchment and Bribie Island. Draft Integrated Management Strategy - Main Report. Queensland Depart of Environment and Heritage, Brisbane.

Queensland Herbarium (2005) Herbarium collection list from North Stradbroke Island.

Queensland Museum (2008). Fauna Database Records. Queensland Museum, South Brisbane.

Quinn, R. H. (1992) Fisheries Resources of the Moreton Bay Region. Queensland Fish Management Authority

Rasheed, M.A. (2004) Recovery and succession in a multi-species tropical seagrass meadow following experimental disturbance: the role of sexual and asexual reproduction. Journal of Experimental Marine Biology and Ecology 310, 13-45.

Redland Shire Council and Department of Local Government and Planning (1999) Southern Moreton Bay Islands Planning Study – Report on Planning and Land Use Strategy. January 1999.

Roberts, P.E. (1957) Notes on birds of the Cumberland Islands. Emu 57,303-310.

Rochford, D.J. (1951) Studies in Australian estuarine hydrology - I. Introductory and comparative features. Australian Journal of Marine and Freshwater Research 2, 1-117.

Roy, P.S., Williams, R.J., Jones, A.R., Yassini, I., Gibbs, P.J., Coates, B., West, R.J., Scanes, P.R., Hudson, J.P., Nichol, S. (2001) Structure and Function of South-east Australian Estuaries. Estaurine, Coastal and Shelf Science 53, 351-384.

Saenger, P., Specht, M.M., Specht, R.L., Chapman, V.J. (1977) Mangal and Coastal Saltmarsh Communities in Australia. In Chapman, V.J. (ed.) Wet Coastal Ecosystems. Elsevier Scientific Publishing Company Amsterdam.

Saintilan, N. (2004) Relationships between estuarine geomorphology, wetland extent and fish landings in New South Wales estuaries. Estuarine, Coastal and Shelf Science 61, 591-601.

Samson, P.R. (1989) Morphology and biology of *Acrodipsas illidgei* (Waterhouse and Lyell), a myrmecophagous lycaenid (Lepidoptera: Lycaenidae: Theclinae). Journal of the Australian Entomological Society 28, 161–168.

Sands, D.P.A., New, T.R. (2002) The Action Plan for Australian Butterflies, Environment Australia, Canberra.

Sands, D.P.A., Sands, M.C. (2005) New butterfly records in Miscellaneous Notes. Australian Entomologist 32, 4.

Sattler, P., William, R. (eds.) (1999) The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

Schlacher, T., Richardson, D.L., McLean, I. (2008) Impacts of off-road vehicles (ORVs) on macrobenthic assemblages on sandy beaches. Environmental Management 41, 878-892.

Searle, J. (2006) Fauna Survey Report South Stradbroke Island Management Area. An unpublished report prepared by the Environmental Planning and Sustainable Development Section, Gold Coast City Council.

Seitz, R.D. (1998) Incorporation of soft-sediment systems into a model of marine benthic community regulation. Marine and Freshwater Research 49, 817-826.

Semple, G.P. (1991) Reproductive behaviour and early developement of the Honey Blue-eye, *Pseudomugil mellis* Allen and Ivantsoff 1982 (Pisces: Pseudomugilidae), from the north-east coast division, south-eastern Queensland. Australian Journal of Marine and Freshwater Research 42, 277-286.

SEQ HWP (2007) South East Queensland Healthy Waterways Strategy 2007 – 2012 (Final Document) – Moreton Bay Action Plan, prepared by the South East Queensland Healthy Waterways Partnership, December 2007.

SEQTOLSMA 2008 OUR PLAN, the South East Queensland Aboriginal Traditional Owner Cultural Resource Management Plan. Brisbane: South East Queensland Traditional Owner Land and Sea Management Alliance.

Smales, M., Ledward, C.P. (1942) Notes on the life histories of some lycaenid butterflies. Part 1. Queensland Naturalist 12, 14–18.

Smith, P. (1990) The biology and management of the Little Tern (*Sterna albifrons*) in NSW. NSW National Parks and Wildlife Service, Hurstville.

Smyth, A.K., Corben, C. (1984) Seabird observations on North Stradbroke Island. In Coleman, R.J., Covacevich, J., Davie, P. (eds.) Focus on Stradbroke – New Information on North Stradbroke Island and Surrounding areas, 1974-1984. Stradbroke Island Management Organisation. Boolarong Publications, Brisbane.

Society for Growing Australian Plants (Logan River Branch) (2005) Mangroves to Mountains, Volume 2. Copyright Publishing, Brisbane.

Sonnenburg, R. (2006) Assessment of Shorebird Habitat on South Stradbroke Island. Unpublished Report to Environmental Planning & Conservation Section, Gold Coast City Council.

Staples, D.J., Vance, D.J., Heals, D.S. (1985) Habitat Requirements of Juvenile Penaeid Prawns and their Relationship to Offshore Fisheries. In Rothlisberg, P.C., Hill, B.J., Staples, D.J. (eds.) Second Australian National Prawn Seminar. pp. 47-54.

State of Queensland (2007) Water Resource (Moreton) Plan 2007.

Stephenson, W. (1980a) Flux in the sublittoral macrobenthos of Moreton Bay. Australian Journal of Ecology 5, 95-116.

Stephenson, W. (1980b) Relationships of the macrobenthos of Moreton Bay to prawns and to abiotic factors. Australian Journal of Ecology 5, 143-149.

Stephenson, W. (1980c) Time-patterns of macrobenthic species in Moreton Bay. Australian Journal of Ecology 5, 245-262.

Stephenson, W., Cook, S.D., Newlands, S.J. (1978) The macrobenthos of the Middle banks area of Moreton Bay. Memoirs of the Queensland Museum 18, 185-212.

Stephenson, W., Sadacharan, D.H. (1983) Investigations of microtopographical patterns in sublittoral macrobenthos in northern Moreton Bay. Proceedings of the Royal Society of Queensland 94, 19-32.

Stephenson, W., Williams, W.T., Lance, G.N. (1970) The macrobenthos of Moreton Bay. Ecological Monographs 40, 459-494.

Stephenson, W., Cook, S.D., Newlands, S.J. (1978) The macrobenthos of the Middle banks area of Moreton Bay. Memoirs of the Queensland Museum 18, 185-212.

Straughan, I.R., Main, A.R. (1966) Speciation and polymorphism in the genus *Crinia Tschudi* (Anura, Leptodactylidae) in Queensland. Proceedings of the Royal Society of Queensland 78, 11-28.

Sumpton, W., Greenwood, J. (1990) Pre- and post-flood feeding ecology of four species of juvenile fish from the Logan-Albert estuarine system, Moreton Bay, Queensland. Australian Journal of Marine and Freshwater Research 41, 795-806.

Tanimoto, M., Courtney, A.J., O'Neill, M.F., Leigh, G.M. (2006) East Coast Banana Prawn Fishery Stock assessment 2006. DPI&F, Brisbane. pp. 89.

Thompson, J.J. (1990a) A reassessment of the importance of Moreton Bay to migrant waders. Sunbird 20, 83-8.

Thompson, J.J. (1990b) The sex and age-related distribution of bar-tailed godwits in Moreton Bay, Queensland, during the northward migration. Emu 90, 169-74.

Thompson, J.J. (1992) Spatial and temporal patterns of shorebird habitat utilisation in Moreton Bay, Queensland. Unpublished doctoral thesis, University of Queensland, Brisbane.

Tibbetts, I.R., Connolly, R.M. (1998) The Nekton of Moreton Bay. In Tibbets, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland: Brisbane.

Timms, B. V. (1982) Coastal waterbodies of north-eastern New South Wales. Australian Journal of Marine and Freshwater Research 33, 203-222.

TSSC (2007). Little Tern (western Pacific) (*Sterna albifrons sinensis*). Advice to the Minister for the Environment and Heritage from the Threatened Species Scientific Committee on Amendments to the list of Threatened Species under the Environment Protection and Biodiversity Conservation Act 1999. Accessed via www.environment.gov.au/biodiversity/threatened/species/sterna-albifrons-sinensis.html

Tyler, M.J. (1997) The Action Plan for Australian Frogs. Wildlife Australia, Canberra, ACT.

Udy, J.W., Dennison, W.C. (1998) The use of the seagrass, *Zostera capricorni*, to identify anthropogenic nutrient sources in Moreton Bay. In Tibbetts, I.R., Hall, N.J., Dennison, W.C. (eds.) Moreton Bay and Catchment. School of Marine Science, University of Queensland: Brisbane. pp. 213-228.

Udy, J., Levy, D. (2002) Deep seagrass and coral habitats found in Eastern Moreton Bay, University of Queensland, Brisbane

Van Dyck, S. (1997) *Xeromys myoides* Thomas, 1889 (Rodentia: Muridae) in mangrove communities of North Stradbroke Island, south-east Queensland. Memoirs of the Queensland Museum 42, 337-366.

Van Dyck, S, Durbidge, E. (1992) A nesting community of false water rats *Xeromys myoides* on the Myora sedgelands, North Stradbroke Island. Memoirs of the Queensland Museum 32, 374.

Van Dyck, S., Gynther, I. (2003) Nesting strategies of the Water Mouse *Xeromys myoides* in south-east Queensland. Memoirs of the Queensland Museum 49, 453-479.

Vernon, D.P., Martin, J.H.D. (1975) Birds of Stradbroke Island. Proceedings of the Royal Society of Queensland 86, 61-72.

Voice M., Harvey, N., Walsh K. (eds.) (2006) Vulnerability to Climate Change of Australia's Coastal Zone: Analysis of gaps in methods, data and system thresholds. Report to the Australian Greenhouse Office, Department of Environment and Heritage. Canberra

Watkins, D. (1993) A National Plan for Shorebird Conservation in Australia. Australian Wader Studies Group, Royal Australasian Ornithologists Union (Report No. 90) and World Wide Fund for Nature, Melbourne.

Watson, P. (2001) The Role and Use of Fire for Biodiversity Conservation in South-east Queensland: Fire Management Guidelines Derived From Ecological Research. SEQ Fire and Biodiversity Consortium.

WBM (2001) Historical Trends in Water Quality - Gold Coast Region. Report prepared for Gold Coast City Council by WBM Pty Ltd, Brisbane.

WBM (2002a) Mining at Enterprise Aquatic Fauna Baseline Surveys Final Report. Report prepared for CRL by WBM Pty Ltd, Brisbane.

WBM (2002b) Surveys of the Aquatic Fauna Communities Adjacent to Ibis Mine – Stage 3 Final Report.' Report prepared for CRL by WBM Pty Ltd, Brisbane.

WBM (2002c) Significant Species Management Plan (Fish) Report – June Quarter and 2002 Annual Summary. Report prepared for CRL.

WBM (2003) Quarterly Significant Species Management Plan (Fish) Report – May 2003. Report prepared for CRL by WBM Pty Ltd, Brisbane.

WBM (2005) Pumicestone Passage Water Quality Modelling Final Report. Report prepared for Moreton Bay Waterways and Catchments Partnership, Brisbane.

Westman, W.E. (1975) Pattern and diversity in swamp and dune vegetation, North Stradbroke Island. Australian Journal of Botany 23, 339-354.

Whitmore, M., De Lacy, T. (2005) Sustainable Development and Management of Tourism in Moreton Bay. Sustainable Tourism CRC. Brisbane.

Williams, L.E. (2002) Queensland's fisheries sources - Current Coindition and Recent Trends 1988-2000. Department of Primary Industries, Brisbane.

Young, P.C. (1978) Moreton Bay, Queensland: a nursery area for juvenile penaeid prawns. Australian Journal of Marine and Freshwater Research 29, 55-75.

Young, P.C., Kirkman, H. (1975) The seagrass communities of Moreton Bay, Queensland. Aquatic Botany 1, 191-202.

Young, R, Lee, J., Connolly, R. (2006) Policy Implications Summary for a Smart Approach to Monitoring Urban Pressures on Estuarine Fisheries Habitat. Short Paper submitted as part of the Growing the Smart State PhD Funding Programme.

9 GLOSSARY

Acceptable change, means the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. Acceptable variation is that variation that will sustain the service, component or process to which it refers.

Aquatic/marine fauna, the context of this report relates to fauna species that spend all or the majority of their life cycle in or underwater. As such this grouping primarily relates to fish, marine reptiles, aquatic mammals such as dugong and cetaceans, and aquatic/marine invertebrates.

Congener, species within the same genus.

Ecological character, defined under Resolution IX.1 Annex A: 2005 of the Ramsar Convention as, the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.

IBRA bioregion, refers to Interim Biogeographic Regionalisation for Australia (IBRA). IBRA is a biogeographic regionalisation of Australia developed by the Australian Government's Department of the Environment, Water, Heritage and the Arts. It was developed for use as a planning tool, for example for the establishment of a National Reserve System.

IMCRA bioregion, refers to the Interim Marine and Coastal Regionalisation for Australia (Mesoscale) to the 200 meter isobath and derived from biological and physical data, (eg. coastal geomorphology, tidal attributes, oceanography, bathymetry and intertidal invertebrates). IMCRA is the marine equivalent of IBRA.

National Framework document, refers to the Draft National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands (DEWHA 2008b) and its successive documents as endorsed by the Natural Resource Management (NRM) Ministerial Council.

Parapatry speciation is a form of speciation that occurs due to variations in mating frequency of a population within a continuous geographical area.

Ramsar criteria, refers to the nine criteria for the listing of a site as internationally significant under the provisions of the Ramsar Convention.

Regional ecosystems are defined by Sattler and Williams (1999) as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.

Values, means the perceived benefits to society, either direct or indirect that result from wetland functions. These values include human welfare, environmental quality and wildlife support.

Wallum, refers to freshwater wetlands and associated vegetation communities occurring on low nutrient sandy soils. While nutrient poor, these soils support a range of vegetation types including melaleuca (paperbark) woodland, sedgeland and heath (the dominant vegetation type on soils of this type). Acidic (pH < 6.0) swamps and lakes are typically found amidst heath vegetation and sedges where water collects above organic hardpan layers and provide essential breeding habitat for 'acid frogs' and other specially adapted species (Meyer *et al.*. 2005).

Wetlands, is used in this report in the context of the definition under the Ramsar Convention which includes, *areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres*.

Wetland-dependant terrestrial fauna, in the context of this report relates to fauna species that occur within or otherwise are dependant on wetland habitats but do not spend the majority of their life cycle underwater (eg. non-aquatic species). As such this grouping primarily relates to birds, amphibians such as frogs, non-aquatic mammals such as water mouse, non-aquatic reptiles and terrestrial invertebrates.

Wetland flora, in the context of this report relates to flora species that are characterised as wetland or wetland-dependant species or populations.

Wetland ecosystem components, as defined in the ECD National Framework document, are the physical, chemical and biological parts or features of a wetland

Wetland ecosystem processes, as defined in the National Framework document, are the dynamic forces within the ecosystem between organisms, populations and the non-living environment. Interactions can be physical, chemical or biological.

Wetland ecosystem benefits or services (includes the term ecosystem services), as defined in the National Framework document, are the benefits that people receive from wetland ecosystems. In general, benefits and services are based on or underpinned by wetland components and processes and can be direct (eg. food for humans or livestock) or indirect (eg. wetland provides habitat for biota which contribute to biodiversity).

APPENDIX A: CONSULTATION DETAILS

Project Committees

This study was overseen and reviewed by two groups established by the Queensland EPA: the project Steering Committee and project Knowledge Management Committee.

These groups were comprised of the following persons:

Project Steering Group

Gay Deacon, Chair	Queensland Environmental Protection Agency
Peter Macdonald	Queensland Environmental Protection Agency
Gayle Partridge	Australian Government Department of Environment, Water, Heritage and the Arts
John Beumer	Queensland Department of Primary Industries and Fisheries
Todd Kelly	Queensland Environmental Protection Agency
Paul Sanders	Queensland Department of Natural Resources and Water
Dave Rissik	Queensland Environmental Protection Agency
Di Tarte	Southeast Queensland Healthy Waterways Partnership

Project Knowledge Management Committee

Gay Deacon, Chair	Queensland Environmental Protection Agency
John Bennett	Queensland Environmental Protection Agency
Brad Zeller	Queensland Department of Primary Industries and Fisheries
Nicola Udy	Queensland Environmental Protection Agency
Sel Sultmann	Queensland Environmental Protection Agency
Roger Jaensch	Wetland International Oceania
Warren Lee Long	Wetland International Oceania
Rod Connolly	Griffith University

Meeting dates for these groups during the project were as follows:

- Project Inception Meeting with EPA Project Team (March 2008)
- Steering Committee Meeting #1 – overview and collection of information sources (May 2008)
- Knowledge Management Committee Meeting #1 – workshop on critical services, processes and components (May 2008)
- Joint Meeting of the Steering Committee and Knowledge Management Committee – presentation of draft ECD document for comment (July 2008)
- A meeting to present the final documentation to the Steering Committee occurred in November 2008

Scientific Expert Panel Process

In light of the potential for positive alignment between significant conservation/management initiatives being developed for Moreton Bay, in parallel with the current project preparing the Ecological Character Description (ECD) for the Moreton Bay Ramsar Site, BMT WBM Pty Ltd and the Scientific Expert Panel (SEP) of the Southeast Queensland Healthy Waterways Partnership (the Partnership) were engaged by the EPA to conduct a number of meetings and workshops to discuss, collate and review the scientific understanding of Moreton Bay's ecological health/character and to identify opportunities for alignment of ecological monitoring (and associated environmental indicators for key ecological assets) in Moreton Bay. The three conservation/management initiatives included:

- the Southeast Queensland Healthy Waterways Strategy (and associated Ecosystem Health Monitoring Program [EHMP]) administered by the Partnership;
- the Ramsar Convention (and associated Ecological Character Description [ECD] in preparation by BMT WBM); and
- the draft Moreton Bay Marine Park Zoning Plan (and the associated monitoring plan currently being implemented by the EPA).

The approach adopted to collate this understanding and identify opportunities was to develop an overall Conceptual Framework (hereafter, 'the Framework') for Moreton Bay with a specific focus on the ecological assets underpinning its ecological health/character identified in the draft ECD and other relevant assessment documents. Key aspects of the Framework identified were:

- Identification of critical or key whole-of-Bay processes that affect the Bay's ecological health/character;
- Identification and agreement of the key ecological assets (eg. habitats and species) that were salient to all three conservation/management initiatives;
- Development of conceptual models for the key ecological assets (i.e. key attributes, threats and indicators of ecosystem health/character including where practicable defining limits or thresholds of acceptable change); and
- Based on the three steps above, assess the extent that key ecological assets were already being monitored and develop new or revised monitoring priorities that were relevant to the management and monitoring objectives of the EHMP, the ECD (in terms of the site's status as a Ramsar site) and the proposed Marine Park Zoning Plan.

The methodology used for developing the Conceptual Framework involved a series of (3) half-day meetings and (2) devoted full day workshops to discuss and address the key aspects of the Conceptual Framework. All meetings were organised and minuted by the Partnership's secretariat staff.

The meetings were convened by John Bennett (EPA and SEP member) and Eva Abal (SEP) as co-chairs at the offices of the Partnership. BMT WBM's role in the process was to prepare inputs for the meetings (agendas, workshop notes and presentations), present the information for discussion by the group and to document and 'write up' technical outputs in the form of conceptual models and diagrams which were distributed for comment and review by participants prior to meetings. A separate report (BMT WBM 2008b) was produced out of this process documenting the proceedings and discussions.

Meeting and workshop dates for the participants were as follows:

- July 2008 – Inception Meeting
- 17 July 2008 – 1st Workshop
- 28 July 2008 – 2nd Workshop
- 12 August 2008 – Meeting
- September 2008 – Meeting

Participants in the Meetings and Workshop (in addition to the BMT WBM study team) were as follows:

SEP Sub-Committee

John Bennett, Chair	Queensland Environmental Protection Agency
Gay Deacon	Queensland Environmental Protection Agency
Eva Abal	SEP, SEQ Partnership
Brad Zeller (Altern. Michelle Winning)	Queensland Department of Primary Industries and Fisheries
Nicole Udy	Queensland Environmental Protection Agency
Dave Rissik	Queensland Environmental Protection Agency
Thomas Schlacher	Sunshine Coast University
Rod Connolly	Griffith University
Tim Stevens	Private Capacity (now GHD Pty Ltd)
Jackie Robinson	University of Queensland

Outputs identified through this SEP review process relevant to the ECD included:

- An overview of the key ecosystem processes underpinning Bay function (and associated 'overview' conceptual model);

- Understanding of how these processes interact and create connectivity between the inshore and offshore habitats of the Bay;
- Recognition of the key threats and stressors operating within and adjacent to the Bay;
- Identification of the key habitats and species of the Bay; and
- Development of conceptual models for the key habitats and species that include:
    - identification of key indicators of habitat/species extent and condition;
    - identification of the key attributes and controls on ecosystem health and character; and
    - identification of stressors and threats (direct and indirect) to the habitats/species.

As outlined in Sections 4 and 5 of the report, from this process, a range of indicators, information gaps and monitoring priorities were identified that are directly relevant to the ECD study.

Other Expert Input and Peer Review

The study team also made contact with specific experts and organisations outside the SEP process. In this context, we recognise and appreciate the assistance of the following individuals and organisations:

- Dr Col Limpus, Queensland Environmental Protection Agency
- Dr Janet Lanyon, University of Queensland
- Dr Don Sands, formerly of the CSIRO
- Dr Ian Gynther, Queensland Environmental Protection Agency
- Dr Steve Van Dyck, Queensland Museum
- Dr Ed Meyer, formerly University of Queensland
- Dr Glen Ingram, formerly Queensland Museum
- David Geering, Queensland Wader Study Group
- Jill Denning, Queensland Wader Study Group
- John Birbeck, Caloundra City Council
- Jason Searle, Gold Coast City Council

External Peer Review of the draft ECD Report was also undertaken by Wetland International Oceania (Roger Jaensch and Warren Lee Long) under contract with BMT WBM Pty Ltd.

APPENDIX B: POLICY AND PLANNING CONTEXT

This Appendix outlines the range of statutory plans, strategies and areas and non-statutory instruments relevant to the management of the Ramsar Site.

Principal Management Plans

Marine Park (Moreton Bay) Zoning Plan

The purpose of the *Marine Parks (Moreton Bay) Zoning Plan 1997* is to provide for the ecologically sustainable use of Moreton Bay Marine Park and to protect its natural, recreational, cultural heritage and amenity values. This is similar to the objectives of the Ramsar Convention, being for the conservation and wise use of the area. The marine park zoning plan operates through the delineation of zones within the declared marine park and regulates activities within these zones through the issue of permits and/or regulatory provisions.

The 1997 zoning plan, developed under the *Marine Parks Act 2004,* expires on 1 September 2008 (EPA 2008b). A review of this plan is currently being undertaken and will consider the objectives of the *Marine Parks Act 2004.*

Table B-1 provides a summary of the zones and their purposes under the current and draft proposed zoning plan. In general, the current marine park zoning plan protects and conserves valuable intertidal and marine habitats such as mangroves, seagrass and coral communities within various protection and habitat zones. The proposed draft zoning plan is seeking to improve the level of protection afforded to a range of representative habitats within the Bay by increasing the area and number of marine national park (green) zones.

Table B-1 Current and proposed Moreton Bay Marine Parks zones and their purposes

Zones	Purpose, Prohibitions and Comments
Marine Parks (Moreton Bay) Zoning Plan 1997	
General Use Zone	o Purpose: to provide for the general use and public enjoyment of the zone in ways that are consistent with the conservation of the marine park. o These areas allow all activities, though some require a permit to occur within the marine park. o This zone constitutes the majority of the marine park.
Habitat Zone	o Purpose: to conserve significant habitats within the marine park and the cultural heritage and amenity values of the marine park, to maintain the productivity and diversity of ecological communities within the marine park, and to provide for reasonable public use and enjoyment of the zone consistent with the conservation of the marine park. o Most activities are allowed in these zones, but activities such as shipping operations and mining are prohibited.
Conservation Zone	o Purpose: to conserve the zone's cultural and natural resources and amenity values, to conserve the zone's natural condition to the greatest possible extent, to allow members of the public to enjoy the relatively undisturbed nature of the zone, and to ensure use of the zone's natural resources is ecologically sustainable. o Recreational activities are permitted but commercial trawling is prohibited.
Buffer Zone	o Purpose: to provide for the protection of the zone's biological diversity and natural condition to the greatest possible extent, while allowing the public to appreciate and enjoy the undisturbed nature of the zone and for the trolling for pelagic fish.
Protection Zones	o To provide for the permanent preservation of the zone's biological diversity and natural condition to the greatest possible extent, while allowing the public to appreciate and enjoy the undisturbed nature of the zone. o All forms of fishing and extracting are prohibited.
Moreton Bay Marine Park Draft Zoning Plan	
General Use Zone	o Purpose: the zoning applied to areas where a higher level of protection could not be achieved or was not required given the percentage of each habitat type protected in other zones. o Most activities can occur with or without a permit under an ecologically sustainable management framework.
Habitat Protection Zone	o Purpose: to provide significant habitat, especially those supporting threatened species, protect areas adjacent to land based national parks, and provide an environmental buffer against threatening processes, while allowing for prevention of substantial economic impacts from phasing out of commercial netting (e.g. allowing areas supporting low levels of trawling). o Activities which disturb the seabed are prohibited.
Conservation Park Zone	o Purpose: to broadly complement the level of protection provided to adjacent land based protected areas while supporting existing recreational use and some limited commercial fishing, to protect special and unique areas where Marine National Park Zones would have resulted in unacceptable social or economic impacts, and to allow continued entry and use of areas of high recreational value, in particular for recreational fishing. o Most forms of large scale extractive use, direct disposal, private structures and development are prohibited. o Limited recreational and commercial line fishing and crabbing may still occur.
Marine National Park Zone	o Purpose: to protect the full range of habitat types and an example of each biodiversity feature, to maintain the ecological viability and integrity of populations, species and communities, to protect species of conservation concern as well as species vulnerable habitats and lifestages, to protect the natural values of the marine environment to ensure greater resilience against future changes or threats, and to provide for adaptive management through assessment of effectiveness of zoning. o All forms of extractive use, direct disposal into the area, coastal development and most maritime infrastructure are prohibited to provide whole-of-ecosystem protection.

Source: Information on *Moreton Bay Marine Park Draft Zoning Plan* taken from EPA (2008a).

South-east Queensland Regional Coastal Management Plan

The application of the South East Queensland Regional Coastal Management Plan (SEQRCMP) (EPA 2006) extends to the coastal zone between and including Maroochy Shire to Coolangatta, and operates in conjunction with the *State Coastal Management Plan.* It aims to achieve sustainable coastal management in SEQ, and to avoid or minimise future adverse impacts on coastal resources.

Within the SEQRCMP, specific regional direction is provided on 17 State Coastal Plan policies, and in addition, includes two regionally specific policies[12] (EPA 2006). Most policies within the Plan are relevant to the Ramsar site, either providing direction on the wise use of the coastal zone for social or economic purposes, or for the conservation of sensitive areas within the coastal zone, including those in Moreton Bay. Applicable policies include:

- *Policy 2.1.10 Tourism and Recreational Activities* – Intense tourism and recreational pressures are important community and economic assets in the SEQ area. The Policy requires the avoidance or minimisation (in order of preference) of potential adverse impacts, including cumulative impacts, on protected species, particularly threatened and migratory species. Further, the Policy requires that planning for tourism and recreation in the SEQ region makes provision, where relevant, for seasonal variations in faunal activity and migrations.
- *Policy 2.8.1 Areas of state significance (natural resources)* – This Policy covers areas within the Ramsar site including significant coastal wetlands, Nature Conservation Act Protected Areas[13] and significant coastal dunes. The Policy recognises that areas of state significance (natural resources) play a critical role in maintaining a healthy functioning coast, and that they must be protected from land uses and activities that may have adverse impacts on their continued integrity and functioning (i.e. wise use).
- *Policy 2.8.2 Coastal Wetlands* –This Policy applies to the conservation and management of coastal wetlands, including land within 100m of a coastal wetland. This policy identifies areas within the Moreton Bay Ramsar site as having large and intact coastal wetland ecosystems with high ecological integrity and functioning. However, it does not cover all areas within the Ramsar site boundary. It also considers that wetlands in some areas within Moreton Bay are experiencing pressures from direct and cumulative impacts including Pumicestone Passage and parts of Bribie Island, parts of the Hays Inlet and Brisbane northern wetland complex, and part of the Carbrook wetland complex south of Beenleigh-Redland Bay Road.
- *Policy 2.8.3 Biodiversity* – This Policy focuses on areas of Coastal Biodiversity Significance including wetlands (significant and coastal) and areas of shorebird habitat. Areas within or immediately adjacent to the Ramsar site boundary are also designated as areas of terrestrial Coastal (State) Biodiversity Significance. The Policy requires future planning consider various aspects of management impacting on the conservation and wise use of the Ramsar site including:

  - to ensure development does not result in further loss, degradation or fragmentation of areas of coastal biodiversity significance and value; and

  - to identify areas that are degraded between areas of biodiversity significance and require rehabilitation to reinstate habitat values and ecological functioning.

[12] Policy 2.1.15 - *Non-tidal artificial waterways* and Policy 2.4.7 - *Algal Bloom Management*.
[13] As identified under the SEQRCMP.

- *Policy 2.8.4 Rehabilitation of Coastal Resources* – The SEQRCMP requires rehabilitation and enhancement of coastal resources to improve values and functioning of the coastal zone. General areas defined for priority rehabilitation and enhancement include coastal wetlands, endangered regional ecosystems and dunal systems (refer Policies 2.8.1 and 2.8.2) and shorebird nesting, roosting and feeding sites (Policy 2.8.3).

A range of other statutory plans, strategies and areas and non-statutory management plans and instruments apply in the Moreton Bay region and to areas or values within the Ramsar site.

Other Statutory Plans

Protected Areas Management Plans

There are a number of terrestrial-based protected areas within the boundaries of the Moreton Bay Ramsar site. Some of these protected areas have management plans to provide for their conservation and wise use, while others have no formal management plans or strategies currently in place.

Moreton Island National Park, Cape Moreton Conservation Park and Moreton Island Recreation Area and Management Plan

The Plan (EPA 2007) aims to maintain and manage protected areas on Moreton Island as relatively undisturbed coastal landscapes where people will continue to access and enjoy the island's regionally unique, nature-based recreational activities. It also aims to make conservation of the island's natural communities, species and cultural heritage a key focus of management on the island. The Plan has been developed to ensure that management considers international agreements including the Ramsar Convention, protected areas legislation, native title, cultural heritage, and local plans (under the jurisdiction of Brisbane City Council). While only applying to a proportion of the Moreton Bay Ramsar site, the Plan aims to maintain and manage values protected by the Ramsar Convention.

Carbrook Wetlands Conservation Park, Serpentine Creek Conservation Park

The Carbrook Wetlands Conservation Park and Serpentine Creek Conservation Park Management Plan (QPWS 1999a) identifies the wetlands systems within these parks as good examples of their type within the South East Queensland bioregion. Desired outcomes, and policies, guidelines and actions are set out in the plan to address management of the protected area including its plants and animals (including wetlands, especially Carbrook Wetland including Native Dog Creek), scenic and aesthetic, scientific and educational, and recreational values.

King Island Conservation Park

The King Island Conservation Park Management Plan (QPWS 1999b) highlights the importance of the Park as an area of extensive tidal flats, rubble banks and seagrass beds which are important to migratory wader birds as feeding grounds. The management plan aims to maintain the island in its natural condition and to allow no developed facilities. It notes that the Park will be managed in accordance with the Ramsar Convention, and consistently with the surrounding marine park zoning requirements.

Buckely's Hole Conservation Park

The Buckely's Hole Conservation Park Management Plan (Department of Environment and Heritage 1998) identifies the Park as being a place of significance for migratory birds, and as providing nature-based recreational opportunities such as bird-watching and bushwalking. The Plan aims to ensure:

- the lagoon and its surrounds are maintained for the continued use by water birds;
- threatened fauna is monitored and their requirements are included in ongoing management programs;
- nature-based recreational and educational day use opportunities are provided; and
- Aboriginal groups and the local community are provided with the opportunity to be involved in the management of the Park.

Other Protected Areas

Other *Nature Conservation Act* protected areas within the Moreton Bay Ramsar site do not currently have management plans, but are managed by QPWS in accordance with the management principles for that class of protected area under the Act:

Bribie Island Recreation Area and Bribie Island National Park - The Bribie Island Recreation Area includes the Bribie Island National Park, and is managed pursuant to the *Recreation Areas Management Act 2006* for the purposes of nature conservation and nature-based recreation. Currently there is no conservation management plan for the area.

St Helena Island National Park - Queensland's first historic national park was the St Helena Island National Park. The aim of the National Park is to preserve the ruins and artefacts on the Island from further degradation, and to provide an educational tool to accurately present the park and its history to visitors.

Southern Moreton Bay Islands National Park - This protected region has an area of more than 1500 ha, and is comprised of Willes, Cobby Cobby, Kangaroo, Woogoompah and Coomera Islands. The southern islands area is managed for conservation of the natural environment, with marine park conservation and protection zones surrounding the islands.

Environmental Values and Water Quality Objectives

Schedule 1 of the *Environmental Protection (Water) Policy 1997* identifies environmental values and water quality objectives for Moreton Bay and its coastal catchments. In particular the schedule sets quantitative objectives for key physico-chemical water quality parameters such as nutrients and sediments that, if achieved, will protect aquatic ecosystem values. A number of areas within the Bay are provided the highest level of ecosystem protection, known as High Ecological Value (or HEV) areas. These areas are to be retained in their current condition (in terms of water quality, biotic quality) to the greatest extent practicable. The environmental values and water quality objectives of the schedule must be considered in decision-making under the Environmental Protection Act in relation to regulated activities that involve discharge of contaminants to waterways as well as in other statutory plans and strategies.

South East Queensland Regional Plan

The purpose of the South East Queensland Regional Plan 2005-2026 (Office of Urban Management (OUM) 2005) is to provide a sustainable growth management strategy for SEQ to the year 2026, including the protection and enhancement of the region's natural environment, biodiversity and natural resources. It is a statutory plan to which all other planning in SEQ, such as local government planning schemes, state plans and policies, must align. The Plan applies to those local government areas (LGAs) in the SEQ region and Queensland waters adjacent to these LGAs, including all of the Moreton Bay Ramsar site.

The vision of the SEQ Regional Plan includes that ecological and culturally significant landscapes are valued, celebrated and protected. The Plan's regional land use pattern identifies "areas of regionally significant conservation, natural resource, landscape, …. and recreational value", with the majority of the Ramsar site being included in the Regional Landscape and Rural Production Area.

Regional policies set out the desired regional outcomes, principles and policies to address growth management in SEQ, and guide planning and decision-making at State and local levels. Desired regional outcome 2 recognises the quality and diversity of the natural environment of SEQ, including features such as rich and diverse native flora and fauna, diverse coastline and marine waters encompassing coastal wetlands (e.g. Pumicestone Passage and Carbrook Wetlands), unique sand islands (Moreton, Stradbroke and Bribie Islands), and the dugong, turtle and fish habitats of Moreton Bay. A number of policies have been developed to implement these principles, including the protection, conservation, management, rehabilitation and/or restoration of coastal wetlands.

Fisheries Management Plans (East Coast Trawl) and (Coral Reef Fin Fish)

These fisheries management plans apply to all of Queensland's waters and provide for the use, conservation and enhancement of the community's fisheries resources by managing the east coast trawl fishery and reef line fishery in a way that seeks to apply and balance the principles of ecologically sustainable development, and promote ecologically sustainable development.

The *Fisheries Management (East Coast Trawl) Plan 1999* requires the use of bycatch reduction devices (BRDs) and turtle excluder devices (TEDs) throughout the fishery, and sets regulated periods for defined waters including within the Moreton Bay area and Ramsar site.

Fish habitat areas

Fish habitat areas are statutory areas defined under the *Fisheries Act 1994* and its regulations for the protection of important fish habitats across the State of Queensland. Several declared areas are within the Moreton Bay Ramsar site and coincide with its boundaries. Declaration of a fish habitat area provides particular powers for the chief executive administering the Fisheries Act to regulate development and activities within them.

Water Resource Plans

Water Resource Plans (WRPs), required under the *Water Act 2000*, are developed to plan the allocation and sustainable management of water to provide a balance between sustainability for river ecosystems and certainty of supply for water users, but also to ensure there is adequate provision for the natural processes that underpin river health. WRPs in the SEQ region must be consistent with the SEQ Regional Plan (see above). All WRPs include environmental outcomes (e.g. needs of specific species), river flow objectives and performance indicators for different flow levels, and monitoring and reporting requirements.

The *Water Resource (Logan Basin) Plan 2007* (Logan WRP) sets out the objectives for the Logan River and its tributaries, which feed southern Moreton Bay including the area within the Ramsar site. In particular it plans for ecological outcomes for water in particular areas within or flowing into the Ramsar site (refer Table B-2).

Table B-2 WRP ecological outcomes for areas within the Logan catchment

Estuary	Ecological Outcome
Logan and Albert Rivers estuary	To minimise changes to the delivery of fresh water, sediment, nutrients and organic matter to the estuary and southern Moreton Bay; and To minimise changes to the brackish water habitat in the estuary.
Canungra Creek, Christmas Creek, Running Creek, Palen Creek and Upper Logan River subcatchment areas, Albert River and parts of its tributaries, Burnett Creek and part of its tributaries and Teviot Brook and part of its tributaries	To minimise changes to the low flow regime of the watercourses; and To minimise changes to the medium and high flow regime important to river forming processes.
Carbrook wetlands	To minimise changes to the flooding regime.

Likewise, the *Water Resource (Moreton) Plan 2007* (Moreton WRP) sets out the objectives for the wider Moreton Bay catchment to the north of the Logan River catchment. This includes the wider Brisbane area, and the catchment of Pumicestone Passage. In particular it plans for ecological outcomes for estuaries within or flowing into the Ramsar site (refer Table B-3).

Table B-3 WRP ecological outcomes for areas within the Moreton catchment

Estuary	Ecological Outcome
Stanley River and tributaries, upstream of the impounded area of Woodford Weir	To minimise changes to flows that support river-forming processes; and To minimise changes to the low flow regime.
Boondall Wetlands	To provide freshwater flows necessary to maintain the long-term pattern of inflows to, and ecological functions of, the wetlands.
Estuarine reaches	To minimise changes to brackish water habitats.
Moreton Bay and Pumicestone Channel	To minimise changes to the natural movement and delivery of sediment, and the delivery of fresh water, natural nutrients and organic matter.

The *Water Resource (Gold Coast) Plan 2006* (Gold Coast WRP) sets out the objectives for the Coomera River and its tributaries, which feed southern Moreton Bay and the Broadwater including the area within the Ramsar site. In particular it plans for ecological outcomes for water in particular areas within or flowing into the Ramsar site (refer Table B-4).

Table B-4 WRP ecological outcomes for areas within Gold Coast river catchments

Estuary	Ecological Outcome
Coomera River Estuary	To minimise changes, as far as practicable, to freshwater flows into the Coomera River estuary and to minimise changes to the freshwater inflows to Coombabah Lake.
For Coomera River within the area known as Canungra Land Warfare Centre, including, in particular, Back Creek, and	To minimise changes to the flow regimes of the waters.

other waters of high ecological value, including, in particular, Tallebudgerra Creek and Currumbin Creek	
Moreton Bay and the Broadwater	To minimise changes, as far as practicable, to the volume and seasonality of freshwater flows into these waterways.

Local Government Planning Schemes

The Moreton Bay Ramsar site includes land and waters within the local government areas of the Gold Coast City Council, Redland City Council, Brisbane City Council, Moreton Bay Regional Council and Sunshine Coast Regional Council.

Each of these Local Governments administers a planning scheme prepared under the *Integrated Planning Act 1997* (IPA) that regulates new development in the local government area such as the change on intensification of a use of land, subdivision of land and related operational and building works.

In addition to the range of strategies and measures administered under planning schemes through IPA, local governments also administer local laws prepared under the *Local Government Act 1993* for the regulation of activities such as vegetation clearing, access restrictions, and control of domestic animals that are not administered through the development provisions of the IPA.

Local Governments play an important role in defining the pattern of urban settlement in Southeast Queensland and in the regulation of construction and operation of development that is relevant to the values of the Ramsar site.

Non-statutory plans

SEQ Healthy Waterways Strategy – Moreton Bay Action Plan

The SEQ Healthy Waterways Strategy 2007 – 2012 (SEQ HWP 2007) has been developed and is implemented by the SEQ Healthy Waterways Partnership. The Partnership is a voluntary alliance of local governments, State government agencies and community and industry representatives.

The Strategy and, in particular, the Moreton Bay Action Plan within it, covers the whole of Moreton Bay including Pumicestone Passage, the southern Broadwater, and to the mouths of all rivers, and aims to sustain and enhance the ecosystem health of the Bay. The purpose of the Plan is similar to that of the Ramsar Convention, addressing particular activities within Moreton Bay to ensure that the Bay's ecosystem health is protected and where necessary stabilised and restored, while allowing for sustainable resource use.

The Plan recognises there is an existing policy and regulatory framework in place for protecting critical habitats and species, and management of human activities to ensure their sustainability, particularly at Commonwealth and State level (i.e. *EPBC Act* and *Marine Parks Act*), and specifically in recognition of Ramsar-listed sites as areas of national environmental significance under the *EPBC Act*.

The Plan focuses on four themes:

- appropriate levels of protection of critical habitats and species;

- management of commercial and recreational activities within the Bay to minimise their impact on the Bay's ecosystems;
- improved understanding of Moreton Bay's ecosystems and the condition and trends in any changes to that ecosystem; and
- high community awareness of the values of the Bay and commitment to their long-term protection.

A series of Management Outcomes for each of the themes, Management Action Targets and a subsequent series of actions have been determined.

The Future in Balance - SEQ Catchments

Formed through the regional arrangements for natural resource management between the Australian and Queensland Governments under the National Heritage Trust, the SEQ Catchments Natural Resource Management (NRM) body administers the regional NRM plan entitled, the *Integrated Natural Resource Management Plan for South East Queensland* (also know as *The Future In Balance*) (NRM SEQ 2004). While a strategic document to guide planning and investment in NRM activities in the region, the Plan aims to incorporate and build on existing plans, influence those that are emerging, conform to Australian and Queensland guidelines, and coordinate implementation of required actions.

The Plan framework sets out targets, actions and organisations, and identifies the major natural assets of the region and threats impacting on them. The SEQC Regional Investment Strategy identifies six natural resource assets to be managed or protected, with the most relevant assets for meeting the principles in the Ramsar Convention being coastal and marine, water and biodiversity. Aspirational (30-50 years), Resource Condition (10-15 years) and Management Action (1-5 years) targets are outlined for each of the assets.

Shorebird Management Strategy – Moreton Bay

In response to the need to protect migratory shorebird species found in Moreton Bay listed under the Japan Australia Migratory Bird Agreement (JAMBA) or the China Australia Migratory Bird Agreement (CAMBA), the EPA and QPWS developed the *Shorebird Management Strategy – Moreton Bay* (EPA 2005b). Within Moreton Bay, five main approaches have been adopted for the conservation of shorebirds:

- Protecting shorebird habitat;
- Protecting shorebirds from disturbance;
- Protecting critical shorebird sites;
- Community education; and
- Research and monitoring.

In particular the actions within the Strategy for the above approaches are relevant to maintenance of the ecological character of the Ramsar site (eg. maintenance and enhancement of shorebird habitats).

APPENDIX C: INDIGENOUS CULTURAL HERITAGE REPORT

The full report prepared by *Converge Heritage + Community Pty Ltd* is included here. A summary of the key aspects of the report as it relates to identification of critical services related to indigenous cultural heritage is contained in Section 7.

1. Introduction

BMT WBM commissioned Converge Heritage + Community to conduct a desktop assessment of indigenous cultural values associated with the Moreton Bay Ramsar areas. This assessment forms part of an audit of existing environmental values being undertaken by BMT WBM.

Resolution IX.21 of the Ramsar Convention, entitled "Taking into account the cultural values of wetlands" was adopted at Ramsar's ninth conference. Through this resolution, Ramsar signatory governments have agreed "… that in the application of the existing criteria for identifying Wetlands of international importance, a wetland may also be considered of international importance when, in addition to relevant ecological values, it holds examples of significant cultural values, whether material or non-material, linked to its origin, conservation and/or ecological functioning" (paragraph 12). Further, the resolution outlines cultural characteristics as follows:

a. Sites which provide a model of wetland wise use, demonstrating the application of traditional knowledge and methods of management and use that maintain the ecological character of the wetland.

b. Sites which have exceptional cultural traditions or records of former civilizations that have influenced the ecological character of the wetlands.

c. Sites where the ecological character of the wetland depends on the interaction with local communities or indigenous peoples.

d. Sites where relevant non-material values such as sacred sites are present and their existence is strongly linked with the maintenance of the ecological character of the wetland (paragraph 15).

This important change to global policy statements of the Ramsar Convention provides a strong mandate for taking into consideration the indigenous cultural values of the Moreton Bay Ramsar areas in the current audit being conducted by BMT WBM.

The scope of this assessment is limited to being desktop, and will be based only on documentation that is already in the public arena. Specifically, consultation with indigenous groups is not part of the scope. This assessment provides:

- Contextual information;
- A discussion of the relationship between indigenous groups and land;
- A summary of available information about cultural connections with Ramsar areas;
- Case studies that demonstrate that significant cultural values may be associated with Moreton Bay Ramsar areas;

- Available information on how cultural values are being sustained; and
- An assessment of the limits of acceptable change if cultural values in Ramsar areas are to be protected and managed.

2. Legislation and Professional Standards

Legislation specific to cultural heritage that is relevant to this assessment is as follows:

Aboriginal Cultural Heritage Act 2003 (ACH Act)

The paramount legislation in Queensland, with regard to Aboriginal cultural heritage, is the Aboriginal Cultural Heritage Act 2003, which states that a person who carries out an activity must take all reasonable and practicable measures to ensure the activity does not harm Aboriginal cultural heritage (the "cultural heritage duty of care") (Section 23[1]). The Act defines cultural heritage as a significant Aboriginal area, object, or evidence, of archaeological or historic significance, of Aboriginal occupation (Section 8). A "significant Aboriginal area" is an area of particular significance to Aboriginal people because of either or both of the following: Aboriginal tradition; the history, including the contemporary history, of any Aboriginal party for the area (Section 9).

The ACH Act states that it is an offence for a person to harm, remove or possess cultural heritage if the person "knows or ought reasonably to know that the object is Aboriginal cultural heritage" (Section 26).

Sections 34-37 of the Act provide directions on how an Aboriginal party for an area is determined. If the area is within the external boundaries of a registered native title claim, then the native title party for that area (also known as the applicant) will be the Aboriginal party. If there is currently no registered claim, but a registered claim once existed, then until a new registered claim is in place, the Aboriginal party for that area will be the native title party of the previous registered claim. Finally, if there is no registered claim and never has been one, then the Aboriginal party is a person "with particular knowledge about traditions, observances, customs or beliefs associated with the area, and has responsibility for the area under Aboriginal tradition.

The application of the ACH Act when defining Aboriginal parties is important to the Ramsar areas of Moreton Bay, some of which are within the external boundaries of registered claims, while others either have never been claimed, or once were within a registered claim that no longer exists.

The Act has established a database and register. While these sources of information are far from complete, they contain information about places, usually archaeological sites, which have been recorded during previous surveys.

In addition to the requirements of legislation, professional standards are established by Resolution IX.21 of the Ramsar Convention (discussed above), and the Burra Charter. The Burra Charter (Marquis-Kyle and Walker 1999) continues to guide cultural heritage management in Australia. First adopted in 1979 by Australia ICOMOS (International Council on Monuments and Sites), the charter was initially designed for the conservation of and management of historical heritage. However, after the addition of further guidelines that defined cultural significance and conservation policy, use of the charter was extended to indigenous studies.

The charter defines conservation as ‘the processes of looking after a place so as to retain its cultural significance’ (Article 1.4). A place is considered significant if it possesses aesthetic, historic, scientific or social value for past, present or future generations (Article 1.2). The definition given for each of these values is as follows (Articles 2.2 to 2.5).

Aesthetic value includes aspects of sensory perception for which criteria can and should be stated. Such criteria may include consideration of the form, scale, colour, texture and material of the fabric; the smells and sounds associated with the place and its use.

Historic value encompasses the history of aesthetics, science and society, and therefore to a large extent underlies all of the terms set out in this section.

A place may have historic value because it has influenced, or has been influenced by, an historic figure, event, phase or activity. It may also have historic value as the site of an important event. For any given place the significance will be greater where evidence of the association or event survives in situ, or where the settings are substantially intact, than where it has been changed or evidence does not survive. However, some events or associations may be so important that the place retains significance regardless of subsequent treatment.

Scientific research value of a place will depend upon the importance of the data involved, on its rarity, quality or representativeness, and on the degree to which the place may contribute further substantial information.

Social value embraces the qualities for which a place has become a focus of spiritual, political, national or other cultural sentiment to a majority or minority group.

Article 2.6 of the Guidelines notes that other categories of cultural significance may become apparent during the course of assessment of particular sites, places or precincts. A range of cultural significance values may apply. Article 5 of the Burra Charter states that “conservation of a place should identify and take into consideration all aspects of its cultural significance without unwarranted emphasis on any one aspect at the expense of others” (Marquis-Kyle and Walker 1999).

3. Context

3.1 Environmental Context

Moreton Bay covers roughly 1 400 square kilometres between Peel and Bribie Islands and is about 50 km long and 25 km wide. Moreton and Stradbroke Islands protect the bay and the mainland shore from ocean waves, with the wave climate dominated by wind-waves rather than swell. Wind-wave direction is mainly from the southeast, northeast and southwest (Stephens 1992). In the north-east, however, swell-waves develop via the channels of the North Entrance tidal delta. The Brisbane River is the only major river that feeds into the bay. Smaller streams, including the Albert and Logan Rivers to the south and the Pine and Caboolture Rivers in the northwest, also feed into the bay.

To the west of the bay, between Redland Bay and Lytton Hill, the shoreline is rocky and dominated by Tertiary basalt. The coastline in the region is fringed by intertidal sand flats and coral reefs (Stephens 1992). The Brisbane River delta extends from Hamilton to Lytton Hill and is comprised of coastal sediments. The Redcliffe Peninsula, in contrast, consists of a series of laterised Tertiary sandstone and basalt headlands. Deception Bay is a coastal plain with estuarine mudflats and beachridges, with the sand supplied by the North Entrance marine tidal delta. Bribie Island is a barrier island comprised of Pleistocene and Holocene beachridges, whereas Moreton and North Stradbroke Islands are dune islands containing prominent bedrock headlands. These islands also consist of dunes of both Pleistocene and Holocene age.

The sedimentary environments of Moreton Bay have been formed by fluvial, tide and wave influences since the last glacial maximum (Lang *et al.*. 1998). Seismic stratigraphic surveys around the Bay have identified various sediments that have been deposited as sea levels have changed over time. The analyses of these sediments have allowed scientists to reconstruct the bay environment from the late Pleistocene through to the present day.

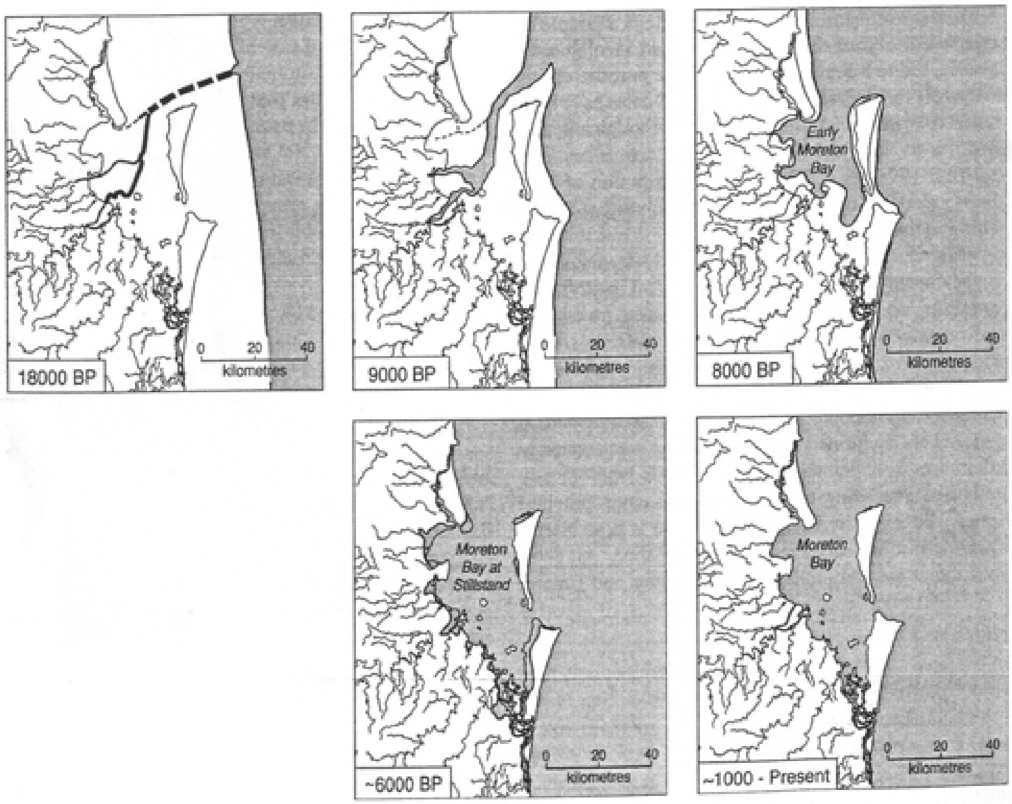


Figure 1: Development of Moreton Bay during the Holocene Period (Hall, 1999: 171).

Seismic testing has revealed that during the last Ice Age (18000 – 10000 BP) the coastline of southeast Queensland was roughly 35 kilometres or more eastwards of its present-day location (see Figure 1). People living on the southern Moreton Islands were effectively living inland on a wide coastal plain and Moreton Island was part of the mainland. Moreton and Stradbroke islands, at this time, were essentially large subcoastal sand dunes overlooking a broad coastal plain to the east and subcoastal river valley to the west (Hall 1999).

Two substantial river systems were present during this time: to the south of Russell Island the palaeo-Logan River system; and to the north a large tributary of the Brisbane River (Willmott and Stevens 1992). The landscape may have been comparable to that which can still be seen inland of the Caloundra Currimundi coastline of northern southeast Queensland. Along major rivers and creeks, open Eucalypt forest would have predominated, with sections of riparian forest present along waterways. On the flat plains, heathlands, swamps and woodland areas would have predominated.

The present day Moreton Bay gradually formed as sea levels rose after the Last Glacial Maximum (-150m at 18 000 BP). Old river systems were gradually flooded with sea water. The marine environment was probably brackish, rather that salt, because of the low tidal influence and entry of fresh water into the system. Vegetation systems along, what once had been riverine environments, gradually died back due to the gradual incursion of salty water.

From 10 000 to 6 500 years BP, as the bay continued to fill, Moreton, Stradbroke, Macleay and Karragarra became islands, and Russell became an extended peninsula into what was becoming a huge bay - not unlike Deception Bay today. The riverine environment was replaced by vegetation and fauna suited to marine conditions. Sea water purity was high, sustaining substantial coral growth around Victoria Point, Peel Island and near the northern parts of North Stradbroke. Sea levels stabilised around 6000 years ago and Moreton Bay, at this time, was more extensive than it is today.

The Moreton Bay regional environment supports an abundance of plant and animal food species. Coastal lowlands or 'wallum' vegetation comprises over one-third of the Moreton Region's area. This bioprovince is defined as being an "undulating lowland belt below the 30m contour which has an assured rainfall, similar soil morphology, Lack of soil fertility and similarly structured floristic communities" (Hall 1980: 80) and encompasses beaches, low dunes, estuaries, fringing forests, dune forests and various types of Wallum forest. Coastal lowland vegetation is commonly in a state of flux as external conditions, such as climatic variation and mobile landscapes, constantly change. Such a dynamic environment creates a diversity of habitats for flora and fauna.

The coastal lowland environment sustains more than 50% of the 60-odd species of terrestrial land mammals listed for the Moreton Region (Hall 1980: 80). Wallum vegetation, in particular, supports a large and diverse range of bird species, including thousands of sea birds and wading birds, reptiles and mammals. Significantly, marine resources are plentiful in Moreton Bay. A wide range of fish species, including mullet, bream, tailor, whiting, flathead and jewfish are present, as well as other marine animals such as dugong, turtles and porpoise.

In summary, Moreton Bay has been an area of considerable change through the past 10,000 years, from part of the mainland to its present marine environment. Throughout this time, changes to the landscape wrought by fluctuating sea levels, inundation, and climate change would have been associated with accompanying changes to vegetation and animal populations.

3.2 Human Context

Humans are thought to have occupied coastal Southeast Queensland since at least the late Pleistocene (up to 20 000 years Before Present [BP]). This estimate is based on archaeological evidence from the Talgai (Morwood 1987) and Wallen Wallen Creek sites (Neal and Stock 1986). Within Moreton Bay itself, however, evidence suggests a more recent occupation of Moreton Bay, with a number of sites dated from between 2000 and 200 years BP (late Holocene) (Hall 1999). A large-scale midden complex, found on the southwest coast of Moreton Island, has been dated to around 2200 years BP and sites in Deception Bay and Sandstone Point to around 3000 years BP (Hall 1989). A comparative dense number of middens were noted along the shores of Pumicestone Passage both on Bribie Island and on the mainland, but no archaeological dating has been done

(Stockton 1974). Interestingly, to date, very few sites have been discovered in the region that date to between 2000 and 6000 years – a period when sea levels in the bay had stabilised and the environment is thought to have been very similar to that of today (Hall 1999) (Figure 2). One exception is the Brisbane Airport Site, with material dating from 1170 to 5837 years BP.

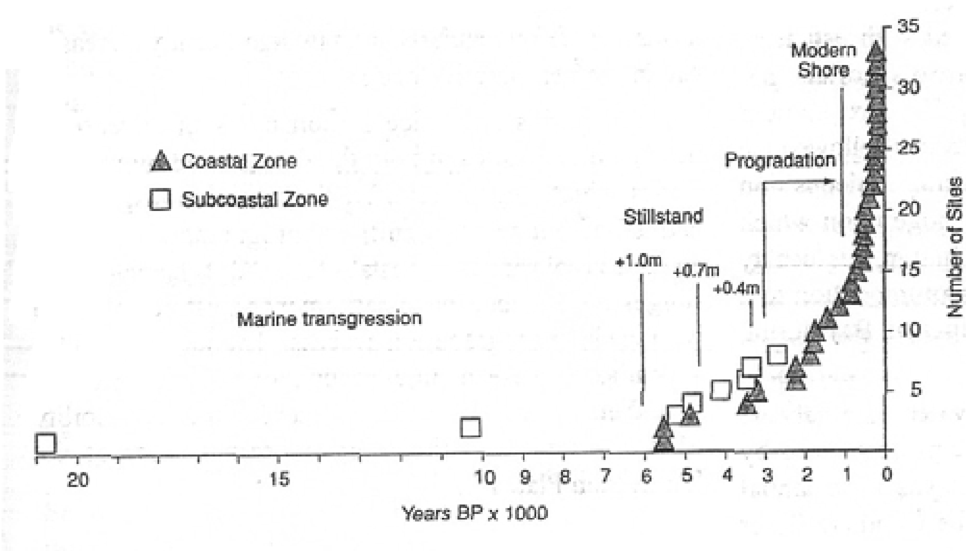


Figure 2: Moreton region sites through time by environmental zone. (Hall 1999: 173)

Evidence from these excavations and other archaeological sites discovered in Moreton Bay indicates that fishing, the collection of shellfish and the gathering of local food plants were important activities for Aboriginal peoples living in the region. As Ulm notes:

> *Over the past 40 years, archaeological investigations in southeast Queensland have focused almost exclusively on the coastal strip…. Although little of the region has been systematically surveyed, over 1,500 coastal midden sites have been documented, 62 of which have been excavated. Of these 62 sites, 27 are said to contain fish remains, although … only 21 have been radiometrically dated (Ulm 2002: 79).*

During the many millennia of occupation, it should be understood that Aboriginal lifeways would have impacted on the natural environment of Moreton Bay, e.g., for example, techniques such as fire stick land management, to keep vegetation clear and managed may have played a role in determining the mosaic of vegetation and thus by implication the spread of fauna populations. Whatever this impact, early ethnographic observations after non-indigenous occupation commenced in the 1820s present a picture of an abundance of fauna populations in a mosaic of landscapes. Examples are provided.

Fish abounded in Moreton Bay. In particular, numerous observations highlight the presence of schools of sea mullet during the late 1800s.

> *I have seen schools so vast that the bay was a solid mass of them….it is impossible for anyone to form an estimate as to the quantity, but I should say that a hundred boats might have been filled out of a wing of this seething mass (Welsby in Thomson 1967: 86).*

A suite of methods were used by Aboriginal groups to fish in Moreton Bay. Stake and brush traps were used on tidal flats. At Woody Point near Redcliffe, Flinders noted that "upon the shoal near the house, there was more than one enclosure of a semi-circular form, and the sticks and branches of which it was made were set and interwoven so close that a fish could not pass between" (Steele 1072: 19).

Nets were commonly referred to in the early records of Moreton Bay. Flinders commented on netting, and his assistant Uniacke wrote that the "nets used for fishing are made by the men from the bark of the kurrajong (hibiscus heterophyllus), a shrub which is very common in the swamps" (Steele 1972: 95). Other bark including that of the native cotton tree (*Hibiscus tiliaceous*) which went by the local name of "Talwalpin" (Watkins 1981: 44) and wattle bark, were twisted together and gum was then used to glue the resulting string to a framework made of sticks. These small "heart shaped" nets about 1.2 metres across were usually used in pairs, and were probably the most well known and consistently described nets known as "tow rows" (Colliver and Woolston 1975: 96; Petrie 1904: 73). Gaiarbau, a traditional person from the Jinibara group described his experiences of using these nets to catch mullet in Deception Bay:

> *One man kept watch in the top of a tree, probably a quarter of a mile away. He remained hidden from view behind a shield of vines and leaves cut from the adjacent scrub, for if had not been screened the mullet would have seen him and not come into shallow water. The rest of the men were placed at a distance beyond him, sitting down and waiting for his signal. As soon as he saw fish he put one hand up. Gradually he would lower it, and when he brought it right down to his side the fishermen would know that the mullet had come past his tree. Then he would raise the other hand, and slowly lower it as they got beyond this sight. The signaling was taken up by another man who was in the water fairly close to the waiting fishermen. If this man stood up, then the others knew that the school was in the deep water, and they remained sitting and let that school pass, and waited patiently until a school came along that was in the water shallow enough for their purpose. If the tree watcher sat down they would know that a school of mullet was coming into shallow water. But if he saw that the fish were in deep water he would not lower his arm below half way, so that the next man could see how the fish were traveling. The latter kept a wet sand-ball, as big as a cricket ball, in his hand. When the conditions were right, he would throw the sand-ball underhand about 10 yards out into the sea. The purpose of this was to cause the mullet to stop. He would then throw a second ball about five yards out to induce them to come in and see what caused the splash, and then he would throw a third sand-ball into water knee deep. All this time he was squatting down in the water so as not to be prominent. In the meantime the fishermen who had been alerted would all sneak up to within about 20 yards of him and quietly enter the water in a half circle, closing in to complete a full circle as soon as the fish got into water that was shallow enough. They then proceeded to catch them. Each man carried two nets, one in each hand (Gaiarbau in Winterbotham n.d.: 51-52).*

Walters makes an important observation that the various forms of fishing observed in Moreton Bay were mostly associated with mudflats, mangrove fringes, inshore sandbars and sandflats, and surf beaches (Walters 1985: 55).

Fish traps and spears were also used in Moreton Bay, with a stone walled fish trap found at Toorbul Point (Walters 1986). The following ethnographic account describes a possible method used to herd fish into the traps.

> *During the Mullet and Tailor seasons, if a shoal was close in, Mrs Birt would row out, trailing a bunch of Bribie pine, torulosa she oak and vanilla lily, this she maintained was necessary to attract the porpoises, very doubtful, but occasionally they would follow the dinghy and frighten a portion of the shoal into the trap. This exercise had to be performed on a falling tide; when it fully receded there would still be a couple of feet in the trap, with the top of the rock enclosure just awash. The fish were then easily caught with either scoop or cast nets… ("Old Salt" in Walters 1986: 44-45).*

Dolphins are also thought to have been employed to herd fish towards nets, particularly when the shore was too steep or Lacked rocks for the construction of fish traps (Hall 1999).

Large dugong herds were also common in the bay. In 1891 Campbell reported a herd spread over 5km long and 300m wide. "It was altogether the largest herd of these animals I ever saw, and I am afraid to make any computation as to the number of it" (Thomsom 1967: 105). A fixed herd of 'three or four hundred' year-round was noted by Welsby. This number greatly expanded during the winter months, when herds from the north migrated down to the bay (Welsby in Thomson 1967: 105). Seagrass beds, nourished by decaying plant matter brought down the rivers during late summer, were abundant during winter and attracted large herds. Groups of Aboriginal men netted the dugong on the shallow flats adjacent to bay islands, or set up nets overnight in channels near seagrass beds (Draper 1978). Although fish were easier to catch, the dugong provided a much larger quantity of meat.

> *Should any of the tribes on the sea coast have been so fortunate as to catch a sea-hog – called youngun – which sometimes is of the size of a young bullock, intelligence of the event is immediately sent along the coast to invite the neighbouring tribes to the banquet; this lasts, between incessant eating and sleeping when quite gorged, two or three days, until the whole animal is consumed…. (Eipper 1841 in Steele 1972: 284).*

In 1853 Stobart described the capture of a dugong, and the ceremony associated with this event.

> *They had just caught a junger (a French Dugong), a species of sea calf which abounds here and which they reckon a great delicacy and affords a great feast for them…. There is a sort of ceremony takes place … when it is brought on shore…. The women and the younger boys and children are not allowed to be present nor the women even to see the animal at all, though they have portions … sent to them. They pitched the head unskinned on the fire, those who assisted at the killing of it have the first slices and the rest seemed more as guests (Stobart in Love 1985:59-60).*

A model of Aboriginal subsistence and settlement by Draper (1978) highlights the seasonal nature of Aboriginal traditional activities in Moreton Bay before the vast impact of non-indigenous settlement.

The model was developed using biogeographical and documentary data and is supported by more recent archaeological research. Winter in Moreton Bay was a time of abundant marine and littoral resources, when dugong, shellfish and fish were plentiful (Draper 1978). Historical and ethnographic evidence suggests that, during this season, Aboriginal peoples concentrated on fishing and collecting shellfish. For people living on large bay islands, such as Moreton, the fishing season started in April when fish began to migrate into the bay. Groups of men mounted co-operative ventures using hand nets and large quantities of mullet, bream and tailor were caught. Staple foods during this season included fish and fern roots, with the diet supplemented with shellfish and other food species. Large numbers of dugong also migrated into Moreton Bay during winter and were an important food resource for Aboriginal groups. Plant foods were harvested from nearby wallum vegetation beyond the coastal dunes. “Midyim” berries, in particular, were plentiful growing in sandhill areas.

Huts were set up along the coast to cater for the concentration and movements of fish (Draper 1978). The following account discusses the presence of these huts in Moreton Bay and the general subsistence and settlement patterns followed by Aboriginal groups.

> *We were informed that these people had several such villages on the island; and that they resorted to one or to another, according to the weather, the season of the year, and the contiguity of food. At present they are near the opening between Moreton and Stradbroke Islands, depending chiefly on the shoals of mullet for food. A few weeks ago, they went further into the interior, collecting honey. At some seasons they resort to places producing wild fruits; and in wet weather, to elevated situations, contiguous to those parts of the coast, abounding with oysters. In these last situations, their huts are said to be large enough for a man to stand up in (Backhouse in Steele 1975: 228).*

Such an abundant supply of food during the winter months provided an opportunity for groups to meet and perform ceremonies. Such large-scale gatherings were an important aspect of Aboriginal culture in southeast Queensland (Sullivan 1977). The winter mullet runs in particular enabled groups to meet and participate in social and ceremonial activities. Bora grounds were often the meeting place used by groups for such gatherings. As with the bunya nut festivals, bora ceremonies lasted for several weeks and involved the gathering of a number of Aboriginal groups, many of who travelled great distances to meet with their neighbours (Petrie, 1904).

In contrast to the abundant food supply, and subsequent large-scale ceremonial gatherings, that took place during the winter months, early summer was both a less productive and less social time of year because of the threat of fire and the hot dry conditions (Draper 1978). During these months, food and freshwater was more abundant along the coast, rather than in inland areas. Fern roots were a staple food during this period and were found in fresh water swamp areas. Bevelled-edged pounders are commonly found in archaeological sites in Moreton Bay, providing evidence for the processing of such roots. Following the summer storms (October to December) more resources became available and several bird species came into season. Swans were caught easily and duck species were plentiful. Stobart recounted, as he sailed in Pumicestone Passage, that “we came upon a flock of some hundred Black swans…. The ducks here too were in great abundance” (Stobart in Love 1985: 63-64). Flying foxes also gathered in large numbers. St. Helena Island was known to be a roosting place. Stobart reported see “an immense flight of them in the air above the trees” (Stobart in Love 1985: 63).

New growth stimulated by the rains attracted larger macropods. Late summer was therefore a time for hunting. Animals were hunted using spears or herded into nets. Snakes, lizards, tortoises, goannas and grubs were also sought after (Hall 1980).

In summary, environmental, ethnographic and archaeological evidence indicates that Moreton Bay, its surrounding islands and mainland formed an extensive, resource-rich and significant landscape in which Aboriginal groups have lived for the past 6,000 years. Before this time, Aboriginal populations would have coped with changes in sea levels and climate, resulting in changes and fluctuations in landscape, flora and faunal populations. The ethnographic sources also provide a basis for comparison with current flora and fauna populations and may be of value in demonstrating changes to the environment of Moreton Bay after non-indigenous settlement.

3.3 A Cultural Landscape

While environmental, ethnographic and archaeological evidence may indicate the richness of the Moreton Bay environment during the past 6,000 or so years that would have been an important and sustaining resource for Aboriginal groups, these observations only give partial insights into the relationship between those Aboriginal groups and the land in which they lived and indeed continue to live. Often, the ethnographic reports provide a commentary on what the observer has found interesting, thus emphasizing a perspective that tends to focus on resources, rather than placingon the public record an understanding of the complex cultural and social network that existed, and continues to exist amongst Aboriginal people of Southeast Queensland.

Approximately one third of Queensland's Aboriginal and Torres Strait Islander population lives in Southeast Queensland (South East Queensland Regional Plan 2005). Many of these people have moved to the region. As contemporary residents, these people are often referred to as "historically associated", and may be regarded as stakeholders in the region similar to the non-indigenous population. In contrast, those Aboriginal people who are descendants of ancestors who lived in Southeast Queensland before non-indigenous settlement identify as Traditional Owners. Each of these groups is an important stakeholder in the community of Southeast Queensland, but Traditional Owners have additional and different aspirations to non-indigenous and historically associated indigenous stakeholders. Through their lineage, Traditional Owners inherit responsibilities under traditional law and custom to manage their land (often referred to as country), as well as a connection to country that is a cultural and spiritual relationship. This is best summed up in the words of Southeast Queensland's Traditional Owners:

> *As the current Aboriginal Traditional Owners in South East Queensland we have inherited a responsibility to look after our country. This responsibility has been handed to us by our ancestors, whose spirits continue to guide our decisions. We in turn have a responsibility to manage our country to the best of our abilities and to teach our youth the values and skills and provide them with the knowledge that they will need to manage our country with and after us….*
>
> *Cultural resources are all the tangible and intangible things in our land and sea country that are essential to our wellbeing: land, water, plants and animals (biodiversity), coastal and marine things, the air (atmosphere), and community. As Aboriginal people, we have such a deep and integral connection and set of relationships with these 'natural' elements that we consider them as cultural entities., Our identity as well as our cultural, spiritual and material*

> *wellbeing is entwined with the country and its health; without strong and healthy country, our people cannot be strong and healthy (SEQTOLSMA 2008: 8)*

In the absence of consultation as part of this brief, two important points should be made. Firstly, the statements of SEQTOLSMA would suggest that those Traditional Owners relevant to the Ramsar areas of Moreton Bay will have strong views on what will be considered their country or cultural resource, and will wish to take part in management decisions. Secondly, a further consideration is that the Traditional Owners relevant to Ramsar areas may have valuable historical knowledge of what these areas were like in the past, and what management strategies would be preferred. These points are best demonstrated through some case studies that are provided below.

Case Study 1 – Blue Lake, North Stradbroke Island

In 2007, consideration was given by the Queensland Government to the potential to harvest fresh water from aquifers on North Stradbroke Island for the water grid being developed across Southeast Queensland. Consultation was commenced with the Minjerribah Moorgumpin Elders in Council, the Aboriginal Cultural Heritage Body for North Stradbroke Island. During initial consultation, the Elders expressed deep concern about the project, as it potentially could impact directly on water levels in Blue Lake, a natural freshwater lake on the island. The Elders were particularly worried about such impacts because of the high levels of cultural significance associated with the lake. What constitutes the lake's cultural significance cannot be reported here, without consultation with and the permission of the Elders. Suffice to say that the Elders were extremely relieved when the project was abandoned because of general public concern.

This case study illuminates Traditional Owners' responsibilities and connection with country. Other people in the North Stradbroke community were concerned about the environmental impact of water harvesting on Blue Lake, a known and much appreciated natural part of the island. But the Traditional Owners' concerns were amplified by their cultural connection to the lake which is a significant Aboriginal area in the meaning of the ACH Act.

Case Study 2 – Traditional Hunting Guidelines

An excellent example of on-going traditional responsibilities and customs working today is provided by the Quandamooka people.

> *The Quandamooka people of the Moreton Bay area are continuing their ages old traditional hunting, which provides an important part of their diet. Working with the Queensland Environmental Protection Agency (EPA), the Quandamooka people have developed Traditional Hunting Guidelines to ensure that hunting practices are sustainable. With the new zoning plan in Moreton Bay Marine Park the Quandamooka people are looking to progress the Traditional Hunting Guidelines into a Traditional Use of Marine Resources Agreement (TUMRA) which will be the new best practice. Quandamooka people have demonstrated their commitment to making the Agreement work through six years of sound management since the establishment of the traditional Hunting Guidelines (SEQTOLSMA 2008: 13).*

Case Study 3 – Native Title's Rights and Interests

Whether or not native title is relevant from the perspective of land tenure in the Ramsar areas of Southeast Queensland is not a discussion for this assessment. Rather, the point being made is that the rights and interests detailed in the various native title claims in the Moreton Bay area give an indication of Traditional Owners' perspectives about their traditional responsibilities and rights. While the native title process may result in these claimed rights and interests only being relevant where native title has not been extinguished, from the Traditional Owners' perspectives, it is likely that they would prefer these rights and interests to be relevant in all of their country.

Consistent in the native title rights and interests claimed in all of the claim applications that cover parts of the Ramsar areas are the following themes:

- Access to enter and remain on lands and waters;
- Use and enjoy land and waters, including traditional hunting and gathering;
- Protection and management of the resources of lands and waters;
- Capacity to exercise customary rights and discharge traditional responsibilities;
- Recognition as Traditional Owners

The themes enunciated by the claimed rights and interests show that there is no differentiation between land and water – both are country – and all country requires protection and management.

Case Study 4 – SEQTOLSMA

The Moreton Bay region is home for a number of Traditional Owner groups. These are as follows:

Moreton Bay Region and Ramsar Areas	
North of the Pine River, Deception Bay, Pumicestone Passage and Bribie Island and the Sunshine Coast	Kabi Kabi (sometimes called Gubbi Gubbi) families
Between the Pine and Logan Rivers and over Brisbane, with the exception of the coastal strip around Cleveland and Mt Cotton	Jagera and Turrbal families
Moreton and North Stradbroke Islands, many of the island of southern Moreton Bay, the coastal strip around Cleveland and Mt Cotton, and the sea between	Quandamooka (Ngugi, Noonucle, Gorenpul) families
Southern end of Moreton Bay, including islands and coastal strip	Yugambeh (eight groups) and Ngarang-Wal/Kombumeri families.

Table 1: Traditional Groups of Moreton Bay

Other Traditional Owner groups include the Jinibara and Mulinjarlie families, but these groups are sub-coastal and may not necessarily have Ramsar areas in their traditional countries.

In 2005, representatives of all but two of these groups commenced negotiations about forming a body "to establish more comprehensive and meaningful Traditional Owner involvement and ownership in improving the condition of the region's natural resources", and "to promote more comprehensive and effective engagement of Traditional Owners in cultural (natural) resource management" (SEQTOLSMA 2008, p. iv). The outcome is the development of an on-going body of Traditional Owner representatives who have now developed a plan, called OUR PLAN, for the future (SEQTOLSMA 2008). Actions relevant to Ramsar areas that have been nominated by OUR PLAN include: the development of a Memorandum of Agreement with SEQ Catchments; developing alliances and partnerships at all levels of government and with the wider community; and becoming fully engaged in planning, decision-making and delivery of on-ground works (SEQTOLSMA 2008: 26).

The foundation of SEQTOLSMA is an important initiative that has the capacity to provide a central body with which consultation and management planning can be developed. SEQTOLSMA does not reduce the responsibilities of Traditional Owners, and recognizes that within the organization, certain Traditional Owners speak for parts (their country) of Southeast Queensland. In regard to the Ramsar areas of Moreton Bay, no one Traditional Owner will speak for them all; rather specific areas will be associated with certain groups, as shown in Table 1. In large part, this arrangement also reflects the requirements of the ACH Act in regard to cultural heritage decision-making by Aboriginal Parties.

Taking these arrangements into account, SEQTOLSMA offers an opportunity for the development of overarching management planning for Ramsar areas, with the additional capacity for relevant Traditional Owners to have input into those areas that are within their countries.

4. Summary

Aboriginal people have lived in Southeast Queensland and the Moreton region for many millennia. While traditional customs such as hunting and fire stick management would have impacted to some extent on the environment of the area, groups and families were supported by a rich variety of resources. The traditional perspective of and relationship with the region is much more than acknowledgement of rich resources, and is a spiritual and social linkage that is important to the wellbeing of Traditional Owners. Ethnographic sources emphasize the richness of available resource, but do not usually give insight into the cultural connection between Traditional Owners and the country that contained these resources.

Traditional Owners have a responsibility to manage their country. Although the brief to this assessment precluded consultation with Traditional Owners, the case studies provided above underline that the Traditional Owners of Southeast Queensland are continuing their traditional responsibilities. In the absence of guidance from Traditional Owners on this matter, it is reasonable to predict the following:

- Each of the Ramsar areas will hold significant cultural values to the relevant Traditional Owner group/s. These values may include physical and non-physical cultural heritage areas and objects, oral knowledge, such as stories, animals and plants, and the natural environment itself;

- The values of each of the Ramsar areas may be different to the others, e.g., the environmental, spiritual and cultural nature of Pumicestone Passage may have been different to those of North Stradbroke Island, and thus require differences in traditional management.

- Traditional Owners are already taking an active role in managing Ramsar areas as part of their management of the wider Moreton Bay area, and that they will wish to increase this role if offered the opportunity.
- The Traditional Owners have already formed an encompassing organization (SEQTOLSMA) which may prove to be a vehicle through which consultation and planning for the future could be organized. Only through consultation with the individual Traditional Owner groups could this be ascertained.

5. Sustaining Cultural Values

This assessment has demonstrated that there has been little to no assessment to date that is available in the public record about the cultural values of Ramsar area in Moreton Bay. Although this lack of information gives little insight into how cultural values are being sustained, hints are provided by initiatives detailed in case studies above.

6. Limits of Acceptable Change

Limits of acceptable change can only be measured through consultation with Traditional Owners. Limits of acceptable change will only become apparent, if indeed they do, after a detailed understanding about cultural values and how they are being sustained is achieved.

7. Appendix References

Colliver, F.S. and F.P. Woolston 1975 “The Aborigines of Stradbroke Island”, Proceedings of the Royal Society of Queensland 86: 91-104.

Draper, N. 1978 A Model of Aboriginal Subsistence and Settlement in the Moreton Bay Region of Southeast Queensland. Unpublished Thesis. Department of Anthropoloy, University of Queensland.

Hall, H. J. 1980 ‘Sitting on the crop of the bay: an historical and archaeological sketch of Aboriginal settlement and subsistence in Moreton Bay, southeast Queensland’. (in) S. Bowdler (ed.) Coastal archaeology in eastern Australia. Canberra, Dept. of prehistory, ANU.

1999 The impact of sea level rise on the archaeological record of the Moreton region, southeast Queensland. In: Australian Coastal Archaeology (eds Hal, J and McNiven, I. J). pp 169-184. Canberra, Department of Archaeology and Natural History.

Hall, J. and I. Lilley. 1978 Excavation at the New Brisbane Airport Site (LB:C69): Evidence for early Holocene coastal occupation in Moreton Bay, SE Queensland. Queensland Archaeological Research 4: 54 – 79.

Love, W.R.F. 1985 “Some References to Aboriginal Life in the Moreton Region from Stobart’s Journal (1853)”, Queensland Archaeological Research 2:58-70.

Marquis-Kyle, P. and M. Walker 1999 The Illustrated Burra Charter. Sydney: Australian ICOMOS Inc.

Morwood, M. J. 1987 The archaeology of social complexity in south-east Queensland. Proceedings of the Prehistoric Society. 53: 337 – 350.

Neal, R and E. Stock 1986 Pleistocene occupation in the south-east Queensland coastal region. Nature 323: 618-621.

Petrie, C. C. 1904 Tom Petrie's Reminiscences of Early Queensland. Sydney: Angus and Robertson (1st ed. 1903).

Queensland Government 2005 South East Queensland Regional Plan 2005-2006. Brisbane: Office of Urban Management, Department of Local Government, Planning, Sport and Recreation.

SEQTOLSMA 2008 OUR PLAN, the South East Queensland Aboriginal Traditional Owner Cultural Resource Management Plan. Brisbane: South East Queensland Traditional Owner Land and Sea Management Alliance.

Steele, J. G. 1972 The Explorers of the Moreton Bay district 1770-1830. St. Lucia, University of Queensland Press.

1984 Aboriginal Pathways in Southeast Queensland and the Richmond River. Brisbane: University of Queensland Press.

Stephens, A. W. 1992 Geological evolution and earth resources of Moreton Bay. In: Moreton Bay in the Balance (ed Crimp, O) pp 3 – 23. Australian Littoral Society & Australian marine Science Consortium, Brisbane.

Stockton, J. 1974 "Report on an Archaeological Survey in the Vicinity of Bribie Island, South-east Queensland". Unpublished BA(Hons) Thesis, University of Queensland.

Sullivan, H. 1977 "Aboriginal Gatherings in South east Queensland". B.A. Hons. Thesis. Canberra, Australian National University.

Thomson, A. K (ed) 1967 The Collected Works of Thomas Welsby. Vols 1 & 2. Jacaranda Press, Brisbane.

Ulm, S. 2002 "Reassessing Marine Fishery Intensification in Southeast Queensland", Queensland Archaeological Research 13: 79-96.

Walters, I. N. 1985 "Some Observations on the Material Culture of Aboriginal Fishing in the Moreton Bay Area: Implications for Archaeology", Queensland Archaeological Research 2: 50-57.

1986 "Another Kettle of Fish: The Prehistoric Moreton Bay Fishery". Unpublished PhD thesis, Department of Anthropology and Sociology, University of Queensland, Brisbane.

Watkins, G. 1891 "Notes on the Aboriginals of Stradbroke and Moreton Islands", Proceedings of the Royal Society of Queensland 8:40-50.

Willmott, W. F & N. C. Stevens 1992 Rocks and Landscapes of Brisbane and Ipswich. Geological Society of Australia: Brisbane.

Winterbotham, L.P. n.d. "The Gaiarbau Story", Queensland Ethnohistory Transcripts no. 1. Brisbane: Archaeology Branch, Department of Community Service.

APPENDIX D: LIST OF KEY SPECIES AND COMMUNITIES

Group	Species/Communities	Justification
Seagrass	*Halophila ovalis; H. decipiens; H. spinolsa; Halodule uninervis; Syringodium isoetifolium; Cymodocea serrulata; Zostera capricorni*	Ecosystem services
Mangroves	*Aegiceras corniculatum; Avicennia marina; Bruguiera gymnorhiza; Ceriops australis; Excoecaria agallocha; Lumnitzera racemosa; Rhizophora stylosa*	Ecosystem services
Saltmarsh	Numerous species	Ecosystem services
Freshwater emergent macrophytes	Numerous species	Ecosystem services
Ramsar habitat type	Unforested peatland (Type U); Forested peatlands (Type Xp); Permanent freshwater lakes (Type O).	Uncommon habitat types in bioregion
swamp daisy	*Olearia hygrophila*	Threatened
swamp orchids	*Phaius australis, P. bernaysii* and *P. tancarvilleae*	Threatened
knotweed	*Persicaria elatior*	Threatened
Marine turtles	*Chelonia mydas; Caretta caretta*	Threatened
dugong	*Dugong dugon*	Threatened
Wallum specialist fish species	*Nannoperca oxleyana; Pseudomugil mellis*	Threatened
Frog species	*Adelotus brevis, Crinia tinnula, Litoria cooloolensis, Litoria freycineti, Litoria olongburensis*	Threatened
Mangrove specialist species	*Xeromys myoides; Acrodipsas illidgei*	Threatened
Avifauna	*Botaurus poiciloptilus, Esacus*	Threatened

	neglectus, Rostratula australis, Sterna albifrons	
Vertebrates	Refer to Tables 9-1 to 9-6.	Species present

Table D-1 Shorebirds

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB	MB Status
Scolopacidae	*Actitis hypoleucos*	common sandpiper	C	M	1	1	INBM
Scolopacidae	*Arenaria interpres*	ruddy turnstone	C	M	1	1	INBM
Scolopacidae	*Calidris acuminata*	sharp-tailed sandpiper	C	M	1	1	INBM
Scolopacidae	*Calidris alba*	Sanderling	C	M	1	1	INBM
Scolopacidae	*Calidris canutus*	red knot	C	M	1	1	INBM
Scolopacidae	*Calidris ferruginea*	curlew sandpiper	C	M	1	1	INBM
Scolopacidae	*Calidris melanotos*	pectoral sandpiper	C	M	1	1	INBM
Scolopacidae	*Calidris ruficollis*	red-necked stint	C	M	1	1	INBM
Scolopacidae	*Calidris subminuta*	long-toed stint	C	M	1	1	INBM, V
Scolopacidae	*Calidris tenuirostris*	great knot	C	M	1	1	INBM
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	C	M	1	1	INBM
Scolopacidae	*Heteroscelus brevipes*	grey-tailed tattler	C	M	1	1	INBM
Scolopacidae	*Heteroscelus incanus*	wandering tattler	C	M	1	1	INBM
Scolopacidae	*Limicola falcinellus*	broad-billed sandpiper	C	M	1	1	INBM
Scolopacidae	*Limnodromus semipalmatus*	Asian dowitcher	C	M	1	1	INBM
Scolopacidae	*Limosa lapponica*	bar-tailed godwit	C	M	1	1	INBM
Scolopacidae	*Limosa limosa*	black-tailed godwit	C	M	1	1	INBM
Scolopacidae	*Numenius madagascariensis*	eastern curlew	R	M	1	1	INBM
Scolopacidae	*Numenius minutus*	little curlew	C	M	1	1	INBM
Scolopacidae	*Numenius phaeopus*	whimbrel	C	M	1	1	INBM
Scolopacidae	*Phalaropus lobatus*	red-necked phalarope	C	M	1	1	INBM, V
Scolopacidae	*Philomachus pugnax*	ruff	C	M	1	1	INBM, V
Scolopacidae	*Tringa flavipes*	lesser yellowlegs	C	M	1	1	INBM, V
Scolopacidae	*Tringa glareola*	wood sandpiper	C	M	1	1	INBM
Scolopacidae	*Tringa nebularia*	common greenshank	C	M	1	1	INBM
Scolopacidae	*Tringa stagnatilis*	marsh sandpiper	C	M	1	1	INBM
Scolopacidae	*Xenus cinereus*	terek sandpiper	C	M	1	1	INBM
Rostratulidae	*Rostratula australis*	Australian painted snipe	V	V,M	1	1	PBR
Jacanidae	*Irediparra gallinacea*	comb-crested jacana	C	M	1	1	BR
Burhinidae	*Burhinus grallarius*	bush stone-curlew	C		1	1	BR
Burhinidae	*Esacus neglectus*	beach stone-curlew	V		1	1	BR
Haematopodidae	*Haematopus fuliginosus*	sooty oystercatcher	R		1	1	BR
Haematopodidae	*Haematopus longirostris*	pied oystercatcher	C		1	1	BR
Recurvirostridae	*Cladorhynchus leucocephalus*	banded stilt	C	M	1		ANBR,V
Recurvirostridae	*Himantopus himantopus*	black-winged stilt	C	M	1	1	BR
Recurvirostridae	*Recurvirostra novaehollandiae*	red-necked avocet	C	M	1	1	BR
Charadriidae	*Charadrius bicinctus*	double-banded plover	C	M	1	1	INBM
Charadriidae	*Charadrius leschenaultii*	greater sand plover	C	M	1	1	INBM
Charadriidae	*Charadrius mongolus*	lesser sand plover	C	M	1	1	INBM
Charadriidae	*Charadrius ruficapillus*	red-capped plover	C		1	1	BR
Charadriidae	*Charadrius veredus*	oriental plover	C	M	1	1	INBM
Charadriidae	*Elseyornis melanops*	black-fronted dotterel	C		1	1	BR
Charadriidae	*Erythrogonys cinctus*	red-kneed dotterel	C		1	1	BR

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB	MB Status
Charadriidae	*Pluvialis fulva*	Pacific golden plover	C	M	1	1	INBM
Charadriidae	*Pluvialis squatarola*	grey plover	C	M	1	1	INBM
Charadriidae	*Thinornis rubricollis*	hooded plover	C		1		ANBR,V
Charadriidae	*Vanellus miles*	masked lapwing	C		1	1	BR
Charadriidae	*Vanellus tricolor*	banded lapwing	C		1	1	BR
Glareolidae	*Glareola maldivarum*	oriental pratincole	C	M	1	1	INBM,V
Glareolidae	*Stiltia isabella*	Australian pratincole	C	M	1	1	ANBR,V
Species Richness					**50**	**48**	

INBM Interntaional non-breeding migrant

BR Breeding resident

ANBR Australian non-breeding resident

PBR Possible breeding resident (though no breeding records to date)

Table D-2 Waterbirds

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Anseranatidae	*Anseranas semipalmata*	magpie goose	C	M	1	1
Anatidae	*Anas castanea*	chestnut teal	C	M	1	1
Anatidae	*Anas gracilis*	grey teal	C	M	1	1
Anatidae	*Anas rhynchotis*	Australasian shoveler	C	M	1	
Anatidae	*Anas superciliosa*	Pacific black duck	C	M	1	1
Anatidae	*Aythya australis*	hardhead	C	M	1	1
Anatidae	*Biziura lobata*	musk duck	C	M	1	1
Anatidae	*Chenonetta jubata*	Australian wood duck	C	M	1	1
Anatidae	*Cygnus atratus*	black swan	C	M	1	1
Anatidae	*Dendrocygna arcuata*	wandering whistling-duck	C	M	1	1
Anatidae	*Dendrocygna eytoni*	plumed whistling-duck	C	M	1	1
Anatidae	*Malacorhynchus membranaceus*	pink-eared duck	C	M	1	
Anatidae	*Nettapus coromandelianus*	cotton pygmy-goose	R	M	1	1
Anatidae	*Nettapus pulchellus*	green pygmy-goose	C	M	1	
Anatidae	*Oxyura australis*	blue-billed duck	C	M	1	1
Anatidae	*Stictonetta naevosa*	freckled duck	R	M	1	1
Anatidae	*Tadorna radjah*	radjah shelduck	R	M	1	
Anatidae	*Tadorna tadornoides*	Australian shelduck	C	M	1	
Podicipedidae	*Podiceps cristatus*	great crested grebe	C		1	1
Podicipedidae	*Poliocephalus poliocephalus*	hoary-headed grebe	C		1	1
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe	C		1	1
Anhingidae	*Anhinga melanogaster*	darter	C		1	1
Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant	C		1	1
Phalacrocoracidae	*Phalacrocorax melanoleucos*	little pied cormorant	C		1	1
Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant	C		1	1
Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant	C		1	1
Pelecanidae	*Pelecanus conspicillatus*	Australian pelican	C		1	1
Ardeidae	*Ardea alba*	great egret	C	M	1	1
Ardeidae	*Ardea ibis*	cattle egret	C		1	1
Ardeidae	*Ardea intermedia*	intermediate egret	C		1	1
Ardeidae	*Ardea pacifica*	white-necked heron	C		1	1
Ardeidae	*Ardea sumatrana*	great-billed heron	C		1	
Ardeidae	*Botaurus poiciloptilus*	Australasian bittern	C		1	1
Ardeidae	*Egretta garzetta*	little egret	C		1	1
Ardeidae	*Egretta novaehollandiae*	white-faced heron	C		1	1
Ardeidae	*Ixobrychus flavicollis*	black bittern	C		1	1
Ardeidae	*Ixobrychus minutus*	little bittern	C		1	1
Ardeidae	*Nycticorax caledonicus*	nankeen night heron	C		1	1
Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill	C		1	1
Threskiornithidae	*Platalea regia*	royal spoonbill	C		1	1
Threskiornithidae	*Plegadis falcinellus*	glossy ibis	C		1	1
Threskiornithidae	*Threskiornis molucca*	Australian white ibis	C		1	1
Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis	C		1	1
Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork	R		1	1
Gruidae	*Grus rubicunda*	brolga	C	M	1	1
Rallidae	*Amaurornis olivaceus*	bush-hen	C		1	1
Rallidae	*Fulica atra*	Eurasian coot	C		1	1
Rallidae	*Gallinula tenebrosa*	dusky moorhen	C		1	1
Rallidae	*Gallinula ventralis*	black-tailed native-hen	C		1	
Rallidae	*Gallirallus philippensis*	buff-banded rail	C		1	1
Rallidae	*Porphyrio porphyrio*	purple swamphen	C		1	1
Rallidae	*Porzana fluminea*	Australian spotted crake	C		1	1

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Rallidae	*Porzana pusilla*	Baillon's crake	C		1	1
Rallidae	*Porzana tabuensis*	spotless crake	C		1	
Rallidae	*Rallus pectoralis*	Lewin's rail	R		1	1
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	C	M	1	1
Rostratulidae	*Rostratula australis*	australian painted snipe	V	V,M	1	1
Jacanidae	*Irediparra gallinacea*	comb-crested jacana	C		1	1
Recurvirostridae	*Cladorhynchus leucocephalus*	banded stilt	C	M	1	
Recurvirostridae	*Himantopus himantopus*	black-winged stilt	C	M	1	1
Recurvirostridae	*Recurvirostra novaehollandiae*	red-necked avocet	C	M	1	1
Charadriidae	*Elseyornis melanops*	black-fronted dotterel	C	M	1	1
Charadriidae	*Erythrogonys cinctus*	red-kneed dotterel	C	M	1	1
Charadriidae	*Vanellus miles*	masked lapwing	C		1	1
Laridae	*Chlidonias hybridus*	whiskered tern	C		1	1
Laridae	*Chlidonias leucopterus*	white-winged black tern	C	M	1	1
Species Richness					**66**	**57**

Table D-3 Mammals

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Ornithorhynchidae	*Ornithorhynchus anatinus*	platypus	C		1	
Tachyglossidae	*Tachyglossus aculeatus*	short-beaked echidna	C		1	1
Dasyuridae	*Antechinus flavipes*	yellow-footed antechinus	C		1	1
Dasyuridae	*Antechinus subtropicus*		C		1	
Dasyuridae	*Dasyurus hallucatus*	northern quoll	C		1	
Dasyuridae	*Dasyurus maculatus*	spotted-tailed quoll (southern subspecies)	V	E	1	
Dasyuridae	*Phascogale tapoatafa*	brush-tailed phascogale	C		1	1
Dasyuridae	*Planigale maculata*	common planigale	C		1	1
Dasyuridae	*Sminthopsis murina*	common dunnart	C		1	1
Peramelidae	*Isoodon macrourus*	northern brown bandicoot	C		1	1
Peramelidae	*Perameles nasuta*	long-nosed bandicoot	C		1	1
Phascolarctidae	*Phascolarctos cinereus*	koala (SEQ bioregion)	V		1	1
Vombatidae	*Vombatus ursinus*	common wombat	R		1	
Burramyidae	*Cercartetus nanus*	eastern pygmy-possum	C		1	
Petauridae	*Petaurus australis*	yellow-bellied glider	C		1	
Petauridae	*Petaurus breviceps*	sugar glider	C		1	1
Petauridae	*Petaurus norfolcensis*	squirrel glider	C		1	1
Pseudocheiridae	*Petauroides volans*	greater glider	C		1	
Pseudocheiridae	*Pseudocheirus peregrinus*	common ringtail possum	C		1	1
Acrobatidae	*Acrobates pygmaeus*	feathertail glider	C		1	1
Phalangeridae	*Trichosurus caninus*	short-eared possum	C		1	
Phalangeridae	*Trichosurus vulpecula*	common brushtail possum	C		1	1
Potoroidae	*Aepyprymnus rufescens*	rufous bettong	C		1	
Potoroidae	*Potorous tridactylus*	long-nosed potoroo	V	V	1	
Macropodidae	*Macropus agilis*	agile wallaby	C		1	1
Macropodidae	*Macropus dorsalis*	black-striped wallaby	C		1	
Macropodidae	*Macropus giganteus*	eastern grey kangaroo	C		1	1
Macropodidae	*Macropus parryi*	whiptail wallaby	C		1	
Macropodidae	*Macropus robustus*	common wallaroo	C		1	
Macropodidae	*Macropus rufogriseus*	red-necked wallaby	C		1	1
Macropodidae	*Petrogale herberti*	Herbert's rock-wallaby	C		1	
Macropodidae	*Petrogale penicillata*	brush-tailed rock-wallaby	V	V	1	
Macropodidae	*Thylogale stigmatica*	red-legged pademelon	C		1	
Macropodidae	*Thylogale thetis*	red-necked pademelon	C		1	
Macropodidae	*Wallabia bicolor*	swamp wallaby	C		1	1
Pteropodidae	*Nyctimene robinsoni*	eastern tube-nosed bat	C		1	
Pteropodidae	*Pteropus alecto*	black flying-fox	C		1	1
Pteropodidae	*Pteropus poliocephalus*	grey-headed flying-fox	C	V	1	1
Pteropodidae	*Pteropus scapulatus*	little red flying-fox	C		1	1
Pteropodidae	*Syconycteris australis*	eastern blossom bat	C		1	1
Megadermatidae	*Macroderma gigas*	ghost bat	V		1	
Rhinolophidae	*Rhinolophus megaphyllus*	eastern horseshoe-bat	C		1	
Rhinolophidae	*Rhinolophus philippinensis*	greater large-eared horseshoe bat	E	E	1	
Hipposideridae	*Hipposideros semoni*	Semon`s leaf-nosed bat	E	E	1	
Emballonuridae	*Saccolaimus flaviventris*	yellow-bellied sheathtail bat	C		1	1
Emballonuridae	*Taphozous georgianus*	common sheathtail bat	C		1	
Molossidae	*Mormopterus beccarii*	Beccari's freetail bat	C		1	1
Molossidae	*Mormopterus norfolkensis*	east coast freetail bat	C		1	1
Molossidae	*Mormopterus planiceps*	southern freetail bat	C		1	
Molossidae	*Mormopterus sp. 2*	eastern freetail bat	C		1	1

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Molossidae	*Nyctinomus australis*	white-striped freetail bat	C		1	1
Vespertilionidae	*Chalinolobus dwyeri*	large-eared pied bat	R	V	1	
Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat	C		1	1
Vespertilionidae	*Chalinolobus morio*	chocolate wattled bat	C		1	1
Vespertilionidae	*Chalinolobus nigrogriseus*	hoary wattled bat	C		1	1
Vespertilionidae	*Chalinolobus picatus*	little pied bat	R		1	
Vespertilionidae	*Falsistrellus tasmaniensis*	eastern false pipistrelle	C		1	
Vespertilionidae	*Kerivoula papuensis*	golden-tipped bat	R		1	
Vespertilionidae	*Miniopterus australis*	little bent-wing bat	C		1	1
Vespertilionidae	*Miniopterus schreibersii*	eastern bent-wing bat	C	CD	1	1
Vespertilionidae	*Myotis macropus*	large-footed myotis	C		1	1
Vespertilionidae	*Nyctophilus bifax*	northern long-eared bat	C		1	1
Vespertilionidae	*Nyctophilus geoffroyi*	lesser long-eared bat	C		1	
Vespertilionidae	*Nyctophilus gouldi*	Gould's long-eared bat	C		1	1
Vespertilionidae	*Nyctophilus timoriensis*	eastern long-eared bat	V	V	1	
Vespertilionidae	*Pipistrellus adamsi*	Cape York pipistrelle	C		1	
Vespertilionidae	*Scoteanax rueppellii*	greater broad-nosed bat	C		1	1
Vespertilionidae	*Scotorepens balstoni*	inland broad-nosed bat	C		1	
Vespertilionidae	*Scotorepens greyii*	little broad-nosed bat	C		1	
Vespertilionidae	*Scotorepens orion*	south-eastern broad-nosed bat	C		1	1
Vespertilionidae	*Scotorepens sanborni*	northern broad-nosed bat	C		1	
Vespertilionidae	*Scotorepens sp. (Parnaby)*	central-eastern broad-nosed bat	C		1	1
Vespertilionidae	*Vespadelus darlingtoni*	large forest bat	C		1	
Vespertilionidae	*Vespadelus pumilus*	eastern forest bat	C		1	
Vespertilionidae	*Vespadelus regulus*	souther forest bat	C		1	
Vespertilionidae	*Vespadelus troughtoni*	eastern cave bat	C		1	1
Vespertilionidae	*Vespadelus vulturnus*	little forest bat	C		1	
Muridae	*Hydromys chrysogaster*	water rat	C		1	1
Muridae	*Melomys burtoni*	grassland melomys	C		1	1
Muridae	*Melomys cervinipes*	fawn-footed melomys	C		1	1
Muridae	*Pseudomys delicatulus*	delicate mouse	C		1	1
Muridae	*Pseudomys gracilicaudatus*	eastern chestnut mouse	C		1	
Muridae	*Pseudomys novaehollandiae*	New Holland mouse	C		1	
Muridae	*Pseudomys oralis*	Hastings River mouse	V	E	1	
Muridae	*Pseudomys patrius*	eastern pebble-mound mouse	C		1	
Muridae	*Rattus fuscipes*	bush rat	C		1	1
Muridae	*Rattus lutreolus*	swamp rat	C		1	1
Muridae	*Rattus sordidus*	canefield rat	C		1	
Muridae	*Rattus tunneyi*	pale field-rat	C		1	
Muridae	*Xeromys myoides*	false water-rat	V	V	1	1
Canidae	*Canis lupus dingo*	dingo			1	
Species Richness					**91**	**45**

Table D-4 Reptiles

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Chelidae	*Chelodina expansa*	broad-shelled river turtle	C		1	
Chelidae	*Chelodina longicollis*	eastern snake-necked turtle	C		1	1
Chelidae	*Elseya dentata*	northern snapping turtle	C		1	
Chelidae	*Elseya latisternum*	saw-shelled turtle	C		1	1
Chelidae	*Elusor macrurus*	Mary River turtle	E	E	1	
Chelidae	*Emydura macquarii krefftii*	Krefft's river turtle	C		1	
Chelidae	*Emydura macquarii macquarii*	Murray turtle	C		1	
Chelidae	*Emydura macquarii nigra*	Fraser Island short-neck turtle	C		1	
Chelidae	*Emydura macquarii signata*	Brisbane short-necked turtle	C		1	1
Gekkonidae	*Diplodactylus steindachneri*	Steindachner's gecko	C		1	
Gekkonidae	*Diplodactylus vittatus*	wood gecko	C		1	1
Gekkonidae	*Gehyra australis*	northern dtella	C		1	
Gekkonidae	*Gehyra dubia*		C		1	1
Gekkonidae	*Gehyra variegata*	tree dtella	C		1	
Gekkonidae	*Heteronotia binoei*	Bynoe's gecko	C		1	1
Gekkonidae	*Nephrurus milii*		C		1	
Gekkonidae	*Oedura lesueurii*	Lesueur's velvet gecko	C		1	
Gekkonidae	*Oedura monilis*		C		1	
Gekkonidae	*Oedura ocellata*		C		1	
Gekkonidae	*Oedura rhombifer*	zig-zag gecko	C		1	
Gekkonidae	*Oedura robusta*	robust velvet gecko	C		1	1
Gekkonidae	*Oedura tryoni*	southern spotted velvet gecko	C		1	
Gekkonidae	*Phyllurus caudiannulatus*	ringed thin-tailed gecko	R		1	
Gekkonidae	*Saltuarius cornutus*	northern leaf-tailed gecko	C		1	
Gekkonidae	*Saltuarius salebrosus*	rough-throated leaf-tailed gecko	C		1	
Gekkonidae	*Strophurus elderi*	jewelled gecko	C		1	
Gekkonidae	*Strophurus taenicauda*	golden-tailed gecko	R		1	
Gekkonidae	*Strophurus williamsi*	soft-spined gecko	C		1	
Gekkonidae	*Underwoodisaurus milii*				1	
Pygopodidae	*Delma inornata*		C		1	
Pygopodidae	*Delma plebeia*	common delma	C		1	
Pygopodidae	*Delma tincta*		C		1	
Pygopodidae	*Delma torquata*	collared delma	V	V	1	
Pygopodidae	*Lialis burtonis*	Burton's legless lizard	C		1	1
Pygopodidae	*Paradelma orientalis*	brigalow scaly-foot	V	V	1	
Pygopodidae	*Pygopus lepidopodus*	common scaly-foot	C		1	1
Pygopodidae	*Pygopus schraderi*		C		1	
Agamidae	*Amphibolurus muricatus*	jacky lizard	C		1	
Agamidae	*Amphibolurus nobbi*		C		1	
Agamidae	*Chlamydosaurus kingii*	frilled lizard	C		1	1
Agamidae	*Diporiphora australis*		C		1	1
Agamidae	*Diporiphora bilineata*	two-lined dragon	C		1	
Agamidae	*Hypsilurus spinipes*	southern angle-headed dragon	C		1	
Agamidae	*Physignathus lesueurii*	eastern water dragon	C		1	1
Agamidae	*Pogona barbata*	bearded dragon	C		1	1
Varanidae	*Varanus gouldii*	sand monitor	C		1	1

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Varanidae	*Varanus tristis*	black-tailed monitor	C		1	
Varanidae	*Varanus varius*	lace monitor	C		1	1
Scincidae	*Anomalopus leuckartii*		C		1	
Scincidae	*Anomalopus verreauxii*		C		1	1
Scincidae	*Calyptotis lepidorostrum*		C		1	
Scincidae	*Calyptotis scutirostrum*		C		1	1
Scincidae	*Calyptotis temporalis*		C		1	
Scincidae	*Carlia amax*		C		1	
Scincidae	*Carlia foliorum*		C		1	1
Scincidae	*Carlia munda*		C		1	
Scincidae	*Carlia pectoralis*		C		1	
Scincidae	*Carlia schmeltzii*		C		1	
Scincidae	*Carlia tetradactyla*		C		1	
Scincidae	*Carlia vivax*		C		1	1
Scincidae	*Cautula zia*		R		1	
Scincidae	*Coeranoscincus reticulatus*	three-toed snake-tooth skink	R	V	1	
Scincidae	*Coggeria naufragus*	satinay sand skink	C		1	
Scincidae	*Cryptoblepharus plagiocephalus*		C		1	
Scincidae	*Cryptoblepharus virgatus*		C		1	1
Scincidae	*Ctenotus arcanus*		C		1	1
Scincidae	*Ctenotus eurydice*		C		1	
Scincidae	*Ctenotus robustus*		C		1	1
Scincidae	*Ctenotus taeniolatus*	copper-tailed skink	C		1	1
Scincidae	*Cyclodomorphus gerrardii*	pink-tongued lizard	C		1	1
Scincidae	*Egernia cunninghami*	Cunningham's skink	C		1	
Scincidae	*Egernia frerei*	major skink	C		1	1
Scincidae	*Egernia major*	land mullet	C		1	1
Scincidae	*Egernia mcpheei*		C		1	
Scincidae	*Egernia modesta*		C		1	
Scincidae	*Egernia rugosa*	yakka skink	V	V	1	
Scincidae	*Egernia striolata*	tree skink	C		1	1
Scincidae	*Egernia whitii*	White's skink	C		1	
Scincidae	*Eremiascincus fasciolatus*	narrow-banded sand swimmer	C		1	
Scincidae	*Eremiascincus richardsonii*	broad-banded sand swimmer	C		1	
Scincidae	*Eroticoscincus graciloides*		R		1	
Scincidae	*Eulamprus brachysoma*		C		1	
Scincidae	*Eulamprus martini*		C		1	1
Scincidae	*Eulamprus murrayi*		C		1	
Scincidae	*Eulamprus quoyii*	eastern water skink	C		1	
Scincidae	*Eulamprus tenuis*		C		1	1
Scincidae	*Eulamprus tryoni*		C		1	
Scincidae	*Hemisphaeriodon gerrardii*				1	
Scincidae	*Lampropholis adonis*		C		1	
Scincidae	*Lampropholis amicula*		C		1	1
Scincidae	*Lampropholis colossus*		R		1	
Scincidae	*Lampropholis couperi*		C		1	
Scincidae	*Lampropholis delicata*		C		1	1
Scincidae	*Lampropholis guichenoti*		C		1	1
Scincidae	*Lerista fragilis*		C		1	
Scincidae	*Lerista punctatovittata*		C		1	
Scincidae	*Menetia greyii*		C		1	
Scincidae	*Menetia timlowi*		C		1	

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Scincidae	*Morethia boulengeri*		C		1	
Scincidae	*Morethia taeniopleura*	fire-tailed skink	C		1	1
Scincidae	*Nangura spinosa*	Nangur skink	R		1	
Scincidae	*Ophioscincus cooloolensis*		R		1	
Scincidae	*Ophioscincus ophioscincus*		C		1	
Scincidae	*Ophioscincus truncatus*		R		1	1
Scincidae	*Saiphos equalis*		C		1	1
Scincidae	*Saproscincus rosei*		R		1	
Scincidae	*Saproscincus spectabilis*		R		1	
Scincidae	*Tiliqua scincoides*	eastern blue-tongued lizard	C		1	1
Typhlopidae	*Ramphotyphlops affinis*		C		1	
Typhlopidae	*Ramphotyphlops ligatus*		C		1	1
Typhlopidae	*Ramphotyphlops nigrescens*		C		1	
Typhlopidae	*Ramphotyphlops proximus*		C		1	1
Typhlopidae	*Ramphotyphlops silvia*		R		1	
Typhlopidae	*Ramphotyphlops unguirostris*		C		1	
Typhlopidae	*Ramphotyphlops wiedii*		C		1	1
Boidae	*Antaresia maculosus*		C		1	
Boidae	*Aspidites melanocephalus*	black-headed python	C		1	
Boidae	*Morelia spilota*	carpet python	C		1	1
Colubridae	*Boiga irregularis*	brown tree snake	C		1	1
Colubridae	*Dendrelaphis punctulata*	common tree snake	C		1	1
Colubridae	*Tropidonophis mairii*	freshwater snake	C		1	1
Elapidae	*Acanthophis antarcticus*	common death adder	R		1	1
Elapidae	*Brachyurophis australis*	coral snake	C		1	
Elapidae	*Cacophis harriettae*	white-crowned snake	C		1	1
Elapidae	*Cacophis krefftii*	dwarf crowned snake	C		1	1
Elapidae	*Cacophis squamulosus*	golden crowned snake	C		1	
Elapidae	*Cryptophis boschmai*	Carpentaria whip snake	C		1	
Elapidae	*Cryptophis nigrescens*	eastern small-eyed snake	C		1	1
Elapidae	*Cryptophis nigrostriatus*	black-striped snake	C		1	
Elapidae	*Demansia psammophis*	yellow-faced whip snake	C		1	1
Elapidae	*Demansia torquata*	collared whip snake	C		1	
Elapidae	*Demansia vestigiata*	black whip snake	C		1	
Elapidae	*Denisonia devisi*	De Vis' Banded Snake	C		1	
Elapidae	*Furina diadema*	red-naped snake	C		1	
Elapidae	*Furina dunmalli*	Dunmall's snake	V	V	1	
Elapidae	*Furina ornata*	orange-naped snake	C		1	
Elapidae	*Hemiaspis damelii*	grey snake	E		1	
Elapidae	*Hemiaspis signata*	black-bellied swamp snake	C		1	1
Elapidae	*Hoplocephalus bitorquatus*	pale-headed snake	C		1	
Elapidae	*Hoplocephalus stephensii*	Stephens' banded snake	R		1	
Elapidae	*Notechis scutatus*	eastern tiger snake	C		1	
Elapidae	*Oxyuranus scutellatus*	taipan	C		1	
Elapidae	*Pseudechis australis*	king brown snake	C		1	
Elapidae	*Pseudechis guttatus*	spotted black snake	C		1	
Elapidae	*Pseudechis porphyriacus*	red-bellied black snake	C		1	1
Elapidae	*Pseudonaja nuchalis*	western brown snake	C		1	
Elapidae	*Pseudonaja textilis*	eastern brown snake	C		1	1
Elapidae	*Simoselaps warro*	robust burrowing	R		1	

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
		snake				
Elapidae	*Suta suta*	Myall Snake	C		1	
Elapidae	*Tropidechis carinatus*	rough-scaled snake	C		1	
Elapidae	*Vermicella annulata*	bandy-bandy	C		1	1
Species Richness					**151**	**52**

Table D-5 Frogs

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Myobatrachidae	*Adelotus brevis*	tusked frog	V		1	1
Myobatrachidae	*Assa darlingtoni*	pouched frog	R		1	
Myobatrachidae	*Crinia deserticola*	chirping froglet	C		1	
Myobatrachidae	*Crinia parinsignifera*	beeping froglet	C		1	1
Myobatrachidae	*Crinia signifera*	clicking froglet	C		1	1
Myobatrachidae	*Crinia tinnula*	wallum froglet	V		1	1
Myobatrachidae	*Lechriodus fletcheri*	black soled frog	R		1	
Myobatrachidae	*Limnodynastes dumerilii*	grey bellied pobblebonk	C		1	
Myobatrachidae	*Limnodynastes fletcheri*	barking frog	C		1	
Myobatrachidae	*Limnodynastes peronii*	striped marshfrog	C		1	1
Myobatrachidae	*Limnodynastes salmini*	salmon striped frog	C		1	
Myobatrachidae	*Limnodynastes tasmaniensis*	spotted grassfrog	C		1	1
Myobatrachidae	*Limnodynastes terraereginae*	scarlet sided pobblebonk	C		1	
Myobatrachidae	*Mixophyes fasciolatus*	great barred frog	C		1	
Myobatrachidae	*Mixophyes fleayi*	Fleay's barred frog	E	E	1	
Myobatrachidae	*Mixophyes iteratus*	giant barred frog	E	E	1	
Myobatrachidae	*Opisthodon ornatus*	ornate burrowing frog	C		1	1
Myobatrachidae	*Philoria kundagungun*	mountain frog	R		1	
Myobatrachidae	*Philoria loveridgeri*	Loveridege's Frog	R		1	
Myobatrachidae	*Pseudophryne coriacea*	red backed broodfrog	C		1	1
Myobatrachidae	*Pseudophryne major*	great brown broodfrog	C		1	1
Myobatrachidae	*Pseudophryne raveni*	copper backed broodfrog	C		1	1
Myobatrachidae	*Taudactylus pleione*	Kroombit tinkerfrog	E	V	1	
Myobatrachidae	*Uperoleia fusca*	dusky gungan	C		1	1
Myobatrachidae	*Uperoleia laevigata*	eastern gungan	C		1	1
Myobatrachidae	*Uperoleia rugosa*	chubby gungan	C		1	1
Hylidae	*Cyclorana alboguttata*	greenstripe frog	C		1	
Hylidae	*Cyclorana brevipes*	superb collared frog	C		1	
Hylidae	*Cyclorana novaehollandiae*	eastern snapping frog	C		1	
Hylidae	*Litoria bicolor*	northern sedgefrog	C		1	
Hylidae	*Litoria brevipalmata*	green thighed frog	R		1	
Hylidae	*Litoria caerulea*	common green treefrog	C		1	1
Hylidae	*Litoria chloris*	orange eyed treefrog	C		1	
Hylidae	*Litoria cooloolensis*	Cooloola sedgefrog	R		1	1
Hylidae	*Litoria dentata*	bleating treefrog	C		1	1
Hylidae	*Litoria fallax*	eastern sedgefrog	C		1	1
Hylidae	*Litoria freycineti*	wallum rocketfrog	V		1	1
Hylidae	*Litoria gracilenta*	graceful treefrog	C		1	1
Hylidae	*Litoria inermis*	bumpy rocketfrog	C		1	
Hylidae	*Litoria latopalmata*	broad palmed rocketfrog	C		1	1
Hylidae	*Litoria nasuta*	striped rocketfrog	C		1	1
Hylidae	*Litoria olongburensis*	wallum sedgefrog	V	V	1	1
Hylidae	*Litoria pearsoniana*	cascade treefrog	E		1	
Hylidae	*Litoria peronii*	emerald spotted treefrog	C		1	1

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Hylidae	*Litoria rothii*	northern laughing treefrog	C		1	
Hylidae	*Litoria rubella*	ruddy treefrog	C		1	1
Hylidae	*Litoria tyleri*	southern laughing treefrog	C		1	1
Hylidae	*Litoria verreauxii*	whistling treefrog	C		1	
Hylidae	*Litoria wilcoxii*	stony creek frog	C		1	1
Species Richness					**49**	**26**

Table D-6 Birds

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Casuariidae	*Dromaius novaehollandiae*	emu	C		1	1
Megapodiidae	*Alectura lathami*	Australian brush-turkey	C		1	1
Phasianidae	*Coturnix chinensis*	king quail	C		1	1
Phasianidae	*Coturnix pectoralis*	stubble quail	C		1	1
Phasianidae	*Coturnix ypsilophora*	brown quail	C		1	1
Anseranatidae	*Anseranas semipalmata*	magpie goose	C		1	1
Anatidae	*Anas castanea*	chestnut teal	C		1	1
Anatidae	*Anas gracilis*	grey teal	C		1	1
Anatidae	*Anas rhynchotis*	Australasian shoveler	C		1	
Anatidae	*Anas superciliosa*	Pacific black duck	C		1	1
Anatidae	*Aythya australis*	hardhead	C		1	1
Anatidae	*Biziura lobata*	musk duck	C		1	1
Anatidae	*Chenonetta jubata*	Australian wood duck	C		1	1
Anatidae	*Cygnus atratus*	black swan	C		1	1
Anatidae	*Dendrocygna arcuata*	wandering whistling-duck	C		1	1
Anatidae	*Dendrocygna eytoni*	plumed whistling-duck	C		1	1
Anatidae	*Malacorhynchus membranaceus*	pink-eared duck	C		1	
Anatidae	*Nettapus coromandelianus*	cotton pygmy-goose	R		1	1
Anatidae	*Nettapus pulchellus*	green pygmy-goose	C		1	
Anatidae	*Oxyura australis*	blue-billed duck	C		1	1
Anatidae	*Stictonetta naevosa*	freckled duck	R		1	1
Anatidae	*Tadorna radjah*	radjah shelduck	R		1	
Anatidae	*Tadorna tadornoides*	Australian shelduck	C		1	
Podicipedidae	*Podiceps cristatus*	great crested grebe	C		1	1
Podicipedidae	*Poliocephalus poliocephalus*	hoary-headed grebe	C		1	1
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe	C		1	1
Sulidae	*Morus serrator*	Australasian gannet	C		1	1
Sulidae	*Sula dactylatra*	masked booby	C		1	1
Sulidae	*Sula leucogaster*	brown booby	C		1	1
Anhingidae	*Anhinga melanogaster*	darter	C		1	1
Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant	C		1	1
Phalacrocoracidae	*Phalacrocorax melanoleucos*	little pied cormorant	C		1	1
Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant	C		1	1
Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant	C		1	1
Pelecanidae	*Pelecanus conspicillatus*	Australian pelican	C		1	1
Fregatidae	*Fregata ariel*	lesser frigatebird	C		1	1
Fregatidae	*Fregata minor*	great frigatebird	C		1	1
Ardeidae	*Ardea alba*	great egret	C		1	1
Ardeidae	*Ardea ibis*	cattle egret	C		1	1
Ardeidae	*Ardea intermedia*	intermediate egret	C		1	1
Ardeidae	*Ardea pacifica*	white-necked heron	C		1	1
Ardeidae	*Ardea sumatrana*	great-billed heron	C		1	
Ardeidae	*Botaurus poiciloptilus*	Australasian bittern	C		1	1
Ardeidae	*Butorides striatus*	striated heron	C		1	1
Ardeidae	*Egretta garzetta*	little egret	C		1	1
Ardeidae	*Egretta novaehollandiae*	white-faced heron	C		1	1
Ardeidae	*Egretta sacra*	eastern reef egret	C		1	1
Ardeidae	*Ixobrychus flavicollis*	black bittern	C		1	1
Ardeidae	*Ixobrychus minutus*	little bittern	C		1	1
Ardeidae	*Nycticorax caledonicus*	nankeen night heron	C		1	1
Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill	C		1	1
Threskiornithidae	*Platalea regia*	royal spoonbill	C		1	1

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Threskiornithidae	*Plegadis falcinellus*	glossy ibis	C		1	1
Threskiornithidae	*Threskiornis molucca*	Australian white ibis	C		1	1
Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis	C		1	1
Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork	R		1	1
Accipitridae	*Accipiter cirrhocephalus*	collared sparrowhawk	C		1	1
Accipitridae	*Accipiter fasciatus*	brown goshawk	C		1	1
Accipitridae	*Accipiter novaehollandiae*	grey goshawk	R		1	1
Accipitridae	*Aquila audax*	wedge-tailed eagle	C		1	1
Accipitridae	*Aviceda subcristata*	Pacific baza	C		1	1
Accipitridae	*Circus approximans*	swamp harrier	C		1	1
Accipitridae	*Circus assimilis*	spotted harrier	C		1	1
Accipitridae	*Elanus axillaris*	black-shouldered kite	C		1	1
Accipitridae	*Elanus scriptus*	letter-winged kite	C		1	
Accipitridae	*Erythrotriorchis radiatus*	red goshawk	E	V	1	
Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle	C		1	1
Accipitridae	*Haliastur indus*	brahminy kite	C		1	1
Accipitridae	*Haliastur sphenurus*	whistling kite	C		1	1
Accipitridae	*Hamirostra melanosternon*	black-breasted buzzard	C		1	
Accipitridae	*Hieraaetus morphnoides*	little eagle	C		1	1
Accipitridae	*Lophoictinia isura*	square-tailed kite	R		1	1
Accipitridae	*Milvus migrans*	black kite	C		1	
Accipitridae	*Pandion haliaetus*	osprey	C		1	1
Falconidae	*Falco berigora*	brown falcon	C		1	1
Falconidae	*Falco cenchroides*	nankeen kestrel	C		1	1
Falconidae	*Falco hypoleucos*	grey falcon	R		1	
Falconidae	*Falco longipennis*	Australian hobby	C		1	1
Falconidae	*Falco peregrinus*	peregrine falcon	C		1	1
Falconidae	*Falco subniger*	black falcon	C		1	
Gruidae	*Grus rubicunda*	brolga	C		1	1
Rallidae	*Amaurornis olivaceus*	bush-hen	C		1	1
Rallidae	*Fulica atra*	Eurasian coot	C		1	1
Rallidae	*Gallinula tenebrosa*	dusky moorhen	C		1	1
Rallidae	*Gallinula ventralis*	black-tailed native-hen	C		1	
Rallidae	*Gallirallus philippensis*	buff-banded rail	C		1	1
Rallidae	*Porphyrio porphyrio*	purple swamphen	C		1	1
Rallidae	*Porzana fluminea*	Australian spotted crake	C		1	1
Rallidae	*Porzana pusilla*	Baillon's crake	C		1	1
Rallidae	*Porzana tabuensis*	spotless crake	C		1	
Rallidae	*Rallus pectoralis*	Lewin's rail	R		1	1
Otididae	*Ardeotis australis*	Australian bustard	C		1	
Turnicidae	*Turnix maculosa*	red-backed button-quail	C		1	1
Turnicidae	*Turnix melanogaster*	black-breasted button-quail	V	V	1	1
Turnicidae	*Turnix pyrrhothorax*	red-chested button-quail	C		1	1
Turnicidae	*Turnix varia*	painted button-quail	C		1	1
Turnicidae	*Turnix velox*	little button-quail	C		1	1
Scolopacidae	*Actitis hypoleucos*	common sandpiper	C		1	1
Scolopacidae	*Arenaria interpres*	ruddy turnstone	C		1	1
Scolopacidae	*Calidris acuminata*	sharp-tailed sandpiper	C		1	1
Scolopacidae	*Calidris alba*	sanderling	C		1	1
Scolopacidae	*Calidris canutus*	red knot	C		1	1
Scolopacidae	*Calidris ferruginea*	curlew sandpiper	C		1	1
Scolopacidae	*Calidris melanotos*	pectoral sandpiper	C		1	1
Scolopacidae	*Calidris ruficollis*	red-necked stint	C		1	1
Scolopacidae	*Calidris subminuta*	long-toed stint	C		1	1

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Scolopacidae	*Calidris tenuirostris*	great knot	C		1	1
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	C		1	1
Scolopacidae	*Heteroscelus brevipes*	grey-tailed tattler	C		1	1
Scolopacidae	*Heteroscelus incanus*	wandering tattler	C		1	1
Scolopacidae	*Limicola falcinellus*	broad-billed sandpiper	C		1	1
Scolopacidae	*Limnodromus semipalmatus*	Asian dowitcher	C		1	1
Scolopacidae	*Limosa lapponica*	bar-tailed godwit	C		1	1
Scolopacidae	*Limosa limosa*	black-tailed godwit	C		1	1
Scolopacidae	*Numenius madagascariensis*	eastern curlew	R		1	1
Scolopacidae	*Numenius minutus*	little curlew	C		1	1
Scolopacidae	*Numenius phaeopus*	whimbrel	C		1	1
Scolopacidae	*Phalaropus lobatus*	red-necked phalarope	C		1	1
Scolopacidae	*Philomachus pugnax*	ruff	C		1	1
Scolopacidae	*Tringa flavipes*	lesser yellowlegs	C		1	1
Scolopacidae	*Tringa glareola*	wood sandpiper	C		1	1
Scolopacidae	*Tringa nebularia*	common greenshank	C		1	1
Scolopacidae	*Tringa stagnatilis*	marsh sandpiper	C		1	1
Scolopacidae	*Xenus cinereus*	terek sandpiper	C		1	1
Rostratulidae	*Rostratula benghalensis*	painted snipe	V	V	1	1
Jacanidae	*Irediparra gallinacea*	comb-crested jacana	C		1	1
Burhinidae	*Burhinus grallarius*	bush stone-curlew	C		1	1
Burhinidae	*Esacus neglectus*	beach stone-curlew	V		1	1
Haematopodidae	*Haematopus fuliginosus*	sooty oystercatcher	R		1	1
Haematopodidae	*Haematopus longirostris*	pied oystercatcher	C		1	1
Recurvirostridae	*Cladorhynchus leucocephalus*	banded stilt	C		1	
Recurvirostridae	*Himantopus himantopus*	black-winged stilt	C		1	1
Recurvirostridae	*Recurvirostra novaehollandiae*	red-necked avocet	C		1	1
Charadriidae	*Charadrius bicinctus*	double-banded plover	C		1	1
Charadriidae	*Charadrius leschenaultii*	greater sand plover	C		1	1
Charadriidae	*Charadrius mongolus*	lesser sand plover	C		1	1
Charadriidae	*Charadrius ruficapillus*	red-capped plover	C		1	1
Charadriidae	*Charadrius veredus*	oriental plover	C		1	
Charadriidae	*Elseyornis melanops*	black-fronted dotterel	C		1	1
Charadriidae	*Erythrogonys cinctus*	red-kneed dotterel	C		1	1
Charadriidae	*Pluvialis fulva*	Pacific golden plover	C		1	1
Charadriidae	*Pluvialis squatarola*	grey plover	C		1	1
Charadriidae	*Thinornis rubricollis*	hooded plover	C		1	
Charadriidae	*Vanellus miles*	masked lapwing	C		1	1
Charadriidae	*Vanellus tricolor*	banded lapwing	C		1	1
Glareolidae	*Glareola maldivarum*	oriental pratincole	C		1	
Glareolidae	*Stiltia isabella*	Australian pratincole	C		1	1
Laridae	*Chlidonias hybridus*	whiskered tern	C		1	1
Laridae	*Chlidonias leucopterus*	white-winged black tern	C		1	1
Laridae	*Larus novaehollandiae*	silver gull	C		1	1
Laridae	*Stercorarius parasiticus*	Arctic jaeger	C		1	1
Laridae	*Stercorarius pomarinus*	pomarine jaeger	C		1	
Laridae	*Sterna albifrons*	little tern	E		1	1
Laridae	*Sterna bengalensis*	lesser crested tern	C		1	1
Laridae	*Sterna bergii*	crested tern	C		1	1
Laridae	*Sterna caspia*	Caspian tern	C		1	1
Laridae	*Sterna hirundo*	common tern	C		1	1
Laridae	*Sterna nilotica*	gull-billed tern	C		1	1
Columbidae	*Chalcophaps indica*	emerald dove	C		1	1
Columbidae	*Columba leucomela*	white-headed pigeon	C		1	1

Family	Scientific Name	Common Name	NCA	EPBCA	SEQ	MB
Columbidae	*Columba livia*	rock dove				
Columbidae	*Geopelia cuneata*	diamond dove	C		1	
Columbidae	*Geopelia humeralis*	bar-shouldered dove	C		1	1
Columbidae	*Geopelia striata*	peaceful dove	C		1	1
Columbidae	*Geophaps scripta scripta*	squatter pigeon	V	V	1	
Columbidae	*Leucosarcia melanoleuca*	wonga pigeon	C		1	1
Columbidae	*Lopholaimus antarcticus*	topknot pigeon	C		1	1
Columbidae	*Macropygia amboinensis*	brown cuckoo-dove	C		1	1
Columbidae	*Ocyphaps lophotes*	crested pigeon	C		1	1
Columbidae	*Phaps chalcoptera*	common bronzewing	C		1	1
Columbidae	*Phaps elegans*	brush bronzewing	C		1	
Columbidae	*Ptilinopus magnificus*	wompoo fruit-dove	C		1	1
Columbidae	*Ptilinopus regina*	rose-crowned fruit-dove	C		1	1
Columbidae	*Ptilinopus superbus*	superb fruit-dove	C		1	1
Columbidae	*Streptopelia chinensis*	spotted turtle-dove				
Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo	C		1	1
Cacatuidae	*Cacatua leadbeateri*	Major Mitchell's cockatoo	V		1	
Cacatuidae	*Cacatua roseicapilla*	galah	C		1	1
Cacatuidae	*Cacatua sanguinea*	little corella	C		1	1
Cacatuidae	*Calyptorhynchus banksii*	red-tailed black-cockatoo	C		1	1
Cacatuidae	*Calyptorhynchus funereus*	yellow-tailed black-cockatoo	C		1	1
Cacatuidae	*Calyptorhynchus lathami*	glossy black-cockatoo	V		1	1
Cacatuidae	*Nymphicus hollandicus*	cockatiel	C		1	
Psittacidae	*Alisterus scapularis*	Australian king-parrot	C		1	1
Psittacidae	*Aprosmictus erythropterus*	red-winged parrot	C		1	
Psittacidae	*Barnardius zonarius*	Australian ringneck	C		1	
Psittacidae	*Barnardius zonarius barnardi*	mallee ringneck	C		1	
Psittacidae	*Cacatua tenuirostris*	long-billed corella	C		1	
Psittacidae	*Cyclopsitta diophthalma coxeni*	Coxen's fig-parrot	E	E	1	
Psittacidae	*Glossopsitta concinna*	musk lorikeet	C		1	1
Psittacidae	*Glossopsitta porphyrocephala*	purple-crowned lorikeet	C		1	
Psittacidae	*Glossopsitta pusilla*	little lorikeet	C		1	1
Psittacidae	*Lathamus discolor*	swift parrot	E	E	1	
Psittacidae	*Melopsittacus undulatus*	budgerigar	C		1	
Psittacidae	*Neophema pulchella*	turquoise parrot	R		1	
Psittacidae	*Neophema splendida*	scarlet-chested parrot	C		1	
Psittacidae	*Northiella haematogaster*	blue bonnet	C		1	
Psittacidae	*Pezoporus wallicus wallicus*	ground parrot	V		1	
Psittacidae	*Platycercus adscitus*	pale-headed rosella	C		1	1
Psittacidae	*Platycercus elegans*	crimson rosella	C		1	1
Psittacidae	*Platycercus eximius*	eastern rosella	C		1	
Psittacidae	*Psephotus haematonotus*	red-rumped parrot	C		1	1
Psittacidae	*Psitteuteles versicolor*	varied lorikeet	C		1	
Psittacidae	*Trichoglossus chlorolepidotus*	scaly-breasted lorikeet	C		1	1
Psittacidae	*Trichoglossus haematodus*	rainbow lorikeet	C		1	1
Cuculidae	*Cacomantis flabelliformis*	fan-tailed cuckoo	C		1	1
Cuculidae	*Cacomantis variolosus*	brush cuckoo	C		1	1
Cuculidae	*Chrysococcyx basalis*	Horsfield's bronze-cuckoo	C		1	1
Cuculidae	*Chrysococcyx lucidus*	shining bronze-cuckoo	C		1	1
Cuculidae	*Chrysococcyx minutillus*	little bronze-cuckoo	C		1	1
Cuculidae	*Chrysococcyx osculans*	black-eared cuckoo	C		1	1
Cuculidae	*Chrysococcyx russatus*	Gould's bronze-cuckoo	C		1	1
Cuculidae	*Cuculus pallidus*	pallid cuckoo	C		1	1

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Cuculidae	*Cuculus saturatus*	oriental cuckoo	C		1	1
Cuculidae	*Eudynamys scolopacea*	common koel	C		1	1
Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo	C		1	1
Centropodidae	*Centropus phasianinus*	pheasant coucal	C		1	1
Strigidae	*Ninox connivens*	barking owl	C		1	1
Strigidae	*Ninox novaeseelandiae*	southern boobook	C		1	1
Strigidae	*Ninox rufa queenslandica*	rufous owl (sth. subsp.)	V		1	
Strigidae	*Ninox strenua*	powerful owl	V		1	1
Tytonidae	*Tyto alba*	barn owl	C		1	1
Tytonidae	*Tyto capensis*	grass owl	C		1	1
Tytonidae	*Tyto novaehollandiae*	masked owl	C		1	
Tytonidae	*Tyto tenebricosa*	sooty owl	R		1	
Podargidae	*Podargus ocellatus plumiferus*	plumed frogmouth	V		1	
Podargidae	*Podargus strigoides*	tawny frogmouth	C		1	1
Caprimulgidae	*Caprimulgus macrurus*	large-tailed nightjar	C		1	
Caprimulgidae	*Eurostopodus argus*	spotted nightjar	C		1	
Caprimulgidae	*Eurostopodus mystacalis*	white-throated nightjar	C		1	1
Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar	C		1	1
Apodidae	*Apus affinis*	house swift	C		1	
Apodidae	*Apus pacificus*	fork-tailed swift	C		1	1
Apodidae	*Collocalia esculenta*	glossy swiftlet	C		1	
Apodidae	*Collocalia spodiopygius*	white-rumped swiftlet	R		1	
Apodidae	*Collocalia vanikorensis*	uniform swiftlet	C		1	
Apodidae	*Hirundapus caudacutus*	white-throated needletail	C		1	1
Alcedinidae	*Alcedo azurea*	azure kingfisher	C		1	1
Halcyonidae	*Dacelo leachii*	blue-winged kookaburra	C		1	
Halcyonidae	*Dacelo novaeguineae*	laughing kookaburra	C		1	1
Halcyonidae	*Todiramphus chloris*	collared kingfisher	C		1	1
Halcyonidae	*Todiramphus macleayii*	forest kingfisher	C		1	1
Halcyonidae	*Todiramphus pyrrhopygia*	red-backed kingfisher	C		1	
Halcyonidae	*Todiramphus sanctus*	sacred kingfisher	C		1	1
Meropidae	*Merops ornatus*	rainbow bee-eater	C		1	1
Coraciidae	*Eurystomus orientalis*	dollarbird	C		1	1
Pittidae	*Pitta versicolor*	noisy pitta	C		1	1
Menuridae	*Menura alberti*	Albert's lyrebird	R		1	
Menuridae	*Menura novaehollandiae*	superb lyrebird	R		1	
Atrichornithidae	*Atrichornis rufescens*	rufous scrub-bird	V		1	
Climacteridae	*Climacteris affinis*	white-browed treecreeper	C		1	
Climacteridae	*Climacteris erythrops*	red-browed treecreeper	R		1	
Climacteridae	*Climacteris picumnus*	brown treecreeper	C		1	
Climacteridae	*Cormobates leucophaeus*	white-throated treecreeper	C		1	1
Maluridae	*Malurus cyaneus*	superb fairy-wren	C		1	1
Maluridae	*Malurus lamberti*	variegated fairy-wren	C		1	1
Maluridae	*Malurus melanocephalus*	red-backed fairy-wren	C		1	1
Maluridae	*Stipiturus malachurus*	southern emu-wren	V		1	
Pardalotidae	*Acanthiza apicalis*	inland thornbill	C		1	
Pardalotidae	*Acanthiza chrysorrhoa*	yellow-rumped thornbill	C		1	1
Pardalotidae	*Acanthiza lineata*	striated thornbill	C		1	1
Pardalotidae	*Acanthiza nana*	yellow thornbill	C		1	1
Pardalotidae	*Acanthiza pusilla*	brown thornbill	C		1	1
Pardalotidae	*Acanthiza reguloides*	buff-rumped thornbill	C		1	1
Pardalotidae	*Chthonicola sagittata*	speckled warbler	C		1	1
Pardalotidae	*Dasyornis brachypterus*	eastern bristlebird	E	E	1	
Pardalotidae	*Gerygone fusca*	western gerygone	C		1	

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Pardalotidae	*Gerygone levigaster*	mangrove gerygone	C		1	1
Pardalotidae	*Gerygone mouki*	brown gerygone	C		1	1
Pardalotidae	*Gerygone olivacea*	white-throated gerygone	C		1	1
Pardalotidae	*Gerygone palpebrosa*	fairy gerygone	C		1	
Pardalotidae	*Hylacola pyrrhopygia*	chestnut-rumped heathwren	C		1	
Pardalotidae	*Pardalotus punctatus*	spotted pardalote	C		1	1
Pardalotidae	*Pardalotus rubricatus*	red-browed pardalote	C		1	
Pardalotidae	*Pardalotus striatus*	striated pardalote	C		1	1
Pardalotidae	*Sericornis citreogularis*	yellow-throated scrubwren	C		1	1
Pardalotidae	*Sericornis frontalis*	white-browed scrubwren	C		1	1
Pardalotidae	*Sericornis magnirostris*	large-billed scrubwren	C		1	1
Pardalotidae	*Smicrornis brevirostris*	weebill	C		1	1
Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater	C		1	1
Meliphagidae	*Acanthorhynchus tenuirostris*	eastern spinebill	C		1	1
Meliphagidae	*Anthochaera carunculata*	red wattlebird	C		1	1
Meliphagidae	*Anthochaera chrysoptera*	little wattlebird	C		1	1
Meliphagidae	*Certhionyx niger*	black honeyeater	C		1	
Meliphagidae	*Conopophila rufogularis*	rufous-throated honeyeater	C		1	
Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater	C		1	1
Meliphagidae	*Epthianura albifrons*	white-fronted chat	C		1	
Meliphagidae	*Grantiella picta*	painted honeyeater	R		1	
Meliphagidae	*Lichenostomus chrysops*	yellow-faced honeyeater	C		1	1
Meliphagidae	*Lichenostomus fasciogularis*	mangrove honeyeater	C		1	1
Meliphagidae	*Lichenostomus fuscus*	fuscous honeyeater	C		1	1
Meliphagidae	*Lichenostomus leucotis*	white-eared honeyeater	C		1	
Meliphagidae	*Lichenostomus melanops*	yellow-tufted honeyeater	C		1	
Meliphagidae	*Lichenostomus penicillatus*	white-plumed honeyeater	C		1	
Meliphagidae	*Lichenostomus versicolor*	varied honeyeater	C		1	
Meliphagidae	*Lichenostomus virescens*	singing honeyeater	C		1	
Meliphagidae	*Lichmera indistincta*	brown honeyeater	C		1	1
Meliphagidae	*Manorina flavigula*	yellow-throated miner	C		1	
Meliphagidae	*Manorina melanocephala*	noisy miner	C		1	1
Meliphagidae	*Manorina melanophrys*	bell miner	C		1	
Meliphagidae	*Meliphaga lewinii*	Lewin's honeyeater	C		1	1
Meliphagidae	*Melithreptus albogularis*	white-throated honeyeater	C		1	1
Meliphagidae	*Melithreptus brevirostris*	brown-headed honeyeater	C		1	
Meliphagidae	*Melithreptus gularis*	black-chinned honeyeater	R		1	1
Meliphagidae	*Melithreptus lunatus*	white-naped honeyeater	C		1	1
Meliphagidae	*Myzomela obscura*	dusky honeyeater	C		1	
Meliphagidae	*Myzomela sanguinolenta*	scarlet honeyeater	C		1	1
Meliphagidae	*Philemon buceroides*	helmeted friarbird	C		1	
Meliphagidae	*Philemon citreogularis*	little friarbird	C		1	1
Meliphagidae	*Philemon corniculatus*	noisy friarbird	C		1	1
Meliphagidae	*Phylidonyris albifrons*	white-fronted honeyeater	C		1	
Meliphagidae	*Phylidonyris nigra*	white-cheeked honeyeater	C		1	1
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland honeyeater	C		1	1
Meliphagidae	*Plectorhyncha lanceolata*	striped honeyeater	C		1	1
Meliphagidae	*Ramsayornis fasciatus*	bar-breasted honeyeater	C		1	
Meliphagidae	*Xanthomyza phrygia*	regent honeyeater	E	E	1	
Petroicidae	*Eopsaltria australis*	eastern yellow robin	C		1	1
Petroicidae	*Melanodryas cucullata*	hooded robin	C		1	
Petroicidae	*Microeca fascinans*	jacky winter	C		1	1
Petroicidae	*Petroica goodenovii*	red-capped robin	C		1	1

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Petroicidae	*Petroica multicolor*	scarlet robin	C		1	
Petroicidae	*Petroica phoenicea*	flame robin	C		1	1
Petroicidae	*Petroica rosea*	rose robin	C		1	1
Petroicidae	*Tregellasia capito*	pale-yellow robin	C		1	
Orthonychidae	*Orthonyx temminckii*	logrunner	C		1	
Pomatostomidae	*Pomatostomus halli*	Hall's babbler	C		1	
Pomatostomidae	*Pomatostomus superciliosus*	white-browed babbler	C		1	
Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler	C		1	
Cinclosomatidae	*Cinclosoma punctatum*	spotted quail-thrush	C		1	1
Cinclosomatidae	*Psophodes olivaceus*	eastern whipbird	C		1	1
Neosittidae	*Daphoenositta chrysoptera*	varied sittella	C		1	1
Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush	C		1	1
Pachycephalidae	*Colluricincla megarhyncha*	little shrike-thrush	C		1	1
Pachycephalidae	*Falcunculus frontatus*	crested shrike-tit	C		1	
Pachycephalidae	*Oreoica gutturalis*	crested bellbird	C		1	
Pachycephalidae	*Pachycephala olivacea*	olive whistler	R		1	
Pachycephalidae	*Pachycephala pectoralis*	golden whistler	C		1	1
Pachycephalidae	*Pachycephala rufiventris*	rufous whistler	C		1	1
Dicruridae	*Dicrurus bracteatus*	spangled drongo	C		1	1
Dicruridae	*Grallina cyanoleuca*	magpie-lark	C		1	1
Dicruridae	*Monarcha leucotis*	white-eared monarch	C		1	1
Dicruridae	*Monarcha melanopsis*	black-faced monarch	C		1	1
Dicruridae	*Monarcha trivirgatus*	spectacled monarch	C		1	1
Dicruridae	*Myiagra alecto*	shining flycatcher	C		1	1
Dicruridae	*Myiagra cyanoleuca*	satin flycatcher	C		1	1
Dicruridae	*Myiagra inquieta*	restless flycatcher	C		1	1
Dicruridae	*Myiagra rubecula*	leaden flycatcher	C		1	1
Dicruridae	*Rhipidura fuliginosa*	grey fantail	C		1	1
Dicruridae	*Rhipidura leucophrys*	willie wagtail	C		1	1
Dicruridae	*Rhipidura rufifrons*	rufous fantail	C		1	1
Campephagidae	*Coracina lineata*	barred cuckoo-shrike	C		1	
Campephagidae	*Coracina maxima*	ground cuckoo-shrike	C		1	
Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike	C		1	1
Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike	C		1	1
Campephagidae	*Coracina tenuirostris*	cicadabird	C		1	1
Campephagidae	*Lalage leucomela*	varied triller	C		1	1
Campephagidae	*Lalage sueurii*	white-winged triller	C		1	1
Oriolidae	*Oriolus sagittatus*	olive-backed oriole	C		1	1
Oriolidae	*Sphecotheres viridis*	figbird	C		1	1
Artamidae	*Artamus cinereus*	black-faced woodswallow	C		1	
Artamidae	*Artamus cyanopterus*	dusky woodswallow	C		1	1
Artamidae	*Artamus leucorynchus*	white-breasted woodswallow	C		1	1
Artamidae	*Artamus minor*	little woodswallow	C		1	1
Artamidae	*Artamus personatus*	masked woodswallow	C		1	1
Artamidae	*Artamus superciliosus*	white-browed woodswallow	C		1	
Artamidae	*Cracticus nigrogularis*	pied butcherbird	C		1	1
Artamidae	*Cracticus torquatus*	grey butcherbird	C		1	1
Artamidae	*Gymnorhina tibicen*	Australian magpie	C		1	1
Artamidae	*Strepera graculina*	pied currawong	C		1	1
Paradisaeidae	*Ptiloris paradiseus*	paradise riflebird	C		1	
Corvidae	*Corvus bennetti*	little crow	C		1	
Corvidae	*Corvus coronoides*	Australian raven	C		1	1
Corvidae	*Corvus orru*	Torresian crow	C		1	1

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Corcoracidae	*Corcorax melanorhamphos*	white-winged chough	C		1	
Corcoracidae	*Struthidea cinerea*	apostlebird	C		1	
Ptilonorhynchidae	*Ailuroedus crassirostris*	green catbird	C		1	
Ptilonorhynchidae	*Ailuroedus melanotis*	spotted catbird	C		1	
Ptilonorhynchidae	*Chlamydera maculata*	spotted bowerbird	C		1	
Ptilonorhynchidae	*Ptilonorhynchus violaceus*	satin bowerbird	C		1	1
Ptilonorhynchidae	*Sericulus chrysocephalus*	regent bowerbird	C		1	
Alaudidae	*Mirafra javanica*	singing bushlark	C		1	1
Motacillidae	*Anthus novaeseelandiae*	Richard's pipit	C		1	1
Passeridae	*Lonchura castaneothorax*	chestnut-breasted mannikin	C		1	1
Passeridae	*Neochmia modesta*	plum-headed finch	C		1	
Passeridae	*Neochmia temporalis*	red-browed finch	C		1	1
Passeridae	*Stagonopleura guttata*	diamond firetail	C		1	
Passeridae	*Taeniopygia bichenovii*	double-barred finch	C		1	1
Passeridae	*Taeniopygia guttata*	zebra finch	C		1	
Nectariniidae	*Nectarinia jugularis*	yellow-bellied sunbird	C		1	
Dicaeidae	*Dicaeum hirundinaceum*	mistletoebird	C		1	1
Hirundinidae	*Cheramoeca leucosternus*	white-backed swallow	C		1	1
Hirundinidae	*Hirundo ariel*	fairy martin	C		1	1
Hirundinidae	*Hirundo neoxena*	welcome swallow	C		1	1
Hirundinidae	*Hirundo nigricans*	tree martin	C		1	1
Hirundinidae	*Hirundo rustica*	barn swallow	C		1	
Sylviidae	*Acrocephalus stentoreus*	clamorous reed-warbler	C		1	1
Sylviidae	*Cincloramphus cruralis*	brown songlark	C		1	
Sylviidae	*Cincloramphus mathewsi*	rufous songlark	C		1	
Sylviidae	*Cisticola exilis*	golden-headed cisticola	C		1	1
Sylviidae	*Cisticola juncidis laveryi*	zitting cisticola	C		1	
Sylviidae	*Megalurus gramineus*	little grassbird	C		1	1
Sylviidae	*Megalurus timoriensis*	tawny grassbird	C		1	1
Zosteropidae	*Zosterops lateralis*	silvereye	C		1	1
Muscicapidae	*Zoothera heinei*	russet-tailed thrush	C		1	
Muscicapidae	*Zoothera lunulata*	Bassian thrush	C		1	
Species Richness					**403**	**290**

APPENDIX E: CURRICULAR VITAE OF AUTHORS

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FOI 180818
Document 22

From: s22
To: s22
Cc: s22; 's22
Subject: RE: Heritage (historic shipwrecks) Advice on referral for Toondah Harbour Dev [SEC=UNCLASSIFIED]
Date: Wednesday, 20 June 2018 1:55:30 PM
Attachments: image001.png
Importance: High

Hi s22

The remains of the *Toonah* are protected under the *Historic Shipwrecks Act 1976*. The wreck is located amongst the mangroves on Cassim Island (see YouTube video of the wreck below), which I believe is a protected environment, so the channel dredging will not directly impact the shipwreck. However, any indirect impact on the natural marine environment of Cassim Island could have the potential to impact on the preservation of the *Toonah* remains e.g. loss of marine growth that protects the iron hull and would accelerate corrosion processes.

https://www.youtube.com/watch?v=dnki-t9cIY4

Cheers, s22

s22
Senior Program Officer
Historic Heritage Section
Heritage, Reef and Marine Division
Department of the Environment and Energy
Ph: (02) 6274s22
Fax: (02) 6274 s22
GPO Box 787, CANBERRA ACT 2601
http://www.environment.gov.au/heritage/shipwrecks/index.html

From: s22
Sent: Wednesday, 20 June 2018 11:40 AM
To: s22
Subject: Fwd: Heritage (historic shipwrecks) Advice on referral for Toondah Harbour Dev [SEC=UNCLASSIFIED]

From: "s22 @environment.gov.au>
Date: 20 June 2018 at 11:23:35 am AEST
To: Heritage EPBC Mailbox <HeritageEPBC.HeritageEPBC@environment.gov.au>
Cc: "s22 @environment.gov.au>
Subject: Heritage (historic shipwrecks) Advice on referral for Toondah Harbour Dev [SEC=UNCLASSIFIED]

Request for Advice from Heritage Branches

Hello

I am writing to request comments on the following EPBC project:

EPBC Number: 2018/8225

Referral Title: Toondah Harbour Development, Queensland.

Project stage: Referral

Project Documentation: http://epbcnotices.environment.gov.au/referralslist/

Potential Issues:

The Queensland Department of Environment and Science have advised us that there is a historic shipwreck called the “Toondah” located on Cassim Island immediately adjacent to Fision Channel which is proposed to be dredged as part of the proposed action. The Toondah shipwreck is protected under the *Historic Shipwreck Act 1976*.

The referral documentation does not mention the historic shipwreck.

While the consideration of the proposed action under the EPBC Act does not require the historic shipwreck to be considered, is the proposed action likely to cause impacts to the shipwreck that need to be considered under other legislation?

Timeframe for providing advice:

Please email your advice to the primary EAB contact officer by **29 June 2018**.

Name of primary EAB contact officer:

s22

Name of secondary EAB contact officer:

s22

Kind regards

s22

s22
Assessment Officer
Environment Standards Division
Department of the Environment and Energy
GPO Box 787 Canberra ACT 2601
P: 02 6275 s22
s22 @environment.gov.au

DEPARTMENT OF THE ENVIRONMENT AND ENERGY

FOI 180818
Document 23

COMMONWEALTH ENVIRONMENTAL WATER OFFICE

EPBC ACT REFERRAL ADVICE FROM WETLANDS SECTION

REFERRAL: EPBC 2018/8225

DATE DUE BACK TO ESD: 22 JUNE 2018

TOONDAH HARBOUR DEVELOPMENT, MORETON BAY, QLD

Brief Description of Proposal

This referral relates to a modified proposal for a development that was referred in 2017 (2017/7939). The Minister's decision on that proposal was that it was a controlled action with controlling provisions being wetlands of international importance, listed threatened species and ecological communities and listed migratory species.

The proposed action involves the dredging and reclamation of areas of Moreton Bay for the construction of a new ferry terminal, upgraded boat harbour and channel, a marina and residential development. The proposed development is located within a Priority Development Area (PDA) at the existing Toondah Harbour, on the foreshore of Moreton Bay about 30km southeast of Brisbane. Approximately 12 hectares of the referral area is on existing developed land which includes the existing Toondah Ferry terminal, etc. Approximately 42 hectares of the referral area (of 56 hectares) is within the Moreton Bay Ramsar site and within the Moreton Bay Marine Park (Figure 1). The proposed action will create 32 hectares of new land within Moreton Bay, 12 hectares will be urban and infrastructure development and 3.5 hectares of being park land and 3.5 hectares of onservation areas (which will act as a buffer between the marina and Cassim Island and within the 250 metre setback indicated in the referral).

The project construction period is15 to 20 years, with the initial dredging and reclamation occurring intermittently over a 3-5 year period.

The master plan (Figure 2), establishes the general layout. The project involves:

- Two new barge terminals and two ferry terminals (passenger and car)
- Dredging of the existing Toondah Harbour marine access (Fison Channel) – to straighten and widen channel, and extend the swing basin.
- Reclamation of areas within Moreton Bay, using dredged material (approx. 32 hectares).
- Mixed use development including residential (2 to10 storeys – up to 3,600 dwellings), retail, commercial and tourism facilities
- A marina, with 200 berths at floating pontoons and berths alongside shores (see Figure 3)
- Open space/parkland (3.5 hectares of conservation area, with limited public access, and 3.5 hectares of foreshore park) plus upgrade of existing land-based park
- A wetland and cultural education centre, boardwalks and nature trails.

The referral states that the current facility services over one million passengers and 200,000 vehicle movements through the port annually. It is not clear whether the vehicle movements refer exclusively to the boat trips made or encompass the number of vehicles that use the existing car ferry service, The scale of change due to the project is not clear in the referral but will involve a substantial intensification of use as a result of:

- An additional 3,600 dwellings (over 6,000 additional people) living at the site
- 200 new berths for recreational and commercial vessels
- An increase in ferry car parks from 667 to over 1,000 (and possibly an extra 500 in multi-deck)

- Provision for recreational boat launching.
- Deepening the channel to provide access for larger vessels.

The Walker Corporation[1i] website provides additional information and indicates that the proposed Toondah Harbour development is to become a regional tourist hub with a hotel and convention facilities, a marina plaza with boutique retail and dining precinct, and a launch point for ecotourism opportunities to the rest of Moreton Bay. The role this site plays in the Queensland Government's superyacht strategy[2] to increase the berthing opportunities for such vessels along the Queensland coast has not been articulated in the referral but the widening and deepening of the channels opens up opportunities for larger vessels to access Toondah Harbour.

This advice relates specifically to the potential impact of the referral proposal on the elements of the ecological character of the Moreton Bay Ramsar site. This advice does not provide commentary on mitigations, including aspects of site design which may be more sympathetic to wetland conservation, or which may or may not support a case that elements of the proposed project could amount to "wise use" of the Ramsar site under the terms of the Ramsar Convention.

Issues Checklist

How far is the proposal from a Ramsar site?

The proposed action is both within and adjacent to the Ramsar site. The boundary of the Ramsar site and the Priority Development Area (within which much of the development is contained) is at Figure 2.

The Moreton Bay Ramsar site is located in and around Moreton Bay, east of Brisbane in Queensland and was listed in 1993 under six of the nine Ramsar criteria (details from 1999 RIS – new RIS and ECD are under development by Queensland Government):

- **Criterion 1:** contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region – one of largest estuarine bays, enclosed by barrier island of vegetated sand dunes.
- **Criterion 2:** supports vulnerable, endangered, or critically endangered species or threatened ecological communities – supports vulnerable green and hawksbill turtles, the endangered loggerhead turtle and ranked among the top 10 dugong habitats in Queensland.
- **Criterion 3:** supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region – supports over 355 species of marine invertebrates, at least 43 species of shorebirds, 55 species of algae associated with mangroves, seven species of mangrove and seven species of seagrass.
- **Criterion 4:** supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions – significant feeding ground for green turtles, and feeding and breeding ground for dugong. Also has the most significant concentration of young and mature loggerhead turtles in Australia.
- **Criterion 5:** regularly supports 20,000 or more waterbirds – supports more than 50,000 wintering and staging shorebirds during the non-breeding season.

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[1] http://www.toondah-harbour.com.au/downloads/fact-sheet-project-overview.pdf and http://www.toondah-harbour.com.au/faq/

[2] https://www.statedevelopment.qld.gov.au/defence-industries/sea/queensland-superyacht-strategy.html

- **Criterion 6:** regularly supports 1% of the individuals in a population of one species or subspecies of waterbird – significant for population of wintering eastern curlews (3,000 to 5.000) and the grey-tailed tattler (more than 10,000), both substantially more than 1% of Flyway population.

Moreton Bay is a semi-enclosed basin bounded on its eastern side by two large sand islands. Islands in the site include all of Moreton Island, and parts of North and South Stradbroke Islands, Bribie Island and the Southern Bay Islands. Other parts of the site include waters and tributaries of Pumicestone Passage, some intertidal and subtidal areas of the western bay, southern bay and sandy channels of the Broadwater region, marine areas and sand banks within the central and northern bay and some ocean beach habitats.

Wetlands on the site include seagrass and shoals in the eastern banks, tidal flats and associated estuarine assemblages within the Pumicestone Passage, mangroves and saltmarsh in the southern bay, coral communities of the eastern bay, freshwater wetlands and peatland habitats on the Bay Islands and ocean beaches and foredunes on Moreton Island.

The extensive mangrove and tidal flats provide a nursery for fish and crustaceans, and also support birds and other marine life. The wetlands also provide roosting sites for migratory birds.

The seagrass areas provide food and habitat for fish, crustaceans, the internationally vulnerable dugong, and the nationally threatened loggerhead turtles, hawksbill turtle and green turtle.

The site supports more than 50,000 migratory waders during their non-breeding season. At least 43 species of wading birds use the intertidal habitats, including 30 migratory species listed on international conservation agreements. Moreton Bay is one of only two Ramsar sites in Australia that support the critically endangered eastern curlew all year round, with juvenile birds not migrating until they are 2-3 years old.

Is there a real chance or possibility that the proposed action will result in:

Issue	Y	N
areas of the wetland being destroyed or substantially modified?	X	
a substantial and measurable change in the hydrological regime of the wetland?	X	
the habitat or lifecycle of native species dependent upon the wetland being seriously affected?	X	
a substantial and measurable change in the physico-chemical status of the wetland?	X	
an invasive species that is harmful to the ecological character of the wetland being established or encouraging the spread of existing invasive species?	X	

Issues to note

Potential impacts

<u>Areas of the wetland being destroyed or substantially modified</u>

Major elements of the proposed action are located inside the Moreton Bay Ramsar site, with areas of the Ramsar site to be destroyed or substantially modified including the creation of land formerly under water. The referral indicates that the size of the area within the Ramsar site to be affected by dredging, reclamation and disturbance is approximately 42 hectares.

The access channel, swing basin and areas of the marina will be dredged during construction, with maintenance dredging required during operation.

Dredging

Dredging will involve the removal of a significant amount of the seabed in the Fison Channel and in the surrounding coastal areas to the north of the channel. An approximate amount has not been provided but it is likely that to create 32 hectares of new land will involve well in excess of one million cubic metres of dredge material. The Saunders Havill group report, Toondah Harbour Development Project Description, attached to the referral states that preliminary engineering analysis indicates that a minimum of 500 000 cubic metres of material would need to be removed from the channel (p3 refers).

Dredging produces plumes of suspended sediment which can then be transported by wind and currents to areas distant from the development site. The extent of sediment plumes depend on the strength and direction of prevailing winds and currents.

The referral also notes the current dredging of the Fison Channel does not require EPBC Act referral. As an activity existing prior to the introduction of the Act, the maintenance dredging of Fison Channel does not require referral. However, the channel will be widened and deepened, requiring dredging to a target depth of -3 m LAT and a width of 75 m (currently -2.5 LAT and 45 m wide) which will mean that as a minimum an area of 30 metres by 2.55 kilometres (the current length of Fison Channel) of untouched seabed will be destroyed. It is highly likely that the widening of the Fison Channel will cause wash and sediment plumes to impact on the nearby Nandeebie Clay Pan which is of high conservation value to migratory bird species.

No information has been provided for the dredging depth that will occur in areas outside of the Fison Channel to enable the construction of 200 marina berths and connecting channels. It is highly likely that the dredging and deposition of land to construct new conservation areas close by Cassim Island will also create sediment plumes which will significantly impact an area of high conservation value to migratory species. The mangroves of Cassim Island provide nurseries for crustaceans and fish which are part of the food web for other species including migratory birds.

The nature of the materials in sediment plumes may have further impacts which will be discussed below.

Reclamation

Dredged material will be used to form new parcels of land within the site. The project involves 32 hectares of reclamation, of which 12 hectares will be developed (with buildings and facilities) and 3.5 hectares of park land and 3.5 hectares of conservation area.

These activities will destroy or substantially modify wetlands within those areas (including the seabed), and this will be a permanent change. In addition, the development will alter the hydrodynamics of the local area, which could destroy or modify wetland areas beyond the development footprint. The mangroves on Cassim Island, adjacent to the development may be subject to significantly greater amplitude and frequency of waves because of decreased distance to the shoreline. The constriction produced by the proposed conservation reserve could also lessen wave action to the western boundary of Cassim Island which could lead to deposition which could negatively impact the seagrass and mangroves in that area. Hydrodynamic modelling would be required to confirm the area of impact on the Ramsar site and the nature of that impact.

If there is a net excess of material from dredging/reclamation, the proponent states it may be disposed of offshore, onshore or re-used. If this material is disposed of anywhere within the Ramsar site, it may destroy or modify further areas of wetland. Mud Island is mentioned as a possible disposal site for excess spoil. Mud Island is part of the Moreton Bay Ramsar site and supports endangered migratory species such as the eastern curlew. The referral also mentions Mud Island as a temporary land-based handling facility for dredge material which would then mean that dredge material is transported back and forth across Moreton Bay which could lead to further areas being impacted. Detail on the extent of possible impact or damage to the ecosystem values of Mud Island is not sufficient to provide a more definitive analysis at this stage.

Other areas of the Moreton Bay Ramsar wetland are also likely to be modified by the presence of an intensively developed residential/commercial tourist hub bringing increased visitor and boating activity throughout the southern Bay and islands, with expected impacts on hydrology, water quality and habitats.

Overall, the proposed action will have a substantially adverse impact in terms of destruction and modification of areas of the wetland. This impact is not confined to the development footprint.

A substantial and measurable change in the hydrological regime of the wetland

The hydrology of Moreton Bay is influenced by the interaction of the semi-diurnal tide which propagates mainly through the northern entrance with the depth variation inside the Bay. Tidal currents depend on the depth and topography of the Bay. Dredging and reclamation will change the depth and topography of the seabed within the referral area and this has the potential to impact on wave action, currents and the dispersal of sediments. In the absence of detailed hydrological monitoring it is difficult to predict the actual impacts that will occur within the Moreton Bay Ramsar site but some general observations can be made.

As the reclaimed land extends into Moreton Bay, it is likely that the proposed reclamation, marina and channel dredging could affect coastal currents in the area. These changes could result in changes to sand and sediment movement in the adjacent areas of the Ramsar site which could impact the biota in those areas, including through changes to light penetration and smothering of seagrasses. Changes in tidal action could also erode mud flats which provide foraging habitat for migratory species. Hydrological constriction points may be created such as between the conservation reserve and Cassim Island which have the potential to negatively impact seagrass and mangroves.

The Toondah Harbour Master plan indicates that there are 12.5 hectares of waterways in the reclaimed area (ibid p3), presumably consisting of the marina berths and associated channels. The hydrological impacts of these new waterways is unknown. Slow moving water with high levels of nutrients in microtidal areas are however associated with the growth of algal blooms which can be toxic to humans and to aquatic species.

The proponent identifies a number of studies to be undertaken to better understand the risks, including hydrodynamic modelling, which will be taken into account in the final design of the project. It is unclear how these risks can be mitigated.

The proposed action is likely to have an adverse impact on the hydrological regime of the wetland. These impacts are not confined to the development footprint.

The habitat or lifecycle of native species dependent on the wetland being seriously affected

The referral area contains intertidal and shallow subtidal habitats including:

- mangrove forests
- intertidal and subtidal mudflats and sand banks
- seagrass meadows.

These habitats are important for the ecological character of the Moreton Bay Ramsar site and support a range of native species dependent upon the wetland. They provide intertidal feeding habitat for migratory shorebirds, including the critically endangered Eastern Curlew, the vulnerable Bar-tailed Godwit, and the critically endangered Great Knot. These important areas of foraging habitat cover a large proportion of the development site, are within the Moreton Bay Ramsar site, and will be removed through construction of the marina and reclamation for construction of residential/commercial buildings. The increased presence of humans and pets in turn has the potential to disturb migratory birds using the site.

The impacts of dredging associated with the proposal are highly likely to impact areas outside the development footprint. It is difficult to estimate the extent of impact in the absence of detailed modelling on dredge plumes associated with excavation and deposition, the nature of the dredged material (in particular whether it contains contaminants that are detrimental to aquatic species) and the transport regime for the deposition and storage of dredged material.

Two high tide roost sites are adjacent to the development area, at the Nandeebie Claypan (to the south west) and Cassim Island (to the east). Oyster Point is also another roost site (600 m from the proposed action) which forms part of a network of feeding and roosting sites. These sites are of high importance to shorebirds in the region. Likely impacts include disturbance from dredging and deposition of dredged material (increased turbidity and wave action and sedimentation), construction noise, lights and activity and by increased urban populations and boat use in the area once the area has been developed.

The proponent has identified a number of mitigating measures for these bird habitats, including measures to reduce sediment during construction, management of acid sulfate soils, buffers, barriers, management of public access, lighting, vegetation screening and sound attenuation and signage.

However, the impacts to these habitats will be difficult to fully mitigate, particularly disturbance during the dredging and construction period, including increased turbidity impacting foraging sites, noise, light, vibration, sediment, etc. In terms of design, the development is proposed to be set back 250 metres of the roosting sites, to limit disturbance to the Eastern Curlew (which is easily disturbed). However, the conservation reserve within the 250 metre buffer could create provide a pathway for predators and the roosting and feeding sites will be overlooked by large high-rise developments and be impacted long-term, due to an increase in numbers of residents and visitors, and an increase in boating traffic.

With one of the stated purposes of the development being an ecotourism hub, the increased numbers of boats and visitors using the upgraded harbour and marina are also likely to access other less-developed areas of the Moreton Bay Ramsar site, including the Bay itself and North Stradbroke Island, creating broader impacts on native species within the Ramsar site.

The site and its surrounds also support important foraging habitat for green and loggerhead turtles, as well as dugongs (with 32.7 hectares of seagrass in the PDA). Loss of seagrass directly by removal or indirectly by sedimentation or smothering, increased recreational boat traffic and dredging of the channel are likely to have adverse impacts on turtles and dugongs within the Bay.

The proposed action is likely to lead to a substantial increase in vessel traffic, which may cause adverse impacts on whales and dolphins within Moreton Bay.

The proponent has identified some of these risks and has provided some information on proposed management measures such as those listed above It is difficult to assess whether they would be sufficient to mitigate the risks to the habitat or life cycle of native species dependent upon the wetland and the potential impacts on the ecological character of the Moreton Bay Ramsar site.

The referral does not address potential impacts on the adjacent coastal saltmarsh community (which is [3]listed as vulnerable under the EPBC Act). This habitat provides valuable feeding and roosting areas for waders and contributes to intertidal food webs.

The referral does not make clear who will take responsibility for management actions in the longer term (operational phase), as the marina and residential sites will be sold to private owners, nor does it indicate where management responsibility lies for the parklands and conservation area.

It is considered that the proposed action has the potential to disrupt the habitat, lifecycle and foodwebs of an ecologically significant proportion of the populations of migratory shorebirds, and may adversely affect populations of turtles and dugongs.

A substantial and measurable change in the physico-chemical status of the wetland

Any action involving the clearing of vegetation, dredging, excavation and/or reclamation creates the potential for sediments and/or other contaminates to be discharged. Regardless of the amount of disturbance or final design for any action, physico-chemical changes will occur and need to be managed to reduce the risk of impacts to the ecological character of a Ramsar site. These changes include increased nutrient load, increased turbidity (reduced light penetration), increased potential for acidified water, and changes to pH which can change the competitive advantage of some species. These impacts have potential to impact well beyond the development site.

The referral site is in a land area where acid sulfate soils (ASS) are less than 5 metres below the surface[4]. The proposed action will expose coastal marine sediments to air which creates a risk of the exposure of ASS, the associated acidification of water and the potential release of metals and other contaminants, dissolved in the acidified water. This may potentially result in chronic or acute impacts on biota. The referral's Marine Ecology report states that sudden acidification has been responsible for fish kills, disease and other disturbances and that chronic low level acidity may reduce vigour and predispose marine biota to other diseases. The proponent intends to establish a sediment and analysis plan but no details are available.

The proponent has identified some of these risks but inadequate information is available on proposed management measures to assess whether they would be sufficient to mitigate the risks to the physico-chemical status of the wetland and potential impacts on the ecological character of the Moreton Bay Ramsar site.

There are highly likely to be adverse impacts on the physico-chemical status of the wetland.

An invasive species that is harmful to the ecological character of the wetland being established or encouraging of existing invasive species

Invasive species in water

Dredging of acid sulfate soils can release iron into the water column which benefits the growth of toxic lyngbya algal blooms. Other areas of Moreton Bay have been affected by the bloom which produces algal mats which smother seagrass disrupting the foraging habitat for migratory and aquatic species.

The increased ship and boat movements envisaged under this proposal increases the risk of harmful species entering the site through ship ballast water or biofouling.

The design of the marina berths create microtidal areas which create conditions beneficial to the growth of algal blooms. Algal blooms can block light penetration reducing seagrass areas and creating anoxic or

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[4] Redlands Planning Scheme – Acid Sulfate Soils Overlay – http://www2.redland.qld.gov.au/PlanningandBuilding/RPS/RPSV71%20Overlay%20Maps/Acid_Sulfate_Soils_MI_V7.1.pdf

hypoxic conditions which can lead to invertebrate and fish mortality which in turn impacts the food webs of migratory species that use the site.

Invasive species on land.

There is a possibility of weeds spreading in to the site due to residential development and parklands unless plantings are limited to local coastal native species.

The proposed action has a potential risk of establishing new invasive species or encouraging existing invasive species.

Conclusion

On the basis of the available information, the proposed action is likely to result in substantially adverse impacts both within the PDA and in broader areas within the Ramsar affected by the proposal due to loss of areas of wetland, changes to the hydrological regime and physico-chemical status of the wetland and impacts on the habitat and life cycle of a number of species, including migratory shorebirds.

Although detailed project specification and/or environmental assessments have not been undertaken, the scale and nature of the action is such that a substantially adverse impact on the ecological character of the Moreton Bay Ramsar site is likely, due to impacts within the PDA and broader areas of the site. Design and operational measures have been proposed to mitigate some of the impacts, but it is not possible, with the limited information available at this stage of the process, to assess the effects of these mitigating measures. Changes to the ecological character of the Ramsar site are nevertheless unavoidable, through direct removal of habitat (dredging and reclamation), operation of the marina and residential/commercial facilities, and by the increased use of the development site and other areas of the Ramsar site for recreational purposes.

With regard to any further assessment processes for the proposal, and measures to manage or mitigate potential impacts, it is important that all State legislative requirements are met (including requirements under the Queensland Marine Parks Act).

On the basis of the available information, there is a real chance or possibility that there will be an adverse impact on the ecological character of the Moreton Bay Ramsar site as a result of the proposed action.

Advice prepared by:	s22
Other DoEE areas consulted:	Migratory Species
Is OWS providing advice?	No
EACD Referral Officer:	s22

Cleared by: s22, Director: Wetlands Section

Signature:..

Date:

Cleared by: Mark Taylor, Assistant Secretary: Wetlands, Policy and Northern Basin Branch

Signature: s22

Date: 5 July 2018

Sources:

- Moreton Bay Ramsar Information Sheet
- Moreton Bay Ramsar site Draft ECD
- Wylie Mapping Application
- Referral documentation

Attachments:

Figure 1: Location of Toondah Harbour proposal and Moreton Bay Ramsar site

Figure 2: Master Plan – Broad Land Uses

Figure 3: Concept Urban Development Precinct

Location of Toondah Harbour proposal and Moreton Bay Ramsar site

Legend

- PDA - Toondah Harbour
- Approved dredge area
- Moreton Bay RAMSAR wetland

Figure 1a Site Context

File ref. 8444_E_01_Context_approved_DA_A
Date 4/05/2018
Project Toondah Harbour

0 1 2 3 4 5 6 km

Scale (A4): 1:160,000 [GDA 1994 MGA Z56]

walker

saunders havill group

Layer Sources: QLD GIS Layers (QLD Gov. Information Service 2018)

Figure 2

Toondah Harbour proposal, Moreton Bay – Master Plan – Broad Land Uses

saunders havill group

walker

TOONDAH HARBOUR, CLEVELAND

Figure 3

Concept Urban Development Precinct

FOI 180818
Document 24

Department of the Environment and Energy

Biodiversity Conservation Division

EPBC Act Referral Advice from the Migratory Species Section

Toondah Harbour Development, QLD (EPBC 2018/8225)

Proposed action

The proposed action involves the filling in of marine areas for urban development and public open space, the excavation of a marina and the widening, deepening and lengthening of Fison Channel, which is the existing entrance channel to Toondah Harbour, on the foreshore of Moreton Bay about 30km southeast of Brisbane.

The project involves:

- New ferry terminals to improve access to North Stradbroke Island;
- Mixed use development including (high rise) residential, retail, commercial and tourism uses;
- A marina;
- Public open space;
- Capital and maintenance dredging; and
- Reclamation of areas within Moreton Bay.

The project footprint contains intertidal and shallow subtidal habitats including: mangrove forests; intertidal and subtidal un-vegetated mudflats and sand banks; seagrass meadows; and subtropical coastal saltmarsh community.

It is noted that there is a change in the project footprint from the previous referral (EPBC 2017/7939), however the likely impacts to listed migratory species has not been demonstrated to be lower the last referral. As such the advice below is the same as advice provided on the previous referral by the Migratory Species Section on 23 May 2017.

Migratory Birds

Moreton Bay supports more than 50,000 migratory waterbirds during their non-breeding season. At least 43 species of waterbirds use the intertidal habitats, including 30 migratory species listed on international conservation agreements. Moreton Bay is one of only two Ramsar sites in Australia that supports the critically endangered eastern curlew all year round, with juvenile birds not migrating until they are 2-3 years old. This means that the juveniles are residents in Moreton Bay until they reach maturity and are ready to migrate.

Migratory shorebirds need to maintain an energy intake greater than their energy expenditure to recover from the southward migration, and to build fat reserves in preparation for the northward migration. Relative amounts of time spent feeding and resting, and the distances between their feeding and roosting areas, are important factors in the energy budgets of individual shorebirds.

The Moreton Bay Ramsar site provides an important network of foraging and roosting habitats. Shorebirds move within these areas depending on the time of day, availability of resources, levels of disturbance and environmental conditions. Some habitats are important refuges during extreme high tides or when weather conditions prohibit occupancy of more commonly used habitats.

Because migratory shorebirds mostly feed on intertidal mudflats, they require safe roosting areas to rest during high tide periods. The high energy demands on migratory shorebirds resulting from their migratory lifecycle means that resting is critical when not breeding. Generally, migratory shorebirds prefer roosting areas in open habitat on slightly elevated ground so they can watch for potential predators.

The proposal is considered likely to result in adverse impacts to the EPBC listed eastern curlew (critically endangered; migratory), bar-tailed godwit (vulnerable/critically endangered; listed migratory), whimbrel (migratory) and grey-tailed tattler (migratory).

Eastern curlew (*Numenius madagascariensis*) (EPBC Act critically endangered; migratory)

Usually, eastern curlews feed singly or in loose flocks. Occasionally, this species is seen in large feeding flocks of hundreds (Marchant & Higgins, 1993). Moreton Bay Ramsar site is one of the most important areas for eastern curlew in Australia (maximum count 3,500 individuals on 1 January 1996). It remains internationally important all year round because of the high number of juvenile birds during the Austral winter.

Eastern curlew are sensitive to certain development activities due to their high site fidelity, tendency to aggregate, very high energy demands, and need for habitat networks containing both roosting and foraging sites (DotE 2015). The eastern curlew is extremely wary and will take flight at the first sign of danger, long before other nearby shorebirds become nervous. The ***minimum*** distance between a disturbance event (stimuli) and important eastern curlew habitat is 200m.(http://www.avianbuffer.com/)

The proposed development will remove a substantial amount of foraging habitat of this species and impact two known roosting sites (Nandeebie claypan and offshore mangrove roost), one of which has recorded a maximum count of 180 individuals (Nandeebie claypan). The mosaic of roost sites and foraging sites must be maintained.

The proposed development will:

- reduce the area of occupancy of the species by removing a considerable area of foraging habitat.
- adversely affect important habitat critical to the survival of the species, such as roosting habitat (Nandeebie claypan and Mangrove roost)
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, such as the proximity of the residential development and tourism providing humans and animals with greater access to foraging and roosting areas, thus increasing stressors on the birds.
- result in invasive species that are harmful to a critically endangered species becoming established in the species' habitat by linking the offshore mangrove roost sites to the mainland.
- interfere with the recovery of the species by removing important habitat and causing increased disturbance.
- will seriously disrupt the lifecycle (feeding, migration and resting behaviour) of an ecologically significant proportion of a population of eastern curlew.

Bar-tailed godwit (EPBC Act spp. *baueri* vulnerable; spp *menzbieri* critically endangered; listed migratory)

The bar-tailed godwit (both subspecies combined) has been recorded in the coastal areas of all Australian states. Moreton Bay Ramsar site is likely to provide habitat for *Limosa lapponica baueri* (western Alaskan subspecies) but may also contain *Limosa lapponica menzbieri* (northern Siberian subspecies). In Australia, *L. l. baueri* mainly occur along the north and east coasts (Garnett et al. 2011) such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. The bar-tailed godwit (western Alaskan) usually forages near the edge of water or in shallow water, mainly in tidal estuaries and harbours. They prefer exposed sandy or soft mud substrates on intertidal flats, banks and beaches. The bar-tailed godwit (western Alaskan) usually roosts on sandy beaches, sandbars, spits and also in near-coastal saltmarsh (Higgins & Davies 1996).

Migratory shorebirds, such as the bar-tailed godwit (western Alaskan), are sensitive to certain development activities due to their: high site fidelity, tendency to aggregate, very high energy demands, and need for habitat networks containing both roosting and foraging sites (Department of the Environment 2015a,b). Threats in Australia, especially eastern and southern Australia, include ongoing human disturbance as well as habitat loss and degradation from pollution, changes to the water regime and invasive plants (Rogers et al. 2006; Garnett et al. 2011; Department of the Environment 2015a,b).

Habitat loss and degradation

In Australia, the loss of important habitat reduces the availability of foraging and roosting sites. This affects the ability of the birds to build up the energy stores required for successful migration and breeding. Some sites are important all year round for juveniles who may stay in Australia throughout the breeding season until they reach maturity. A variety of activities may cause habitat loss. These include direct losses through land clearing, inundation, infilling or draining. Indirect loss may occur due to changes in water quality, hydrology or structural changes near roosting sites (Department of the Environment 2015a,b). Anthropogenic nutrient enrichment of wetland areas can cause cyanobacterium blooms that may impact the prey species of bar-tailed godwits (e.g. at Roebuck Bay; Estrella et al. 2011).

Disturbance

Human disturbance can cause shorebirds to interrupt their feeding or roosting and may influence the area of otherwise suitable feeding or roosting habitat that is actually used. Disturbance from human recreation activities may force migratory shorebirds to increase the time devoted to vigilance and anti-predator behaviour and/or may compel the birds to move to alternative, less favourable feeding areas (Goss-Custard et al. 2006; Glover et al., 2011; Weston et al., 2012). Human disturbance can interrupt feeding and may restrict the area of feeding habitat available for bar-tailed godwits. Bar-tailed godwits (western Alaskan) at Phillip Island, Victoria, were recorded taking flight when humans approached within 10–70 m of them (Taylor & Bester 1999). The ***minimum*** distance between a disturbance event (stimuli) and important bar-tailed godwit habitat is 50m.(http://www.avianbuffer.com/)

The proposed development will remove a substantial amount of foraging habitat of this species and impact two known roosting sites (Nandeebie claypan and offshore mangrove roost). The maximum count of bar-tailed godwits on Nandeebie claypan is 2,300 birds (approximately 20% of bar-tailed godwits recorded in Moreton Bay (Bamford et al. 2008)). Birds using the Nandeebie Claypan also use the nearby Oyster Point shoreline roost, moving between the two roost sites depending on the height of the tide and extent of disturbance at Oyster Point. The mosaic of roost sites and foraging sites must be maintained.

The proposed development will:

- reduce the area of occupancy of the species by removing a considerable area of foraging habitat.
- adversely affect important habitat critical to the survival of the species, such as roosting habitat (Nandeebie claypan, Oyster Point and Mangrove roost)
- modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, such as the proximity of the residential development and tourism providing humans and animals with greater access to foraging and roosting areas, thus increasing stressors on the birds.
- interfere with the recovery of the species by removing important habitat and causing increased disturbance.
- will seriously disrupt the lifecycle (feeding, migration and resting behaviour) of an ecologically significant proportion of a population of bar-tailed godwit.

Migratory shorebirds (whimbrel, grey-tailed tattler, bar-tailed godwit, eastern curlew)

The proposed development is in an area of nationally important habitat for migratory shorebirds. At this site, >0.1% of the flyway population of eastern curlew, whimbrel, grey-tailed tattler and bar-tailed godwit occur, particularly at Nandeebie claypan and the Cassin Island roosting sites (see EPBC Act Policy Statement 3.21).

The proposed development:

- will substantially modify, destroy or isolate nationally important habitat for eastern curlew, whimbrel, grey-tailed tattler and bar-tailed godwit.
- could result in an invasive species that is harmful to listed migratory species becoming established in an area of important habitat by linking the offshore mangrove roost sites to the mainland (Cassin Island).
- will seriously disrupt the lifecycle (feeding, migration and resting behaviour) of an ecological significant proportion of the population of eastern curlew, whimbrel, grey-tailed tattler and bar-tailed godwit.

Marine turtle

Moreton Bay supports important foraging populations of green, hawksbill and loggerhead turtles and is close to the southern-most extent of their range. The area is considered a significant feeding ground for the green turtle (Australian Wetlands Database).

***Loggerhead turtle* (EPBC Act endangered; migratory)**

Loggerhead turtles in Australia are divided into two genetically distinct populations. Those found in Moreton Bay are part of the East Australian breeding stock (Limpus 2008) and are referred to as the loggerhead south-west Pacific stock (Recovery Plan for Marine Turtles in Australia, 2017). The *Marine Bioregional Plan for the Temperate East Marine Region* (2012) (bioregional plan) states that large concentrations of foraging loggerhead turtles have been found in Moreton Bay. Minor breeding aggregations occur in Moreton Bay, including Moreton Island and Stradbroke Island (Limpus 2008). The bioregional plan identifies the waters between Bustard Head QLD and Ballina in NSW as being biologically important for nesting loggerhead turtles. Moreton Bay forms the southern extent of their foraging range making this foraging population an important population.

Adults and large juvenile loggerhead turtles inhabit environments with both hard and soft substrata, including rocky and coral reefs, muddy bays, sand flats, estuaries and seagrass meadows (*Marine*

Bioregional Plan for the Temperate East Marine Region, 2012). Loggerhead turtles are carnivorous, feeding primarily on benthic invertebrates including gastropod molluscs, clams and small amounts of jellyfish, starfish, corals, crabs and fish (SPRAT). In Moreton Bay, loggerhead turtles inhabit seagrass beds and are often found resting in channels.

Currently, the recovery plan (2017) identifies chemical and terrestrial discharge, vessel disturbance and habitat modification (through dredging/trawling and infrastructure/coastal development) as moderate threats for this species. The categorisation of these threats as moderate means that while they have not begun to reduce the population in their own right they are cumulatively acting with other threats to undermine population viability.

In addition, the Australian Government led the development of the Convention on the Conservation of Migratory Species (CMS) *Single Species Action Plan for Loggerhead Turtles (*Caretta caretta*) in the Pacific Ocean* (Loggerhead Plan). The Loggerhead Plan was unanimously adopted by the CMS Convention of the Parties in 2014 and calls on Australia to address threats to this population. The Loggerhead Plan identifies dredging and marina construction within foraging areas as a threat to the stock. In accordance with Australia's international obligations impacts to important loggerhead habitat in Moreton Bay should be minimised.

The proposed action is likely to reduce the area of occupancy of an important population of loggerhead turtles and may interfere with the recovery of the species. **Adverse impacts to loggerhead turtles are considered likely.**

***Green turtle* (EPBC Act vulnerable; migratory)**

Green turtles that occur in Moreton Bay are part of the southern Great Barrier Reef breeding stock (Recovery Plan for Marine Turtles in Australia, 2017). Important nesting sites for this stock generally occur from the Fraser Coast area north to the Capricornia Bunker Islands, however very low density nesting may occur on beaches in the Moreton Bay area.

Green turtles can be found in shallow waters where they forage principally on seagrass, algae and mangrove fruits, living in coral and rocky reefs, seagrass beds and algal mats. The *Marine Bioregional Plan for the Temperate East Marine Region* (2012) identifies Moreton Bay as being biologically important for foraging green turtles. The referral states that extensive areas of intertidal seagrass beds occur within and adjacent to the project footprint.

Currently, the recovery plan (2017) identifies light pollution, vessel disturbance and habitat modification (through dredging/trawling and infrastructure/coastal development) as moderate threats for this species. The categorisation of these threats as moderate means that while they have not begun to reduce the population in their own right they are cumulatively acting with other threats to undermine population viability.

The proposed action will result in the loss of important foraging habitat from dredging and reclamation activities. This will result in a reduced area of occupancy for an important population. Further, interactions with dredge vessels, construction and operational disturbance may lead to mortality of individuals within the population and changes to water quality may affect seagrass habitat outside the proposed footprint, thus reducing available foraging habitat further.

The project is also likely to facilitate activities that will adversely impact green turtles within the greater area such as disturbance from and collision with vessels and increased potential for the ingestion of marine debris. It is unclear if the project will result in additional ferry services which may also increase disturbance and the risk of vessel strike.

The proposed action is likely to reduce the area of occupancy of an important population of green turtle. Further, it is likely to modify, destroy, remove or isolate, or decrease the availability or quality of green turtle habitat to the extent that this important population is likely to decline. **Adverse impacts to green turtles are considered likely.**

***Hawksbill turtle* (EPBC Act vulnerable; migratory)**

Moreton Bay represents the southernmost extent of hawksbill distribution. Hawksbills forage in seagrass beds and coral reefs and as such may utilise areas within the proposed development. Hawksbills foraging in SE Queensland may be part of the north Queensland genetic stock, or may come from stocks nesting in other areas throughout the Pacific.

The proposed action may impact on a small number of foraging hawksbill turtles, but is **unlikely to have an adverse impact** on the north Queensland genetic stock, or other regional hawksbill stocks.

Dugong (EPBC Act migratory)

In Australia, dugongs occur from Shark Bay in Western Australia across the northern coastline to Moreton Bay in Queensland (Marsh, H., et al. (2011)).

In Moreton Bay, the eastern Amity Banks, Moreton Banks and areas adjacent to these sandbanks are considered the most important habitats with Rous Channel and east of South Passage also important in cooler months (SPRAT).

An assessment by Marsh et al (2011) on the status of the 'urban coast of Queensland' (Cooktown to Moreton Bay) dugong population indicates that this population meets the IUCN criteria for Critically Endangered. Delisle et al (2014) states that if the urban coast population is to recover it is essential that all anthropogenic sources of direct dugong mortality be minimised.

Dugongs are seagrass community specialists and the range of the dugong is broadly coincident with the distribution of seagrasses. There is also evidence that dugongs use specialised habitats for various activities, such as avoiding shark attack by resting on the edge of sandbanks (SPRAT).

Dugong have traits that make them susceptible to threats, including being long-lived with low reproductive potential, delayed sexual maturity, high female investment in each offspring, and a reliance on inshore habitats (GBRMPA 2014).

The Dugong Vulnerability Assessment for the GBR (GBRMPA 2014) identifies the following threats to the 'urban coast dugong management unit':

Incidental drowning in nets used by commercial fishing.

- Cumulative pressures to their primary food, seagrasses, from habitat loss and degradation as a result of extreme weather events (i.e. floods), coastal development (ports/mariners/harbours development and land reclamation), reduced water quality due to coastal development (ports/mariners/harbours operations and dredging).
- Increased occurrence of boat strike and disturbance.
- Ingestion of and entanglement in marine debris.

- Dugong face a variety of pressures that may reduce their resilience to current and future impacts of climate change and impede their capacity to adapt including, accelerated rates of climate change, depleted population, cumulative impacts of human related threats and a reduction of alternative habitats for foraging along the developing urban coast.

The proposed action is likely to substantially modify, destroy or isolate an area of important habitat for dugong; seriously disrupt the lifecycle of an ecologically significant proportion of a population of dugong. **Adverse impacts to dugong are considered likely**.

Cetaceans

***Southern right whale* (EPBC Act endangered; migratory)**

The core range of the southern right whale includes the coastal waters of southern Australia from Sydney to Perth, however they are known to occur further north with the extremities of their range recorded as far north as Hervey Bay in QLD (*Southern Right Whale recovery Plan 2012), and are known to visit Moreton Bay (Department of National Parks, Sport and Racing). Within their range they generally occur within two km off shore.

Preliminary data suggests that the south-eastern and south-western Australian whales may represent distinct genetic stocks. Southern right whales in south-western Australia appear to be increasing at the maximum biological rate, however there is limited evidence of increase in south-eastern waters (Recovery Plan 2012).

High risk threats identified in the Recovery Plan (2012) include:

- Vessel collision.
- Noise interference – loud noise or long exposure may lead to avoidance of important habitat areas. Potential forms of noise interference include industrial noise such as pile driving and dredging, and vessel noise.
- Habitat modification – through the development of infrastructure such as ports and marinas could lead to the displacement of whales from preferred habitat or disruption to behaviour.

The Recovery Plan (2012) states that vessel collision is greater for the southern right whale when they are in costal zones due to the higher probability of encountering vessels and that as shipping traffic increases '*the impact on an individual, especially in south east Australia, is likely to have a significant, potentially population-scale effect, if further evidence confirms this as a small demographically discrete population*'.

Southern right whales appear to be the primary whales species involved in vessel collision in the southern hemisphere (Van Waerebeek et al, 2007). According to media reports (http://www.abc.net.au/news/2014-08-17/whale-washes-up-in-moreton-bay-with-propeller-cuts-to-head/5676732) a southern right whale was killed in 2014 when it was struck by a ferry travelling between the existing Toondah harbour and Stradbroke Island.

In conclusion the proposed development may:

- *Reduce the area of occupancy of the species:* The proposed action may result in the disturbance and interference of whales due to an increase in vessel traffic and pilling activities. Southern right whales that occur in Moreton Bay are part of a population that is at the limit of the species range.

- *Interfere with the recovery of the species*: A potential increase in ferry traffic is likely to increase the risk of vessel collision to the southern right whale.

There is insufficient information in the referral to understand the potential threats to this species, especially the risks associated with increased vessel traffic. **The proposed action may result in adverse impacts to the southern right whale**.

* The Conservation Management Plan for the Southern Right Whale is recognised as a Recovery Plan under section 269A of the EPBC Act.

***Humpback Whale* (EPBC Act vulnerable; migratory)**

Humpback whales are frequent visitors to Moreton Bay as they migrate from the southern feeding grounds to breed in warmer waters. The *Marine Bioregional Plan for the Temperate East Marine Region* (2012) identifies Moreton Bay as being biologically important for migration, peaking in June–July (northbound) and August– mid-October (southbound). Resting females and calves can be present from August –October.

Threats identified in the Humpback Whale Conservation Advice (2015) include:

- Noise Interference – e.g. industrial noise (pile driving, some forms of dredging, use of explosives, blasting and drilling) and shipping noise;
- Habitat degradation including coastal development and port expansion; and
- Vessel disturbance and strike.

The referral lacks sufficient information to understand the expected increase of vessel traffic and how this might impacts on migrating or resting humpback whales. There is also insufficient information on the expected level of noise in the marine environment.

In the absence of adequate information, it is likely that the action will increase the likelihood of vessel disturbance and strike, and increase the level of anthropogenic noise, at times when humpback whales are present in Moreton Bay.

Dolphin

Indo-Pacific humpback dolphin (EPBC listed Migratory)

Indo-Pacific humpback dolphins are found in coastal and estuarine areas of Queensland and New South Wales, generally at depths less than 20 m, including inshore reefs, tidal and dredged channels, mangroves and river mouths (SPRAT).

The *Marine Bioregional Plan for the Temperate East Marine Region* (2012) identifies the waters off Cooloola National Park to the New South Wales border (including Moreton Bay) within the 20 m depth contour as being biologically important for foraging and breeding Indo-Pacific humpback dolphins.

The Plan states that pressures of concern for inshore dolphins in this region include physical habitat modification while pressures of potential concern include noise pollution and collision with vessels.

The referral lacks sufficient information to determine the presence of this species in the local and greater region and the potential impacts.

Australian snubfin dolphin (EPBC listed migratory) *dusky dolphin* (EPBC listed Migratory)

The Australian snubfin dolphin occur in coastal water off the northern half of Australia, including as far south as the Brisbane River on the east coast. This species shares similar habitat preferences as the Indo-Pacific humpback dolphins (SPRAT). While the dusky dolphin may occur in Moreton Bay, it is primarily found in temperate and sub-Antarctic waters. Adverse impacts are considered unlikely.

The referral lacks sufficient information to determine the presence of these species in the local and greater region and the potential impacts.

Advice prepared by: s22 [redacted]

Checked by: s22 [redacted], Director Migratory Species Section

Cleared by: Geoff Richardson, Assistant Secretary Protected Species and Communities Branch.

Signature: s22 [redacted]

Date: 22/6/2018

References

- Australian Wetlands Database- Moreton Bay RAMSAR Site https://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=41
- Conservation Management Plan for the Southern Right Whale – A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999* – (2011- 2021).
- Department of National Parks, Sport and Racing (QLD) http://www.nprsr.qld.gov.au/parks/moreton-bay/culture.html
- Humpback Whale Conservation Advice (2015) http://www.environment.gov.au/biodiversity/threatened/species/pubs/38-conservation-advice-10102015.pdf
- *Marine Bioregional Plan for the Temperate East Marine Region* (2012)
- Marsh, H., et al. (2011). *Ecology and Conservation of the Sirenia. Dugong and Sirenia* Cambridge, University Press.
- Species Profile and Threat Database (SPRAT)
- Van Waerebeek et al (2007) Vessel collision s with small cetacean's worldwide and large whales in the Southern Hemisphere, and initial assessment, Latin American Journal of Aquatic Mammals.
- Great Barrier Reef Marne Park Authority: Vulnerability Assessment for the GBR – Dugong (2014) http://elibrary.gbrmpa.gov.au/jspui/bitstream/11017/2867/1/gbrmpa_VA_Dugong_15%20September%202014_final.pdf

FOI 180818
Document 25

Queensland
Government

Department of
Environment and Science

Ref 101/0003868-006

19 June 2018

Mr s22
Queensland North Assessments Section
Assessment and Governance Branch
Department of Environment and Energy
GPO Box 787
CANBERRA ACT 2601

Dear Mr s22

Consultation on referral EPBC 2018/8225 – Toondah Harbour Development, Moreton Bay, Qld

Thank you for your letter dated 5 June 2018 inviting consultation on the proposed Toondah Harbour Development action being assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Department of Environment and Science (the department) provides the following information to assist in your decision as to whether you consider the proposed action is likely to have a significant impact on any of the matters protected under the EPBC Act:

1. The boundary of the referral area outlined in the referral documents does not include all of the capital and maintenance dredging components of the proposed project. The project description attached to the referral documents (Attachment 2) refers to capital dredging to straighten and widen the Fision Channel and extend the swing basin. It states that a minimum of 500,000 cubic meter of material would need to be removed from the channel in addition to future maintenance dredging. The referral footprint shown in Figure 2 (titled '*Master Plan –broad land uses*') only incorporates dredging within the Priority Development Area and does not show the additional area proposed to be dredged to widen Fision Channel.

2. There is a historic shipwreck called the 'Toondah[1]' located on Cassim Island immediately adjacent to the Fision channel which is proposed to be dredged as part

[1] https://dmzapp17p.ris.environment.gov.au/shipwreck/public/wreck/wreck.do?key=2422

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of the project. The Toondah shipwreck is protected under the Commonwealth *Historic Shipwreck Act 1976* and the Queensland *Heritage Act 1992*. This shipwreck is not mentioned under section 3.8 of the referral which discusses heritage values.

In regards to your request for advice on whether the above action will be assessed in a manner described in Schedule 1 of the Agreement between the Commonwealth of Australia and the State of Queensland (the Bilateral Agreement) developed under Section 45 of the EPBC Act, I provide the following advice.

- The proposal will not be assessed using the EIS process in chapter 3 of the *Environmental Protection Act 1994*.

- The Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) has reviewed the referral documentation and advised that the Coordinator-General has not received a request for declaration of this proposal as a coordinated project under Part 4 of the *State Development and Public Works Organisation Act 1971*. However, the Project Facilitation unit of DSDMIP are leading discussions with the proponent and State Government on possible assessment processes for the proposal. This includes the assessment of the proposal by EIS under the Queensland *Marine Parks Act 2004.* You will be advised at the earliest opportunity when a decision has been made about the assessment approach.

Should you have any further enquiries, please contact me on telephone s 22.

Yours sincerely

s22

s22

Director, Impact Assessment and Operational Support

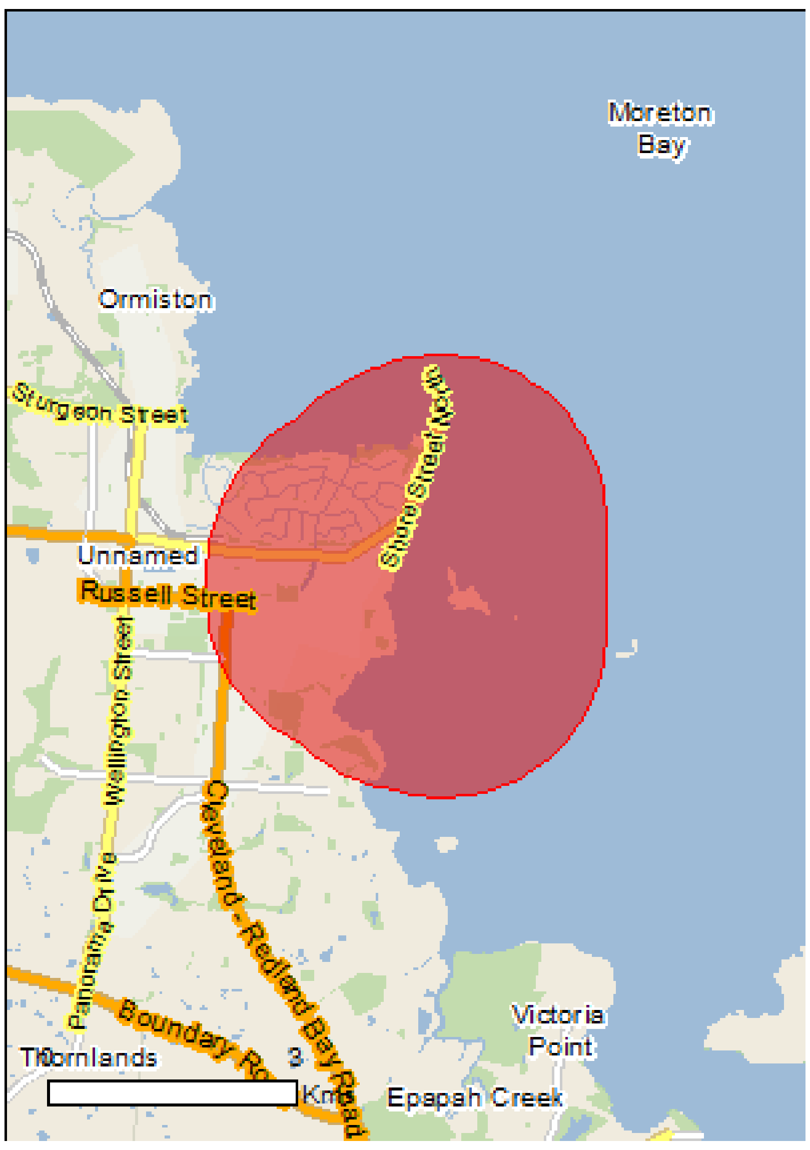
intranet
DEPARTMENT OF THE ENVIRONMENT AND ENERGY

FOI 180818
Document 26

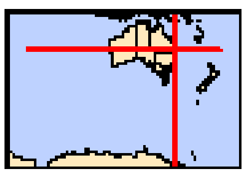
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

2018-8225 Toondah Harbour Project 2km buffer



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010



Report created: 29/06/18 14:11:51

Summary

Matters of National Environment Significance

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Threatened Ecological Communities:	2
Threatened Species:	58
Migratory Species:	76

Other Matters Protected by the EPBC Act

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	110
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	35
Nationally Important Wetlands:	1
EPBC Act Referrals:	10
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Moreton bay	Within Ramsar site

Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Threatened Species [Resource Information]

Name	Status	Type of Presence
BIRDS		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat likely to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western) [64450]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat likely to occur within area
FISH		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat may occur within area
INSECTS		
Argynnis hyperbius inconstans Australian Fritillary [88056]	Critically Endangered	Species or species habitat may occur within area
MAMMALS		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus		
Long-nosed Potoroo (SE mainland) [66645]	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Xeromys myoides		
Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat likely to occur within area
PLANTS		
Arthraxon hispidus		
Hairy-joint Grass [9338]	Vulnerable	Species or species habitat may occur within area
Cryptocarya foetida		
Stinking Cryptocarya, Stinking Laurel [11976]	Vulnerable	Species or species habitat may occur within area
Cryptostylis hunteriana		
Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
Phaius australis		
Lesser Swamp-orchid [5872]	Endangered	Species or species habitat likely to occur within area
Samadera bidwillii		
Quassia [29708]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe		
Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
REPTILES		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Delma torquata		
Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Foraging, feeding or

Name	Status	Type of Presence
		related behaviour known to occur within area
SHARKS		
Carcharias taurus (east coast population)		
Grey Nurse Shark (east coast population) [68751]	Critically Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans		
Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor		
Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli		
Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Sternula albifrons		
Little Tern [82849]		Species or species habitat may occur within area
Thalassarche cauta		
Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche eremita		
Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered*	Species or species habitat known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa incana Wandering Tattler [831]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area

Name	Threatened	Type of Presence
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Cuculus saturatus Oriental Cuckoo, Himalayan Cuckoo [710]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area

Name	Threatened	Type of Presence
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area
Himantopus himantopus Black-winged Stilt [870]		Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat likely to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish [66193]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys ocellatus Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus kelloggi Kellogg's Seahorse, Great Seahorse [66723]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse [66240]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus andersonii Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Microphis manadensis Manado Pipefish, Manado River Pipefish [66258]		Species or species habitat may occur within area
Solegnathus dunckeri Duncker's Pipehorse [66271]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Laticauda laticaudata a sea krait [1093]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit,

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Sturnus vulgaris		
Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina		
Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus		
Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris		
Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis		
Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus		
House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus		
Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus		
Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus		
Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides		
Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia		
Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus		
Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Cabomba caroliniana		
Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. rotundata		
Bitou Bush [16332]		Species or species habitat likely to occur within area
Cryptostegia grandiflora		
Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Moreton Bay	QLD

EPBC Act Referrals

[Resource Information]

Further details about the referral or advice - including its current status if still active - are available in its PINK report; click on the title.

Referral

Title	Reference	Referral Outcome	Assessment Status
Eprapah Heights Bushland Residential Subdivision	2001/286	NCA	Referral Decision Made-Completed
Prawn Aquaculture Enterprise Expansion	2001/294	NCA	Referral Decision Made-Completed
Eddie Santagiuliana Way Boardwalk	2005/2049	NCA	Referral Decision Made-Completed
establishment of a car wash and service station facility on Lot 12 RP 57455	2005/2077	NCA	Referral Decision Made-Completed
Residential estate Bunker Rd	2005/2130	NCA	Referral Decision Made-Completed
works within the Black Swamp	2005/2334	NCA	Referral Decision Made-Completed
Breeding program for Grey Nurse Sharks	2007/3245		Withdrawn-Completed
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	NCA	Referral Decision Made-Close
Toondah Harbour Project, Moreton Bay, Qld	2015/7612		Withdrawn-Close
Toondah Harbour Development	2017/7939	CA	Assessment Method not yet determined-Case Decision

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

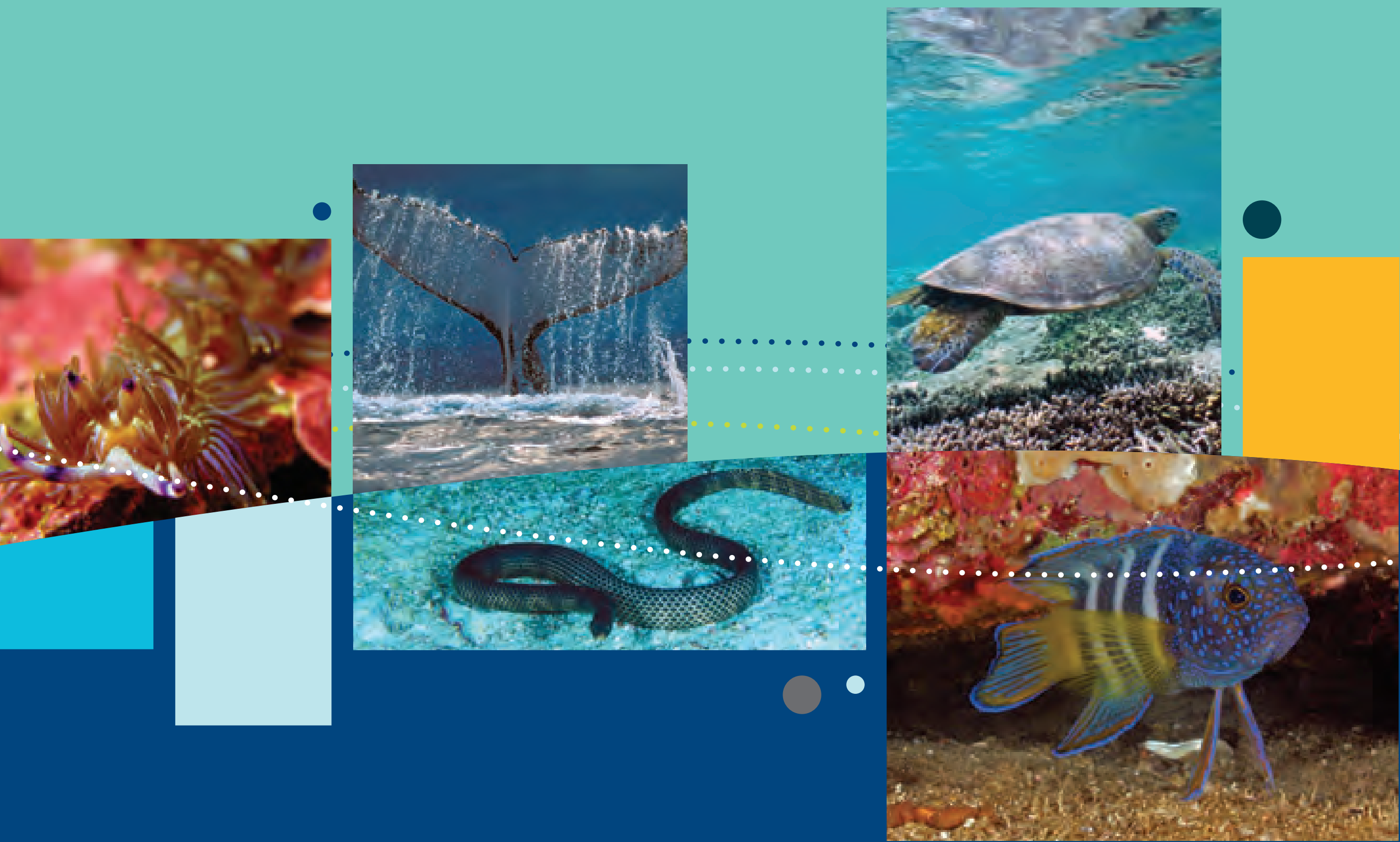
Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environment and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-Forestry Corporation of NSW
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Australian Government
Department of Sustainability, Environment,
Water, Population and Communities



Marine bioregional plan for the Temperate East Marine Region

prepared under the *Environment Protection and Biodiversity Conservation Act 1999*

Disclaimer

Images:
A Green turtle swims in shallows over reef top – GBRMPA, Blue Devil – D.Harasti, Nudibranch – M.Lawrence, Dubois' Sea Snake – GBRMPA, Whale tail – D.Paton, Olive sea snake searching for food over coral and algae – GBRMPA, Flesh-footed shearwater and Balls Pyramid – I.Hutton, Runic wreck on Middleton Reef – Director of National Parks, Black-browed Albatross – M.Double, Acropora species – R.Chesher Ph.D, Red Sea Star – M.Lawrence

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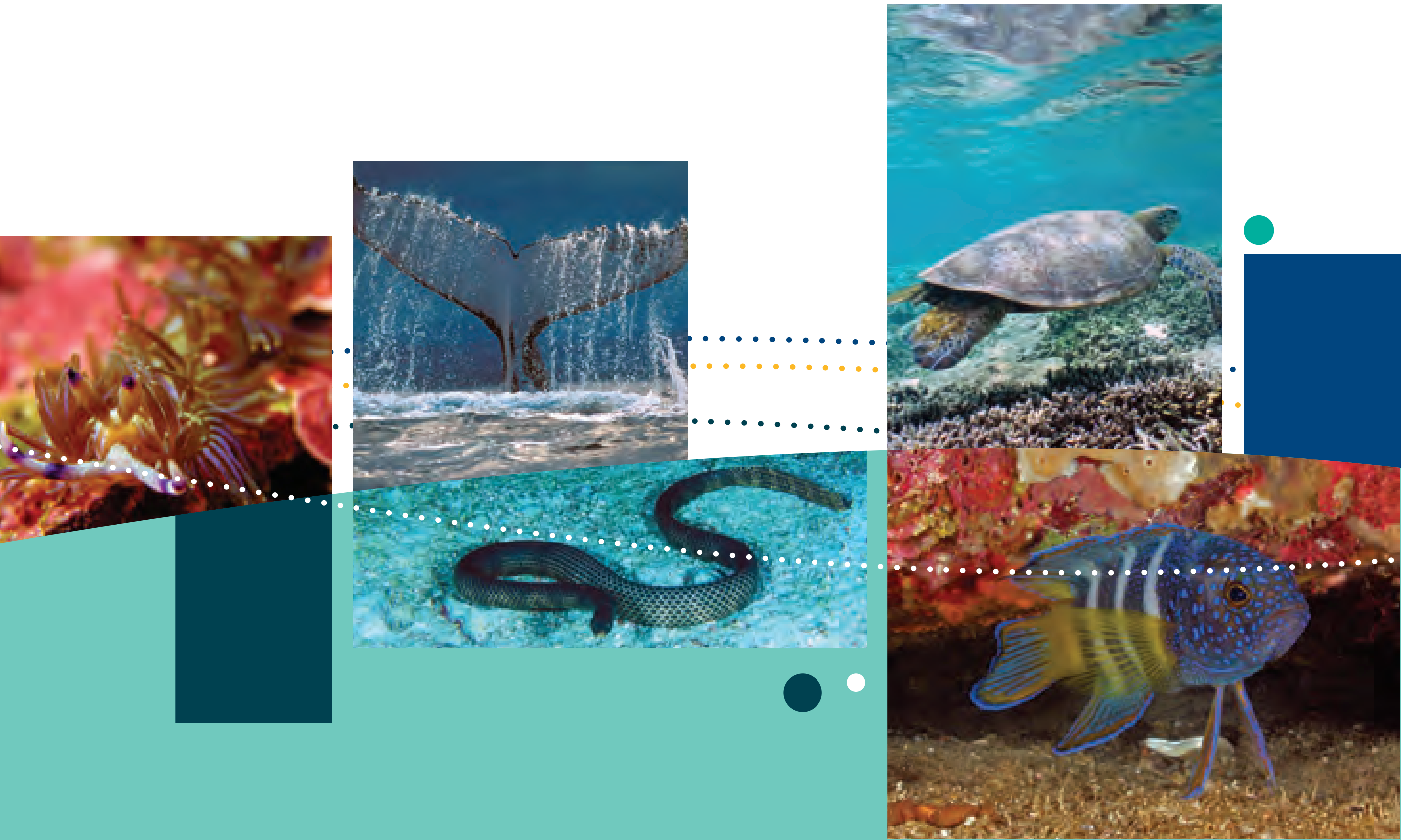

Marine bioregional plan for the Temperate East Marine Region

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MINISTERIAL FOREWORD

Temperate East Marine Bioregional Plan

For generations, Australians have enjoyed a unique relationship with the sea.

Our oceans play a massive role in Australian life – they provide us wit sh to eat, a place t sh, business and tourism opportunities and a place for families to enjoy.

Australians know, better than anyone, how important it is that our oceans remain healthy and sustainable.

Right now, our iconic marine environment is coming under more and more pressure from industry, from pollution and, increasingly, from climate change.

That is why the Australian Government has committed to creating a network of Commonwealth marine reserves around the country. We will protect our precious ecosystems in our oceans as we have done on land with our national parks.

The Temperate East Marine Region runs from the southern boundary of the Great Barrier Reef Marine Park to Bermagui in southern New South Wales, and includes the waters surrounding Lord Howe and Norfolk Islands.

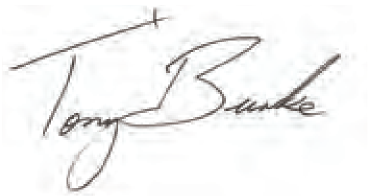
It is home to the critically endangered east coast population of grey nurse shark and has important offshore reef habitat at Elizabeth and Middleton Reefs and Lord Howe Island that support the threatened black cod.

It includes the southern-most extent of many reef-building coral species. A number of seamount chains run parallel to the coast in this region, and scientists have recently discovered that these features support hundreds of species, including some previously unknown to science.

These plans have been developed under the *Environment Protection and Biodiversity Conservation Act 1999* and backed by the best available science.

During the statutory consultation period, submissions were received from a wide range of stakeholders in the Temperate East Marine Region. The comments and information provided by communities and industries have informed th nalisation of the plan.

Our oceans contain a diversity of species and ecosystems which deserve protection. In this Temperate East Marine Bioregional Plan, you wi nd information about this extraordinary array of marine life and ecosystems.



Tony Burke
Minister for the Environment

CONTENTS

1 THE TEMPERATE EAST MARINE BIOREGIONAL PLAN

1.1 Introduction to Marine Bioregional Planning

Australia has one of the largest marine jurisdictions of any nation in the world. Australian waters cover 14.7 million square kilometres, including waters around the external territories of Cocos (Keeling), Christmas, Heard and McDonald Islands as well as waters adjacent to Australia's Antarctic Territory. Within that area, Commonwealth waters surrounding the Australian continent and Tasmania cover 7.4 million square kilometres. The biodiversity of Australia's vast marine jurisdiction has been recognised as globally signi cant. Australia's oceans provide a home to a diverse array of marine species including marine mammals and reptiles, more than 4000 species o sh and tens of thousands of species of invertebrates, plants and micro-organisms. Many of Australia's marine species are endemic, and therefore occur nowhere else in the world. Others utilise Australian waters as part of their global migrations.

As well as being home to an amazing diversity of marine environments, Australia's oceans support a range of marine industries, providing a signi cant contribution to the national economy. These industries include commercia shing and aquaculture, petroleum and mineral exploration and production, shipping, ports, recreational and charte shing, and tourism.

With 80 per cent of Australia's population living in the coastal zone, the marine environment has important social and cultural values, including recreational opportunities, amenity, cultural heritage, conservation and scienti c signi cance. Many Aboriginal and Torres Strait Islander peoples have a close, long-standing relationship with coastal and marine environments and continue to rely on these environments and resources for their cultural identity, health and wellbeing, as well as their domestic and commercial economies.

Marine bioregional planning is about improving the way Australia's marine environment is managed and helping our oceans to remain healthy and productive. Marine bioregional plans have been prepared under section 176 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for the South-west, North-west, North and Temperate East marine regions in Commonwealth waters around Australia (Figure 1.1) and relate to a number of matters of national environmental signi cance (Box 1.1).

A draft marine bioregional plan was released for the Temperate East Marine Region in November 2011 for a 90 day statutory consultation period. Thi nal plan has been informed by comments received from a range of stakeholders including Commonwealth and state government agencies, industry, recreational and conservation organisations and members of the public. The Australian Government will work with stakeholders to achieve the objectives of the plan.

The preparation of marine bioregional plans represents an important step towards a genuine “ecosystem approach” (Box 1.2) to biodiversity conservation and marine resource management. The plans provide a basis for the recognition and valuation of the many essential and largely irreplaceable ecosystem services provided by the Australian marine environment, including food production, waste management, climate stabilisation and recreation.

Figure 1.1: Australia’s Marine Regions

Box 1.1 Matters of national environmental signi ance

Under the EPBC Act actions that have or are likely to have a signi cant impact on matters of national environmental signi cance require approval by the environment minister. There are currently eight matters of national environmental signi cance protected under the EPBC Act:

- world heritage properties
- national heritage places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species (except those listed as extinct or conservation dependent) and ecological communities (except those listed as vulnerable)
- migratory species protected under international agreements
- the Commonwealth marine environment
- the Great Barrier Reef Marine Park
- nuclear actions, including uranium mines.

Box 1.2 The ecosystem approach

What is it?

The ecosystem approach is one of the most important principles of sustainable environmental management. Essentially, it recognises that all elements of an ecosystem are interconnected and requires that the effects of actions on the different elements of an ecosystem be taken into consideration in decision-making.

Why do we do it?

Ecosystems are complex and interconnected—what affects one species or habitat will have cascading and possibly unpredictable implications for other species or habitats. In addition, different activities within a marine environment may affect different parts of the interconnected whole or amplify the impacts on particular parts of the natural system.

We wish to prevent problems rather than react to them. This is why we want to address the drivers of biodiversity loss, rather than their symptoms. A focus on building and maintaining the resilience of ecosystems is more ef cient and effective than trying to address problems after they have occurred.

1.2 Goal and objectives of the plan

The Temperate East Marine Bioregional Plan aims to strengthen the operation of the EPBC Act in the region to help ensure that the marine environment remains healthy and resilient. The plan will be used by government and industry to improve the way the marine environment is managed and protected.

Consistent with the objectives of the EPBC Act, and in the context of the principles for ecologically sustainable development as defined in the Act, the plan sets the following objectives for the region:

- conserving biodiversity and maintaining ecosystem health
- ensuring the recovery and protection of threatened species
- improving understanding of the region's biodiversity and ecosystems and the pressures they face.

The marine bioregional plan will contribute to these objectives by:

- supporting strategic, consistent and informed decision-making under Commonwealth environment legislation in relation to Commonwealth marine areas
- supporting efficient administration of the EPBC Act to promote the conservation and ecologically sustainable use of the marine environment and its resources
- providing a framework for strategic intervention and investment by government to meet its policy objectives and statutory responsibilities.

The Temperate East Marine Bioregional Plan describes the marine environment and conservation values of the region, identifies and characterises the pressures affecting these conservation values, identifies regional priorities and outlines strategies to address them, and provides advice to decision-makers and people planning to undertake activities in the Temperate East Marine Region in relation to some of the region's conservation values.

1.3 Application of the plan

This plan is for the Temperate East Marine Region, which covers the Commonwealth marine area (Box 1.3) extending from the southern boundary of the Great Barrier Reef Marine Park to Bermagui in southern New South Wales, as well as the waters surrounding Lord Howe and Norfolk islands (Figure 1.2). The plan does not cover state or territory waters but, where relevant, does include information about inshore environments and the way they interact with species and habitats of the Commonwealth marine area.

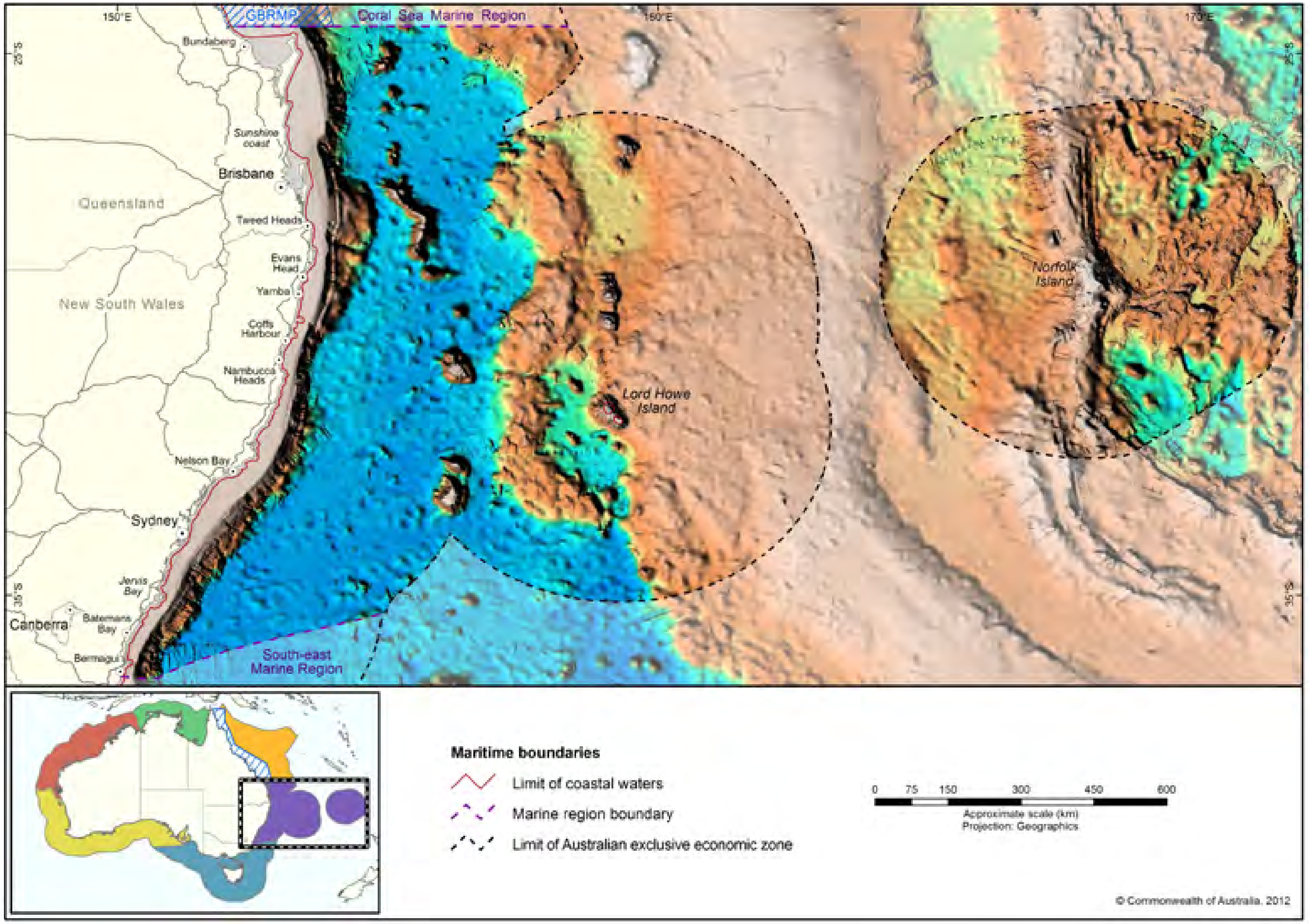


Figure 1.2: Temperate East Marine Region

Under section 176 of the EPBC Act, once a bioregional plan has been prepared, the minister responsible for the environment must have regard to it when making any decision under the Act to which the plan is relevant. The plan does not alter the scope of the minister's statutory responsibilities or narrow the matters the minister is required to take into account or may wish to take into account in making decisions. The EPBC Act provides that this plan is not a legislative instrument. This plan will commence six weeks after it is approved by the minister.

Box 1.3 Commonwealth marine areas

The Australian Government is responsible for the Commonwealth marine area (also known as Commonwealth waters) as de ned in section 24 of the EPBC Act (glossary **www.environment.gov.au/marineplans**). The Commonwealth marine area extends beyond the outer edge of state/territory waters, generally some 3 nautical miles (or 5.5 kilometres) from the coast, to the boundary of Australia's exclusive economic zone, generally around 200 nautical miles (or 370 kilometres) from shore (Figure 1.3). In this plan, the Commonwealth marine environment refers to the environment in a Commonwealth marine area.

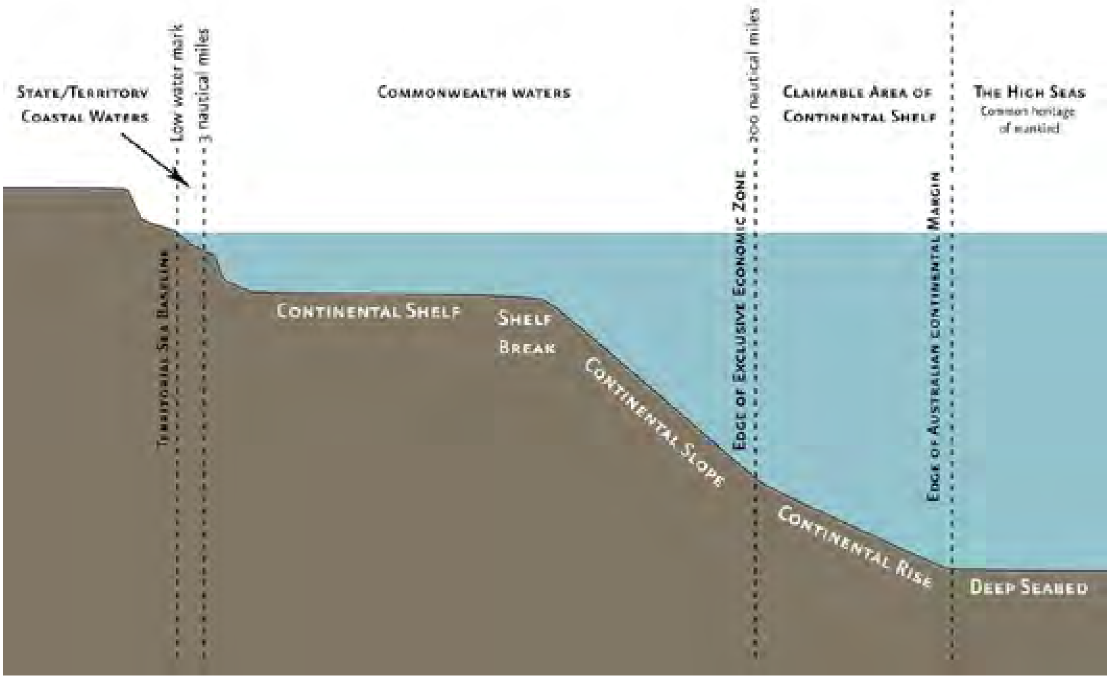


Figure 1.3: Australia's maritime zones

1.4 Key elements of the plan and supporting information

There wer ve key steps in the preparation of this marine bioregional plan.

1. Characterisation of the marine region

Currently available scienti c and other information were used to describe the bio-physical environment and socio-economic characteristics of the marine region and its conservation values, including key ecological features, protected places and species and species groups protected by the EPBC Act. This information was combined in a Bioregional Pro le for the region.

2. Regional analysis of the conservation values

The pressures potentially affecting conservation values were identi ed and characterised against a scale *of concern* in relation to their impacts on the values. The regional pressure analysis was informed by peer reviewed scienti c literature, and it ndings subject to external review by experts in the relevan elds. The outcomes of the regional pressure analysis are described in schedule 1 and informed both the identi cation of regional priorities (Part 4) and regional advice on matters of national environmental signi cance (Schedule 2).

3. Development of regional priorities

The regional pressure analysis assisted in the identi cation of conservation values that were, or potentially were, adversely affected by multiple pressures, as well as pressures that were impacting on multiple conservation values. Where warranted by the level *of concern*, these conservation values or pressures have been identi ed as regional priorities and consideration given to the strategies required to address them (Part 4).

4. Development of regional advice

The regional pressure analysis has also informed the development of regional advice in relation to matters of national environmental signi cance. This advice has been developed to assist people planning to undertake activities in Commonwealth marine areas to better understand and comply with their obligations under the EPBC Act, including helping them to decide whether to refer their proposed activity and determine what information would most usefully accompany any referral.

5. Public consultation on the draft marine bioregional plan

This marine bioregional plan was released in draft form for a 90 day public consultation period. The comments received have been taken into account i nalising this plan.

The plan is made up of a number of parts and is supported by a suite of information resources.

The plan

Part 1 (this part) of the plan provides context about marine bioregional plans. Part 2 of the plan describes the conservation values of the Temperate East Marine Region. Part 3 presents a summary of the analysis of pressures affecting conservation values in the region, undertaken to inform the development of regional priorities. Part 4 introduces the regional priorities and outlines strategies and actions to address them.

Schedules

Schedule 1 of the plan presents a full description of the pressures on conservation values of the Temperate East Marine Region that have been assessed as being *of concern* or *of potential concern*. Schedule 2 provides speci c advice on matters of national environmental signi cance in the region. This regional advice will assist people who plan to undertake activities in, or potentially impacting on, the Commonwealth marine environment to better understand and meet their obligations under the EPBC Act. It will also assist in deciding whether a proposed action should be referred to the minister for assessment, and identify any information that is likely to be required as part of the referral.

Glossary

A glossary of terms used in this plan and relevant to marine bioregional planning is located at **www.environment.gov.au/marineplans**.

Conservation values report cards

The conservation values report cards contain comprehensive information about the conservation values of the Temperate East Marine Region. Conservation values include species and places protected under the EPBC Act and key ecological features. There are three types of conservation value report cards:

- protected species groups
- Commonwealth marine environment (including key ecological features)
- protected places.

The report cards support the information provided in this plan and are available at **www.environment.gov.au/marineplans/temperate-east**. They include:

- a description of the conservation values of the region
- an overview of the vulnerabilities and pressures on the conservation values (*of concern* and *of potential concern*)
- a list of relevant protection measures
- references.

Conservation Values Atlas

The Department of Sustainability, Environment, Water, Population and Communities, as the Australian Government department responsible for administering the EPBC Act, maintains a suite of interactive tools that allow users to search nd and generate reports on information and data describing matters of national environmental signi cance and other conservation values in the marine environment.

The Conservation Values Atlas is designed to provide a visual representation of the conservation values in each marine region. It shows the location and spatial extent of conservation values (where suf cient information exists) and is available at **www.environment.gov.au/cva**.

Other resources

A number of important reference documents for the Temperate East Marine Region are available at **www.environment.gov.au/marineplans**.

1.5 Who will use the plan?

People who have responsibility for, or interest in, management of marine based activities, environment protection and marine science

The Temperate East Marine Bioregional Plan is an important document for individuals and organisations with an interest in the region and the way national environmental law is administered within Commonwealth waters. The plan provides information that enables people to better understand the Australian Government's marine environment protection and biodiversity conservation responsibilities, objectives and priorities in the region.

People planning to undertake activities in Commonwealth waters, or planning to undertake activities that are likely to have a signi ant impact on the Commonwealth marine environment

The plan is not a legislative instrument and therefore does not alter the EPBC Act referrals process. People planning to undertake activities within the Temperate East Marine Region can use the plan and supporting information to help decide whether their proposal should be referred in accordance with the EPBC Act.

The minister and department administering the EPBC Act

The minister must have regard to the Temperate East Marine Bioregional Plan in making any decision under the EPBC Act to which the plan is relevant.

Other government agencies

The requirement to have regard to the Temperate East Marine Bioregional Plan in making decisions applies only to the Commonwealth minister administering the EPBC Act. However, the plan provides comprehensive information about the region that assists government decision-making relevant to the Commonwealth marine environment. The plan is underpinned by an ecosystem approach (Box 1.2). This approach requires government decision-makers to consider issues across jurisdictional, sectoral and disciplinary boundaries, so that actions are not considered in isolation from one another. The information provided in the plan assists decision-makers in the Australian Government and other jurisdictions to collaborate more effectively across jurisdictional and sectoral boundaries.

2 THE TEMPERATE EAST MARINE REGION AND ITS CONSERVATION VALUES

The Temperate East Marine Region comprises Commonwealth waters from the southern boundary of the Great Barrier Reef Marine Park to Bermagui in southern New South Wales. It also includes the waters surrounding Lord Howe and Norfolk islands (Figure 1.2). The region covers approximately 1.47 million square kilometres of temperate and subtropical waters and abuts the coastal waters of southern Queensland and New South Wales. It extends from shallow waters on the continental shelf, 3 nautical miles (5.5 kilometres) from shore, to the deep ocean environments at the edge of Australia's exclusive economic zone, 200 nautical miles from shore.

The main physical features of the region are:

- three seamount chains that run parallel to the East coast—the Tasmantid and Lord Howe seamount chains and the Norfolk Ridge
- the East Australian Current, which dominates the oceanography of the region. The East Australian Current brings warm waters from the Coral Sea south along the outer edge of the continental shelf until it moves offshore at approximately 33 degrees south (offshore from the central coast of New South Wales). Along its path, it gives rise to large eddy features that support important areas of enhanced productivity
- the Tasman Front, which forms between 20 and 30 degrees south and represents the meeting point for two distinct bodies of water—the warm, nutrient-poor Coral Sea and the cold, nutrient-rich Tasman Sea. Localised oceanographic processes along the Tasman Front trap nutrients and plankton, creating an important region of enhanced productivity and connectivity pathways
- the canyons of the eastern continental slope, which add critical habitat diversity to the region.

The remainder of this chapter describes the conservation values of the region, including the Commonwealth marine environment and its protected species and places.

2.1 Identification of conservation values

A range of conservation values have been identified in the Temperate East Marine Region. Conservation values are defined as those elements of the region that are:

- key ecological features of the Commonwealth marine area
- species listed under Part 13 of the EPBC Act that live in the Commonwealth marine area or for which the Commonwealth marine area is necessary for a part of their life cycle
- protected places including marine reserves, heritage places and historic shipwrecks in the Commonwealth marine area.

2.2 Conservation values—the Commonwealth marine environment

Biodiversity

The Temperate East Marine Region is characterised by a narrow continental shelf, significant variation in sea-floor features (including seamount chains and canyons), dynamic oceanography, and a unique mix of tropical and cold water reef systems. Temperate species dominate the southern parts of the region, and tropical species become progressively more common towards the north.

The region supports high levels of species richness and diversity, particularly among corals, crustaceans, echinoderms, molluscs, sea sponges and fish. Due to the latitudinal range of the region, this diversity includes both tropical and temperate species. Oceanography is a strong driver for the region's biodiversity. This is particularly true in places like Lord Howe Island and the Elizabeth and Middleton reefs where both warm and cold water species flourish alongside each other. These unusual communities are mainly supported by the tongue of warm water that is driven southwards by the East Australian Current, extending the geographic range of the tropical species.

Further offshore, the East Australian Current influences biodiversity by connecting remote communities, such as those found on the seamounts, through the transport of species between areas. Our understanding of these deeper areas is constantly developing; current data suggests that these areas support exceptional levels of species endemism (as high as 34 per cent) with little overlap in distribution across sea floor features. The varied sea-floor features in the region may function as isolated systems and could support species that may be new to science.

Key ecological features

Key ecological features (KEFs) are elements of the Commonwealth marine environment in the Temperate East Marine Region that, based on current scientific understanding, are considered to be of regional importance for either the region's biodiversity or ecosystem function and integrity.

The criteria used to identify KEFs in the region are:

- a species, group of species or community with a regionally important ecological role, where there is specific knowledge about why the species or species group is important to the ecology of the region, and the spatial and temporal occurrence of the species or species group is known
- a species, group of species or community that is nationally or regionally important for biodiversity, where there is specific knowledge about why the species or species group is regionally or nationally important for biodiversity, and the spatial and temporal occurrence of the species or species group is known
- an area or habitat that is nationally or regionally important for
  - enhanced or high biological productivity
  - aggregations of marine life
  - biodiversity and endemism
- a unique seafloor feature with ecological properties of regional significance.

KEFs were first described in the bioregional profile for each region and have since been modified as a result of further analysis and review by scientific experts.

Eight key ecological features have been identified in the Temperate East Marine Region (Figure 2.1 and Table 2.1). Further information on the KEFs can be found in the Commonwealth marine environment report card (**www.environment.gov.au/marineplans/temperate-east**). Understanding of KEFs may evolve as new scientific information emerges.

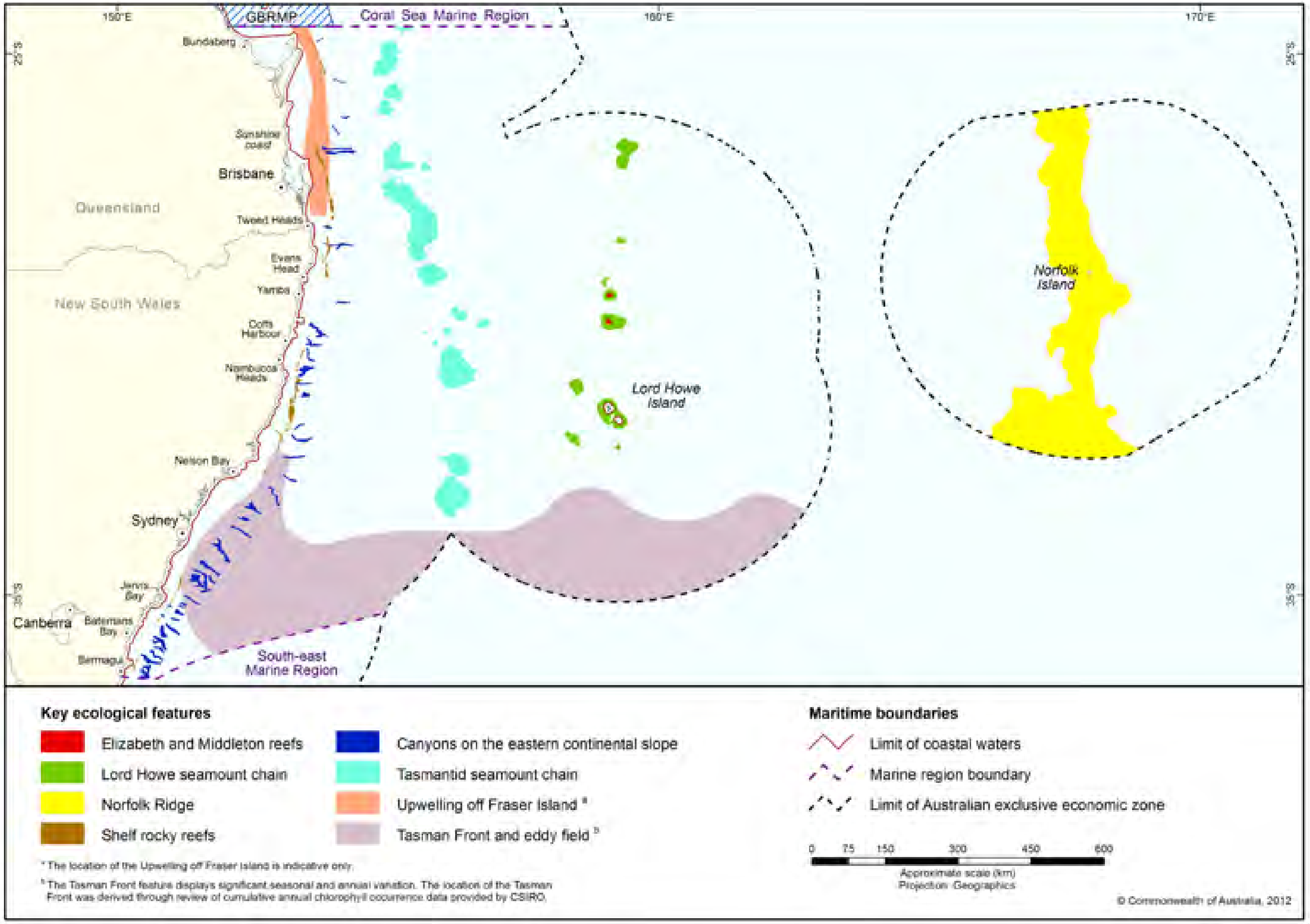


Figure 2.1: Key ecological features of the Temperate East Marine Region

Table 2.1: Key ecological features of the Temperate East Marine Region

Feature	Values	Description
Shelf rocky reefs	Unique sea- oor feature with ecological properties of regional signi cance	Along the continental shelf south of the Great Barrier Reef, communities associated with the shift from algae-dominated sea- oor communities to those dominated by attached invertebrates (including large sponges, moss animals and soft corals). This shift generally occurs at a depth of 45 m. These invertebrates create a complex habitat that supports a multitude of animals including crabs, snails, worms and star sh. The habitats also contain a diverse assemblage of bottom-dwelling shes that show distinct patterns of association with shelf-reef habitats.
Canyons on the eastern continental slope	Unique sea- oor feature with ecological properties of regional signi cance	Canyon systems have a marked in uence on the diversity and abundance of species, driven by the combined effects of steep and rugged topography, ocean currents, sea- oor types and nutrient availability. They signi cantly contribute to the overall habitat diversity of the se oor, by providing hard surfaces in depth zones where soft sediment habitats prevail. Large benthic animals such as sponges and feather stars are abundant, with particularly high diversity found in the upper slope regions (150–700 m). Canyons also create localised changes in productivity in the water column above them, providing feeding opportunities for a range of species, many of which are commercially important or threatened.
Tasman Front and edd eld	High productivity; aggregations of marine life; biodiversity and endemism	The Tasman Front is a region of intermediate productivity that separates the warm, nutrient-poor waters of the Coral Sea from the cold, nutrient-rich waters of the Tasman Sea. The front is located between 27° S and 33° S, moving north during winter and south in summer. It is associated with warm-core eddies, a number of which are semipermanent features.

Feature	Values	Description
Upwelling off Fraser Island	High productivity; aggregations of marine life	In two areas near Fraser Island, upwellings of cold, deep waters mix with surface waters. Tides, wind and currents draw these nutrient-rich waters onto the shelf, where they generate blooms of phytoplankton that support animals higher in the food chain, including a number of commercially valuable and threatened species.
Tasmantid seamount chain	High productivity; aggregations of marine life; biodiversity and endemism	The Tasmantid seamount chain is a prominent chain of underwater volcanic mountains, plateaux and terraces that runs north–south at approximately 155° E, extending into the Tasman Basin. At the deepest point of the chain, features rise to a depth of 1400–900 m below sea level. At the northernmost extent, features rise to a depth of 400–150 m below sea level, with some breaking the surface to form islands. The Tasmantid seamount chain contains a range of habitats, from deep sea sponge gardens to near-pristine tropical coral reef systems. Collectively, these are biological hotspots with high species diversity. They are also known feeding and breeding grounds for a number of open ocean species (e.g. bill sh, marine turtles, marine mammals) and have high species endemism.
Lord Howe seamount chain	High productivity; aggregations of marine life; biodiversity and endemism	The Lord Howe seamount chain runs for approximately 1000 km along the western margin of the Lord Howe Rise, extending from Lord Howe Island in the south to Nova Bank in the north. It supports tropical shallow coral reefs and deep cold water corals.

Feature	Values	Description
Norfolk Ridge	High productivity; aggregations of marine life; biodiversity and endemism	The Norfolk Ridge occurs in a region of remnant volcanic arcs, plateaux, troughs and basins. The ridge runs southward from New Caledonia to New Zealand, between the New Caledonia Trough to the west and the Norfolk Basin to the east. There are likely to be high levels of diversity in seamount communities, caused by relatively productive sea-floor habitats that support population densities far higher than surrounding areas. Benthic habitats along the Norfolk Ridge are also thought to act as 'stepping stones' for animal dispersal, connecting deep water species from New Caledonia to New Zealand.
Elizabeth and Middleton reefs	Aggregations of marine life; biodiversity and endemism	Elizabeth and Middleton reefs are small, isolated, oceanic platform reefs that occur on top of the volcanic seamounts of the Lord Howe seamount chain. The reefs are impacted by the East Australian Current, exposing the area to its warm waters as well as the surrounding cooler ocean. This key ecological feature supports tropical and temperate marine life, including both warm and cold water corals and over 30 fish species. The lagoons of both reefs are important areas for populations of black cod and the Galapagos shark.

2.3 Conservation values—protected species

The Temperate East Marine Region is an important area for protected species. Species listed under the EPBC Act are commonly referred to as protected species and can be listed as threatened species (critically endangered, endangered, vulnerable, conservation dependent), migratory species, cetaceans and marine species (see glossary for a full de nition). An individual species may be listed under more than one category.

Threatened species are, in broad terms, those species that have been identi ed as being in danger of becoming extinct. Species may be listed in the following categories:

- conservation dependent
- vulnerable
- endangered
- critically endangered
- extinct in the wild
- extinct.

(see the glossary for further explanation of these categories).

Migratory species are those species that are listed under:

- the *Convention on the Conservation of Migratory Species of Wild Animals 1979* (CMS or Bonn Convention)
- the *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974* (JAMBA)
- the *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986* (CAMBA)
- the *Agreement between the Government of Australia and the Government of the Republic Of Korea on the Protection of Migratory Birds 2007* (ROKAMBA)
- any other international agreement, or instrument made under other international agreements approved by the environment minister.

Further information on the CMS, JAMBA, CAMBA and ROKAMBA is provided at **www.environment.gov.au/biodiversity/migratory/index.html**

Cetaceans (whales, dolphins and porpoises) are all are protected under the EPBC Act in the Australian Whale Sanctuary and, to some extent, beyond its outer limits.

Marine species belong to taxa that the Australian Government has recognised as requiring protection to ensure their long-term conservation (in accordance with sections 248–250 of the EPBC Act). (Refer to Table A in Schedule 2 for listed marine species in the region).

The lists of protected species established under the EPBC Act are updated periodically. This plan refers to the lists of protected species in the region and includes detailed information about species distribution and ecology in the Temperate East Marine Region. Species groups identi ed as conservation values in the Temperate East Marine Region are:

- bon shes (10 species)
- cetaceans (9 species)
- marine reptiles (families Cheloniidae, Dermochelyidae, Hydrophiidae and Laticaudidae) (24 species)
- seabirds—(i.e. bird species that occur naturally in Commonwealth marine areas) (34 species)
- sharks (6 species).

Report cards describe the protected species (as of May 2012) and include detailed information about species distribution and ecology in the Temperate East Marine Region.

Biologically important areas have been identi ed for some of the region's protected species. These are areas that are particularly important for the conservation of protected species and where aggregations of individuals display biologically important behaviour such as breeding, foraging, resting or migration. They have been identi ed using expert scienti c knowledge about species' distribution, abundance and behaviour in the region. The presence of the observed behaviour is assumed to indicate that the habitat required for the behaviour is also present. The selection of species for which biologically important areas have been identi ed was informed by the availability of scienti c information, the conservation status of listed species and the importance of the region for the species. The range of species for which biologically important areas are identi ed will continue to expand as reliable spatial and scienti c information becomes available.

The process for identifying biologically important areas involves mapping proposed areas digitally, based on expert advice and published literature, then obtaining independent scienti c review of the maps and descriptions of the proposed areas.

Biologically important area maps and descriptions are available in the Temperate East Marine Region Conservation Values Atlas (**www.environment.gov.au/cva**).

2.4 Conservation values—protected places

Protected places are those places protected under the EPBC Act as matters of national environmental signi cance—places listed as World Heritage, National Heritage, or wetlands of international importance. Protected places may also include Commonwealth marine reserves and places deemed to have heritage value in the Commonwealth marine environment such as places on the Commonwealth heritage list or shipwrecks under the *Historic Shipwrecks Act 1976*.

Protected places in the region are shown in Figure 2.2 and described in Table 2.2.

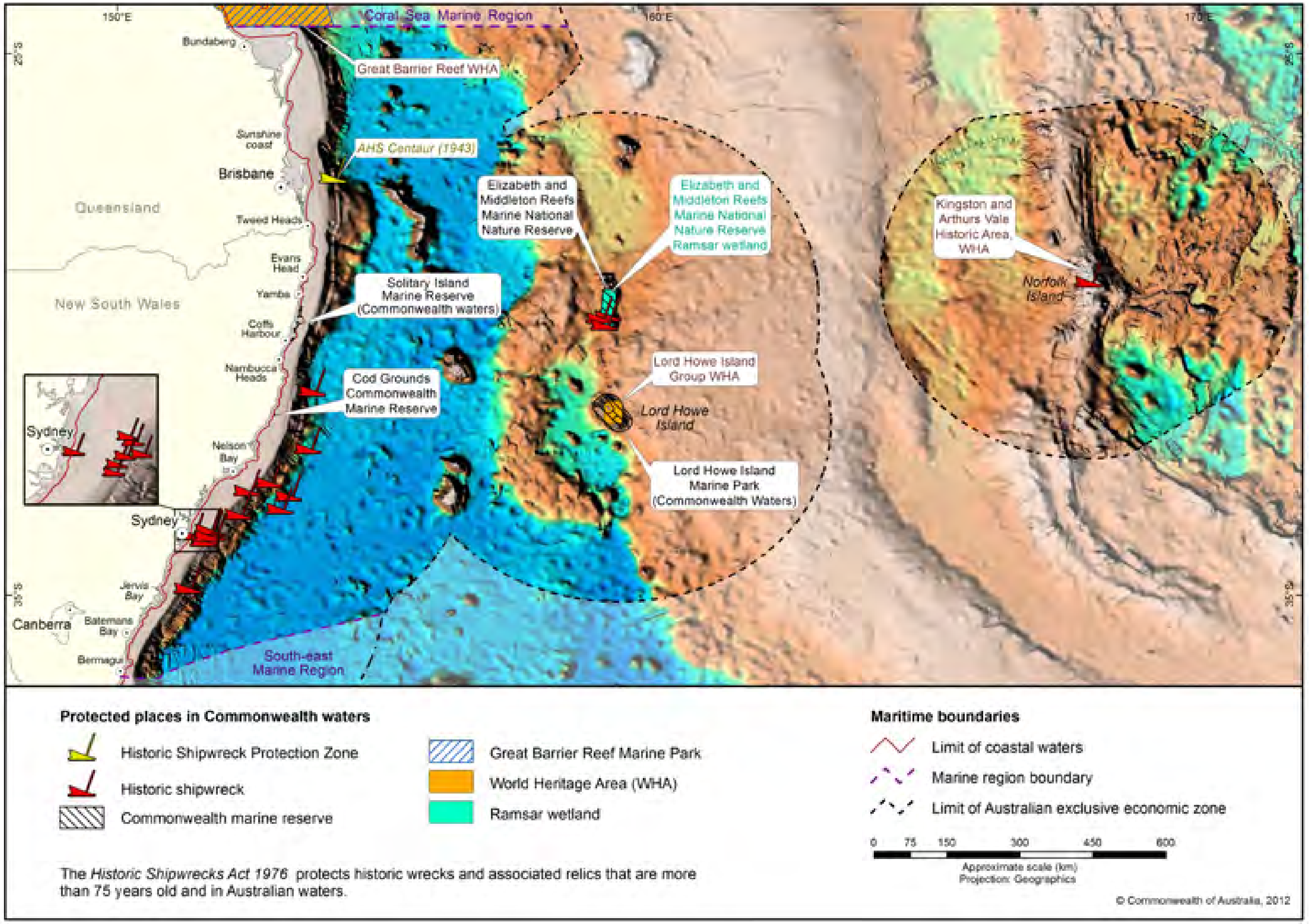


Figure 2.2: Protected places in the Temperate East Marine Region as of May 2012

Table 2.2: Protected places in the Temperate East Marine Region as of May 2012

Protected place	Protection measure	Relevant key ecological feature
Elizabeth and Middleton Reefs Marine National Nature Reserve	Commonwealth marine reserve Ramsar site	Elizabeth and Middleton Reefs
Solitary Islands Marine Reserve (Commonwealth waters)	Commonwealth marine reserve	
Cod Grounds Commonwealth Marine Reserve	Commonwealth marine reserve	
Lord Howe Island Marine Park (Commonwealth waters)	Commonwealth marine reserve World Heritage List National Heritage List	Lord Howe seamount chain

Commonwealth marine reserves are relevant in EPBC Act decision making on referred matters and explicitly referenced in the *EPBC Act Policy Statement 1.1 Signi cant Impact Guidelines*.

3 PRESSURES AFFECTING CONSERVATION VALUES

3.1 Analysis of pressures on conservation values

The pressure analysis assessed present and emerging pressures affecting conservation values in the Temperate East Marine Region and the effectiveness of mitigation and management arrangements that are currently in place to address these pressures. The analysis enabled pressures to be categorised in terms of their relative importance or concern, and has informed the identification of regional conservation priorities and the development of regional advice. For the purpose of this plan, pressures are defined broadly as human-driven processes and events that do or can detrimentally affect the region's conservation values.

The analysis considered pressures affecting all key ecological features and protected places and a number of species belonging to the species groups bony fishes, cetaceans, reptiles, seabirds and sharks. Considerations used for selecting the species for analysis were specific to the biological characteristics of the species groups, but broadly centred on the relative significance of the region to the conservation of the particular species. In assessing the significance of the region for a species' conservation, key considerations included the species' conservation status, distribution, population structure within the region and life history characteristics, and the potential for the population(s) in the region to be genetically distinct from populations elsewhere. Table 3.1 lists and provides an explanation of the species selected for inclusion in the pressure analysis for the Temperate East Marine Region.

A range of pressures from a range of sources was considered in the pressure analysis. Table S1.1 in Schedule 1 provides a list of the type and source of pressures available for inclusion in the analysis. Not every type and source of pressure in this list was assessed against every conservation value. Only those pressures relevant to the conservation value being analysed were considered.

The analysis included a review of scientific and expert literature, and was informed by the findings of relevant environmental and impact assessment studies, risk assessments and expert opinion. The pressure analysis considered, for each selected conservation value, information derived from available reports and research about:

- the spatial location and intensity of the pressure(s), both current and anticipated
- the location of the conservation value—that is, its distribution and the location of areas important to it

- current understanding of impacts (at relevant scales) resulting from the interaction between the pressure(s) and the conservation value
- the effectiveness of current management and impact mitigation measures.

Table 3.1: Protected species selected for the pressure analysis

Species group	Group-specific considerations for selection	Species selected for detailed pressure analysis
Bony fishes	Species were selected on the basis of their occurrence in the region, their listing under the EPBC Act, and the importance of the region to their survival.	**Eastern gemfish** **Orange roughy** **Black cod** **Big-bellied or pot-bellied seahorse** **Bullneck seahorse** **Duncker's pipehorse** **Great (Kellogg's) seahorse** **Hardwick's pipehorse** **Sad seahorse** **Weedy seadragon**
Cetaceans	Species were selected on the basis of their occurrence in the region, their listing as threatened and/or migratory and/or cetacean species under the EPBC Act, and the importance of the region to their survival. The two inshore dolphin species selected, although generally coastal species, also occur in the Commonwealth marine environment of the Temperate East Marine Region. The Indo-Pacific humpback dolphin occurs in a variety of habitats, usually less than 20 m deep, including inshore reefs, tidal and dredged channels, mangroves and river mouths. The Indo-Pacific bottlenose dolphin occurs in riverine and coastal waters, shallow waters on the continental shelf and around oceanic islands.	**Blue whale** **Dwarf minke whale** **Humpback whale** **Killer whale** **Fin whale** **Sei whale** **Southern right whale** **Indo-Pacific (coastal) bottlenose dolphin** **Indo-Pacific humpback dolphin**

Species group	Group-speci considerations for selection	Species selected for detailed pressure analysis
Marine Reptiles	Marine turtle species were selected on the basis of their occurrence in the region, their listing as threatened species under the EPBC Act, and the presence of important breeding or foraging areas for the species in and adjacent to the region. Sea snake species were selected on the basis of their occurrence in the region, and their listing under the EPBC Act as marine species.	**Green turtle** **Hawksbill turtle** **Leatherback turtle** **Loggerhead turtle** **Beaked seasnake** **Blue-lipped sea krait** **Colubrine sea krait** **Dubois' seasnake** **Elegant seasnake** **Horned seasnake** **Laboute's seasnake** **Littl le snake** **Marbled or spine-tailed seasnake** **Olive-headed seasnake** **Olive seasnake** **Plain-banded seasnake** **Small-headed seasnake** **Spectacled seasnake** **Spotted seasnake** **Stokes' seasnake** **Turtle-headed seasnake** **White-bellied mangrove snake** **Yellow seasnake** **Yellow-bellied seasnake**

Species group	Group-speci considerations for selection	Species selected for detailed pressure analysis
Seabirds	Seabird species were selected on the basis of their occurrence in the region, their listing as threatened and/or migratory and/or marine species under the EPBC Act, and the presence of important breeding or foraging areas for the species in and adjacent to the region. The Lord Howe Island group and Norfolk Island group support internationally and nationally signi cant breeding sites for a number of seabirds in the region.	**Black noddy** **Common noddy** **Crested tern** **Roseate tern** **Sooty tern** **White tern** **Grey ternlet** **Flesh-footed shearwater** **Little shearwater** **Short-tailed shearwater** **Sooty shearwater** **Wedge-tailed shearwater** **Black petrel** **Black-winged petrel** **Gould's petrel** **Great-winged petrel** **Kermadec petrel** **Providence petrel** **White-bellied storm-petrel** **White-faced storm-petrel** **White-necked petrel** **Wilson's storm-petrel** **Northern giant-petrel** **Southern giant-petrel** **Antipodean albatross** **Black-browed albatross** **Campbell albatross** **Indian yellow-nosed albatross** **Salvin's albatross** **Wandering albatross** **White-capped albatross** **Little penguin** **Masked booby** **Red-tailed tropicbird**

Species group	Group-specific considerations for selection	Species selected for detailed pressure analysis
Sharks	Shark species were selected on the basis that they were protected under the EPBC Act and have or are presumed to have important feeding, breeding or nursery areas within the region. They include species under consideration for listing under the EPBC Act known to occur in the Temperate East Marine Region.	**Grey nurse shark** **Porbeagle shark** **Longfin mako shark** **Shortfin mako shark** **Whale shark** **White shark**

3.2 Outcome of pressure analysis

Human pressures on marine ecosystems and biodiversity in the Temperate East Marine Region are, by global standards, low. However, the region is adjacent to the highly populated coasts of New South Wales and southern Queensland, and parts of the region closest to the coast will be subject to higher impact. These pressures are addressed, in part, by Australia's generally sound management of the marine environment.

A number of sources of pressures nevertheless exist in the region. The main drivers and sources of anthropogenic pressure on conservation values in the region are:

- climate change and associated large-scale effects, including shifts in major currents, rising sea levels, ocean acidification, and changes in the variability and extremes of climatic features (e.g. sea temperature, winds, storm frequency and intensity)
- extraction of living resources
- increasing urban and industrial development in areas adjacent to the region
- increasing shipping and port activities.

The findings of the pressure analysis are presented in Schedule 1 of the plan and in the Temperate East Marine Region conservation value report cards (**www.environment.gov.au/marineplans/temperate-east**).

4 REGIONAL PRIORITIES, STRATEGIES AND ACTIONS

4.1 Regional priorities

Regional priorities are key areas of focus that have been identi ed to inform decision-making about marine conservation and planning, as well as industry development and other human activities. The regional priorities provide context for implementing the government's statutory responsibilities, such as recovery planning for threatened species and the development and implementation of threat abatement measures. They also point to where future government initiatives and future investments in marine conservation, including in research and monitoring, would be best directed.

The identi cation of regional priorities for the Temperate East Marine Region has been guided by the outcomes of the pressure analysis. In identifying regional priorities, consideration has been given to the following:

- conservation values that are subject to
  - a pressure considered *of concern* for the conservation value, and
  - pressures that together are likely to result in cumulative impacts on the value, and/or
  - pressure(s) that are likely to increase substantially in intensity and extent over the next 5–10 years
- pressures that are considered *of concern* for multiple conservation values
- areas where better knowledge would improve the government's capacity to meet conservation and ecologically sustainable use objectives
- Australian Government policy priorities for the marine region.

Only a subset of conservation values and pressures assessed as being *of concern* or *of potential concern* has been identi ed as regional priorities. Generally, when a pressure affects multiple values and its effects are *of concern* for at least some of these values, then the pressure is identi ed as a regional priority. Similarly, if a conservation value is, or is likely to be, affected detrimentally by multiple pressures, and at least one of the pressures has been assessed as *of concern*, it is considered to be a regional priority. Other key considerations in determining pressure-based regional priorities included issues of scale, legislative responsibility, conservation status, effectiveness of existing management arrangements, and level of uncertainty about distribution, abundance and status of conservation values and the pressures acting on them.

Temperate East Marine Region priorities

This plan identi es 16 regional priorities for the Temperate East Marine Region: 12 conservation values and four pressures, which are further discussed in Tables 4.1 and 4.2 respectively. The strategies and actions to address these priorities are detailed in Section 4.2.

Building on the identi cation of regional priorities, available information and existing administrative guidelines, this plan provides advice to assist decision-makers, marine industries and other users to understand and meet the obligations that exist with respect to these priorities under the EPBC Act (Schedule 2).

Table 4.1: Conservation values of regional priority for the Temperate East Marine Region

	Conservation value	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
1	**Inshore dolphins** Indo Paci c humpback dolphin (EPBC Act listed as cetacean and migratory) Indo Paci c bottlenose dolphin (EPBC Act listed as cetacean)	The Indo-Paci c humpback dolphin and Indo-Paci c bottlenose dolphin are known to occur in the Temperate East Marine Region. Both species are listed as cetacean, while the Indo-Paci c humpback is also listed as migratory under the EPBC Act. The Temperate East Marine Region and adjacent waters are known breeding and foraging/feeding areas for both species. Dolphins are particularly vulnerable to impacts from human activities because of the overlap between their preferred inshore habitats and the highly populated coastal fringe. This vulnerability is compounded by biological characteristics such as late-age sexual maturation and low reproduction rates. Inshore dolphin species in the Temperate East Marine Region are subject to a number of pressures assessed as *of concern*: physical habitat modi cation (urban and coastal development), bycatch (commercia shing) and bycatch (bather protection). A further suite of pressures are *of potential concern*. These are physical habitat modi cation (dredging and dredge spoil), climate change (ocean acidi cation, sea level rise, changes in sea temperature, changes in oceanography, changes in hydrological regimes), oil pollution (shipping), chemical pollution (onshore activities e.g. agriculture) and nutrient pollution (onshore activities e.g. agriculture), noise pollution (shipping, urban development), collision with the vessels and marine debris.	Strategy A, Action 3 and 6 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Action 1 and 5 Strategy E, Action 3

	Conservation value	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
2	**Marine turtles** Green turtle Hawksbill turtle (EPBC Act listed as vulnerable, migratory and marine) Leatherback turtle Loggerhead turtle (EPBC Act listed as endangered, migratory and marine)	Four of the world's seven marine turtles are known to inhabit the Temperate East Marine Region. All four species are listed as threatened under the EPBC Act. The region and adjacent areas are known to support important nesting and/or foraging areas for all four species. The varied use of the marine environment by marine turtles across different developmental stages (e.g. juvenile, young adult) means that they are exposed to a wide range of pressures. In the Temperate East Marine Region, marine turtles are subject to a number of pressures assessed as *of concern* and *of potential concern*, with differences in the two ratings varying between the four species. For example, bycatch was assessed as *of concern* to green, loggerhead and leatherback turtles, and *of potential concern* to hawksbill turtles. Climate change, including sea level rise, changes in sea temperatures and sand temperatures was assessed as *of concern* to loggerhead turtles. Changes in sea temperatures and oceanography are *of potential concern* to green, hawksbill and leatherback turtles, while sea level rise is *of potential concern* to green turtles. Other pressures, such as chemical pollution/contaminants, nutrient pollution, marine debris, light pollution, physical habitat modi cation, extraction of living resources, invasive species and oil pollution were rated *of potential concern* to one or more of the four species assessed. The conservation status of marine turtles, the signi cance of the Temperate East Marine Region to their recovery, and the pressures facing them in the region make this species group a priority for conservation effort.	Strategy A, Actions 2, 3 and 6 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Action 1 and 5 Strategy E, Actions 1 and 2 Strategy G, Action 1
3	**Grey nurse shark** *(east coast population)* (EPBC Act listed as critically endangered)	The Temperate East Marine Region and adjacent state waters are known to support aggregation, mating and pupping areas for the grey nurse shark. The Cod Grounds and Solitary Islands are also recognised as important areas for this species in Commonwealth waters. The eastern grey nurse shark population is subject to bycatch from both the commercial and recreational sectors; these pressures are assessed as *of concern*. Pressures *of potential concern* include climate change (changes in sea temperature, changes in oceanography) and human presence at sensitive sites. The grey nurse shark is a regional priority because of the species' conservation status, the importance of the region to the species and the pressures impacting the population in the region.	Strategy A, Actions 2 and 3 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Action 1 Strategy E, Actions 1 and 2

	Conservation value	Rationale	Strategies and actions identified to address the priority (see Section 4.2)
4	**White shark** (EPBC Act listed as vulnerable)	The Temperate East Marine Region and adjacent waters are known to support aggregations of the white shark. White sharks move seasonally along the coast between temporary residence sites which typically correspond to regions of high prey density. The Stockton Beach–Hawks Nest area and Fraser Island are recognised as aggregation areas. The white shark is vulnerable to a number of pressures. Bycatch from the recreational fishing sector is considered *of concern*, while a range of additional pressures are considered *of potential concern*. These include bycatch (commercial fishing), extraction of living resources (non-domestic commercial fisheries), extraction of living resources (illegal, unreported and unregulated fishing) and climate change (changes in sea temperature and oceanography). The white shark is a regional priority because of the species' conservation status, the importance of the region to the species and the pressures impacting the population in the region.	Strategy A, Actions 2, 3 and 6 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Action 1 Strategy E, Actions 1 and 2

	Conservation value	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
5	**Seabirds breeding on islands in the Temperate East Marine Region** **Terns *(including noddies)*** Black noddy Common noddy Crested tern Sooty tern White tern Grey ternlet **Shearwaters** Flesh footed shearwater Little shearwater Short-tailed shearwater Wedge-tailed shearwater **Petrels** Black-winged petrel	A number of islands across the region support globally important nesting sites, most notably the Lord Howe and Norfolk Island groups, as well as a series of smaller islands along the NSW coast, including Cabbage Tree, Broughton, Little Broughton and Montague islands. In addition to nesting activity, the surrounding waters support foraging areas for parents to provide food for chicks. Seabirds breeding in the region are subject to a range of pressures. Invasive species are considered to be *of concern*. Pressures rated *of potential concern* are: climate change (changes in sea temperature and oceanography, ocean acidi cation), oil and chemical pollution and contaminants (shipping), marine debris, light pollution (for selected petrel and shearwater species), bycatch (for selected shearwater species) associated with commercial and recreationa shing and human presence at sensitive sites. The analysis of these pressures varied across the twenty species, and these rating examples have not been applied uniformly. Breeding seabirds are a regional priority because of their conservation status, the importance of the region in the provisioning of young, the pressures impacting populations in the region, and their status as an Australian Government policy priority.	Strategy A, Actions 2, 3 and 6 Strategy B, Action 1 Strategy C, Action 3 Strategy D Actions 1 and 5 Strategy E, Actions 1 and 2 Strategy G, Action 1

	Conservation value	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
5	Gould's petrel (EPBC Act listed as endangered) Kermadec petrel Providence petrel White-bellied storm-petrel (EPBC Act listed as vulnerable) White-faced storm-petrel White-necked petrel Other Little penguin Masked booby Red-tailed tropicbird	A number of islands across the region support globally important nesting sites, most notably the Lord Howe and Norfolk Island groups, as well as a series of smaller islands along the NSW coast, including Cabbage Tree, Broughton, Little Broughton and Montague islands. In addition to nesting activity, the surrounding waters support foraging areas for parents to provide food for chicks. Seabirds breeding in the region are subject to a range of pressures. Invasive species are considered to be *of concern*. Pressures rated *of potential concern* are: climate change (changes in sea temperature and oceanography, ocean acidi cation), oil and chemical pollution and contaminants (shipping), marine debris, light pollution (for selected petrel and shearwater species), bycatch (for selected shearwater species) associated with commercial and recreationa shing and human presence at sensitive sites. The analysis of these pressures varied across the twenty species, and these rating examples have not been applied uniformly. Breeding seabirds are a regional priority because of their conservation status, the importance of the region in the provisioning of young, the pressures impacting populations in the region, and their status as an Australian Government policy priority.	Strategy A, Actions 2, 3 and 6 Strategy B, Action 1 Strategy C, Action 3 Strategy D Actions 1 and 5 Strategy E, Actions 1 and 2 Strategy G, Action 1
6	**Shelf rocky reefs**	Shelf rocky reefs of the Temperate East Marine Region support a range of complex benthic habitats that, in turn, support diverse benthic communities. The ecosystem functioning and integrity of Temperate East shelf rocky reefsare subject to a number of pressures rated as *of potential concern*: bycatch and extraction of living resources (commercia shing), physical habitat modi cation (shing gear), climate change (ocean acidi cation, changes to sea temperature and oceanography) and marine debris. It has been identi ed as a regional priority on the basis of its important contribution to the region's biodiversity. Its selection also acknowledges the need to prioritise research to further understand its ecological functioning.	Strategy A, Actions 3 and 4 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Actions 1 and 2 Strategy F, Action 1

	Conservation value	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
7	**Canyons on the eastern continental slope**	The canyons on the eastern continental slope provide habitat (through changes in topography and productivity) that supports a diverse range of benthic, demersal and pelagic species. The ecosystem functioning and integrity of the canyons are subject to a number of pressures rated as *of potential concern*: physical habitat modi cation, bycatch and extraction of living resources (commercia shing), climate change (changes to sea temperature and oceanography), marine debris, and oil and chemical pollution/ contaminants (shipping). The canyons on the eastern continental slope have been identi ed as a regional priority on the basis of their important contribution to the region's biodiversity. This selection also acknowledges the need to prioritise research to further understand its ecological functioning.	Strategy A, Actions 3 and 4 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Actions 1 and 2 Strategy F, Action 1
8	**Tasman Front and edd eld**	The Tasman Front and edd eld contains complex and dynamic oceanographic processes support transient patches of enhanced productivity that, in turn, attract aggregations of species across trophic levels, including top predators such as tuna and sharks. This feature also supports biological connectivity with seamount habitats further offshore. The ecosystem functioning and integrity of this key ecological feature is subject to a number of pressures rated as *of potential concern*: bycatch and extraction of living resources (commercia shing), climate change (changes to sea temperature and oceanography), marine debris, and shipping-related oil and chemical pollution/ contaminants. This key ecological feature has been identi ed as a regional priority on the basis of its important contribution to the region's biodiversity. Its selection also acknowledges the need to prioritise research to further understand its ecological functioning.	Strategy A, Actions 3 and 4 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Actions 1 and 2 Strategy F, Action 1

	Conservation value	Rationale	Strategies and actions identified to address the priority (see Section 4.2)
9	**Upwelling off Fraser Island**	The upwelling off Fraser Island provides nutrient-rich waters which support a range of species, including a number of commercially valuable and protected species. The ecosystem functioning and integrity of the upwelling are subject to a number of pressures rated as *of potential concern*: bycatch and extraction of living resources (commercial fishing), climate change (changes to sea temperature and oceanography), marine debris, and ship-related oil and chemical pollution. The upwelling has been identified as a regional priority on the basis of its important contribution to the region's biodiversity. Its selection also acknowledges the need to prioritise research to further understand its ecological functioning.	Strategy A, Actions 3 and 4 Strategy C, Action 3 Strategy D, Actions 1 and 2 Strategy F, Action 1
10	**Tasmantid seamount chain**	The Tasmantid seamount chain supports aggregations of marine life, biodiversity and endemism. The feature supports a range of habitats in temperate and subtropical waters, significant demersal and pelagic diversity, important feeding and breeding sites for a number of open ocean species (e.g. billfish, marine turtles, marine mammals) and high levels of endemism. The ecosystem functioning and integrity of this key ecological feature is subject to a number of pressures rated as *of potential concern*: bycatch and extraction of living resources (commercial fishing), climate change (changes to sea temperature and oceanography), marine debris, and shipping-related oil and chemical pollution. This key ecological feature has been identified as a regional priority on the basis of its important contribution to the region's biodiversity and endemism. Its selection also acknowledges the need to prioritise research to further understand its ecological functioning.	Strategy A, Actions 3 and 4 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Actions 1 and 2 Strategy F, Action 1

	Conservation value	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
11	**Lord Howe seamount chain**	The Lord Howe seamount chain supports aggregations of marine life, biodiversity and endemism. It provides important benthic habitat diversity and is thought to act as an important biological 'stepping stone', connecting deepwater fauna from New Caledonia to New Zealand. The ecosystem functioning and integrity of the seamount chain are subject to a number of pressures rated *of potential concern*: bycatch and extraction of living resources (commercia shing activities), climate change (ocean acidi cation, changes to sea temperature and oceanography), marine debris, and shipping-related oil and chemical pollution. The Lord Howe seamount chain has been identi ed as a regional priority on the basis of its important contribution to the region's biodiversity and endemism. Its selection also acknowledges the need to prioritise research to further understand its ecological functioning.	Strategy A, Actions 3 and 4 Strategy B, Action 1 Strategy C, Action 3 Strategy D, Actions 1 and 2 Strategy F, Action 1
12	**Elizabeth and Middleton reefs**	The Elizabeth and Middleton reefs support aggregations of marine life, biodiversity and endemism. A small and isolated area, the reefs supports a diverse range of tropical and temperate marine life, including both warm water and cold water corals, and over 30 sh species. The lagoons of both reefs are strongholds for populations of black cod and the Galapagos shark. The ecosystem functioning and integrity of the reefs are vulnerable to climate change impacts, particularly changes in sea temperature and ocean acidi cation, pressures that have been rated as *of concern*. Pressures rated *of potential concern* are: sea level rise, changes in oceanography, marine debris, and shipping-related oil, chemical and light pollution. The Elizabeth and Middleton reefs are identi ed as a regional priority on the basis of their important contribution to the region's biodiversity and endemism, the pressures impacting on those values, and its status as an Australian Government priority as an existing Commonwealth marine reserve.	Strategy A, Actions 3 and 4 Strategy B, Action 1 Strategy C, Action 3 Strategy F, Action 1

Table 4.2: Pressures of regional priority for the Temperate East Marine Region

	Pressure	Rationale	Strategies and actions identified to address the priority (see Section 4.2)
13	**Climate change**	Climate change-related pressures including changes in sea temperature and oceanographic processes, ocean acidification, sea level and storm intensity, are predicted to increase in the Temperate East Marine Region, with the potential to impact the region's conservation values (key ecological features and protected species) to varying extents. There is considerable variation in the ratings *of concern* and *of potential concern* across the conservation values. Overall, changes in sea temperatures and oceanography were considered *of potential concern* to many of the key ecological features and species, with ocean acidification of greater significance for deep and shallow water reef features, cetaceans and seabirds and sea level rise more important for habitats associated with inshore dolphins and some breeding seabirds. Increasing sand temperature was identified as a pressure for nesting marine turtles. Climate change has been identified as a priority because of the extent of predicted impacts on conservation values in the region, particularly the cumulative nature of these impacts. Its selection also acknowledges the need to prioritise research to further understand the nature and extent of climate change impacts in the region.	Strategy A, Action 3 Strategy B, Action 2 Strategy E, Action 1 Strategy G, Action 1

	Pressure	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
14	**Marine debris**	The EPBC Act lists *'injury and fatality to vertebrate marine life caused by the ingestion of, or entanglement in, harmful marine debris'* as a key threatening process. Information on the extent and impact of marine debris in the Temperate East Marine Region is limited; however, a number of activities in and adjacent to the region increase the likelihood of the prevalence of marine debris, including commercial and recreationa shing, shipping, and urban and industrial development along the coast. In the Temperate East Marine Region, marine debris has emerged as a pressure with the potential to impact on many of the region's conservation values to varying extents. It has been assessed as *of concern* for marine turtles (green and loggerhead) and *of potential concern* for cetaceans, seabirds, school shark and all key ecological features. Marine debris has been identi ed as a priority because of its interaction with a range of conservation values across the region, and its status as an Australian Government policy priority. Its selection also acknowledges the need to prioritise research to further understand the nature and extent of its impacts in the region.	Strategy A, Action 5 Strategy B, Action 2 Strategy E, Actions 1 and 4 Strategy G, Action 1

	Pressure	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
15	**Bycatch**	Bycatch associated wit shing activities is one of the most pervasive pressures on conservation values in the region. Bycatch refers to marine life that is accidentally caught durin sheries operations and cannot be retained, thereby impacting on species populations and the diversity associated with key ecological features. The Temperate East Marine Region supports a signi cant commercia shing industry and bycatch from commercia shing activities has been assessed as *of concern* for inshore dolphins, killer whale, marine turtles (green, loggerhead and leatherback), the grey nurse shark and foraging seabirds (selected petrel, albatross and shearwater species). It is considered *of potential concern* for hawksbill turtle, white shark, , foraging seabirds (selected shearwater, albatross and petrel species) and a number of key ecological features (Tasman Front and edd eld, upwelling off Fraser Island, Norfolk Ridge, Tasmantid and Lord Howe seamount chains, shelf rocky reefs and canyons). Bycatch from recreationa shing has also been identi ed as *of concern* for grey nurse and white sharks, and *of potential concern* for th eshfooted shearwater. In addition, bycatch from bather protection schemes is *of concern* for the Indo-Paci c (coastal) bottlenose dolphin and the Indo-Paci c humpback dolphin and bycatch from illega shing activities is *of concern* to four turtle species, and *of potential concern* for the humpback whale. Bycatch has been identi ed as a priority because of its interaction with a high number of priority conservation values across the region.	Strategy A, Action 5 Strategy B, Action 2 Strategy D, Action 1 Strategy E, Actions 1 and 4

	Pressure	Rationale	Strategies and actions identi ed to address the priority (see Section 4.2)
16	**Extraction of living resources**	A number of conservation values in the Temperate East Marine Region are vulnerable to the extraction of living resources by commercial and recreational shing and illegal, unregulated and unreporte shing. Commercia shing effort overlaps with seven of the eight key ecological features in the region, and was assessed as *of potential concern* for these features. Currently, it is dif cult to quantify the exact impacts of target and by-product species take at these features, however, depending on the intensity of effort and composition of catch, the extraction of living resources from these key ecological features has the potential to affect trophic structures and ecological functioning. Extraction of living resources has been identi ed as a priority because it interacts with multiple conservation values, and because there is a limited understanding of its impacts on ecosystem function.	Strategy A, Action 5 Strategy B, Action 2 Strategy D, Action 2 Strategy E, Action 1 and 4 Strategy G, Action 1

4.2 Strategies and actions

The Temperate East Marine Bioregional Plan includes seven strategies to address its priorities:

Strategy A: Increase collaboration with relevant research organisations to inform and in uence research priorities and to increase the uptake of researc ndings to inform management and administrative decision-making.

Strategy B: Establish and manage a Commonwealth marine reserve network in the Temperate East Marine Region as part of a national representative system of marine protected areas.

Strategy C: Provide relevant, accessible and evidence-based information to support decision-making with respect to development proposals that come under the jurisdiction of the EPBC Act.

Strategy D: Increase collaboration with relevant industries to improve understanding of the impacts of anthropogenic disturbance and address the cumulative effects on the region's key ecological features and protected species.

Strategy E: Develop targeted collaborative programs to coordinate species recovery and environmental protection efforts across Australian Government and state and territory agencies with responsibilities for the marine environment.

Strategy F: Improve monitoring, evaluation and reporting on ecosystem health in the marine environment.

Strategy G: Participate in international efforts to manage conservation values and pressures of regional priority.

Within each strategy, actions have been designed to address one or more of the regional priorities. A few actions are not linked directly to regional priorities but have been included as enabling actions—that is, they provide the necessary foundation and/or mechanisms for addressing the regional priorities in a coordinated, effective and ef cient way.

Actions under the strategies are classi ed in terms of their implementation timeframe:

- **immediate actions** are those expected to be implemented within 6–12 months (these usually relate to priorities where the level *of concern* is high and management responses are either under way or expected to begin in the near future)
- **short-term actions** are those expected to be implemented within 2 years
- **medium-term actions** are those expected to be implemented within 3–5 years
- **long-term actions** are those expected to be implemented within 8–10 years, and usually relate to research into ecological effects that involves observational studies requiring long timeframes
- **ongoing actions** commonly cover routine administrative decision-making under the EPBC Act (e.g. administration of th sheries assessment provisions).

The actions identi ed to address the Temperate East Marine Region's priorities are listed under each strategy (in no particular order) below:

Strategy A:
Increase collaboration with relevant research organisations to inform and in uence research priorities and to increase the uptake of research ndings to inform management and administrative decision-making

1. Improve existing mechanisms and establish new mechanisms to facilitate the uptake of marine researc ndings so that they can inform administrative and management decisions (short term).

2. Support research undertaken through relevant recovery plans for marine turtles, seabirds, white shark and grey nurse shark (regional priorities 2–5— short term).

3. Support research to improve information on the impacts of climate change on protected species and key ecological features; in particular, their vulnerability and adaptive capacity to predicted changes (regional priorities 1–13—medium to long term).

4. Improve knowledge of the processes driving biodiversity and ecosystem functioning of priority key ecological features of the Temperate East Marine Region (regional priority 6–12—medium to long term).

5. Improve knowledge on the pressures of marine debris, bycatch and extraction of living marine resources on conservation values in the Temperate East Marine Region (regional priorities 14–16—short to medium term).

6. Improve information on biologically important areas for protected species and species considered under pressure within the Temperate East Marine Region, with priority given to:

- inshore dolphin (regional priority 1—short to medium term)
- marine turtles (regional priority 2—short to medium term)
- white shark (regional priority 4—short to medium term)
- seabirds (regional priority 5—short to medium term).

Strategy B:
Establish and manage a Commonwealth marine reserve network in the Temperate East Marine Region as part of the national representative system of marine protected areas

1. Ensure that management arrangements for marine reserves contribute to the protection and conservation of the region's biodiversity and ecosystem function and integrity (regional priorities 1–8 and 10–12—medium to long term).
2. Ensure that management arrangements for the reserves minimise, where appropriate, the risk and impacts of pressures rated as being *of concern* or *of potential concern* in the Temperate East Marine Region (regional priorities 13–16—medium to long term).

Strategy C:
Provide relevant, accessible and evidence-based information to support decision-making with respect to development proposals that come under the jurisdiction of the EPBC Act

1. Improve access to information, particularly spatial data, on the region's key ecological features and protected species and the pressures on them (short to medium term).
2. Assess the need for—and, if appropriate, promote—strategic assessments under the EPBC Act of coastal and inshore marine environments adjacent to the region that are expected to experience rapid change and have the potential to increase pressure on the Commonwealth marine environment (short to medium term).
3. Provide regional advice to assist in assessing and determining the signi cance of potential impacts on the region's conservation values to the extent that they are (or are components of) matters of national environmental signi cance (see Schedule 2) (regional priorities 1–12—immediate).
4. Evaluate the role of the plan and its supporting information resources in streamlining the decision-making under the EPBC Act at all levels (i.e. the environment minister, the environment department, or persons proposing to take actions likely to impact on matters of national environmental signi cance in the Temperate East Marine Region (short to medium term).

Strategy D:
Increase collaboration with relevant industries to improve understanding of the impacts of anthropogenic disturbance and address the cumulative effects on the region’s key ecological features and protected species

1. Collaborate with relevan sheries management organisations and industry to support research, information exchange and the development of improved management initiatives to address bycatch of protected species—particularly marine turtles, inshore dolphins, grey nurse shark, white shark, killer whale and breeding seabirds—focusing on improving information on the cumulative effects of bycatch across multipl sheries and the establishment of ongoing monitoring indicators (regional priorities 1–4, 6–11 and 15—short to medium term).

2. Collaborate with relevan sheries management organisations and industry to support research into the impacts of the extraction of living marine resources on key ecological features and improve management initiatives where appropriate (regional priorities 6–11 and 16—short to medium term).

3. Collaborate with industry and research organisations to improve mechanisms for data collection, management and reporting of interactions between industries and biodiversity (short to medium term).

4. Pursue, where feasible, collaborative agreements authorising the shared use of industry-gathered marine information, particularly spatial data (short to medium term).

5. Collaborate with industry to improve understanding of the effects of: vessel collision and marine debris on marine turtles; invasive species on breeding seabirds; and physical habitat modi cation arising from urban and coastal development on inshore dolphins (regional priorities 1, 2 and 5—short to medium term).

Strategy E:
Develop targeted collaborative programs to coordinate species recovery and environmental protection efforts across Australian Government, state and territory agencies and coastal communities with responsibilities for the marine environment

1. Collaborate with relevant government agencies and coastal communities to implement mitigation measures to address the key pressures on marine turtles, seabirds, grey nurse and white shark, and assess their effectiveness in reducing the risk to the species' recovery (regional priorities 2–5, 13–16—short to medium term).

2. Collaborate with the Queensland and New South Wales governments and coastal communities to develop protection measures to limit disturbances during the nesting season for marine turtles and seabirds, the pupping season for grey nurse shark, and seasons of aggregation for white shark, focusing on areas in proximity to inhabited areas or areas where sources of disturbance exist or are emerging (regional priorities 2–5—short to medium term).

3. Collaborate with the Queensland and New South Wales governments to develop protection measures to minimise the impacts of bather protection programs on inshore dolphins (regional priority 1—short to medium term).

4. Increase information on the sources and impacts of marine debris, bycatch and extraction of living resources on the region's marine life and ecosystems, including supporting monitoring of these pressures at selected locations in and adjacent to the Temperate East Marine Region (regional priorities 14–16—short to medium term).

Strategy F:
Improve monitoring, evaluation and reporting on ecosystem health in the marine environment

1. Collate information on the ecosystem components, functioning, pressures and potential cumulative impacts on key ecological features in the region and develop effective ecological indicators that will facilitate future monitoring, evaluation and reporting of marine ecosystem health (medium to long term).

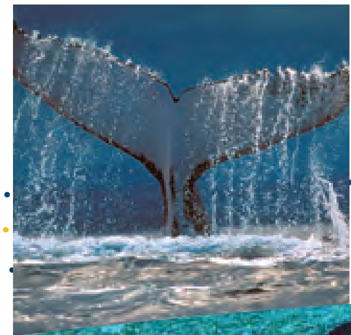
   Key ecological features to be investigated are:

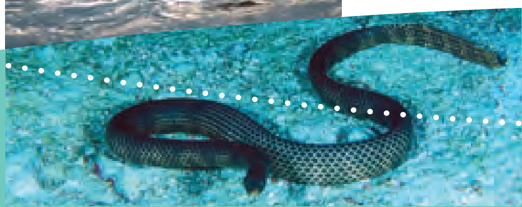
   – shelf rocky reefs (regional priority 6)
   – canyons on the eastern continental slope (regional priority 7)
   – Tasman Front and edd eld (regional priority 8)
   – upwelling off Fraser Island (regional priority 9)
   – Tasmantid seamount chain (regional priority 10)
   – Lord Howe seamount chain (regional priority 11)
   – Elizabeth and Middleton reefs (regional priority 12).

Strategy G:
Participate in international efforts to manage conservation values and pressures of regional priority

1. Collaborate with government and non-government organisations through regional and international initiatives to protect conservation values and address pressures of regional priority (regional priority 2, 5, 13, 14, 16—ongoing).

The Australian Government will work towards implementing these strategies and actions in order to address the regional priorities for conservation effort identi ed for the Temperate East Marine Region.




SCHEDULE 1

Analysis of pressures affecting conservation values of the Temperate East Marine Region

SCHEDULE 1 ANALYSIS OF PRESSURES AFFECTING CONSERVATION VALUES OF THE TEMPERATE EAST MARINE REGION

This schedule summarises the methods an ndings of the regional pressure analysis undertaken for the Temperate East Marine Region.

S1.1 How were the pressures on conservation values analysed?

The pressure analysis process considered the impact of pressures on the region's conservation values, with a focused evaluation of the effectiveness of current mitigation and management arrangements in place to respond to those pressures. For the purpose of this plan, pressures are de ned broadly as human-driven processes and events that do or can detrimentally affect the region's conservation values. Table S1.1 lists the type and source of pressures available for inclusion in the analysis. Only those pressures relevant to the conservation value being analysed were considered.

The analysis enabled pressures to be categorised in terms of their relative importance and has contributed to identi cation of regional priorities for the Temperate East Marine Region. Regional priorities are described in section 4.1 of the plan. The conservation values selected for the pressure analysis are discussed in Part 3 of the plan.

Table S1.1: Pressures and sources of pressures available for selection in the Temperate East Marine Region pressure analysis

Pressure	Source
Sea level rise	Climate change
Changes in sea temperature	Climate change
	Urban development
Changes in oceanography	Climate change
Ocean acidi cation	Climate change
Changes in terrestrial sand temperature	Climate change
Chemical pollution/contaminants	Shipping
	Vessels (other)
	Aquaculture operations
	Renewable energy operations
	Urban development (urban and/or industrial infrastructure)
	Agricultural activities
	Onshore and offshore mining operations
Nutrient pollution	Aquaculture operations
	Agricultural activities
	Urban development
Changes in turbidity	Dredging (spoil dumping)
	Land-based activities
	Onshore and offshore mining operations
	Climate change (changes in rainfall, storm frequency)
Marine debris[1]	Land-based activities
	Fishing boats
	Shipping
	Vessels (other)
	Oil rigs
	Aquaculture infrastructure
	Renewable energy infrastructure
	Urban development

Pressure	Source
Noise pollution	Seismic exploration
	Urban development
	Defence/surveillance activities
	Shipping
	Vessels (other)
	Aquaculture infrastructure
	Renewable energy infrastructure
	Onshore and offshore mining operations
	Onshore and offshore construction
Light pollution	Oil and gas infrastructure
	Fishing boats
	Vessels (other)
	Land-based activities
	Onshore and offshore activities
	Renewable energy infrastructure
	Onshore and offshore mining operations
Physical habitat modification	Fishing gear (active and derelict)
	Dredging (and/or dredge spoil)
	Shipping (anchorage)
	Defence/surveillance activities
	Telecommunications cables
	Offshore construction and installation of infrastructure
	Onshore and offshore construction
	Offshore mining operations
	Ship grounding
	Tourism (diving, snorkelling)
	Climate change (changes in storm frequency etc.)
	Urban/coastal development

Pressure	Source
Human presence at sensitive sites	Aquaculture operations
	Seismic exploration operations
	Tourism
	Recreational and charte shing (burleying)
	Research
	Defence/surveillance activities
	Aircraft
Nuisance species[2]	Aquaculture operations
Extraction of living resources[3]	Commercial shing (domestic or non-domestic)
	Recreational and charte shing
	IU shing (domestic or non-domestic)
	Indigenous harvest
	Commercial shing—prey depletion
	Commercial, recreational and charte shing— sheries discards
Bycatch[4]	Commercial shing
	Recreational and charte shing
	IU shing (domestic or non-domestic)
Oil pollution	Shipping
	Vessels (other)
	Oil rigs
	Onshore and offshore mining operations
Collision with vessels	Shipping
	Fishing
	Tourism
Collision/entanglement with infrastructure	Aquaculture infrastructure
	Renewable energy infrastructure
	Oil and gas infrastructure

Pressure	Source
Disease	Aquaculture operations
	Fishing
	Shipping
	Tourism
Invasive species	Shipping
	Fishing vessels
	Vessels (other)
	IU shing and illegal immigration vessels
	Aquaculture operations
	Tourism
	Land-based activities
Changes in hydrological regimes	Land-based activities
	Aquaculture infrastructure
	Renewable energy infrastructure
	Climate change (e.g. changes in rainfall, storm frequency)

IUU = illegal, unreported and unregulated

1 Marine debris is de ned in the Threat Abatement Plan for the impacts of marine debris on vertebrate marine life May 2009 (**www.environment.gov.au/biodiversity/threatened/publications/tap/marine-debris.html**) and refers to 'land-sourced plastic garbage shing gear from recreational and commercia shing abandoned into the sea, and ship-sourced, solid non-biodegradabl oating materials disposed of at sea'. In concordance with International Convention for the Prevention of Pollution From Ships, 1973 as modi ed by the Protocol of 1978 (MARPOL 73/78), plastic material is de ned as bags, bottles, strapping bands, sheeting synthetic ropes, syntheti shing nets oats berglass, piping, insulation, paints and adhesives.

2 Nuisance species are opportunistic native species (e.g. seagulls) whose populations boom when humans modify the ecosystem by increasing food supply.

3 Extraction of living resources includes the removal of target and byproduct species.

4 Bycatch includes all non-targeted catch fro shing operations, including by-product, discards and gear interactions. By-product refers to the unintended catch that may be kept or sold by th sher. Discards refer to the product that is returned to the sea. Gear interactions refer to all species and habitat affected by th shing gear.

Levels of concern for the interactions between pressures and conservation values

Based on a review of scienti c and expert literature, and informed by th ndings of relevant environmental and impact assessment studies, risk assessments and expert opinion, the interaction between selected conservation values and each pressure was assigned a level *of concern*. The levels *of concern* are:

- *of concern*
- *of potential concern*
- *of less concern*
- *not of concern*.

A pressure is *of concern* for a conservation value when:

- there is evidence that it interacts with the conservation value within the region and there are reasonable grounds to expect that it may result in a **substantial impact** (Box S1.1), and
- there are no management measures in place to mitigate the impact(s), or there is inadequate or inconclusive evidence of the effectiveness of management measures within the region.

A pressure is *of potential concern* for a conservation value when:

- there is evidence that the conservation value is vulnerable to the type of pressure, although there is limited evidence of a **substantial impact** within the region, and
- the pressure is widespread or likely to increase within the region, and
- there are no management measures in place to mitigate potential or future impacts, or there is inadequate or inconclusive evidence of the effectiveness of management measures.

A pressure is *of less concern* for a conservation value either when:

- there is evidence of interaction with the conservation value within the region and there are reasonable grounds to expect that the impacts are unlikely to be substantial, or
- there is evidence of interaction with the conservation value within the region and there are reasonable grounds to expect that current management measures in place are effective in minimising or mitigating the impact.

A pressure is *not of concern* for a conservation value when:

- the pressure is rare or absent from the region, or
- there are reasonable grounds to expect that the impacts are minimal or the pressure does not interact with the conservation value, or
- there is evidence that the pressure is managed effectively through routine management measures.

In some instances, where a pressure operating outside of the region is having a substantial impact on a region's conservation value, consideration has been given to it.

Only those interactions between conservation values and pressures assessed as being *of concern* and *of potential concern* are described in this Schedule. Further information on the ndings of the pressure analyses can be found in the conservation value report cards (**www.environment.gov.au/marineplans/temperate-east**).

Box S1.1 What is a substantial impact?

A pressure was considered likely to cause a substantial impact on a conservation value if there was a reasonable possibility that it would have any of the following effects:

- introduction of a known or potential pest or invasive species
- extensive modi cation, destruction, fragmentation, isolation or disturbance of habitat, which results in changes to community composition and/or trophic relationships and/ or ecosystem services
- modi cation, destruction, fragmentation, isolation or decline in availability of quality habitat important for a species of conservation value, to the extent that the species' conservation status is affected or its recovery is hindered
- substantial change in air or water quality, which may adversely impact biodiversity, ecological function or integrity, social amenity or human health
- introduction of persistent organic chemicals, heavy metals or potentially harmful chemicals, which adversely impact on biodiversity, ecosystem function or integrity, social amenity or human health
- change in community dynamics or structure that results in adverse impacts on biodiversity, ecological function or integrity, social amenity or human health
- increase in mortality of conservation values to an extent that may affect their conservation status or hinder recovery
- reduction in the area of occupancy of a species of conservation value, which may affect its conservation status or hinder recovery
- fragmentation of populations of conservation value
- reduced breeding success of a species or population of conservation value
- extensive or prolonged disturbance that affects the conservation status of a species or population of conservation value.

Note that the criteria above for de ning substantial impact have been informed by *EPBC Act Policy Statement 1.1—Signi cant Impact Guidelines*.

S1.2 Findings of the analysis

A summary of the pressure analysi ndings on the key ecological features and historic shipwrecks of the Temperate East Marine Region is presented in Table S1.2. A summary of the pressure analysi ndings on selected protected species in the Temperate East Marine Region is presented in Table S1.3.

A more detailed overview of the pressures assessed as *of concern* and *of potential concern* for these conservation values is presented in Tables S1.4–S1.14:

- Key ecological features of the Temperate East Marine Region
  - Pressures *of concern*—Table S1.4
  - Pressures *of potential concern*—Table S1.5
- Selected bony sh species
  - Pressures *of potential concern*—Table S1.6
- Selected cetacean species
  - Pressures *of concern*—Table S1.7
  - Pressures *of potential concern*—Table S1.8
- Selected marine reptile species
  - Pressures *of concern*—Table S1.9
  - Pressures *of potential concern*—Table S1.10
- Selected seabird species
  - Pressures *of concern*—Table S1.11
  - Pressures *of potential concern*—Table S1.12
- Selected shark species
  - Pressures *of concern*—Table S1.13
  - Pressures *of potential concern*—Table S1.14

Further information on the pressure analyses and thei ndings are provided in the conservation value report cards.

Table S1.2: Summary of pressures on key ecological features and historic shipwrecks of the Temperate East Marine Region

Key ecological feature	Pressure[5]								
	Sea level rise	Changes in sea temperature	Change in oceanography	Ocean acidi cation	Chemical pollution / contaminants	Nutrient pollution	Marine debris	Noise pollution	Light pollution
1. Shelf rocky reefs	not of concern	of potential concern	of potential concern	of potential concern	of less concern	of less concern	of potential concern	not of concern	not of concern
2. Canyons on the eastern continental slope	not of concern	of potential concern	of potential concern	of less concern	of potential concern	of less concern	of potential concern	not of concern	not of concern
3. Tasman Front and edd eld	not of concern	of potential concern	of potential concern	of less concern	of potential concern	not of concern	of potential concern	not of concern	of less concern
4. Upwelling off Fraser Island	not of concern	of potential concern	of potential concern	of less concern	of potential concern	of less concern	of potential concern	not of concern	of less concern
5. Tasmantid seamount chain	not of concern	of potential concern	of potential concern	of potential concern	of potential concern	not of concern	of potential concern	not of concern	not of concern
6. Lord Howe seamount chain	not of concern	of potential concern	of potential concern	of potential concern	of potential concern	not of concern	of potential concern	not of concern	not of concern
7. Elizabeth and Middleton reefs	of potential concern	of concern	of potential concern	of concern	of potential concern	not of concern	of potential concern	not of concern	of potential concern
8. Norfolk Ridge	not of concern	of potential concern	of potential concern	of potential concern	of less concern	of less concern	of potential concern	not of concern	not of concern
Historic Shipwrecks									
On shelf shipwrecks	data de cient or not assessed	of potential concern	data de cient or not assessed	data de cient or not assessed	of less concern	data de cient or not assessed	data de cient or not assessed	data de cient or not assessed	data de cient or not assessed
Off shelf shipwrecks	data de cient or not assessed	of less concern	data de cient or not assessed	data de cient or not assessed	not of concern	data de cient or not assessed	data de cient or not assessed	data de cient or not assessed	data de cient or not assessed

Legend of concern | of potential concern | of less concern | not of concern | data de cient or not assessed

5 Some pressures considered in this analysis are made up of more than one category but are presented in this summary table under one heading. For example, some conservation values were assessed against the pressures of *bycatch from commercia shing* and *bycatch from recreationa shing*; however these categories are presented in the summary table under *bycatch*. Where the ratings for a conservation value differ across the pressures in a category, the highest rating has been listed in the table. For example, if *bycatch from commercia shing* is rated *of potential concern* and *bycatch from recreationa shing* is rated *of less concern*, the pressure of *bycatch* will be rated *of potential concern* for the conservation value in the table. More information about the pressure analyses for key ecological features and heritage places can be found in the conservation value report cards.

Table S1.2 continued: Summary of pressures on key ecological features and historic shipwrecks of the Temperate East Marine Region

Key ecological feature	Pressure[5]							
	Physical habitat modi cation	Human presence at sensitive sites	Extraction of living resources	Bycatch	Oil pollution	Collisions with vessels	Invasive species	Changes in hydrological regimes
1. Shelf rocky reefs	of potential concern	not of concern	of potential concern	of potential concern	of less concern	of less concern	of less concern	of less concern
2. Canyons on the eastern continental slope	of potential concern	not of concern	of potential concern	of potential concern	of potential concern	not of concern	not of concern	not of concern
3. Tasman Front and edd eld	not of concern	not of concern	of potential concern	of potential concern	of potential concern	not of concern	not of concern	not of concern
4. Upwelling off Fraser Island	not of concern	of less concern	of potential concern	of potential concern	of potential concern	of less concern	of less concern	of less concern
5. Tasmantid seamount chain	of less concern	not of concern	of potential concern	of potential concern	of potential concern	not of concern	not of concern	not of concern
6. Lord Howe seamount chain	of less concern	not of concern	of potential concern	of potential concern	of potential concern	not of concern	not of concern	not of concern
7. Elizabeth and Middleton reefs	of less concern	of less concern	of less concern	of less concern	of potential concern	of less concern	of less concern	of less concern
8. Norfolk Ridge	not of concern	not of concern	of potential concern	of potential concern	of less concern	not of concern	not of concern	not of concern
Historic Shipwrecks								
On shelf shipwrecks	of less concern	of less concern	data de cient or not assessed	data de cient or not assessed	data de cient or not assessed	of less concern	data de cient or not assessed	of less concern
Off shelf shipwrecks	not of concern	of less concern	data de cient or not assessed	data de cient or not assessed	data de cient or not assessed	not of concern	data de cient or not assessed	of less concern

Legend of concern | of potential concern | of less concern | not of concern | data de cient or not assessed

5 Some pressures considered in this analysis are made up of more than one category but are presented in this summary table under one heading. For example, some conservation values were assessed against the pressures of *bycatch from commercia shing* and *bycatch from recreationa shing*; however these categories are presented in the summary table under *bycatch*. Where the ratings for a conservation value differ across the pressures in a category, the highest rating has been listed in the table. For example, if *bycatch from commercia shing* is rated *of potential concern* and *bycatch from recreationa shing* is rated *of less concern*, the pressure of *bycatch* will be rated *of potential concern* for the conservation value in the table. More information about the pressure analyses for key ecological features and heritage places can be found in the conservation value report cards.

Table S1.3: Summary of pressures on selected protected species in the Temperate East Marine Region

Species group	Protected species	Pressure[6]: Sea level rise	Changes in sea temperature	Changes in oceanography	Ocean acidi cation	Changes in terrestrial sand temperatures	Chemical pollution/ contaminants	Nutrient pollution	Marine debris	Noise pollution
Bony hes	Eastern gem sh	not of concern	of potential concern	of potential concern	of less concern	data de cient or not assessed	of less concern	of less concern	of less concern	not of concern
	Orange roughy	not of concern	of potential concern	of potential concern	of less concern	data de cient or not assessed	of less concern	not of concern	of less concern	not of concern
	Black cod	of less concern	of potential concern	of potential concern	of less concern	data de cient or not assessed	of potential concern	of potential concern	of less concern	not of concern
	Seahorses, pipehorses and sea dragons	of less concern	of potential concern	of potential concern	of less concern	data de cient or not assessed	of less concern	not of concern	of less concern	not of concern
Cetaceans	Blue whale	not of concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of less concern	not of concern	of potential concern	of less concern
	Dwarf Minke whale	not of concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of less concern	not of concern	of potential concern	of less concern
	Humpback whale	not of concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of less concern	not of concern	of potential concern	of less concern
	Killer whale	not of concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of less concern	not of concern	of potential concern	of less concern
	Fin whale	not of concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of less concern	not of concern	of potential concern	of less concern
	Sei whale	not of concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of less concern	not of concern	of potential concern	of less concern
	Southern right whale	not of concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of less concern	not of concern	of potential concern	of less concern
	Indo-Paci c (coastal) bottlenose dolphin	of potential concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of potential concern	of potential concern	of potential concern	of potential concern
	Indo-paci c humpback dolphin	of potential concern	of potential concern	of potential concern	of potential concern	data de cient or not assessed	of potential concern	of potential concern	of potential concern	of potential concern
Marine reptiles *Marine turtles*	Green turtle	of potential concern	of potential concern	of potential concern	of less concern	of potential concern	of potential concern	of potential concern	of potential concern	of less concern
	Hawksbill turtle	not of concern	of potential concern	of potential concern	of less concern	not of concern	of potential concern	of potential concern	of less concern	of less concern
	Leatherback turtle	not of concern	of potential concern	of potential concern	of less concern	not of concern	of potential concern	of less concern	of less concern	of less concern
	Loggerhead turtle	of concern	of concern	of potential concern	of less concern	of concern	of potential concern	of potential concern	of potential concern	of less concern
Sea snakes	Sea snakes	of less concern	of potential concern	not of concern	not of concern	not of concern	of less concern	not of concern	not of concern	of less concern

Legend of concern | of potential concern | of less concern | not of concern | data de cient or not assessed

6 Some pressures considered in this analysis are made up of more than one category but are presented in this summary table under one heading. For example, some conservation values were assessed against the pressures of *bycatch from commercia shing* and *bycatch from recreationa shing*; however these categories are presented in the summary table under *bycatch*. Where the ratings for a conservation value differ across the pressures in a category, the highest rating has been listed in the table. For example, if *bycatch from commercia shing* is rated *of potential concern* and *bycatch from recreationa shing* is rated *of less concern*, the pressure of *bycatch* will be rated *of potential concern* for the conservation value in the table. More information about the pressure analyses for key ecological features and heritage places can be found in the conservation value report cards.

Table S1.3 continued: Summary of pressures on selected protected species in the Temperate East Marine Region

Species group	Protected species	Pressure[6]: Light pollution	Physical habitat modi cation	Human presence at sensitive sites	Extraction of living resources	Bycatch	Oil pollution	Collision with vessels	Invasive species	Changes in hydrological regimes
Bony hes	Eastern gem sh	not of concern	not of concern	not of concern	of less concern	of less concern	of less concern	not of concern	not of concern	data de cient or not assessed
	Orange roughy	not of concern	of potential concern	not of concern	of less concern	of less concern	of less concern	not of concern	not of concern	data de cient or not assessed
	Black cod	not of concern	of potential concern	not of concern	of potential concern	of potential concern	of less concern	not of concern	not of concern	data de cient or not assessed
	Seahorses, pipehorses and sea dragons	not of concern	of potential concern	not of concern	of less concern	of potential concern	of less concern	not of concern	of less concern	data de cient or not assessed
Cetaceans	Blue whale	not of concern	not of concern	not of concern	not of concern	not of concern	of less concern	not of concern	not of concern	not of concern
	Dwarf Minke whale	not of concern	not of concern	of less concern	not of concern	not of concern	of less concern	not of concern	not of concern	not of concern
	Humpback whale	not of concern	not of concern	of less concern	not of concern	of potential concern	of less concern	not of concern	not of concern	not of concern
	Killer whale	not of concern	not of concern	not of concern	not of concern	of concern	of less concern	not of concern	not of concern	not of concern
	Fin whale	not of concern	not of concern	not of concern	not of concern	not of concern	of less concern	not of concern	not of concern	not of concern
	Sei whale	not of concern	not of concern	not of concern	not of concern	not of concern	of less concern	not of concern	not of concern	not of concern
	Southern right whale	not of concern	not of concern	not of concern	not of concern	not of concern	of less concern	not of concern	not of concern	not of concern
	Indo-Paci c (coastal) bottlenose dolphin	not of concern	of concern	of less concern	not of concern	of concern	of potential concern	of potential concern	not of concern	of potential concern
	Indo-paci c humpback dolphin	not of concern	of concern	of less concern	not of concern	of concern	of potential concern	of potential concern	not of concern	of potential concern
Marine reptiles	Green turtle	of potential concern	of potential concern	of less concern	of potential concern	of concern	of potential concern	of concern	of potential concern	of less concern
Marine turtles	Hawksbill turtle	of less concern	of less concern	of less concern	of potential concern	of potential concern	of potential concern	of concern	of less concern	of less concern
Sea snakes	Leatherback turtle	of less concern	of less concern	not of concern	not of concern	of concern	of potential concern	of less concern	not of concern	not of concern
	Loggerhead turtle	of potential concern	of potential concern	of less concern	of less concern	of concern	of potential concern	of concern	of potential concern	of less concern
	Sea snakes	not of concern	of potential concern	not of concern	not of concern	of potential concern	of potential concern	of less concern	not of concern	data de cient or not assessed

Legend of concern | of potential concern | of less concern | not of concern | data de cient or not assessed

6 Some pressures considered in this analysis are made up of more than one category but are presented in this summary table under one heading. For example, some conservation values were assessed against the pressures of *bycatch from commercia shing* and *bycatch from recreationa shing*; however these categories are presented in the summary table under *bycatch*. Where the ratings for a conservation value differ across the pressures in a category, the highest rating has been listed in the table. For example, if *bycatch from commercia shing* is rated *of potential concern* and *bycatch from recreationa shing* is rated *of less concern*, the pressure of *bycatch* will be rated *of potential concern* for the conservation value in the table. More information about the pressure analyses for key ecological features and heritage places can be found in the conservation value report cards.

Table S1.3 continued: Summary of pressures on selected protected species in the Temperate East Marine Region

Species group	Protected species	Pressure[6]: Sea level rise	Changes in sea temperature	Changes in oceanography	Ocean acidification	Changes in terrestrial sand temperatures	Chemical pollution/ contaminants	Nutrient pollution	Marine debris	Noise pollution
Seabirds	Black noddy	of potential concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Common noddy	of potential concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Crested tern	of potential concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Roseate tern	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Sooty tern	of less concern	of potential concern	of concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	White tern	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Grey ternlet	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Flesh-footed shearwater	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Little shearwater	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Short-tailed shearwater	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Sooty shearwater	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Wedge-tailed shearwater	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Black petrel	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Black-winged petrel	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Gould's petrel	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Great-winged petrel	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Kermadec petrel	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Providence petrel	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	White-bellied storm petrel	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	White-faced storm petrel	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	White-necked petrel	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern

Legend of concern | of potential concern | of less concern | not of concern | data deficient or not assessed

6 Some pressures considered in this analysis are made up of more than one category but are presented in this summary table under one heading. For example, some conservation values were assessed against the pressures of *bycatch from commercial fishing* and *bycatch from recreational fishing*; however these categories are presented in the summary table under *bycatch*. Where the ratings for a conservation value differ across the pressures in a category, the highest rating has been listed in the table. For example, if *bycatch from commercial fishing* is rated *of potential concern* and *bycatch from recreational fishing* is rated *of less concern*, the pressure of *bycatch* will be rated *of potential concern* for the conservation value in the table. More information about the pressure analyses for key ecological features and heritage places can be found in the conservation value report cards.

Table S1.3 continued: Summary of pressures on selected protected species in the Temperate East Marine Region

Species group	Protected species	Pressure[6]								
		Light pollution	Physical habitat modification	Human presence at sensitive sites	Extraction of living resources	Bycatch	Oil pollution	Collision with vessels	Invasive species	Changes in hydrological regimes
Seabirds	Black noddy	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Common noddy	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Crested tern	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Roseate tern	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of potential concern	data deficient or not assessed
	Sooty tern	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	White tern	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Grey ternlet	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Flesh-footed shearwater	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Little shearwater	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Short-tailed shearwater	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Sooty shearwater	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Wedge-tailed shearwater	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Black petrel	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Black-winged petrel	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Gould's petrel	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Great-winged petrel	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data deficient or not assessed
	Kermadec petrel	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	Providence petrel	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	White-bellied storm petrel	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	White-faced storm petrel	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data deficient or not assessed
	White-necked petrel	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of concern	data deficient or not assessed

Legend of concern | of potential concern | of less concern | not of concern | data deficient or not assessed

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Table S1.3 continued: Summary of pressures on selected protected species in the Temperate East Marine Region

Species group	Protected species	Pressure[6]: Sea level rise	Changes in sea temperature	Changes in oceanography	Ocean acidification	Changes in terrestrial sand temperatures	Chemical pollution/ contaminants	Nutrient pollution	Marine debris	Noise pollution
Seabirds	Wilson's storm petrel	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Northern giant-petrel	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Southern giant-petrel	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Antipodean (Gibson's) albatross	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Black-browed albatross	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Campbell albatross	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Indian yellow-nosed albatross	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Salvin's albatross	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Wandering albatross	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	White-capped albatross	not of concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Little penguin	of less concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Masked booby	of potential concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
	Red-tailed tropicbird	of potential concern	of potential concern	of potential concern	of potential concern	data deficient or not assessed	of potential concern	of less concern	of potential concern	of less concern
Sharks	Grey nurse shark	not of concern	of potential concern	of potential concern	of less concern	data deficient or not assessed	of less concern	not of concern	of less concern	not of concern
	Porbeagle shark	not of concern	of potential concern	of potential concern	not of concern	data deficient or not assessed	of less concern	not of concern	of less concern	not of concern
	Longfin mako shark	not of concern	of potential concern	of potential concern	not of concern	data deficient or not assessed	of less concern	not of concern	of less concern	not of concern
	Shortfin mako	not of concern	of potential concern	of potential concern	not of concern	data deficient or not assessed	of less concern	not of concern	of less concern	not of concern
	Whale shark	not of concern	of potential concern	of potential concern	not of concern	data deficient or not assessed	of less concern	not of concern	of less concern	not of concern
	White shark	not of concern	of potential concern	of potential concern	not of concern	data deficient or not assessed	of less concern	not of concern	of less concern	of less concern

Legend of concern | of potential concern | of less concern | not of concern | data deficient or not assessed

6 Some pressures considered in this analysis are made up of more than one category but are presented in this summary table under one heading. For example, some conservation values were assessed against the pressures of *bycatch from commercial fishing* and *bycatch from recreational fishing*; however these categories are presented in the summary table under *bycatch*. Where the ratings for a conservation value differ across the pressures in a category, the highest rating has been listed in the table. For example, if *bycatch from commercial fishing* is rated *of potential concern* and *bycatch from recreational fishing* is rated *of less concern*, the pressure of *bycatch* will be rated *of potential concern* for the conservation value in the table. More information about the pressure analyses for key ecological features and heritage places can be found in the conservation value report cards.

Table S1.3 continued: Summary of pressures on selected protected species in the Temperate East Marine Region

Species group	Protected species	Pressure[6]: Light pollution	Physical habitat modi cation	Human presence at sensitive sites	Extraction of living resources	Bycatch	Oil pollution	Collision with vessels	Invasive species	Changes in hydrological regimes
Seabirds	Wilson's storm petrel	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Northern giant-petrel	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Southern giant-petrel	of potential concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Antipodean (Gibson's) albatross	of less concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Black-browed albatross	of less concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Campbell albatross	of less concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Indian yellow-nosed albatross	of less concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Salvin's albatross	of less concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Wandering albatross	of less concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	White-capped albatross	of less concern	not of concern	of potential concern	of less concern	of potential concern	of potential concern	not of concern	of potential concern	data de cient or not assessed
	Little penguin	of potential concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data de cient or not assessed
	Masked booby	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data de cient or not assessed
	Red-tailed tropicbird	not of concern	not of concern	of potential concern	of less concern	not of concern	of potential concern	not of concern	of concern	data de cient or not assessed
Sharks	Grey nurse shark	not of concern	not of concern	of potential concern	of less concern	of concern	of less concern	not of concern	not of concern	data de cient or not assessed
	Porbeagle shark	not of concern	not of concern	not of concern	not of concern	of less concern	of less concern	not of concern	not of concern	data de cient or not assessed
	Long n mako shark	not of concern	not of concern	not of concern	not of concern	of less concern	of less concern	not of concern	not of concern	data de cient or not assessed
	Short n mako	not of concern	not of concern	not of concern	not of concern	of less concern	of less concern	not of concern	not of concern	data de cient or not assessed
	Whale shark	not of concern	not of concern	not of concern	of less concern	not of concern	of less concern	not of concern	not of concern	data de cient or not assessed
	White shark	not of concern	not of concern	not of concern	not of concern	of concern	of less concern	not of concern	not of concern	data de cient or not assessed

Legend of concern | of potential concern | of less concern | not of concern | data de cient or not assessed

6 Some pressures considered in this analysis are made up of more than one category but are presented in this summary table under one heading. For example, some conservation values were assessed against the pressures of *bycatch from commercia shing* and *bycatch from recreationa shing*; however these categories are presented in the summary table under *bycatch*. Where the ratings for a conservation value differ across the pressures in a category, the highest rating has been listed in the table. For example, if *bycatch from commercial shing* is rated *of potential concern* and *bycatch from recreationa shing* is rated *of less concern*, the pressure of *bycatch* will be rated *of potential concern* for the conservation value in the table. More information about the pressure analyses for key ecological features and heritage places can be found in the conservation value report cards.

Table S1.4: Pressures *of concern* to key ecological features of the Temperate East Marine Region

Key ecological features assessed = 8		
Pressure	**KEF**	**Rationale**
Changes in sea temperature (climate change)	Elizabeth and Middleton reefs	Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 °C warmer by 2030 (Lough 2009). Elizabeth and Middleton reefs are valued for their aggregations of marine life and biodiversity. Ocean warming is expected to alter food web dynamics (Hoegh-Guldberg & Bruno 2010), potentially increase the frequency or severity of coral bleaching events and result in southerly distribution shifts of pelagi sh species (Hobday et al. 2006). The reefs are at risk from these expected impacts, however, the overall implications for ecosystem processes and responses are not known, and will be in uenced by species tolerance and adaptive capacity.
Ocean acidi cation (climate change)	Elizabeth and Middleton reefs	Driven by increasing levels of atmospheric CO_2 and subsequent chemical changes in the ocean, ocean acidi cation is already under way and detectable. Since pre-industrial times, acidi cation has lowered ocean pH by 0.1 units (Howard et al. 2009). Climate models predict this trend will continue, with a further 0.2–0.3 unit decline by 2100 (Howard et al. 2009). Elizabeth and Middleton reefs are valued for their aggregations of marine life and biodiversity, and expected impacts of acidi cation include a reduction in coral growth rates and resilience, which may make the reef systems more vulnerable to erosion and disturbance from storms (Anthony & Marshall 2009) and affect the ability of molluscs, echinoderms and some planktonic organisms to form skeletal material (Doney et al. 2009). Corals provide structural habitat complexity for a range of invertebrates an sh (Althaus et al. 2009); therefore, any impact on coral reef habitat is likely to result in changes to the distribution and abundance of species that depend on the reefs for food and shelter.

Table S1.5: Pressures *of potential concern* to key ecological features of the Temperate East Marine Region

Key ecological features assessed = 8		
Pressure	**KEFs**	**Rationale**
Sea level rise (climate change)	Elizabeth and Middleton reefs	Global sea levels rose by 20 cm between 1870 and 2004, and predictions estimate a further rise of 5–15 cm by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5–1 m by 2100, relative to 2000 levels (Climate Commission 2011). Elizabeth and Middleton reefs are shallow water reefs valued for their aggregations of marine life and biodiversity. Over time, rising sea levels are expected to decrease the amount of light that reaches the corals, thereby reducing coral growth rates (Anthony & Marshall 2009). Any impact on coral reef habitat is likely to change the distribution and abundance of species that depend on the reefs for food and shelter (Chambers et al. 2009b).
Changes in sea temperature (climate change)	Shelf rocky reefs Canyons on the eastern continental slope Tasman Front and edd eld Upwelling off Fraser Island Tasmantid seamount chain Lord Howe seamount chain Norfolk Ridge	Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 °C warmer by 2030 (Lough 2009). Ocean warming is *of potential concern* for all of the region's key ecological features, except the Elizabeth and Middleton reefs, where it is *of concern* **(see Table S1.4)**. Expected impacts include changes to food web dynamics (Hoegh-Guldberg & Bruno 2010), potentially increasing the frequency or severity of coral bleaching events, and a southerly shift in the distribution of pelagic sh species (Hobday et al. 2006). For features located in the deeper waters of the region (such as the shelf rocky reefs, seamounts and ridges), the impacts of rising sea temperatures are more complex. Rising temperatures drive changes such as thermal expansion (Hoegh-Gulberg & Bruno 2010), resulting in greater strati cation in the water column, reducing mixing in some parts of the ocean, and consequently affecting nutrient availability and primary production at depth (Hoegh-Gulberg & Bruno 2010).

Key ecological features assessed = 8

Pressure	KEFs	Rationale
Changes in oceanography (climate change)	Shelf rocky reefs Canyons on the eastern continental slope Tasman Front and eddy field Upwelling off Fraser Island Tasmantid seamount chain Lord Howe seamount chain Elizabeth and Middleton reefs Norfolk Ridge	Changes in oceanography include consideration of circulation patterns; current intensities; wind strength and direction; the location and strength of eddy and upwelling events; and climatic oscillations such as the El Niño–Southern Oscillation. In the region, changes in oceanography will be primarily influenced by the East Australian Current, which is one of the key drivers of the region's biological productivity, species distribution and abundance (Dambacher et al. 2011). The East Australian Current has been strengthening, pushing warmer, saltier water further southward along the east coast (for up to 350 km) (Ridgway & Hill 2009). Changes in the strength and extent of the current are likely to impact on productivity, shifting trophic webs, and changing migration patterns and reef and shelf habitats, all of which have implications for marine species (Chin et al. 2010). Offshore, the current is partly responsible for the unique mix of warm and cold water species associated with Elizabeth and Middleton reefs and the Tasmantid and Lord Howe seamount chains (Dambacher et al. 2011).

Key ecological features assessed = 8		
Pressure	**KEFs**	**Rationale**
Ocean acidi cation (climate change)	Shelf rocky reefs Tasmantid seamount chain Lord Howe seamount chain Norfolk Ridge	Driven by increasing levels of atmospheric CO_2 and subsequent chemical changes in the ocean, ocean acidi cation is already under way and detectable. Since pre-industrial times, acidi cation has lowered ocean pH by 0.1 units (Howard et al. 2009). Furthermore, climate models predict this trend will continue, with a further 0.2–0.3 unit decline by 2100 (Howard et al. 2009). The key ecological features listed here are particularly vulnerable to ocean acidi cation because they support a range of shallow and deepwater coral reef systems. The direct impacts of ocean acidi cation are expected to be most marked for organisms with calcareous skeletons, such as corals, plankton, molluscs and echinoderms (Doney et al. 2009). Increasing acidity reduces the ability of these organisms to form skeletal structures, which is likely to affect not only their ability to function within the ecosystem, but the functioning of the ecosystem as a whole (Kleypas & Yates 2009). For example, research on coral cores in the Great Barrier Reef identi ed a 14% decline in coral calci cation rates between 1990 and 2005 (De'ath et al. 2009), which the authors attribute to excessive temperature increases, ocean acidi cation, or a combination of the two. For this region, increased ocean acidi cation and sea surface temperatures are predicted to have combined impacts, prompting reef conditions to shift from 'marginal' (Kleypas et al. 1999) to 'extremely marginal' by the middle of this century (Noreen 2010). For the subtropical regions of the Tasmantid and Lord Howe seamount chains, it is likely that increased ocean acidity will reduce coral growth rates and resilience, making the reef systems more susceptible to erosion and disturbance from storms (Anthony & Marshall 2009). Predictive climate models indicate that the unique, deep, cold water reefs and sponge gardens of the Norfolk Ridge, shelf edge and seamount chains are also at risk from a similar range of impacts (Cohen & Holcomb 2009; Howard et al. 2009; Hyder Consulting 2008). Corals provide structural habitat complexity for a range of invertebrates an sh (Althaus et al. 2009). Consequently, any impact on coral reef habitat is likely to change the distribution and abundance of species that depend on them for food and shelter.

Key ecological features assessed = 8		
Pressure	**KEFs**	**Rationale**
Chemical pollution	Canyons on the eastern continental slope Tasman Front and edd eld Upwelling off Fraser Island Tasmantid seamount chain Lord Howe seamount chain Elizabeth and Middleton reefs	Chemical pollution/contaminants is *of potential concern* for key ecological features with values that make them particularly vulnerable to the impacts of a chemical spill, such as important aggregations of marine life at or near the sea surface. Vulnerable key ecological features include the Tasman Front and edd eld; the Fraser upwelling; the Tasmantid and Lord Howe seamount chains; canyons on the eastern continental slope; and Elizabeth and Middleton reefs. As is the case with oil spills, chemical spills are unpredictable events and their likelihood is low in the context of the international and domestic regulatory mitigation measures that apply in Australia. The effects of a major chemical spill can be similar to those of oil spills (GBRMPA 2009), particularly in areas and at times of biological signi cance for important or threatened species. The impacts vary depending on the toxicity of chemicals, how the materials are packaged and transported, the quantity spilled, the site and ecological sensitivity.

Key ecological features assessed = 8		
Pressure	**KEFs**	**Rationale**
Marine debris	Shelf rocky reefs Canyons on the eastern continental slope Tasman Front and edd eld Upwelling off Fraser Island Tasmantid seamount chain Lord Howe seamount chain Elizabeth and Middleton reefs Norfolk Ridge	Marine debris is de ned as any persistent, manufactured or processed solid material that has been disposed of, or abandoned, in the marine and coastal environment (UNEP 2005). This includes a range of materials from plastics (e.g. bags, bottles, ropes breglass and insulation) to derelic shing gear, and ship-sourced, solid, non-biodegradabl oating materials (DEWHA 2009a). Although region-speci c marine debris data is limited, key sources for the introduction and spread of debris (such as shipping, commercia shing and major current systems) are present across the region. This suggests that all key ecological features will experience a high degree of overlap with this pressure (Katsanevakis 2008). Marine debris has been listed as a key threatening process under the EPBC Act, in recognition of its negative impacts on substantial numbers of Australia's marine wildlife, including protected species of birds, turtles and marine mammals. Therefore, this pressure has implications for key ecological feature values such as biodiversity and aggregations of marine life. The Australian Government has developed a threat abatement plan that provides a coordinated national approach to prevent and mitigate the effects of harmful marine debris on marine life (DEWHA 2009a).
Light pollution	Elizabeth and Middleton reefs	Light pollution is *of potential concern* to Elizabeth and Middleton reefs as they are known to support important aggregations of marine life that are vulnerable to light (e.g. turtles). Light quality is important for turtles (Salmon 2003) and lighting from shipping an shing vessels offshore can attract hatchlings to vessel hulls, exposing them to predation. Shipping traf c, includin shing vessels anchoring in close proximity to Elizabeth and Middleton reefs, have the potential to negatively impact turtles that forage in these areas.

Key ecological features assessed = 8

Pressure	KEFs	Rationale
Physical habitat modification (fishing gear)	Shelf rocky reefs Canyons on the eastern continental slope	Physical habitat modification due to fishing gear can result in loss or significant degradation of key ecological features that are subject to bottom trawl activities or are inherently vulnerable to habitat modification, including the shelf rocky reefs and canyons on the eastern continental slope. Both of these features are characterised by complex communities of benthic species that are highly vulnerable to the impacts of demersal trawl fishing, which removes, modifies or disturbs seabed flora and fauna (Furlani et al. 2007). These communities, particularly the deepwater coral species, are highly fragile, long lived and therefore susceptible to disturbance (Williams et al. 2010). Potential impacts include declines in the richness, diversity and density of benthic species and the range of invertebrates and fish that depend on these habitats for prey opportunities and shelter (Althaus et al. 2009).
Extraction of living resources (commercial fishing)	Shelf rocky reefs Canyons on the eastern continental slope Tasman Front and eddy field Upwelling off Fraser Island Tasmantid seamount chain Lord Howe seamount chain Norfolk Ridge	The ecosystem effects of fishing are not well understood. The key ecological features highlighted here are considered valuable for their aggregations of marine life and unique features which support ecological properties of regional significance. The rating *of potential concern* is primarily driven by the impact of the targeted take of commercial fisheries on top-order predators, which are considered to be a key functional species group within these features. The extraction of top predators by fishing activities has implications for ecological communities as it influences the abundance, recruitment, species composition, diversity and behaviour of prey species. Removal of top predators can have a 'cascading' effect on all the components of a food web (Baum & Worm 2009; Ceccarelli & Ayling 2010). Reef sharks, cod and groupers are important for coral reef communities, while tuna and billfish are important for pelagic systems (Ceccarelli & Ayling 2010). In the context of active fisheries management and the steady move towards ecosystem-based management of fisheries by all jurisdictions in Australia, the *of potential concern* rating is considered a conservative assessment. This rating highlights the limited understanding of both the ecosystem effects of individual fisheries and the cumulative effects of a number of fisheries on protected species, marine communities, habitats and ecosystems.

Key ecological features assessed = 8		
Pressure	**KEFs**	**Rationale**
Bycatch (commercial shing—domestic)	Shelf rocky reefs Canyons on the eastern continental slope Tasman Front and edd eld Upwelling off Fraser Island Tasmantid seamount chain Lord Howe seamount chain Norfolk Ridge	Commercia shing operations are a key activity in the region and overlap, to varying extents, with these ecological features (e.g. Eastern Tuna and Bill sh Fishery, Southern and Eastern Scale sh and Shark Fishery). In the context of activ sheries management and the steady move towards ecosystem-based management o sheries by all jurisdictions in Australia, the *of potential concern* rating is considered a conservative assessment. For example, a recent review of all Commonwealt sheries found that the current numbers of independent observers are not suf cient to allow a cumulative assessment of the catch of non-target species (Phillips et al. 2010). The review stated that such assessment is important to understand the environmental performance o sheries more broadly and to underpin a holistic approach to the management of ecosystem impacts (Phillips et al. 2010). Generally, there is also a need to increase our understanding of the effectiveness of bycatch mitigation measures (Bensley et al. 2010).

Key ecological features assessed = 8		
Pressure	**KEFs**	**Rationale**
Oil Pollution	Canyons on the eastern continental slope Tasman Front and edd eld Upwelling off Fraser Island Tasmantid seamount chain Lord Howe seamount chain Elizabeth and Middleton reefs	Oil pollution is *of potential concern* for key ecological features with values that make them particularly vulnerable to the impacts of an oil spill, such as important aggregations of marine life at or near the sea surface. Vulnerable key ecological features include the Tasman Front and eddy eld; upwelling off Fraser Island; Tasmantid and Lord Howe seamount chains; canyons on the eastern continental slope; and Elizabeth and Middleton reefs. These key ecological features are highlighted because of their characteristics that make their ecosystems and communities vulnerable to the effects of an oil spill; for example, features that include regions of high productivity that attract aggregations of marine life. Australia has a strong system for regulating industry activity that is the potential source of oil spills and this system has been strengthened further in response to the Montara oil spill. While oil spills are unpredictable events and their likelihood is low based on past experience, their consequences, especially for threatened species at important areas can be severe. The level of impact that actually occurs depends on a number of factors including the concentration of oil; chemical and physical properties of the oil (or oil and dispersant mixture). Also in uencing the impact of an oil spill event are the timing of breeding cycles and seasonal migrations of species, the amount of contact, the susceptibility of particular species; and the health, age and reproductive status of the individuals (AMSA 2011a). Particular ecological values associated with the KEFs that may be impacted by such an event include seasonal feeding aggregations of pelagic invertebrates sh and mammals associated with the Tasman Front and edd eld and the upwelling off Fraser Island, seabirds and turtles that forage at Elizabeth and Middleton reef and the tropical and temperate demersal and pelagic sh assemblages supported by these reefs sh that seek refuge on seamounts; and predatory sh and seabirds that forage in waters surrounding seamounts. Both the intensity and distribution of activities that might lead to oil spills (such as transport) are expected to increase in the region.

Table S1.6: Pressures *of potential concern* to bony fishes of the Temperate East Marine Region

Species assessed = 10 (seahorses, pipehorses and sea dragons assessed as a group)		
Pressure	**Species**	**Rationale**
Changes in sea temperature (climate change)	Eastern gemfish Orange roughy Black cod Seahorses, pipehorses and sea dragons	Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 °C warmer by 2030 (Lough 2009). Research from Europe suggests that the warming of deep waters may have negative consequences for ecosystem function and community distribution (Weaver et al. 2009). All species assessed are likely to experience shifts in distribution and abundance due to sea temperature rises, with impacts on their life cycle stages, prey availability and habitat. Adult black cod and syngnathids are particularly vulnerable given the species' tendency to have specific habitat preferences within a small home range, thus reducing their ability to find and adapt to new habitats (Malcolm 2011; McClatchie et al. 2006).
Changes In oceanography (climate change)	Eastern gemfish Orange roughy Black cod Seahorses, pipehorses and sea dragons	Changes in oceanography include consideration of circulation patterns; current intensities; wind strength and direction; the location and strength of eddy and upwelling events and climatic oscillations such as the El Niño–Southern Oscillation. Although species-specific responses to oceanographic changes are limited, consequences are expected for the structure, function and dynamics of deep sea habitats. For example, there is likely to be an impact on the transport of matter and energy to depths (Entoyer 2010; Weaver et al. 2009), thereby impacting on food supplies reaching these systems. Evidence from Europe suggests that this change alone will alter the population dynamics of commercial deep sea species such as orange roughy (Weaver et al. 2009). In New South Wales ocean current changes resulting from climate change are predicted to cause a reduction in the flow of freshwater to estuaries, and an increase in nutrient laden waters in near coastal areas. These changes will alter species distribution and abundance and potentially decrease sources of prey for juvenile black cod which use these habitats (DTIRIS 2012). Eastern gemfish are considered vulnerable to changes in productivity associated with changes in wind strength (Hobday et al. 2008), and the annual pre-spawning migration may also be impacted by changes in oceanography; however, it is unclear whether the impacts on migration will be positive or negative on the species (Prince & Griffin 2001; Rowling 2001). Black cod, seahorses, pipehorses and sea dragons have specific habitat preferences with small home ranges, and this may reduce their ability to find and adapt to new habitats (Malcolm 2011; McClatchie et al. 2006).

Species assessed = 10 (seahorses, pipehorses and sea dragons assessed as a group)

Pressure	Species	Rationale
Chemical pollution/ contaminants **Nutrient pollution (agricultural activities, urban development)**	Black cod	Black cod's use of estuaries as juvenile development grounds makes them vulnerable to the effects of water pollution, in the form of pollutants contained within run-off from urban development and agricultural activities. These pollutants can degrade the quality of habitats, alter the water chemistry, encourage the growth of algae and smother benthi ora and fauna species. In particular, heavy metals and organochlorine pesticides pose high risks to estuarine biota, as they persist in the environment, magnify along food chains and reduce the relative abundance of top-order predators (ANZECC 2000; DECC 2009). Over time, changes in the water chemistry, food chain and turbidity caused by urban and agricultural run-off may signi cantly impact the long term viability of black cod within estuaries (DTIRIS 2012).
Physical habitat modi cation (dredging)	Seahorses, pipehorses and sea dragons	Physical habitat modi cation due to dredging activities is expected to increase adjacent to the Temperate East Marine Region due to the growth in recreational boating activity (Bay Journal 2008; MSQ 2011). Seahorses, pipehorses and sea dragons have a sedentary lifestyle and close af nity to sponge and reef habitats, which makes them vulnerable to impacts arising from this pressure. Impacts on habitat include a reduction in structural diversity and fewer opportunities for the settlement of new coral colonies, due to the removal of biogenic substratum (Althaus et al. 2009; Lack et al. 2003; Pogonoski et al. 2002).
Physical habitat modi cation (shing gear)	Orange roughy Seahorses, pipehorses and sea dragons	Physical habitat modi cation fro shing gear (e.g. trawling) has the potential to impact on seahorses, pipehorses and sea dragons due to their speci c habitat requirements and limited geographic range (Foster & Vincent 2004; Kuiter 2009). These species are distributed across the shing grounds of the Queensland East Coast Otter Trawl Fishery. As is the case with dredging, mobil shing gear crushes, buries and exposes marine animals and their habitat (e.g. sponge gardens and rocky reefs), and reduces the structural diversity of preferred habitat (Althaus et al. 2009; Lack et al. 2003; Pitcher et al. 2009; Pogonoski et al. 2002). Commercial bottom trawling on seamounts can cause physical damage to benthic environments affecting benthic fauna. Damage to seamounts could affect orange roughy recruitment due to the link between their spawning aggregations and this habitat feature.
Physical habitat modi cation (urban/coastal development)	Black cod	Estuaries provide a nursery, refuge and feeding opportunities for black cod in its juvenile development stages. Physical habitat modi cation of estuaries as a result of urban and coastal development can impact black cod prior to their migration to coastal rocky reefs. In particular, the ongoing building and repair of seawalls, designed to protect low-lying foreshore infrastructure from sea level rise associated with climate change (DTIRIS 2012) can have a detrimental effect o ows, vegetation and habitat, impacting juvenile black cod.

Species assessed = 10 (seahorses, pipehorses and sea dragons assessed as a group)		
Pressure	**Species**	**Rationale**
Extraction of living resources (illegal, unregulated and unreported shing)	Black cod	Isolated incidences of the illegal take of black cod by recreational spea shers along the New South Wales coast are occasionally reported (DTIRIS 2012), and illega shing is *of potential concern* for black cod. The New South Wales Fisheries' 2003 draft recovery plan for black cod reported anecdotal evidence of large catches of black cod in the early 1980s from Elizabeth and Middleton Reefs, and in 1993 a commercia shing boat crew was found to have taken 24 black cod from the same area (TSSC 2012).
Bycatch (commercial shing)	Black cod Seahorses, pipehorses and sea dragons	There is evidence that black cod, seahorses, pipehorses and sea dragons are caught in commercia sheries in the region. Commercial take of black cod is prohibited, however, the species is still caught as bycatch in Commonwealt sheries, wit sh suffering mortality due to hooks fro shers and barotrauma (Baker 2009). Indiscriminat shing methods such as bottom-set baited lines (e.g. setlining, trotlining, handlining) are the most widely used methods with the potential to have a signi cant negative impact on black cod numbers and distribution (DTRIS 2012). Commercia sheries targeting estuarine species may also impact juvenile black cod numbers, in particular thos sheries trapping in the lower reaches of estuaries on the north coast of New South Wales (DTIRIS 2012). Seahorses, pipehorses and sea dragons are considered vulnerable to Danish-seine operations, as these activities occur in relatively shallow waters and use nets with a small mesh size. They are also caught as bycatch in the Queensland East Coast Otter Trawl Fishery, particularly Duncker's and Hardwick's pipehorses, although numbers are low and considered to be declining (Coles et al. 2008). In New South Wales, bycatch of these species, particularly *Solegnathus* spp. (pipehorses) is a concern (Bowles & Martin-Smith 2003).
Bycatch (recreational shing)	Black cod	As for commercia shing, recreationa shing of black cod is prohibited; however recreational shers are still known to occasionally catch black cod. Limited recognition or knowledge of the species has meant that it is not always released, or even when released does not survive due to barotrauma. Ne shing technologies have improved recreationa shing effectiveness, particularly in deeper waters where adult black cod are found, which may increase the risk of recreational bycatch of the species (TSSC 2012).

Table S1.7: Pressures *of concern* to selected cetaceans of the Temperate East Marine Region

Species assessed = 9

Pressure	Species	Rationale
Physical habitat modi cation (urban/coastal development)	Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	Increased physical habitat modi cation associated with urban and coastal development is expected adjacent to the region, along the south-east Queensland and New South Wales coastline. Studies on coastal and riverine cetaceans worldwide indicate that habitat degradation is a serious threat that fragments populations and, in some cases, eliminates habitat (Reeves & Smith 1999). In the Temperate East, the overlap between coastal development and habitats used by inshore dolphins makes them vulnerable to this pressure. Indo-Paci c humpback dolphin populations are particularly susceptible because they are highly localised, occur in small subpopulations and are extremely sensitive to disturbance in their preferred habitats (Corkeron et al. 1997; Parra et al. 2006).
Bycatch (commercial shing)	Killer whale Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	Bycatch of cetacean species predominantly results in drowning and may cause changes to species distribution and population health. Diet studies of inshore dolphins by Heinshohn (1979), Marsh et al. (1989) and Parra & Jendensjo (2009) indicate that coastal estuarine waters are important foraging habitats for these species and, as a result, they are at greater risk of directly or indirectly interacting wit sheries operating in coastal waters (Parra & Jendensjo 2009). For inshore dolphins, bycatch in gillnets has emerged as a key threat to their survival (D'Agrosa et al. 2000; Northridge 1991; Rojas-Bracho & Taylor 1999). Australian ne sheries' catch is taken close to the coast, at depths less than 50 m (Kearney et al. 1996) and there is evidence that coastal dolphin bycatch occurs in thes sheries (Corkeron et al. 1997). For example, the outcome of the ecological risk assessment process by AFMA for the Small Pelagic Fishery (purse seine) assessed both the coastal bottlenose and Indo-Paci c humpback dolphin as at high risk of capture. The Small Pelagic Fishery Bycatch Action Plan is intended to reduce bycatch in thi shery. The rating assigned for the killer whale has been led by the outcomes of the AFMA ecological risk assessment process, which assessed the species as at high risk of capture within the Eastern Skipjack Tuna Fishery. *Australia's tuna purse sein sheries bycatch action plan* (AFMA 2005) is intended to reduce bycatch and associated impacts in the Commonwealth tuna purse-seine sheries.

Species assessed = 9		
Pressure	**Species**	**Rationale**
Bycatch **(bather protection programs)**	Indo-Pacific (coastal) bottlenose dolphin Indo-Pacific humpback dolphin	Bather protection (shark meshing) programs have been in operation for over 70 years, deploying nets and drumlines to protect swimmers from the risk of shark attacks in coastal waters adjacent to the Temperate East Marine Region (Queensland and New South Wales). However, these programs lead to the bycatch of other marine species, including inshore dolphins. Between 1995 and 2009, 257 dolphins were caught in nets and drumlines associated with the bather protection programs (228 were caught in nets and 29 on drumlines); of these, 47 were bottlenose dolphins and 26 were Indo-Pacific humpback dolphins (Nias 2011).

Table S1.8: Pressures *of potential concern* to selected cetaceans of the Temperate East Marine Region

Species assessed = 9		
Pressure	**Species**	**Rationale**
Sea level rise (climate change)	Indo-Pacific (coastal) bottlenose dolphin Indo-Pacific humpback dolphin	Global sea levels rose by 20 cm between 1870 and 2004, and predictions estimate a further rise of 5–15 cm by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5–1 m by 2100, relative to 2000 levels (Climate Commission 2011). Inshore dolphins are vulnerable to rising sea levels because of the predicted impacts on their preferred foraging habitat (seagrass). In general, seagrass abundance and extent is predicted to decline as sea level rise decreases the light available for photosynthesis (Connolly 2009). A decrease in the extent of seagrass is expected to impact negatively on inshore dolphins.
Changes in sea temperature (climate change)	Blue whale Dwarf minke whale Humpback whale Killer whale Fin whale Sei whale Southern right whale Indo-Pacific (coastal) bottlenose dolphin Indo-Pacific humpback dolphin	Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 °C warmer by 2030 (Lough 2009). Inshore dolphins are vulnerable to rising sea temperatures because of the expected impacts on their preferred foraging habitat (seagrass) (Connolly 2009; Parra & Corkeron, 2001; Parra et al. 2002; Parra, 2006). Temperature is a key factor determining the distribution of seagrasses (Poloczanska et al. 2007) and shallow subtidal species are considered at risk from warming ocean and air temperatures (Seddon et al. 2000). Climate variability may also affect other cetaceans; for example, research on climate variability and reproduction in southern right whales suggests a detrimental impact on reproductive success with warming events (Pirzl et al. 2008). Environmental fluctuations may impact on reproduction by affecting body condition and health through changes in foraging conditions, with krill availability in the summer feeding grounds influencing reproductive success the following winter (Trathan & Murphy 2002; Trathan et al. 2003).

Species assessed = 9		
Pressure	**Species**	**Rationale**
Changes in oceanography (climate change)	Blue whale Dwarf minke whale Humpback whale Killer whale Fin whale Sei whale Southern right whale Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	Changes in oceanography include consideration of circulation patterns, current intensities, wind strength and direction, the location and strength of eddy and upwelling events and climatic oscillations such as the El Niño–Southern Oscillation. Oceanographic changes in the region will be primarily driven by the East Australian Current. Studies indicate this major boundary current has been strengthening, pushing warmer, saltier water further southward along the east coast (for up to 350 km). Predictive climate models have medium con dence that this trend will increase (Ridgway & Hill 2009). There will also be associated circulation effects arising from expected changes to the El Niño–Southern Oscillation. Potential consequences of changes in ocean circulation patterns and the bifurcation point of the East Australian Current include shifts in upwelling events, increased thermal strati cation, increased eddy activity and a shift in the thermocline depth (Chin et al. 2010). For cetaceans, these changes may in uence the availability of prey, migration patterns and selection of calving sites (Chin et al. 2010).
Ocean acidi cation (climate change)	Blue whale Dwarf minke whale Humpback whale Killer whale Fin whale Sei whale Southern right whale Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	Driven by increasing levels of atmospheric CO_2 and subsequent chemical changes in the ocean, acidi cation is already under way and detectable. Since pre-industrial times, acidi cation has lowered ocean pH by 0.1 units (Howard et al. 2009). Furthermore, climate models predict this trend will continue, with a further 0.2–0.3 unit decline by 2100 (Howard et al. 2009). Recent research indicates signi cant impacts of ocean acidi cation on Antarctic krill (Kawaguchi et al. 2011), which are a key food source for many whale species that visit Australian waters. While there are no observed impacts of climate change on zooplankton in Australian waters, based on knowledge of impacts elsewhere, Australia is likely to start losing calcifying zooplankton from its southern waters (Richardson et al. 2009).

Species assessed = 9		
Pressure	**Species**	**Rationale**
Chemical pollution/ contaminants (urban development, agricultural activities)	Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	Cetaceans that frequent nearshore areas, such as the Indo-Paci c bottlenose dolphin and the Indo-Paci c humpback dolphin, may be exposed to higher levels of chemical pollutants than wholly offshore species (Jacob 2009). Shipping is a key activity in the region, with shipping routes servicing a number of ports that are adjacent to the region and inshore dolphin habitat. Higher levels of polychlorinated biphenyls (PCBs) have been found in dolphins from the Gold Coast compared to anywhere else in Australia; high levels of PCBs have been linked to impaired reproductive capacity in dolphins (Gaus et al. 2001). There is limited data on the likelihood of chemical spills in the region; however, like oil spills, they are unpredictable events that may have severe consequences for marine species. Inshore dolphins are particularly vulnerable because of their highly localised populations along the east coast.
Nutrient pollution (urban development, agricultural activities)	Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	Nutrient pollution, also known as eutrophication, refers to an increase in the rate of supply of organic matter into an ecosystem, particularly nitrogen, phosphorus and silica. Eutrophication is considered a threat to coastal marine environments, leading to an increased frequency of harmful algal blooms, loss of ecosystem integrity and changes to biodiversity. High rainfall and catchment run-off, particularly in south-east Queensland, increases the exposure of dolphins to bioaccumulated toxins (Lawler et al. 2007). For example, inshore dolphins can be directly exposed to toxins through algae outbreaks associated with increased nutrient loads, absorbing toxins from water or ingesting algal cells; or indirectly through eating prey that contain toxins (Carmago & Alonso 2006).

Species assessed = 9		
Pressure	**Species**	**Rationale**
Marine debris	Blue whale Dwarf minke whale Humpback whale Killer whale Fin whale Sei whale Southern right whale Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris* was listed in 2009 as a key threatening process under the EPBC Act (DEWHA 2009a). Marine debris is de ned as any persistent, manufactured or processed solid material that has been disposed of or abandoned in the marine and coastal environment (UNEP 2005). Cetaceans are considered vulnerable to entanglement in marine debris, and the threat abatement plan lists a number of cetaceans that are known to be adversely affected by marine debris, including the southern right whale, blue whale and humpback whale (DEWHA 2009a). The potential for marine debris to affect inshore dolphin habitat is high because of the high number of people living adjacent to the coast (ABS 2001), the popularity of recreationa shing, and the number of commercia sheries operating in and adjacent to the region (DEWHA 2009b). The Australian Government has developed a threat abatement plan that provides a coordinated national approach to prevent and mitigate the effects of harmful marine debris on marine life (DEWHA 2009a).
Noise pollution (shipping, urban development)	Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	There is growing concern that the impacts of human-made noise on marine life, particularly cetaceans, may result in physical or behavioural effects on these species (DEWHA 2008a). With pressures such as coastal development, a number of important ports and associated shipping activity, there is concern that noise may interfere with the ability of inshore dolphins to communicate, resulting in displacement from preferred habitat, or physical trauma and damage to sensory systems (Bejder & Samuels 2003; Mattson et al. 2005; Nowacek et al. 2007; Richardson et al. 1995). Evidence of changes in behaviour can be found in Moreton Bay, where the rate of whistling by humpback dolphins has increased in the presence of travelling boats, particularly in mother–calf pairs (van Parijs & Corkeron 2001).
Physical habitat modi cation (dredging/ dredge spoil)	Indo-Paci c (coastal) bottlenose dolphin Indo-Paci c humpback dolphin	Physical habitat modi cation from dredging activities is expected adjacent to the Temperate East Marine Region due to the growth in recreational boating activity (Bay Journal 2008; MSQ 2011). Dredging can also occur in association with development projects for extractive purposes and for the installation of pipelines and cables. Dredging modi es nearshore habitats by removing or smothering benthi ora and fauna, and changing wate ows (GBRMPA 2009). Studies on coastal and riverine cetaceans worldwide indicate that habitat degradation is a serious threat that fragments populations and, in some cases, eliminates habitat (Reeves & Smith 1999). In the region, the overlap between coastal development and habitats used by inshore dolphins makes them vulnerable to this pressure. The Indo-Paci c humpback dolphin populations are particularly susceptible because they are highly localised, occur in small subpopulations and are extremely sensitive to disturbance in their preferred habitats (Corkeron et al. 1997; Parra et al. 2006).

Species assessed = 9

Pressure	Species	Rationale
Bycatch (bather protection programs)	Humpback whale	Bather protection (shark meshing) programs have been in operation for over 70 years, deploying nets and drumlines to protect swimmers from the risk of shark attacks along the New South Wales and Queensland coasts. However, these programs lead to the bycatch of other marine species. The number of humpback whales caught in nets along the Queensland coast during migration has remained relatively constant over recent years (DERM 2009); however, as the population recovers, the interaction between humpback whales and shark meshing may increase.
Oil pollution (shipping, vessels)	Indo-Pacific (coastal) bottlenose dolphin Indo-Pacific humpback dolphin	Oil spills are unpredictable events and their likelihood is low, particularly in the context of the international and domestic regulatory mitigation measures that apply in Australia. However, their consequences can be severe, particularly in biologically significant areas or times. Shipping is a key activity in the region, with shipping routes servicing a number of ports that are adjacent to the region and inshore dolphin habitat. In the event of an oil spill, dolphins have been known to detect oil and avoid it; however, at other times they have been exposed to floating oil (AMSA 2010). Inshore dolphin species are particularly vulnerable to oil spills because of their highly localised populations along the east coast.
Collisions with vessels **(shipping, tourism, fishing)**	Indo-Pacific (coastal) bottlenose dolphin Indo-Pacific humpback dolphin	Collisions between dolphins and vessels have been recorded in Australian waters, with records of dolphin mortality attributed to boat strike in Victoria (DSE 2011) and South Australia (News Limited 2010). The growth in recreational boating activity in the region (Bay Journal 2008; MSQ 2011), combined with a preference for nearshore habitats, makes inshore dolphins vulnerable to collisions with vessels.
Changes in hydrological regimes **(climate change)**	Indo-Pacific (coastal) bottlenose dolphin Indo-Pacific humpback dolphin	Changes in hydrological regimes through, for example, an increase in the frequency and intensity of storm and flooding events could impact on nearshore environments used by inshore dolphins. The predicted increase in intensity of storm events, combined with rising sea levels, is expected to cause shoreline erosion, thereby increasing turbidity of shallow coastal waters (Cabaco et al. 2008; Hennessy et al. 2007; Waycott et al. 2007) and reducing the amount of light available for photosynthesis in seagrasses (Connolly 2009), the preferred habitat of inshore dolphins. Increases in turbidity within mangrove environments may also reduce the efficiency of predators (Abrahams & Kattenfeld, 1997), including both species of inshore dolphin.

Table S1.9: Pressures *of concern* to selected marine reptiles of the Temperate East Marine Region

Species assessed = 24 (sea snakes assessed as a group)		
Pressure	**Species**	**Rationale**
Sea level rise (climate change)	Loggerhead turtle	Global sea levels rose by 20 cm between 1870 and 2004, and predictions estimate a further rise of 5–15 cm by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5–1 m by 2100, relative to 2000 levels (Climate Commission 2011). The implications of sea level rise for marine turtles include an increased risk of tidal inundation or destruction of nests, the selection of suboptimal nesting areas, and risk of nest destruction by other turtles associated with higher nesting densities (Hamann et al. 2007; Poloczanska et al. 2010). Collectively, these impacts may reduce breeding success. It is expected that the effects of sea level rise will be particularly marked in regions of extensive coastal development, such as eastern Australia, where development acts as a barrier to the landward movement of beaches or hinders natural accretion of beach material and the evolution of beach morphology (Poloczanska et al. 2010).
Changes in sea temperatures (climate change)	Loggerhead turtle	Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 °C warmer by 2030 (Lough 2009). Increasing sea temperatures have the potential to impact on marine turtles in a number of ways, including a shift in distribution, which may either increase or decrease the species range (Hawkes et al. 2009; Milton & Lutz 2003); alterations to life history characteristics such as growth rates and age at maturity (Balazs & Chaloupka 2004; Chaloupka & Limpus 2001; Hamann et al. 2007); and reduced prey availability (Chaloupka et al. 2008; Fuentes et al. 2009). For example, higher mean annual sea surface temperatures in core loggerhead foraging areas correlate with trends towards smaller annual nesting populations during the following summer in eastern Australia (Chaloupka et al. 2008).
Changes in terrestrial sand temperatures (climate change)	Loggerhead turtle	Changes in terrestrial sand temperature have implications for nesting marine turtles: higher sand temperatures increase the female bias in the sex ratio of turtle hatchlings, which may lead to a female bias in marine turtle populations (Fuentes et al. 2009). A rise in sand temperature may also compromise egg incubation, leading to lower hatchling success and reduced hatchling survival (Fuentes et al. 2009). Emerging research suggests that turtles are responding to these pressures in a highly adaptive manner; for example, by shifting nesting periods to correspond to lower temperatures (Poloczanska et al. 2010).

Species assessed = 24 (sea snakes assessed as a group)

Pressure	Species	Rationale
Bycatch (commercial shing)	Green turtle Leatherback turtle Loggerhead turtle	Bycatch associated with commercia sheries operating in the region is *of concern* to marine turtles that are listed as threatened, including the green, leatherback and loggerhead turtle. Turtles are vulnerable to trawl, gillnet and longline sheries gear, and bycatch interactions typically result in the death of individuals by drowning. All three gear types are used across the region and records indicate that all three species of turtle are caught (Limpus 2008a, 2008b, 2009). The population effects of bycatch mortality are unknown for some species; however, for others such as the loggerhead and green turtle, it has led to population declines. For example, mortality associated with otter trawl operations across eastern and northern Australia were identi ed as the cause of the 86% decline in loggerhead annual nesting numbers in eastern Australia from the mid-1970s to 2000. In the past decade, the introduction of turtle excluder devices (TEDs) in several key traw sheries such as the Queensland East Coast Otter Trawl Fishery has resulted in a signi cant reduction of bycatch. Despite their success, TEDs are not universally used. For example, New South Wales traw sheries (e.g. New South Wales Otter Trawl Fishery) do not use these devices and it is expected this will slow the recovery of threatened species across the Temperate East Marine Region and in the south-west Paci c. For othe sheries, such as longline operations, where TEDs cannot be used, bycatch levels continue to be considered a high risk. For example, in the Eastern Tuna and Bill sh Fishery, green and leatherback turtles are the most frequently caught turtle species.
Collision with vessels	Green turtle Hawksbill turtle Loggerhead turtle	Boat strikes are a common cause of death and injury in marine turtles, with turtles' poor hearing and vision hampering their ability to avoid boats. Turtles are most vulnerable to boat strike when they are in shallow waters, or basking or breathing at the surface. Growing coastal development and the associated rise in recreational boating activities in the region are expected to exacerbate this issue (Limpus 2008a, b, 2009a). Adult turtles are particularly vulnerable, and this compounds the impact of this pressure on turtle populations by disproportionately reducing the numbers of breeding-age individuals (Limpus 2008a). Some very effective mitigation measures are in place, such as the 'Go slow' zones in the Moreton Bay Conservation Park; however, experts remain concerned about the impact of boat strikes on turtle populations within the region.

Table S1.10: Pressures *of potential concern* to selected marine reptiles of the Temperate East Marine Region

Species assessed = 24 (sea snakes assessed as a group)		
Pressure	**Species**	**Rationale**
Sea level rise (climate change)	Green turtle	Global sea levels have risen by 20 cm between 1870 and 2004, and predictions estimate a further rise of 5–15 cm by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5–1 m by 2100, relative to 2000 levels (Climate Commission 2011). The implications of sea level rise for marine turtles include an increased risk of tidal inundation or destruction of nests, the selection of suboptimal nesting areas, and risk of nest destruction by other turtles associated with higher nesting densities (Hamann et al. 2007; Poloczanska et al. 2010). Collectively, these impacts may reduce breeding success. It is expected that the effects of sea level rise will be particularly marked in regions of extensive coastal development, such as eastern Australia, where development acts as a barrier to the landward movement of beaches or hinders natural accretion of beach material and the evolution of beach morphology (Poloczanska et al. 2010).
Changes in sea temperature (climate change)	Green turtle Hawksbill turtle Leatherback turtle Sea snakes	Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 °C warmer by 2030 (Lough 2009). Increasing sea temperatures have the potential to impact on marine turtles in a number of ways, including a shift in distribution that may either increase or decrease the species range (Hawkes et al. 2009; Milton & Lutz 2003), alterations to life history characteristics (e.g. growth rates, age at maturity and reproductive periodicity) (Balazs & Chaloupka 2004; Chaloupka & Limpus 2001; Fuentes et al. 2009; Hamann et al. 2007) and reduced prey availability (Chaloupka et al. 2008). Sea snakes depend on water temperatures for their body heat while foraging (Guinea 1995; Heatwole 1981). Little is known about the thermal requirements and tolerances of sea snakes and how they will respond to increasing water temperatures (Hamann et al. 2007). Potential impacts from changes in sea temperatures include changes to the availability of prey species and seasonal movements for breeding or feeding (Fuentes et al. 2009; Hamann et al. 2007).

Species assessed = 24 (sea snakes assessed as a group)		
Pressure	**Species**	**Rationale**
Changes in oceanography (climate change)	Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle	Changes in oceanography broadly refer to changes in ocean circulation patterns, current intensities, wind strength and direction, the location and strength of eddy and upwelling events and climatic oscillations such as the El Niño–Southern Oscillation. For turtles, changes to these ocean characteristics may have implications for hatchling dispersal, migration and feeding. For example, dispersal of loggerhead and green turtle hatchlings from the Great Barrier Reef occurs via offshore currents (Boyle 2006; Hamann et al. 2007), and any changes in offshore current will in uence this dispersal.
Changes in terrestrial sand temperature (climate change)	Green turtle	Changes in terrestrial sand temperature have implications for nesting marine turtles: higher sand temperatures increase the female bias in the sex ratio of turtle hatchlings, which may lead to a female bias in marine turtle populations (Fuentes et al. 2009). A rise in sand temperature may also compromise egg incubation, leading to lower hatchling success and reduced hatchling survival (Fuentes et al. 2009). Emerging research suggests that turtles are responding to these pressures in a highly adaptive manner; for example, by shifting nesting periods to correspond to lower temperatures (Poloczanska et al. 2010).
Chemical pollution/ contaminants (shipping, vessels, urban development, agricultural activities)	Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle	The Temperate East Marine Region is highly exposed to possible vectors for chemical pollutants, including signi cant shippin shing and agricultural activities in and adjacent to the region. It is expected that the effects of a major chemical spill would be similar to, or possibly exceed, those of a major oil spill (GBRMPA 2009). The implications of small and gradual in uxes of chemicals (e.g. agricultural run-off) are harder to ascertain, and the effects on turtle populations are unknown (Muusee et al. 2006). Studies indicate that turtles, as high-order predators, bioaccumulate and biomagnify chemicals, meaning that chemicals can reach high concentrations in individuals, with potentially negative consequences (Muusee et al. 2006). A number of management measures are in place to respond to this risk, including the National plan to combat pollution of the sea by oil and other noxious and hazardous substances and the International Convention for the Prevention of Pollution from Ships (MARPOL), both of which are implemented through the Australian Maritime Safety Authority. Although these measures mitigate the risk of a signi cant pollution event, the potential for such an event remains.

Species assessed = 24 (sea snakes assessed as a group)

Pressure	Species	Rationale
Nutrient pollution (urban development, agricultural activities)	Green turtle Hawksbill turtle Loggerhead turtle	Nutrient pollution, also known as eutrophication, refers to an increase in the rate of supply of organic matter into an ecosystem, particularly nitrogen, phosphorus and silica. Eutrophication is considered a threat to coastal marine environments, leading to an increased frequency of harmful algal blooms, loss of ecosystem integrity and changes to biodiversity. Algal blooms have been associated with substandard diets in turtles, which may hamper growth and development and reduce reproduction (Arthur et al. 2006). It is also suggested that these blooms are associated with tumour-promoting toxins in turtles. Given the expected increase in nutrient pollution associated with the growth in coastal development, experts consider this pressure to be of increasing concern to turtle populations that are already compromised.
Marine debris	Green turtle Loggerhead turtle	*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris* was listed in 2003 as a key threatening process under the EPBC Act (DEWHA 2009a). Marine debris is de ned as any persistent, manufactured or processed solid material that has been disposed of, or abandoned, in the marine and coastal environment (UNEP 2005). The green and loggerhead turtles are known to be adversely affected by marine debris. Ingestion of debris is common, particularly plastic bags, which can be mistaken for prey (i.e. jelly sh) (Derraik 2002). This can cause turtles t oat, thereby affecting foraging and animal health. Young turtles are especially vulnerable, as they drift within convergence zones (e.g. rips, fronts and drift lines formed by ocean currents) where high densities of marine debris accumulate. In a recent study by Boyle & Limpus (2008), synthetic materials accounted for up to 46% of total stomach content in green turtle post-hatchlings. Hatchlings are not able to compensate for the intake of non-nutritional items, and this results in reduced energy uptake. Research also indicates that toxins within materials are absorbed by turtles (Bjorndal et al. 1994).

Species assessed = 24 (sea snakes assessed as a group)

Pressure	Species	Rationale
Light pollution (onshore activities and offshore activities)	Green turtle Loggerhead turtle	The Temperate East Marine Region is adjacent to a highly populated coastline where lighting from coastal development, ports and associated shipping activity is considered *of potential concern* to marine turtles, particularly during the breeding season. Light pollution along, or adjacent to, nesting beaches may alter nocturnal turtle behaviours, particularly the selection of nesting sites and the passage of adult females and emerging hatchlings from the beach to the sea (Limpus 2008b). The impacts of these changes in behaviour include a decrease in nesting success, beach avoidance by nesting females and disorientation, leading to increased mortality through predation, road kill and dehydration (Limpus 2008b; Lorne & Salmon 2007; Witherington & Martin 2000). Managers have addressed the issue by applying management zones to the majority of nesting sites (Limpus 2008b); for example, at Mon Repos Conservation Park, a 1.5 km radius darkness zone has been applied to protect nesting turtles. However, lighting from nearby towns is extensive and thought to remain visible out to sea for distances greater than 3 km, thereby in uencing hatchling behaviour at Mon Repos (Limpus 2008b).
Physical habitat modi cation (dredging)	Green turtle Loggerhead turtle Sea snakes	Physical habitat modi cation due to dredging activities is expected to increase in areas adjacent to the Temperate East Marine Region due to the growth in recreational boating activity (Bay Journal 2008; MSQ 2011). Dredging can also occur in association with development projects for extractive purposes and for the installation of pipelines and cables. Dredging modi es nearshore habitats by removing or smothering benthi ora and fauna, and changing wate ows (GBRMPA 2009). Marine turtles and sea snakes are likely to use habitats that are affected by dredging and are therefore vulnerable to this pressure.
Extraction of living resources (commercial shing, non-domestic)	Green turtle Hawksbill turtle	Marine turtles are protected in Australian waters but, because they roam internationally, declines may be due to unsustainabl shing in other parts of the species' range. Evidence indicates that shing occurs in neighbouring South Paci c countries (Meylan & Donnelly 1999), with green and hawksbill turtles preferentially taken for their meat and shells, respectively, and sold in markets (e.g. Daru and Koki markets in Papua New Guinea). Long life spans and late sexual maturity make these species vulnerable to continued harvesting and impacts on populations both within and beyond the region (Dethmers et al. 2010).

Species assessed = 24 (sea snakes assessed as a group)		
Pressure	**Species**	**Rationale**
Bycatch (commercial shing)	Hawksbill turtle Sea snakes	Turtles are vulnerable to trawl, gillnet and longlin sheries gear and bycatch interactions typically result in the death of individuals by drowning. All three gear types are used across the region, and records indicate that hawksbill turtles are caught as bycatch (Limpus 2008a; 2008b; 2009). In the past decade, the introduction of turtle excluder devices (TEDs) in several key traw sheries has signi cantly reduced bycatch levels. Despite their success, TEDs are not universally used; for example, New South Wales traw sheries (e.g. New South Wales Ocean Trawl Fishery) do not use these devices. Bycatch from the Queensland traw shery is the main pressure impacting on sea snakes (Cogger 2000). In particular, the redspot king praw shery records signi cant sea snake bycatch (Courtney et al. 2010. Thi shery has the potential to impact on all species, especially the spectacled and small-headed seasnakes. Very little is known about either of these species, other than that they are slow to mature, have few young and do not survive well in trawl nets.
Bycatch (illegal, unregulated and unreported shing)	Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle	Illegal, unregulated and unreported (IUU shing is considered *of potential concern* for all turtle species. IU shing encompasses a complex range o sheries activities, but generally refers to sheries operations that violate the governing laws and conventions of th sh stock. Although not explicitly targeting turtle species, IU sheries operations create signi cant collateral damage to ecosystems. By their nature, such operations do not respect national and international actions designed to reduce bycatch and mitigate the incidental mortality of marine animals such as marine turtles (Agnew et al. 2009). Although IU shing is not a signi cant issue within the region, it is widespread in adjacent waters and is thought to be contributing to declines in turtle populations within the Temperate East Marine Region.

Species assessed = 24 (sea snakes assessed as a group)

Pressure	Species	Rationale
Oil pollution (shipping, vessels)	Green turtle Hawksbill turtle Leatherback turtle Loggerhead turtle Sea snakes	Oil spills are unpredictable events and their likelihood is low, particularly in the context of the international and domestic regulatory mitigation measures that apply in Australia. However, their consequences can be severe, particularly in biologically signi cant areas and times. Shipping is a key activity in the region, with shipping routes servicing a number of ports adjacent to the region, and adjacent to habitat for turtles and sea snakes. Marine reptiles are affected by oil pollution through exposure when surfacing to breath, contaminated food supplies, fouling of nesting beaches and absorption through the skin (Anon 2010; Gagnon 2009; Watson 2009). Physical contact may result in a range of impacts including burns, damage to internal organs, and toxicity resulting in reduced hatchling success and deformities in developing embryos (AMSA 2010).
Invasive species	Green turtle Loggerhead turtle	Egg predation by invasive or introduced species is a signi cant issue for marine turtle populations. An invasive species is de ned as one that occurs and thrives outside its normal geographical distribution as a result of human activities, and can include animals, weeds, diseases and parasites (Olsen et al. 2006). Of particular concern to turtle populations within the region are the European red fox and feral pig, both of which have had impacts on turtle populations, particularly the eastern loggerhead stocks (Limpus & Limpus 2003; Limpus & Parmeter 1985; Tisdell et al. 2004). Extensive monitoring of (index) nesting sites both within the region (e.g. Mon Repos) and beyond (e.g. Gulf of Carpentaria) indicate that a high proportion of nests are destroyed by foxes and pigs. In the case of Mon Repos, a key nesting site for the loggerhead, predation has seriously impacted on the recruitment of females to the population, reducing overall stocks (Limpus & Limpus 2003). A Queensland Government fox eradication program has reduced fox impacts to negligible levels at key sites (i.e. Mon Repos); however, uncontrolled predation remains an issue. Threat abatement plans have been prepared under the EPBC Act for foxes and pigs (DEWHA 2008c; DEH 2005a).

Table S1.11: Pressures *of concern* to selected seabirds of the Temperate East Marine Region

Species assessed = 34		
Pressure	**Species**	**Rationale**
Changes in oceanography (climate change)	Sooty tern	Changes in oceanography broadly refer to changes in ocean circulation patterns; current intensities; wind strength and direction; the location and strength of eddy and upwelling events; and climatic oscillations such as the El Niño–Southern Oscillation. The sooty tern is considered especially vulnerable to changes in oceanography through impacts on the distribution and availability of prey species, and on its breeding success. In the region, changes in oceanography will be primarily driven by the East Australian Current, which has been strengthening, pushing warmer, saltier water further southward along the east coast (for up to 350 km). Models suggest with medium con dence that this trend will increase (Ridgway & Hill 2009). For the sooty tern, El Niño events have also been linked to breeding failure. In 2002, following an El Niño–Southern Oscillation event, sooty terns at Lord Howe Island experienced almost complete breeding failure, with the majority of chicks dying of starvation (Congdon et al. 2007).

Species assessed = 34		
Pressure	**Species**	**Rationale**
Invasive species	Black noddy Common noddy Crested tern Sooty tern White tern Grey ternlet Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Little penguin Masked booby Red-tailed tropicbird	Invasive species impact on seabird populations by preying on adults and nest contents (eggs and chicks), destroying nests and modifying habitat (DEH 2005). Invasive species are considered to be the greatest threat to seabirds after habitat loss, contributing to the threatened status of many species breeding within the region (Olsen et al. 2006). An invasive species is de ned as one that occurs and thrives outside its normal geographical distribution as a result of human activities, and can include animals, weeds, diseases and parasites (Olsen et al. 2006). European settlers are implicated in the introduction of Australia's most established invasive species—the rat, rabbit and fox—all of which are known to threaten seabirds. More recent invaders also known to threaten seabirds include the Argentine ant and kikuyu grass. Rat predation on Lord Howe Island have resulted in the localised extinction of the Kermadec petrel, little shearwater and white-bellied storm-petrel (Garnett et al. 2011); severe degradation by rabbits of nesting habitat for Gould's petrel on Cabbage Tree Island (NSW NPWS 2000); and kikuyu grass mats on Montague Island that entangle little penguin adults and chicks (DECC 2009). Threat abatement plans have been prepared under the EPBC Act for pigs, rabbits, foxes, and exotic rodents on small islands (DEH 2005b; DEWHA 2008b; DEWHA 2008c; DEWHA 2009c).

Table S1.12: Pressures *of potential concern* to selected seabirds of the Temperate East Marine Region

Species assessed = 34		
Pressure	**Species**	**Rationale**
Sea level rise (climate change)	Black noddy Common noddy Crested tern Masked booby Red-tailed tropicbird	Global sea levels have risen by 20 cm between 1870 and 2004, and predictions estimate a further rise of 5–15 cm by 2030, relative to 1990 levels (Church et al. 2009). Longer term predictions estimate increases of 0.5 to 1 m by 2100, relative to 2000 levels (Climate Commission 2011). Seabird species nesting on the lowland parts of the Lord Howe Island group are at risk from sea level rise (Congdon et al. 2007). The impacts of rising sea levels on seabirds include loss of habitat through inundation of breeding sites, greater effect from storms (compounded by the predicted increase in frequency and intensity of storms), and impacts from altered erosion and deposition patterns (Chambers et al. 2009a). Impacts are expected to vary with breeding habitat and location, and high rocky islands are at lower risk than low-lying, less stable islands. However, there are no known quantitative links between observed sea level rise and changes in the distribution and abundance of nesting Australian seabirds (Chambers et al. 2009b).

Species assessed = 34		
Pressure	**Species**	**Rationale**
Changes in sea temperature (climate change)	Black noddy Common noddy Crested tern Roseate tern Sooty tern White tern Grey ternlet Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Great-winged petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Wilson's storm-petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross Little penguin Masked booby Red-tailed tropicbird	Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 °C warmer by 2030 (Lough 2009). Seabirds are expected to be impacted by rising sea temperatures through changes in the availability and distribution of prey species (Feng et al. 2009), thereby shifting the distribution of seabirds in the region. Distributions are most likely to move southward, which may alter reproductive timing and success (Chambers et al. 2009a). Beyond the region, impacts have been observed in the Great Barrier Reef on populations of sooty tern, black noddy and wedge-tailed shearwater. These species have experienced decreased breeding success linked to reduced prey rates driven by increasing water temperatures (Congdon et al. 2007; Peck et al. 2004; Smithers et al. 2003). Data from across the central and eastern Paci c, Indian and Southern oceans also indicate similar impacts in a number of seabird species (Chambers et al. 2009a). For species such as those breeding on the Lord Howe Island group that are already at the extremity of their breeding range and travel long distances to obtain food, any southward shifts in prey distribution are likely to greatly impact breeding success.

Species assessed = 34		
Pressure	**Species**	**Rationale**
Changes in oceanography (climate change)	Black noddy Common noddy Crested tern Roseate tern White tern Grey ternlet Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Great-winged petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Wilson's storm-petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross Little penguin Masked booby Red-tailed tropicbird	Changes in oceanography broadly refer to changes in ocean circulation patterns; current intensities; wind strength and direction; the location and strength of eddy and upwelling events; and climatic oscillations such as the El Niño–Southern Oscillation. In the region, changes in oceanography will be primarily driven by the East Australian Current, which has been strengthening, pushing warmer, saltier water further southward along the east coast (for up to 350 km). Models suggest with medium con dence that this trend will increase (Ridgway & Hill 2009). At sea, seabirds commonly seek out regions of enhanced productivity (e.g. eddies or fronts) for foraging opportunities (BirdLife International 2010; Hyrenbach et al. 2000), and the breeding success of seabirds in the region is linked to the stability of a small number of highly productive nutrient hotspots along the edge of the continental shelf (Chambers et al. 2009a; Congdon et al. 2007). Temporal or spatial shifts in areas of upwelling are expected to in uence the distribution, migration, foraging and breeding habits of seabirds (Chambers et al. 2009a). For example, El Niño events have been linked to breeding failure in seabirds (particularly temperate species) due to changes in ocean strati cation and associated impacts on prey species. The southward movement of the East Australian Current is also expected to bring subtropical species into temperate waters, thereby increasing competition in foraging and nesting habitats (Chambers et al. 2009a).

Species assessed = 34		
Pressure	**Species**	**Rationale**
Ocean acidi cation (climate change)	Black noddy Common noddy Crested tern Roseate tern Sooty tern White tern Grey ternlet Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Great-winged petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Wilson's storm-petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross Little penguin Masked booby Red-tailed tropicbird	Driven by increasing levels of atmospheric CO_2 and subsequent chemical changes in the ocean, ocean acidi cation is already under way and detectable. Since pre-industrial times, acidi cation has lowered ocean pH by 0.1 units (Howard et al. 2009). Climate models predict this trend will continue, with a further 0.2–0.3 unit decline by 2100 (Howard et al. 2009). The impacts of ocean acidi cation on seabirds are expected to be indirect, through changes in the abundance, availability and distribution of prey species. For example, research indicates potentially signi cant impacts on Antarctic krill (Kawaguchi et al. 2011) and squid (Frisch 2006), which are important food sources for seabirds that visit the Temperate East Marine Region.

Species assessed = 34		
Pressure	**Species**	**Rationale**
Chemical pollution/ contaminants (shipping, vessel)	Black noddy Common noddy Crested tern Roseate tern Sooty tern White tern Grey ternlet Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Great-winged petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Wilson's storm-petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross Little penguin Masked booby Red-tailed tropicbird	The Temperate East Marine Region is highly exposed to possible vectors for chemical pollutants, including signi cant shipping an shing activities in and adjacent to the region. It is expected that the effects of a major chemical spill would be similar to, or possibly exceed, those of a major oil spill (GBRMPA 2009). As top-order predators, seabirds are vulnerable to persistent chemical pollutants such as organochlorines, which accumulate through the food chain. Data in other regions show that chemical bioaccumulation results in seabird mortality and breeding failure (Becker 1989). A number of management measures are in place to respond to the risk of chemical spills, including the National plan to combat pollution of the sea by oil and other noxious and hazardous substances and the International Convention for the Prevention of Pollution from Ships (MARPOL), both of which are implemented through the Australian Maritime Safety Authority.

Species assessed = 34		
Pressure	**Species**	**Rationale**
Marine debris	Black noddy Common noddy Crested tern Roseate tern Sooty tern White tern Grey ternlet Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Great-winged petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Wilson's storm-petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross Little penguin Masked booby Red-tailed tropicbird	*Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris* was listed in 2003 as a key threatening process under the EPBC Act (DEWHA 2009a). Marine debris is de ned as any persistent, manufactured or processed solid material that has been disposed of or abandoned in the marine and coastal environment (UNEP 2005). Impacts of marine debris on seabirds include death through drowning, injury through entanglement, or starvation following ingestion (Baker et al. 2002). Seabirds are particularly prone to ingesting polystyrene balls and plastic buoys (which they confuse wit sh eggs) and entanglement (which can kill individuals or slow them down, reducing their ability to catch prey and avoid predators) (Ceccarelli 2009). A regional study analysing 205 known interactions between seabirds and plastic debris across 29 species found approximately 70 per cent of birds perished (C&R Consulting 2009).

Species assessed = 34		
Pressure	**Species**	**Rationale**
Light pollution (land-based activities)	Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Great-winged petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Wilson's storm-petrel Northern giant petrel Southern giant petrel Little penguin	Light pollution from onshore sources is *of potential concern* for shearwaters, petrels and the little penguin because it can attract and disorientate seabirds. Petrels, shearwaters and penguins are vulnerable to this pressure as they commonly return to their breeding colonies at night (Aubrecht et al. 2010). Juvenile seabirds are thought to be particularly vulnerable to disorientation from arti cial lighting because they are less familiar with visual cues (e.g. moon and stars) (Aubrecht et al. 2010). Although research on the impact of light pollution on seabird populations is limited, preliminary studies in Hawaii, the Reunion Islands and the Canary Islands indicate that light-induced mortality rates are an issue for petrels and small shearwaters (Aubrecht et al. 2010).

Species assessed = 34

Pressure	Species	Rationale
Human presence at sensitive sites (tourism, recreational and charte shing, research)	Black noddy Common noddy Crested tern Roseate tern Sooty tern White tern Grey ternlet Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Great-winged petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Wilson's storm-petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross Little penguin Masked booby Red-tailed tropicbird	Disturbance to seabirds during the breeding season may result in decreased the breeding success an tness of adult birds, particularly when adult birds are distracted from foraging, roosting or resting (WMB Oceanics & Claridge 1997). For example, if adult birds are disturbed from a nest, the unattended eggs and chicks become vulnerable to predation. The extent of the impact at a breeding site is in uenced by visitor frequency, approach distances and the sensitivity of particular species to disturbance. In general, ground nesting species (e.g. tern and booby species) are more vulnerable to disturbance; highly sensitive species include the roseate tern, little tern and crested tern (Langham & Hulsman 1986; Surman & Nicholson 2006; WMB Oceanics & Claridge 1997).

Species assessed = 34		
Pressure	**Species**	**Rationale**
Bycatch (commercial shing)	Flesh-footed shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Great-winged petrel White-necked petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross	Bycatch associated with commercia sheries operating in the region is *of concern* for 16 species of seabird. Direct interactions with commercia shing operations can lead to seabird death by drowning (e.g. on longline hooks), death by collision (e.g. warp strike) and more broadly, decreased fecundity. Bycatch generally affects larger species of seabird because they can swallow baited hooks and habitually follow ships (Baker et al. 2002). Seabirds are known to be particularly vulnerable to longline operations, and thes sheries (e.g. the Eastern Tuna and Bill sh Fishery) implement bycatch mitigation measures guided by the threat abatement plan for the incidental catch of seabirds in longlin shing operations (DEWR 2006). However, further efforts are required to reduce the impacts of bycatch on seabirds and this pressure remains *of concern* (Bensley et al. 2010; DEWR 2006; Phillips et al. 2010; Wilcox & Donlan 2007).
Bycatch (recreational and charte shing)	Flesh-footed shearwater	Bycatch associated with the domestic recreational and charte shing sector is considered *of potential concern* for th esh-footed shearwater. Recreational and charte shing activities are widespread along Australia's east coast, and recreational boating activity is growing (Bay Journal 2008; MSQ 2011). The likelihood of seabird– sher interactions is high, and these interactions can result in seabird injury and death from the ingestion of baited hooks an shing line, and entanglement (McPhee et al. 2002). Trolling in particular is known to affec esh-footed shearwaters (Australian Bird and Bat Banding Scheme, unpublished data).

Species assessed = 34		
Pressure	**Species**	**Rationale**
Oil pollution (shipping, vessels)	Black noddy Common noddy Crested tern Roseate tern Sooty tern White tern Grey ternlet Flesh-footed shearwater Little shearwater Short-tailed shearwater Sooty shearwater Wedge-tailed shearwater Black petrel Black-winged petrel Gould's petrel Great-winged petrel Kermadec petrel Providence petrel White-bellied storm-petrel White-faced storm-petrel White-necked petrel Wilson's storm-petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross Little penguin Masked booby Red-tailed tropicbird	Oil spills are unpredictable events and their likelihood is low, particularly in the context of the international and domestic regulatory mitigation measures that apply in Australia. However, their consequences can be severe, particularly in biologically signi cant areas and times. Shipping is a key activity in the region, with shipping routes servicing a number of ports adjacent to the region, and adjacent to seabird habitat. Seabirds are vulnerable to oil pollution because oil sticks to feathers, affecting their insulation and waterproo ng properties, rendering some bird ightless or vulnerable to predation. Oil may also indirectly impact seabirds through effects on prey species such as damage t sh eggs, larvae and youn sh (AMSA 2010). Chemicals used to disperse oil can themselves be toxic to marine life (AMSA 2010). Adjacent to the region, a study on the effects of oil spills on birds at Moreton and Bribie islands found that sites affected by the spill contained 50% fewer species than unaffected sites. Seabirds such as terns and gulls were considered among those most at risk (Birds Australia 2010).

Species assessed = 34

Pressure	Species	Rationale
Invasive species	Roseate tern Great-winged petrel Wilson's storm petrel Northern giant petrel Southern giant petrel Antipodean albatross Black-browed albatross Campbell albatross Indian yellow-nosed albatross Salvin's albatross Wandering albatross White-capped albatross	Invasive species impact on seabird populations by preying on adults and nest contents (eggs and chicks), destroying nests and modifying habitat (DEH 2005b). Invasive species are considered to be the greatest threat to seabirds after habitat loss, contributing to the threatened status of many species within the region (Olsen et al. 2006). An invasive species is defined as one that occurs and thrives outside its normal geographical distribution as a result of human activities, and can include animals, weeds, diseases and parasites (Olsen et al. 2006). European settlers are implicated in the introduction of Australia's most established invasive species—the rat, rabbit and fox—all of which are known to threaten seabirds. More recent invaders also known to threaten seabirds include the Argentine ant and kikuyu grass. Threat abatement plans have been prepared under the EPBC Act for exotic rodents on islands and rabbits (DEWHA 2009c, 2008a).

Table S1.13: Pressures *of concern* to selected sharks of the Temperate East Marine Region

Species assessed = 9		
Pressure	**Species**	**Rationale**
Bycatch (commercial shing)	Grey nurse shark	The grey nurse shark is listed as threatened under the EPBC Act and is protected in Australian waters. The species interacts with a range of commercia sheries, and there are reports of sharks wit shing gear trailing from their mouths (Bansemer & Bennett 2010). The effectiveness of management measures is not fully understood and bycatch mortality will continue to be *of concern* for this species until evidence of management effectiveness is conclusive.
Bycatch (recreational and charte shing)	Grey nurse shark	The grey nurse shark is listed as threatened under the EPBC Act and is protected in Australian waters. The species interacts with the recreational and charte shing sector, and there are reports of individuals with recreationa shing gear (e.g. trolling lures) trailing from their mouths (Bansemer & Bennett 2010). Due to the small population size and conservation status, any shing-related mortality is *of concern* to the species.
	White shark	The white shark is listed as threatened under the EPBC Act and is protected in Australian waters. Evidence suggests there is a partial failure to report captures of individuals and interactions within the recreationa shing sector (DEWHA 2009b). Data from the Great Barrier Reef Marine Park suggests post-release mortality could account for the majority of recreationa shing mortality. Mortality can occur as a result of capture and subsequent handling or, as seen in grey nurse shark populations, attache shing gear (Lynch et al. 2009).

Table S1.14: Pressures *of potential concern* to selected sharks of the Temperate East Marine Region

Species assessed = 9		
Pressure	**Species**	**Rationale**
Changes in sea temperature (climate change)	Grey nurse shark Porbeagle shark Long n mako shark Short n mako shark Whale shark White shark	Sea temperatures have warmed by 0.7 °C between 1910–1929 and 1989–2008, and current projections estimate ocean temperatures will be a further 1 °C warmer by 2030 (Lough 2009). Increasing sea temperatures may result in changes in the metabolism, behaviour and movement patterns of sharks (Chin & Kyne 2007). Climate change vulnerability assessments for the grey nurse shark and white shark in the Great Barrier Reef assessed both species as moderately vulnerable to rising sea temperatures (Chin et al. 2010). Indirect effects on sharks in general relate to potential changes in abundance and distribution of prey species. For example, studies predict that ocean warming will cause a large southward shift in the distribution of many tropical and subtropical zooplankton (Hobday et al. 2006), which may in uence the distribution of whale sharks both within the region and beyond.
Change in oceanography (climate change)	Grey nurse shark Porbeagle shark Long n mako shark Short n mako shark Whale shark White shark	Changes in oceanography broadly refer to changes in ocean circulation patterns; current intensities; wind strength and direction; the location and strength of eddy and upwelling events; and climatic oscillations such as the El Niño–Southern Oscillation. In the region, changes in oceanography will be primarily driven by the East Australian Current, which has been strengthening, pushing warmer, saltier water further southward along the east coast (for up to 350 km). Models suggest with medium con dence that this trend will increase (Ridgway & Hill 2009). These changes are likely to impact on productivity, resulting in subsequent shifts in trophic webs and migration patterns, and changes to reef and shelf habitats, all of which have implications for shark species (Chin et al. 2010). For example, a climate change vulnerability assessment of sharks in the Great Barrier Reef region suggested that white sharks would have high exposure and vulnerability to oceanographic change (Chin et al. 2010). As a specialist plankton feeder, whale sharks are also considered to have high exposure and vulnerability to oceanographic change due to expected impacts on the abundance and distribution of plankton populations (Chin et al. 2010). Other migratory species (e.g. mako and porbeagle sharks) are expected to be similarly impacted.

Species assessed = 9		
Pressure	**Species**	**Rationale**
Human presence at sensitive sites (tourism, recreational and charte shing, research)	Grey nurse shark	Aggregation sites for grey nurse sharks off New South Wales and Queensland are popular recreational diving locations, and this threatened species is considered a major drawcard for recreational divers (Pollard et al. 1996). Interactions between divers and grey nurse sharks are common, and studies have found that sharks milled less in the presence of six or more divers, and the frequency of behaviours such as jaw gaping, rapid withdrawal and stiff or jerky movements correlated with the distance between divers and sharks (Pollard et al. 1996). Diving regulations are in place to limit the adverse effects of divers on sharks, particularly diver harassment of sharks (Smith et al. 2010). As recreational diving continues to grow in popularity, however, so does the potential for negative impacts at sensitive grey nurse shark sites.
Extraction of living resources (commercial shing)	Short n mako shark	The short n mako is listed as migratory under the EPBC Act and the targeted commercial take of short n mako is prohibited in Commonwealth waters; however, individuals can be retained (as byproduct) if they are dead upon capture. Since their migratory listing in 2010, there has been a 30% reduction in the level of byproduct take and a number of management arrangements are in place; however, they remain vulnerable to capture in commercia shing operations and this pressure remains *of potential concern*.
Extraction of living resources (commercial shing—non-domestic)	Porbeagle shark Long n mako shark Short n mako shark White shark	The white shark is listed as both threatened and migratory under the EPBC Act and is protected in Australian waters; the short n and long n mako sharks and porbeagle shark are listed as migratory under the EPBC Act. All are highly migratory, and it is expected that these species will cross over the region's exclusive economic zone boundary and thus be exposed to international commercia sheries targeting sharks for their meat an ns. This pressure is devastating northern Australian shark populations and although temperate east populations are not expected to interact with this pressure to the same extent, it nonetheless has the potentially to signi cantly impact them (Lack & Sant 2008).

Species assessed = 9		
Pressure	**Species**	**Rationale**
Extraction of living resources (illegal, unregulated and unreported shing—non-domestic)	Long n mako shark Short n mako shark	The short n and long n mako sharks are listed as migratory under the EPBC Act and the targeted commercial take of both species is prohibited in Commonwealth waters; however, individuals can be retained (as byproduct) if they are dead upon capture. Mako sharks are an important component of the international shar n trade (Clarke et al. 2006) and are vulnerable to capture in longline operations. It is likely that all non-domestic illegal, unregulated and unreported take, both within and beyond Australian waters, will impact on populations of mako sharks within the region.
Extraction of living resources (illegal, unregulated and unreported shing—domestic)	White shark	The white shark is listed as threatened under the EPBC Act and is protected in Australian waters. Althoug shing of white shark is prohibited, the illegal capture of white sharks by the commercial and recreationa shing sector and the illegal trade in white shark products threaten populations in Australian waters (DEWHA 2010). Demand for white shark products as trophies (e.g. jaws and teeth), as well a ns for th n trade, has increased their value and there is evidence that these items support both international and national illegal trade (EA 2002). Despite strict regulations in both sectors, the high prices obtained for white shark products continue to provide incentive for this illegal trade (DEWHA 2010).
Bycatch (commercial shing)	White shark	The white shark is listed as threatened under the EPBC Act and is protected in Australian waters. Individuals have been recorded hooked on longlines and caught in the nets of commercia shing operations and aquaculture cages (e.g. tuna farms) (DEWHA 2010). Given the lack of data on white shark populations, it is unknown whether the species is recovering. Consequently, the effectiveness of management measures is not fully understood and bycatch mortality continues to be *of potential concern* for this species until conclusive evidence of management effectiveness is provided.

References

Abrahams, M & Kattenfeld, M 1997, 'The role of turbidity as a constraint on predator prey interactions in aquatic environments', *Behavioral Ecology and Sociobiology*, vol. 40, pp. 169–174.

ABS (Australian Bureau of Statistics) 2001, *Regional population growth, Australia and New Zealand*, ABS, Canberra, viewed 23 March 2011, **<www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/1301.0Feature per cent20Article32004?opendocumentand tabname=Summaryand prodno=1301.0and issue=2004and num=and view>**.

AFMA (Australian Fisheries Management Authority) 2005, *Australia's tuna purse seine sheries action plan*, AFMA, Canberra.

Agnew, D, Pearce, J, Pramod, G, Peatman, T, Watson, R, Beddington, J & Pitcher, T 2009, 'Estimating the worldwide extent of illega shing', PLoS ONE, vol. 4, no. 2, pp. e4570.

Althaus, F, Williams, A, Schlacher, TA, Kloser, RJ, Green, MA, Bax, NJ, Brodie, P, Schlacher-Hoenlinger, MA 2009, 'Impacts of bottom trawling on deep-coral ecosystem of seamounts are long lasting', *Marine Ecology Progress Series*, vol. 397, pp. 279–294.

AMSA (Australian Maritime Safety Authority) 2010, *The effects of oil on wildlife*, AMSA, viewed 10 March 2011, **<www.amsa.gov.au/marine_environment_protection/educational_resources_and_information/teachers/the_effects_of_oil_on_wildlife.asp>**.

AMSA (Australian Maritime Safety Authority) 2011a, *National marine oil spill contingency plan*, AMSA, Canberra,

Anon 2010, *Response to the Paci c Adventurer incident: operational and technical issues reports*, Australian Maritime Safety Authority, Canberra.

Anthony, KRN & Marshall, P 2009, 'Coral reefs and climate change', in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *A marine climate change impacts and adaptation report card for Australia 2009*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Arthur, KE, Limpus, C, Roelfsema, CM, Udy, JW & Shaw, GR 2006, 'A bloom of *Lyngbya majuscula* in Shoalwater Bay, Queensland, Australia: an important feeding ground for the green turtle *(Chelonia mydas)', Harmful Algae*, vol. 5, no. 3, pp. 251–265.

Aubrecht, C, Elvidge, C, Ziskin, D, Rodrigues, P & Gil, A 2010, 'Observing stress of arti cial night lighting on marine ecosystems: a remote sensing application study', in W Wagner & B Székely (eds), *The International Society for Photogrammetry and Remote Sensing (ISPRS) TC VII Symposium—100 years*, Vienna, Austria, 5–7 July 2010.

Baker, B, Gales, R, Hamilton, S & Wilkinson, V 2002, ‘Albatross and petrels in Australia: a review of their conservation and management’, *Emu*, vol. 102, pp. 71–97.

Baker, JL 2009, *Marine Species of Conservation Concern in South Australia: Volume 1—Bony and Cartilaginous Fishes*. Report for the South Australian Working Group for Marine Species of Conservation Concern, Department for Environment and Heritage; Marine and Coastal Community Network of S.A., and Threatened Species Network.

Balazs, GH & Chaloupka, M 2004, ‘Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock’, *Biological Conservation*, vol. 117, pp. 491–498.

Bansemer, CS & Bennett, MB 2010, ‘Retaine shing gear and associated injuries in the east Australian grey nurse sharks (*Carcharias taurus*): implications for population recovery’, *Marine and Freshwater Research*, vol. 61, pp. 97–103.

Baum, JK & Worm, B 2009, ‘Cascading top-down effects of changing oceanic predator abundances’, *Journal of Animal Ecology*, vol. 78, pp. 699–714.

Bay Journal 2008, *Queensland now biggest boating community in Australia*, viewed 19 July 2011 <**http://bayjournal.com.au/joomla/component/content/article/1674-queensland-now-biggest-boating-community-in-australia.html>**.

Becker, P 1989, ‘Seabirds as monitor organisms of contaminants along the German North Sea coast’, *Helgoland Marine Research*, vol. 43, no. 3–4, pp. 395–403.

Bejder, L & Samuels, A 2003, ‘Evaluating the effects of nature-based tourism on cetaceans’, in NJ Gales, M Hindell & R Kirkwood (eds), *Marine mammals and humans sheries, tourism and management*, CSIRO Publishing, Collingwood, pp. 229–256,

Bensley, N, Stobutzki, I, Woodhams, J & Mooney, C 2010, *Review of wildlife bycatch management in Commonwealt sheries*, Bureau of Rural Sciences report prepared for the Australian Government Department of Agriculture, Fisheries and Forestry, Fisheries Policy Branch, Canberra.

BirdLife International 2010, *Marine Important Bird Areas toolkit: standardised techniques for identifying priority sites for the conservation of seabirds at-sea*, BirdLife International, Cambridge.

Birds Australia 2010, ‘The state of Australia’s birds 2010: islands and birds’, *Wingspan*, vol. 20, no. 4 (suppl.).

Bjorndal, K, Bolten, A, Gordon, J & Cami as, J 1994, '*Caretta caretta* (loggerhead) growth and pelagic movement', *Herpetological Review*, vol. 25, pp. 23–24.

Bowles, D & Martin-Smith, K 2003, Catch and trade of Solegnathus spp. *(pipehorses) from demersal traw shery landing sites in New South Wales and Victoria (Australia)*, Project Seahorse/NSW Fisheries Scienti c Committee.

Boyle, M 2006, 'Post hatchling sea turtle biology', PhD thesis, James Cook University, Townsville, Queensland.

Boyle, MC & Limpus, CJ 2008, 'The stomach contents of post-hatchling green and loggerhead sea turtles in the southwest Paci c: an insight into habitat association', *Marine Biology*, vol. 155, pp. 233–241.

Cabaco, S, Santos, R & Duarte, CM 2008, 'The impact of sediment burial and erosion on seagrasses: a review', *Estuarine, Coastal and Shelf Science*, vol. 79, pp. 354–366.

C&R Consulting 2009, *Impacts of plastic debris on Australian marine wildlife*, report for the Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

Carmago, JA, & Alonso, A 2006, 'Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: a global assessment', *Environment International*, vol. 32 pp. 831–849.

Ceccarelli, D 2009, *Impacts of plastic debris on Australian marine wildlife*, report prepared by C&R Consulting for the Australian Government Department of the Environment, Water, Heritage and the Arts.

Ceccarelli, D & Ayling, T 2010, *Role, importance and vulnerability of top predators on the Great Barrier Reef: a review*, research publication no. 105, Great Barrier Reef Marine Park Authority, Townsville, Queensland.

Chaloupka, M & Limpus, C 2001, 'Trends in the abundance of sea turtles resident in southern Great Barrier Reef waters', *Biological Conservation*, vol. 102, pp. 235–249.

Chaloupka, M, Kamezaki, N & Limpus, C 2008, 'Is climate change affecting the population dynamics of the endangered Paci c loggerhead sea turtle?' *Journal of Experimental Marine Biology and Ecology*, vol. 356, pp. 136–143.

Chambers, L, Congdon, B, Dunlop, N, Dann, P & Devney, C 2009a, 'Seabirds and climate change', in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *A marine climate change impacts and adaptation report card for Australia*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Chambers, L, Congdon, B, Dunlop, N, Dann, P & Devney, C 2009b, 'Seabirds and climate change supplement', in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *A marine climate change impacts and adaptation report card for Australia*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Chin, A & Kyne, PM 2007, 'Vulnerability of chondrichthya sh of the Great Barrier Reef to climate change', in JE Johnson & PA Marshall (eds), *Climate change and the Great Barrier Reef: a vulnerability assessment*, Great Barrier Reef Marine Park Authority, Townsville, & Australian Greenhouse Of ce, Canberra, pp. 393–425.

Chin, A, Kyne, PM, Walker, TI & McAuley, RB 2010, 'An integrated risk assessment for climate change: analysing the vulnerability of sharks and rays on Australia's Great Barrier Reef', *Global Change Biology*, vol. 16, pp.1936–1953.

Church, J, White, N, Hunter, J, McInnes, K & Mitchell, W 2009, 'Sea level rise and climate change', in E Poloczanska, A Hobday & AJ Richardson (eds), *Marine climate change impacts and adaptation report card for Australia*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Clarke, SC, Magnussen, JE, Abercrombie, DL, McAllister, MK & Shivji, MS 2006, 'Identi cation of shark species composition and proportion in the Hong Kong shar n market based on molecular genetics and trade records', *Conservation Biology*, vol. 20, pp. 201–211.

Climate Commission 2011, *The critical decade: climate science, risks and responses*, Australian Government Department of Climate Change and Energy Ef ciency, Canberra.

Cogger, HG 2000, *Reptiles and amphibians of Australia*, 6th edn, Reed Books Australia, Sydney.

Cohen, AL & Holcomb, M 2009, 'Why corals care about ocean acidi cation: uncovering the mechanism', *Oceanography*, vol. 22, pp. 118–127.

Coles, R, Grech, A, Dew, K, Zeller, B & McKenzie, L 2008, *A preliminary report on the adequacy of protection provided to species and benthic habitats in the east coast otter trawl shery by the current system of closures*, Queensland Department of Primary Industries and Fisheries, Brisbane.

Congdon, BC, Erwin, CA, Peck, DR, Baker, GB, Double, MC, & O'Neill, P 2007, 'Vulnerability of seabirds on the Great Barrier Reef to climate change', in JE Johnson & PA Marshall (eds), *Climate change and the Great Barrier Reef*, pp. 427–463, Great Barrier Reef Marine Park Authority, Townsville, & Australian Greenhouse Of ce, Canberra.

Connolly, RM 2009, 'Seagrass', in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *Marine climate change impacts and adaptation report card for Australia 2009*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Corkeron, PJ, Morissette, NM, Porter, LJ, & Marsh, H 1997, 'Distribution and status of hump-backed dolphins, Sousa chinensis, in Australian waters', *Asian Marine Biology*, vol. 14, pp. 49–59.

Courtney, AJ, Schemel, BL, Wallace, R, Campbell, MJ, Mayer, DG & Young, B 2010, *Reducing the impact of Queensland's traw sheries on protected sea snakes*, report to the Fisheries Research and Development Corporation, project no. 2005/053, The State of Queensland.

D'Agrosa, C, Lennert-Cody, CE & Vidal, O 2000, 'Vaquita bycatch in Mexico's artisianal gillnet sheries: driving a small population to extinction', *Conservation Biology*, vol. 14, pp. 1110–1119.

Dambacher, JM, Hosack, GR & Rochester, W 2011, *Ecological indicators for the exclusive economic zone of Australia's East Marine Region*, a report for the Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra.

De'ath, G, Lough, JM & Fabricius, KE 2009, 'Declining coral calci cation on the Great Barrier Reef', *Science*, vol. 323, pp. 116–119.

DECC (Australian Government Department of Environment and Climate Change) 2009, *The little penguin celebrating 50 years of Montague Island shearwater research*, anniversary fact sheets, NSW Parks and Wildlife Service, Narooma, viewed 13 May 2011, **<www.montagueisland.com.au/download/factsheets/penguin_factsheet.pdf>**.

DEH (Australian Government Department of the Environment and Heritage) 2005a, T*hreat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs*, DEH, Canberra.

DEH (Australian Government Department of the Environment and Heritage) 2005b, *Issues paper: population status and threats to ten seabird species listed as threatened under the* Environment Protection and Biodiversity Conservation Act 1999, viewed 17 June 2011, **<www.environment.gov.au/biodiversity/threatened/publications/pubs/seabirds-issues.pdf>**.

DERM (Department of Environment and Resource Management) 2009, *Marine mammal conservation plan review discussion paper*, Queensland Government, Brisbane.

Derraik, JGB 2002, 'The pollution of the marine environment by plastic debris: a review Marine', *Pollution Bulletin*, vol. 44, pp. 842–852.

Dethmers, K, Jensen, M, FitzSimmons, N, Broderick, D, Limpus, C & Moritz, C 2010, 'Migration of green turtles (Chelonia mydas) from Australasian feeding grounds inferred from genetic analyses', Marine and Freshwater Research, vol. 61, pp. 1–12.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2008a, Background paper to EPBC Act policy statement 2.1—interaction between offshore seismic exploration and whales, DEWHA, Canberra, viewed 28 October 2010, <**www.environment.gov.au/epbc/publications/pubs/seismic-whales-background.pdf**>.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2008b *Threat Abatement Plan for competition and land degradation by rabbits*, DEWHA, Canberra.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2008c *Threat Abatement Plan for predation by the European red fox*, DEWHA, Canberra.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2009a, *Background paper for the threat abatement plan for the impacts of marine debris on vertebrate life, DEWHA*, Canberra, viewed 1 July 2011 **<www.environment.gov.au/biodiversity/threatened/publications/tap/marine-debris.html>**.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2009b, *The East Marine Bioregional Plan: bioregional pro le*, DEWHA, Canberra.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2009c, *Threat Abatement Plan Threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100 000 hectares*, DEWHA, Canberra.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2010, *Draft recovery plan for the white shark* (Carcharodon carcharias), DEWHA, Canberra, viewed 6 October 2011, **<www.environment.gov.au/biodiversity/threatened/publications/recovery/pubs/white-shark-draft-recovery-plan.pdf>**.

DEWR (Australian Government Department of the Environment and Water Resources) 2006, *Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline shing operations*, DEWR, Canberra.

Doney, S, Fabry, V, Feely, R & Kleypas, J 2009, 'Ocean acidi cation: the other CO_2 problem', *Annual Review of Marine Science*, vol. 1, pp. 169–192.

DSE (Department of Sustainability and the Environment) 2011, *Boat strike: a threat to Victoria's dolphins*, media release, 7 January 2011, viewed 24 March 2011, **<www.dse.vic.gov.au/DSE/dsencor.nsf/LinkView/F46D4F6345FA29A5CA257810007A7425250370F0D4508518CA256F040021E0EB>**.

DTIRIS (Department of Trade and Investment, Regional Infrastructure and Services) 2012, *Black Rockcod (Epinephelus daemelii) recovery plan, 2nd edition*, Aquaculture, Conservation and Marine Parks Unit, Port Stephens Fisheries Institute, Department of Primary Industries, NSW, viewed 19 April 2012, **<www.dpi.nsw.gov.au/__data/assets/pdf_ le/0017/307232/Black-Rockcod-recovery-plan.pdf>**.

EA (Environment Australia) 2002, *White shark* (Carcharodon carcharias) *recovery plan 2002*, Environment Australia, Canberra.

Entoyer, P 2010, 'Deep-sea corals on seamounts', *Oceanography*, vol. 23, no. 1, pp. 128–129.

Feng, M, Weller, E & Hill, K 2009, 'The Leeuwin Current', in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *A marine climate change impacts and adaptation report card for Australia 2009*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Foster, SJ & Vincent, ACJ 2004, 'Life history and ecology of seahorses: implications for conservation and management', *Journal of Fish Biology*, vol. 65, pp. 1–61.

Frisch, H 2006, *2006 migratory species and climate change: impacts of a changing environment on wild animals*, United Nations Environment Programme/Convention on Migratory Species Secretariat, Bonn, Germany.

Fuentes, MMPB, Hamann, M & Limpus, CJ 2009, 'Past, current and future thermal pro les of green turtle nesting grounds: implications from climate change', *Journal of Experimental Marine Biology and Ecology*, vol. 383, no. 1, pp. 56–64.

Furlani, D, Dowdney, J, Bulman, C, Sporcic, M & Fuller, M 2007, *Ecological risk assessment for effects o shing*, report for the demersal trawl sub- shery of the coral se shery, Australian Fisheries Management Authority, Canberra.

Gagnon, MM 2009, *Report on biopsy collections from specimens collected from the surrounds of the West Atlas oil leak: sea snake specimen*, Curtin University, Western Australia.

Garnett, ST, Szabo, J & Dutson, G 2011, *The 2011 action plan for Australian birds*, CSIRO Publishing, Collingwood, draft viewed April 2011.

Gaus, C, Paepke, O, Dennison, N, Haynes, D, Shaw, GR, Connell, DW & Mueller, JF 2001, ‘Evidence for the presence of a widespread PCDD source in coastal sediments and soils from Queensland, Australia’, *Chemosphere*, vol. 43, issue 4–7, pp.549–558.

GBRMPA (Great Barrier Reef Marine Park Authority) 2009, *Great Barrier Reef outlook report 2009*, Townsville, Queensland.

Guinea, ML 1995, *The sea turtles and sea snakes of Ashmore Reef Nature Reserve*, report to the Australian Nature Conservation Agency, Northern Territory University, Darwin.

Hamann, M, Limpus, C & Read, M 2007, ‘Vulnerability of marine reptiles in the Great Barrier Reef to climate change’, in J Johnson & P Marshall (eds), *Climate change and the Great Barrier Reef: a vulnerability assessment*, Great Barrier Reef Marine Park Authority, Townsville, & Australian Greenhouse Of ce, Canberra.

Hawkes, LA, Broderick, AC, Godfrey, MH & Godley, BJ 2009, ‘Climate change and marine turtles’, *Endangered Species Research*, vol. 7, pp. 137–154.

Heatwole, H 1981, ‘Temperature relations of some sea snakes’, *The Snake*, vol. 13, pp. 53–57.

Heinsohn, GE 1979, *Biology of small cetaceans in north Queensland waters*, Great Barrier Reef Marine Park Authority, Townsville.

Hennessy, K, Fitzharris, B, Bates, BC, Harvey, N, Howden, SM, Hughes, L, Salinger, J & Warrick, R 2007, ‘Australia and New Zealand’, in ML Parry, OF Canziani, JP Palutikof, PJ van der Linden & CE Hanson (eds) *Climate change 2007: impacts, adaptation and vulnerability*, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, pp.507–540.

Hobday, AJ, Okey, TA, Poloczanska, ES, Richardson, AJ & Kunz, TJ 2006, *Impacts of climate change on Australian marine life*, report to the Australian Greenhouse Of ce, prepared by CSIRO Division of Marine and Atmospheric Research, Hobart.

Hobday, AJ, Poloczanska, ES & Matear, RJ (eds) 2008, *Implications of climate change for Australia sheries and aquaculture: a preliminary assessment*, report to the Australian Government Department of Climate Change, Canberra.

Hoegh-Guldberg, O & Bruno, J 2010, ‘The impact of climate change on the world’s marine ecosystems’, *Science*, vol. 328, no. 5985, pp. 1523–1528.

Howard, R, Havenhand, J, Parker, L, Raftos, D, Ross, P, Williamson, J & Matear, R 2009, ‘Ocean acidi cation’, in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *A marine climate change impacts and adaptation report card for Australia*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Hyder Consulting 2008, *The impacts and management implications of climate change for the Australian Government’s protected areas*, report to the Australian Government Department of Environment, Water, Heritage and the Arts & the Australian Government Department of Climate Change, Canberra.

Hyrenbach, D, Forney, K & Dayton, P 2000, ‘Marine protected areas and ocean basin management’, *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol. 10, pp. 437–458.

Jacob, S 2009, ‘The ecology and conservation of tropical inshore dolphins S*ousa chinensis, Orcaella heinsohni and Orcaella brevirostris:* a review of current knowledge’, Masters thesis, University of New England.

Katsanevakis, S 2008, ‘Marine debris, a growing problem: sources, distribution, composition and Impacts’, in T Hofer (ed), Marine pollution: new research, Nova Science Publishers, New York, pp. 53–100.

Kawaguchi, S, Kurihara, H, King, R, Hale, L, Berli, T, Robinson, JP, Ishida, A, Wakita, M, Virtue, P, Nicol, S & Ishimatsu, A 2011, ‘Will krill fare well under Southern Ocean acidi cation?’, *Biology Letters*, vol. 7, no. 2, pp. 288–291.

Kearney, RE, Andrew, NL & West, RJ 1996, ‘Some issues in the management of Australia’s marine and coasta sheries resources’, *Ocean and Coastal Management*, vol. 33, issues 1–3, p. 133–146.

Kleypas, J & Yates, K 2009, ‘Coral reefs and ocean acidi cation’, *Oceanography*, vol. 22, pp. 108–117.

Kuiter, RH 2009, *Seahorses and their relatives*, Aquatic Photographics, Seaford, Australia.

Lack, M & Sant, G 2008, *Illegal, unreported and unregulated shark catch: a review of current knowledge and action*, Australian Government Department of the Environment, Water, Heritage and the Arts & TRAFFIC, Canberra.

Lack, M, Short, C & Willock, A 2003, *Managing risk and uncertainty in deep-se sheries: lessons from orange roughy*, a joint report by TRAFFIC Oceania and the WWF Endangered Seas Programme, viewed 7 July 2011, **<www.traf c.org/ sh>**.

Langham, N & Hulsman, K 1986, 'The breeding biology of the crested tern *Sterna bergii', Emu*, vol. 86, pp. 23–32.

Lawler, I, Parra, G & Noad, M 2007, 'Vulnerability of marine mammals in the Great Barrier Reef to climate change', in J Johnson & P Marshall (eds), *Climate change and the Great Barrier Reef: a vulnerability assessment*, Great Barrier Reef Marine Park Authority, Townsville, & Australian Greenhouse Of ce, Canberra.

Limpus, CJ 2008a, *A biological review of Australian marine turtle species. 2. Green turtle*, Chelonia mydas *(Linnaeus)*, Queensland Environmental Protection Agency, Brisbane.

Limpus, CJ 2008b, A biological review of Australian marine turtles. 1. Loggerhead turtle Caretta caretta (Linneaus), Queensland Environmental Protection Agency, Brisbane.

Limpus, CJ 2009, *A biological review of Australian marine turtle species. 3. Hawksbill turtle*, Eretmochelys imbricata *(Linnaeus)*, Queensland Environmental Protection Agency, Brisbane.

Limpus, CJ & Limpus, DJ 2003, 'Loggerhead turtles in the Equatorial and Southern Paci c Ocean: a species in decline', in AB Bolten & BE Witherington (eds), *Loggerhead sea turtles*, Smithsonian Institution, Washington, DC.

Limpus, C & Parmeter, C 1985, *The sea turtle resources of the Torres Strait region*, in AK Haines, GC Williams & D Coates (eds), *Torres Strait Fisheries Seminar, Port Moresby, 11–14 February 1985*, Australian Government Publishing Service, Canberra.

Lorne, JK & Salmon, M 2007, 'Effects of exposure to arti cial lighting on orientation of hatchling sea turtles on the beach and in the ocean', *Endangered Species Research*, vol. 3, pp. 23–30.

Lough, JM 2009, 'Temperature', in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *A marine climate change impacts and adaptation report card for Australia 2009*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Lynch, A-MJ, Sutton, SG & Simpfendorfer, CA 2009, 'Implications of recreationa shing for elasmobranch conservation in the Great Barrier Reef Marine Park', *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol. 20, pp. 312–318.

Malcolm, H 2011, *Cross-shelf patterns of black cod Epinephelus daemelii at three important locations in Northern Rivers marine waters, unpublished report to the Northern Rivers Catchment Management Authority*, viewed 19 April 2012, **<www.northern.cma.nsw.gov.au/downloads/publications/marine-and-coastal/pub-black-cod- nal-report.pdf>**.

Marsh, H, Lloze, R, Heinsohn, GE, & Kasuya, T 1989, 'Irrawaddy dolphin Orcaella brevirostris', in SH Ridgeway & R *Harrison (eds), Handbook of marine mammals, river dolphins and the larger toothed whales*, vol. 4, pp. 101–118.

Mattson, M, Thomas, J & Aubin, D 2005, 'Effects of boat activity on the behaviour of bottlenose dolphins *(Tursiops truncatus)* in waters surrounding Hilton Head Island, South Carolina', *Aquatic Mammals*, vol. 31, no. 1, pp. 133–140.

McClatchie, S, Middleton, J, Pattiaratchi, C, Currie, D & Kendrick, G (eds) 2006, *The South-west Marine Region: ecosystems and key species groups*, Australian Government Department of the Environment and Water Resources, Canberra.

McPhee, DP, Leadbitter, D & Skilleter, GA 2002, 'Swallowing the bait: is recreationa shing in Australia ecologically sustainable?' *Paci c Conservation Biology*, vol. 8, no. 1, pp. 40–51.

Meylan, A & Donnelly, M 1999, 'Status justi cation for listing the hawksbill turtle *(Eretmochelys imbricata)* as critically endangered on the 1996 IUCN Red List of Threatened Animals', *Chelonian Conservation and Biology*, vol. 3, no. 2, pp. 200–224.

Milton, S & Lutz, P 2003, 'Physiological and genetic responses to environmental stress', in P Lutz, J Musick & J Wyneken (eds), *Biology of sea turtles*, CRC Press, Boca Raton, Florida.

MSQ (Marine Safety Queensland) 2011, *Dredging initiatives in Queensland*, viewed 19 July 2011, **<www.msq.qld.gov.au/Waterways/Boating-infrastructure/Dredging-initiatives>**.

Muusse, M, Hermanussen, S, Limpus, CJ, Päpke, O & Gaus, C 2006, 'Maternal transfer of PCDD/Fs and PCBS in marine turtles', *Organohalogen Compounds*, vol. 68, pp. 596–599.

News Limited 2010, *Dolphin died from sanctuary boat strike*, online article, 21 December 2010, viewed 24 March 2010, **<www.news.com.au/breaking-news/dolphin-died-from-sanctuary-boat-strike/story-e6frfku0-1225974393091>**.

Nias, R 2011, *A case for legal protection: the Australian snub n dolphin*, report prepared by Dr Ray Nias, TierraMar Consulting for WWF-Australia.

Noreen, A 2010, 'Ecological and evolutionary connectivity of reef corals in subtropical eastern Australia: implications for the persistence of high-latitude coral populations', PhD thesis, Southern Cross University, Lismore, New South Wales.

Northridge, SP 1991, *Drift sheries and their impacts on non-target species: a worldwide review*, FAO Fisheries technical paper no. 320, FAO, Rome.

Nowacek, PD, Thorne, HL, Johnston, WD, Tyack, LP 2007, 'Response of cetaceans to anthropogenic noise', *Marine Mammal Review*, vol. 37, no. 2, pp. 81–115.

NSWNPWS (New South Wales National Parks and Wildlife Service) 2000, *Threatened species information: Gould's petrel*, NSW National Parks and Wildlife Service, Sydney, viewed 12 May 5 2011, **<www.environment.nsw.gov.au/resources/nature/TSpr leGouldsPetrel.pdf>**

Olsen, P, Silcocks, A & Weston, M 2006, 'The state of Australia's birds 2006: invasive species', *Wingspan*, vol. 16, no. 4 (suppl.).

Parra, GJ 2006, 'Resource partitioning in sympatric delphinids: space use and habitat preferences of Australian snub n and Indo-Paci c humpback dolphins', *Journal of Animal Ecology*, vol. 75, pp. 862–874.

Parra, GJ & Corkeron, PJ 2001, 'Feasibility of using photo-identi cation techniques to study the Irrawaddy dolphin, *Orcaella brevirostris* (Owen in Gray 1866)', Aquatic Mammals, vol. 27, pp. 45–49.

Parra, GJ & Jedensjo, M 2009, *Feeding habits of Australian snub n* (Orcaella heinsohni) *and Indo-Paci c humpback dolphin*s (Sousa chinensis), project report to Reef and Rainforest Research Centre Limited, Cairns.

Parra, GJ, Azuma, C, Preen, AR, Corkeron, PJ & Marsh, H 2002, 'Distribution of Irrawaddy dolphins, *Orcaella brevirostris*, in Australian waters', *Raf es Bulletin of Zoology Supplement*, vol. 10, pp. 141–154.

Parra, GJ, Corkeron, PJ & Marsh, H 2006, 'Population sizes, site delity and residence patterns of Australian snub n and Indo-Paci c humpback dolphins: implications for conservation', *Biological Conservation*, vol. 129, pp 167–180.

Peck, DR, Smithers, BV, Krockenberger, AK & Congdon, BC 2004, 'Sea-surface temperature constrains wedge-tailed shearwater foraging success within breeding seasons', *Marine Ecology Progress Series*, vol. 281, pp. 259–266.

Phillips, K, Giannini, F, Lawrence, E & Bensley, N 2010, *Cumulative assessment of the catch of non-target species in Commonwealt sheries: a scoping study*, Bureau of Rural Sciences, Canberra.

Pirzl, R, Thiele, D, Bannister, JL & Burnell, SR 2008, *ENSO and SAM affect reproductive output in southern right whales*, report to the Australian Government Department of Environment, Water, Heritage and the Arts, Canberra.

Pitcher, CR, Burridge, CY, Wassenberg, TJ, Hill, BJ & Poiner, IR 2009, 'A large scale BACI experiment to test the effects of prawn trawling on seabed biota in a closed area of the Great Barrier Reef Marine Park, Australia', *Fisheries Research*, vol. 99, no. 3, pp. 168–183.

Pogonoski, JJ Pollard, DA & Paxton, JR, 2002, *Conservation overview and action plan for threatened and potentially threatened marine and estuarine fishes*, Environment Australia, Canberra.

Pollard, DA, Lincoln Smith, MP & Smith, AK 1996, 'The biology and conservation status of the grey nurse shark (*Carcharias taurus* Rafinesque 1810) in New South Wales, Australia', *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol. 6, pp. 1–20.

Poloczanska, ES, Babcock, RC Butler, A Hobday, AJ Hoegh-Guldberg, O Kunz, T.J Matear, R Milton, DA Okey TA & Richardson, AJ 2007, 'Climate change and Australian marine life', *Oceanography and Marine Biology: An Annual Review, 2007*, vol. 45, pp. 407–478.

Poloczanska, ES, Limpus, CJ & Hays, G 2010, 'Vulnerability of marine turtles to climate change', *Advances in Marine Biology*, vol. 56, pp. 151–211.

Prince, JD & Griffin, DA 2001, 'Spawning dynamics of the eastern gemfish *(Rexea solandri)* in relation to regional oceanography in south-eastern Australia', *Marine and Freshwater Research*, vol. 52, no. 4, pp. 611–622.

Reeves, RR & Smith, BD 1999, 'Interrupted migrations and dispersal of river dolphins: some ecological effects of riverine development', in UNEP/CMS (eds) *Proceedings of the CMS Symposium on Animal Migration* (Gland, Switzerland, 13 April 1997), CMS Technical series publication no. 2, Bonn/The Hague, pp. 9–18.

Richardson, WJ, Greene, CRJ, Malme, CI & Thomson, DH 1995, *Marine mammals and noise*, Academic Press, San Diego.

Richardson AJ, McKinnon, D & Swadling, KM 2009, 'Zooplankton', in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *Marine climate change impacts and adaptation report card for Australia,* National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Ridgway, K & Hill, K 2009, 'The East Australian Current', in ES Poloczanska, AJ Hobday & AJ Richardson (eds), *Marine climate change impacts and adaptation report card for Australia*, National Climate Change Adaptation Research Facility, viewed 9 March 2011, **<www.oceanclimatechange.org.au>**.

Rojas-Bracho, L & Taylor, BL 1999, 'Risk factors affecting the vaquita *(Phocoena sinus)'*, *Marine Mammal Science*, vol. 15, pp. 974–989.

Rowling, K 2001, 'A comment on 'Spawning dynamics of the eastern gem sh (Rexea solandri) in relation to regional oceanography in south-eastern Australia' by J D Prince & DA Grif n', *Marine and Freshwater Research*, vol. 52, pp. 611–22.

Salmon, M 2003, 'Arti cial night lighting and sea turtles', *Biologist*, vol. 50, pp. 163–168.

Seddon, S, Connolly, RM & Edyvane, KS 2000, 'Large-scale seagrass dieback in northern Spencer Gulf, South Australia', *Aquatic Botany*, vol.66, pp.297–310.

Smith, K, Scarr, M & Scarpaci, C 2010, 'Grey nurse shark *(Carcharias taurus)* diving tourism: tourist compliance and shark behaviour at Fish Rock, Australia', *Environmental Management*, vol. 46, pp. 699–710.

Smithers, BV, Peck, DR, Krockenberger, AK & Congdon, BC 2003, 'Elevated sea-surface temperature reduced provisioning and reproductive failure of wedge-tailed shearwaters in the Southern GBR', *Marine and Freshwater Research*, vol. 55, pp. 973–977

Surman, C & Nicholson L 2006, 'Seabirds', in S McClatchie, J Middleton, C Pattiaratchi, D Currie & G Hendrick (eds), *The South-west Marine Region: ecosystems and key species groups*, Australian Government Department of the Environment and Heritage, Canberra.

Thresher, R, Koslow, J, Morison, A & Smith, D 2007, 'Depth-mediated reversal of the effects of climate change on long-term growth rates of exploited marin sh', *Proceedings of the National Academy of Sciences*, vol. 104, no. 18, pp. 7461–7465.

Tisdell, C, Wilson, C & Swarna Nantha, H 2004, *Australian tropical reptile species: ecological status, public valuation and attitudes to their conservation and commercial use*, Working papers on Economics, Ecology and the Environment, working paper no. 106, University of Queensland.

Trathan, PN & Murphy, EJ 2002, 'Sea surface temperature anomalies near South Georgia: relationships with the pacific El Niño regions', *Journal of Geophysical Research*, vol. 108, pp. 8075.

Trathan, PN, Brierley, AS, Brandon, MA & Bone, DG 2003, 'Oceanographic variability and changes in Antarctic krill Euphausia superba abundance at South Georgia' *Fisheries Oceanography*, vol. 12, pp. 569–583.

TSSC (Threatened Species Scientific Committee) 2009, *Commonwealth listing advice* on Rexea solandri, Australian Government Department of the Environment, Water, Heritage and the Arts, viewed 3 March 2011, **<www.environment.gov.au/biodiversity/threatened/species/pubs/76339-listing-advice.pdf>**.

TSSC (Threatened Species Scientific Committee) 2012, *Commonwealth listing advice* on Epinephelus daemelii, Australian Government Department of Sustainability, Environment, Water, Population and Communities, viewed 19 April 2012, **<www.environment.gov.au/biodiversity/threatened/species/pubs/68449-listing-advice.pdf>**.

UNEP (United Nations Environment Programme) 2005, *Marine litter, an analytical overview*, Regional Seas Coordinating Office, the Secretariat of the Mediterranean Action Plan (MAP), the Secretariat of the Basel Convention, and the Coordination Office of the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA) of the UNEP, in cooperation with the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, UNEP, Nairobi.

van Parijs, SM & Corkeron, P 2001, 'Boat traffic affects the acoustic behaviour of Pacific humpback dolphins, *Sousa chinensis', Journal of the Marine Biological Association of the United Kingdom*, vol. 81, pp. 533–538.

Watson, JEM, Joseph, LN & Watson, AWT 2009, *A rapid assessment of the impacts of the Montara oil leak on birds, cetaceans and marine reptiles*, report prepared on behalf of the Australian Government Department of the Environment, Water, Heritage and the Arts, Spatial Ecology Laboratory, University of Queensland, Brisbane.

Waycott, M, Collier, C, McMahon, K, Ralph, P, McKenzie, L, Udy, J & Grech, A 2007, 'Vulnerability of seagrasses in the Great Barrier Reef to climate change', in JE Johnson & PA Marshall (eds) *Climate change and the Great Barrier Reef*, Great Barrier Reef Marine Park Authority, Townsville, & Australian Greenhouse Office, Canberra, pp. 193–299.

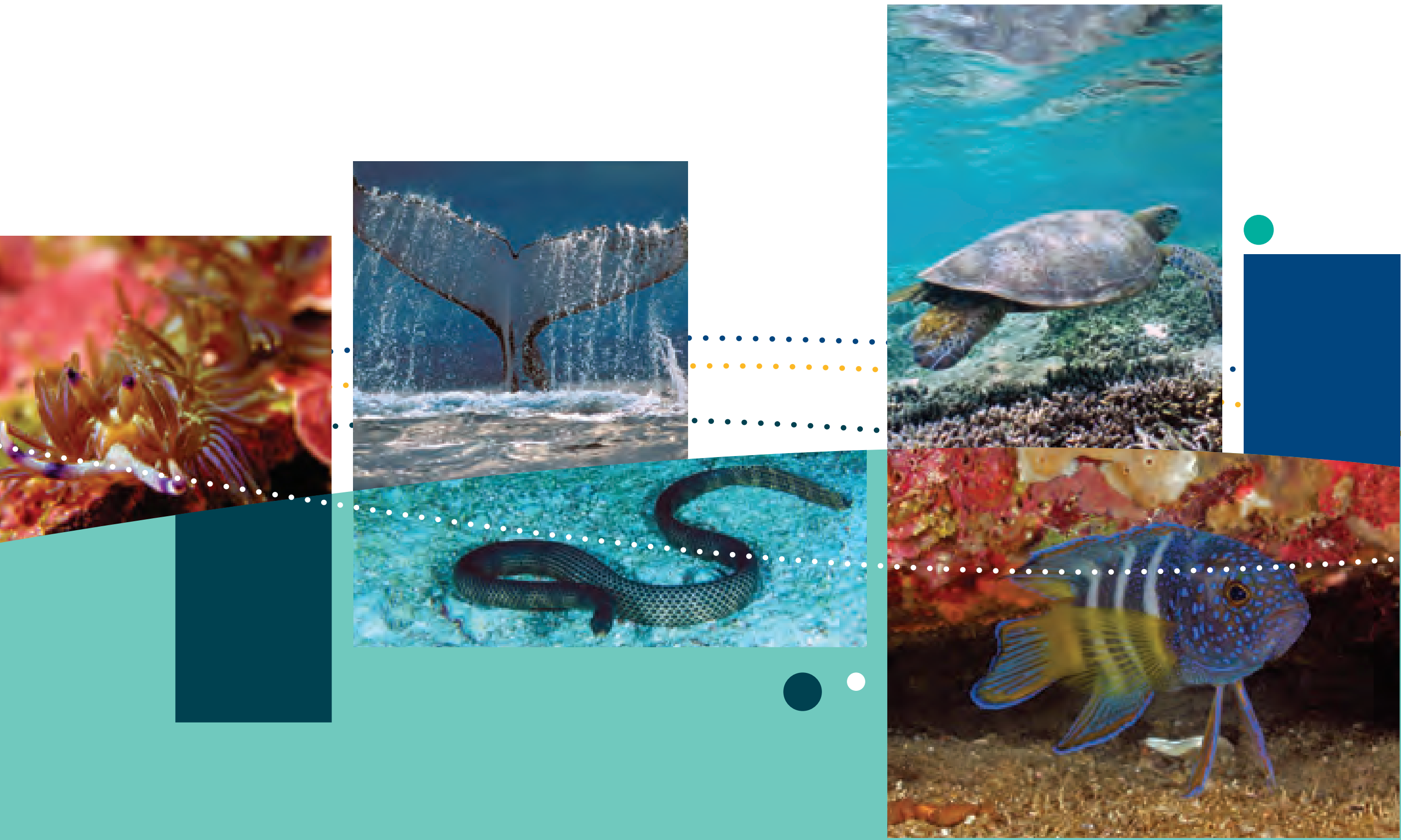
WBM Oceanics Australia & Claridge, G 1997, *Guidelines for managing visitation to seabird breeding islands*, Great Barrier Reef Marine Park Authority & Environment Australia, Canberra & Townsville.

Weaver, P, Boetius, A, Danovaro, R, Friewald, A, Gunn, V, Heussner, S, Morato, T, Schewe, I & Van den Hove, S 2009, 'The future of integrated deep-sea research in Europe: the HERMIONE project', *Oceanography*, vol. 22, no. 1, pp. 170–183.

Wilcox, C & Donlan, C 2007, 'Compensatory mitigation as a solution t sheries bycatch', *Biodiversity Conservation*, vol. 5, no. 6 pp. 325–331.

Williams, A, Schlacher, T, Rowden, A, Althaus, F, Clark , M, Bowden , D, Stewart , R, Bax, N, Consalvey, M & Kloser, R 2010, 'Seamount megabenthic assemblages fail to recover from trawling impacts', *Marine Ecology*, vol. 31, pp. 183–199.

Witherington, BE & Martin, RE 2000, *Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches*, Florida Marine Research Institute technical report TR-2, St. Petersburg, Florida.



SCHEDULE 2

Regional advice on matters of national environmental significance

SCHEDULE 2
REGIONAL ADVICE ON MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

Introduction

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action requires approval from the environment minister if it has, will have or is likely to have a signi cant impact (refer to glossary **www.environment.gov.au/marineplans**) on a matter of national environmental signi cance. A person proposing to take an action that they think is, or may be, such an action must refer it to the minister for a decision as to whether further assessment and approval are required under the EPBC Act. Substantial penalties apply for taking such an action without approval.

There are currently eight matters of national environmental signi cance protected under the EPBC Act:

- world heritage properties
- national heritage places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species (except those listed as extinct or conservation dependent) and ecological communities (except those listed as vulnerable)
- migratory species protected under international agreements
- the Commonwealth marine environment
- the Great Barrier Reef Marine Park
- nuclear actions, including uranium mines.

This schedule to the Temperate East Marine Bioregional Plan has been prepared under the EPBC Act. It contains information about matters of national environmental signi cance within the Temperate East Marine Region and should be considered when deciding whether a proposed action needs to be referred to the environment minister for a decision.

Under section 176 of the EPBC Act, once a bioregional plan has been made, the environment minister must have regard to it when making any decision under the Act to which the plan is relevant. The minister will have regard to the information provided in Schedule 2 when making decisions about referrals, assessments and approvals, as well as other relevant decisions under the EPBC Act. However, this does not limit the information the minister may consider when making decisions.

The advice contained in this schedule is not comprehensive (i.e. it does not cover all matters of national environmental signi cance occurring in the Temperate East Marine Region) and should not be regarded as de nitive in relation to those matters for which advice is provided.

The regional advice should be read as supplementary to, and not as replacing, EPBC Act policy statements. In particular, the following policy statement is the key guidance document for determining whether a referral is required:

- *EPBC Act Policy Statement 1.1: Signi cant impact guidelines—matters of national environmental signi cance.*

Depending on the type of action proposed, industry policy statements also provide important information:

- *EPBC Act Policy Statement 2.1: Interaction between offshore seismic exploration and whales*
- *EPBC Act Policy Statement 2.2: Industry—offshore aquaculture*
- *EPBC Act Policy Statement 2.3: Wind farm industry.*

Other policy statements and guidelines may also be developed and provide important information. Further information and assistance can be obtained by contacting the referral business entry point through the department's community information unit on 1800 803 772 or by sending an email to **epbc.referrals@environment.gov.au**.

Schedule 2 does not provide advice for the assessment of the environmental performance of sheries managed under Commonwealth legislation and state expor sheries. Guidelines for the strategic assessment o sheries under Part 10 of the EPBC Act; assessments relating to impacts on protected marine species under Part 13; and assessments for the purpose of export approval under Part 13A are contained within the document Guidelines for the Ecologically Sustainable Management of Fisheries (**www.environment.gov.au/coasts/ sheries/publications/guidelines.html**).

Using the regional advice

This schedule is a guide and is not de nitive. The regional advice provided in this schedule is augmented by information provided in the conservation value report cards, which are available on the website of the Department of Sustainability, Environment, Water, Population and Communities at **www.environment.gov.au/marineplans/temperate-east**.

The rating of risks in this schedule was developed to provide practical information on the kinds of actions which should be referred to determine if approval under the EPBC Act is needed. The ratings here are not designed to prioritise environmental risks. They relate to the risk of a proposed action needing to be referred under the EPBC Act. The highlighted advice provide further assistance in identifying types of activities that are at low risk of needing to be referred and those that are at higher risk of needing to be referred.

Considerations underpinning the rating of a risk include:

- pressure rating (of key ecological features and species, see Tables S1.2 and S1.3)
- conservation status (of species)
- presence of a biologically important area (for species; see Conservation Values Atlas **www.environment.gov.au/cva**)
- trends in pressures.

Commonwealth marine environment: Section 24 of the EPBC Act de nes a Commonwealth marine area (see glossary for further details). It is the area that extends beyond the outer edge of State and Territory waters, generally 3 nautical miles (or 5.5 kilometres) from the coast, to the boundary of Australia's exclusive economic zone generally 200 nautical miles (370 kilometres) from shore. Under the EPBC Act, the environment within the Commonwealth marine area is a matter of national signi cance.

Where suf cient information exists to aid decision-making, this schedule presents regional advice on the Commonwealth marine environment in relation to:

- key ecological features of the Temperate East Marine Region and protected places
- protected species that occur in the Temperate East Marine Region that are not otherwise matters of national environmental signi cance.

Some advice provided in this schedule refers to **biologically important areas**. These are areas that are particularly important for the conservation of protected species and where aggregations of individual species display biologically important behaviour, such as breeding, foraging, resting or migration. The presence of the observed behaviour is assumed to indicate that habitat required for the behaviour is also present. Regional advice has been developed for biologically important areas due to their relevance to a protected species. The advice focused on these areas should not be construed to mean that legislative obligations do not apply outside these areas. Biologically important areas are not protected matters and should not be confused with ‘critical habitat’ as de ned in the EPBC Act.

A register of **critical habitat** is maintained under the EPBC Act. The register lists habitats considered critical to the survival of a listed threatened species or listed threatened ecological community. If a habitat occurs in or on a Commonwealth area and is listed in the register, it is an offence under the EPBC Act to take an action when it is known that the action signi cantly damages the critical habitat.

Species protected under the EPBC Act may be listed as threatened, migratory or marine species. Those protected species that are matters of national environmental signi cance are:

- threatened species (other than those categorised as extinct or conservation dependent)
- migratory species.

Species that are listed under the EPBC Act but are *not* matters of national environmental signi cance include those species that are listed as:

- marine (s. 248 of the EPBC Act)
- cetaceans (whales, dolphins and porpoises)
- threatened species listed as extinct or conservation dependent.

However, it is possible for listed marine species and cetaceans to also be matters of national environmental signi cance; that is, where they have been listed as a threatened species (other than in the conservation dependent category) or as migratory. For example, the humpback whale is listed as a cetacean but it is also a matter of national environmental signi cance because it is listed as vulnerable and migratory under the EPBC Act.

A number of terms related to protected species that are matters of national environmental signi cance have speci c meaning under the EPBC Act, namely:

- **Population:** A population of a species is de ned under the EPBC Act as an occurrence of the species in a particular area. In relation to species that are categorised as critically endangered, endangered or vulnerable occurrences include but are not limited to:
  - a geographically distinct regional population or collection of local populations
  - a population or collection of local populations that occurs within a particular bioregion.
- **Important population:** This term relates to populations of threatened species that are categorised as vulnerable under the EPBC Act. An important population is a population that is necessary for a species’ long-term survival and recovery. This may include populations identi ed as such in recovery plans, and/or populations that are:
  - key source populations either for breeding or dispersal
  - necessary for maintaining genetic diversity
  - near the limit of the species’ range.

This de nition is consistent with that provided in EPBC Act *Policy Statement 1.1: Signi cant impact guidelines—matters of national environmental signi cance*. In accordance with these guidelines, in determining the signi cance of an impact on a vulnerable species, consideration should be given to whether an important population is found in the area.

- **Ecologically signi ant proportion of a population:** This term applies to species listed as migratory. In accordance with Policy Statement 1.1: Signi cant impact guidelines—matters of national environmental signi cance, for migratory listed species, consideration should be given to whether an ecologically signi cant proportion of a population is found in an area. Whether the species in an area represents an ecologically signi cant proportion of a population needs to be determined on a case-by-case basis, as different species have different life histories and populations. Some key factors that should be considered include the species' population status, genetic distinctiveness and species-speci c behavioural patterns (for example, sit delity and dispersal rates).

Schedule 2.1
The Commonwealth marine environment of the Temperate East Marine Region

The Commonwealth marine environment, including the Temperate East Marine Region, is a matter of national environmental signi cance under the EPBC Act. An action requires approval if it is taken:

- in a Commonwealth marine area (refer to glossary **www.environment.gov.au/marineplans**), and the action has, will have, or is likely to have a signi cant impact on the environment, or
- outside a Commonwealth marine area but within Australian jurisdiction and the action has, will have, or is likely to have a signi cant impact on the environment in a Commonwealth marine area.[7]

7 Actions taken outside the Commonwealth marine area may impact on its environment through downstream effects—for example, by resulting in water quality changes that can spread offshore beyond 3 nautical miles or by adversely affecting species that are an important component of the Commonwealth marine environment, either throughout, or at speci c stages of, their lifecycle. For example, seagrass beds are an important nursery habitat for a number of species, some of which move offshore in their adult stages. Reductions in seagrass beds—for example, as a result of dredging—depending on their extent, have the potential to impact on the population dynamics of a number of species that inhabit the Commonwealth marine area

The Temperate East Marine Region covers Commonwealth waters extending from the southern boundary of the Great Barrier Reef Marine Park to Bermagui in southern New South Wales, as well as the waters surrounding Lord Howe and Norfolk islands. The marine environment is made up of numerous habitats, biological communities and ecosystems. Determining whether a proposed action has the potential to cause a signi cant impact on the marine environment requires consideration of its individual and combined components at a scale relevant to the action.

The EPBC Act Policy Statement 1.1 outlines criteria to assist in determining the signi cance of impacts on the Commonwealth marine environment. Speci cally, an action is likely to have a signi cant impact on the Commonwealth marine environment if there is a real chance or possibility that the action will:

- result in a known or potential pest species becoming established in the Commonwealth marine area
- modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that there will be an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area
- have a substantial adverse effect on a population of a marine species or cetacean, including its lifecycle (e.g. breeding, feeding, migration behaviour or life expectancy) and spatial distribution
- result in a substantial change in air quality or water quality (including temperature) that may adversely impact on biodiversity, ecological integrity, social amenity or human health
- result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected
- have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck.

The regional advice in this schedule has been developed to assist the interpretation of some of these criteria within the context of the Temperate East Marine Region. The regional advice addresses:

- S2.1.1: establishment of marine pest species
- S2.1.2: adverse impacts on marine ecosystem functioning and integrity
- S2.1.3: adverse effects on populations of a marine species or cetacean (excluding those listed as threatened or migratory)
- S2.1.4: adverse impacts on heritage values
- S2.1.5: actions in Commonwealth marine reserves.

S2.1.1 Establishment of marine pest species

Although the Commonwealth waters of the Temperate East Marine Region contain introduced marine species, no pest species[8] has been recorded yet in this region. Adjacent to the region, Queensland has no recorded established invasive marine pests; however, 26 invasive marine pests are listed as posing a potential threat to the state (Hayes et al. 2004). In New South Wales waters, six listed marine pest species occur (Table S2.1) (NSW Industry & Investment 2011).

The invasive strain of the green alga Caulerpa which occurs in State waters adjacent to the region, is capable of invading benthic communities in depths up to 100 metres. Other species in State waters capable of spreading into deeper water environments include the European/green shore crab, European fan worm, Japanese goby, and the New Zealand screw shell. The National System for the Prevention and Management of Marine Pest Incursions maintains a 'trigger list' of species that may become invasive if introduced as part of its Emergency Marine Pest Plan.[9]

8 Introduced marine pests are marine plants or animals that are not native to Australia but have been introduced by human activities such as shipping and have become aggressive pests.

9 **www.marinepests.gov.au**

Table S2.1: Marine pests known to be established in State waters, adjacent to the Temperate East Marine Region

Pest name	Location	Impact	Habitat
Caulerpa *(Caulerpa taxifolia)*	Batemans Bay Botany Bay Brisbane Waters Burril Lake Durras Lake Lake Conjola Narrawallee Inlet Hawkesbury River Pittwater Port Hacking Port Jackson St Georges Basin Wallagoot Lake	Overgrows native habitat and can establish vast beds on soft sediment, degradin sh habitat Tangles in nets and anchors	Depths up to 100 m Exposed and sheltered estuaries, coastal lagoons and bays Rock, sand, mud and seagrass beds

Pest name	Location	Impact	Habitat
European or green shore crab *(Carcinus maenas)*	Clyde River Batemans Bay Tomaga River/ Barlings Beach Candlagan Creek Coila Lake Wagonga Inlet Nangudga Lake Corunna Lake Tilba Tilba Lake Bermagui River Cuttagee Lake Wapengo Lake Nelson Lagoon Merimbula Lake Pambula Lake Twofold Bay Towamba River Kiah Creek Wonboyn River Nadgee Lake	Aggressive predator, outcompetes native species for food and habitat	Prefers bays and estuaries but found on all types of shores at depths up to 60 m Tolerates temperatures up to 30 °C

Pest name	Location	Impact	Habitat
European fan worm (*Sabella spallanzanii)*	Twofold Bay (near Eden)	Forms dense colonies that consume vast amounts of food No known predators in Australia	Tubes attached to hard surfaces, arti cial structures, rocks, shells and seagrass on soft sediments Sheltered waters, depths up to 30 m
Japanese goby *(Tridentiger trigonocephalus)*	Sydney Harbour Port Kembla	Competes with native species	Prefers estuaries and rocky reef areas
New Zealand screw shell *(Maoricolpus roseus)*	Continental shelf off Merimbula and Bermagui	Forms a dense covering on the se oor and competes with native shell sh for food	Depths up to 130 m Prefers sand, mud or gravel in intertidal to subtidal areas
Paci c oyster *(Crassostrea gigas)*	Most New South Wales estuaries south of the Macleay River and some offshore areas	Establish dense populations in some areas, displacing native intertidal species, with the potential to modify habitat for non-oyster species	Depths up to 3 m On hard substrate in intertidal and shallow subtidal areas Favours brackish waters in sheltered estuaries but tolerates a range of salinity and water quality Can also occur offshore

Marine pests can be introduced through ballast water exchange or via biofouling. High-risk vessels for the introduction of species include those that are slow moving, have space where marine species can settle, come in close contact with the sea bottom or remain in a single area for extended periods. These characteristics increase the likelihood that a species can establish on a vessel, from where it can be introduced to new regions. Vessels in this category include dredges, supply boats, drilling rigs and som shing boats. Other high-risk ships include some of th ag-of-convenience carriers that are low-cost operators with poorly maintained vessels, as well as small private recreational vessels from other parts of the world.

Shallow and inshore areas, particularly port areas and sites where infrastructure development and maintenance take place, have the highest risk of marine pests becoming established. Some introduced species have the potential to settle or expand into deeper waters, including in the offshore Commonwealth marine environment.

The introduction of marine pests is a particularly important issue for the Temperate East Marine Region given the high levels of sea transport to and through the region, an shing activity in the region.

The following types of actions have a real chance or possibility of resulting in marine pests becoming established in the Commonwealth marine environment, thereby affecting the biodiversity values and/or ecological integrity of the Commonwealth marine environment:

- development of new ports or upgrades of existing port facilities that substantially increase shipping traffic
- construction of infrastructure or any other action involving the translocation into the region of marine equipment (e.g. dredges or platforms), from within or outside Australia.

There is a low risk of marine pests becoming established in the Commonwealth marine environment or affecting its biodiversity values and/or ecological integrity as a result of these actions when appropriate mitigation measures are adopted. Mitigation measures consistent with the National System for the Prevention and Management of Marine Pest Incursions, the Australian Ballast Water Management Requirements and the *National biofouling management guidelines for commercial vessels*[10] and the *National biofouling management guidelines for recreational vessels*[11] aim to reduce the risk that actions will result in the introduction of marine pests, which may significantly impact on the Commonwealth marine environment, in port and inshore environments. Further information on responsibilities regarding the management of marine pest incursions is provided at **www.marinepests.gov.au**.

S2.1.2 Adverse impacts on marine ecosystem functioning and integrity

The Temperate East Commonwealth marine environment report card provides an overview of key ecological features defined for the region and their relevance to ecosystem processes and structure. While the report card provides useful context, determining potential impacts of specific activities on the Commonwealth marine environment requires consideration of habitats and biodiversity at an appropriate subregional and local scale.

10 **www.marinepests.gov.au/_data/pdf_file/001/1109594/Bifouling_guidelines_commercial_vessels.pdf**.
11 **www.marinepests.gov.au/_data/pdf_file/001/1109594/Bifouling_guidelines_rec.pdf**.

The regional advice below provides further guidance for considering impacts on areas and habitats that are defined as key ecological features in the Temperate East Marine Region by virtue of their regional importance for biodiversity and/or ecosystem functioning and integrity. The Temperate East Commonwealth marine environment report card provides further information, including references to relevant scientific literature, on the region's key ecological features.

The advice here provides information of relevance to people considering impacts on the Commonwealth marine environment. It is essential to note that provision of advice in relation to the key ecological features does not imply that they are the only habitats, areas, species or species groups that should be considered when determining the significance of potential impacts on the Commonwealth marine environment. It remains the responsibility of a person proposing to take an action to determine whether there is a real chance or possibility that the action is likely to result in a significant impact on the Commonwealth marine environment.

The Temperate East Marine Region has eight areas and/or types of habitats that are key ecological features (see Figure S1). Further information on these key ecological features is provided in the Temperate East Commonwealth marine environment report card (**www.environment.gov.au/marineplans/temperate-east**).

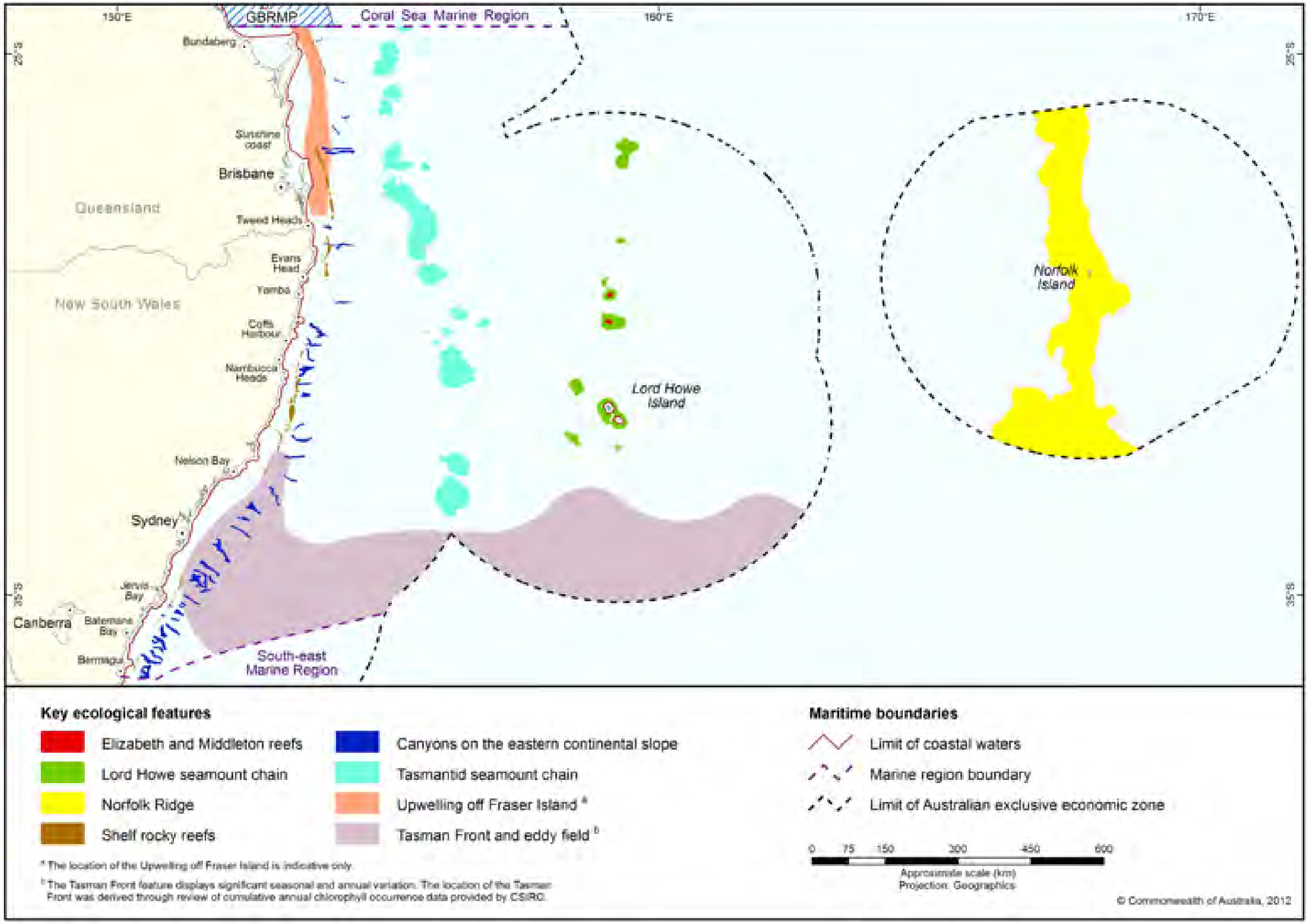


Figure S2.1: Key ecological features in the Temperate East Marine Region

In assessing the impacts of a proposed action on the Commonwealth marine environment and their signi cance, the relevance of the proposed action to the regional importance and vulnerabilities of the key ecological features described below should be considered.

Shelf rocky reefs: This key ecological feature is recognised for its enhanced ecological functioning and integrity, and biodiversity, which apply to its benthic habitats.

Along the continental shelf south of the Great Barrier Reef, benthic communities on rock outcrops and boulder substrates shift from algae-dominated communities to those dominated by attached invertebrates. This shift generally occurs at a depth of 45 metres, and these habitats are densely populated by large sponges, with a mixed assemblage of moss animals and soft corals. Below wave-in uenced areas, massive and branched forms of sponges are more prevalent, and sponge species richness and density generally increases with depth along the New South Wales coast. Collectively, these invertebrates create a complex habitat–forming community that supports a multitude of microorganisms and invertebrates, such as crustaceans, molluscs, annelids and echinoderms. These habitats also provide refuge from predation for juvenil shes, thereby increasing their survival. Rocky reef habitats on Australia's east coast support a diverse assemblage of demersa sh, which show distinct patterns of association with shelf reef habitats. For example, jackass morwong, barracouta, orange-spotted catshark, eastern orange perch, butter y perch and warehou are species that distinguish rocky reef habitats at depths greater than 45 metres from those of soft sediments.

Pressures *of potential concern* on this key ecological feature include:

- climate change, which has the potential to alter ecological values through changes to sea temperatures and oceanographic processes, and causing ocean acidi cation. These changes alter localised productivity and/or community structures through shifts in marine species distribution
- marine debris from vessel based sources
- physical habitat modi cation fro shing gear
- extraction of living resources by commercia shing impacting on the feature's ecosystem functioning and integrity
- bycatch.

Generally, most actions in or adjacent to the Temperate East Marine Region are unlikely to impact adversely on the ecosystem functioning and integrity of the Shelf rocky reefs.

Canyons on the eastern continental slope: This key ecological feature is recognised for its enhanced ecological functioning and integrity, and biodiversity, which apply to both its benthic and pelagic habitats.

Submarine canyons are widespread features around the Australian continent and island margins, and a large number of these features are present on the eastern continental slope. Canyon systems have a marked in uence on the diversity and abundance of species, driven by the combined effects of steep and rugged topography, ocean currents, varied sea- oor types and nutrient availability. Large benthic species such as attached sponges and feather stars are abundant, with high diversity at upper-slope canyon depths of 150–700 metres. Canyons also provide critical feeding grounds for a wide range of species, including many which are commercially important (e.g. tuna) and threatened (e.g. marine turtles). Canyons contribute to habitat diversity by providing a hard surface that offers anchoring points and vertical relief fo lter feeder benthic species (e.g. sponges and bryozoans). A range of higher trophic level species, including crustaceans, echinoderms, bivalves, cephalopods an sh are then attracted to these regions.

Pressures *of potential concern* on this key ecological feature include:

- climate change, which has the potential to alter ecological values through changes to sea temperatures and oceanographic processes. These changes alter localised productivity and/or community structures through shifts in marine species distribution
- oil pollution and chemical pollution/contaminants from shipping traf c which can impact on water quality and ecosystem functioning and integrity
- marine debris from vessel based sources
- extraction of living resources by commercia shing impacting on the feature’s ecosystem functioning and integrity
- bycatch.

Actions that, irrespective of where they occur, have a real chance or possibility of resulting in:

- a substantial change in water quality that may adversely impact on biodiversity or ecological integrity in the area of the canyons on the eastern continental slope
- persistent organic chemicals, heavy metals or other potentially harmful chemicals accumulating in the waters surrounding the canyons on the eastern continental slope

have a **high risk** of a signi cant impact on the Commonwealth marine environment.

Actions that introduce a new source from which a severe oil spill or other chemical pollution has a reasonable potential of arising (e.g. increased shipping and drilling) in the canyons on the eastern continental slope have a **risk** of signi cant impact on the Commonwealth marine environment of the Temperate East Marine Region.

Tasman Front and edd eld: This key ecological feature is recognised for its signi cant ecological functioning and integrity, and biodiversity, which apply to its pelagic habitats.

The Tasman Front is described as a region of intermediate productivity that separates the nutrient-poor waters of the Coral Sea from the nutrient-rich waters of the Tasman Sea. The front is formed by a meandering current located between 27° S and 33° S, which moves northward in winter months and southward in summer months. Across the southern portion of the Temperate East Marine Region, the Tasman Front creates a complex oceanographic environment where waters mix vertically. Patches of productivity are important for mid-level consumers including turtles and to sh predators, as well as catch in the Eastern Tuna and Bill sh Fishery. Fishery oceanography studies describe a positive relationship between catch rates and proximity to frontal features, and a predominance of bigeye tuna and sword sh associated with the Tasman Front. The feature is also important for providing connectivity of tropical species to the Lord Howe seamount chain and Norfolk Ridge.

Pressures *of potential concern* on this key ecological feature include:

- climate change, which has the potential to alter ecological values through changes to sea temperatures and oceanographic processes. These changes alter localised productivity and/or community structures through shifts in marine species distribution
- oil pollution and chemical pollution/contaminants from shipping traf c which can impact on water quality and ecosystem functioning and integrity
- marine debris from vessel based sources
- extraction of living resources by commercia shing impacting on the feature’s ecosystem functioning and integrity
- bycatch.

Actions that, irrespective of where they occur, have a real chance or possibility of resulting in:

- a substantial change in water quality that may adversely impact on biodiversity or ecological integrity in the area of the Tasman Front and edd eld
- persistent organic chemicals, heavy metals or other potentially harmful chemicals accumulating in the waters in the area of the Tasman Front and edd eld

have a **high risk** of a signi cant impact on the Commonwealth marine environment.

Actions that introduce a new source from which a severe oil spill or other chemical pollution has a reasonable potential of arising (e.g. increased shipping and drilling) in the area around the Tasman Front and edd eld have a **risk** of signi cant impact on the Commonwealth marine environment of the Temperate East Marine Region.

Upwelling off Fraser Island: This key ecological feature is recognised for its enhanced ecological functioning and integrity, and biodiversity, which apply to its pelagic habitats.

In the vicinity of Fraser Island, two areas of upwelled waters mix with surface waters and are drawn onto the shelf through a number of processes, including tidal currents, wind and eddy in uence. The upwelled waters support blooms of large diatoms that are important to food chains for commercially valuable species in the area. Examples of food chains include diatoms → macrozooplankton → latern sh → squid → tuna and bill sh (long-chain), and diatoms→ crustaceans → tuna (short-chain). However, the entire food web for this system is complex and includes small pelagi shes, mid-size sh predators and top predators. The feature also appears to be an important node of connectivity in migrations of small pelagi shes and top predators. The subtropical waters are an important spawning area for temperate small pelagic shes (e.g. tailor, sardine, round herring and Australian anchovy), the adults of which appear to migrate from the south, and their larvae are subsequently transported back into temperate nursery areas by the East Australian Current.

Pressures *of potential concern* on this key ecological feature include:

- climate change, which has the potential to alter ecological values through changes to sea temperatures and oceanographic processes. These changes alter localised productivity and/or community structures through shifts in marine species distribution

- oil pollution and chemical pollution/contaminants from shipping traf c which can impact on water quality and ecosystem functioning and integrity
- marine debris from vessel based sources
- extraction of living resources by commercia shing impacting on the feature's ecosystem functioning and integrity
- bycatch.

Actions that, irrespective of where they occur, have a real chance or possibility of resulting in:

- a substantial change in water quality that may adversely impact on biodiversity or ecological integrity in the area of the upwelling off Fraser Island
- persistent organic chemicals, heavy metals or other potentially harmful chemicals accumulating in the waters in the area of the Fraser upwelling

have a **high risk** of a signi cant impact on the Commonwealth marine environment.

Actions that introduce a new source from which a severe oil spill has a reasonable potential of arising (e.g. port developments that increase shipping and drilling) in the area of the upwelling off Fraser Island have a **risk** of signi cant impact on the Commonwealth marine environment of the Temperate East Marine Region.

Tasmantid seamount chain: This key ecological feature is recognised for its enhanced ecological functioning and integrity, and biodiversity, which apply to both its benthic and pelagic habitats.

The Tasmantid seamount chain is a prominent chain of submarine guyots, plateaux and terraces, running north–south at approximately 155° E, and extending down into the Tasman Basin. At its deepest, features rise from 1400–900 metres below sea level; at its northern extent, features rise to from 400–150 metres below sea level, with some breaking the surface to form islands. The Tasmantid seamount chain supports a diverse range of habitats, including deep sea sponge gardens and near-pristine tropical coral reef systems. Collectively, these are known to be biological hotspots, supporting signi cant demersal and pelagic diversity, and feeding grounds and reproduction sites for a number of open ocean species (e.g. bill sh, marine turtles, marine mammals). There is limited information regarding pelagic species composition around these seamounts, but little information on benthic species. High species diversity and endemicity has been reported from the neighbouring Lord Howe seamount chain, however, which may be used as an indicator for biodiversity levels for the Tasmantid chain.

Pressures *of potential concern* on this key ecological feature include:

- climate change, which has the potential to alter ecological values through changes to sea temperatures and oceanographic processes, and causing ocean acidi cation. These changes alter localised productivity and/or community structures through shifts in marine species distribution
- oil pollution and chemical pollution/contaminants from shipping traf c which can impact on water quality and ecosystem functioning and integrity
- marine debris from vessel based sources
- extraction of living resources by commercia shing impacting on the feature's ecosystem functioning and integrity
- bycatch.

Actions that, irrespective of where they occur, have a real chance or possibility of resulting in:

- a substantial change in water quality that may adversely impact on biodiversity or ecological integrity in the area of the Tasmantid seamount chain
- persistent organic chemicals, heavy metals or other potentially harmful chemicals accumulating in the waters surrounding the Tasmantid seamount chain (i.e. waters adjacent to areas of the seamount chain that break the surface and those above areas that do not break the surface)

have a **high risk** of a signi cant impact on the Commonwealth marine environment.

Actions that introduce a new source from which a severe oil spill or other chemical pollution has a reasonable potential of arising (e.g. increased shipping and drilling) over the Tasmantid seamount chain have a **risk** of signi cant impact on the Commonwealth marine environment of the Temperate East Marine Region.

Lord Howe seamount chain: This key ecological feature is recognised for its enhanced ecological functioning and integrity, and biodiversity, which apply to both its benthic and pelagic habitats.

The Lord Howe seamount chain runs for approximately 1000 kilometres along the western margin of the Lord Howe Rise, extending from Lord Howe Island in the south to Nova Bank in the north. The chain includes Lord Howe Island, Balls Pyramid, Elizabeth Reef, Middleton Reef and Gifford Guyot within the Temperate East Marine Region, and to the north of the Region are Capel, Kelso, Argo and Nova banks. The seamount chain supports tropical shallow coral reefs and deep cold water corals (depths greater than 40 metres). The fringing coral reefs around Lord Howe Island, and Elizabeth and Middleton reefs to the north, are the southernmost tropical coral reefs in the Paci c Ocean. The seamount chain lies in the path of the Tasman Front, which brings a mix of warm tropical waters and colder, nutrient-rich waters from the south, depending on the season. In general, waters surrounding this feature are nutrient-de cient and relatively unproductive. However, signi cantly higher catch rates of a range of tuna species along the seamounts suggest periodic bursts of productivity, presumably from subantarctic waters to the south. Deep-water, large, benthic animals occur on the Lord Howe Rise and southern portion of the Norfolk Ridge, with distributions in uenced by the Tasman Front. The distribution of benthic invertebrates does extend from the Lord Howe Rise across to the northern part of the Norfolk Ridge as these features lack a hydrographic connection.

Pressures *of potential concern* on this key ecological feature include:

- climate change, which has the potential to alter ecological values through changes to sea temperatures and oceanographic processes, and causing ocean acidi cation. These changes alter localised productivity and/or community structures through shifts in marine species distribution
- oil pollution and chemical pollution/contaminants from shipping traf c which can impact on water quality and ecosystem functioning and integrity
- marine debris from vessel based sources
- extraction of living resources by commercia shing impacting on the feature’s ecosystem functioning and integrity
- bycatch.

Actions that, irrespective of where they occur, have a real chance or possibility of resulting in:

- a substantial change in water quality that may adversely impact on biodiversity or ecological integrity in the area of the Lord Howe seamount chain
- persistent organic chemicals, heavy metals or other potentially harmful chemicals accumulating in the waters surrounding the Lord Howe seamount chain (i.e. waters adjacent to areas of the seamount chain that break the surface and those above areas that do not break the surface)

have a **high risk** of a signi cant impact on the Commonwealth marine environment.

Actions that introduce a new source from which a severe oil spill or other chemical pollution has a reasonable potential of arising (e.g. increased shipping and drilling) over the Lord Howe seamount chain have a **risk** of signi cant impact on the Commonwealth marine environment of the Temperate East Marine Region.

Elizabeth and Middleton temperate and tropical reefs: This key ecological feature is recognised for its enhanced ecological functioning and integrity, and biodiversity, which apply to both its benthic and pelagic habitats.

The Elizabeth and Middleton reefs are small, isolated, oceanic platform-reefs on volcanic seamounts of the Lord Howe seamount chain. The reefs are within the presen laments of the East Australian Current and represent an overlapping area of tropical, reef-building corals and cool-water, non-reef-building corals, which provide habitat for both tropical and temperate species o sh and invertebrates. The lagoons of both reefs are strongholds for populations of the black cod and Galapagos shark. A recent study of the genetic diversity of the reefs and their connectivity suggests that their gene pools are periodically supplemented by long-distance migrants and they are likely to have population sizes that are large enough to avoid inbreeding and maintain genetic diversity. For example, 48 per cent of the coral species of the southern Great Barrier Reef are also found on Elizabeth and Middleton reefs.

A pressure *of concern* on this key ecological feature is climate change, which has the potential to alter the ecological values of this feature through changes to sea temperature and ocean acidi cation. These changes alter localised productivity and/or community structures through shifts in marine species distribution.

Pressures *of potential concern* on the ecosystem functioning and integrity of this key ecological feature include:

- climate change, which has the potential to alter ecological values through changes to sea levels and oceanographic processes. These changes alter localised productivity and/or community structures through shifts in marine species distribution
- oil pollution and chemical pollution/contaminants from shipping traf c which can impact on water quality and ecosystem functioning and integrity
- marine debris from vessel based sources
- light pollution from offshore activities such as shipping traf c.

Actions that, irrespective of where they occur, have a real chance or possibility of resulting in:

- a substantial change in water quality that may adversely impact on biodiversity or ecological integrity in the area of Elizabeth and Middleton reefs
- persistent organic chemicals, heavy metals or other potentially harmful chemicals accumulating in the waters surrounding Elizabeth and Middleton reefs
- the introduction of a new source from which light pollution may modify, destruct, fragment, isolate or disturb an important or substantial area of habitat within the Elizabeth and Middleton reef ecosystems

have a **high risk** of a signi cant impact on the Commonwealth marine environment.

Actions that introduce a new source from which a severe oil spill or other chemical pollution has a reasonable potential of arising (e.g. increased shipping) at Elizabeth and Middleton reefs have a **risk** of signi cant impact on the Commonwealth marine environment of the Temperate East Marine Region.

Norfolk Ridge: This key ecological feature is recognised for its enhanced ecological functioning and integrity, and biodiversity, which apply to both its benthic and pelagic habitats.

The Norfolk Ridge is set within a region of remnant volcanic arcs, plateaux, troughs and basins. The ridge runs southward from New Caledonia to New Zealand, and lies between the New Caledonia Trough to the west and the Norfolk Basin to the east. The high level of diversity in seamount benthos in this area is likely to be caused by relatively productive benthic habitats that support far higher population densities than surrounding regions. The Tasman Front conveys tropical species to the southern portion of the ridge within the Temperate East Marine Region, supporting a diverse assemblage of tropical and temperate species, with evidence of connectivity to the benthic fauna of Lord Howe Rise. The semipermanent Norfolk Eddy may create a closed system that limits connectivity and increases endemism within the South Norfolk Basin.

Pressures *of potential concern* on this key ecological feature include:

- climate change, which has the potential to alter ecological values through changes to sea temperatures and oceanographic processes, and causing ocean acidi cation. These changes alter localised productivity and/or community structures through shifts in marine species distribution
- marine debris from vessel based sources
- extraction of living resources by commercia shing impacting on the feature's ecosystem functioning and integrity
- bycatch.

Generally, most actions in or adjacent to the Temperate East Marine Region are unlikely to impact adversely on the ecosystem functioning and integrity of the Norfolk Ridge.

S2.1.3 Adverse impacts on populations of a marine species or cetacean (excluding those listed threatened or migratory)[12]

An impact on the Commonwealth marine environment might be significant if there is a real chance or possibility that it will result in a substantial adverse effect on a population of a marine species, including its lifecycle and spatial distribution. The regional advice below provides further guidance that might assist in considering impacts on the Commonwealth marine environment of the Temperate East Marine Region and their significance, with respect to:

- protected marine species, which are not considered matters of national environmental significance, including
  - cetaceans of known regional importance (that are not listed as threatened or migratory species under the EPBC Act)
  - listed marine species of known regional importance (that are not listed as threatened or migratory species under the EPBC Act)
  - threatened species listed as conservation dependent that are of known regional importance
- species and/or communities that have been defined as key ecological features, as they are believed to play an important role in the Temperate East Marine Region's ecosystem structure and functioning and/or to have particular relevance to its biodiversity and conservation.

It is essential to note that the provision of advice in relation to these species does not imply that they are the only species that should be considered in determining the significance of potential impacts on the Commonwealth marine environment. It remains the responsibility of a person proposing to take an action to determine whether the action will adversely and substantially affect any other marine species in a way that results in a significant impact on the Commonwealth marine environment.

12 Advice on the significance of actions for species listed as threatened and/or migratory that are matters of national environmental significance is provided in Schedules 2.2 to 2.5. (Listed threatened species that are conservation dependent and are not, of themselves, matters of national environmental significance are discussed here.)

Protected species of known regional importance (not listed as threatened or migratory)

Sixty-eight species protected under Part 13 of the EPBC Act (but not listed as threatened or migratory) are currently known to occur in the Temperate East Marine Region (see Table A appended to this schedule). The information currently available on many of these species is insuf cient to provide separate regional advice. Six species are of known importance in the context of the region's biodiversity and/or ecological functioning. These species are described below to assist in the interpretation of the signi cant impacts criteria of EPBC Act Policy Statement 1.1.

The **Indo-Paci c (coastal) bottlenose dolphin** *(Tursiops aduncus)* is listed as cetacean and protected under the EPBC Act. Biologically important areas are de ned for this species within the Temperate East Marine Conservation Values Atlas (**www.environment.gov.au/cva**). The Indo-Paci c bottlenose dolphin was only recently recognised and is considered taxonomically distinct from the common bottlenose dolphin. The common bottlenose dolphin is found throughout offshore waters of the region (including Norfolk and Lord Howe islands), but Indo-Paci c bottlenose dolphins occur in riverine and coastal waters, over shallow coastal waters on the continental shelf and around oceanic islands.

Pressures *of concern* to this species include:

- physical habitat modi cation associated with urban/coastal development
- bycatch associated with commercia shing and bather protection programs.

Pressures *of potential concern* include:

- climate change (sea level rise, changes in sea temperature, oceanography and storm events and ocean acidi cation)
- chemical pollution/contaminants and nutrient pollution associated with urban development and agricultural activities
- marine debris
- noise pollution associated with shipping and urban development
- physical habitat modi cation associated with dredging activities
- oil pollution associated with shipping
- collision with vessels
- changes in hydrological regimes.

Actions that have a real chance or possibility of increasing the likelihood of chemical contamination, oil pollution and sediments in biologically important areas for the Indo-Pacific (coastal) bottlenose dolphin have a **risk** of resulting in substantial adverse effects on populations of these species.

Actions that have a real chance or possibility of increasing localised vessel traffic, including small crafts, in areas where Indo-Pacific (coastal) bottlenose dolphins reside, have a **risk** of substantial adverse impact on populations of these species.

Actions that have a real chance or possibility of increasing noise levels above ambient levels (e.g. dredging, pile-driving or blasting) have a **risk** of substantial adverse impact on populations of both bottlenose dolphin species.

Actions that have a real chance or possibility of modifying, destroying or isolating habitat (e.g. dredging or changes to hydrological regimes) have a **risk** of substantial adverse impact on populations of both bottlenose dolphin species.

Actions that have a real chance or possibility of introducing marine debris to the biologically important areas of the Indo-Pacific (coastal) bottlenose dolphins have a risk of resulting in substantial adverse effects on populations of these species.

The **little shearwater** *(Puffinus assimilis)* breeds on islands of the Lord Howe and Norfolk Island groups and, after breeding, disperses over the Tasman Sea and possibly the Coral Sea. Lord Howe Island has one of the larger breeding colonies of little shearwater in the Australian region. Biologically important areas are defined for this species within the Temperate East Marine Conservation Values Atlas. The little shearwater is vulnerable to a range of impacts from a number of invasive species. Other potential pressures include climate change (changes in sea temperature and oceanography, ocean acidification), oil pollution and chemical pollution/contaminants associated with shipping, light pollution associated with land-based activities, marine debris and human presence at sensitive sites associated with tourism, recreational and charter fishing and research activities.

The **white-necked petrel's** *(Pterodroma cervicalis)* only known breeding location in Australia is Phillip Island, off Norfolk Island. However, no breeding pairs were recorded during a recent survey of Phillip Island. Globally, the species has a very small range, breeding on two to three small islands (BirdLife International 2011). Biologically important areas are defined for this species within the Temperate East Marine Conservation Values Atlas. This species is vulnerable to a range of impacts from a number of sources. Other potential pressures include bycatch associated with commercial fishing activities, climate change (changes in sea temperatures and oceanography, ocean acidification), oil pollution and chemical pollution/ contaminants associated with shipping, light pollution associated with land-based activities shortfin and longfin, marine debris and human presence at sensitive sites associated with tourism, recreational and charter fishing and research activities.

The **eastern gemfish** *(Rexea solandri)* is listed as conservation dependent under the EPBC Act. The species is distributed from southern Queensland to the central western Australian coast, including Tasmania. Genetic studies have indicated two distinct populations in Australia, one in eastern Australian waters (referred to as the eastern gemfish) and another west of Bass Strait. Gemfish are meso-pelagic, inhabiting oceanic waters around the continental shelf and upper slope, and are known to feed near the ocean floor at 100–800 metres. The only confirmed spawning area for eastern gemfish in Australian waters is off the central New South Wales coast, and fish migrate there during the spawning season. Potential pressures on this species include climate change (changes in sea temperatures and oceanography). Biologically important areas have not been identified for this species.

Orange roughy *(Hoplostethus atlanticus)* is listed as conservation dependent under the EPBC Act. A high-value commercial species, it is highly vulnerable to depletion because of its long-lived and late maturing nature. It is a deep water species associated with pinnacles, seamounts (e.g. Lord Howe Rise) and other features where its prey aggregates. In Australia, the species is widely distributed in temperate waters between southern Western Australia and central New South Wales, including Tasmania, and is most commonly found on the continental slope at depths of 500–1400 metres. Potential pressures on this species include climate change (changes in sea temperature and oceanography) and physical habitat modification. Biologically important areas have not been identified for this species.

S2.1.4 Adverse impacts on heritage values

Historic shipwrecks

There are likely to be hundreds of historic shipwrecks in the Temperate East Marine Region, but the precise location in Commonwealth waters of many of these shipwrecks in unknown (Figure S2.2). The protected places report card provides further information (**www.environment.gov.au/marineplans/temperate-east**). It is an offence under the Historic Shipwreck Act 1976 to damage, destroy or interfere with a historic shipwreck without a permit.

> Actions that have a real chance or possibility of resulting in substantial adverse impacts on the heritage values of the Commonwealth marine area, including damage to or destruction of a historic shipwreck, have a **high risk** of a significant impact on the Commonwealth marine environment.

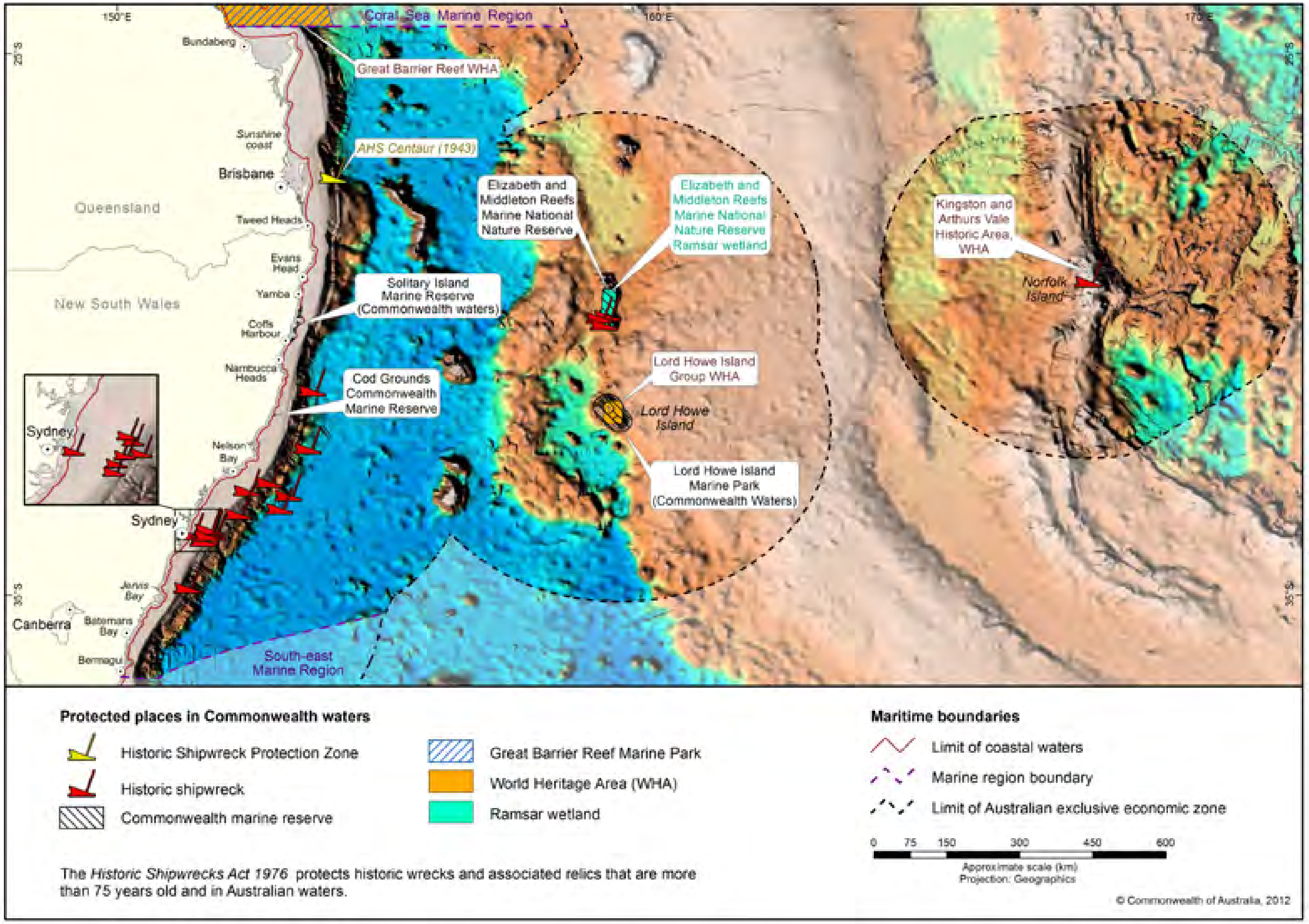


Figure S2.2: Heritage places in the Temperate East Marine Region

Other heritage places

The Lord Howe Island group is listed within several heritage categories under the EPBC Act (Table S2.2).

Table S2.2: Heritage places in the Temperate East Marine Region as of May 2012

Heritage place	Commonwealth marine reserve	World Heritage List	Commonwealth Heritage List	National Heritage List	Ramsar site	Relevant key ecological feature
Lord Howe Island group	✓	✓	✗	✓	✗	Lord Howe seamount chain

* The Lord Howe Island group World Heritage place and National Heritage place sits partly within the Lord Howe Island Marine Park (Commonwealth waters).

Heritage places adjacent to the region include the Great Barrier Reef and Kingston and Arthurs Vale Historic Area on Norfolk Island. These sites, along with the Lord Howe Island group, are listed on both the World Heritage and National Heritage lists therefore they are protected under the EPBC Act. The Act requires approval to be obtained before any action takes place that could have a signi cant impact on the world heritage or national heritage values of a listed place. For information on the speci c world heritage and national heritage values of the three sites, visit the Australian Heritage Database at **www.environment.gov.au/heritage**.

Actions that have a real chance or possibility of causing one or more of the world heritage and/or national heritage values to be lost, degraded, damaged, or notably altered, modi ed, obscured or diminished, have a **high risk** of signi cant impact on the Lord Howe Island Group.

S2.1.5 Actions in Commonwealth marine reserves

Commonwealth marine reserves (also called marine protected areas) in the Temperate East Marine Region are areas recognised as having high conservation value. Marine protected areas in the region (Figure S2.2) for which information is provided in this plan include:

- Elizabeth and Middleton Reefs Marine National Nature Reserve
- Solitary Islands Marine Reserve (Commonwealth Waters)
- Cod Grounds Commonwealth Marine Reserve
- Lord Howe Island Marine Park (Commonwealth Waters).

The Director of National Parks is the statutory authority responsible for managing all Commonwealth reserves (including marine protected areas) as speci ed by the EPBC Act. The Act also requires all Commonwealth reserves (terrestrial and marine) to have a management plan. The Act prohibits some activities being carried out on or in a Commonwealth reserve unless they are expressly provided for by a management plan for the reserve or are approved in writing by the Director of National Parks when a management plan is not in operation. This includes actions that affect native species, commercial activities and mining operations.

People considering actions in or adjacent to the Temperate East Marine Region should check the Commonwealth environment department's web site (**www.environment.gov.au/marinereserves**) for the current list and location of Commonwealth marine reserves in the Temperate East Marine Region.

Elizabeth and Middleton Reefs Marine National Nature Reserve

Elizabeth and Middleton Reefs Marine National Nature Reserve is located in the Tasman Sea, approximately 600 kilometres east of Coffs Harbour and to the north of Lord Howe Island. The reserve includes two separate reefs, Elizabeth Reef and Middleton Reef. The reserve was proclaimed in 1987 and has two zones: Habitat Protection Zone (IUCN Category II) and Sanctuary Zone (IUCN Category Ia). Activities undertaken in the reserve are regulated under the management plan for the Elizabeth and Middleton Reefs Marine National Nature Reserve. This management plan is due to expire in 2013. People intending to undertake activities in Elizabeth and Middleton Reefs Marine National Nature Reserve must apply for approval from the Director of National Parks. For more information on Elizabeth and Middleton Reefs Marine National Nature Reserve, please visit **www.environment.gov.au/coasts/mpa/elizabeth/index.html**.

Solitary Islands Marine Reserve (Commonwealth Waters)

Solitary Islands Marine Reserve (Commonwealth Waters) (SIMR) is located off the coast of northern New South Wales, 600 kilometres north of Sydney, between Coffs Harbour and Plover Island. It is adjacent to the Solitary Islands Marine Park (New South Wales waters) and extends from the 3-nautical mile state limit seaward to the 50-metre depth contour. The Solitary Islands Marine Reserve encompasses the waters, seabed and subsoil beneath the seabed to a depth of 1000 metres. The Solitary Islands Marine Park covers 710 square kilometres; the Solitary Islands Marine Reserve covers a further 160 square kilometres. The reserve was proclaimed in 1993 and has three zones: General Use Zone (IUCN Category VI); Sanctuary Zone (IUCN Category Ia) and Habitat Protection Zone (IUCN Category IV). Activities undertaken in the reserve are regulated under management arrangements. People intending to undertake activities in the Solitary Islands Marine Reserve (Commonwealth waters) must apply for approval from the Director of National Parks. For more information on the Solitary Islands Marine Reserve, please visit **www.environment.gov.au/coasts/mpa/solitary/index.html**.

Cod Grounds Commonwealth Marine Reserve

The Cod Grounds Reserve comprises a 1000-metre radius from a point at 152°54’37”E 31°40’52”S, offshore of Laurieton, New South Wales. The reserve was proclaimed in 2007 as an IUCN Category 1a strict nature reserve (Sanctuary Zone) to protect important habitat of the critically endangered east coast population of grey nurse shark. Activities undertaken in the reserve are regulated under interim management arrangements. People intending to undertake activities in the Cod Grounds Commonwealth Marine Reserve must apply for approval from the Director of National Parks. For more information on the Cod Grounds Commonwealth Marine Reserve, please visit **www.environment.gov.au/coasts/mpa/cod-grounds/index.html**.

Lord Howe Island Marine Park

The Lord Howe Island Marine Park is approximately 700 kilometres north-east of Sydney. The park comprises State waters around Lord Howe Island and Ball’s Pyramid and the Commonwealth waters between 3 nautical miles and 12 nautical miles around Lord Howe Island and Ball’s Pyramid form the Lord Howe Island Marine Park (Commonwealth Waters). The perimeter of the Lord Howe Island Marine Park (Commonwealth Waters) roughly corresponds to the 1800-metre depth contour, which follows the base of the seamounts that underlie Lord Howe Island and Ball’s Pyramid. The sea area of the Commonwealth Marine Park is estimated to be 3005 square kilometres and includes the seabed to a depth of 100 metres. The reserve was proclaimed in 2000 and has two zones: Sanctuary Zone (IUCN Category 1a) and Habitat Protection Zone (IUCN Category IV). Activities undertaken in the reserve are regulated under management arrangements. People intending to undertake activities in the Lord Howe Island Marine Park (Commonwealth Waters) must apply for approval from the Director of National Parks. For more information on the Lord Howe Island Marine Park (Commonwealth Waters), please visit **www.environment.gov.au/coasts/mpa/lordhowe/index.html**.

Actions in or near Commonwealth marine reserves have a **greater risk** of signi cant impacts on the Commonwealth marine environment.

Advice for preparing a referral with respect to impacts on the Commonwealth marine environment of the Temperate East Marine Region

The 'referral of proposed action' form is available electronically at **www.environment.gov.au/epbc/index.html** and can also be obtained in hard copy by telephoning 1800 803 772. It includes detailed instructions about the type of information that is required in referring a proposed action for consideration.

In addition to the instructions included in the referral of proposed action form, if an action is referred because of the risk of signi cant impact on the Commonwealth marine environment of the Temperate East Marine Region, consideration of the following matters is recommended:

- For actions associated with physical habitat modi cation, for example dredging, independent dredge plume modelling undertaken to predict suspended sediment levels and the extent of sediment dispersal as a result of the proposed action would assist in assessing the action.
- For actions involving physical habitat modi cation, for example the dumping of dredge spoils or other materials into the Commonwealth marine environment, requirements under the Environment Protection (Sea Dumping) Act 1981 and the National assessment guidelines for dredging 2009 (DEWHA 2009) apply. An application for a sea dumping permit should be submitted. Further information on sea dumping is available at **www.environment.gov.au/coasts/pollution/dumping/index.html**.
- For actions likely to release nutrients or pollutants into the Commonwealth marine environment, modelling of nutrient or pollutant dispersal and accumulation undertaken to determine potential impacts on marine ecosystems would assist in assessing the action.
- To mitigate the effects of an accidental hydrocarbon spill from a vessel, an approved shipboard oil pollution emergency plan should be in place. For actions relating to petroleum facilities and pipelines, an approved environment plan containing an oil spill contingency plan should be in place. Further information on responsibilities regarding the protection of the marine environment from oil spills is available on the National Offshore Petroleum Safety and Environmental Management Authority's website: **www.nopsema.gov.au**.

References

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2009, *National Assessment Guidelines for Dredging, Commonwealth of Australia*, DEWHA, Canberra.

Hayes, K, Sliwa, C, Migus, S, McEnnulty, F & Dunstan, P 2004, *National priority pests: part II—ranking of Australian marine pests* nal report for the Australian Government Department of Environment and Heritage, Canberra.

BirdLife International, 2011, Species factsheet: *Pterodroma cervicalis,* BirdLife International, Cambridge, UK, viewed July 2011, **<www.birdlife.org>**.

NSW Department of Primary Industries 2011, Marine Pests, viewed October 2011, **<www.dpi.nsw.gov.au/ sheries/pests-diseases/marine-pests>**.

Schedule 2.2
Cetaceans of the Temperate East Marine Region

All cetaceans are protected under the EPBC Act in the Australian Whale Sanctuary[13] (and, to some extent, beyond its outer limits). Of the 45 cetacean species (whales, dolphins and porpoises) recorded in Australian waters, 11 are known to occur in the Temperate East Marine Region, and one other species may occur infrequently in the region. Please refer to the conservation values report card—cetaceans, for a complete list of cetaceans and additional information (**www.environment.gov.au/marineplans/temperate-east**).

The Temperate East Marine Region supports diverse and abundant cetacean populations, whose use of the region's marine habitats and resources varies markedly. Toothed whales found in the region include killer whales, the Indo-Paci c humpback and Indo-Paci c (coastal) bottlenose dolphins, known to feed on a wide range of prey includin sh and squid, are also found in the region, and the area is used as a migration pathway for humpback whales between their feeding and breeding areas.

The following advice relates only to those species listed above for which it has been possible to identify biologically important areas (Table S2.3). The Indo-Paci c bottlenose dolphin is listed as cetacean and is considered in Schedule 2.1.

Table S2.3: Cetaceans listed as threatened and/or migratory with known biologically important areas in or adjacent to the Temperate East Marine Region

Species	Listing status
Humpback whale (*Megaptera novaeangliae*)	Vulnerable, migratory
Indo-Paci c humpback dolphin (*Sousa chinensis*)	Migratory

13 The Australian Whale Sanctuary was established under the EPBC Act to protect all whales and dolphins in Australian waters. The Australian Whale Sanctuary comprises the Commonwealth marine area and covers all of Australia's Exclusive Economic Zone which generally extends out to 200 nautical miles from the coast and includes the waters surrounding Australia's external territories such as Christmas, Cocos (Keeling), Norfolk, Heard and Macdonald Islands. Within the Australian Whale Sanctuary it is an offence to kill, injure or interfere with a cetacean. Severe penalties apply to anyone convicted of such offences. More information about the Australian Whale Sanctuary can be found at **www.environment.gov.au/coasts/species/cetaceans/conservation/sanctuary.html**.

Key considerations in relation to significant impacts on cetacean species in the Temperate East Marine Region

Population status and ecological significance

The **humpback whale** is listed as vulnerable and migratory. The population is estimated to be growing consistently at about 10 per cent per year (Bannister & Hedley 2001; Bryden, Kirkwood & Slade 1990; Chaloupka & Osmond 1999; Paterson, Paterson & Cato 2001; Paterson, Paterson & Cato 2004). The Australian east coast population is estimated to be 10 000 individuals (Noad et al. 2008).

The **Indo-Pacific humpback dolphin** is listed as migratory. The total Australian population size of this species is unknown, but it is likely that the Indo-Pacific humpback dolphin occurs as one genetic population within Australia (DSEWPaC 2011). Regional population levels are likely to be in the low thousands on the east coast of Queensland, with populations in particular bays in the region varying between approximately 50 and 100 individuals. Populations of this inshore dolphin are highly localised, occur in small subgroups, and have low gene flow between groups (Cagnazzi 2010; Corkeron et al. 1997; Parra, Corkeron & Marsh 2006).

Top-order predators—such as dolphins—are a key functional species group, influencing abundance, recruitment, species composition, diversity and behaviour of prey species. Their removal can have a cascading effect on all the components of a food web (Heithaus 2001; Baum & Worm 2009; Ings et al. 2009, cited in Ceccarelli & Ayling 2010).

For the purposes of determining the significance of impacts of proposed actions on the two species listed above, note that:

- the humpback whale is listed as vulnerable under the EPBC Act. It should be assumed that populations of this species in and adjacent to the Temperate East Marine Region are important populations[14] of the species
- the Indo-Pacific humpback dolphin is listed as migratory under the EPBC Act. There is insufficient information to determine whether an ecologically significant proportion of the population occurs in the Temperate East Marine Region. However, it should be taken into consideration that this species generally exhibits small group sizes (less than 100 individuals), high site fidelity and geographic isolation with low gene flow between populations. As such, the loss (i.e. anthropogenic mortality) of even a very small percentage of mature animals may cause population decline or local extinction.

Species distribution and biologically important areas

Humpback whales migrate annually between their summer feeding grounds in Antarctica and their winter tropical and subtropical breeding grounds. In general, the species is sighted in southern Australian waters in May, and migrates slowly up the east and west coasts. By October, most whales have started their southward migration, and sightings are less frequent after November. During migration, individuals travel alone or in temporary aggregations of generally non-related individuals (cow–calf pairs being the exception) (Valsecchi et al. 2002).

14 Definitions of 'important population' and 'ecologically significant population' are provided in Section 1 of this schedule and are consistent with EPBC Act Policy Statement 1.1: Significant impact guidelines—matters of national environmental significance. In accordance with Policy Statement 1.1 for threatened species listed as vulnerable, such as the humpback whale, consideration should be given to whether an important population

Biologically important areas have been identified for the **humpback whale** in the Temperate East Marine Region and include (from north to south):

- the Hervey Bay area for migration/resting during migration, including resting during northbound migration (June–July) and as a resting area for females and calves on southbound migration (August–mid-October)
- Fraser Island to Moreton Bay, between the coast and 15 km offshore as a migration pathway (northbound migration peaking in June–July and southbound migration peaking in August–mid-October)
- the Moreton Bay area, for migration/resting during migration, including resting during northbound migration (peaking June–July), and as a resting area for females and calves on southbound migration (peaking August–mid-October)
- from the Queensland/New South Wales border to the Eden area for migration/resting during migration. Resting during migration between May and November, northbound (peaking June–July) and southbound (peaking August–mid-October). Feeding has been observed just to the south of the region, off Eden.

Actions undertaken offshore from the continental shelf and not affecting waters over the continental shelf have a **low risk** of significant impact on the humpback whale.

The **Indo-Pacific humpback dolphin** is found in coastal and estuarine areas of Queensland and New South Wales (Parra & Ross 2009). It occurs in a variety of inshore shallow water habitats at depths less than 20 metres, including inshore reefs, tidal and dredged channels, mangroves and river mouths (Karczmarski, Cockroft & McLachlan 2000; Parra 2006). The Indo-Pacific humpback dolphin is a generalist feeder, preying on bottom-dwelling and pelagic fish and cephalopods associated with coastal and estuarine waters (Parra & Jendensjo 2009).

Biologically important areas have been identi ed for the **Indo-Paci c humpback dolphin** in and adjacent to the Temperate East Marine Region and include (from north to south):

- from Hervey Bay north-east to Commonwealth waters, within the 20-metre depth contour (Queensland), for foraging
- from Hervey Bay south to Tin Can Bay, within the 20-metre depth contour (Queensland), for foraging/feeding and breeding year-round
- the southern tip of Fraser Island in coastal waters adjacent to Rainbow Beach, within the 20-metre depth contour (Queensland), for foraging
- from the north-eastern tip of Cooloola National Park south to the Queensland/New South Wales border (including Moreton Bay), within the 20-metre depth contour (Queensland), for foraging/feeding and breeding year-round
- coastal waters south of the Queensland—New South Wales border to Cabarita Beach, within the 20-metre depth contour (New South Wales), for foraging.

Further information on these areas is found in the Temperate East Conservation Values Atlas (**www.environment.gov.au/cva**).

Table S2.4 should be considered in assessing the risk of signi cant impact on each of the three species within and outside known biologically important areas.

Table S2.4: Advice on the risk of signi cant impact on humpback whale and Indo-Paci c humpback dolphin[15]

Species	Action in biologically important areas	Action outside biologically important areas	Temporal considerations[18]
Humpback whale	**High risk** of signi cant impact, depending on the type of action[16]	Actions undertaken outside of, and not affecting[17], biologically important areas for the humpback whale and, in the case of seismic activities, undertaken in accordance with EPBC Act Policy Statement 2.1, have a **low risk** of signi cant impact on this species	In the Temperate East Marine Region from early December to April[18], there is a low likelihood of encounter with humpback whales. Generally, actions undertaken anywhere in the region during this period have a **low risk** of signi cant impact on the species
Indo-Paci c humpback dolphin	**High risk** of signi cant impact, depending on the type of action[16]	Actions undertaken outside of, and not affecting[17], biologically important areas for the Indo-Paci c humpback dolphin have a **low risk** of signi cant impact on this species	Indo-Paci c humpback dolphins use biologically important areas all year

Further information on biologically important areas can be found in the Temperate East Conservation Values Atlas (**www.environment.gov.au/cva**).

15 This advice does not apply to actions that inherently result in prolonged or enduring changes to the biologically important areas or the marine environment in general. Actions should also be conducted in accordance with EPBC Act Policy Statement 2.1: Interaction between offshore seismic exploration and whales, where relevant.

16 see ‘Nature of proposed action’, following page

17 Actions that might affect a biologically important area, even when undertaken outside the area, include sound transmission that may result in behavioural reactions of whale species and/or prey, such that a physical impact is likely.

18 This time period re ects a precautionary approach and includes a buffer of one month on either end of the known periods during which humpback whales are found in these areas. The buffer has been used as there is a limited understanding of the migratory movements of humpback whales or the seasonality of their occurrence in the region before or after they are sighted in known biologically important areas.

Nature of the proposed action

The conservation values report card—cetaceans, provides an overview of the vulnerabilities and pressures on protected cetaceans in the Temperate East Marine Region. Inshore dolphins and humpback whale are particularly vulnerable to impacts from human activities because their nearshore coastal distribution overlaps with the areas of highest human use in the marine environment. Anthropogenic activities in coastal environments have the potential to signi cantly impact on inshore dolphins and humpback whales.

The Indo-Paci c humpback dolphin is vulnerable to physical habitat modi cation associated with urban/coastal development, and bycatch associated with commercia shing activities and bather protection programs.

Pressures *of potential concern* on humpback whales include:

- climate change (changes in sea temperature, oceanography and ocean acidi cation)
- marine debris from a range of sources
- bycatch associated with bather protection programs.

Pressures *of potential concern* on the Indo-Paci c humpback dolphin include:

- climate change (sea level rise, changes in sea temperature and oceanography and ocean acidi cation)
- chemical pollution/contaminants and nutrient pollution associated with urban development and agricultural activities
- marine debris from a range of sources
- noise pollution associated with shipping and urban development
- physical habitat modi cation associated with dredging
- oil pollution associated with shipping
- collision with vessels
- changes in hydrological regimes.

People planning to undertake actions in biologically important areas for cetaceans should carefully consider the potential for their actions to have a signi cant impact on the species. For actions proposed outside biologically important areas for cetaceans, the risk of signi cant impact on the species is likely to be lower.

In addition to this general advice, the following actions have a **high risk** of a signi cant impact on humpback whales:

- actions that have a real chance or possibility of increasing rates of entanglement that potentially result in a long-term decrease in population size.

The following actions have a **risk** of a signi cant impact on Indo-Paci c humpback dolphins:

- actions that have a real chance or possibility of introducing a new source from which a severe chemical spill or nutrient pollution has a reasonable potential of arising (e.g. construction of ports or expansion in port facilities, development of residential, industrial or agricultural areas) within biologically important areas when the species is present
- actions that have a real chance or possibility of increasing relevant noise[19] above the ambient levels (e.g. actions resulting in a substantial increase in underwater acoustic noise from construction or ship noise) within any of the biologically important areas for this species when the species is present
- actions that have a real chance or possibility of substantially modifying, destroying or isolating habitat (e.g. dredging, changes to hydrological regimes, urban/coastal development) in a biologically important area
- actions that have a real chance or possibility increasing the rate of ship strike (e.g. increased shipping traf c associated with new or expanding port construction) within biologically important areas for this species when the species is present.

Actions that have a real chance or possibility of introducing marine debris to the biologically important areas of the Indo-Paci c humpback dolphin have a **risk** of signi cant impact on the Indo-Paci c humpback dolphin.

Actions that introduce a new source from which a severe oil spill or other chemical pollution has a reasonable potential of arising (e.g. increased shipping and drilling) in biologically important areas have a **risk** of signi cant impact on the Indo-Paci c humpback dolphin.

19 Relevant noise is de ned here as low-frequency sounds (below 200Hz) that are within the same range of frequencies used by some whales.

For the Indo-Paci c humpback dolphin, given the currently incomplete knowledge of their population distribution, there is a risk of a signi cant impact from the actions described above outside known biologically important areas which are, however, still within the species' distribution and seasonal range in the region.

Ecotourism operations in biologically important areas for the Indo-Paci c humpback dolphin undertaken in accordance with the *Australian national guidelines for whale and dolphin watching 2005* (DEH 2005b) have a low risk of signi cant impact on the species. The national guidelines require strict management measures to be applied in areas where dolphin watching operations might be *of concern* (e.g. locations with a high number of operators). In an instance where these operations may be *of concern*, early advice should be sought from the Australian Government department responsible for the environment.

Advice for preparing a referral with respect to impacts on humpback whales and Indo-Paci umpback dolphins in the Temperate East Marine Region

The 'referral of proposed action' form is available electronically at **www.environment.gov.au/epbc/indedex.html** and can also be obtained in hard copy by telephoning 1800 803 772. It includes detailed instructions about the type of information required in referring a proposed action for consideration.

In addition to the instructions included in the referral of proposed action form, if an action is referred because of the risk of signi cant impact on the humpback whale or Indo-Paci c humpback dolphin, consideration of the following matters is also recommended:

- If the action proposed is within a biologically important area, information should be considered about any alternative locations for the proposed action that would be outside the area, why the action is unlikely to have a signi cant impact or why any signi cant impact can be reduced to an acceptable level.
- If planning recreational or tourism operations, the *Australian national guidelines for whale and dolphin watching* (DEH 2005b) provides standards on approach distances and operating procedures.
- Referrals should be supported by scienti cally credible information that places the proposal in the context of existing pressures on cetaceans and the life history characteristics of the species. The conservation values report card—cetaceans provides additional information on the range of pressures on cetaceans.
- For areas marked for long-term development involving noise-generating activities, passive acoustic monitoring programs (e.g. installation of sonobuoys) might assist in gaining the necessary understanding of th ner scale spatial and temporal patterns of some cetaceans and improve the ability to assess and mitigate impacts. It is recommended that early advice be sought from the Australian Government department responsible for the environment.

References

Bannister, JL & Hedley, SL 2001, 'Southern hemisphere group IV humpback whales: their status from recent aerial survey', *Memoirs of the Queensland Museum*, vol. 47, no. 2, pp. 587–98.

Baum, JK & Worm, B 2009, 'Cascading top-down effects of changing oceanic predator abundances', *Journal of Animal Ecology* vol. 78, no. 4, pp. 699–714.

Bryden, MM, Kirkwood, GP & Slade, RW 1990, 'Humpback whales, area V: an increase in numbers off Australia's east coast', in KR Kerry & G Hempel (eds), *Antarctic ecosystems: ecological change and conservation*, Springer-Verlag, Berlin, pp. 271–7.

Cagnazzi, D & Harrison, P 2010, 'Evidence of genetic isolation by habitat fragmentation in Indo-Paci c humpback dolphins *(Sousa chinesnsis)* from central Queensland, Australia': poster presented at American Genetic Association Annual Symposium, Hawaii, 26-28 July 2010.

Ceccarelli, D & Ayling, T 2010, 'Role, importance and vulnerability of top predators on the Great Barrier Reef: a review', research publication no. 105 for the Great Barrier Reef Marine Park Authority, Townsville, Queensland.

Chaloupka, M & Osmond, M 1999, 'Spatial and seasonal distribution of humpback whales in the Great Barrier Reef region', *American Fisheries Society Symposium*, vol. 23, pp. 89–106.

Corkeron, PJ, Morissette, NM, Porter, LJ & Marsh, H 1997, 'Distribution and status of hump-backed dolphins, *Sousa chinensis*, in Australian waters', *Asian Marine Biology*, vol. 14, pp. 49–59.

DEH (Department of the Environment and Heritage) 2005a, Blue, Fin and Sei Whale Recovery Plan 2005–2010, viewed 29 September 2011, **<www.environment.gov.au/biodiversity/threatened/publications/recovery/balaenoptera-sp/pubs/balaenoptera-sp.pdf>**.

DEH (Australian Government Department of the Environment and Heritage 2005b, *Australian national guidelines for whale and dolphin watching*, DEH, Canberra, viewed 3 March 2011, **<www.environment.gov.au/coasts/publications/whale-watching-guidelines-2005.html>**.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2008, EPBC Act Policy Statement 2.1: I*nteraction between offshore seismic exploration and whales*, DEWHA, Canberra.

DSEWPaC (Australian Government Department of Sustainability, Environment, Water, Population and Communities) 2011, *Indo-Paci c humpback dolphin*, viewed 20 June 2011, **<www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=50>**.

Heithaus, MR 2001, 'Predator–prey and competitive interactions between sharks (order selachii) and dolphins (suborder odontoceti): a review', *Journal of Zoology*, vol. 253, no. 1, pp. 53–68.

Ings, TC, Montoya, JM, Bascompte, J, Bluethgen, N, Brown, L, Dormann, CF, Edwards, F, Figueroa, D, Jacob, U, Jones, JI, Lauridsen, RB, Ledger, ME, Lewis, HM, Olesen, JM, van Veen, FJF, Warren, PH & Woodward, G 2009, 'Ecological networks: beyond food webs', *Journal of Animal Ecology* vol. 78, pp. 253–69.

Karczmarski, L, Cockcroft, VG & McLachlan, A 2000, 'Habitat use and preferences of Indo-Paci c humpback dolphins Sousa chinensis in Algoa Bay, South Africa', *Marine Mammal Science*, vol. 16, no. 1, pp. 65–79.

Noad, MJ, Dunlop, RA, Paton, D & Cato, DH 2008, 'An update of the east Australian humpback whale population (E1) rate of increase', paper SC/60/SH31 submitted for consideration by the International Whaling Commission Scienti c Committee, Cambridge, UK.

Parra, GJ 2006, 'Resource partitioning in sympatric delphinids: space use and habitat preferences of Australian snub n and Indo-Paci c humpback dolphins', *Journal of Animal Ecology*, vol. 75, pp. 862–74.

Parra, GJ, Corkeron, PJ & Marsh, H 2006, 'Population sizes, site delity and residence patterns of Australian snub n and Indo-Paci c humpback dolphins: implications for conservation', *Biological Conservation*, vol. 129, pp. 167–80.

Parra, GJ & Jedensjo, M 2009, Feeding habits of Australian Snub n (Orcaella heinsohni) and *Indo-Paci c humpback dolphins* (Sousa chinensis), project report to the Great Barrier Reef Marine Park Authority, Townsville, Queensland, and Reef & Rainforest Research Centre, Cairns (22 pp.).

Parra, GJ & Ross, JGB 2009, 'Humpback dolphins, S. chinensis and S. teuszii', in WF Perrin, B Würsig & JGM Thewissen (eds) 2009, *Encyclopedia of marine mammals*, 2nd edn, Academic Press, San Diego, pp. 1100–1103.

Paterson, RAP, Paterson, R & Cato, DH 2001, 'Status of humpback whales, Megaptera novaeangliae, in east Australia at the end of the 20th century',*Memoirs of the Queensland Museum*, vol. 47, no. 2, pp. 579–86.

Paterson, R, Paterson, R & Cato, DH 2004, 'Continued increase in east Australian humpback whales in 2001, 2002', *Memoirs of the Queensland Museum*, vol. 49, no. 2, p. 712.

Valsecchi, E, Hale, P, Corkeron, P & Amos, W 2002, Social structure in migrating humpback whales (Megaptera novaeangliae), Molecular Ecology, vol. 11, pp. 507–18.

Schedule 2.3
Marine turtles of the Temperate East Marine Region

Four species of marine turtle listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are known to occur in the Temperate East Marine Region, and all are listed as threatened and migratory under the EPBC Act.

Green and loggerhead turtles are the most common marine turtles found in the Temperate East Marine Region, with nesting sites dotted along the New South Wales and south-east Queensland coasts. Hawksbill and leatherback turtles are likely to be found foraging in the region.

The following advice relates to the marine turtles for which it has been possible to identify biologically important areas, listed in Table S2.5. Please refer to the conservation values report card—marine reptiles for a complete list of reptiles in the region and additional information (**www.environment.gov.au/marineplans/temperate-east**).

Table S2.5: Marine turtles listed as threatened and/or migratory in or adjacent to the Temperate East Marine Region for which biologically important areas have been iden ed

Species	Listing status
Green turtle *(Chelonia mydas)*	Vulnerable, migratory, marine
Loggerhead turtle *(Caretta caretta)*	Endangered, migratory, marine

Key considerations in relation to signi ant impacts on green and loggerhead turtles in the Temperate East Marine Region

Population status and ecological significance

The **green turtle** is listed as vulnerable and migratory under the EPBC Act. Three breeding aggregations (considered to be separate stock) exist in and adjacent to the region: the northern and southern Great Barrier Reef stock and the Coral Sea stock. The Temperate East Marine Region is most important for the southern Great Barrier Reef stock. This population is estimated to include 36 500 breeding females (Dethmers et al. 2010). This stock was thought to be in decline, but recent studies indicate it is now increasing (Chaloupka et al. 2007). The northern Great Barrier Reef and Coral Sea populations have an estimated 133 500 and 15 500 breeding females, respectively (Dethmers et al. 2010).

The **loggerhead turtle** is listed as endangered and migratory under the EPBC Act. The eastern Australian stock, the most important within the Temperate East Marine Region, has undergone a sharp decline since the 1970s, with estimates from the 1999–2000 breeding season of less than 500 breeding females (Limpus 2008).

For the purposes of determining the signi cance of impacts of proposed actions on the four species[20] listed above, note that:

- the loggerhead turtle is endangered under the EPBC Act. It is known that populations of this species occur in and adjacent to the Temperate East Marine Region
- the green turtle is listed as vulnerable under the EPBC Act. It is known that populations of this species occur in and adjacent to the Temperate East Marine Region.

Species distribution and biologically important areas

Green turtles are a global species that generally live in tropical environments within the 20 °C isotherm, but they are occasionally known to enter temperate waters. Adults forage mainly on seagrass and algae, and occasionally eat mangroves (Forbes 1994; Limpus & Limpus 2000; Pendoley & Fitzpatrick 1999) sh egg cases (Forbes 1994), jelly sh (Limpus, Couper & Read 1994) and sponges (Whiting, Guinea & Pike 2000). The species is common throughout north-eastern Australia and there are seven distinct genetic stocks within the Australian region (Dethmers et al. 2006; FitzSimmons et al. 1997). The northern Great Barrier Reef supports the largest population of nesting green turtles in Australia, with smaller breeding areas in the south (DEWHA 2009). Beyond the boundaries of the Great Barrier Reef, the islets that make up the Coringa-Herald National Nature Reserve in the Coral Sea, to the east of Cairns and Townsville, support the most signi cant nesting sites in the region.

20 De nitions of 'important population' and 'ecologically signi cant population' are provided in Section 1 of this schedule and are consistent with EPBC Act Policy Statement 1.1: Signi cant Impact Guidelines—Matters of National Environmental Signi cance. In accordance with Policy Statement 1.1, for threatened species listed as vulnerable, such as the green turtle, consideration should be given to whether an important population occurs in the area where the action is proposed; for listed migratory species, consideration should be given to whether an ecologically signi cant proportion of a population may be impacted.

In their post-hatchling and juvenile stages, green turtles drift on ocean currents (Carr & Meylan 1980). They travel south along the east coast of Australia on the East Australian Current, leaving the region as they move east to northern New Zealand, then continuing on the South Pacific Gyre to re-enter the region via the Coral Sea (DEWHA 2009). In their next phase, they move to shallow waters to forage on seagrass and algae, living in coral and rocky reefs, inshore seagrass beds and algal mats (Musick & Limpus 1997; Poiner & Harris 1996; Robins, Bache & Kalish 2002; Whiting, Guinea & Pike 2000). Green turtles are much smaller than other marine turtles when they leave their open ocean phase, and it is presumed that they do not travel as extensively as some other species within the south Pacific (Limpus et al. 2005, DEWHA 2009).

Biologically important areas have been identified for **green turtles** in the Temperate East Marine Region and include (from north to south):

- Mon Repos Conservation Park, for nesting, with an internesting buffer of 20 kilometres (November to February)
- Moreton Bay for foraging (year round).

The **loggerhead turtle** breeds in eastern Australia and forages throughout Queensland and New South Wales. Females predominantly nest on beaches near Bundaberg and the islands of the southern Great Barrier Reef. The largest nesting sites are Mon Repos on the mainland and Wreck Island in the Great Barrier Reef, where several hundred females lay their eggs every year. Some isolated nesting occurs south of Bundaberg and as far south as Ballina in northern New South Wales (Limpus 1985; DEWHA 2009). In their early life they are carried south by the East Australian Current to around 30° S (Limpus, Couper & Read 1994; Walker 1994), leaving the region as they move east to northern New Zealand, then travelling on the South Pacific Gyre and re-entering the region via the Coral Sea (DEWHA 2009). As large, immature turtles, their oceanic, pelagic, post-hatchling phase moves to a benthic feeding phase (Bjorndal 1997; Lanyon, Limpus & Marsh 1989; Limpus & Limpus 2000; Limpus et al. 2005). Adults and large juveniles inhabit environments with both hard and soft substrata, including rocky and coral reefs (Limpus, Fleay & Guinea 1984), muddy bays (Conway 1994), sand flats, estuaries and seagrass meadows (Limpus, Couper & Read 1994; Preen 1996; McCauley & Bjorndal 1999). Large concentrations of foraging loggerhead turtles have been found in the lagoons of the southern Great Barrier Reef islands (e.g. Heron and Wistari), as well as the Hervey Bay and Moreton Bay areas (DEWHA 2009).

Biologically important areas have been identi ed for **loggerhead turtles** in the Temperate East Marine Region and include (from north to south):

- the coastline between Bustard Head, Queensland, and Ballina, New South Wales for nesting, with an internesting buffer of 20 kilometres (November to February)
- Mon Repos Conservation Park–Woongara Coast for nesting, with an internesting buffer of 20 kilometres (November to February).

Further information on these areas is found in the Temperate East Conservation Values Atlas (**www.environment.gov.au/cva**).

Nature of the proposed action

The life history patterns of marine turtles, including long life spans and late sexual maturity, make them vulnerable to a range of pressures in the marine environment. Marine turtles spend their life at sea other than when adult females return to beaches in their natal region to nest (FitzSimmons et al. 1997; Chaloupka & Limpus 2001). They are highly migratory and occupy different habitats at different stages of their life.

The conservation values report card—reptiles provides a summary of the existing environment and pressures in the Temperate East Marine Region. Proposals for new actions should consider the existing environment, vulnerabilities and pressures acting on marine turtles in the region.

The green turtle is vulnerable to extraction of living resources associated with (non-domestic) commercia shing activities; bycatch from commercia shing activities; climate change (sea level rise); marine debris from a range of sources; and collision with vessels. Potential pressures include physical habitat modi cation from dredging activities; extraction of living resources from illegal, unregulated and unreporte shing activities; climate change (changes in sea and sand temperatures and oceanography); oil and chemical pollution/contaminants associated with shipping; chemical pollution/contaminants and nutrient pollution associated with urban development and agricultural activities; and light pollution from land-based and offshore activities.

The loggerhead turtle is vulnerable to bycatch from commercia shing activities; climate change (sea level rise, changes in sea and sand temperatures); marine debris from a range of sources; and collision with vessels. Potential pressures include invasive species; physical habitat modi cation from dredging activities; extraction of living resources from illegal, unregulated and unreporte shing activities; climate change (changes in oceanography); oil and chemical pollution/contaminants associated with shipping; chemical pollution/contaminants and nutrient pollution associated with urban development and agricultural activities; and light pollution from land-based and offshore activities.

Growing urban and industrial development in the region is leading to an increase in recreational vessels and shipping in areas frequented by marine turtles, increasing the potential of vessel collisions for both species.

Pressures *of concern* and *of potential concern* on the loggerhead and green turtles in the Temperate East Marine Region are as follows:

- increases in sea temperature, changes in sea level and changes in terrestrial sand temperature are *of concern* for the loggerhead turtle and *of potential concern* for the green turtle
- bycatch as a result of commercia shing activities is a pressure *of concern* while bycatch as a result of illegal, unregulated and unreporte shing is *of potential concern* for both turtle species
- vessel collision is a pressure *of concern* for both turtle species
- changes in oceanography is *of potential concern* for both species
- chemical and nutrient pollution as a result of industrial and coastal development and agricultural activities is a pressure *of potential concern* for both turtle species
- marine debris from a range of sources is a pressure *of potential concern* for both turtle species
- light pollution from onshore activities (e.g. petroleum facilities, ports and urban development) is a pressure *of potential concern* for both turtle species
- physical habitat modi cation through dredging is a pressure *of potential concern* for both turtle species
- oil pollution is *of potential concern* for both species
- invasive species (e.g. foxes and feral pigs) is a pressure *of potential concern* for both turtle species
- non-domestic commercia shing is *of potential concern* for green turtles.

People planning to undertake actions in biologically important areas for marine turtles should carefully consider the potential for their action to have a signi cant impact on the species. For actions proposed outside biologically important areas for marine turtles, the risk of signi cant impact on the species is likely to be lower.

The following actions have a **very high risk** of a signi cant impact on the loggerhead turtle:

- actions that have a real chance or possibility of resulting in an increase in collision with vessels.

The following actions have a **high risk** of a signi cant impact on both the loggerhead and the green turtle:

- actions that have a real chance or possibility of resulting in an increase in lighting at important nesting sites during breeding seasons. Examples of such actions include onshore sources of lighting (e.g. petroleum processing facilities, ports)
- actions, such as dredging, that have a real chance or possibility of modifying, destroying or decreasing the availability of habitat for the species
- actions that have a real chance or possibility of changing the water quality of; increasing nutrient pollution of; or introducing contaminants into, biologically important areas
- actions that have a real chance or possibility of leading to the introduction of invasive species into biologically important areas.

Actions with a real chance or possibility of resulting in an increase in collision with vessels have a **high risk** of a signi cant impact on the green turtle.

Actions that have a real chance or possibility of introducing marine debris to the biologically important areas of the loggerhead and green turtle have a **risk** of signi cant impact on these species.

Actions that introduce a new source from which a severe oil spill or other chemical pollution has a reasonable potential of arising (e.g. increased shipping and drilling) have a **risk** of signi cant impact on the loggerhead and green turtles.

Advice for preparing a referral with respect to impacts on green and loggerhead turtles in the Temperate East Marine Region

The ‘referral of proposed action’ form is available electronically at **www.environment.gov.au/epbc/indedex.html** and can also be obtained in hard copy by telephoning 1800 803 772. It includes detailed instructions about the type of information required in referring a proposed action for consideration.

In addition to the instructions included in the referral of proposed action form, if an action is referred because of the risk of signi cant impact on either of the two species of marine turtle considered here, consideration of the following matters is recommended:

- If the action is proposed within a biologically important area classi ed in a nesting, internesting or foraging area, information should be considered about alternative locations for the proposed action that would be outside the area, why the action is unlikely to have a signi cant impact or why any signi cant impact can be reduced to an acceptable level.
- Referrals should include information on how the likelihood of any signi cant impacts will be mitigated, considering the advice provided above on likely signi cant impacts to any marine turtles. Independent scienti c assessments of any intended mitigation measures should be sought before submitting a referral and these assessments should be included in the referral.
- Referrals should be supported by scienti cally credible information that places the proposal in the context of existing pressures on marine turtles and the life history characteristics of the species. The conservation values report card—reptiles provides information on the range of pressures on marine turtles addressed in this regional advice.

References

Bjorndal, KA 1997, ‘Foraging ecology and nutrition of sea turtles’, in *The Biology of Sea Turtles*, PL Lutz & JA Musick (eds), CRC Press, Boca Raton, Florida, pp. 199–232.

Carr, A & Meylan, AB 1980, ‘Evidence of passive migration of green turtle hatchlings in Sargassum’, *Copeia*, vol. 1980, no. 2, pp. 366–368.

Chaloupka, M & Limpus C 2001, ‘Trends in the abundance of sea turtles resident in southern Great Barrier Reef waters’, *Biological Conservation*, vol. 102, pp. 235–49.

Chaloupka, M, Bjorndal, KA, Balazs, GH, Bolten, AB, Ehrhart, LM, Limpus, CJ, Suganuma, H, Troeng, S & Yamaguchi, M 2007, 'Encouraging outlook for recovery of a once severely exploited marine megaherbivore', *Global Ecology and Biogeography*, vol. 17, pp. 297–304.

Conway, SP 1994, *Diets and feeding biology of adult olive ridley* (Lepidochelys olivacea) *and loggerhead* (Caretta caretta) *sea turtles in Fog Bay (Northern Territory)*, Graduate Diploma of Science thesis, Northern Territory University, Darwin.

Dethmers, KM, Broderick, D, Moritz, C, FitzSimmons, NN, Limpus, CJ, Lavery, S, Whiting, S, Guinea, M, Prince, RIT & Kennett, R 2006, 'The genetic structure of Australasian green turtles (Chelonia mydas): exploring the geographical scale of genetic exchange', *Molecular Ecology*, vol. 15, no. 13, pp. 3931–46.

Dethmers, KM, Jensen, MP, FitzSimmons, NN, Broderick, D, Limpus, CJ & Moritz, C 2010, 'Migration of green turtles *(Chelonia mydas)* from Australasian feeding grounds inferred from genetic analyses', *Marine and Freshwater Research*, vol. 61, pp. 1376–87.

DEWHA (Australian Government Department of the Environment, Water, Heritage and the Arts) 2009, 'The East Marine Bioregional Plan: Bioregional Pro le', DEWHA, Canberra.

FitzSimmons, N, Limpus, C, Norman, J, Goldizen, A, Miller, JD & Moritz, C 1997, 'Philopatry of male marine turtles inferred from mitochondrial DNA markers', in *Proceedings of the National Academy of Sciences of the United States of America*, vol. 94, no. 16, pp. 8912–17.

Forbes, GA 1994, 'The diet of the green turtle in an algal based coral reef community-Heron Island, Australia', in BA Schroeder & BE Witherington (eds), P*roceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation*, NOAA technical memorandum NMFS-SEFSC-341, National Technical Information Service, Spring eld, pp. 57–9.

Lanyon, J, Limpus, CJ & Marsh, H 1989, 'Dugongs and turtles: grazers in the seagrass system', in AWD Larku, AJ McComb & SA Shepherd (eds), *Biology of Australian seagrasses: an Australian perspective*, Elsevier, Amsterdam, pp. 610–34.

Limpus, CJ 1985, A study of the loggerhead turtle, Caretta caretta, in eastern Australia, PhD thesis, Zoology Department, University of Queensland, Brisbane.

Limpus, CJ 2008, A biological review of Australian marine turtles. 1. Loggerhead turtle Caretta caretta (Linneaus), Queensland Environment Protection Agency, Brisbane, viewed 1 July 2011, **<www.derm.qld.gov.au/register/p02785aa.pdf>**.

Limpus, CJ, Couper, PJ & Read, MA 1994, 'The loggerhead turtle, Caretta caretta, in Queensland: population structure in a warm temperate feeding area', Memoirs of the Queensland Museum, vol. 37, pp. 195–204.

Limpus, CJ, Fleay, AF & Guinea, M 1984, 'Sea turtles of the Capricorna Section, Great Barrier Reef', in *The Capricornia Section of the Great Barrier Reef: past, present and future*, WT Ward & P Saenger (eds), Royal Society of Queensland and Australian Coral Reef Society, Brisbane, pp. 61–78.

Limpus, CJ & Limpus, DJ 2000, 'Mangroves in the diet of *Chelonia mydas* in Queensland, Australia', *Marine Turtle Newsletter*, vol. 89, pp. 13–5.

Limpus, CJ, Limpus, DJ, Arthur, KE & Parmenter, CJ 2005, *Monitoring green turtle population dynamics in Shoalwater Bay: 2000–2004*, research publication no. 83, report prepared for the Queensland Environmental Protection Agency, Brisbane, and the Great Barrier Reef Marine Park Authority, Townsville, Queensland.

McCauley, S & Bjorndal, K 1999, 'Conservation implications of dietary dilution from debris ingestion: sub lethal effects in post-hatchling loggerhead sea turtles', *Conservation Biology*, vol. 13, no. 4, pp. 925–9.

Musick, J & Limpus, C 1997, 'Habitat utilization and migration in juvenile sea turtles', in PL Lutz & JA Musick (eds), *The biology of sea turtles*, CRC Press, Boca Raton, Florida, pp. 137–63.

Pendoley, K & Fitzpatrick, J 1999, 'Browsing of mangroves by green turtles in Western Australia', *MarineTurtle Newsletter*, vol. 84, p. 10.

Poiner, I & Harris, A 1996, 'Incidental capture, direct mortality and delayed mortality of sea turtles in Australia's Northern Prawn Fishery', *Marine Biology*, vol. 125, pp. 813–25.

Preen, A 1996, 'Infaunal mining: a novel foraging method of loggerhead turtles', *Journal of Herpetology*, vol. 30, no. 1, pp. 94–6.

Robins, CM, Bache, SJ & Kalish, SR 2002, *Bycatch of sea turtles in pelagic longli sheries: Australia*, Fisheries Research and Development Corporation, Canberra.

Walker, T 1994, 'Post-hatchling dispersal of sea turtles', in R James (comp.), *Proceedings of the Marine Turtle Conservation Workshop*, Seaworld Nara Resort, Gold Coast, 14–17 November 1990, Australian National Parks Service, Canberra.

Whiting, SD, Guinea, M & Pike, GD 2000, 'Sea turtles nesting in the Australian territory of Ashmore and Cartier islands, eastern Indian Ocean', in N Pilcher & G Ismail (eds), *Sea turtles of the Indo-Paci c: research management and conservation*, ASEAN Academic Press, London, pp. 86–93.

Schedule 2.4
Seabirds of the Temperate East Marine Region

Twenty species of seabird listed as threatened and/or migratory are known to have biologically important areas in the Temperate East Marine Region (Table S2.6), and a further 21 species may occur infrequently in the region.[21] Seabirds listed as threatened and/or migratory are matters of national environmental significance and protected under the EPBC Act. Regional advice for some seabird species in the region that are not listed as threatened or migratory is included in Schedule 2.1.

Table S2.6: Seabird species listed as threatened and/or migratory with biologically important areas in and adjacent to the Temperate East Marine Region

Species	Listing status	Breeding season and habits
Terns and noddies		
Common noddy *(Anous stolidus)*	Migratory, marine	Breeds in the region from October to January (Lord Howe and Norfolk Island groups)
Shearwaters		
Flesh-footed shearwater *(Ardenna carneipes)*	Migratory, marine	Breeds in the region from August to May Forages in the region from September to November and January to February
Short-tailed shearwater *(Ardenna tenuirostris)*	Migratory, marine	Breeds in the region from November to April
Sooty shearwater *(Ardenna grisea)*	Migratory, marine	Breeds in the region from September to April
Wedge-tailed shearwater *(Ardenna pacifica)*	Migratory, marine	Breeds in the region from November to April (Coral Sea, Great Barrier Reef, Montague Island, Muttonbird Island, Broughton Island) Breeds in the region from September to April (Lord Howe Island group) Breeds in the region from October to May (Norfolk Island group)

21 All birds that occur naturally in the region (including the airspace) are protected under the EPBC Act as listed marine species. Seabirds are those birds that rely on and have an ecological association with the marine environment. Not all the birds that occur in the Temperate East Marine Region are seabirds (a complete list of all the birds known to occur in the region is provided in the report card on seabirds).

Species	Listing status	Breeding season and habits
Petrels and storm-petrels		
Gould's petrel *(Pterodroma leucoptera)*	Endangered, migratory	Breeds in the region from August to May
Southern giant-petrel *(Macronectes giganteus)*	Endangered, migratory, marine	Forages in the region from June to October
Northern giant-petrel *(Macronectes halli)*	Vulnerable, migratory, marine	Forages in the region from June to October
Kermadec petrel *(Pterodroma neglecta)*	Vulnerable, marine	Breeds in the region from November to June
White-bellied storm-petrel *(Fregetta grallaria)*	Vulnerable, marine	Breeds in the region from February to May
Black petrel *(Procellaria parkinsoni)*	Migratory, marine	Forages in the region year-round
Providence petrel *(Pterodroma solandri)*	Migratory, marine	Breeds in the region from March to November
Wilson's storm-petrel *(Oceanites oceanicus)*	Migratory, marine	Migrates through the region North migration from April to June South migration from September to November
Albatrosses		
Antipodean albatross *(Diomedea antipodensis)*	Vulnerable, migratory, marine	Forages in the region year-round
Black-browed albatross *(Thalassarche melanophris)*	Vulnerable, migratory, marine	Forages in the region from May to November
Campbell albatross *(Thalassarche impavida)*	Vulnerable, migratory, marine	Forages in the region from June to August
Indian yellow-nosed albatross *(Thalassarche carteri)*	Vulnerable, migratory, marine	Forages in the region from May to November
Wandering albatross *(Diomedea exulans)*	Vulnerable, migratory, marine	Forages in the region from July to November

Species	Listing status	Breeding season and habits
White-capped albatross *(Thalassarche steadi)*	Vulnerable, migratory, marine	Forages in the region May to November
Boobies		
Masked booby *(Sula dactylatra)*	Migratory, marine	Breeds in the region year-round

The Temperate East Marine Region supports diverse seabird species, with areas such as the Lord Howe and Norfolk Island groups recognised both nationally and internationally as signi cant breeding sites (Dutson et al. 2009). The East Australian Current and the Tasman Front drive biological productivity, which offers key foraging opportunities for both resident and migratory species (DEWHA 2009).

The following advice relates only to those species listed in Table S2.6 which have known biologically important areas in the region. There is limited information on those species that may infrequently occur in the region. Please refer to the conservation values report card—seabirds for a complete list of seabirds and additional information (**www.environment.gov.au/marineplans/temperate-east**).

No speci c advice is provided for birds tha y over but do not breed or feed within the Commonwealth marine area of the Temperate East Marine Region. A complete list of birds that are known to over y the Temperate East Marine Region is provided in the conservation values report card—seabirds and migratory shorebirds.

Most actions would have low risk of signi cant impact on those birds listed as threatened and/or migratory which onl y over the region.

Key considerations in relation to significant impacts on 20 species of seabird in the Temperate East Marine Region

Population status and ecological significance

The **common noddy** is listed as migratory and marine. The species breeds on Lord Howe and Norfolk Islands, as well as beyond the region (e.g. Great Barrier Reef and Coral Sea) (Higgins & Davies 1996). There are estimated to be 2000 breeding pairs on islands adjacent to the Temperate East Marine Region (Higgins & Davies 1996).

The **flesh-footed shearwater** is listed as migratory and marine. The species breeds on Lord Howe Island and, in 2002–2003, there were an estimated 17 462 breeding pairs on the island (DSEWPaC 2011c). The species forages in the Tasman Sea, extending west from Lord Howe Island to waters in south-eastern Queensland (McKean & Hindwood 1965) and south-eastern Tasmania (Marchant & Higgins 1990).

The **short-tailed shearwater** is listed as migratory and marine. The species breeds on islands off the New South Wales coast, including Montague, Tollgate, Lion, Cabbage, Broughton, Little Broughton, Muttonbird, Boondelbah, Martin, Big, Bowen, Brush and Grasshopper islands. This species migrates to the northern hemisphere during the austral winter (Marchant & Higgins 1990). The global population of short-tailed shearwater is estimated to be 23 million individuals (Birdlife International 2011c).

The **sooty shearwater** is listed as migratory and marine. The species breeds on islands off the New South Wales Coast, including Montague, Tollgate, Lion, Cabbage, Broughton, Little Broughton, Muttonbird, Boondelbah, Martin, Big, Bowen, Brush and Grasshopper islands (Marchant & Higgins 1990). There were estimated to be 250 breeding pairs in New South Wales in 1979 (Lane & White 1983). This species migrates to the northern Pacific Ocean during the non-breeding (austral winter) season (BirdLife International 2011d; Brooke 2004).

The **wedge-tailed shearwater** is listed as migratory and marine. The species breeds on islands in the Lord Howe Island group, Norfolk Island group, off the New South Wales and Queensland coasts, and beyond the region (e.g. the Coral Sea) (Marchant & Higgins 1990). There is no information on breeding populations in the region.

The **black petrel** is listed as migratory and marine. The species breeds in New Zealand and there are estimated to be 1750 breeding pairs. The species forages in the Tasman Sea (ACAP 2009e).

Gould's petrel is listed as endangered and migratory. The species breeds at four locations in New South Wales: Cabbage Tree Island (1000 breeding pairs), Boodelbah Island (35 breeding pairs), Broughton Island and Little Broughton Island (Garnett, Szabo & Dutson 2011; DSEWPaC 2011a). The Australian birds are considered to be an endemic subspecies, *Pterodroma leucoptera leucoptera* (Garnett, Szabo & Dutson 2011). The species disperses throughout the Tasman Sea and eastern Paci c Ocean (BirdLife International 2011a).

The **Kermadec petrel** is listed as vulnerable and marine. The species breeds on Balls Pyramid and Phillip Island and there are estimated to be 40 breeding birds on these islands (Garnett & Crowley 2000). The species forages in the Tasman Sea.

The **providence petrel** is listed as migratory and marine. The species breeds on Lord Howe Island (32 000 breeding pairs) and Phillip Island (20 individuals). The species forages in the western Tasman Sea (Birdlife International 2011b).

The **white-bellied storm-petrel** is listed as vulnerable and marine. The species breeds on Roach Island (around 1000 breeding pairs), Ball's Pyramid, Muttonbird Island and possibly Blackburn Island in the Lord Howe Island group (Garnett, Szabo & Dutson 2011; DSEWPaC 2011b). The Australian birds are considered to be a subspecies, *Fregetta grallaria grallaria* (Garnett, Szabo & Dutson 2011). The species is highly pelagic, foraging in the Tasman and Coral Seas, and rarely approaches land except near breeding colonies (Garnett, Szabo & Dutson 2011; Marchant & Higgins 1990).

Wilson's storm-petrel is listed as migratory and marine. The species breeds in Australian territory (Macquarie Island, Heard Island) and there are estimated to be 10 000 breeding birds on Australia's subantarctic islands (Garnett & Crowley 2000). The species migration path appears to follow the edge of the continental shelf until approximately the New South Wales–Queensland border and then turns eastwards (Marchant & Higgins 1990).

The **northern giant-petrel** is listed as vulnerable, migratory and marine. The species breeds in Australian territory (Macquarie Island) and there are estimated to be 1793 breeding pairs on Macquarie Island (ACAP 2010c). The species forages in the Tasman Sea.

The **southern giant-petrel** is listed as endangered, migratory and marine. The species breeds in Australian territory (Heard Island and McDonald Island, Macquarie Island) and there are estimated to be 5625 breeding pairs on Australia's subantarctic islands (ACAP 2010b). The species forages in the Tasman Sea.

The **antipodean albatross** is listed as vulnerable, migratory and marine. The species breeds in New Zealand and there are estimated to be 11 557 breeding pairs. The antipodean albatross forages in the Tasman Sea (ACAP 2009a).

The **black-browed albatross** is listed as vulnerable, migratory and marine. The species breeds in Australian territory (Heard Island and McDonald Island, Macquarie Island) and there are estimated to be 787 breeding pairs on Australia's subantarctic islands (ACAP 2010a). The black-browed albatross forages over the New South Wales shelf and generally not north of the New South Wales–Queensland border.

The **Campbell albatross** is listed as vulnerable, migratory and marine. The species breeds in New Zealand and there are estimated to be 21 000 breeding pairs. During winter, adults can be found widely dispersed in the Tasman Sea (ACAP 2009b).

The **Indian yellow-nosed albatross** is listed as vulnerable, migratory and marine. The species breeds in France, South Africa and New Zealand (a single pair has been recorded on Chatham Island), and there are estimated to be 36 500 breeding pairs globally. The species forages in the Tasman Sea (ACAP 2009c).

The **wandering albatross** is listed as vulnerable, migratory and marine. The species breeds in Australian territory (Macquarie Island) and there are estimated to be 5–10 breeding pairs on Macquarie Island (ACAP 2009d). The wandering albatross forages in the Tasman Sea.

The **white-capped albatross** is listed as vulnerable, migratory and marine. The species breeds in New Zealand and there are estimated to be 97 111 breeding pairs. The species forages in the Tasman Sea (ACAP 2011).

The **masked booby** is listed as migratory and marine. The species breeds on islands in the Lord Howe Island and Norfolk Island groups, as well as beyond the region (e.g. Great Barrier Reef and Coral Sea) (Marchant & Higgins 1990). There are estimated to be 400 breeding pairs on islands adjacent to the Temperate East Marine Region (Marchant & Higgins 1990).

As a group, seabirds consume large amounts of marine resources and therefore play an important functional role in marine ecosystems. Examples of their role include nutrient transfer from pelagic and offshore regions to islands, reefs and coasts, dispersal of seeds and movement of organic matter through the soil layers, particularly by burrow-nesting species (Congdon et al. 2007).

For the purpose of determining the signi cance of impacts of proposed actions on the 20 species[22] listed above, note that:

- Gould's petrel and the southern giant-petrel are listed as endangered under the EPBC Act. It is known that populations of these species occur in and adjacent to the region.

The following species are listed as vulnerable under the EPBC Act: Kermadec petrel, white-bellied storm-petrel, northern giant-petrel, Antipodean albatross, black-browed albatross, Campbell albatross, Indian yellow-nosed albatross, wandering albatross and white-capped albatross. It should be assumed that populations of these species in and adjacent to the Temperate East Marine Region are important populations of the species.

The following species are listed as migratory under the EPBC Act: common noddy esh-footed shearwater, short-tailed shearwater, sooty shearwater, wedge-tailed shearwater, black petrel, providence petrel, Wilson's storm-petrel and masked booby. It should be assumed that important habitat for these species occurs in the Temperate East Marine Region.

Species distribution and biologically important areas

The 20 species listed in Table S2.6 are known to either breed and/or forage in the region. In general, the albatross and petrel species only forage, feeding in offshore waters, mainly along the edge of the continental shelf. The shearwaters, boobies, terns, noddies and some smaller petrels breed on islands in and adjacent to the region, including islands in the Great Barrier Reef, Lord Howe and Norfolk Island groups and smaller islands off New South Wales.

22 De nitions of 'important population' and 'ecologically signi cant population' are provided in Section 1 of this schedule and are consistent with EPBC Act Policy Statement 1.1: Signi cant Impact Guidelines—Matters of National Environmental Signi cance. In accordance with Policy Statement 1.1, for threatened species listed as vulnerable, such as the antipodean albatross, consideration should be given to whether an important population occurs in the area where the action is proposed; for listed migratory species, consideration should be given to whether an ecologically signi cant proportion of a population may be impacted.

Biologically important areas have been identi ed for all 20 species and include:

- breeding areas (encompasses breeding sites and areas where the species is likely to forage to provision young)
- foraging areas
- migration pathways.

Further information on these areas is found in the Temperate East Conservation Values Atlas (**www.environment.gov.au/cva**).

Nature of the proposed action

The conservation values report card—seabirds provides an overview of the vulnerabilities and pressures on protected seabirds in the Temperate East Marine Region. Anthropogenic activities in coastal environments and offshore have the potential to signi cantly impact on seabirds.

Disturbance of colonies by invasive species, particularly during the breeding season, can reduce breeding success or cause direct mortality. **All seabird species** that breed in the region (see Table S2.6) are vulnerable to pest species, such as rats, rabbits and ants (e.g. Argentine ant, African big-headed ant).

Pressures *of potential concern* on **all seabird species** in the region include:

- climate change (changes in sea temperature and oceanography, ocean acidi cation)
- oil and chemical pollution/contaminants associated with shipping
- marine debris from a range of sources
- human presence at sensitive sites (e.g. breeding colonies).

Pressures *of potential concern* on speci c species occurring in the region include:

- light pollution associated with land-based activities (shearwater and petrel species)
- bycatch from commercia   shing activities (foraging seabirds, particularly the larger species, such as the   esh-footed shearwater, short-tailed shearwater, sooty shearwater, wedge-tailed shearwater, black petrel, northern giant-petrel, southern giant-petrel, Antipodean albatross, black-browed albatross, Campbell albatross, Indian yellow-nosed albatross, wandering albatross and white-capped albatross)
- bycatch associated with recreational and charte   shing (esh-footed shearwater)

People planning to undertake actions in biologically important areas for seabirds used for breeding, during breeding season, should carefully consider the potential for their actions to have a signi cant impact on the species. The risk of actions proposed outside 'breeding area' biologically important areas to have a signi cant impact on the species is likely to be signi cantly lower. For biologically important areas used for foraging, the potential for signi cant impact is not as high however actions undertaken within these areas during times when the species are present do carry a higher risk than actions undertaken outside these areas.

In addition to this general advice, actions with a real chance or possibility of resulting in the establishment of harmful invasive species into the biologically important areas of Gould's petrel (e.g. tourism development) have a **very high risk** of a signi cant impact on that species.

Actions with a real chance or possibility of resulting in the establishment of harmful invasive species in biologically important areas for all other seabird species in the region have a **high risk** of a signi cant impact on those species (e.g. tourism development).

The following actions have a **high risk** of a signi cant impact on all seabird species in the region:

- actions with a real chance or possibility of introducing a new source from which chemical contamination has a reasonable potential of arising in biologically important areas (e.g. construction of ports or expansion in port facilities leading to greater shipping traf c)
- actions with a real chance or possibility of increasing disturbances at breeding colonies (e.g. tourism, research), potentially disrupting the breeding cycle of an important population (of a threatened species) or ecologically signi cant proportion of the population (such as a non-breeding aggregation of a migratory species).

The following actions have a **high risk** of a signi cant impact on shearwaters (esh-footed shearwater, short-tailed shearwater, sooty shearwater, wedge-tailed shearwater) and petrels (black petrel, Gould's petrel, Kermadec petrel, providence petrel, white-bellied storm-petrel, Wilson's storm-petrel, northern giant-petrel and southern giant-petrel):

- actions with a real chance or possibility of increasing lighting from land-based activities (e.g. construction of ports or expansion in port facilities; lighthouses and buildings at or around breeding colonies).

Actions that have a real chance or possibility of introducing marine debris within biologically important areas of the 20 species of seabirds have a **risk** of signi cant impact on these species.

Actions that introduce a new source from which a severe oil spill has a reasonable potential of arising in biologically important areas have a **risk** of signi cant impact on all seabird species (e.g. increased shipping).

Advice for preparing a referral with respect to impacts on 20 species of seabirds of national environmental significance in the Temperate East Marine Region

A referral of proposed action form is available electronically at **www.environment.gov.au/epbc/index.html** and can also be obtained in hard copy by telephoning 1800 803 772. It includes detailed instructions about the type of information that is required in referring a proposed action for consideration.

In addition to the instructions included in the referral of proposed action form, if an action is referred because of the risk of significant impact on any of the 20 species of seabird discussed in this schedule, consideration of the following matters is recommended:

- If the action is proposed within a biologically important area classified as a breeding area (including breeding colonies and/or foraging areas that are likely to incorporate chick provisioning), information about alternative locations for the proposed action that would be outside the area and/or why the action is unlikely to have a significant impact or why any significant impact can be reduced to a level that is acceptable should be considered.
- Referrals should include information on how it is proposed that the likelihood of any significant impacts will be mitigated, considering the advice provided above on likely significant impacts to any seabirds. It is recommended that independent scientific assessments of any intended mitigation measures be sought before submitting a referral and that any such assessment is included in the referral.
- Referrals should be supported by scientifically credible information that places the proposal in the context of the advice on existing pressures on seabirds and the particular life history characteristics of the species. The conservation values report card—seabirds provides information on the current understanding of the range of pressures on seabirds addressed in this regional advice.

References

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2009a, *ACAP species assessment: antipodean albatross Diomedea antipodensis*, ACAP, Hobart, viewed 18 September 2010, **<www.acap.aq>.**

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2009b, *ACAP species assessment: Campbell albatross* Thalassarche impavida, ACAP, Hobart, viewed 26 August 2010, **<www.acap.aq>**.

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2009c, *ACAP species assessments: Indian yellow-nosed albatross* Thalassarche carteri, ACAP, Hobart, viewed 27 August 2010, **<www.acap.aq>**.

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2009d, *ACAP species assessment: wandering albatross* Diomedea exulans, ACAP, Hobart, viewed 10 September 2010, **<www.acap.aq>**.

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2009e, ACAP species assessment: black petrel Procellaria parkinsoni, ACAP, Hobart, viewed 20 August 2010, **<www.acap.aq>**.

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2010a, *ACAP species assessment: black-browed albatross* Thalassarche melanophris, ACAP, Hobart, viewed 11 October 2010, **<www.acap.aq>**.

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2010b, *ACAP species assessment: southern giant petrel* Macronectes giganteus, ACAP, Hobart, viewed 20 October 2010, **<www.acap.aq>**.

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2010c, *ACAP species assessment: northern giant petrel* Macronectes halli, ACAP, Hobart, viewed 13 October 2010, **<www.acap.aq>**.

ACAP (Agreement on the Conservation of Albatrosses and Petrels) 2011, *ACAP species assessment: white-capped albatross* Thalassarche steadi, ACAP, Hobart, viewed 1 February 2011, **<www.acap.aq>**.

Birdlife International 2011a, *Species factsheet*: pterodroma leucoptera, Birdlife International, Cambridge, UK, viewed 4 July 2011, **<www.birdlife.org/datazone/speciesfactsheet.php?id=3887>**.

Birdlife International 2011b, *Species factsheet*: pterodroma solandri, Birdlife International, Cambridge, UK, viewed 27 May 2011, **<www.birdlife.org/datazone/speciesfactsheet.php?id=3902>**.

Birdlife International 2011c, *Species factsheet*: puf nus tenuirostris, Birdlife International, Cambridge, UK, viewed 27 May, **<www.birdlife.org/datazone/speciesfactsheet.php?id=3934>**.

Birdlife International 2011d, *Species factsheet*: puf nus griseus, Birdlife International, Cambridge, UK, viewed 4 July 2011, **<www.birdlife.org/datazone/speciesfactsheet.php?id=3933>**.

Brooke, M 2004, *Albatrosses and petrels across the world*, Oxford University Press, Oxford.

Congdon, BC, Erwin, CA, Peck, DR, Baker, GB, Double, MC & O'Neill, P 2007, 'Vulnerability of seabirds on the Great Barrier Reef to climate change', in JE Johnson & PA Marshall (eds), *Climate change and the Great Barrier Reef*, Great Barrier Reef Marine Park Authority, Townsville, and Australian Greenhouse Of ce, Canberra, pp. 427–63.

DEWHA (Department of the Environment, Water, Heritage and the Arts) 2009, *The East Marine Bioregional Plan: Bioregional Pro le*, DEWHA, Canberra.

DSEWPaC (Australian Government Department of Sustainability, Environment, Water, Population and Communities) 2011a, '*Pterodroma leucoptera leucoptera*', in *Species pro le and threats database*, DSEWPaC, Canberra, viewed 27 May 2010, **<www.environment.gov.au/sprat>**.

DSEWPaC (Australian Government Department of Sustainability, Environment, Water, Population and Communities) 2011b, '*Fregetta grallaria grallaria*', in *Species pro le and threats database*, DSEWPaC, Canberra, viewed 27 May 2010, **<www.environment.gov.au/sprat>**.

DSEWPaC (Australian Government Department of Sustainability, Environment, Water, Population and Communities) 2011c, '*Ardenna carneipes*', in *Species pro le and threats database*, DSEWPaC, Canberra, viewed 27 May 2010 **<www.environment.gov.au/sprat>**.

Dutson, G, Garnett, S & Gole, C 2009, *Australia's important bird areas: key sites for bird conservation*, Birds Australia conservation statement no. 15, October 2009.

Garnett, ST & Crowley, GM 2000, *The action plan for Australian birds*, Environment Australia, Canberra.

Garnett, ST, Szabo, J & Dutson, G 2011, *The action plan for Australian birds 2010*, CSIRO Publishing, Collingwood.

Higgins, P & Davies, S (eds) 1996, *Handbook of Australian, New Zealand and Antarctic birds: volume 3—snipe to pigeons*, Oxford University Press, Melbourne.

Lane, SG & White, G 1983, 'Nesting of the sooty shearwater in Australia', *Emu*, vol. 83 no. 2, pp. 117–8.

Marchant, S & Higgins, PJ (eds) 1990, *Handbook of Australian, New Zealand and Antarctic birds: volume 1—ratites to ducks*, Oxford University Press, Melbourne.

McKean, JL & Hindwood, KA 1965, 'Additional notes on the birds of Lord Howe Island', *Emu*, vol. 64, pp. 79–97.

Schedule 2.5
Sharks of the Temperate East Marine Region

Six species of shark listed under the EPBC Act are known to occur in the Temperate East Marine Region. In addition to these listed species, two sharks occurring in the region have been nominated for listing under the EPBC Act, Harrison's dogfish and the southern dogfish.

Important breeding, feeding and aggregation areas for sharks are found throughout and adjacent to the Temperate East Marine Region. Grey nurse sharks are found on the continental shelf, occasionally venturing off the shelf to aggregate around inshore rocky reefs, islands or in rocky caves. Pelagic species such as the white, whale, mako (shortfin and longfin) and porbeagle sharks are wide ranging and diverse in their ecological niches. In general, sharks in the region predominantly feed on bony fishes and cephalopods, although some species feed on other sharks, rays, crustaceans, birds and marine mammals. Whale sharks are plankton feeders.

The following advice relates only to the grey nurse shark and the white shark for which biologically important area information is available (Table S2.7). Please refer to the conservation values report card—sharks for a complete list of sharks and additional information (**www.environment.gov.au/marineplans/temperate-east**).

Table S2.7: Sharks listed as threatened and/or migratory with biologically important areas identified within the Temperate East Marine Region

Species	Listing status
Grey nurse shark [east coast population] (*Carcharias taurus*)	Critically endangered
White shark (*Carcharodon carcharias*)	Vulnerable, migratory

Key considerations in relation to significant impacts on sharks species in the Temperate East Marine Region

Population status and ecological significance

The **grey nurse shark** is listed as two separate populations under the EPBC Act. The west coast population is listed as vulnerable, while the east coast population is listed as critically endangered. The east coast population is estimated at 1365 individuals, with 95 per cent confidence that the population is between 1146 and 1662 individuals (Cardno Ecology Lab 2010).

The **white shark** is listed as vulnerable and migratory under the EPBC Act. There are currently no estimates of the white shark population in Australian waters and no reliable measures with which to compare changes in population status over time. This is partly due to the scarcity of white sharks, but also the dif culty in distinguishing population changes from the high rates of variability in numbers observed in any one site or region between years (Bruce 2008).

Top-order predators—such as grey nurse and white sharks—are a key functional species group, in uencing abundance, recruitment, species composition, diversity and behaviour of prey species. Their removal can have a cascading effect on all components of a food web (Baum & Worm 2009; Heithaus 2001; Ings et al. 2009, cited in Ceccarelli & Ayling 2010).

For the purposes of determining the signi cance of impacts of proposed actions on the two species[23] listed above, note that:

- the grey nurse shark (east coast population) is critically endangered under the EPBC Act. It is known that populations of this species occur in and adjacent to the Temperate East Marine Region
- the white shark is listed as vulnerable under the EPBC Act. It should be assumed that populations of this species in and adjacent to the Temperate East Marine Region are important populations of the species.

23 De nitions of 'important population' and 'ecologically signi cant population' are provided in Section 1 of this schedule and are consistent with EPBC Act Policy Statement 1.1: Signi cant Impact Guidelines—Matters of National Environmental Signi cance. In accordance with Policy Statement 1.1, for threatened species listed as vulnerable, such as the antipodean albatross, consideration should be given to whether an important population occurs in the area where the action is proposed; for listed migratory species, consideration should be given to whether an ecologically signi cant proportion of a population may be impacted.

Species distribution and biologically important areas

The **grey nurse shark** has a broad distribution within Australian waters, from subtropical to cool temperate waters. The east coast population, estimated at 1146–1662 individuals (Cardno Ecology Lab 2010) is found between the Capricornia coast of central Queensland and Narooma in southern New South Wales, although records from locations further north and south also exist. The species is found primarily in subtropical to cool temperate inshore waters around rocky reefs and islands, and is occasionally found in the surf zone and shallow bays. Grey nurse sharks have been recorded at varying depths to 230 metres, but are most commonly found at depths of 15–40 metres (Otway & Parker 2000). Critical habitats and key aggregation sites are adjacent to the region in New South Wales and southern Queensland state waters and there are also several sites in Commonwealth waters at the Cod Grounds and Solitary Islands. These regular aggregation sites may play an important role in pupping or mating activities.

Biologically important areas have been identi ed for the **grey nurse shark** in the Temperate East Marine Region and include:

- foraging areas
- aggregation areas
- seasonal breeding areas (mating or pupping).

Further information on these areas is found in the Temperate East Conservation Values Atlas (**www.environment.gov.au/cva**).

The **white shark** is widely distributed throughout temperate and subtropical regions and most frequently observed in inshore cool to warm temperate continental waters. Off eastern Australia, white sharks regularly range from central–southern Queensland southwards (Bruce et al. 2006; Last & Stevens 2009), from inshore rocky reefs, surf beaches and shallow coastal bays, to outer continental shelf and slope areas. They also make open ocean excursions and can cross ocean basins. Both adults and juveniles have been recorded diving to depths of 1000 metres, but most white shark movements and activities in Australian waters occur between the coast and the 100-metre depth contour (Bruce & Bradford 2008; Bruce et al. 2006). White sharks are often found in regions with high prey density and in sites where prey species aggregate. They do not live in one speci c area or territory, but travel great distances between sites of temporary residency. There is also mounting evidence that they have common migratory routes between some areas of temporary residency in Australian waters (Bruce & Bradford 2008; Bruce et al. 2006). White shark movement data suggest a northerly movement along the east coast during autumn and winter, and a return to southern Australia by early summer (Bruce et al. 2006).

Biologically important areas have been identi ed for the **white shark** in the Temperate East Marine Region and include:

- a juvenile aggregation area off Port Stephens between September and mid-January (extending from the shoreline to the 120-metre depth contour and approximately 10–15 kilometres offshore) (Bruce & Bradford 2008)
- the distribution generally between the 120 and 1000-metre depth contours during autumn, winter and spring.

The location of pupping grounds is not known (Bruce 2008). Further information on these areas is found in the Temperate East Conservation Values Atlas (**www.environment.gov.au/cva**).

Actions undertaken offshore of the continental shelf and not affecting waters over the continental shelf in the Temperate East Marine Region have a **low risk** of signi cant impact on the grey nurse shark and white shark.

Nature of the proposed action

The conservation values report card—sharks provides an overview of the vulnerabilities and pressures on protected sharks in the Temperate East Marine Region.

Like most sharks, **grey nurse and white sharks** are characterised by a life history (late age at maturity, slow growth rate, low fecundity, longevity, low rate of natural mortality), which restricts productivity. They therefore have a limited capacity to withstand human-induced pressures and to recover from population depletion as a result of these pressures.

As coastal environments appear to be a preferred habitat for the grey nurse and white sharks, both species could be adversely affected by anthropogenic activities in these habitats, particularly by types of actions that have the potential to result in habitat degradation.

Pressures *of concern* for the grey nurse shark include bycatch from commercial, recreational and charte shing activities. Pressures *of potential concern* include human presence at sensitive sites and changes in sea temperature and oceanography associated with climate change.

Pressures *of concern* for the white shark include bycatch from recreational and charter shing activities. Pressures *of potential concern* include bycatch associated with commercial shing activities and illegal, unregulated and unreporte shing, extraction of living resources associated with non-domestic commercia sheries and climate change (changes in sea temperature and oceanography).

People planning to undertake actions in biologically important areas for grey nurse and white sharks should carefully consider the potential for their action to have a signi cant impact on these species. For actions proposed outside biologically important areas the risk of signi cant impact on these species is likely to be lower.

Actions which have a real chance or possibility of increasing human disturbance in biologically important areas of the grey nurse shark and have a **high risk** of signi cant impact on this species.

Advice for preparing a referral with respect to impacts on grey nurse and white sharks in the Temperate East Marine Region

A referral of proposed action form is available electronically at **www.environment.gov.au/epbc/index.html** and can also be obtained in hard copy by telephoning 1800 803 772. It includes detailed instructions about the type of information required in referring a proposed action for consideration.

In addition to the instructions included in the referral of proposed action form, if an action is referred because of the risk of signi cant impact on either of the two species of shark considered here, consideration of the following matters is recommended:

- If the action is proposed within a biologically important area classi ed as a breeding area (including mating, pupping and aggregation areas), information about alternative locations for the proposed action that would be outside the area and/or why the action is unlikely to have a signi cant impact or why any signi cant impact can be reduced to a level that is acceptable should be considered.
- Referrals should include information on how it is proposed that the likelihood of any signi cant impacts will be mitigated, considering the advice provided above on likely signi cant impacts to sharks. It is recommended that independent scienti c assessments of any intended mitigation measures be sought before submitting a referral and that any such assessment is included in the referral.
- Referrals should be supported by scienti cally credible information that places the proposal in the context of the advice on existing pressures on sharks and the particular life history characteristics of the species. The conservation values report card—sharks provides information on the current understanding of the range of pressures on sharks addressed in this regional advice.

References

Baum, JK & Worm, B 2009, 'Cascading top-down effects of changing oceanic predator abundances', *Journal of Animal Ecology*, vol. 78, no. 4, pp. 699–714.

Bruce, BD 2008, 'The biology and ecology of the white shark (Carcharodon carcharias)', in M Camhi & EK Pikitch (eds), *Sharks of the open ocean*, Blackwell Scienti c, Oxford, pp. 69–81.

Bruce, BD & Bradford, RW 2008, *Spatial dynamics and habitat preferences of juvenile white sharks: identifying critical habitat and options for monitoring recruitment* nal report to the Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

Bruce, BD, Stevens, JD & Malcolm, H 2006, 'Movements and swimming behaviour of white sharks *(Carcharodon carcharias)* in Australian waters', *Marine Biology*, vol. 150, pp. 161–72.

Cardno Ecology Lab 2010, *Development and implementation of a population estimation protocol to provide an estimate of east coast population numbers for grey nurse sharks* (Carcharias taurus), report for the Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Ceccarelli, D & Ayling, T 2010, *Role, importance and vulnerability of top predators on the Great Barrier Reef: a review*, research publication no. 105 for the Great Barrier Reef Marine Park Authority, Townsville, Queensland.

Heithaus, MR 2001, 'Predator-prey and competitive interactions between sharks (order Selachii) and dolphins (suborder Odontoceti): a review', *Journal of Zoology*, vol. 253, pp. 53–68.

Ings TC, Montoya, JM, Bascompte, J, Bluethgen N, Brown, L, Dormann, CF, Edwards, F, Figueroa, D, Jacob, U, Jones, JI, Lauridsen, RB, Ledger, ME, Lewis, HM, Olesen, JM, van Veen, FJF, Warren, PH & Woodward, G 2009, 'Ecological networks: beyond food webs', *Journal of Animal Ecology*, vol. 78, pp. 253–69.

Last, PR & Stevens, JD 2009, *Sharks and rays of Australia*, 2nd edn, CSIRO Publishing, Collingwood.

Otway, NM & Parker, PC 2000, *The biology, ecology, distribution, abundance and identi cation of marine protected areas for the conservation of threatened grey nurse sharks in south east Australia waters*, NSW Fisheries Of ce of Conservation, Port Stephens.

Table A: Listed marine and cetacean species known to occur in the Temperate East Marine Region

Species (common/scienti c name)	Conservation status[24]
Bony hes	
Big-bellied or pot-bellied seahorse *(Hippocampus abdominalis)*	Marine
Bullneck seahorse *(Hippocampus minotaur)*	Marine
Duncker's pipehorse *(Solegnathus dunckeri)*	Marine
Hardwick's pipehorse *(Solegnathus hardwickii)*	Marine
Kellogg's seahorse *(Hippocampus kelloggi)*	Marine
Sad seahorse *(Hippocampus tristis)*	Marine
Weedy seadragon *(Phyllopteryx taeniolatus)*	Marine
Cetaceans	
Dolphins	
Bottlenose dolphin *(Tursiops truncatus)*	Cetacean
Common dolphin *(Delphinus delphis)*	Cetacean
Fraser's dolphin *(Lagenodelphis hosei)*	Cetacean
Indian Ocean bottlenose dolphin *(Tursiops aduncus)*	Cetacean
Pantropical spotted dolphin *(Stenella attenuate)*	Cetacean

Species (common/scientific name)	Conservation status[24]
Risso’s dolphin *(Grampus griseus)*	Cetacean
Rough-toothed dolphin *(Steno bredanensis)*	Cetacean
Southern right whale dolphin *(Lissodelphis peronii)*	Cetacean
Spinner dolphin *(Stenella longirostris)*	Cetacean
Striped dolphin *(Stenella coeruleoalba)*	Cetacean
Other cetaceans	
Andrew’s beaked whale *(Mesoplodon bowdoini)*	Cetacean
Arnoux’s beaked whale *(Berardius arnuxii)*	Cetacean
Blainville’s beaked whale *(Mesoplodon densirostris)*	Cetacean
Cuvier’s beaked whale *(Ziphius cavirostris)*	Cetacean
Dwarf minke whale *(Balaenoptera acutorostrata)*	Cetacean
Dwarf sperm whale *(Kogia simus)*	Cetacean
False killer whale *(Pseudorca crassidens)*	Cetacean
Ginkgo-toothed beaked whale *(Mesoplodon ginkgodens)*	Cetacean
Gray’s beaked whale, scamperdown whale *(Mesoplodon grayi)*	Cetacean

Species (common/scienti c name)	Conservation status[24]
Hector’s beaked whale *(Mesoplodon hectori)*	Cetacean
Long- nned pilot whale *(Globicephala melas)*	Cetacean
Melon-headed whale *(Peponocephala electra)*	Cetacean
Pygmy killer whale *(Feresa attenuate)*	Cetacean
Pygmy sperm whale *(Kogia breviceps)*	Cetacean
Shepherd’s beaked whale or Tasman beaked whale *(Tasmacetus shepherdi)*	Cetacean
Short- nned pilot whale *(Globicephala macrorhynchus)*	Cetacean
Southern bottlenose whale *(Hyperoodon planifrons)*	Cetacean
Strap-toothed beaked whale, strap-toothed whale, Layard’s beaked whale *(Mesoplodon layardii)*	Cetacean
True’s beaked whale *(Mesoplodon mirus)*	Cetacean
Marine Reptiles	
Sea snakes	
Beaked seasnake *(Enhydrina schistosa)*	Marine
Blue-lipped sea krait *(Laticauda laticaudata)*	Marine
Colubrine sea krait, banded sea krait or yellow-lipped sea krait *(Laticauda colubrine)*	Marine

Species (common/scienti c name)	Conservation status[24]
Dubois' seasnake *(Aipysurus duboisii)*	Marine
Elegant seasnake *(Hydrophis elegans)*	Marine
Horned seasnake *(Acalyptophis peronii)*	Marine
Laboute's seasnake *(Hydrophis laboutei)*	Marine
Littl le snake *(Acrochordus granulatus)*	Marine
Marbled or spine-tailed seasnake *(Aipysurus eydouxii)*	Marine
Olive-headed seasnake *(Hydrophis major)*	Marine
Olive seasnake *(Aipysurus laevis)*	Marine
Plain-banded seasnake *(Hydrophis vorisi)*	Marine
Small-headed seasnake *(Hydrophis macdowelli)*	Marine
Spectacled seasnake *(Hydrophis kingii)*	Marine
Spotted seasnake *(Hydrophis ornatus)*	Marine
Stokes' seasnake *(Astrotia stokesii)*	Marine
Turtle-headed seasnake *(Emydocephalus annulatus)*	Marine
White-bellied mangrove snake *(Fordonia leucobalia)*	Marine

Species (common/scientific name)	Conservation status[24]
Yellow seasnake *(Hydrophis spiralis)*	Marine
Yellow-bellied seasnake *(Pelamis platurus)*	Marine
Seabirds	
Terns and noddies	
White tern *(Gygis alba)*	Marine
Crested tern *(Thalasseus bergii)*	Marine
Sooty tern *(Onychoprion fuscata)*	Marine
Grey ternlet *(Procelsterna cerulea)*	Marine
Black noddy *(Anous minutus)*	Marine
Shearwaters	
Little shearwater *(Puffinus assimilis)*	Marine
Petrels and storm-petrels	
Black-winged petrel *(Pterodroma nigripennis)*	Marine
Great-winged petrel *(Pterodroma macroptera)*	Marine
White-faced storm-petrel *(Pelagodroma marina)*	Marine
White-necked petrel *(Pterodroma cervicalis)*	Marine

Species (common/scientific name)	Conservation status[24]
Penguins	
Little penguin *(Eudyptula minor)*	Marine
Tropicbirds	
Red-tailed tropicbird *(Phaethon rubricauda)*	Marine

24 Species listed as threatened and/or migratory under the EPBC Act are not listed in this table

MAP DATA SOURCES

DSEWPaC (2011): Australia, World Heritage Areas

DSEWPaC (2011): Key Ecological Features in the Temperate East Marine Planning Region

DSEWPaC (2011): Ramsar Wetlands of Australia

DSEWPaC (2010): Historic Shipwrecks Register

DSEWPaC (2010): Collaborative Australian Protected Areas Database (CAPAD)

DSEWPaC (2007): Commonwealth Marine Protected Areas Managed by DSEWPaC

DSEWPaC (2006): Integrated Marine and Coastal Regionalisation of Australia v4.0

DSEWPaC (2006): Commonwealth Marine Planning Regions

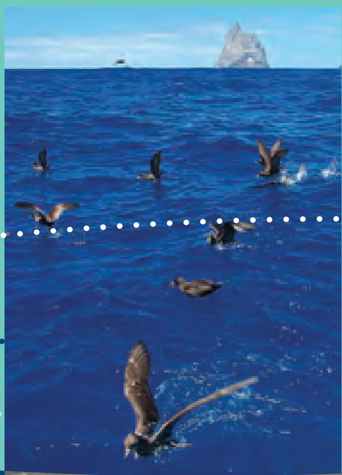
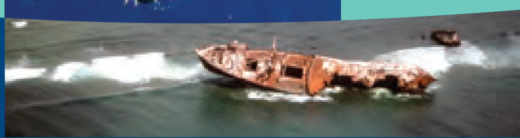
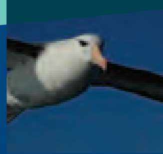
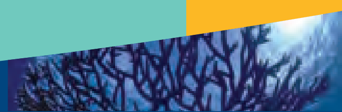
Geoscience Australia (2006): Australian Maritime Boundaries (AMB) v2.0

Geoscience Australia (2009): Australian Bathymetry and Topography

Geoscience Australia (2004): Gazetteer of Australia

Geoscience Australia (2003): Australia, TOPO-2.5M Topographic Data



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Attachment L

Summary of public submissions
All submissions provided on USB

173 individual submissions- opposed
1238 campaign submissions - opposed
8 individual submissions – support

From	**Support / Oppose**	**Key Issues**
Australian Marine Conservation Society	Oppose	▪ The values of the Moreton Bay Ramsar Wetland will be significantly negatively impacted ▪ Species protected by the EPBC Act will be negatively impacted by the duration of the activity and increased boat activity and pollution ▪ The development will impact a large number of feeding and roosting sites for migratory species protected under international agreements ▪ The proposal will impact a significant population of koalas ▪ The project will destroy seagrass habitats upon which EPBC listed species are dependent ▪ Ongoing light, noise and physical pollution impacts to the Ramsar wetland post construction ▪ The proposed action is not critical infrastructure as the housing and shopping developments can be built on less sensitive and already disturbed areas
Birdlife Australia	Oppose	▪ The project is expected to have clearly unacceptable impacts on Matters of National Environmental Significant protected under the EPBC Act ▪ The Australian Government's *Wildlife Conservation Plan for Migratory Shorebirds (2016)* identifies the need to protect migratory shorebird habitat across the flyway, including important habitat in Australia ▪ Conservation advice for the Eastern Curlew identifies Australia's obligation to maintain and improve protection of all feeding and roosting sites for the species, for which there is no evidence to suggest that habitat can be successfully recreated ▪ Australia is obligated to protect migratory shorebird habitat under several international agreements

From	Support / Oppose	Key Issues
Birds Queensland (Queensland Ornithological Society Inc)	Oppose	▪ The proposal does not support a key strategy in the Federal Department of Environment "Conservation Plan for Migratory Shorebirds" ▪ Australia should take its obligations under the Ramsar treaty seriously ▪ Any reclamation of the Moreton Bay Marine Park would be unacceptable under the EPBC Act
Brisbane Marketing (Brisbane City Council)	Support	▪ The development will enable the region to showcase natural assets
Brisbane Residents United	Oppose	▪ The proposal shows a lack of response to the known climate change impacts on this region ▪ Mangroves and wetlands protect shorelines and will be beneficial in the future against increased storm surges and sea invasion ▪ The development is outside of what was the agreed urban footprint ▪ The development will have negative impacts on three matters protected by the EPBC Act o A wetland of international significance o Listed Threatened Species o Migratory Species ▪ Australia has an international obligation to protect Ramsar-listed wetlands
s47F [redacted] – Global Flyway Network	Oppose	▪ The development is in a Ramsar site ▪ The development is in habitat for critically endangered fauna
Community Alliance for Responsible Planning (C.A.R.P)	Oppose	▪ The proposed project would adversely impact an area which uniquely combines the internationally significant wetlands, habitat for migratory shorebirds and a healthy koala population ▪ Dredging activity would destroy many hectares of seagrass beds and harm corals ▪ The proposed project will destroy feeding grounds for migratory shorebirds, including the Eastern Curlew (critically endangered)

From	Support / Oppose	Key Issues
		▪ All that is wanted and needed at Toondah Harbour is an upgrade of the harbour facilities
s47F [redacted] PhD Candidate | Centre for Biodiversity and Conservation Science School of Biological Sciences University of Queensland	Oppose	▪ The proposed development site contains wildlife species that of significant conservation concern ▪ The federal government has a responsibility to see the conservation of species listed under the Act ▪ Australia has an obligation to protect Ramsar Wetlands and species that rely on the area ▪ Australia is a party to the United Nation's Convention on Biological Diversity. The 20 Aichi Biodiversity Targets were adopted in 2010. o Australia must, by 2020, prevent the extinction of known threatened species and improve their conservation status o Australia must, by 2020, drastically reduce the loss of natural habitats and must reduce pollution. ▪ The approval of Toondah Harbour directly contravenes the targets and would set a dangerous precedent for other coastal development
s47F [redacted] State Council Wildlife Preservation Society of Queensland	Oppose	▪ The referral lacks a real understanding of the migratory wader birds that frequent the area, their roost sites and their feeding grounds ▪ There is great concern for how the fauna will be protected, including marine life
s47F [redacted] Adjunct Research Fellow Environmental Futures Research Institute Griffith University	Oppose	▪ Developments like Toondah Harbour with up to 10,000 people concentrated in a small area will have a large impact on the viability of ecosystems in the bay ▪ These types of over-developments chip away at the environment undermining its health and capacity to recover
East Asian-Australasian Flyway Partnership (EAAFP) Shorebird Working Group	Oppose	▪ The Moreton Bay Ramsar site is an internationally significant site for the Eastern Curlew ▪ The development footprint includes high quality feeding habitat for this species ▪ The Australian Government led the International Single Species Action Plan for the

From	Support / Oppose	Key Issues
		Conservation of Far Eastern Curlew with key priorities such as ensuring all important non-breeding habitat is protected and adequately managed ▪ The Australian Government should uphold its obligations under the plan, as well as other international agreements ▪ The development of this site would set a dangerous precedent to develop other Ramsar-listed wetlands
s47F – Former Redland Shire Councillor	Oppose	▪ The barge and ferry terminal need a makeover, not an enormous development as there is no need for thousands of apartments in Moreton Bay ▪ This proposal was deemed unsuitable for environmental impacts because of the acid sulphate soils
Friends of Stradbroke Island Association Inc.	Oppose	▪ The project should be declared clearly unacceptable due to the proposed destruction of Ramsar protected wetlands ▪ The proposed action will destroy the feeding grounds of different species of migratory birds, including critically endangered birds ▪ The foreshore area included in the proposal holds a significant population of koalas ▪ The referral states that approximately 50% of the area proposed to be destroyed is covered in seagrass – an important source of food for EPBC listed species ▪ The high risk of pollution from the construction and ongoing operation which will impact on the values of the Ramsar site
Infrastructure Association of Queensland	Support	▪ Provide an upgrade to ageing infrastructure ▪ Boost the amenity of the area and the capacity of the marine facilities ▪ Positive economic impact
Koala Action Group Qld Inc	Oppose	▪ The Assessment of Federal Environmental issues should not be given to the Queensland State Government as the state has proclaimed its support and is likely to be biased.

From	Support / Oppose	Key Issues
		▪ The Project has been established under the Economic Development Act 2012 which is not covered by the bilateral agreement with the Federal Government ▪ The proposal is likely to have a significant impact on matters protected by the EPBC Act ▪ Dredging will cause silt plumes and they will destroy corals of Moreton Bay before they are able to be studied ▪ The area hosts an important koala population ▪ The koala population has declined by 80% in the last 20 years, however the area still has a colony of healthy breeding koalas that should be protected under the act ▪ 10,000 people participated in the most recent koala survey – indicating far more support for the population to remain protected and not threatened by this proposal
s47F – Freelance Writer	Oppose	▪ Moreton Bay is known to provide shelter to migrating whales, often with calves ▪ The area has an important population of koalas that would be negatively impacted by the increased traffic in the area ▪ There are turtle nesting beaches in Moreton Bay, and important feeding grounds for multiple species of turtles, including green and loggerhead ▪ Moreton Bay is home to approximately 800 dugongs that feed on the seagrasses that will be destroyed by the development ▪ New corals have been discovered in Moreton Bay ▪ A newer safer harbour is needed, but not at Toondah where the ecology of the bay and the islands is too valuable.
National Parks Association of Queensland	Oppose	▪ NPAQ support an upgrade to the current ferry terminal, however the scale and extent of the Toondah Harbour Project is inappropriate given its location within and adjacent to the Moreton Bay Ramsar site ▪ Direct and permanent damage to over 40 ha of the Moreton Bay Ramsar wetland through

From	Support / Oppose	Key Issues
		dredging, sedimentation, litter and runoff ▪ Significant impacts on EPBC Act listed migratory bird species ▪ Significant impacts on the local koala population ▪ Significant loss of seagrass – important food source for dugongs and turtles, and also for fish and prawn spawning ▪ The protection of the wetlands should be upheld according to Australia's commitment nationally and internationally
s47F Centre for Biodiversity and Conservation Science Centre for Marine Science University of Queensland	Oppose	▪ The dredging and reclamation of over 40ha of protected wetlands should be sufficient to refuse approval ▪ Dredging will have cascading impacts on water quality within Moreton Bay, leading to declines of coral reef and seagrass habitat, as well as the species that depend on these habitats ▪ Key Australian objectives for migratory species include: Maintain and enhance important habitat ▪ Declines in wetland habitats can have impacts on the fishing and prawning industry as breeding and recruitment grounds will be destroyed
Queensland Conservation Council	Oppose	▪ The proposal will impact significantly on matters protected by the EPBC Act ▪ The proposal should be declared a controlled action ▪ It should not be made a 'coordinated project' under the Queensland *State Development and Public Works Organisation Act 1971*
Queensland Wader Study Group (QWSG)	Oppose	▪ The Federal Department of Environment's 'Conservation Plan for Migratory Shorebirds', launched by the Minister for the Environment in 2016 notes the importance of conserving shorebird habitat as the key strategy. ▪ There is a need to revitalise the Toondah Harbour ferry terminal, however the proposed development extends beyond the needs of the community ▪ If development occurs it should be undertaken in an environmentally sensitive way that

From	Support / Oppose	Key Issues
		respects Australia's obligations under the Ramsar Convention and protects threatened species ▪ The proposed development will contribute to the on-going decline in the number of migratory birds ▪ There is no discernible strategy to address the long-term impacts of the lengthy development period on shorebirds ▪ The consultant reports produced state that the immediate site development will have a negative effect on the near by roosting site (Cassim Island)
Redlands 2030	Oppose	▪ There is no demonstrable demand for a development such as Toondah ▪ As the increasing effects of urban development along the coastline impact EPBC Act listed species, remnant habitat should be more highly regarded and preserved due to the dwindling areas of Protected Areas ▪ The studies suggest that the loss of salt marsh community is offset because similar habitat is nearby, however this is an endangered ecological community and needs to be considered more substantially
Sealink Travel Group	Support	▪ Support a new marina, improved ferry facilities and improved amenities.
Secretariat – Ramsar Convention on Wetlands	Oppose	▪ The proposed development extends into the Moreton Bay Ramsar Site ▪ The proposed project will have an adverse impact on the ecological character of the Moreton Bay Ramsar Site and the criteria under which the wetland was designated ▪ Loss of wetland habitat for development will set a precedent for other developments in the future ▪ The Referral document states that the proposed development will likely impact on the ecological character of the Ramsar Site and this impact will be significant ▪ The Government of the Commonwealth of Australia has an obligation to promote the conservation of the Moreton Bay Ramsar Site and to consider its international responsibilities

From	Support / Oppose	Key Issues
		for the conservation, management and wise use of the migratory shorebirds at the site ▪ The impacts from increased disturbance to the area from greater boat traffic has not been evaluated ▪ The impact from increased pollution have not been mentioned ▪ With reference to the Articles of the Ramsar Convention on Wetlands which are relevant to this case, it states that: ~ Contracting Parties shall "…formulate and implement their planning so as to promote the conservation…" of their Ramsar Sites (Article 3.1); ~ "Each Contracting Party shall consider its international responsibilities for the conservation, management and wise use of migratory stocks of waterfowl…" (Article 2.6); ~ "Each Contracting Party shall arrange to inform the Ramsar Secretariat "…at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference." (Article 3.2); ~ Contracting Parties have the right to restrict the boundary of their Ramsar Site because of "…urgent national interests…" and to inform the Ramsar Secretariat "…at the earliest time…" if this were to happen (Article 2.5); ~ "Where a Contracting Party in its urgent national interest, deletes or restricts the boundaries of a wetland included in the List, it should as far as possible compensate for any loss of wetland resources, and in particular it should create additional nature reserves for waterfowl and for the protection, either in the same area or elsewhere, of an adequate portion of the original habitat." (Article 4.2) ~ "If Contracting Parties make alterations to their list of Ramsar Sites or changes in the character of the Ramsar Sites, then the Secretariat will "…arrange for these matters to be discussed at the next Conference." (Article 8.2d)
s47F [redacted] MSc (Conservation Biology), Ba Inf & Tech, Dip Applied Science (Marine Resources). Program Wildlife	Oppose	▪ The proponent fails to adequately address the negative impacts to fauna ▪ The proponent fails to disclose the high fidelity migratory wader birds have towards their feeding sites and roosting areas

From	Support / Oppose	Key Issues
Queensland Coastal Citizen Science. Secretary, Wildlife Preservation Society of Queensland Bayside Branch (QLD) Inc.		▪ The subject site is an important site for migratory shorebirds ▪ Cumulative pressures are not addressed by the proponent, a matter raised in the 2016 State of the Environment Report ▪ The seagrass meadows within the subject site are regularly used by EPBC listed species ▪ Urbanisation of a wetland of international importance is not a wise use of a wetland
Southern Moreton Bay Islands Coastcare	Oppose	▪ The Development should be refused due to the potential impacts on MNES ▪ Significant earthworks and construction will have long term and structurally significant impacts on the viability of the threatened species and ecological communities in the wider Moreton Bay area
Stradbroke Island Management Organisation Inc. (SIMO)	Oppose	▪ The development will have negative impacts on MNES ▪ As a contracting party to the Ramsar Convention, Australia has an international obligation to protect Ramsar listed wetlands
Straddie Chamber of Commerce	Support	▪ The area is already significantly impacted and an environmentally sensitive development may improve water quality ▪ There is only a small amount of intact habitat in the area ▪ Providing controls are implemented, the impact of the development could be managed and would not increase impacts on sensitive areas such as wading bird habitat or seagrass beds
Wildlife Preservation Society of Queensland Logan Branch Inc	Oppose	▪ The proposal fails to demonstrate how the fauna will be adequately and appropriately protected. The area supports biodiversity of international significance ▪ The proponents have not adequately addressed how the marine life, mangroves and seagrass meadows will be protected ▪ The proposal does not address cumulative impacts on the Moreton Bay Marine Park ▪ The imposition of numerous and complex conditions tend to be meaningless as there are not the resources available to police the conditions

From	Support / Oppose	Key Issues
		▪ The development could be implemented if it did not propose to dredge a Ramsar wetland and kept all development on land
Individual Submissions x 149	Oppose	▪ The proposal should be rejected because the referral states that it will have a significant impact on matters protected by the EPBC Act ▪ Australia has international obligations to protect wetlands, migratory birds and threatened species ▪ Dredging and reclamation of 40ha of Moreton Bay Ramsar Site goes against the obligations under the Ramsar Convention, it will impact other areas within the Moreton Bay Ramsar Site and will destroy habitat critical to the survival of turtles, dugongs, fish, prawns, seabirds, migratory wader species ▪ The impacts to migratory species such as the Eastern Curlew will be too significant for a critically endangered species ▪ The site will significantly impact the local koala population ▪ Concerns over the long-term impacts from the development, including noise, lighting and pollution on the species impacted ▪ The development should not be considered critical infrastructure as there are many other suitable sites and proposals that would benefit the community and have no need to dredge reclaim areas of a Ramsar Site ▪ The community supports an upgrade to the ferry terminal, but not the proposed development as it looks currently
Individual Submissions x 4	Support	▪ The proposal will improve the ferry terminal and upgrade the local infrastructure ▪ There will be potential to increase access to North Stradbroke Island ▪ There is support for it to progress so the proposal is given a thorough Environmental Impact Assessment

From	Support / Oppose	Key Issues
		▪ There is support, as long as key environmental aspects of the area are preserved
Campaign Submissions x 1238	Oppose	▪ This development proposal will have negative impacts on three Matters of National Environmental Significance protected under the EPBC Act ▪ Australia is a contracting party to the Ramsar Convention, and therefore has an international obligation to protect Ramsar-listed wetlands. ▪ Any development that intends to reclaim part of a Ramsar site should be declared a ‘clearly unacceptable action’ under the EPBC Act.

Attachment L

FOI 180818
Document 29

Summary of Public Submissions – EPBC 2015/7612

All Submissions provided on USB???

65 individual submissions – opposed

From	**Support / Opposed**	**Key issues**
Wildlife Preservation Society of Queensland - Bayside Branch/ Logan Branch	Opposed	• Referral information is flawed/misleading, and an approval decision will likely be open to challenge. • Ecological surveys are inadequate and omit a number of factors that impact upon Matters of National Environmental Significance. • Bilateral agreement between the Commonwealth and Queensland Government should not be applicable in this matter, as the Queensland Government has conflict of interest in supporting proposal. • Independent information shows that the subject site supports significant amounts of seagrass. Seagrass and mangrove habitat on the site are critical to a number of protected species including Dugongs, marine turtles and migratory birds. • The proposal will result in increased boat traffic representing a significant threat to turtles and dugongs. • Concerns regarding the proponent’s environmental history and their attention to protecting ecological values. • Subject site likely supports a population of Illidge's ant blue butterfly, *Acrodipsas illidgei*, listed as Vulnerable under the *Queensland Nature Conservation Act*.
Community Alliance for Responsible Planning (CARP) Redlands Inc	Opposed	• The community has been protecting the harbour from overdevelopment for over twenty years.

Summary of Public Submissions – EPBC 2015/7612

All Submissions provided on USB???

		• Supports the submission of the *Wildlife Preservation Society Queensland* (see above).
Eprapah Creek Catchment Landcare Association Inc.	Opposed	• Referral information is flawed and has excluded expertise within groups with local environmental knowledge. • Ecological surveys are inadequate and omit a number of factors that impact upon Matters of National Environmental Significance. • Subject site supports dugongs, green turtles. • Subject site likely supports a population of Illidge's ant blue butterfly, *Acrodipsas illidgei*, listed as Vulnerable under the *Queensland Nature Conservation Act*. • The significant local population of koalas will be seriously impacted by proposal.
Friends of Stradbroke Island	Opposed	• Development of management plan for the entire Moreton Bay Ramsar site is required to allow the proper and full assessment of impacts. • Proposal is likely to have a prolonged, significant impact upon listed threatened species and communities, migratory species and a Ramsar wetland under the EPBC Act. • Cumulative impacts of this proposal and other current activities on the Moreton Bay should be assessed.
Koala Action Group Qld Inc.	Opposed	• G.J. Walter Park has many trees planted by the Koala Action Group over 20 years ago in cooperation with the Redland Council which now forms koala habitat. • Proposal will result in loss of heritage values at G. J. Walter Park and the 'Fernleigh' precinct.

Summary of Public Submissions – EPBC 2015/7612

All Submissions provided on USB???

		• Proposal will destroy the ambience of the G.J. Walter Park, concerns of noise and pollution. • Bilateral agreement between the Commonwealth and the State of Queensland should not be applicable in this matter, as the Queensland Government is unsuitable to be engaged in the assessment of this proposed development. • Concern of dangerous precedent being set if approval is given which is inconsistent with Ramsar principles.
Redlands 2030	Opposed	• Ecological studies are inadequate and have only considered the impact of the initial PDA development area. Ecological studies and technical documentation are inadequate to describe the impacts protected matters under the EPBC Act. • Referral information is misleading and inaccurate and require accreditation and rigorous analysis. • There is no demonstrable demand for urban land supply within Redlands, or the Cleveland urban area. • Concerns that previous public consultation undertaken during the initial PDA development did not consider public submissions and was inadequate. • Concerns that Redland City Council and the Queensland Government do not have good record of protecting the regional koala population. • Concerns that Walker Group have a history of proposing inappropriate developments in environmentally sensitive areas, and breaching environmental legislation relevant to their development approval conditions. • Queensland Government should not be involved in approval of proposal.

Summary of Public Submissions – EPBC 2015/7612

All Submissions provided on USB???

Queensland Wader Study Group (a special interest group of the Queensland Ornithological Society Inc)	Opposed	• Roost nearby. • High tide roosts and intertidal areas of migratory bird species will be subject to disturbance from the increased human activity by the people living within the development. These birds are highly likely to abandon these roosts due to this increased disturbance.
Stradbroke Island Management Organisation Inc.	Opposed	• Queensland Government and Redland City Council have direct interests in proposal and bilateral assessment should not apply. • Previous public consultation undertaken during the initial PDA development did not consider public submissions and was inadequate.

Summary of Public Submissions – EPBC 2015/7612

All Submissions provided on USB???

Individual submissions number		• Proposed site is too far from the Cleveland town centre, there is a more suitable site for a marina village on the northern bay edge of the township of Cleveland. • Proposal would destroy almost all of the seagrass and coral, which would destroy fish population. This would also impact on fishing industry in Moreton Bay. • No justification for planning to cause such widespread environmental destruction and no information on how impacts might be avoided, reduced, mitigated or offset. • The proposal is significantly larger than the development plan presented as a PDA and has a large impact on the environment which is inconsistent with the original vision of the PDA • Proposal should be downsized to a marine facility-oriented land development. • Proposal should be restricted to appropriate size and no more than seven storeys high. • Project will require continual maintenance dredging, which is both environmentally damaging and a huge ongoing cost to the ratepayers. • Any marina placed in this location in the shallow southern part of the Bay, is suitable for low draft vessels only, therefore dredging is unnecesary. • Ecological studies must consider seasonal variables (i.e. currents and wind patterns change through the seasons). • Proposal is located in an area of known high risk of acid sulphate soils presence

Summary of Public Submissions – EPBC 2015/7612

All Submissions provided on USB???

		• Dredging and spoil disposal from excavation to depth of thirty metres will have enormous impact on water quality of a relatively pristine area. Measurements and volumes are not available until planning proceeds further. • Proposal has a high social, community, visual and economic impact on the adjacent existing foreshore residential areas along Cleveland Point. The proposed development will block many views and viewsheds of significance. The coastline as seen from the Bay is also a viewshed that deserves protection. • Destruction of environmental values will emanate from high-density residential, commercial and recreational uses, including a 400-berth marina and additional boating activity. These consequential impacts will diminish the value of Moreton Bay Marine Park overall. • Residents appreciate the site as it is now and will be disturbed by increased noise and activity in the area. • The referral has not dealt appropriately with Indigenous cultural heritage values. The rights of Quandamooka should be fully taken into account before approval decision is made. • No discussion of alternative locations in Cleveland, Raby Bay should be considered as the alternative location. • As provisions of the Economic Development Act 2012 give priority to development over environmental protection, the bilateral agreement is not applicable. • Community should have access to all information about proposal. • Abrogation of international Ramsar obligations has the potential to damage Australia's standing on environmental protection particularly at a time when the

Summary of Public Submissions – EPBC 2015/7612

All Submissions provided on USB???

		Prime Minister and the Minister for the Environment are negotiating environmental matters on the world stage.

Attachment L

FOI 180818
Document 30

Summary of Public Submissions – EPBC 2018/8225

All Submissions provided on USB???

74 individual submissions – opposed

2224 campaigns submissions – opposed

1 individual submission – support

From	**Support / Opposed**	**Key issues**
Birdlife Australia	Opposed	• The project should be determined "clearly unacceptable" due to significant impacts to listed threatened species, migratory species and wetlands of international importance. • Project does not address the concerns raised for previous Toondah Harbour development proposals (EPBC 2017/7939 and EPBC 2015/7612) and their unacceptable, negative impacts from the projects.
Birdlife Southern Queensland	Opposed	• Project does not address the concerns raised for previous Toondah Harbour referrals • Development of the Toondah PDA will impact on feeding habitat used by Critically Endangered, Endangered and Vulnerable Migratory Shorebirds. • There is a viable alternative to this development.
Birdlife International	Opposed	• Impacts to the Moreton Bay Important Bird and Biodiversity Area (IBA) and Key Biodiversity Area (KBA) and Ramsar site and its migratory shorebirds. • Will set a precedent for future developments within Ramsar sites. • Development within the Ramsar site is in direct contravention with Australia's obligations under the Ramsar Convention.
Humane Society International	Opposed	• The project should be considered clearly unacceptable.

		• Impacts to listed threatened species, migratory species and wetlands of international importance.
Australian Conservation Foundation	Opposed	• Impacts to threatened species, migratory species, wetlands of international significance.
One Mile Residents Aboriginal Corporation	Opposed	• Impacts to cultural heritage values of Toondah Harbour, Moreton Bay and North Stradbroke Island. • As a signatory, Australia agreed to protect the Ramsar wetland. • Impacts to threatened species and migratory species.
Community Alliance for Responsible Planning (CARP)	Opposed	• Previous concerns and objections are still valid and unanswered. • Project should be considered clearly unacceptable. • The project is inconsistence with the Wise Use approach required under the Ramsar Convention. • Impacts to migratory birds. • The Moreton Bay Ramsar site is already under considerable pressure form a range of direct and indirect human-induced impacts.
Queensland Wader Study Group (a special interest group of Birds Queensland)	Opposed	• Acknowledges the need to revitalise Toondah Harbour ferry terminal. • Submission of another referral does not constitute a replacement for a comprehensive response to an EIS. • Impacts to migratory shorebirds. • Australia is subject to a number of obligations and agreements for migratory birds. • The proposal seeks to apply the 'wise principle' to the development.
Koala Action Group	Opposed	• Impacts to Ramsar wetland and migratory shorebirds and important population of Koala.

		• Loss of important part of Queensland's heritage – impacts to G.J.Walter Park. • The community consultation process was flawed.
Friends of Stradbroke Island (FOSI)	Opposed	• The proposal should be considered clearly unacceptable as it would breach the Ramsar Convention. • Misleading referral information regarding the projects footprint. The first (2015) referral area was 167.5 ha because it acknowledged that the Fison Channel work should in included in the approval. The current referral is 56 ha and provides little detail on the works to be carried out in Fison Channel. • Comments from May 2017 submission are still relevant and referred to in this submission.
National Trust (Late)	Opposed	• Impacts to listed threatened species, migratory species and wetlands of international importance. • Heritage values of the area have not been adequately considered.
Redlands2030		• Impacts to listed threatened species, migratory species and wetlands of international importance. • As a contracting party to the Ramsar Convention, Australia has an international obligation to protect Ramsar listed wetlands • The project is not in the national interest • Referral lacks detail of construction impacts. • Much of the 250m buffer is a channel providing access into the 200 berth marina and public boat ramp. This waterway will be a busy place so disturbance to migratory shorebirds is unlikely to be mitigated. • Submission includes photograph suggesting higher count of Bar-tailed Godwit in the site than stated in the referral.

		• Claims that the project will offset the loss of jobs when sand mining finishes on North Stradbroke Island in 2019 are not credible. In recent years this industry has employed very few people and North Stradbroke Island is already transitioning to a future based on eco-tourism. • The referral states that the industry type is 'tourism and recreation'. However the 3600 residential dwelling suggest that the proposal should be considered 'residential development'. • The referral lacks details relating to construction. • The inclusion of the 'Blue Lagoon' – a large public swimming lagoon is not consistent with activities in a Ramsar wetland. • Environmental history of proponent.
Wildlife Preservation Society of Queensland, Logan.	Opposed	• The proposal fails to adequately address the needs of wildlife, their habitat and the impacts on Moreton Bay Marine Park and the listed Ramsar wetland. • Is there science to demonstrate that the increase in buffer width is adequate?
Queensland Conservation	Opposed	• The proposal should be considered clearly unacceptable due to the impacts to Ramsar wetlands, migratory species and threatened species.
Stradbroke Chamber of Commerce	Support	• The project as reduced the reclamation footprint from previous referral. • The project has provided a larger buffer to separate the development from the adjacent Cassim Island. • Membership supports the revised plans for the port facility and the promise of a higher standard of facility, suitable for the gateway to North Stradbroke Island. • Support for a substantial increase in public car parking spaces.
Birdlife Australia - MC18-011071	Opposed	• Impacts to Ramsar wetlands, migratory species and threatened species.
s 47F	Opposed	• Project should be considered clearly unacceptable.

3 submissions		• Impacts to listed threatened species, migratory species and wetlands of international importance. • Proposal does not represent wise use of the Ramsar wetland. • Non-essential residential development. • The referral states that the industry type is tourism and recreation rather than residential. • The reduced referral area without reducing the number of dwellings raises concerns about density. • A legislated amendment to the Marine Park should not be tolerated. • The project does not align with the Shaping SEQ Regional Plan 2017. • Impacts associated with acid sulphate soils. • No amount of hydrological modelling could have predicted what happened at Noosa. The same applies to Toondah Harbour. • Environmental record of proponent • The attempt to down play the importance of the existing Toondah Harbour Ramsar site on the basis that it represents only a fraction of the total Moreton Bay Ramsar area needs to be closely tested.
s 47F (traditional owner)	Opposed	• PDA area is aboriginal land and sea and contains cultural and ecological diversity of the region. • The project may lead to high rise developments on North Stradbroke Island. • The proposal forms part of a state government plan to increase the number of tourists and visitors to North Stradbroke Island before there has been proper ecological and cultural assessments of the impacts associated with increased visitors.

		• A suitable agreed management plan for North Stradbroke Island is necessary to maintain the cultural and ecological integrity of the island. • Concerned about the dredging in the Ramsar wetlands and Australia's role as a signatory to Ramsar Convention. • Impacts to habitat for listed threatened and migratory bird species. • Increased chance of Koala mortalities from increased traffic. • Impacts to the immediate area, Ramsar site and wider Moreton Bay area from dredge spoil and 10,000 people living in the new units.
s 47F (traditional owner)	Opposed	• Impacts to listed threatened species, migratory species and wetlands of international importance from construction and operation. • Concerns about Quandamooka Nations existing rights.
54 individual submissions	Opposed	• Impacts to listed threatened species, migratory species and wetlands of international importance. • Community and social impacts. Community support is misrepresented. Misleading or inaccurate information in the referral. • Concern the Walker group is trying to avoid an EIS. • Alternative proposals have not been considered. • Current oversupply of housing in the southern Moreton Bay area, and therefore no need for additional residence. • Irresponsible to sign off on a project where there is a similar neighbouring project (Raby Bay) with evidence of continued impacts to the environment. • Considering that the sand mine on Stradbroke is set to close – is there a need to upgrading the ferry terminal? • Aesthetic and environmental values will be damaged.

		• Heritage values of the site have not been considered. • Only upgrade the harbour. • Australia’s obligation under the Ramsar Convention. • Walker Group compliance history. • Non-essential development. • Project is inconsistent with South East Queensland Regional Plan 2017.
Campaign – 2224 submissions	Opposed	• Impacts to listed threatened species, migratory species and wetlands of international importance. • Project benefits are misleading and false, the community won’t benefit from immediate jobs. • Developer’s compliance history is poor. • Support for project is overstated. • There is another alternative to this project. • International obligations under the Ramsar Convention. • Extra stress that 12,000-15,000 people will have on the Ramsar site. • Ferry terminal has been misused by the proponent to justify a residential development. • Development is not in the urgent national interest. • Development raises population density from 13.03 people per ha to 140.28-200.4 people per hectare • Project is not tourism related it is a residential development. • Negative construction impacts, not outlined in current proposal.

		• No assessment to do with acid sulphate soils, increased silt, construction foundations, walls of land reclaimed from the sea. • No value add to the community infrastructure from this project.