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Commonwealth Environmental Water Office Monitoring, Evaluation and Research Program: Junction of the Warrego and Darling Rivers Selected Area Monitoring, Evaluation and Research Plan (2019-2022)

Final Plan

July 2019

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Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Description
2rog	2rog Consulting
ANAE	(Interim) Australian National Aquatic Ecosystems (Classification Framework)
ASL	Above Sea Level
BoM	Bureau of Meteorology
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
EWKR	Environmental Water Knowledge and Research Project
EWP	Environmental Watering Plan (Basin Plan)
IMEF	Integrated Monitoring of Environmental Flows
JMAC	Joint Aboriginal Advisory Committee
LTIM	Long-Term Intervention Monitoring Project
M&E Adviser	Monitoring and Evaluation Adviser
M&E Plan	Monitoring and Evaluation Plan
M&E Provider	Monitoring and Evaluation Provider
M&E Requirements	Monitoring and Evaluation Requirements
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MDMS	Monitoring Data Management System
MER	Monitoring, Evaluation and Research
OEH	(NSW) Office of Environment and Heritage
QA/QC	Quality Assurance / Quality Control
SRA	Sustainable Rivers Audit
STIM	Short-term Intervention Monitoring
The Department	Department of the Environment (Commonwealth)
UNE	University of New England
WHS	Work Health and Safety

1. Introduction

The Commonwealth Environmental Water Holder (CEWH) is responsible under the *Water Act 2007* for managing Commonwealth water for the environment holdings. The holdings must be managed to protect or restore the environmental assets of the Murray-Darling Basin (MDB), and other areas where the Commonwealth holds water, including to give effect to relevant international agreements. The Basin Plan (2012) further requires that the holdings must be managed in a way that is consistent with the Basin Plan's Environmental Watering Plan. The *Water Act 2007* and the Basin Plan also impose obligations to report on the contribution of Commonwealth water for the environment to the environmental objectives of the Basin Plan.

Monitoring, evaluation and research are critical for supporting effective and efficient use of Commonwealth water for the environment. Monitoring and evaluation of outcomes will also provide important information to support the CEWH in meeting their reporting, communication and engagement obligations.

The Commonwealth Environmental Water Office (CEWO) implemented the Long Term Intervention Monitoring Project (LTIM) to evaluate the outcomes of water for the environment delivery at seven Selected Areas across the MDB from 2014-15 to 2018-19. From July 2019 the LTIM Project will be extended to provide monitoring continuity and include specific research, communication and engagement outcomes. This extended program is called the Monitoring Evaluation and Research Program (MER Program) and runs from mid-2019 to the end of 2022. The LTIM monitoring design has been amended for the MER Program to incorporate learnings from the 5 year LTIM Project, advances in scientific methods and ongoing stakeholder feedback. To ensure data continuity from the LTIM Project to the MER Program, core indicators, locations and methods have been retained. In addition, the MER Program includes extended Research and Contingency Monitoring sub-Plans, and a Communication and Engagement sub-Plan that includes a specific approach for communication and engagement with Aboriginal people, organisations and communities.

The MER Program is the primary means by which the CEWO will undertake monitoring and evaluation of the environmental outcomes of Commonwealth water for the environment.

The MER Program will be implemented at seven Selected Areas over a three year period from mid-2019 to December 2022 to deliver five high-level outcomes (in order of priority):

1. Evaluate the contribution of Commonwealth environmental watering to the objectives of the Murray-Darling Basin Authority's (MDBA) Environmental Watering Plan
2. Evaluate the ecological outcomes of Commonwealth water for the environment at each of the seven Selected Areas
3. Infer ecological outcomes of Commonwealth water for the environment in areas of the MDB not monitored
4. Support the adaptive management of Commonwealth water for the environment
5. Monitor the ecological response to Commonwealth water for the environment at each of the seven Selected Areas.

This document presents an amended Junction of the Warrego and Darling Rivers Monitoring and Evaluation Plan (Warrego-Darling MER Plan or MER Plan) delivered under the LTIM Project (CEWO 2014) and details additional contingency monitoring, research and communication aspects to create the MER Plan. To ensure program and data continuity, the MER Plan retains the essential design (methods and sampling locations) undertaken throughout the LTIM Project. Minor amendments to the

design have been made to incorporate learnings from the LTIM Project implementation and stakeholder input.

1.1 Warrego-Darling MER Plan Structure

The Warrego-Darling MER Plan details the monitoring, evaluation, research, communication and guidance activities that will be implemented for the Warrego-Darling Selected Area. This MER Plan includes:

- A brief description of the Warrego-Darling Selected Area (Section 2)
- An overview of environmental watering options in the Warrego-Darling Selected Area (Section 3)
- An overview of the monitoring and research priorities in the Warrego-Darling Selected Area (Section 4)
- Indicator monitoring and evaluation (Section 5), including:
    - Evaluation questions (Basin-scale and Selected Area)
    - Monitoring schedule (where, what, when, how)
    - Evaluation approach (Basin-scale and Selected Area)
- An integrated research plan (Section 6)
- A project schedule comprising monitoring, research and communications activities (Section 7)
- A communication and engagement strategy (Section 8)
- Project reporting schedule (Section 9)
- A project management plan (Section 10), addressing:
    - Project governance and risk assessment
    - Quality assurance plan
    - Personnel
    - Equipment and infrastructure
- A data management plan (Section 11)
- Appendices including:
    - A work health and safety (WHS) plan (Appendix A)
    - Standard operating procedures for indicators monitored (Appendix B)
    - Progress Report Template (Appendix C)
    - Selected Area Working Group membership (Appendix D)
    - Proformas (Appendix E)
    - Contingency Communications and Engagement – Schedule 6 Work Order (Appendix F)
    - Contingency Research – Schedule 6 Work Order (Appendix G)
    - Contingency Monitoring – Schedule 6 Work Order (Appendix H)

2. Warrego-Darling Selected Area

The Junction of the Warrego and Darling Rivers is one of seven Selected Areas to be monitored under the MER Program. The Warrego-Darling Selected Area is located around 80 km south-west of Bourke in north western NSW (Figure 2-1), and is contained within the boundary of the Toorale National Park and State Conservation Area (Figure 2-2). The Selected Area is approximately 92,000 ha in size, and receives flow from both the Darling and Warrego River systems. The Darling River catchment drains the north westerly portion of the MDB and has a total catchment area of 699,500 km^2. Most of its tributaries (Macquarie, Castlereagh, Namoi, Gwydir, Macintyre and Condamine-Balonne Rivers) drain from the Great Dividing Range in northern New South Wales and southern Queensland, and provide relatively high volumes of runoff to the catchment. In contrast, other catchments such as the Warrego and the Paroo Rivers to the west drain more arid, flat catchments and only flow intermittently during periods of high rainfall in their upper catchments, usually manifesting downstream as slow moving freshes and floods of relatively long duration. Generally, the Selected Area shows high climatic variability, with low average annual rainfall and high rates of evaporation.

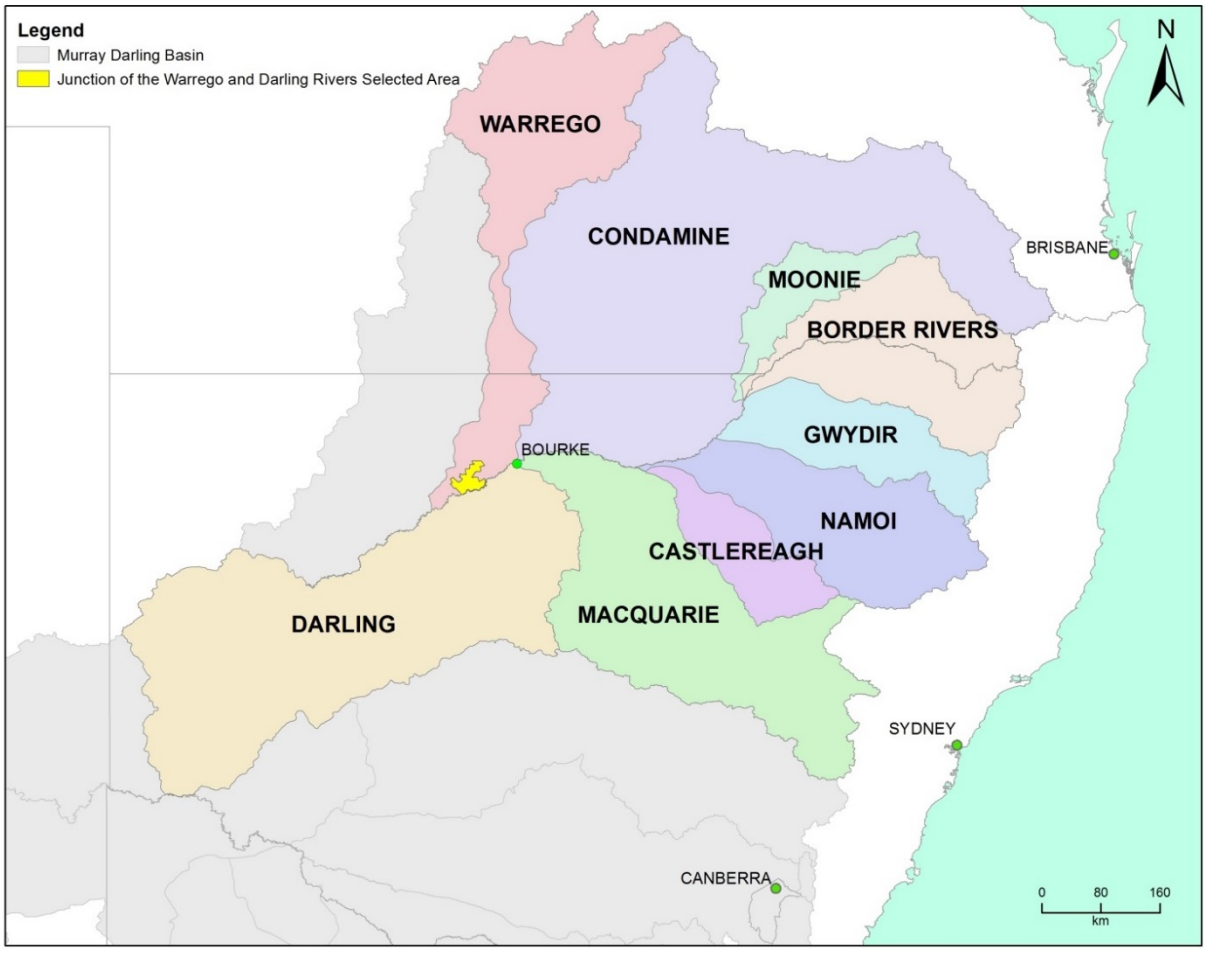

Figure 2-1 The location of the selected area within the Murray-Darling Basin showing catchments upstream of the Darling.

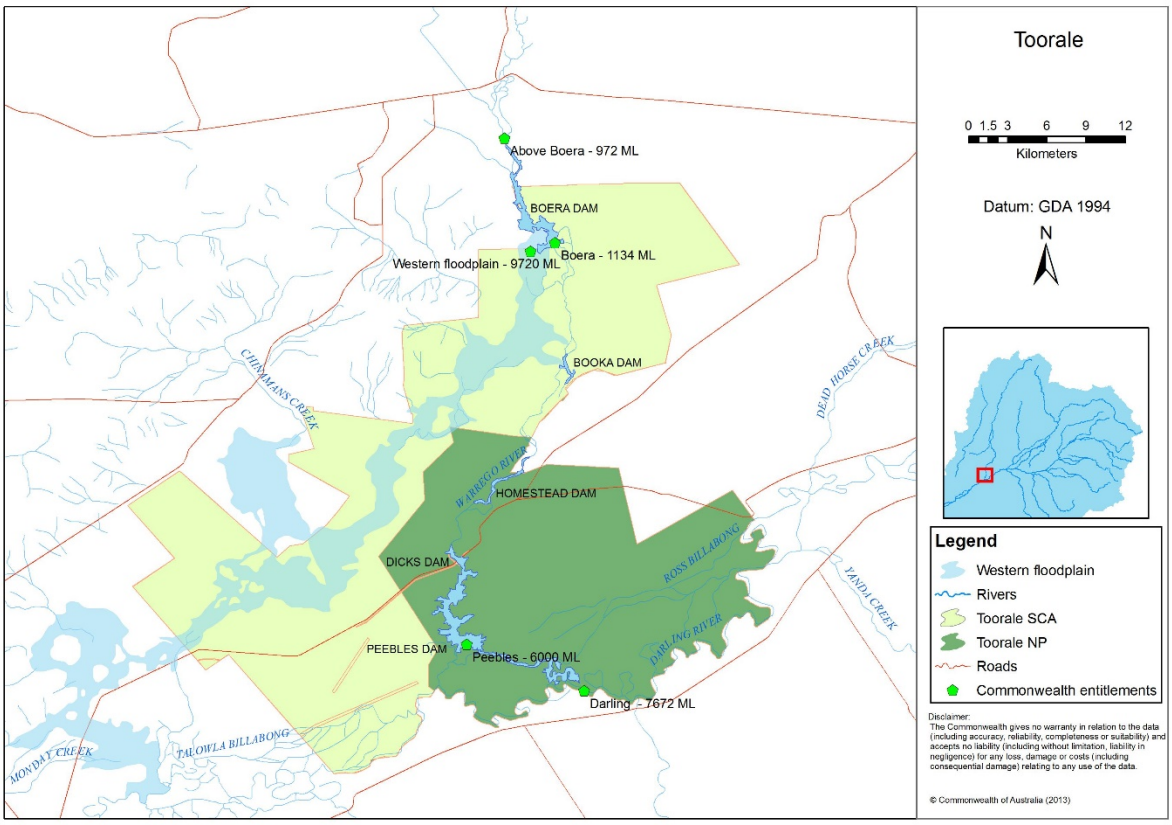

Figure 2-2 The Junction of the Warrego and Darling rivers Selected Area bounded by Toorale NP and SCA. CEWO water entitlements are given for each storage.

2.1 Climate

Climate across the Darling catchment is sub-tropical in the east to semi-arid in the west. Annual average rainfall varies from around 770 mm in Stanthorpe to around 260 mm at Wilcannia in the west (Southwell 2008). The average annual rainfall at Bourke, approximately 80 km upstream of the Selected Area is 354 mm (BoM 2014a). Rainfall is summer dominant, with the highest rainfall occurring from December through to March (Figure 2-3). February shows the highest mean monthly rainfall of 42 mm and September the lowest at 20 mm. Monthly evaporation always exceeds rainfall, with an annual average (Class A pan) evaporation of 1854 mm (BoM 2014a). Summer temperatures are hot, with a mean daily maximum temperature of 35 °C at Bourke (Figure 2-3).

In the Warrego catchment, average maximum temperatures in both the north (Tambo) and south (Bourke) are similar despite the catchment stretching 650 km from north to south, with the south having slightly warmer mean maximum and minimum temperatures. On average, the north of the Warrego catchment (Bogarella) receives 230 mm more rainfall annually than the south (Enngonia).

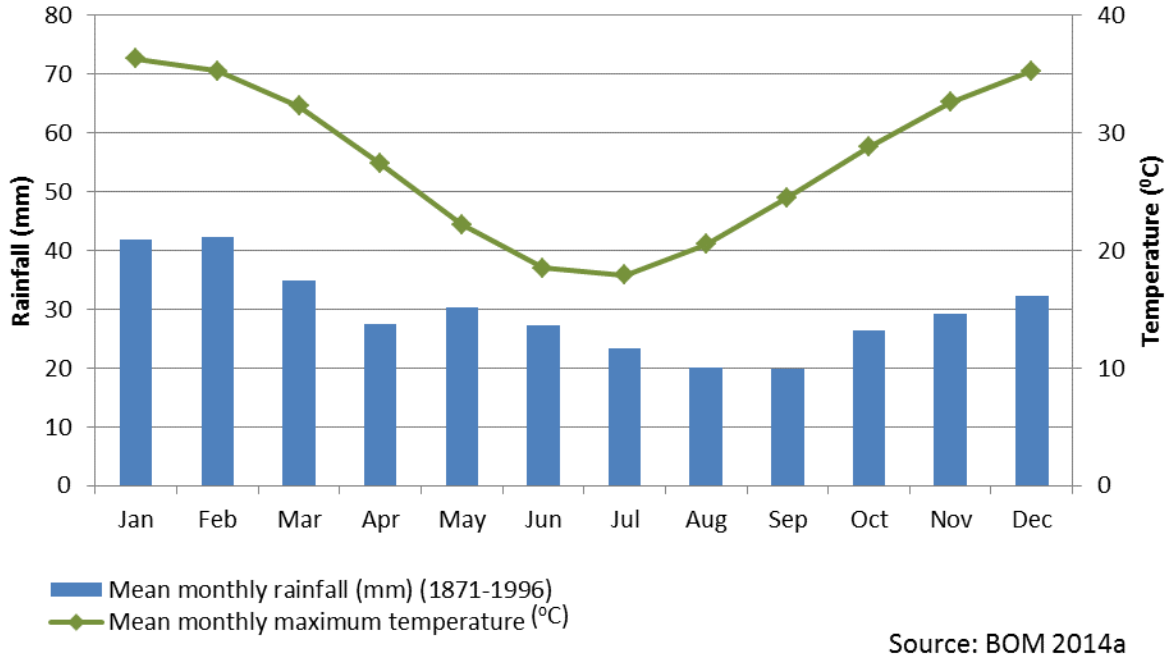

Figure 2-3 Monthly climate averages (Bourke Post Office).

2.2 Physical environment

The Selected Area is covered by six physiographic regions, being the Alluvial Plains of the Darling and Warrego Rivers, Playas and Basins of the backplains of the Darling and Warrego Rivers, Plains bordering the Darling River, Dunefields, Rolling Downs and Lowland, and Tablelands (Hazelton and Johnson 1972 in Gowens et al. 2012). In all, around two-thirds (62,000 ha) of the Selected Area is considered as floodplain with the remaining third (30,000 ha) classed as dryland (Gowens et al. 2012). The following sections outline the characteristic physical and vegetative features of the Darling and Warrego River systems.

2.2.1 Darling River

In its upper catchment, the Darling River and its tributaries drain relatively high relief sections of the Great Dividing Range. However, relief soon reduces as the river flows westward, and in the vicinity of the Selected Area, the river drains a flat, semi-arid landscape with expansive floodplains. Here, the Darling takes the form of a typical semi-arid river, with a deep, narrow main channel, steep banks and high sinuosities (>2, Thoms et al. 2004). The main Darling channel and its riparian zones show high geomorphic complexity, with physical features such as deep pools, shallow runs, in-channel benches, rock bars and large woody debris forming important physical habitats and storage areas for organic material (Boys and Thoms 2006, Sheldon and Thoms 2006). These habitats support a diverse fish population with 23 native species from 10 families and 7 exotic species recorded in the Darling catchment (Gerhke and Harris 2004).

The Darling River channel is bordered by river red gum (*Eucalyptus camaldulensis)* woodlands, in which river red gums and coolibah (*Eucalyptus coolabah)* form the overstory, river cooba *(Acacia stenophylla)* and lignum (*Muehlenbeckia florulenta)* form the mid and understory, and a number of herb species such as Darling pea (*Swainsona greyana*), common sneezeweed (*Centipeda*

cunninghamii), joyweed (*Alternanthera species*) and the introduced smooth mustard (*Sisymbrium erysimoides*) form the groundcover (Westebrooke et al. 2004). These woodlands provide significant inputs of litter and organic matter that is temporarily stored on in-channel benches along the river, and then incorporated into riverine food webs during in-channel flow pulses (Sheldon and Thoms 2006). Many of these in-channel benches are inundated at relatively low flow levels, thus forming potential targets for environmental flow deliveries (Southwell 2008).

There are several natural wetlands within the Selected Area along the Darling River, these include: Ross Billabong in the lower reaches of the Warrego River; and Talowa Billabong, a billabong/distributary system which comes off the Darling River downstream of the Warrego confluence.

A 2000 ha irrigation area was established on the Darling River floodplain in the east of the Selected Area in 1980 (Aurecon 2009) prior to the area being designated as National Park (Figure 2-4). This area is now effectively cut off from the surrounding floodplain by levee banks and will not be influenced by water for the environment in the future unless decommissioning of structures takes place.

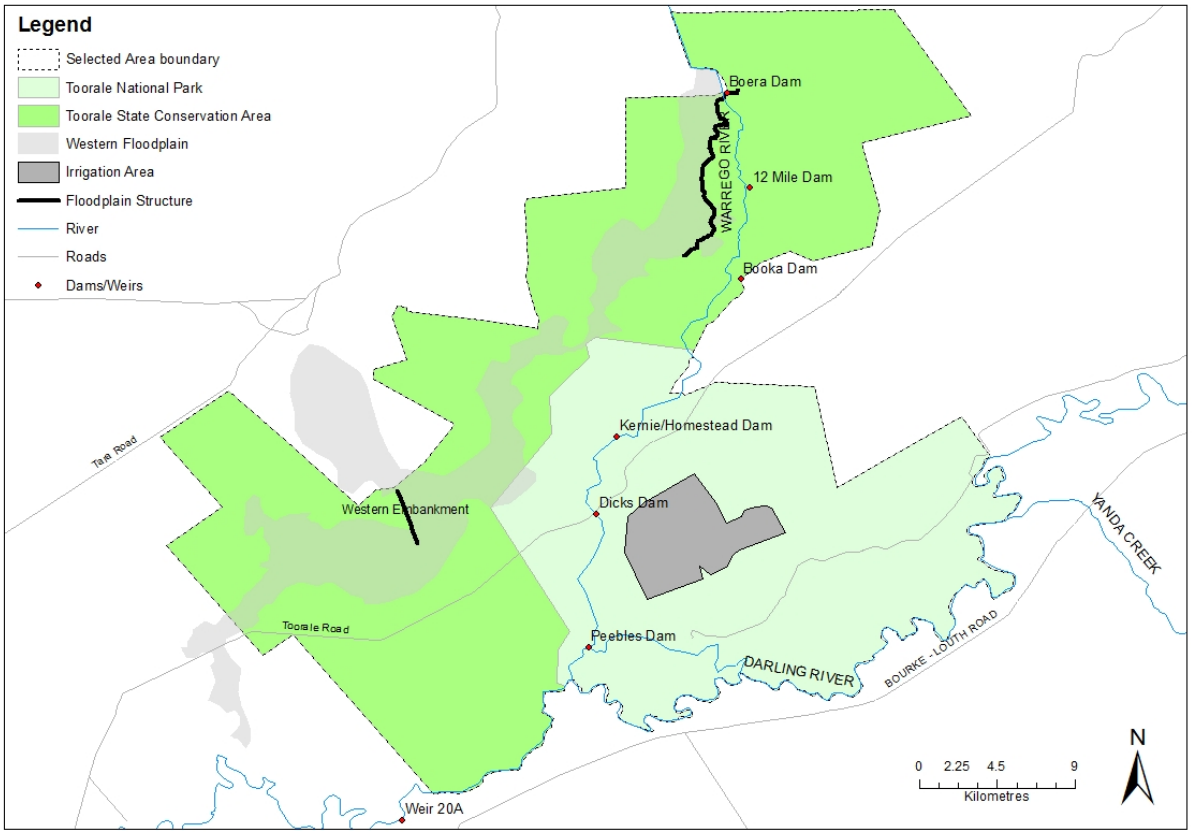

Figure 2-4 Existing infrastructure influencing the hydrology within the Selected Area.

2.2.2 Warrego River

In its lower reaches, the Warrego River forms a complex of multiple small channels flowing through the floodplain. Within the Selected Area, a main channel winds its way south to the Darling River, bordered to the west by an extensive floodplain system known as the Western Floodplain. Channel bank sediments consist of fine-grained sandy silt and clay material with numerous bar and bench features (Holz et al. 2008). While natural waterholes are a feature of the Warrego channel in the Queensland section of the river (Holz et al. 2008), there are no natural waterholes within the boundary of the Selected Area. Instead, a series of seven in-channel dams control water flow down the channel and create a longitudinal series of weir pools during times of river flow (Figure 2-2). These weir pools now form important in-channel refugia for aquatic organisms during periods of no surface water flow (Capon 2009). Their presence has also significantly changed the inundation frequency of the surrounding floodplain, with a tenfold increase in inundation frequency as a result of water diverted down the Western Floodplain at Boera Dam (Cox et al. 2012).

The Western Floodplain begins to the north of the Selected Area and is inundated by water breaking from the Warrego channel in the vicinity of Boera Dam (Figure 2-2). The floodplain then runs in a south westerly direction, and during times of high river flows, surface water enters the Darling River 15-20 km downstream of the Toorale SCA boundary (Figure 2-2). In its upper sections, the Western Floodplain is constrained by natural sand hills to the west, and a man-made training embankment and access road to the east, which restricts the return of water from the floodplain back into the Warrego channel (Figure 2-4). Water flow is also diverted within the southern areas of the floodplain by a western embankment, a man-made embankment that diverts water into the neighbouring Uteara property and into several old stock dams on Toorale (Cox et al. 2012). There are currently breaches in this embankment that now provide greater connectivity of water to the lower sections of the floodplain (Figure 2-5).

Figure 2-5 A breach in the western embankment on the lower western floodplain (photo: D. Ryder).

The Western Floodplain supports a range of vegetation species including coolibah, river cooba, black box (*Eucalyptus largiflorens),* lignum (Figure 2-6), patches of perennial grasses including *Eragrostis setifolia*, saltbush (*Atriplex spp.*) and copperburs, and forbs and grasses such as cut leaf medic (*Medicago laciniata*), nardoo (*Marsilea spp.*) and ribbed spike rush (*Eleocharis plana*) as groundcover (Capon 2009). These floodplain habitats along with the refuge weir pools within the Warrego channel have been shown to support waterbirds, including the brolga (*Grus rubicundus*) which is listed as Vulnerable in the NSW Threatened Species Conservation Act 1995 (Capon 2009), and another five species of conservation concern in the Western Division of NSW: pied cormorant (*Phalacrocorax varius*), darter (*Anhinga melanogaster*), Australian pelican (*Pelecanus conspicillatus*), great egret (*Ardea alba*) and royal spoonbill (*Platalea regia*) (Shelley 2003 cited in Capon 2009).

Figure 2-6 Flood channel in the upper section of the Western Floodplain bordered by lignum, river cooba and coolibah (photo D. Ryder).

2.3 Hydrology

Hydrological variability is a feature of rivers in the Darling catchment, with long periods of low to no flow, punctuated with episodic flooding events. This is amplified by climatic conditions such as the El Niño–Southern Oscillation (ENSO). As such, flows in the Darling and Warrego Rivers are highly variable and are strongly correlated with the Southern Oscillation Index (SOI). The long-term flows in the Darling and Warrego Rivers do show some seasonality, with higher flows usually occurring during the summer and autumn months from December to April.

The hydrology of the Selected Area has been highly modified from its natural state. Although the Warrego catchment is still relatively unregulated upstream, in-channel flows are now controlled by seven dams within the Selected Area. The characteristics of these dams are outlined below (Gawne et al. 2013b):

1. Boera Dam: a large storage of approximately 3000 megalitres, likely to have been established since the 1870s. Water persists for around 12 months after filling in the absence of further inflows or local runoff
2. 12 Mile Dam: less than 1000 megalitres in volume, this dam has been recently breached and not reinstated.
3. Booka Dam: approximately 1000 megalitres
4. Mumpher (Broken) Dam
5. Keernie (Homestead) Dam: 1500 – 2000 megalitres (Breached)
6. Dicks Dam: 500 – 1000 megalitres
7. Peebles Dam: a large storage just upstream of the junction of the Warrego and Darling rivers. This is the most permanent of the storages and was previously used for irrigation. The storage holds approximately 10 000 megalitres and is connected to Ross Billabong, an adjacent natural floodplain depression.

Boera Dam (Figure 2-7) has significantly influenced flows onto the Western Floodplain with up to 70% of Warrego River flows now diverted down the Western Floodplain every second year on average (Aurecon 2009). This has increased from a 20 year average recurrence interval (ARI) for inundation of the Western Floodplain under natural conditions. Although the frequency of inundation of the Western Floodplain has increased with development, the Warrego River is still an ephemeral stream, with low to no flow occurring for around half the time. In addition, Peebles Dam on the lower Warrego River has been created specifically to divert water into Ross Billabong, a large floodplain depression to the east. Historically, water was pumped from Ross Billabong for irrigated agricultural use on the Toorale property. Ross Billabong predominantly holds water from the Warrego River when the Warrego is flowing, however during periods of high flow in the Darling River, water can enter Ross Billabong via an upstream flood channel, and therefore during these times Ross Billabong will be a mixture of water from both systems.

Figure 2-7 Boera Dam with regulator pipes in foreground, Western Floodplain bywash to the left and main Warrego river flowpath to the right (photo D.Ryder).

The Toorale property that makes up the Selected Area was purchased by the NSW Government in 2008 with the objective of returning the property's water entitlements back to the river and decommissioning the in-channel structures (dams) along the Warrego River (Capon 2009). Changes to these structures are planned, which will significantly influence the hydrology of the lower Warrego River and its floodplains, their connection with the Darling River, and the movement of fish and other biota between systems with the instillation of fishways on many of the structures.

Flows down the Darling River have been reduced as a result of water resource development in its catchment, especially in the Border Rivers and Gwydir sub-catchments. There are twelve major headwater dams with a combined storage capacity of 5048 GL that significantly influence the flows along the Darling River upstream of Bourke and the Selected Area (Table 2-1). The greatest reduction (50 %) is in small flows (around 1 year ARI) with less change observed in large to medium flows (Thoms et al. 2004). Darling River flows within the Selected Area are controlled by a low level weir (weir 20A) downstream of the Warrego and Darling River confluence, which backs up water along the majority of the Selected Area during low flows (P.Terrill, pers comm).

Although the amount and nature of flows have been influenced by upstream structures, the delivery of water to, and within the Selected Area is essentially unregulated, dependent on rainfall and natural flows rather than from specific water releases from dams. This has implications for the use and monitoring of Commonwealth water for the environment in this Selected Area.

Table 2-1 Darling Basin headwater storages (Thoms and Sheldon 2000).

Dam	Date completed	River system	A. Storage capacity (ML)	B. Mean annual inflow (ML)	Ratio of A to B
Beardmore		Condamine	81000		
Coolmunda	1968	Macintyre	75200	25000	3.01
Glenlyon	1976	Pike Ck	261000	76000	3.43
Leslie Pindari	1985 1962–96	Sandy Ck Severn	108000 312000	186000	1.68
Copeton	1976	Gwydir	1364000	450000	3.03
Split Rock	1987	Manila	397000	113000	3.51
Keepit	1960	Namoi	423000	420000	1.00
Chaffey	1979	Peel	62000	63000	0.98
Burrendong	1967	Macquarie	1678000	750000	2.24
Windamere	1984	Cudgegong	368000	54000	6.81

2.4 Fish communities

The MDB contains approximately 46 of Australia's roughly 300 species of freshwater fish. Genetic studies are prying apart formally complex taxonomic groups (e.g. *Hypseleotris*, *Retropinna*, *Galaxias*) and an increasing body of survey data continues to reveal the presence of species previously unknown from the basin (e.g. Rendahl's tandan and desert rainbowfish). Consequently, the number of species occupying waters within the Murray-Darling basin will likely increase in future years. Not all species occur at all sites: some are restricted to the warmer northern waters (e.g. spangled perch, Hyrtl's tandan) and others to southern locations with access to the sea (e.g. common galaxias, Congolli, lampreys) (Lintermans 2007). Fourteen species of native freshwater fish are known or expected to occur within the Warrego-Darling Selected Area with another three exotic species also present (CEWO 2017). The Darling and Warrego River catchments also form part of the distribution of the Darling River snail (*Notopala sublineata*), which is listed as critically endangered under NSW fisheries legislation (NSW DPI 2018).

Although no Australian freshwater fish species has become extinct since European settlement, approximately 40 per cent of the Australian freshwater fish fauna is now considered of conservation concern. Many species have either suffered a significant decline in distribution, or are now found only in restricted areas. The MDB has a high proportion of alien species—12 of the 47 fish species are alien or translocated. Alien fish now make up about 70 per cent of the numbers and 80–90 per cent of the biomass of fish in many rivers (Lintermans 2007). Threatening processes contributing to species decline in the MDB include (Arthington *et al*. 2016):

- Flow regulation
- Habitat degradation
- Lowered water quality
- Barriers
- Alien species
- Diseases

Twenty-six of the 46 native species in the MDB are recognised as either rare or threatened on State, Territory or National listings (Lintermans 2007). The Warrego-Darling Selected Area contains five species that are listed under state or national conservation listings (Table 2-2). The Selected Area also resides within the Lowland Darling River endangered aquatic ecological community. The aquatic ecological community of the lowland Darling River includes all native fish and aquatic invertebrates within all natural creeks, rivers, streams and associated lagoons, billabongs, lakes, anabranches, flow diversions to anabranches and floodplains of the Darling River within NSW. The listing includes:

- Menindee Lakes
- The Barwon River
- The main Barwon-Darling channel from Mungindi (Queensland-NSW border) to the convergence with the Murray River
- The arid zone intermittent intersecting streams (Warrego, Culgoa, and Narran rivers)
- The Border Rivers (Macintyre, Severn and Dumaresq rivers)
- The regulated tributaries (Gwydir, Namoi, Macquarie, Castlereagh, and Bogan rivers).

The community has a diverse assemblage of native species, including 21 native fish species and hundreds of species of native invertebrates, many of which have not been comprehensively studied (NSW DPI 2007).

The Warrego catchment is considered a key asset for golden and silver perch, with both species known to breed successfully there and contribute to disparate populations downstream during environmental and natural flow events. (Eco Logical Australia 2017, MDBA 2019). A further two species: un-specked hardyhead (*Craterocephalus stercusmuscarum fulvus),* and desert rainbowfish (*Melanotaenia splendida tatei*) also occur rarely with the selected area drainages (CEWO 2017).

Table 2-2 Endangered fish species occurring within the Warrego-Darling Selected Area, according to State, Territory and National listings.

Common Name	Scientific name	NSW	QLD	National
Tandanus catfish	*Tandanus tandanus*	EN POP		
Olive perchlet	*Ambassis agassizii*	EN POP		
Murray cod	*Maccullochella peelii*			V
Silver perch	*Bidyanus bidyanus*	V		CE
Southern purple-spotted gudgeon	*Mogurnda adspersa*	EN		

Key: EN = Endangered; EN POP = endangered population, V = vulnerable, CE = critically endangered
National status determined under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC).

3. Commonwealth Environmental Watering

3.1 Overview of watering options

Options for the use of planned Commonwealth water for the environment need to balance water availability with environmental demand according to on-going ecological and operational considerations. Basin-scale environmental watering needs will be based largely on the Basin's annual environmental watering priorities developed yearly by the MDBA.

The Basin Plan identifies four key environmental objectives to protect and restore water-dependent ecosystem of the MDB (Gawne et al. 2013a); biodiversity, ecosystem function, resilience and water quality. Water for the environment in the Warrego-Darling Selected Area can be used to support five environmentally significant flow types to achieve the Basin Plan key objectives (Very Low Flow, Baseflow, Freshes, Bankfull, Overbank). Each flow type contributes different functions in the three water-dependent ecosystem types occurring in the Warrego and Darling River systems (River, Wetland, Floodplain), by influencing biodiversity, ecosystem function, resilience and/or water quality (Table 3-1).

Each water year, the CEWO develops a series of water options that may be taken in the year to come. These water options are prepared for the full range of catchment inflow scenarios that may occur given the highly variable nature of rainfall experienced across the northern MDB (CEWO 2018). The main determinants for water for the environment actions include the antecedent conditions, the magnitude and pattern of individual flow events, and the current availability of Commonwealth water for the environment entitlements (CEWO 2018).

In addition to these annual watering options, the CEWO in collaboration with NSW Office of Environment and Heritage (OEH) has developed a 5 year strategy for the use of Toorale-Warrego Commonwealth water for the environment. As part of this strategy, a decision tree has been developed to guide the use of Commonwealth water in the Selected Area (Figure 3-1).

Through this process, several watering priorities have been identified that will be targeted depending on the prevailing weather and flow conditions. Essentially, if downstream demand in the Darling River is high, then providing flows through the lower Warrego channel to the Darling confluence will be prioritised, unless the demand on the Western Floodplain is also high, in which case flows will be shared evenly between the Warrego channel and Western Floodplain. Factors that may affect these decisions are; in-stream demand in the Darling River; the length of time since Darling River flows have been in target range, Darling River water quality issues; environmental demand in Darling and Murray Rivers; and in-stream demand in the lower Warrego River. The process of prioritising the use of Warrego Commonwealth water for the environment using this strategy will be done on an event by event basis when the Warrego River flows.

Table 3-1 Flow type function on rivers, wetlands and floodplains (Gawne et al 2013a).

Flow type	River	Wetland	Floodplain
Very low flows, Base flow	Flow that protects refugia, sustains water quality, productivity and biodiversity	-	-
Freshes	In-channel disturbance maintains littoral habitat, scours biofilm and provides longitudinal connectivity Will affect water quality and ecosystem functions but the effects vary	-	-
Bankfull	In-channel disturbance Influences in-channel and riparian habitat, provides longitudinal connectivity Sediment transport influences long-term channel form	Only inundates wetlands connected at bankfull, typically those closely connected to parent river Influence on all water-dependent species habitat, provides some lateral connectivity, major stimulus for primary productivity, decomposition and nutrient cycles Maintain permanent wetlands as refugia	-
Overbank / terminal wetlands	In-channel disturbance Major influence on in-channel and riparian habitat, provides longitudinal and lateral connectivity, major stimulus for other ecosystem functions Sediment transport influences long-term channel form	Major influence on ecosystem diversity and habitat, provides connectivity, major stimulus for primary productivity, decomposition and nutrient cycles Maintain permanent wetlands as refugia	Major influence on ecosystem diversity and habitat, provides connectivity, major stimulus for primary productivity, decomposition and nutrient cycles Maintain permanent wetlands as refugia Magnitude of flows is important for differentially inundating low lying and higher areas of the floodplain

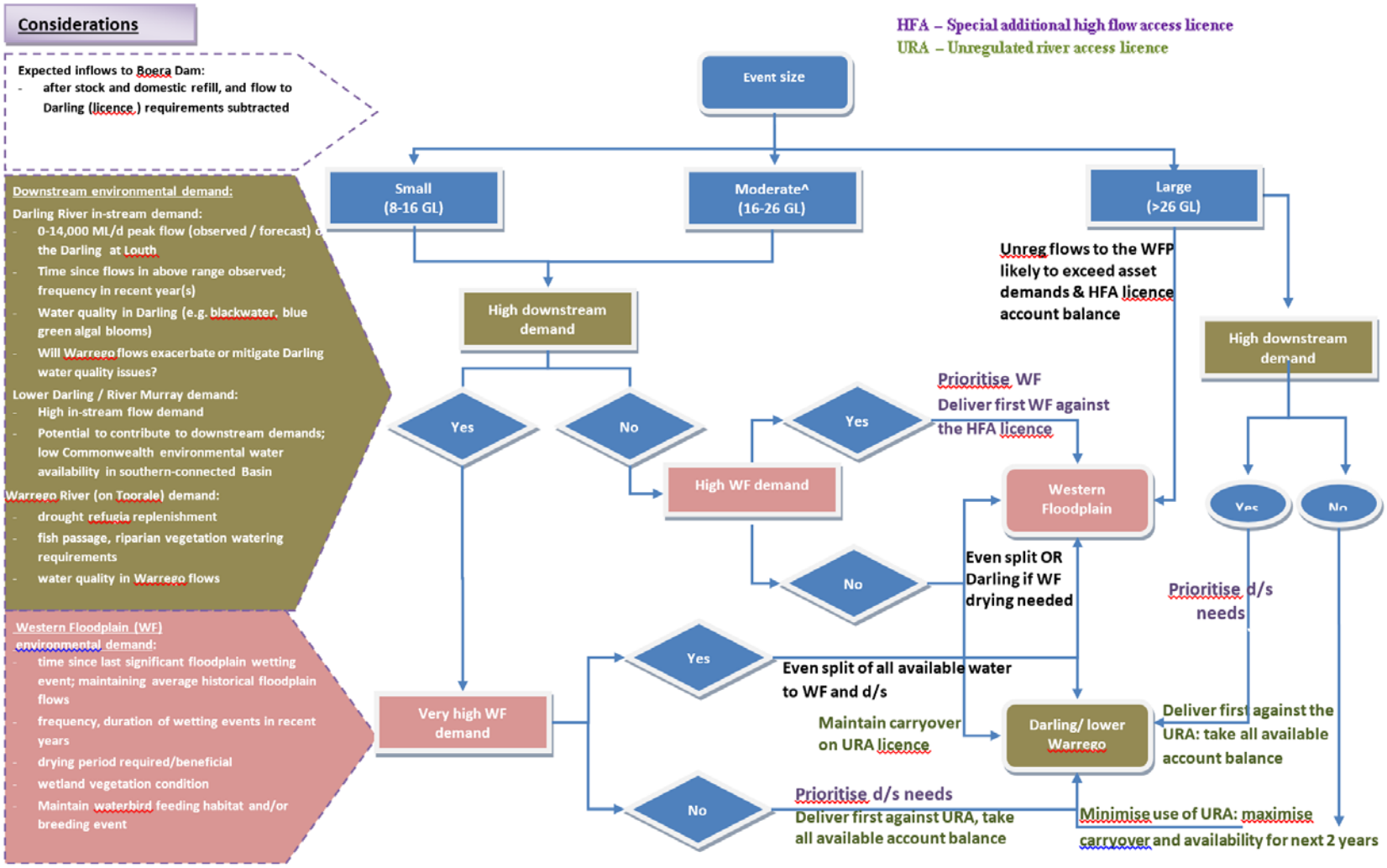

Figure 3-8 Decision tree for considering Toorale Warrego Commonwealth water for the environment.

3.2 Expected outcomes

High-level outcomes have been determined through the LTIM Project for the Selected Area for the Darling River (Table 3-2) and the Warrego River (Table 3-3). Watering options for the Northern Intersecting Streams will be developed each year by CEWO for the term of the MER Project. These options will be developed within the CEWO Outcomes Framework to ensure that expected outcomes of Commonwealth environmental watering are based on the Basin Plan's environmental watering objectives (CEWO 2013b).

More specific flow bands have been identified by the CEWO for the Darling River in the Selected Area that may be most influenced by Commonwealth water for the environment. These flows are in the 'base flows' and 'freshes' flow components below 30,000 ML/day at Bourke (Table 3-4). These flow bands have been identified through the review of a number of flow ecology studies within the Selected Area region (Boys 2007, Mitrovic et al. 2011, Sheldon and Thoms 2006, Southwell 2008).

The CEWO released the 2019-20 Commonwealth watering options for the Barwon-Darling and Queensland unregulated streams (CEWO 2018; 2019). These documents outline both the expected 2019-20 and longer term outcomes from the use of Commonwealth water for the environment in the Intersecting Streams and the Barwon-Darling (Table 3-5). It should be noted that not all these outcomes are relevant to the Warrego-Darling Selected Area (see shading in Table 3-5).

Table 3-2 Expected outcomes for the Darling River (Gawne et al. 2013b).

Flow component	Level 1 objectives	Level 2 and 3 objectives	Suggested < 1 year outcome	Suggested long-term outcomes
Base flow, Freshes	Resilience	Resilience	Affects refugia for aquatic biota.	As for < 1 year outcome
Freshes, Bankfull	Biodiversity	Ecosystem	Affects within ecosystem diversity	Affects ecosystem landscape diversity
Freshes, Bankfull	Biodiversity	Vegetation	Affects riparian native vegetation condition.	Affects vegetation diversity and extent
Freshes, Bankfull	Biodiversity	Fish	Fish breeding and recruitment	Affects native fish population, diversity and condition.
Freshes, Bankfull	Biodiversity	Other vertebrates	Affects frog and turtle condition and breeding and recruitment	Maintain or improve frog and turtle populations
Freshes, Bankfull	Function	Connectivity	Dispersal of native fish (before, during and after breeding)	Maintain or improve landscape fish and other vertebrate diversity
Freshes	Function	Connectivity	Maintain in-channel benches	
Freshes	Function	Process	Affects biofilm productivity	As for < 1 year outcome
Freshes, Bankfull	Water quality	Chemical	Affects water quality	Affects populations of native fish, invertebrates and frogs
Freshes	Water quality	Chemical Biological	Contribute to prevention or amelioration of anoxia and algal blooms	
Base flow, Freshes	Resilience	Resilience	Affects refugia for aquatic biota.	As for < 1 year outcome
Freshes, Bankfull	Biodiversity	Ecosystem	Affects within ecosystem diversity	Affects ecosystem landscape diversity

Table 3-3 Expected outcomes for the Warrego River (Gawne et al. 2013b).

Flow component	Level 1 objectives	Level 2 and 3 objectives	< 1 year outcome	Long-term outcomes
Base flow, Freshes and Overbank (infrastructure assisted)	Biodiversity	Ecosystem	Affects within ecosystem diversity	Affects ecosystem landscape diversity
Freshes and Overbank (infrastructure assisted)	Biodiversity	Vegetation	Affects riparian, wetland and floodplain native vegetation condition	Affects vegetation diversity and extent
Base flow, Freshes and Overbank (infrastructure assisted)	Biodiversity	Fish (see resilience)	Affects native fish condition	Affect native fish populations and diversity
Freshes and Overbank (infrastructure assisted)	Biodiversity	Fish	Affects native fish breeding and recruitment	Affects native fish populations and diversity
Freshes and Overbank (infrastructure assisted)	Biodiversity	Waterbirds	Affects water bird condition	Affects waterbird populations
Freshes and Overbank (infrastructure assisted)	Biodiversity	Other vertebrates	Affects frog and turtle condition and supports breeding and recruitment	Affects frog and turtle populations
Freshes	Function	Connectivity	Maintain in-channel benches	
Base flow, Freshes and Overbank (infrastructure assisted)	Function	Process	Affects biofilm productivity	
Overbank (infrastructure assisted)	Function	Process	Affects floodplain vegetation productivity	
Base flow	Resilience	Resilience	Refugia for aquatic biota	As for < 1 year outcome
Overbank (infrastructure assisted)	Resilience	Resilience	Affects viability of seedbank/rhizomes and long-lived vegetation	Maintain landscape vegetation diversity
Freshes	Water quality	Chemical	Affects water quality in refuge pools	Affects diversity of key biota (fish, frogs, macroinvertebrates)

Table 3-4 Target flow bands for Commonwealth water for the environment identified for the Darling River within the Selected Area.

Flow Type	Flow Band	Expected Outcomes
Freshes	1,000-5,000 ML/day	- Connection of in-channel low flow refugia - Inundation of low level habitat (large wood and benches) - Limited sediment/nutrient transfer - Limited movement of aquatic species
Freshes	5,000-10,000 ML/day	- Connection of entire stream network - Inundation of large wood and mid-level benches - Sediment/nutrient transfer - Movement and reproduction of aquatic species
Freshes	10,000-30,000 ML/day	- Inundation of large wood and high-level benches - Sediment/nutrient transfer - Reproduction of large bodied fish species requiring access to woody debris - Suppression of toxic cyanobacterial blooms

Table 3-5 Priority environmental requirements and active management options in 2019-20 in the Northern Intersecting Streams (CEWO 2019).

Environmental demand	Urgency	Specific actions to be considered in 2018–19
Inundation of core waterbird breeding habitat at Narran Lakes	Critical	Enhance a flow event to achieve 25 GL inflow to Narran Lakes (action development well advanced)
Inundation of waterbird breeding and foraging habitat in northern zone of Narran Lakes	Critical	Enhance a flow event to achieve 50 GL inflow to Narran Lakes (action development well advanced)
Toorale Western Floodplain wetland inundation	Low	Enhance overflow from Boera Dam to the Western Floodplain#
Fresh in the Narran River for fish migration	Critical	Enhance flows to achieve 1,000 ML/day for 14 days at Wilby Wilby. (Likely to overlap with 25 GL Narran inflow option, action development well advanced)
Fresh to inundate snags and benches, enable some fish recruitment along the Barwon-Darling	High	Use Toorale Warrego entitlements to help enhance Darling flows
Lower Balonne channels drought refuge (waterholes)	High	Enhance flows with purchased unregulated/regulated water to achieve flow through in all channels particularly the Narran and Birrie rivers
Large scale waterbird breeding event at Narran Lakes	Critical	Support breeding event with additional inflows, if required (action development well advanced)

#Active management at Toorale National Park in 2019 - 20 will be in accordance with the approved strategy for utilization of the Commonwealth's unregulated entitlements on the NSW Warrego River based on highest environmental demand.

3.3 Description of water holdings

Unlike other Selected Areas, Commonwealth water for the environment that flows into the Junction of the Warrego and Darling Rivers is primarily unregulated, and therefore, reliant on rainfall, flows and water management decisions in upstream tributaries. Exceptions to this are the Gwydir, Namoi and Macquarie catchments, in which regulated water for the environment can potentially influence flows in the Warrego-Darling Selected Area, particularly during low-flow periods in the Barwon-Darling River. Flows into the Warrego-Darling Selected Area are also affected by water management actions such as the release of stock and domestic flows, rainfall rejection flows and embargos on upstream pumping. The Warrego-Darling Selected Area and its upstream tributaries comprise multiple Water Planning Areas, with their own rules, licence types and accounting procedures. This adds to the complexity of environmental water accounting and delivery in the Warrego-Darling Selected Area. The current water holdings and their licence types are given for each major tributary that contributes Commonwealth water for the environment are available on the CEWO's website at https://www.environment.gov.au/water/cewo/about/water-holdings.

3.4 Practicalities of watering

The delivery of Commonwealth water for the environment to, and within the Selected Area, is complex given the highly variable and unregulated nature of the flow regime, the potential for upstream abstractions of flows and the significant natural flow losses in upstream systems. Constraints in the upstream Darling catchment and within the system may mean that environmental requirements are not met at all times as the duration of flows may be limited to the duration of tributary and upstream inflows. The CEWH will enter into arrangements with the NSW state government and other water for the environment holders, managers and authorities (delivery partners) to optimise the delivery of water for the environment (CEWO 2013a).

The catchment upstream of the Warrego-Darling Selected Area is essentially unregulated, with the exception of four sub-catchments, being the Border Rivers, Gwydir, Namoi and Macquarie. Of these catchments only the Gwydir represents any real potential influence for the Selected Area in terms of end of system Commonwealth environmental flows. Unlike other catchments, the majority of water needed to meet the Commonwealth environmental watering requirements in the Warrego-Darling Selected Area cannot be delivered by upstream impoundment releases, rather licencing conditions relating to stream flow limit water extraction to ensure water is retained within the system during natural flow events. The Commonwealth holds water entitlements at various locations within the Selected Area (Figure 2-2) and these become active when certain flow conditions (thresholds) are met under each licence class. Commonwealth water for the environment is accounted for when flow thresholds are met for each flow access class (A, B or C) from the beginning of the year, and then all flows thereafter until the maximum proposed volumes are exhausted (CEWO 2014).

4. Monitoring and Research Priorities

4.1 Prioritisation of hydrological monitoring zones

Monitoring and research priorities in the Selected Area focus on the reaches of the Warrego and Darling Rivers and the Western Floodplain contained within the boundary of the Toorale National Park (NP) and Toorale State Conservation Area (c.f. Figure 2-2). The monitoring zones have been selected using a hierarchical set of criteria:

- Does the reach have uniform hydro-geomorphic characteristics?
- Is the reach a target for CEWO water deliveries?
- Are there specific environmental assets targeted for the delivery of CEWO water via a watering option?
- Do the physical characteristics and infrastructure of reaches allow the discrete delivery of CEWO water?
- Does the reach contain an array of gauging stations (two or more) that permit the description of reach hydrology?

Using this set of criteria, three discrete monitoring zones were selected (Table 4-1, Figure 4-1):

- The Western Floodplain of the lower Warrego River
- The lower Warrego River channel extending from the northern boundary of the Toorale NP to its confluence with the Darling River, including Ross Billabong
- The Darling River from the eastern boundary of the Toorale NP to Weir 20A

These zones represent distinct and discrete regions of the Selected Area in terms of their geomorphology, hydrology, environmental assets, environmental targets and expected outcomes from Commonwealth water for the environment. The delivery of Commonwealth water for the environment to monitoring zones relies on unregulated upstream entitlements during natural flow events. Thus, at this site, Commonwealth water for the environment is water that remains in the system instead of being extracted. The largest influence of Commonwealth water for the environment is on base flows and freshes up to 30,000 ML/day in the Darling River and infrastructure assisted overbank flows to the Warrego's Western Floodplain.

Table 4-1 Junction of the Warrego and Darling Rivers Selected Area monitoring zones.

Zone	Extent	Description	Potential target flow types for monitoring
Western Floodplain	The Western Floodplain of the lower Warrego River from Boera Dam off take to the Darling River	A large floodplain surface heavily dissected by small flood runners. Floodwaters inundate this floodplain from overflows at Boera Dam.	Overbank – infrastructure assisted.
Warrego River	The lower Warrego River channel extending from the northern boundary of Toorale National Park to the junction with the Darling River, including Ross Billabong	A single meandering river that decreases in bankfull capacity downstream. Flows in this lower section of the Warrego River are controlled by a series of six in-channel structures, the lower of which (Peebles Dam) diverts water into Ross Billabong.	Base flows Freshes up to 600 ML/day
Darling River	The Darling River from the eastern boundary of the Toorale National Park near Hells Gate to Weir 20A downstream of the western boundary of Toorale State Conservation Area.	A single meandering channel that has a bankfull height ranging 12-15 m. The bankfull channel is complex and there are a series of natural rock bars and a weir at the downstream end of the reach that influence flows along this section of the river.	Baseflows Freshes: 1,000-5,000 ML/day 5,000-10,000 ML/day 10,000-30,000 ML/day

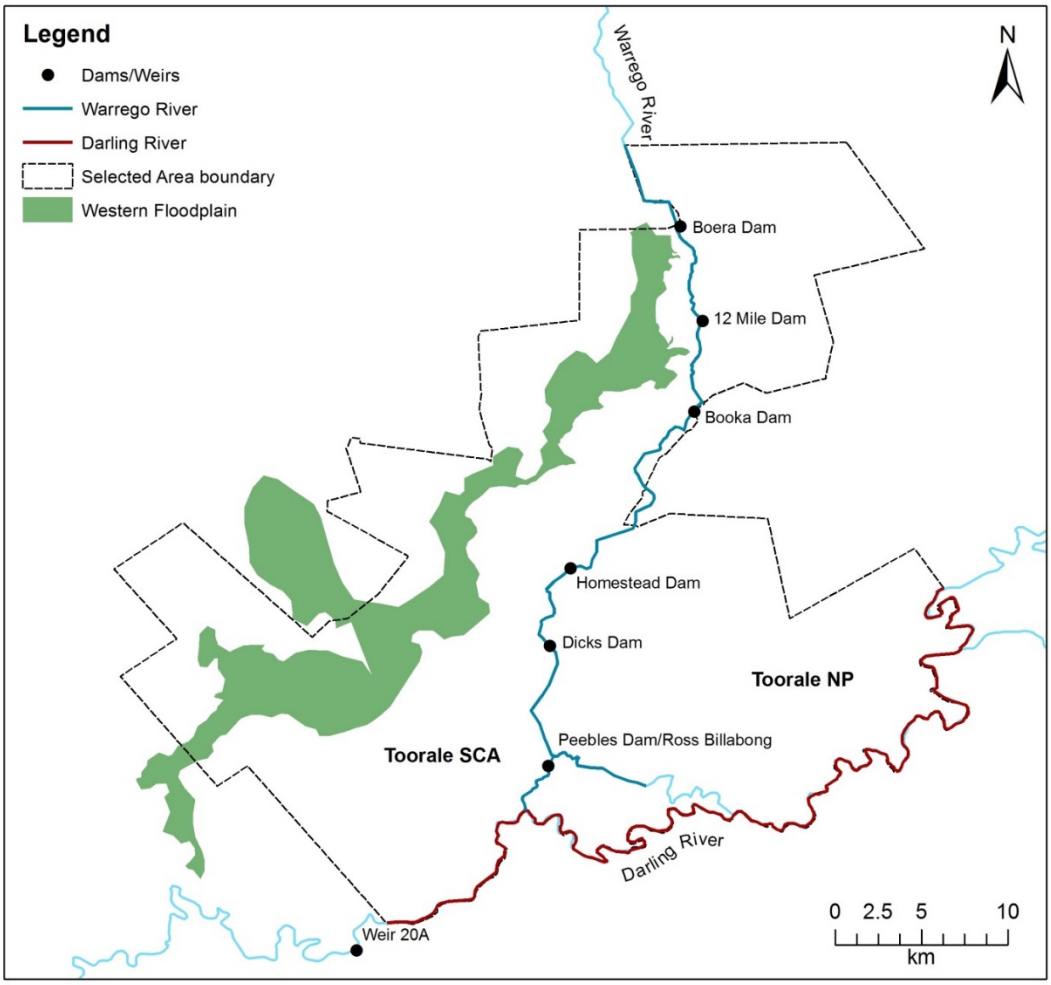

Figure 4-9 Junction of the Warrego and Darling rivers Selected Area monitoring zones.

4.2 Stakeholder priorities for monitoring and research

This plan continues the focus on intervention monitoring of priority indicators selected for the Selected Area following extensive local area consultation (Gawne et al. 2013a; Gawne et al. 2013b), whole of Basin consideration of scalable indicators, and methods of collection and ongoing consultation through the Warrego-Darling Selected Area Working Group and Warrego-Darling LTIM Project and MER Project teams. Basin-scale indicators (Category I) were developed to ensure that Basin-scale evaluation needs are met. In addition, Category II and III indicators have been developed for Selected Area and Basin-scale evaluation with the following definitions:

> *Category I* – Mandatory indicators and standard protocols which are required to inform quantitative Basin Evaluation. Indicators have been identified for each Selected Area in this category and must be applied in a consistent manner following standard protocols;
>
> *Category II* – Optional indicators with mandatory standard protocols which may be used to inform quantitative Basin Evaluation in the future. In the event that any of these indicators are implemented by MER Providers at the Selected Area, the standard protocol must be followed; and

Category III – Optional indicators with Selected Area specific protocols and mandatory reporting requirements. This includes Selected Area specific monitoring using locally appropriate methods.

Extensive stakeholder consultation throughout the LTIM Project (2014-2019) and in the recent MER planning phase (February – May 2019) confirmed that priority monitoring indicators and their evaluation methods are to continue into the 2019-2022 Warrego-Darling MER Project. Consultation included two Warrego-Darling Selected Area Working Group meetings, a whole-of-MER Program Inception meeting, the Northern Basin Environmental Flow forum held at UNE with key government agencies working on water for the environment in the northern MDB, and targeted meetings with collaborators and stakeholders (NSW OEH Science Section, NSW NPWS). From these, 14 indicators relevant to the Warrego-Darling Rivers Selected Area and at the Basin-scale were prioritised and continued from the LTIM program (Table 4-2).

Table 4-2 Junction of the Warrego and Darling Rivers Selected Area monitoring indicators.

Monitoring indicator	Category
Ecosystem Type	I
Hydrology (Northern Tributaries)	III
Hydrology (River)	I
Hydrology (Channel)	III
Hydrology (Floodplain)	III
Hydrology (Habitat)	III
Vegetation Diversity	II
Fish (Channel)	III
Waterbird Diversity	III
Water Quality	III
Stream Metabolism	I + III
Microinvertebrates	III
Macroinvertebrates	III
Frogs	III

As part of the development of the Research Plan (Section 6), we held a Northern Murray Darling Basin Environmental Flows Workshop with stakeholders from CEWO, MDBA, NSW OEH and NPWS, NSW DPI, NSW DoI and WaterNSW, and Qld DNRME. This workshop bought together the major agencies involved in monitoring and research of water for the environment across the regions that encompass the Gwydir River and Warrego-Darling Selected Areas.

This workshop reinforced the direction and themes of the Integrated Research Plan, with priority for the MER Program within four proposed research themes (see detail in Section 6):

1. Modelling inundation extent of floodplain and wetland habitats
2. Building resilience: understanding ecological thresholds in low flow refugia
3. Developing a model to predict food web responses to environmental flow delivery.
4. Biodiversity responses to Commonwealth water for the environment.

5. Indicators

This monitoring and evaluation schedule links the Basin-scale and Selected Area evaluation questions with study design, Standard Methods and Selected Area-specific methods, hypotheses and the analytical and reporting approach. Hypotheses and evaluation methods included are generalised to address only the evaluation questions for each indicator, and are not exhaustive lists of potential hypotheses for each indicator and interactions among indicators.

Standard Operating Procedures (SOPs) including detailed methods are provided in Appendix B.

All indicators monitored under the Warrego-Darling LTIM Project will continue to be monitored under the Warrego-Darling MER Project. To ensure consistency in monitoring data collection and analysis, core monitoring data will be collected using Standard Methods from the LTIM Project (Table 5-1). Minor changes to sampling location and frequency have resulted from incorporating experience and learnings from the LTIM Project and advice from key stakeholders. In most cases the Warrego-Darling MER Project will maintain or extend the monitoring program undertaken during the Warrego-Darling LTIM Project.

To ensure reporting effectiveness and improve communication and engagement of outcomes, several indicators that were reported separately under the LTIM Project will be combined into more comprehensive chapters for MER Project reporting and communication.

For the Warrego-Darling Selected Area, stakeholder engagement and gap analyses have identified that priority research questions are integrated across several indicators. As such, detailed research plans are not included in this section, rather are included in Section 6 as part of the Integrated Research Plan.

Table 5-1 Comparison of LTIM and MER indicators and reporting structure

LTIM indicator	MER Indicator	MER reporting chapter
Hydrology (Northern Tributaries)	Hydrology (Northern Tributaries)	Hydrology (Northern Tributaries)
Hydrology (River)	Hydrology (River)	Hydrology
Hydrology (Channel)	Hydrology (Channel)	
Hydrology (Floodplain)	Hydrology (Floodplain)	
Hydrology (Habitat)	Hydrology (Habitat)	
Ecosystem Type	Ecosystem Type	
Fish (Channel)	Fish (Channel)	Fish
Vegetation Diversity	Vegetation Diversity	Vegetation
Waterbird Diversity	Waterbird Diversity	Waterbirds
Frogs	Frogs	Frogs
Water Quality	Water Quality	Food webs
Stream Metabolism	Stream Metabolism	
Microinvertebrates	Microinvertebrates	
Macroinvertebrates	Macroinvertebrates	

5.1 Hydrology (Northern Tributaries)

5.1.1 Monitoring

This indicator will demonstrate the contributions of Commonwealth water for the environment from upstream tributaries to the Darling River reaches of the Selected Area by using an established hydrological model of these inputs (Figure 5-1) developed from the LTIM Project. Refinement of this indicator will occur through the Warrego-Darling MER Project as new information is incorporated from the active management of environmental flows in the Barwon-Darling, and new rules to protect environmental flows are included in the revised Barwon-Darling Water Sharing Plan and Water Resource Plan. This will provide a broader understanding of the contributions of Commonwealth water for the environment in the Northern MDB. In addition, this indicator will assist in understanding hydrological connectivity and duration for several other indicators.

The SOP for Hydrology (Northern Tributaries) is provided in Appendix B.1.

Monitoring occurs in the broader Darling River catchment upstream of the Selected Area. The gauge network maintained by WaterNSW in this region and in the Selected Area has sufficient distribution and quality to ensure that no additional gauge stations are required for the delivery of this indicator (Table 5-2, Figure 5-1). Where required, discharge data from Queensland gauges will also be used for this indicator.

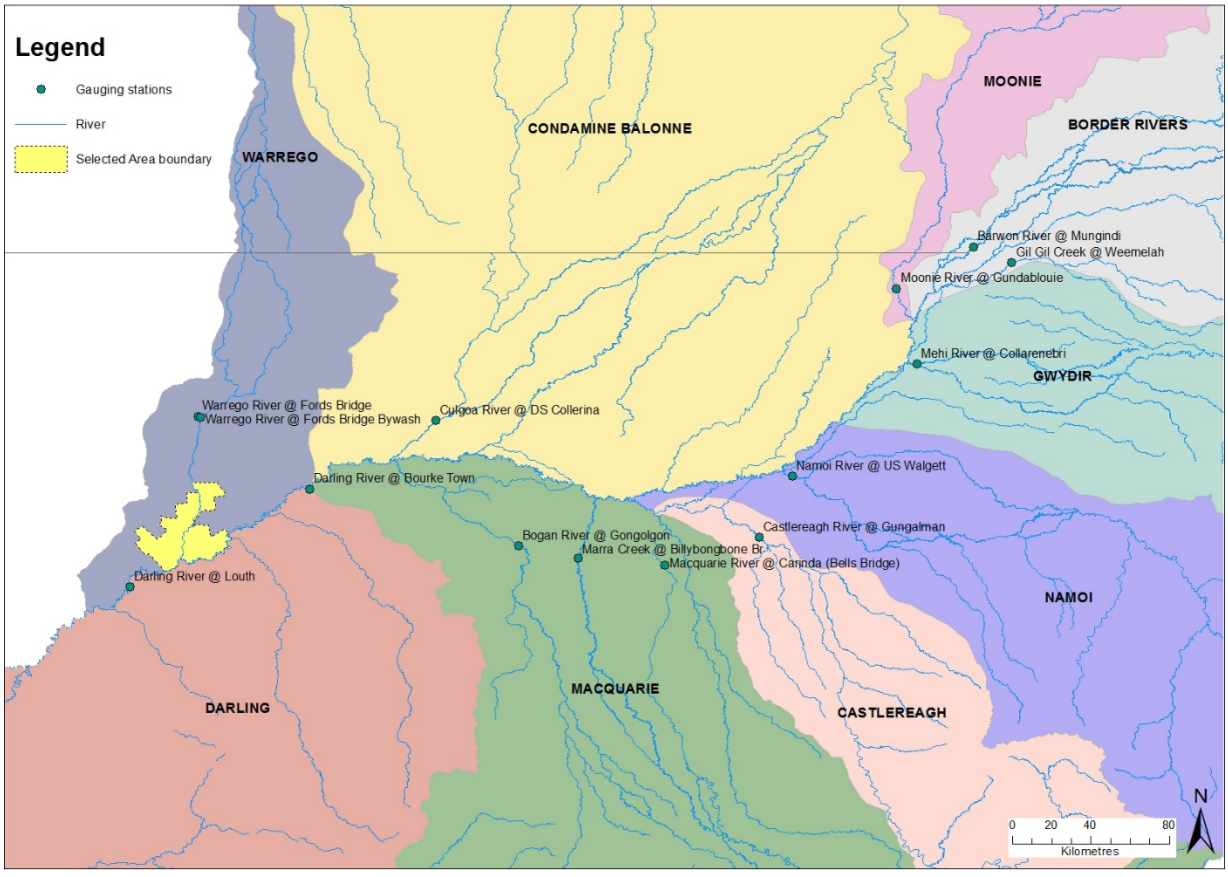

Figure 5-10 WaterNSW gauging stations used for the Hydrology (Northern Tributaries) indicator.

Table 5-2 WaterNSW gauging stations within upstream catchments.

Gauge no.	Gauge Name	Catchment	Latitude	Longitude
416001	Barwon River @ Mungindi	Border Rivers	-28.9762	148.9848
417001	Moonie River @ Gundablouie	Moonie	-29.1671	148.6305
416027	Gil Gil Creek @ Weemelah	Gwydir	-29.0488	149.1599
418055	Mehi River @ Collarenebri	Gwydir	-29.5130	148.7241
419091	Namoi River @ US Walgett	Namoi	-30.0279	148.1529
420020	Castlereagh River @ Gungalman	Castlereagh	-30.3088	147.9999
421012	Macquarie River @ Carinda (Bells Bridge)	Macquarie	-30.4347	147.5696
421107	Marra Creek @ Billybongbone Br	Macquarie	-30.4032	147.1710
421023	Bogan River @ Gongolgon	Bogan	-30.3472	146.8978
422006	Culgoa River @ DS Collerina	Condamine Balonne	-29.7735	146.5179
423001	Warrego River @ Fords Bridge	Warrego	-29.7526	145.4276
423002	Warrego River @ Fords Bridge Bywash	Warrego	-29.7568	145.4408
425003	Darling River @ Bourke Town	Darling	-30.0861	145.9387
425004	Darling River @ Louth	Darling	-30.5347	145.1151

Data will be managed following the requirements outlined in the LTIM Project Standard Protocol: Section 14 Hydrology (River) (Hale et al. 2014) and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

5.1.2 Evaluation

Selected Area evaluation question

- What did Commonwealth water for the environment from upstream tributaries contribute to hydrological connectivity?

Approach to evaluation

This indicator links to Food Webs (Water Quality, Metabolism, Microinvertebrates and Macroinvertebrates), Vegetation Diversity, Fish (River) and Waterbird Diversity indicators.

Statistical Analyses

Standard hydrological analyses will be used to determine relationships between end-of-system Commonwealth water for the environment flows from upstream tributaries and flows entering the Selected Area. These relationships will inform a working hydrological model of inputs of Commonwealth water for the environment from upstream tributaries to the Selected Area. This indicator will also provide context for a number of other indicators.

5.2 Hydrology (River)

5.2.1 Monitoring

This indicator sources and analyses hydrological data to understand the system hydrology and character of Commonwealth water for the environment entering the Selected Area. It also assists to understand hydrological connectivity and duration for several other indicators. The Hydrology (River) indicator is reported with the Hydrology (Channel), Hydrology (Floodplain), Hydrology (Habitat) and Ecosystem Type indicators.

The SOP for Hydrology (River) is provided in Appendix B.2.

Monitoring occurs across the entire Selected Area. Long-term gauging stations operated by WaterNSW are located in the Warrego River upstream of the Selected Area at Fords Bridge on the Warrego, and also at Boera Dam at the northern end of the Selected Area. There are also three gauging stations on the Darling River at Bourke, Weir 19A and Louth (Table5-3, Figure 5-2). At present there are also a number of water level sensors that have been placed along the Western Floodplain and the Darling River within the Selected Area (Figure 5-2, Table 5-4).

Table 5-3 WaterNSW Gauges and the zones to which they relate.

Zone	WaterNSW Gauge Number	Gauge name	Latitude	Longitude	Datum
B	423001	Warrego @ Fords Bridge	−29.7526	145.4276	GDA94
B	423002	Warrego @ Fords Bywash	−29.7568	145.4408	GDA94
B	423008	Warrego @ Boera Dam	−30.09945	145.4278	GDA94
C	425003	Darling @ Bourke Town	−30.0861	145.9387	GDA94
C	425037	Darling @ D/S Weir 19A	−30.2326	145.6957	GDA94
C	425004	Darling @ Louth	−30.5347	145.1150	GDA94

Table 5-4 Locations of water level recorders within the Selected Area.

Zone	Water sensor location	Latitude	Longitude	Datum
Western Floodplain	Site 1 WF	-30.1210	145.4229	GDA94
	Site 2 WF	-30.1311	145.4204	GDA94
	Site 3 WF	-30.1513	145.4158	GDA94
	Site 4 WF	-30.1737	145.4163	GDA94
	Site 5 WF	-30.3268	145.2650	GDA94
Darling River	Weir 19A	-30.2335	145.7119	GDA94
	Hells Gate	-30.2901	145.5616	GDA94
	Acuna Homestead	-30.4098	145.3345	GDA94
	Weir 20A	-30.4764	145.2593	GDA94

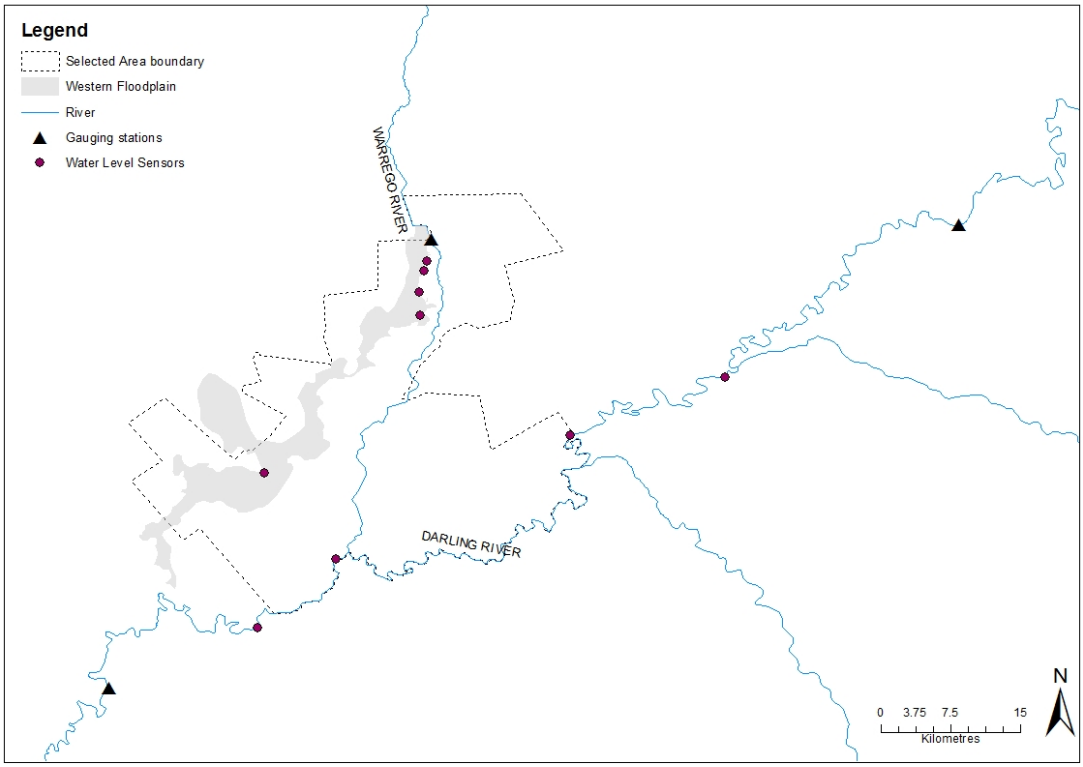

Figure 5-11 WaterNSW gauging stations and water level recorders in the vicinity of the Selected Area.

Data will be managed following the requirements outlined in the LTIM Project Standard Protocol: Section 14 Hydrology (River) (Hale et al. 2014) and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

5.2.2 Evaluation

Basin-scale and Selected Area evaluation questions

- What did Commonwealth water for the environment contribute to hydrological connectivity?

Approach to evaluation

This indicator links to all other indicators.

Statistical Analyses

This indicator will be used to provide context for a number of other indicators. An assessment of the hydrological connectivity experienced throughout the monitoring zones of the Selected Area will be undertaken following the methods outlined in Commonwealth of Australia (2014). Flow connection thresholds estimated through an analysis of historical flow records (from 1990-2014) will be compared with known average stream losses provided by WaterNSW. Once flow thresholds are identified, a spells analysis (Gordon et al. 1992) is undertaken to assess the total duration and frequency of flows passing the gauge. Results for downstream gauges are then subtracted from those at upstream gauges to provide an estimate of full longitudinal connectivity along channels.

5.3 Hydrology (Channel)

5.3.1 Monitoring

The Hydrology (Channel) indicator assesses hydrology within the Warrego River zone to provide a better understanding of the connectivity of the channel and dams along the Warrego River within the Selected Area. Long-term gauging stations operated by WaterNSW are located in the Warrego River upstream of the Selected Area at Fords Bridge, and also at Boera Dam at the northern end of the Selected Area. (Table 5-3, Figure 5-2). Additional depth loggers within this zone will facilitate stage discharge information downstream to the Darling confluence.

The Hydrology (Channel) indicator is reported with the Hydrology (River), Hydrology (Floodplain), Hydrology (Habitat) and Ecosystem Type indicators. This component assists with understanding hydrological connectivity and duration for several other indicators.

The SOP for Hydrology (Watercourse) is provided in Appendix B.3.

5.3.2 Evaluation

Selected Area evaluation questions

Short-term (annual) and long-term questions:

- What did Commonwealth water for the environment contribute to hydrological connectivity along the Warrego River channel?

Approach to evaluation

Evaluation will combine known and measured key flow restrictions (culverts, breached dams etc.) along the Warrego Channel, with current and past hydrological data to continue to refine the model of flow connectivity (hydrodynamic model) within this zone of the Selected Area. This will be done using both existing information of flow restrictions with additional surveying and depth loggers as required. These critical levels will be linked to both gauges within the Selected Area (Boera Dam) and also upstream (Fords Bridge).

This indicator links to Hydrology (River), Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates), Fish (Channel) and Frog indicators.

Statistical analyses

Data gained from this indicator will be linked to hydrological data obtained through the Hydrology (River, Floodplain and Habitat) indicators through a working model, to assess the additional influence of Commonwealth water for the environment on connectivity of various habitats within the Selected Area. In this way we will be able to determine the additional connectivity provided by Commonwealth water for the environment.

5.4 Hydrology (Floodplain)

5.4.1 Monitoring

The Hydrology (Floodplain) indicator assesses the extent and frequency of inundation of the Western Floodplain (Figure 5-3) resulting from the delivery of Commonwealth water for the environment. The LTIM Project has developed a hydrodynamic floodplain model using Lidar imaging, existing water level sensors on the floodplain, soil type and previous inundation mapping. The Warrego-Darling MER Project will continue to use and calibrate this model.

The Hydrology (Floodplain) indicator is reported with the Hydrology (River), Hydrology (Channel), Hydrology (Habitat) and Ecosystem Type indicators. This component assists with understanding hydrological connectivity and duration for several other indicators.

The SOP for Hydrology (Floodplain) is provided in Appendix B.4.

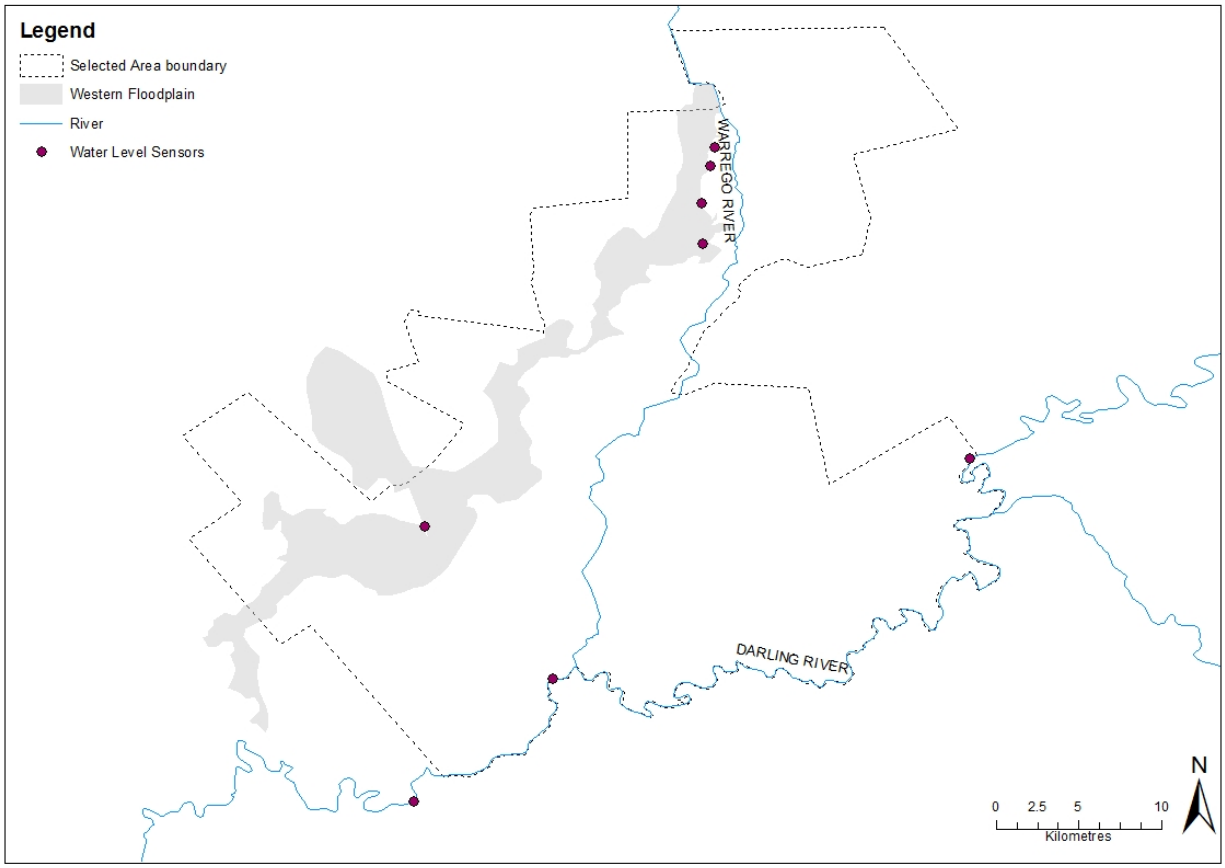

Figure 5-12 Location of Western Floodplain and water sensors.

5.4.2 Evaluation

Basin-scale and Selected Area evaluation questions

Short-term (annual) and long-term questions:

- What did Commonwealth water for the environment contribute to hydrological connectivity of the Western Floodplain?

Approach to evaluation

The hydrodynamic model will be used to create a number of inundation scenarios for the western floodplain. The outputs will be compared to satellite-based mapping. The inundation outputs will be used in conjunction with other locally established gauges to develop location specific knowledge relating flow volume to inundation.

This indicator links to Hydrology (River), Hydrology (Channel), Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates) and Vegetation Diversity indicators.

Statistical analyses

A GIS based analysis will be used to determine the relationship between inundation event (volume) and inundated area and volume in relation to mapped soil and vegetation and ANAE types.

5.5 Hydrology (Habitat)

5.5.1 Monitoring

The Hydrology (Habitat) indicator assesses the connectivity of in-channel habitats including benches, anabranches and large wood in the Darling channel. This indicator uses data from long-term gauging stations operated by WaterNSW located on the Darling River at Bourke, Weir 19A and Louth (Table 5-3, Figure 5-2) as well as a number of water level sensors that have been placed along the Darling River within the Selected Area that are maintained by WaterNSW staff (Figure 5-2, Table 5-4). Flow data will be linked to survey data for in-channel benches, anabranches and large wood following methods outlined in Boys (2007) and Southwell (2008). This information will be combined with current flow data to establish the connectivity and availability of different in-channel habitats, and the related influence of Commonwealth water for the environment on river processes. This provides a reach scale picture of connectivity and habitat availability along the Darling River within the Selected Area.

The Hydrology (Habitat) indicator is reported with the Hydrology (River), Hydrology (Floodplain), Hydrology (Channel) and Ecosystem Type indicators.

The SOP for Hydrology (Habitat) is provided in Appendix B.5.

5.5.2 Evaluation

Selected Area evaluation questions

Short-term (annual) and long-term questions:

- What did Commonwealth water for the environment contribute to in-channel habitat availability along the Darling River?
- What did Commonwealth water for the environment contribute to patterns and rates of primary productivity?

Approach to evaluation

Data gained from this indicator will be linked to hydrological data obtained through the Hydrology (River) indicator to assess the additional influence of Commonwealth water for the environment on connectivity of various habitats within the Selected Area. In this way we will be able to determine the additional connectivity provided by Commonwealth water for the environment.

5.6 Ecosystem Type

5.6.1 Monitoring

The Ecosystem Type indicator will validate all the ANAE category of all new monitoring sites as per the standard methods (Hale et al. 2014). Existing high-resolution imagery, Lidar DEM and fine-scale vegetation mapping will be used as key datasets to help define site polygons through a desk-top analysis. Field verification will then be undertaken to confirm initial classifications. The Ecosystem Type indicator is reported with the Hydrology (River), Hydrology (Floodplain), Hydrology (Channel) and Hydrology (Habitat) indicators.

The SOP for Ecosystem Type is provided in Appendix B.6.

5.6.2 Evaluation

Basin-scale evaluation questions

Short-term (one-year) and long-term (five year) questions:

- What did Commonwealth water for the environment contribute to sustainable ecosystem diversity?
- Were ecosystems to which Commonwealth water for the environment was allocated sustained?
- Was Commonwealth water for the environment delivered to a representative suite of ecosystem types?

Approach to evaluation

This indicator will be evaluated as per the LTIM Project Standard Protocol: Section 2 Ecosystem Type (Hale et al. 2014). Existing high-resolution imagery (e.g., ADS40), Lidar DEM and fine-scale vegetation mapping will be used as key datasets to help define site polygons.

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

Statistical analyses

An aggregated list of ecosystem diversity will ensure adequate and representative suite of ecosystems in the Selected Area. The Hydrology (Floodplain) method reports the area (m^2) ANAE typology and vegetation community inundated from Commonwealth water for the environment. The indicator will document the area of inundated ANAE and vegetation hydrology and will facilitate the scaling of potential Food Webs (Water Quality, Metabolism, Microinvertebrates and Macroinvertebrates), and Vegetation Diversity.

5.7 Fish (Channel)

5.7.1 Monitoring

Both small and large bodied fish will be assessed using Sustainable Rivers Audit (SRA) protocols (Davies et al. 2010). Fish will be sampled using a combination of boat electrofishing (12 x 90 second shots) un-baited bait traps and Fyke nets. All fish will be identified, counted, measured and weighed (maximum of 50 individuals per species per electrofishing shot). The overall design for the Fish (Channel) indicator has been structured to provide Selected Area specific information. This indicator will be sampled in locations in waterholes behind structures in the Warrego River zone and at the junction with the Darling River as these provide the most permanent refugia within this zone, and 5 sites in the Darling River zone of the Selected Area (Figure 4-1).

DPI Fisheries will be contracted to undertake Fish (Channel) monitoring in two events within the three-year Warrego-Darling MER Project. Each event will comprise two samples (pre-event or existing condition and post-event). The current flow and inundation event in the Warrego (May 2019 onwards), will mean the initial survey may be undertaken as soon as possible in the 2019-20 water year and will represent the existing connected and inundated condition at that time.

The SOP for Fish (Channel) is provided in Appendix B.7.

5.7.2 Evaluation

Basin-scale and Selected Area evaluation questions

Short-term (annual) questions:

- What did Commonwealth water for the environment contribute to native fish community resilience?
- What did Commonwealth water for the environment contribute to native fish survival?

Long-term questions:

- What did Commonwealth water for the environment contribute to native fish populations?
- What did Commonwealth water for the environment contribute to native fish diversity?

Approach to evaluation

This indicator links to Hydrology (River and Channel) and Food Webs (Water Quality, Metabolism, Microinvertebrates and Macroinvertebrates) indicators.

Statistical analyses

Analyses based on aggregation will be applied at the Selected Area scale for taxonomic diversity and richness. Additionally, fish community data will be summarised using the three main SRA Indicators:

- "Expectedness" (a comparison of the existing catch composition with that of historical fish distributions),
- "Nativeness" (the proportion of native versus alien fishes), and
- "Recruitment" (the recent reproductive activity of the native fish community).

Quantitative analyses will then be applied at the Selected Area scale based on annual watering and an historical 'reference' condition represented by a pre-European fish assemblage (developed by NSW DPI

Fisheries). Multi-year analyses will be quantitatively analysed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model, and a time-lagged trajectory to a pre-defined condition. Uncertainty propagation within and among years will be possible to quantify based on annual comparisons of sites receiving Commonwealth water for the environment compared with those sites not watered.

Short-term (annual) responses:

- Univariate analysis (e.g. ANOVA - main effect - sampling time) for all taxa, each target taxa, each life history guild, taxa reference richness/diversity.
- Diversity-abundance - multivariate analysis (e.g. Permanova, MDS, PCA - factors – sampling time, target taxa, life history guilds, native/exotic, taxa reference composition).

Long-term responses:

- Univariate analysis (main effects – sampling time, years) for all taxa, each target taxa, each life history guild, taxa reference richness/diversity.

5.8 Vegetation Diversity

5.8.1 Monitoring

Vegetation surveys focus on vegetation diversity responses to inundation and will be conducted twice annually: August-October and March-June. Vegetation diversity will be analysed in targeted wetland communities within the Western Floodplain as these areas represent the sites most likely to have communities influenced by Commonwealth water for the environment (Figure 5-4). Site selection is based on both wetland vegetation community and flooding frequency.

Surveys will target 8 monitoring sites that incorporate Coolibah - River Cooba - Lignum woodlands, Coolibah open woodlands, Lignum shrublands and Chenopod low open shrublands in the Western Floodplain. These sites have been established to directly target zones where environmental watering is likely to be delivered. At each site, three 20 x 20 m plots will be sampled. The 0.04 ha plot size is standard for surveying floristics (Sivertsen 2009) and is consistent with LTIM monitoring and other previous vegetation monitoring within the Selected Area (Gowans et al. 2012). At each site, measures of species abundance, structure, tree recruitment and site flooding will be measured. Projected foliage cover will be used to define cover (Hale et al. 2014). Survey methods conform to with the Standard Methods as a Category II indicator (Hale et al. 2014).

If resources permit, additional vegetation monitoring sites may be added to the monitoring program.

The SOP for Vegetation Diversity is provided in Appendix B.8.

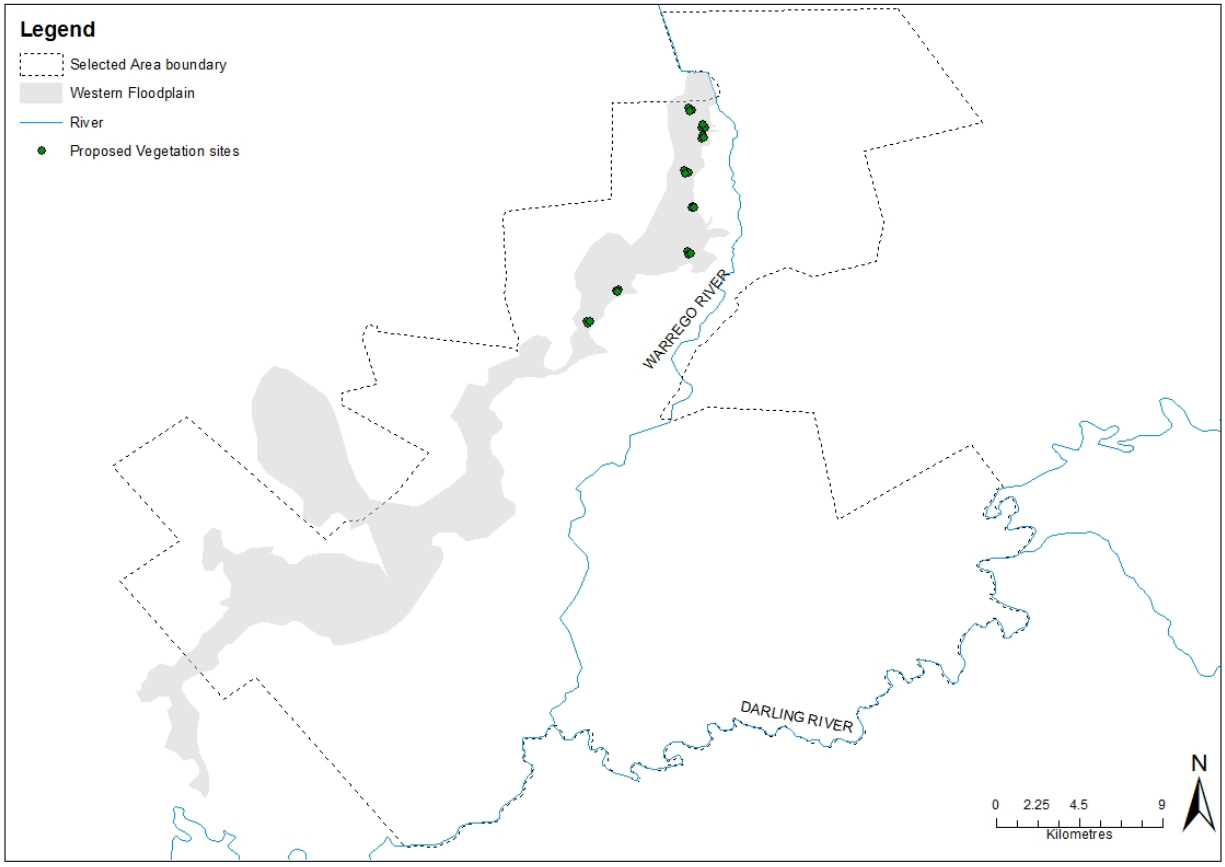

Figure 5-13 Survey sites for vegetation diversity in the Warrego-Darling Selected Area.

5.8.2 Evaluation

Selected Area evaluation questions

Short-term (annual) and long-term questions:

- What did Commonwealth water for the environment contribute to vegetation species diversity?
- What did Commonwealth water for the environment contribute to vegetation community diversity?

Approach to evaluation

This indicator links to Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates) and Hydrology (Floodplain) indicators. There are several Selected Area hypotheses:

Short-term (annual) responses:

- The delivery of Commonwealth water for the environment to wetland and floodplain areas in the Western Floodplain will lead to increased cover and/or richness of wetland vegetation communities.

Long-term responses:

- The delivery of Commonwealth water for the environment to wetland and floodplain areas in the Western Floodplain will lead to increased year-on-year cover and/or richness of wetland vegetation communities.

Statistical analyses

Analyses based on aggregation will be applied at the Basin and Selected Area scales for cover and richness of wetland vegetation communities. Quantitative analyses will be applied at the Selected Area scale to document increased cover and richness of wetland vegetation communities at sites receiving Commonwealth water for the environment. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models. The placement of survey sites has been strategically undertaken to permit quantification of the hydrologic connection and inundation metrics and lead to reduced uncertainty the delivery of Commonwealth water to these sites.

Short-term (annual) responses:

- Hypotheses 1 - univariate analysis (main effect – location, inundation, time) cover and richness and multivariate analysis (factors – location, inundation history, time).

Long-term responses:

- Hypotheses 2 - univariate analysis (main effects – location, inundation history, year, time) and multivariate analysis (factors – location, inundation history, year, time).

Each wetland community within the Western Floodplain has been mapped at a fine spatial scale. Linking wetland vegetation community extent to Commonwealth water for the environment inundation extent should permit extrapolation to the Selected Area scale. The proposed indicator Hydrology (Floodplain) will document the m^2 of inundated ANAE and vegetation hydrology and will facilitate the extrapolation.

5.9 Waterbird Diversity

5.9.1 Monitoring

Waterbird diversity will be undertaken at three sites within the Warrego River zone; Boera Dam, Booka Dam and Peebles Dam/Ross Billabong and opportunistically on the Western Floodplain and Darling River (Figure 4-1). Biannual ground surveys of waterbird diversity will be undertaken on both foot and from a vehicle using observation points or transects depending on the size and shape of the wetland. Surveys are undertaken for at least 20 minutes but no more than 1 hour at each wetland, in order to gain a representative but not necessarily complete, count of all waterbirds in the wetland.

The Waterbird Diversity SOP is given in Appendix B.9.

Surveys will typically occur in February and May but will be responsive to wetland conditions. Sampling will occur three times per event (before, during and after) for two events within the Warrego-Darling MER Project and opportunistically on the Western Floodplain during inundation events (Contingency Monitoring).

5.9.2 Evaluation

Basin-scale and Selected Area evaluation questions

Short-term (annual) and long-term question:

- What did Commonwealth water for the environment contribute to waterbird survival?

Long-term questions:

- What did Commonwealth water for the environment contribute to waterbird populations?
- What did Commonwealth water for the environment contribute to waterbird species diversity?

Approach to evaluation

This indicator links to Food Webs (Water Quality, Metabolism, Microinvertebrates and Macroinvertebrates), Vegetation Diversity and Hydrology (River, Channel and Floodplain) indicators.

There are several Selected Area hypotheses:

Short-term (annual) responses:

- The delivery of Commonwealth water for the environment will lead to increased waterbird survival.

Long-term responses:

- The delivery of Commonwealth water for the environment will lead to larger waterbird populations.
- The delivery of Commonwealth water for the environment will lead to increased waterbird diversity.

Statistical analyses

Analyses based on aggregation will be applied at the Basin and Selected Area scales for abundance (a complete count), richness and diversity of waterbirds. Quantitative analyses will be applied at the Selected Area scale to document increased abundance, richness and diversity of waterbirds at sites receiving Commonwealth water for the environment. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models.

Short-term (annual) responses:

- Hypotheses 1 and 2 - univariate analysis (main effect – site, time) abundance, richness, diversity.
- Hypotheses 2 - (diversity-abundance) multivariate analysis (factors – site, time).

Long-term responses:

- Hypotheses 2 and 3 - univariate analysis (main effects – target site, year, time).
- Hypotheses 3 - (diversity-abundance) multivariate analysis (factors – target site, year, time).

The standard method for Waterbird Diversity reports per m^2 ANAE area surveyed inundated from Commonwealth water for the environment. The Hydrology (Floodplain) indicator will document the m^2 of inundated ANAE.

5.10 Frogs

5.10.1 Monitoring

Frog sampling will be targeted at three locations within the Warrego River zone, Boera Dam, Booka Dam and Peebles Dam/Ross Billabong and opportunistically on the Western Floodplain depending on inundation. Adult frog surveys will be carried out following the protocols developed for the LTIM Project. A 2x20 minute visual encounter (person minutes) transects and a 6 x 1 minute audio survey will be undertaken at each site after dark. A 15-30 watt spotlight or torch will be used to search for frogs along the wetland edge and into the surrounding terrestrial habitats. All individuals observed are identified to species and the number recorded.

Surveys will typically occur in February and May but will be responsive to inundation conditions. Sampling will occur three times per event (before, during and after) for two events within the Warrego-Darling MER Project and opportunistically on the Western Floodplain during inundation events (Contingency Monitoring). Initial frog surveys will occur twice between July and December 2019 based on the current Western Floodplain inundation event in the Selected Area.

5.10.2 Evaluation

Selected Area evaluation questions

Short-term (annual) and long-term questions:

- What did Commonwealth water for the environment contribute to other vertebrate condition?
- What did Commonwealth water for the environment contribute to vertebrate reproduction?

Long-term questions:

- What did Commonwealth water for the environment contribute to other vertebrate community resilience?
- What did Commonwealth water for the environment contribute to other vertebrate species diversity?

Approach to evaluation

This indicator links to Hydrology (River), Hydrology (Channel), Fish (Channel), and Food Webs (Water Quality and Microinvertebrates). There are several Selected Area hypotheses:

Short-term (annual) responses:

- The delivery of Commonwealth water for the environment water for the environment will lead to increased frog species diversity.
- The delivery of Commonwealth water for the environment water for the environment will stimulate frog breeding.

Short-term (annual) responses:

- The delivery of Commonwealth water for the environment water for the environment will lead to larger frog populations.
- The delivery of Commonwealth water for the environment water for the environment will lead to increased frog diversity.

Statistical analyses

Analyses based on Aggregation will be applied at the Selected Area scale for abundance, richness and diversity of frogs. Quantitative analyses will be applied at the Selected Area scale to document increased abundance, richness and diversity of frogs at sites receiving Commonwealth water for the environment. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models.

5.11 Food Webs (Water Quality)

5.11.1 Monitoring

Category III Water Quality monitoring will be conducted in the Darling River zone at two locations - near the 'Yanda' homestead (-30.34906, 145.57685) and near the 'Akuna' homestead (-30.40978, 145.33438, Figure 5-5). These sites are representative of the zone and were selected due to their proximity to NPWS residences to allow for ease of access and sample collection. The Akuna site is located downstream of the Warrego confluence and can be used to assess the influence of Warrego River flow to the water chemistry of the Darling River. Their location will also allow frequent and/or event based monitoring by NPWS staff. Category III Water Quality monitoring will also be undertaken at all Food web Indicator sites in the Warrego channel and Western Floodplain.

Category III Water Quality will include in situ logging of DO and temperature in key locations in the Warrego and Darling River channels in response to connection events and delivery of Commonwealth water for the environment. In addition, spot sampling of DO, temperature EC, pH, and turbidity will be carried out at Food web sampling locations.

The SOP for Food Webs (Water Quality) is provided in Appendix B.11.

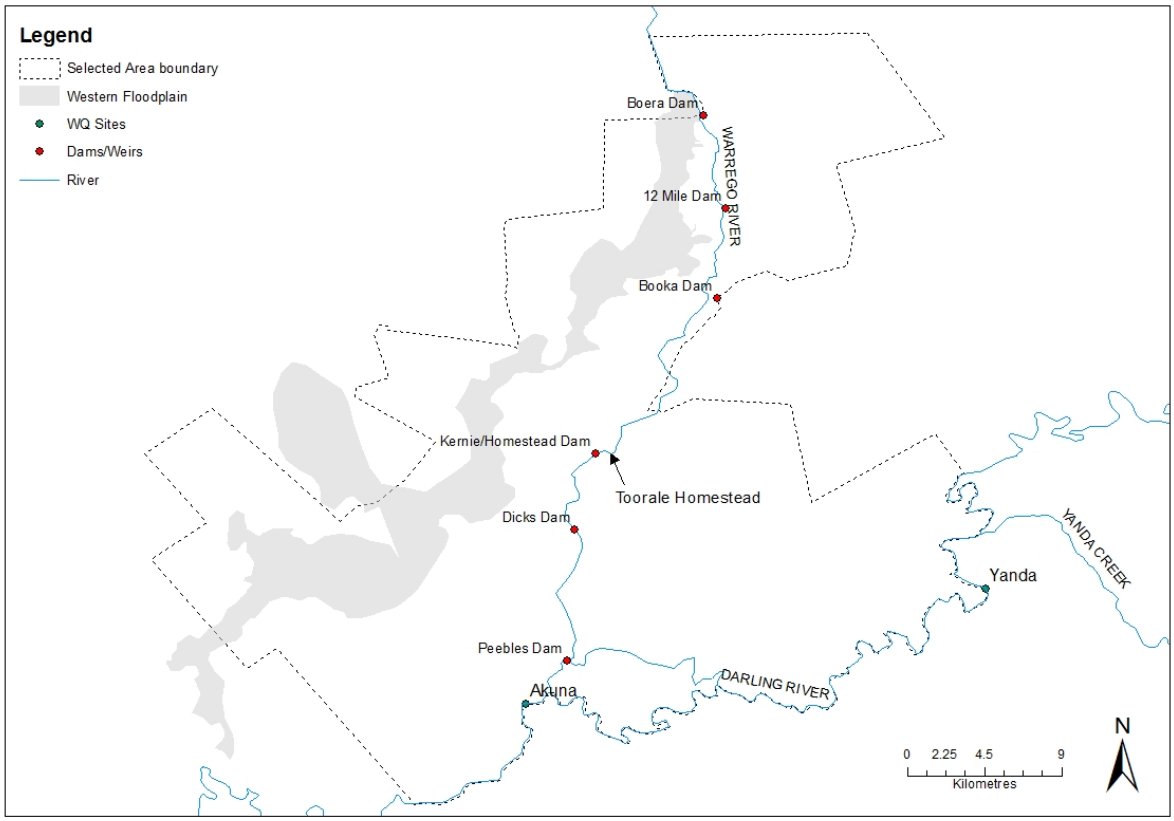

Figure 5-14 Location of Water Quality sensors and sampling sites.

5.11.2 Evaluation

Selected Area evaluation questions

Short-term (annual) and long-term questions:

- What did Commonwealth water for the environment contribute to temperature regimes?
- What did Commonwealth water for the environment contribute to pH levels?
- What did Commonwealth water for the environment contribute to turbidity regimes?
- What did Commonwealth water for the environment contribute to salinity regimes?
- What did Commonwealth water for the environment contribute to dissolved oxygen levels?

Approach to evaluation

This indicator links to Waterbird Diversity, Fish (Channel), Hydrology (River, Channel, Habitat and Northern Tributaries), Food Webs (Stream Metabolism, Microinvertebrates and Macroinvertebrates) and Frog indicators. There are several Selected Area hypotheses:

Short-term and long-term responses:

- Mean daily water temperature, and daily range in water temperature will decrease during the delivery of Commonwealth water for the environment.
- Mean daily pH, and daily range in pH will decrease during the delivery of Commonwealth water for the environment.
- Mean daily turbidity will increase during the delivery of Commonwealth water for the environment.
- Mean daily EC will decrease during the delivery of Commonwealth water for the environment.
- Mean daily DO concentrations will decrease during the delivery of Commonwealth water for the environment.
- Mean daily algal concentrations will decrease during the delivery of Commonwealth water for the environment.

Statistical analyses

Quantitative analyses will be applied at the Selected Area scale to test predicted changes in each water quality variable. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models.

Short-term and long-term responses:

- Hypotheses 1 to 6. Replication derived from randomised daily means of data periods within/outside delivery of Commonwealth water for the environment. One-way ANOVA (WQ variables as dependant variable) comparing among flow periods, and two-way ANOVA (flow period, years) for long term dataset.

5.12 Food Webs (Microinvertebrates)

5.12.1 Monitoring

Monitoring sites for Food Webs (Microinvertebrates) will be located in the Warrego Channel, Darling River and Western Floodplain zones.

The SOP for Microinvertebrates is provided in Appendix B.12. Water Quality Indicators will be monitored at all Food Web sites.

Sampling in the Warrego channel and Darling River zones will follow will be undertaken to occur at the locations aligned with Category 3 Fish (Channel) sampling in the Warrego and Darling channel sites to provide explicit links among these indicators and provide an assessment of a functional ecosystem response. Surveys on the Western Floodplain will sample within representative sites in each of the major wetland vegetation communities inundated by Commonwealth water for the environment. The Hydrology (Floodplain) indicator will facilitate the scaling-up of site based microinvertebrate data (density/L/vegetation type) to the entire inundated area of the Western Floodplain. The focus is on the microinvertebrate response to the inundation of the Western Floodplain.

This design will allow Basin-scale reporting for channel and floodplain habitats and alignment with Fish (Channel) and Vegetation Diversity where relevant.

Microinvertebrate sampling in channel locations will occur pre- (where possible), during and post-connection events for a minimum of 2 events. At each floodplain site, microinvertebrate sampling has three sample events planned to track the flow event cycle, sampling as soon as possible after inundation, at peak area inundation, and during the drying cycle.

The rationale underlying this approach is to seek as much synergy as possible between the components monitoring other vertebrates and wetland fish that also prey on microinvertebrates. A single composite sample (comprised or either 5 benthic cores or 5 pelagic buckets) is taken from each site or flow-habitat within a site. This will reduce the overall number of samples for laboratory processing and provide replication for analyses.

5.12.2 Evaluation

Basin-scale and Selected Area evaluation questions

Short-term (annual) and long-term questions:

- What did Commonwealth water for the environment contribute to microinvertebrate productivity?
- What did Commonwealth water for the environment contribute to microinvertebrate community composition?
- What did Commonwealth water for the environment contribute to connectivity of microinvertebrate and vegetation communities in floodplain watercourses?

Approach to evaluation

This indicator links to Food webs (Water Quality, Metabolism and Macroinvertebrates), Vegetation Diversity, Waterbird Diversity, Fish (River), Hydrology (River) and Hydrology (Floodplain) indicators. There are several Selected Area hypotheses that relate to the outcomes of delivery of Commonwealth water for the environment:

- The delivery of Commonwealth water for the environment will increase the biotic and abiotic resource pools supporting food webs.
- The delivery of Commonwealth water for the environment will shift the trophic position of key taxa.
- The delivery of Commonwealth water for the environment will increase the complexity of food web structure.
- The delivery of Commonwealth water for the environment will increase whole-of-system trophic dynamics (biological productivity, interaction among species, interaction between the system and its biotic and abiotic surroundings).

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Project Standard Protocol and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

Statistical analyses

In river channel habitats, quantitative analyses will be possible for microinvertebrate density and community composition for time since watering, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as water column nutrients and larval and adult fish.

In floodplain habitats, quantitative analyses will be possible for microinvertebrate density and community composition for time since watering and vegetation community, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among additional measured variables of water column nutrient and carbon concentrations and metabolism.

Hydrology (Floodplain) will quantify the area of each vegetation community inundated and the volume of inundation (m3) throughout the delivery cycle of Commonwealth water for the environment. Linking microinvertebrate density to this indicator will facilitate scaling of response from site based (microinvertebrate density/m2) to the inundated vegetation asset scale within the Selected Area.

5.13 Food Webs (Macroinvertebrates)

5.13.1 Monitoring

Monitoring sites for Food Webs (Macroinvertebrates) will be undertaken in conjunction with the Food Webs (Microinvertebrates) indicator. Monitoring sites for Food Webs (Macroinvertebrates) will be located in the Warrego Channel, Darling River and Western Floodplain zones.

Sampling will conform to the methodology prescribed in the Food Webs (Microinvertebrates and Macroinvertebrates) SOP in Appendix B.12.

Sampling in the Warrego Channel and Darling River zones will follow the sampling design for Food Webs (Microinvertebrates), undertaken at the locations aligned with Category 3 Fish (Channel) sampling in the Warrego and Darling River channels to provide explicit links among these indicators and provide an assessment of a functional ecosystem response.

Sampling on the Western Floodplain will sample within representative sites in each of the major wetland vegetation communities inundated by Commonwealth water for the environment. The Hydrology (Floodplain) indicator will facilitate the scaling-up of site based Macroinvertebrate data (density/m^2/vegetation type) to the entire inundated area of the Western Floodplain. The focus is on the Macroinvertebrate response to the inundation of the Western Floodplain.

This design will allow Basin-scale reporting for river channel and floodplain habitats and alignment with Fish (Channel) and Vegetation Diversity where relevant.

Macroinvertebrate sampling in channel locations will occur pre- (where possible), during and post-flow events for a minimum of 2 events. At each floodplain site, macroinvertebrate sampling has three sample events planned to track the inundation and contraction cycle, sampling as soon as possible after inundation, at peak area inundation, and during the drying cycle.

This design will allow Basin-scale reporting for river channel and floodplain habitats and alignment with Fish (River) and Vegetation Diversity where relevant.

5.13.2 Evaluation

Basin-scale and Selected Area evaluation questions

Short-term (annual) and long-term question:

- What did Commonwealth water for the environment contribute to macroinvertebrate diversity?
- What did Commonwealth water for the environment contribute to microinvertebrate community composition?

Approach to evaluation

This indicator links to Vegetation Diversity, Fish (River), Food Webs (Water Quality and Microinvertebrates), Hydrology (River) and Hydrology (Floodplain) indicators. There are two Selected Area hypotheses that relate to the outcomes of delivery of Commonwealth water for the environment:

- The delivery of Commonwealth water for the environment will increase the diversity of macroinvertebrate communities.

- The delivery of Commonwealth water for the environment will increase whole-of-system trophic dynamics (biological productivity, interaction among species, interaction between the system and its biotic and abiotic surroundings).

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Project Standard Protocol and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

Statistical analyses

In river/channel habitats, quantitative analyses will be possible for macroinvertebrate density and community composition for time since watering, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as water column nutrient and carbon concentrations, metabolism and larval and adult fish.

In floodplain habitats, quantitative analyses will be possible for macroinvertebrate density and community composition for time since watering and vegetation community, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among additional measured variables of water column nutrients.

5.14 Food Webs (Stream Metabolism)

5.14.1 Monitoring

Stream Metabolism will be conducted in the Darling River zone at two locations - near the 'Yanda' homestead (-30.34906, 145.57685) and near the 'Akuna' homestead (-30.40978, 145.33438; Figure 5-6). These are sites representative of the zone and were selected due to their proximity to NPWS residences to allow for ease of access and sample collection. The Akuna site is located downstream of the Warrego confluence and can be used to assess the influence of Warrego River flow to the water chemistry of the Darling River. Their location will also allow frequent and/or event based monitoring of the stations by NPWS staff. Category III Water quality will also be undertaken at all these sites.

Stream Metabolism will also be carried out at three locations in the Warrego River. D-Opto loggers will be placed in Boera Dam, Booka Dam, and Peebles Dam/Ross Billabong. Measurement of light (PAR) will be established at the Toorale Homestead within the Selected Area (Figure 5-6). Category III Metabolism will follow the standard methods outlined in Hale et al. (2013) through periodic deployment of D-Opto DO loggers. Water chemistry will be collected at least every 6 weeks for Category I, or at the commencement and completion of each incubation period for Category 3. Water samples will be processed in accredited laboratories.

The SOP for Food Webs (Metabolism) is provided in Appendix B.13.

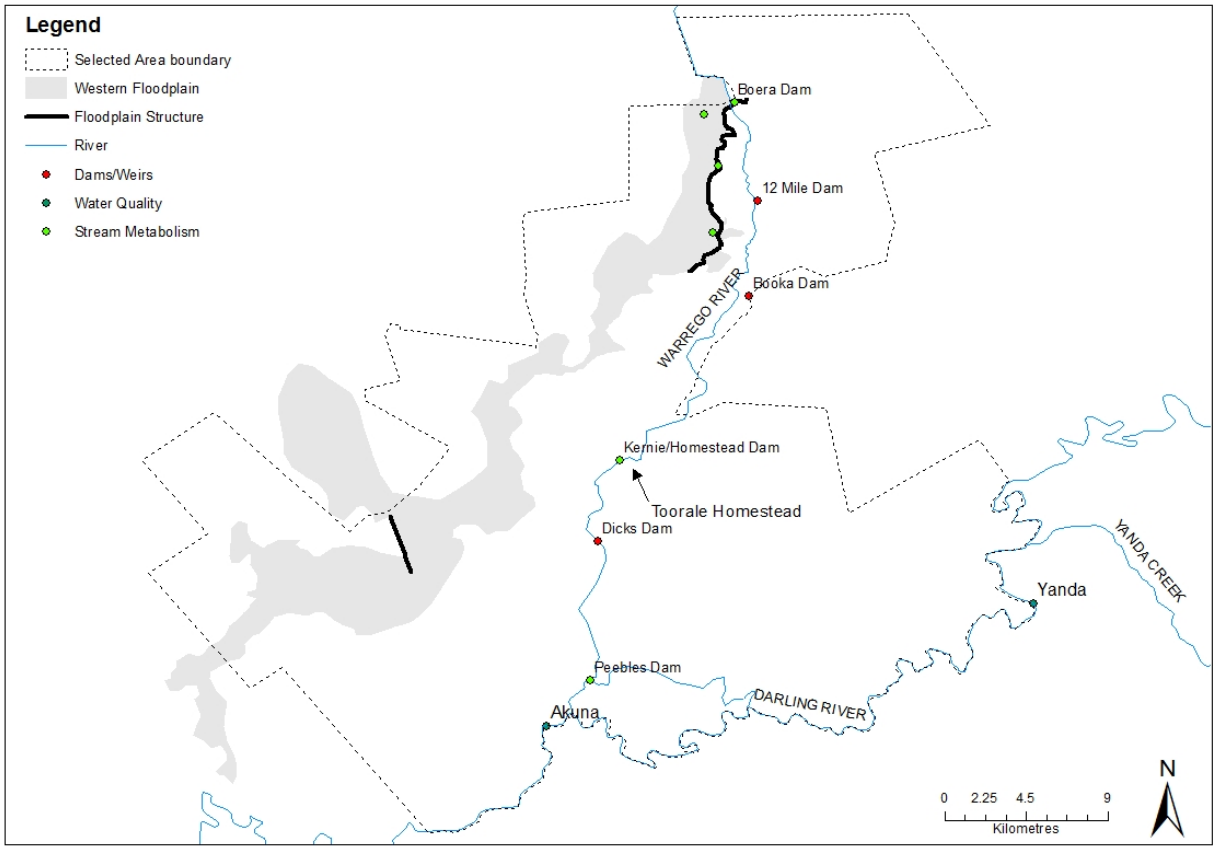

Figure 5-15 Location of Water Quality sensors and sampling sites for the Metabolism indicator.

5.14.2 Evaluation

Basin-scale and Selected Area evaluation questions

Short-term (annual) and long-term questions:

- What did Commonwealth water for the environment contribute to patterns and rates of decomposition?
- What did Commonwealth water for the environment contribute to patterns and rates of primary productivity?

Approach to evaluation

This indicator links to Fish (Channel), Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates) and Hydrology (River) indicators. There are two Selected Area hypotheses that relate to the outcomes of delivery of Commonwealth water for the environment:

- The delivery of Commonwealth water for the environment will influence the rates of primary production and decomposition.
- The delivery of Commonwealth water for the environment will increase whole-of-system trophic dynamics (biological productivity, interaction among species, interaction between the system and its biotic and abiotic surroundings).

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Project Standard Protocol and conform to the LTIM Project Data Standard (Brooks & Wealands 2014).

Statistical analyses

Quantitative analyses will be applied at the Selected Area scale to test predicted changes in dissolved oxygen, nutrients, decomposition and primary productivity using the BASE fitting routine described in the Standard Methods, and reported as DO/L/day and gC/L/day. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model.

Replication derived from randomised daily means of data periods within/outside delivery of Commonwealth water for the environment (Basin scale) and pre-, during- and post-delivery for event-based sampling (Selected Area scale). One-way ANOVA (GPP, ER, NPP, water chemistry as dependant variables) comparing among flow periods, and two-way ANOVA (flow period, years) for long term dataset for Basin scale assessment. Selected Area scale assessment will be determined by one-way ANOVA comparing among flow periods (pre-, during- and post-flow delivery), and two-way ANOVA (flow period, years) for the long term dataset.

5.15 Junction of the Warrego and Darling Rivers Selected Area Contingency Monitoring

Contingency monitoring provides the opportunity to better understand short-term, local-scale or event-based responses to water for the environment. Monitoring and evaluation of category I, II and III indicators in the LTIM Project has demonstrated trends in response of water quality, vegetation, aquatic food webs, waterbirds and fish to water for the environment. However, our understanding of indicator responses to Commonwealth environmental watering events (e.g., Warrego connection flows, Western Floodplain inundation, Warrego channel refuges), whether high flow or drought conditions, will be improved by further targeting monitoring to specific events. Similarly, sampling multiple environmental variables as part of contingency monitoring will improve our understanding of integrated ecosystem responses to water for the environment.

Work orders will be developed in conjunction with the CEWO delivery team as required, with a focus on (but not limited to) the following priority monitoring projects.

5.15.1 Connectivity events

The trade-offs between the connection of the Warrego channel to the Darling River and/or the inundation of the Western Floodplain as part of the activation of Commonwealth licences are largely unquantified. Opening the gates at Boera to re-connect the Warrego channel replenishes refuge waterholes to improve water quality, stimulates food webs and maintains fish communities. Similarly, inundating the Western Floodplain creates biodiversity benefits unique to the region (linked Research project). The period of connection required to: influence channel habitats; improve water quality; and provide for longitudinal connectivity (especially for fish) is also poorly understood. Collaborating with relevant agencies to monitor multiple indicators before, during and after connectivity events will provide evidence for the short-term environmental outcomes from flow releases that is not available from routine monitoring using Standard Methods.

5.15.2 Western Floodplain biodiversity

Plants and animals in the Western Floodplain respond to inundation, and the nature of the response can change with the spatial extent, duration, and frequency of wetting. Current routine monitoring and evaluation as part of routine monitoring programs are not designed to understand a holistic biodiversity response to environmental watering. Understanding the abundance and diversity of key faunal groups not captured from monitoring (e.g., small bodied fish, tadpoles, snakes, turtles) and whether their response changes with inundation timing, frequency and duration will provide information to improve Commonwealth water for the environment management decisions. Linking patterns of fauna abundance and diversity to hydrodynamic information will allow the CEWO to better target water for the environment to the Warrego Channel or Western Floodplain.

5.15.3 Waterbird recruitment

The Western Floodplain has extensive lignum and macrophyte communities that are important habitat for waterbird breeding. These rookery areas will be the target of event-driven survey effort as a contingency monitoring activity. Surveys of colonial bird breeding events and fledging success are proposed using standard methods (Hale et al. 2014). We will rely on established communication networks with the key stakeholder communities (MER survey staff, landholders, birdwatchers and government department/agency staff e.g. OEH, NPWS) to identify bird breeding events or potential events linked to Commonwealth water for the environment. Surveys will be initiated by confirmed commencement of bird breeding events.

5.15.4 Low flow refuges in the Warrego and Darling Rivers

The Warrego Channel has multiple storages (Boera Dam, Booka Dam, Homestead Dam, Dicks Dam, Peebles Dam, Ross Billabong) that are important aquatic habitats in the naturalised system. The Warrego channel is characterised by extended periods of low to no flow that leads to channel waterholes persisting as the only refuges for a number of important fish and aquatic species. Recent sampling in the Warrego revealed juvenile golden perch recruitment associated with a flow event (2019 as part of the LTIM Project) were residents of a refuge pool. Once disconnected, the remnant pools are the only refuge for these important fish species. The flow, habitat and food requirements for these fish to survive, and how these conditions change over time as the pool recedes are all unknown, and can be informed by targeted monitoring.

Similarly, important refuges exist in the Darling River channel under extended low flow conditions. These deeper and more permanent waterholes in the Darling channel provide habitat and food requirements necessary for the long term survival of important taxa such as golden perch and Murray cod. This project will contribute to the evidence base for the CEWO to better target water for the environment to the Warrego Channel, Western Floodplain and Darling River and link to complementary monitoring and research projects in other Selected Areas and the Basin-scale MER Program.

6. Integrated Research Plan

A key objective of the Basin-wide Environmental Watering Strategy is 'Improved Ecological Processes' based on more productive and diverse food webs and ecological communities; 'Increased Connectivity' of channel and floodplain environments to provide a diversity of habitat, to produce 'Diverse Plant and Animal Populations'. In turn, achieving these objectives supports the Basin Plan Objectives of improving the life cycle completion of key plants and animals. The focus of monitoring and research in the Warrego-Darling Selected Area is the main Warrego channel and associated dams, the Western Floodplain, and the Darling River channel.

As part of the development of the Research Plan, we held a Northern MDB Environmental Flows Workshop with stakeholders from CEWO, MDBA, NSW OEH and NPWS, NSW DPI, NSW DoI and WaterNSW and Qld DNRME. This workshop bought together the major agencies involved in monitoring and research of water for the environment across the regions that encompass the Gwydir River and the Warrego-Darling Selected Areas. This workshop reinforced the direction and themes of this Research Plan, and established opportunities for ongoing collaborations.

This Research Plan is deliberately integrative. We aim to undertake research that enhances our understanding of interactions among indicators in response to environmental watering. The following principles will guide the prioritisation of Research Projects undertaken within the Warrego-Darling Selected Area through the CEWO work order process:

- Fills knowledge gaps identified by stakeholders
- Links to Selected Area monitoring and contingency monitoring data
- Links across multiple indicators
- Links to monitoring and research across other Selected Areas
- Provides data and context for Basin Scale evaluation
- Links with and complements external stakeholder projects.

Our Research Plan directly links these objectives through four proposed research themes:

1. Modelling inundation extent and duration of inundation for floodplain and wetland habitats
2. Building resilience: understanding ecological thresholds in low flow refugia, including duration/persistence of key refuge river pools and waterholes
3. Developing a model to predict food web responses to water for the environment delivery
4. Biodiversity responses to Commonwealth water for the environment.

7. Schedule of Monitoring, Evaluation and Research

7.1 Monitoring

The Monitoring, Evaluation and Research Plan for the Selected Area has been designed to capture the variable nature of flow and the relative contribution of Commonwealth water for the environment from the Darling and Warrego catchments. Due to the more persistent presence of water within the Darling River, Category I indicators have been targeted in this zone and will be measured predominantly through sensors and loggers deployed within the river channel. Given the relatively large proportion of Commonwealth water for the environment in the Warrego System, the majority of the Category II and III indicators have been focused on the Warrego channel and Western Floodplain zones, as these zones provide the greatest potential to detect an ecological response from Commonwealth environmental water. Given the ephemeral nature of the Warrego flow regime, event-based monitoring of these indicators will be undertaken with sampling events scheduled before, during and after individual Commonwealth water for the environment events when they occur. A minimum of two events will be sampled from Years 1-3 of the MER project.

This plan was developed based on historical flow patterns, and the relative proportion of Commonwealth water for the environment and related intervention outcomes likely in the system. However, given the highly variable nature of flow, the plan may require reallocation of resources in response to conditions. As the Warrego has had a recent flow event that included connection to the Darling and inundation of the Western Floodplain we propose to consider this flow as a targeted event with the Warrego-Darling MER Project and sample at least twice in 2019. Subsequent sampling will be driven largely by flows. However, if dry conditions prevail we will work with CEWO staff to reallocate resources to optimise monitoring outcomes.

There are limitations to the analytical approaches for evaluation purposes in response to the Standard Methods applied to Category I indicators in the Warrego-Darling Selected Area. The Selected Area has 3 zones that are spatially and geomorphically discrete units, with the evaluation of responses to Commonwealth water for the environment often limited to one zone. As such, this design does not generally permit comparisons of outcomes for those sites that receive Commonwealth water for the environment compared with those that do not. This can make short-term (annual) evaluation of outcomes difficult for the Selected Area scale.

Where possible, we will apply a number of broad approaches to short-term (annual) and long-term (multi-year) analyses to assess the response of individual or suites of indicators to the delivery of Commonwealth water for the environment to ecological assets in the Selected Area.

1. For selected indicators (e.g., Fish (Channel) and Vegetation Diversity) we will develop a 'reference condition' to facilitate predictions that zones receiving Commonwealth water for the environment will have a trajectory towards the reference condition. For example, a reference condition for Fish (Channel) metrics (composition, total length, mass, expectedness, nativeness, and recruitment, and age of target taxa) will be developed in conjunction with NSW DPI Fisheries (SRA) and from existing data (e.g. Gowans et al. 2012) to set annual and long-term targets. Reference condition may need to be developed specific to antecedent condition, with a dry, average and wet extant reference condition used to determine trajectories of change (see Section 5.7). Evaluation of outcomes from Commonwealth water for the environment will be determined by differences between the observed and expected outcomes.
2. Long-term (multi-year) outcomes will require quantitative models that define outcomes for each indicator/zone in response to the delivery of Commonwealth water for the environment. The repeated application of this model over time seeks to quantify a convergence or divergence in

indicator response relative to watering regime (receiving or not receiving Commonwealth water for the environment). Statistical approaches for these indicators will be time series-based (space-time substitution), with predicted differences between sites that have received Commonwealth water for the environment (and the number of times they have received Commonwealth water for the environment) compared with those that do not receive Commonwealth water for the environment at the completion of each annual cycle used to evaluate outcomes. Condition assessment is determined from the reference condition approach outlined above.

The focus of the MER Plan is to target Commonwealth water for the environment in each of the three zones within the Selected Area (Table 7-1). Sample design has been aligned within each zone based on the expected outcomes of Commonwealth environmental watering options. However, as the Commonwealth water for the environment may vary in any one year, the sampling has been designed to maximise potential selected area and basin-scale outcomes by allowing for targeting any individual zone for several indicators in response to the presence of Commonwealth water for the environment.

The watering options for the Selected Area are generally for flows to occur in spring-summer and to continue through summer until all Commonwealth water for the environment is accounted for. The annual sampling design is quite different between the two Warrego and Darling River zones, in response to the contrasting likelihood of flows occurring in each system. For the category I indicators along with Hydrology (Northern tributaries and Habitat) measured in the Darling, they will be monitored continuously for the duration of the project as there is a high likelihood of water being present in the Darling channel throughout (Table 7-2). For the Warrego River and Western Floodplain zones, Hydrology (River, Floodplain, and Channel) will be measured continuously, whenever water is present within the system. Sampling for Vegetation Diversity on the Western Floodplain will be undertaken twice annually for the duration of the project (Table 7-3).

For the event-based indicators, these will be measured during two flow events, beginning in Year 1 of the project (Table 7-3). Timing of sampling for these event-based indicators may be refined in conjunction with the CEWO depending on the past and potential future flows in the Warrego catchment.

The monitoring design (sites, zones, standard methods) has been developed in the knowledge that Commonwealth water for the environment will occur as rainfall driven events and to a lesser degree from end-of-system deliveries of Commonwealth water for the environment from upstream tributaries. As such, the evaluation of outcomes from Commonwealth water for the environment will need to be made relative to antecedent conditions of inundated zones and the proportion of water that is determined to be Commonwealth water for the environment. The MER team will be reliant on the CEWO to establish clear definitions of what constitutes a Commonwealth watering event. Hydrologic gauges nominated for use in the Hydrology indicators will both facilitate detailed information on antecedent conditions prior to the occurrence water for the environment. For example, Commonwealth water for the environment that spills onto the Western Floodplain can be hydrologically quantified by discharge, area inundated and linked explicitly to breeding success.

Table 7-1 Indicator-Zone interactions. SA represents Selected Area.

Monitoring Zone		**Darling River Channel**		**Warrego River Channel**		**Western Floodplain**	
Ecosystem Type		*River*	*River*	*River*	*River*	*Floodplain*	*Floodplain*
CEW watering Option		*1-2*		*3-4*		*5*	
Monitoring Indicator	**Cat.**	***Basin***	***SA***	***Basin***	***SA***	***Basin***	***SA***
Ecosystem type	I						
Vegetation Diversity	II						
Hydrology (River)	I						
Stream metabolism	I & III						
Water quality	III						
Hydrology (Northern tributaries)	III						
Hydrology (Floodplain)	III						
Hydrology (channel)	III						
Hydrology (Habitat)	III						
Fish (Channel)	III						
Micro-invertebrates	III						
Macro-invertebrates	III						
Waterbird Diversity	III						
Frogs	III						

Table 7-2 Annual field survey cycle in the Darling River zone.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Indicator													
Ecosystem Type													Once only in year 2019, or as new sites are added
Hydrology (River)													Ongoing, updating regularly from WaterNSW data
Hydrology (Northern tributaries)													Ongoing and following delivery events
Hydrology (habitat)													Mapping from 2015 may be updated in sections
Stream Metabolism (C1)													In situ, up to 6-weekly maintenance intervals
Water Quality (C3)													In situ DO and temperature, spot sampling

Table 7-3 Annual field survey cycle for indicators within the Warrego River and Western Floodplain zones.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Comments
Indicator													
Ecosystem Type													Once only in year 2019
Hydrology (River)													Ongoing, updating regularly from WaterNSW data
Hydrology (Floodplain)													Ongoing and following delivery events
Hydrology (channel)													Ongoing and following delivery events
Vegetation Diversity													Twice annually around water season
Stream Metabolism (C3)													Event driven, likely from October to April annually
Water Quality (C3)													Event driven, likely from October to April annually
Fish (Channel) (C3)													Event driven, likely from October to April annually
Microinvertebrates													Event driven, likely from October to April annually
Macroinvertebrates													Event driven, likely from October to April annually
Waterbird Diversity													Event driven, likely from October to April annually
Frogs													Event driven, likely from October to April annually

8. Communication and Engagement Plan

8.1 Introduction

The Warrego-Darling Selected Area Long-term Intervention Monitoring (LTIM) Project started in 2015 and the project team has been actively undertaking a communication and engagement program since commencement. The Warrego-Darling MER Project is a modified extension of the Warrego-Darling LTIM Project and will draw on the experience and reflections of the 5-year communication and engagement program that has been undertaken. This communication and engagement plan draws on the relevant experience from the communication and engagement activities already undertaken. Specifically, the plan:

- Reviews the communication and engagement activities undertaken to date, ranks activity effectiveness, and seeks to understand reasons for success or areas for improvement
- Assesses the target audience groups and develops activities specifically to engage with these groups
- Works with the Flow-MER Basin scale communication and engagement team to provide seamless 'whole of team' products and approaches
- Sets out steps to develop an Aboriginal communication and engagement program that moves from engagement to commitment.

This communication and engagement strategy will help the Warrego-Darling MER team to continue to develop and deliver inspiring and enabling communication and engagement activities to better communicate the purpose and outcomes of CEWO water for the environment and flows in the selected area.

Our objectives are to:

- Work effectively with the Flow-MER team (Basin-scale, Selected Area and CEWO and partner agencies including NSW OEH and NPWS) to integrate communication outputs and outcomes of specific environmental flow outcomes in the Warrego-Darling.
- In conjunction with CEWO, OEH, NPWS and others involved, develop and deliver an Aboriginal communication and engagement strategy that moves from engagement to commitment.
- Help to explain the role of water for the environment for key stakeholders, including:
    - The Flow-MER team
    - Local Warrego-Darling community
    - The broader Australian and international community
    - Government agencies and policy makers
    - The science community
- Have fun, engage thoughtfully, engage early, value knowledge, develop trusting relationships through time, celebrate and promote the wins, acknowledge difficulties and issues, and respect cultural and local contexts.

In the Warrego-Darling LTIM Project we achieved a considerable amount in communicating our project without a dedicated budget. We are excited that for the next phase of our work in Warrego-Darling MER Project, we have a specific communication and engagement budget, and support from a

dedicated Stakeholder Engagement and Communications Team (Flow-MER team) which will enable us to achieve even more.

We will take our communication and engagement to the next level this time!

8.2 Previous communication and engagement activities

In the Warrego-Darling LTIM Project a concerted effort was focused on broad engagement with key audience groups:

- Warrego-Darling LTIM Project delivery team.
- CEWO plus relevant water for the environment and NRM agencies.
- Local community groups and organisations.
- Other LTIM providers and the broader science community (academia).

Aboriginal engagement was primarily via regular participation with the Kurnu-Baakandji Joint Management Committee (JMAC). Feedback from the committee and NPWS is that this participation was appreciated and is encouraged to continue.

It should be noted that these groups can, and do, fit in multiple categories. However, for assessment simplicity they have been categorised into a single audience group (Table 8-1). Activities and communication products were considered by the Warrego-Darling LTIM Project lead team and assessed based on considered effectiveness and return for effort/investment (Table 8-1, Table 8-2).

Each activity and product met with a degree of success. The early identification of the importance of communication and engagement and follow on commitment to develop a team approach from the scientist through to end-user, was critical for ongoing communication and engagement activities and successes. Specific presentations and ongoing engagement with the CEWO and MDBA at several levels proved a useful approach to heighten team collaboration and increase team knowledge (both ways). Even activities that met with moderate success are worth further consideration into the Warrego-Darling MER Project as the dedicated budget and focus may allow these activities to achieve success.

Table 8-1 Review of Warrego-Darling LTIM communication and engagement activities and approaches.

Audience group	Audience	Activities	Purpose/Comment	Effectiveness
Monitoring team members	Provider team	Training and review	Guide team on importance of communication and their role at all levels Regular discussion and review of communication outcomes and effectiveness Restate importance of engaging with landholders and protocols for engagement	
Agencies and departments	LLS	Bourke office presentations	Annual (almost) presentation to the NW LLS board. Invited and supported by LLS CEO and Chair. Important high-level communication in the region.	
	CEWO	Annual report	Contractual requirement, designed to have key points, exec summary and scientific appendices. Hosted on CEWO website.	
		Regular phone connection	Discuss watering actions and outcomes, discuss project comms and any issues	
		Annual presentation	Targeted trip to present to CEWO, broader audience than usual project team, in conjunction with MDBA staff.	
		Tweets and other social media	Link to CEWO accounts for broader audience including irrigators	
		Newsletter	Contractual requirement, sent to CEWO for broader audience	
		Linked activities with CEWO LEO	Irregular contact via phone or at events	
		Link with CEWO engagement team	Targeted effort to engage with CEWO engagement team to learn and share. Engagement team at CEWO was disbanded and has recently reformed.	
		In field support for CEWH at events	Support responsive field visits from the CEWH and CEWO staff as required. E.g. Presence at Bourke during the northern connectivity event.	
		General comment: *the staff at the CEWO play multiple roles: client; project team members; and communicators. The CEWO has a dedicated engagement team. Sharing and co-learning with this group is a critical step for comms in the project. CEWO staff (including the CEWH) offer a different, important network for project communication. Invested in effort to assist CEWO staff is a seen as high priority.*		
	MDBA	Annual Presentation	Targeted trip to present to MDBA, broader audience than usual project team, in conjunction with CEWO staff.	

Audience group	Audience	Activities	Purpose/Comment	Effectiveness
	DPI Fisheries	Team collaboration and communication	Regular communication on project functioning and communication opportunities.	
	NPWS	Site access and issues	Regular communication on site issues and opportunities for local project extension and collaboration.	
Academia	LTIM teams	Annual conference, regular SA leader hook up, collaboration workshops	Important activities to build teamwork and collaboration between the various groups	
	Academia	Conference presentations	Engage with academic community. Useful to target a key science demographic and build project credibility, also builds staff experience.	
Local community	Local community	Via trips to Bourke and engagement with key Bourke-based groups	Trips an extended fieldwork trips to meeting with locally based agency staff. Always well received and should be continued. Onsite field day planned to be run via LLS but it didn't eventuate.	
		JMAC presentations	Participation in JMAC meetings run over weekends. Commitment to stay for entire day of meeting rather than present and run.	
		Northern flow event – field day	Support for CEWH presenting during northern connectivity flow.	
	Selected Area working groups	Quarterly presentations	Contractual requirement. After initial meetings attendance dropped off to less than half. Some good feedback at times but it is likely other means were meeting the needs of the SAWG members.	

Table 8-2 Warrego-Darling LTIM communication products.

Product	Item	Purpose	Effectiveness
Regular Newsletter	Pdf	Provide targeted 4 page brochure style, non-scientific publication concerning LTIM activities and watering outcomes	
Social media	Twitter	Generally targeted field staff pictures and short videos. Very effective on occasion. Simple and quick to post. Best results linked to charismatic fauna images or when linked to broader groups such as Landsat user etc.	
	Facebook	Irregular link to newsletter	
	Linkedin	Irregular link to newsletter	

Smiley Key

 Worked well. Continue and maybe enhance.

 Effective but could be improved. Look to revise and improve.

 Not as successful as other approaches. Consider reviewing approach and maybe not repeating.

8.3 Key audience/stakeholder assessment

A structured brain-storming workshop was held by team members to identify key Stakeholder/audience groups to help plan activities for the continued Warrego-Darling MER Project (Table 8-3). We recorded five key audiences and a range of approaches. Each approach was considered important and, as we move into the Warrego-Darling MER Project, we thought it appropriate to expand this audience group and approach rather than contract any efforts.

Table 8-3 Key Audience assessment.

Group	Comment	Stakeholder	Engagement approach
Our team	These are our people on the ground, in the tea room and at the conference	Academia, other MER groups, local community	Team training and focus, regular team catch ups and engagement.
Government agencies	A critical audience group that provides considerable extension of the LTIM/MER network to other stakeholders. Often activities can be shared and/or co-planned.	CEWO (Funding Body and primary client for services provided under this MER plan)	Reports, targeted presentations, regular phone, shared activities, social media tagging, co-planning events, research forum, academic conferences/papers.
		MDBA	Targeted presentations, research forum, academic conferences/papers
		DoI Water	Targeted presentations, research forum, academic conferences/papers
		OEH	Team collaborator, Targeted presentations, research forum, academic conferences/papers, ECA OAC
		WaterNSW	Targeted presentations, research forum, academic conferences/papers
		DPI Fisheries	**Team member**, targeted presentations, research forum, academic conferences/papers
Academia	Adds and tests program scientific validity, build team experience	Academics	Focused effort for publications and conference presentations.
MER teams	A critical audience group that provides considerable extension of the LTIM/MER network to other stakeholders. Often activities can be shared and/or co-planned. Linked to academia item	Selected Area and Basin-scale teams	Sharing of approaches, issues and solutions including for communications. Development of joint cross-SA projects (research and communications).
Local community	Place-based activities from simple conversations to field days and local media	Landholders	Conversations, field days, newsletter
		LLS	Presentations at all levels, shared field events
		Local community	Local media, field days, conversations
		Aboriginal people, organisations and communities	See Section 8.5. Aboriginal interests extend beyond the Selected Area (e.g. Northern Basin Aboriginal Nations (NBAN))
Social media	Integrates across all groups	All community	Twitter and other platforms for regular interaction

8.4 Communication and Engagement Plan 2019 - 2022

Following the review of activities undertaken in the Warrego-Darling LTIM Project we have identified a range of possible activities for the Warrego-Darling MER Project (Table 8-4).

All key audience groups identified in Table 8-3 have been targeted with specific activities and Aboriginal people, organisations and communities have been added as an additional key audience group. Further details of our plans for communication and engagement with Aboriginal people, organisations and communities is highlighted in Table 8-4.

Table 8-4 Possible Warrego-Darling MER Communication and Engagement Plan and activities 2019 - 2022.

Activity	Purpose
Team training and coordination 1-day training event, 3 workshops	Develop and enhance individual approaches to engagement; Maintain focus on importance or on-going communication; Ongoing coordination (in conjunction with Gwydir MER)
CEWO engagement	Annual presentation, joint planning, regular catch ups, quarterly newsletters
MDBA presentation	With CEWO presentation (no additional cost)
Northern Basin Research workshop	Annual workshop of key research agencies and programs in the Northern Murray-Darling Basin (in conjunction with Gwydir MER Project)
Annual comms report	2-4 page summary following team workshop of what happened and what worked
Practitioner Forum (in conjunction with Gwydir MER)	Connect with key MER participants and water managers, 3 events, Adelaide, Albury, Moree, 2 staff. Likely link to other collaboration activities.
Academic events	Promote conference presentations and papers
MER team engagement	1 specific trip per year for 1 day workshop Regular phone hook up This is linked with the research budget
Flow-MER Basin scale	Contribute to Flow-MER team products and engage with Flow-MER team.
	Contribute a minimum of 2 stories per year. Many of the Warrego-Darling specific materials and outputs will be directly transferable to the Flow-MER team requirements.
Aboriginal engagement and communication	Participate in and present to JMAC
	Further engagement to be planned with advice from Jason Wilson, Brad Moggridge, Briony Papps, UNE Oorala centre, Local Aboriginal Land Councils, Traditional Owners and possibly NBAN.
Newsletters	Selected area newsletters developed and distributed twice per year
Local events	Support field days, fisher events, and LLS presentations (at least 2 annually)
Local media articles	Press releases at 4 times per year
Curriculum development	Work with UNE outreach, CEWO Local Engagement Officers and other agencies to develop specific MER items for schools
Web portal	Host and make available all comms activities and events and data; developed in conjunction with Gwydir MER Project. Specific photo point time series.
Social media	Tweets, stories, links

8.5 Aboriginal engagement and communication

Following Brad Moggridge's comments at the MER inception meeting we are keen to develop an Aboriginal engagement and communication strategy that takes us from being engaged to working in partnership with Aboriginal people, organisations and communities. To that end we will develop a separate plan beyond this communication and engagement plan that seeks to:

- Actively source project supply from Aboriginal organisations.
- Brings in UNE's Oorala Aboriginal team.
- Seeks Jason Wilson's expertise.
- Looks to employ Aboriginal people and engage them in the scientific monitoring program.

We would like to build this plan carefully to help create enduring outcomes for the project and inclusion of Aboriginal people. Our first step will be to hold discussions with Northern Basin CEWO LEOs, Brad Moggridge, Briony Papps (CEWO Indigenous Engagement and Co-ordination), and the Oorala organisation.

8.6 Landholder communications

For the MER Program, landholders are individuals and/or organisations where access to or through their land is required to undertake monitoring activities.

Landholders are vital components of the MER Program. They are holders of substantial knowledge and influence within their communities. Respectful, inclusive and engaging communications with landholders is critical to the success of the MER Program as a whole and the Warrego-Darling MER Project in particular.

Landholder contact details and communications will be established upon approval of final sites. The following principles will be adopted:

- No access to any sites will take place without first contacting the landholder and gaining permission to undertake monitoring activities on their land. Initial access will be sought at least 10 working days before accessing a site for the first time, and then within a timeframe as negotiated with each landholder for subsequent access
- The Project team will invite each landholder to participate in or observe monitoring activities as they chose
- The Project team will discuss with CEWO the availability/accessibility of site specific data for each landholder
- All monitoring activities, including access to sites etc. are to be undertaken so that minimal/nil disturbance to the landholders' activities, livestock and/or cropping practices occur
- Providing ongoing project updates to landholders as requested
- Where possible, existing tracks shall be used
- Vehicles/machinery to be operated so that any damaged is minimised
- Notify the landholder immediately if any damage occurs (to property or livestock)
- Appropriate approvals/licences shall be sought as necessary, including Scientific Licence and Permit to Work in NPWS Reserves. All field teams shall have copies of relevant licences when undertaking field work
- Take all reasonable care to ensure that weeds or pests are not spread

- Return gates to original position after use.

8.7 Conduct of Conduct for project staff

Collaboration and cooperation are vital to the overall success of the MER Program. A Code of Conduct has been developed to guide the behaviour of individuals and teams when undertaking monitoring and evaluation activities on behalf of the CEWO.

In all communications related to the MER Program, including both operation and external communications, the MER Project team will comply with the expected behaviours as specified in the Code of Conduct developed by the CEWO for the LTIM Project.

- **Be safe.** The MER Program involves significant periods of field work in potentially hazardous situations. The safety goal for the Warrego-Darling MER Project is "Zero Harm". Project leads are required to develop and regularly review safety plans for their area. Such plans must be compliant with relevant legislation and all guidance provided by CEWO. All personnel are required to actively contribute to the implementation of work health and safety plans and procedures.
- **Be collaborative.** Collaboration will promote the achievement of efficient and effective project outcomes. Efficient and effective collaboration is required within and between the CEWO, Basin-scale Team, MER Providers, Data Management Providers and delivery partners. Communication among personnel working on the MER Project is expected to be conducted in a professional and courteous manner, even where differences of opinion are apparent. All personnel are required to actively participate in organised collaboration activities and opportunities.
- **Be mindful.** All personnel are required to be mindful of their legal and ethical obligations under the contract. This includes obligations relating to conflict of interest and intellectual property.
- **Be consistent.** Consistency with standard methods, QA/QC protocols and data standards at each Selected Area is critical for the Basin-scale evaluation. All personnel are required to adhere to documented methods, standards and protocols. Project leads are responsible for ensuring all relevant team members have appropriate understanding and training to carry out their duties.
- **Be respectful.** Undertaking monitoring activities in some areas will require access to private land. Project leads are responsible for negotiating access to private land, including negotiating any site-specific protocols that must be followed (e.g. protocols relating to notification of access, gate conditions and stock presence). All personnel are required to be respectful when conducting activities on private land and follow any agreed protocols.
- **Be a good representative.** All personnel undertaking work as part of the MER Project will, in effect, be representing the CEWH and the Office more broadly. All personnel are required to be professional and respectful of landholders and community members, taking active steps to listen to their views and where appropriate, relay these back to the Office.

Breaches of the Code of Conduct will be treated seriously. All actual or suspected breaches will be reported to the CEWO Project management team for investigation.

9. Reporting

There are two forms of reporting requirements for the Selected Area Provider to CEWO for the MER Project in the Warrego-Darling Selected Area:

- Project reporting (progress)
- Outcomes reporting.

In addition to formal reporting, the UNE/2rog team will maintain good relationships with the CEWO, MER Advisors and delivery partners and collaborators to support evaluation and adaptive management throughout the MER Project.

9.1 Project progress reporting

Progress reporting requirements for Stage 2 are provided in Table 9-1, including regular forums and teleconferences.

Table 9-1 Progress reporting requirements for the Warrego-Darling Selected Area MER Project.

Activity type	What	Frequency	Timing / due date	Responsibility	Description and high level requirements
Project Status Meetings	Phone conference	Fortnightly	From project inception to submission of final report (December 2022)	MER Provider	Informal phone catch-up with CEWO Area leader to discuss status of the Warrego-Darling MER Project
Information transfer	Monitoring data entry	Monthly	Monthly for the duration of the MER Project to the Monitoring Data Management System and Data Standard (Brooks & Wealands 2014)	MER Provider	Processed monitoring data uploaded to the Monitoring Data Management System in accordance with data management protocols, as outlined in the MER Plan
Reporting	Project progress reports: 2019-22	Quarterly	Sep, Dec, Mar and Jun (last business day of month) for the duration of the MER Project	MER Provider	A written progress report, summarising tasks completed since the last report, tasks planned for the upcoming period, emerging issues etc. The CEWO progress report template will be used
Meeting	Selected Area Working Group meeting	Three times per year		MER Provider	MER Provider must initiate, organise, facilitate and provide secretariat duties for at least three SAWG annually, consisting of project partners and subcontractor personnel involved in the MER plan ToR and membership must be approved by the Department

Meeting	Biannual Steering Committee meeting	Biannual	November and March, each year	CEWO	Leaders of Project teams
Forum	Annual MER forum	Annual	July 2020 –2022 (2 days each)	CEWO	MER Forum to be held each year Four attendees from each MER Provider team are to attend to discuss monitoring efforts (issues and solutions), monitoring results and evaluation (Project Director/Manager and three technical leads)
Forum	Thematic Working Groups	Twice	Specified by Basin Scale Leads	Basin Scale Provider	Selected Area Leads for Fish, Vegetation and Food Webs attend to discuss monitoring efforts (issues and solutions), monitoring results and evaluation

9.2 Outcomes reporting

The Warrego-Darling MER Project has a number of reporting and information transfer requirements. Table 9-2 summarises the outcomes reporting and information transfer activities for the MER Project, including frequency, timing and responsibility. Note this list covers only operational reporting and information transfer activities only: no external reporting or information transfer activities are specified. It also includes reporting requirements that are the responsibility of the MER Advisors (being the Annual Basin Evaluation Report).

MER Providers will also be required to provide other key outputs for monitoring activities in the Selected Area:

- Submit monitoring data in the correct format and according to defined protocols within 1 month of its collection (including the MDMS and the LTIM Project Data Standards (Brooks & Wealands 2014))
- Noting and reporting any incidental observations made during field visits that may contribute to or support Evaluation (Area or Basin) or Adaptive Management. Observations can also include those reported to the MER Provider by stakeholders. This requirement is ongoing, following observations.

Table 9-2 Reporting requirements for the MER Project.

Activity type	What	Frequency	Timing / due date	Responsibility	Receiver	Description and high level requirements
Reporting	Monitoring and Evaluation Plan	One-off	Draft – 30 May 2019 Final – 30 Jun 2019	MER Providers	CEWO	A plan for monitoring and evaluation in each Selected Area over the three-year period from 2019-20 to 2021-22
Annual evaluation plan	Annual evaluation plan	Annually	August (2020-2022)	MER Providers	CEWO	The annual evaluation plan should outline what evaluation activities will be undertaken over the coming water year, based on anticipated environmental watering actions monitoring data availability
Reporting	Area evaluation report	Annually (October)	(Draft – 30 Sep Final – 30 Dec) First report – 2020 Final report – 2022	MER Providers	CEWO	A cumulative evaluation of the outcomes of Commonwealth water for the environment at each Selected Area, prepared in accordance with the MER Plan The report must be prepared in plain English with simple science and be suitable for publication on CEWO website
Reporting	Basin evaluation report	Annually	Draft – Aug 30 Final – Oct 31 First report – 2020 Final report – 2022	MER Advisers	CEWO	A cumulative evaluation of the outcomes of Commonwealth water for the environment at the Basin-scale, based on the Evaluation Plan The report must be prepared in plain English with simple science and be suitable for publication on CEWO website
Reporting	Quarterly Outcomes Newsletter	Quarterly	Last business day of September, December, March and June	MER Providers	CEWO	Plain English observations or initial findings and outcomes relevant to environmental watering Includes opportunistic photos or other relevant visual aids to demonstrate outcomes from environmental watering to the public
Information transfer	Monitoring data entry	Monthly	Monthly for the duration of the MER Project	MER Providers	MDMS	Processed monitoring data is uploaded to the MDMS in accordance with the data management protocols
Information transfer	Information exchange	Ongoing and as required	Ongoing and as required for the duration of the MER Project	MER Providers	Delivery partners inc. Selected Area Working Group	Information exchange on project activities (monitoring, observations, evaluations) and other information that would support the delivery of environmental water

9.3 Warrego-Darling Selected Area Working Group membership

The Terms of Reference and membership of the Warrego-Darling Selected Area Working Group are provided in Appendix D.

10. Project Management

10.1 Project governance

The MER Project is the primary means for measuring the outcomes of Commonwealth environmental watering in the MDB; as such, a robust framework for ongoing project governance is important for the implementation of the MER Project.

The primary line of governance between the CEWO, MER Providers and Basin-scale Team is the Project Manager from each lead agent for the Warrego-Darling Selected Area (Table 10-1). Although this project governance structure reflects the head agreement between the CEWO and UNE, the Warrego-Darling MER Project team will actively seek input from Aboriginal people, organisations and communities through our Communication and Engagement Plan (Section 8.5), regular participation in JMAC meetings and by seeking Aboriginal representation in the SAWG membership (Section 9.3, Appendix D) in consultation with Brad Moggridge, Jason Wilson and Briony Papps (CEWO).

Table 10-1 Primary governance structure for the Warrego-Darling Selected Area MER Project.

Project Lead	Agent	Role of Agent
Paul Frazier Darren Ryder	MER Provider (UNE/2rog) Project Directors	Implement MER Plan Work with CEWO and delivery partners to demonstrate outcomes and support adaptive management
Hilary Rossow	CEWO Aquatic	Lead contact Northern Basin
Gavin Pryde	MER Adviser	Technical coordination and oversight Whole of Basin evaluations of outcomes Support implementation of MER Plan
Michael Peat	CEWO Northern Basin Section	MER Project Area lead for the Warrego-Darling

10.2 Personnel including sub-contractors

Project Directors

Project Directors (Dr Paul Frazier and Professor Darren Ryder) will provide strategic and technical input to the project and are alternative points of contact for CEWO.

Project Manager

Sarah Mika is the principal point of contact for the Project and will report to CEWO's MER Project Manager for the Warrego-Darling Selected Area (Michael Peat). The UNE Project Manager will ensure the MER Plan meets the requirements of the contract and is responsible for meeting the project budget and work program. The project manager is also responsible for managing accounting, correspondence and meeting coordination.

Project Theme Leaders and Technical Scientists

The UNE/2rog/DPI Fisheries/NSW OEH Project Team includes a team of Senior Ecologists who are recognised experts in their field. This Senior Team will guide the operational monitoring project and undertake aspects of field survey, analysis and reporting. Each member of this team has been assigned a

monitoring indicator directly related to their area of expertise. 2rog, NSW OEH, DPI Fisheries and Steve Debus are engaged as subcontractors under UNE's head agreement with the CEWO.

This team is supported by a combined group of UNE/2rog scientists, with a range of skills in riverine and floodplain ecology and function. This group will undertake much of the on-ground survey, data handling and some reporting, and will supervise graduate ecologists in field surveys and laboratory analyses.

10.3 Risk Assessment

A risk assessment has been prepared for the Warrego-Darling Selected Area MER Project, based on this MER Plan. The purpose of this risk assessment is to identify risks to the successful implementation of the MER Project and undertake effective mitigation planning. Three areas of risk were considered:

1. Risks to the success of the Warrego-Darling MER Project and the ability to meet project objectives and outcomes (including risks that monitoring activities will not be able to be implemented)
2. Risks to the environment and aquatic ecosystem as a result of MER Project activities in the Warrego-Darling Selected Area
3. Risks to the health and safety of personnel undertaking MER Project activities in the Warrego-Darling Selected Area.

10.3.1 Risk assessment process

This risk assessment method is compliant with the Australian/New Zealand AS/NZ 31000:2009: Environmental Risk Management – Principles and Process (Standards Australia 2009), and aligns with the principles of Australian Standard AS/NZS 4360:2004 Risk Management (Standards Australia 2004).

Risk is defined as the combination of the likelihood and consequence of an event or outcome, as demonstrated in (Table 10-2).

Table 10-2 Risk assessment matrix.

LIKELIHOOD	CONSEQUENCE				
	Negligible	Minor	Moderate	Major	Critical
Almost Certain	L16	M10	H5	S2	S1
Likely	L17	M12	M11	H6	S3
Possible	L19	L18	M13	H7	S4
Unlikely	L22	L21	L20	M14	H8
Rare	L25	L24	L23	M15	H9

L= low, M=medium, H=High, S=Severe

The likelihood of a risk refers to the probability of a specific event or outcome actually occurring (Table 10-3); the consequence is the outcome of the action (Table 10-4).

Table 10-3 Risk likelihood categories.

Likelihood	Description in terms of full operating life of the site
Almost Certain	Consequences expected to occur in most circumstances
Likely	Consequences will probably occur in most circumstances
Possible	Consequences may occur at some time
Unlikely	Consequences are not expected occur within the life of the project
Rare	Consequences may occur in exceptional circumstances

For each of the three areas of risks considered, possible risks were identified by considering project specific issues and the proposed monitoring activities. Potential hazards and their subsequent impact were considered (i.e. what could happen). Using the definitions provided above, the likelihood and consequence of the potential impacts where then applied to assign an inherent risk rating. Management and risk mitigation measures are then recommended, and the risk rating method re-applied.

10.3.2 Risks to success of the project

Table 10-5 presents the key risks to success of the Warrego-Darling MER Project and suggests risk mitigation measures.

Table 10-4 Risk consequence categories.

Possible risks	Consequence				
	Negligible	**Minor**	**Moderate**	**Major**	**Critical**
Undertaking monitoring activities	Monitoring activities undertaken according to MER Plan, with data from all planned samples available	Minor disruption to the monitoring program with a small number of planned samples (<10%) not collected or data not available	More than 10% of planned samples not collected / available, however sufficient data available for planned analyses	Data from more than 50% of planned samples not collected /available. Limited monitoring outcomes reported	No useable data collected, analyses not possible, no monitoring outcomes reported
Environment	Negligible environmental damage	Short term, localised, reversible damage to the environment	Short term, widespread damage to the environment reversible to intensive effort	Long-term damage to the environment and/or risk of continuing environmental damage	Long-term, widespread, irreversible damage
Health and safety	Incident requiring first aid treatment	Minor incident requiring treatment by a medical practitioner	Moderate incident requiring short term hospitalisation	Serious incident requiring extensive hospitalisation	A fatality, permanent disability , or multiple people affected by a serious incident
Stakeholders	Short-term, isolated complaints from stakeholders	Sustained but isolated complaints from stakeholders Relationship with stakeholder temporarily affected	Sustained complaints from stakeholders Relationship with stakeholder damaged	Short-term but significant complaints from stakeholders Relationship with stakeholder significantly damaged	Sustained and significant complaints from stakeholder Relationship with critical stakeholder irreversible damaged
Project objectives	Short delay in achievement of project objectives	Delay in achievement of project objectives	Element or project objective not met	Project objectives not met	Project objectives harmed (negative impact)

Table 10-5 Warrego-Darling MER Plan risk assessment: successful implementation of the MER Project.

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Unpredictable weather - prolonged natural low flow conditions	Inundation period of system is impacted	Unable to effectively monitor and evaluate MER Project objectives	H7	• Design includes non-event based monitoring to inform the ecological response model and act as pre-flooding data • Annual monitoring plan will consider the long range forecast when developing watering options • If necessary, review asset condition and future priorities for watering	L18
Unpredictable weather – extreme flooding following watering event	Inability to collect monitoring data as access limited	Unable to effectively monitor and evaluate MER Project objectives Potential risk to crops during pre-harvest period	H7	• Assess CEWO water availability for additional watering opportunities – opportunity for sustained wetland inundation • Survey site design considering flood related accessibility • Survey site subset accessible in all conditions to provide a core dataset – design redundancy • All condition remote monitoring devices used where possible • Local field teams able to respond rapidly to changes in field conditions	L21
Other extreme weather events, i.e. flooding out of season, bushfires	Extreme weather events not considered in watering options	Negative impact on ecological assets	M14	• Design includes non-event based monitoring to inform the ecological response model and act as pre-flooding data • Annual monitoring plan will consider the long range forecast when developing watering options	L21
State Agency – poor engagement	Possible inefficiencies in collecting monitoring data Poor public image to landholders and the local community	Unable to effectively monitor and evaluate MER Project objectives	M14	• Communication and data sharing agreement with state agencies • On-going high level engagement to share results, methods refinement and scientific approach • Junction of the Warrego and Darling rivers Selected Area Working Group established and relationships maintained	L24
Short-term responsiveness to watering events	Inability to collect monitoring data after a flow event	Unable to evaluate MER Project objectives	H7	1. Location of the consortium within nine hours of the Selected Area maximises responsiveness to environmental watering. 2. Arrangements with NPWS staff onsite to collect some data • Many indicators being measured by continuously logging sensors	L20
Equipment operational failure (e.g. weir infrastructure)	Either unexpected flow event at an inappropriate time or impediment to flows	Negative impact on environmental outcomes	H7	3. Diversified site locations to spread sites across multiple sites – design redundancy 4. Potential landholder engagement for quick responses to infrastructure maintenance issues 5. Engagement with infrastructure owners to facilitate quick infrastructure repairs 6. Build in design flexibility to allow changes in monitoring effort so sites and indicators can be exchanged depending on the location and type of flow event	L20

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Field Sensor theft	Data sensors deployed remotely stolen or tampered with	Failure to collect data	M14	• Park Ranger visual check of equipment on a regular basis • Locate sensors in 'relatively' safe locations within the study area.	L24
Unexpected ecological response from environmental watering (e.g. algal blooms, incomplete bird breeding event)	Poor water quality impacts ecological assets i.e. native fish (including threatened species)	Negative impact on ecological outcomes from environmental watering	M13	• Prompt communication and data sharing with the Commonwealth and state agencies • UNE/2rog team expertise in biology and ecology of indicators to provide sound advice	L20
Failure to obtain complimentary data	Possible inefficiencies in accessing project data	Do not have sufficient data to meet reporting requirements	M14	• Majority of complimentary data (Flow data, satellite imagery) obtainable through public sources.	L20
Staff resourcing, staff turnover	Insufficient staff numbers to undertake project tasks. Loss of information continuity between staff over time	Failure to collect data and undertake reporting.	M15	• Work program established in early stages of project to ensure staff are prioritised to work on the project 7. Draw upon other UNE/2rog staff to ensure availability of qualified staff to undertake project	L24

10.3.3 Risks to the environment

On-ground activities have the potential to negatively impact the environment of the Junction of the Warrego and Darling rivers Selected Area if not managed appropriately. In particular, the following ecological values were considered during the risk assessment (as identified in Gawne et al. 2013b):

1. The Warrego and Darling systems and floodplain are included in the Lowland Darling River Endangered Ecological Community, listed under the *Fisheries Management Act 2004 (NSW)*.
2. The Warrego and Darling Rivers in the vicinity of the Selected Area support or are expected to support two threatened fish species listed under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*:
    - Murray cod (*Maccullochella peelii*) listed as Vulnerable under the EPBC Act
    - Silver perch (*Bidyanus bidyanus*) listed as Critically Endangered under the EPBC Act and as Vulnerable under the NSW Fisheries Management Act.
3. Both the Warrego and Darling Rivers in the Selected Area are likely to support native fish and other aquatic biota listed under the NSW Fisheries Management Act, including:
    - Olive perchlet (*Ambassis agassizii*) listed as an endangered population
    - Freshwater catfish (*Tandanus tandanus*) listed as an endangered population
    - Purple-spotted gudgeon (*Mondurnda adspersa*) listed as endangered
    - The Darling River snail (*Notopala sublineata*) listed as critically endangered.
4. The Western Floodplain of the Warrego River supports some areas of Coolibah-black box woodland, which is listed as an Endangered Ecological Community (EEC) within the Darling Riverine Plains and Brigalow Belt South bioregions under the NSW Biodiversity Conservation Act 2016 and also under the EPBC Act.
5. Areas in the Warrego-Darling MER Project Selected Area (in particular, the drying beds of Boera Dam, Homestead Dam, Dicks Dam and Ross Billabong) support populations of the native plant 'tiny teeth' (*Dentella minutissima*) listed as endangered under the NSW Biodiversity Conservation Act 2016. The Warrego also forms part of the distribution for the squash bush (*Osteocarpum scleropterum*) listed as endangered under the NSW Biodiversity Conservation Act 2016.
6. Although not currently listed as threatened, slender spurge (*Synostemon trachyspermus*, previously *Sauropus trachyspermus*) found at Toorale has conservation significance due to the rarity of recent collections (NSW NPWS 2018).
7. The Warrego River and Western Floodplain support a number of waterbirds listed under either the EPBC Act or the NSW Biodiversity Conservation Act 2016, including:
    - Blue-billed duck (*Oxyura australis*) listed as Vulnerable under the NSW Biodiversity Conservation Act
    - Brolga (*Grus rubicundas*) listed as Vulnerable under the NSW Biodiversity Conservation Act
    - Eastern great egret (*Ardea modesta*) listed as a migratory bird species under the EPBC Act (these migratory species are also listed under international agreements such as Japan-Australia and China-Australia migratory bird agreements (JAMBA and CAMBA)

- Glossy ibis (*Plegadis falcinellus*) listed as a migratory bird species under the EPBC Act (these migratory species are also listed under international agreements such as Japan-Australia and China-Australia migratory bird agreements (JAMBA and CAMBA)
- Oriental pratincole *(Glareola maldivarum*) listed as a migratory bird species under the EPBC Act (these migratory species are also listed under international agreements such as Japan-Australia and China-Australia migratory bird agreements (JAMBA and CAMBA)
- Rainbow bee-eater (*Merops ornatus*) listed as a migratory bird species under the EPBC Act (these migratory species are also listed under international agreements such as Japan-Australia and China-Australia migratory bird agreements (JAMBA and CAMBA)
- A further four species are of conservation concern in the Western Division of NSW due to their rarity and limited breeding opportunities:
  - Australian pelican (*Pelecanus conspicillatus*)
  - Australasian darter (*Anhinga novaehollandiae*)
  - Great cormorant (*Phalacrocorax carbo*)
  - Pied cormorant (*Phalacrocorax varius*)

8. A number of other aquatic-dependent biota known or expected to occur in the Warrego-Darling MER Selected Area are also of conservation concern due to rarity and limited breeding opportunities including the Murray turtle (*Enydura macquarii*), broad-palmed frog (*Litoria latopalmata*), desert froglet (*Crinia deserticola*) and rough frog (*Cyclorana verrucosa*).
9. The Warrego River is an important source population for golden perch (*Macquaria ambigua*) in the Northern MDB.

Table 10-6 presents the identified risks to the environment (including ecological values) associated with undertaking monitoring activities in the Junction of the Warrego and Darling Rivers Selected Area and the recommended risk mitigation measures.

Table 10-6 Junction of the Warrego and Darling Rivers MER Plan risk assessment: risks to the environment as a result of the MER Project.

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Driving in long, dry grass	Starting bushfires	Loss of or damage to biodiversity and property	H6	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Contacting relevant landowners including NPWS and JMAC prior to fieldwork to identify areas and develop alternative route • Arranging long grass to be cut if alternative route cannot be arranged • If risk of fire is very high, reschedule field work times for affected sites	M14
Working in threatened ecosystems	Implementing structures in protected areas i.e. National Parks	Loss of or damage to biodiversity and property	M10	• Identifying areas which will require bathymetric surveys i.e. depth loggers, artificial substrates for stream metabolism • REF is required for any structure (including depth loggers) within National Parks estates	L17
Monitoring threatened flora	Impacting threatened species and/or habitat i.e. vegetation assessments in Coolibah-Blackbox Woodlands	Loss of or damage to biodiversity	M13	• Standard Operating Procedure for Monitoring Indicator – Vegetation Diversity • Minimise trampling and avoid areas that do not need surveying. Follow requirements of land owner/ manager, incl. government bodies • A scientific licence is required to pick, hold or study native flora • Where possible identify flora species in the field. If a sample is required, take only that needed for identification. Take photos where a sample would affect survival of the individual • If a new location is discovered for a threatened species, note its position and take care not to unnecessarily disturb its root system or habitat, and notify information to NSW Bionet • Clean mud and weed propagules off shoes, clothing and vehicle/quad bike tyres prior to leaving an area where possible (particularly where noxious weeds were identified) • Works should be programmed to consider seeding periods and weed locations • Field staff to sign off on Environmental Site Inspection for prior to undertaken monitoring activities	L18
Monitoring threatened aquatic fauna	Impacting threatened species or damaging habitat i.e. trapping and electrofishing Murray Cod	Loss of or damage to biodiversity	H7	• Standard Operating Procedure for Monitoring Indicators – Fish (Channel) • Ensuring that fish surveys follows the Survey guidelines for Australia's threatened fish. EPBC Act survey guidelines 6.4 • Use minimum impact survey techniques as per survey procedure and required by animal ethics permit • Field staff to sign off on Environmental Site Inspection for prior to undertaken monitoring activities	M14
Monitoring threatened terrestrial fauna	Impacting breeding habitat (waterbirds)	Loss of or damage to biodiversity and property	H6	• Standard Operating Procedures for Monitoring Indicator – Waterbird Diversity • Minimise trampling and avoid areas that do not need surveys • Use minimum impact survey techniques as per survey procedure and required by animal ethics permit • Field staff to sign off on Environmental Site Inspection for prior to undertaken monitoring activities	L18

10.3.4 Risks to individuals

Table 10-7 presents the potential risks to the health and safety of personnel undertaking monitoring activities within the Selected Area and suggested mitigation measures to management them. The development of mitigation measures are in line with UNE's Environment, Safety and Quality framework. Mitigation measures and procedures are described further in the Work Health and Safety Plan (Appendix A).

Table 10-7 Junction of the Warrego and Darling Rivers MER Plan risk assessment: risks to individuals and teams undertaking monitoring activities.

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
Adverse weather conditions	Prolonged rain/flooding	Drowning	H7	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work i.e. checking WaterInfo website • Undertaking JSEA if river conditions rapidly change. • Not entering areas of fast flowing water	M14
	Extreme heat/cold	Sunburn or skin burn, hyperthermia or hypothermia	H6	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Appropriate PPE • Suitable scheduling & rostering of monitoring activities	M14
Adverse weather activity	Storms-lightning strikes	Burns and shock (potentially fatal)	H9	• Do not enter site until 1 hour after the storm passes • If on-site vacate the area and/or seek shelter immediately	L23
	High winds	Struck from falling objects and vehicle control	M14	• Undertaking JSEA before driving if conditions rapidly change • Take cover during periods of high winds away from overhead trees/branches • Reduce speed if driving in high winds	L23
Vehicle and driving hazards	Car accident on way to site/onsite	Death, permanent impairment, lost time injury	H8	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to driving • Site induction in high risk sectors • All staff will have current first aid qualifications and vehicle will carry a first aid kit • All vehicles to carry Emergency First Aid Box (includes consumables and bottled water) and sat phone/spot tracker	M15
	Vehicle breakdown/ bogged	Isolation, thermal stress, dehydration, hunger	H7	• Undertaking JSEA before attempting vehicle recovery • 4WD training for field staff • Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to driving • All staff will have current first aid qualifications. • All vehicles to carry Emergency First Aid Box (includes consumables and bottled water) and sat phone/spot tracker • Field staff to sign off on Remote Location Vehicle check list	M13
	Long distance driving	Wide ranging physical injuries, potentially fatal and vehicle damage	H7	• Undertaking JSEA Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to driving • Two person field teams to ensure that there is a break and swap of drivers every 2 hours • All staff will have current first aid qualifications.	M13

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
				• All vehicles to carry Emergency First Aid Box (includes consumables and bottled water) and sat phone/spot tracker	
	Encountering wildlife	Car accident (with either wildlife, or other vehicles)	H7	• Avoid driving between dusk and dawn where possible. If you must drive during this time keep an eye on the sides of the road and reduce speed to allow brake time if necessary • Safe Work Methods Statement to be completed prior to trip • All staff will have current first aid qualifications. • All vehicles to carry Emergency First Aid Box (includes consumables and bottled water) and sat phone/spot tracker	M14
Quad-biking	Riding over uneven terrain/marshland	Bike rollover, wide ranging physical injuries, potentially fatal and bike damage	H7	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Quad bike training for all field staff • All staff to wear helmets	M14
	Riding in flooded terrain	Bogging of bike, isolation, thermal stress, dehydration, hunger and bike damage	H7	• Only one rider per bike • All staff will have current first aid qualifications • Undertaking JSEA before attempting bike recovery • Carry portable communications (UHF radio, satellite phone) when biking in areas without mobile reception • Staff working in teams when using quad-bikes.	M14
Terrain hazards	Bushfires	Burns, smoke inhalation amd potentially fatal	H7	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Field teams to carry Bushfire safety plan • Regular updates from BOM website and advice from RFS	M15
Flora and fauna	Plant and insect allergens	Allergic reactions (skin/eye), Hay Fever, respiratory reactions, anaphylactic shock which can be potentially fatal	H7	• Ensure staff know who their colleagues are with severe allergic reactions, implement allergy management response plan • Be aware of nearest hospital for treatment and have communications available. • Don't expose staff with known allergies to projects where these risks are unaccepted • Standard Operating Procedures - Wildlife survey procedures • Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • First aid kit to be carried at all times and equipped with 2 snake bandages per staff member and 2 Epi-pens • All staff will have current first aid qualifications • Two persons in the field	M14
	Venomous fauna	Poisoning, potentially fatal	H7	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work	M14

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
				• First aid kit to be carried at all times and equipped with 2 snake bandages per staff member • All staff will have current first aid qualifications. • Two persons in the field	
	Fauna related diseases, including exposure to ticks, mosquitoes, leeches and Anthrax	Bites, Infection and Illness	H7	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • PPE and applying permethrin to field clothing • Performing daily tick checks and removing ticks as soon as they are detected • First aid kit to be carried at all times and equipped with 2 snake bandages per staff member and 2 Epi-pens • All staff will have current first aid qualifications • All staff to avoid contact with material that could be potentially contaminated with Anthrax	M14
Remote site hazards	Remote area surveys	Slow response time from external source/services to an injury or incident	H7	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Emergency response procedures developed for remote area surveys • Vehicles to be equipped with sat phone/spot tracker, bottled water • Field staff to sign off on Remote Location Vehicle check list • First aid kit to be carried at all times and equipped with 2 snake bandages per staff member • All staff will have current first aid qualifications	M14
	Working with others in remote areas	Sexual harassment, bullying, inappropriate behaviour	M15	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Two person field team • Prior discussion with landowners, if required.	L23
General field work	Field equipment use (e.g. Traps)	Muscle and back strain, joint injury, Lacerations and other injuries from equipment	H6	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • PPE • Manual Handling training • Complete JSEA if activity is not specified in the Standard Operating Procedures for the relevant Monitoring indicator • First aid kit to be carried at all times and equipped • All staff will have current first aid qualifications.	M13
	Long hours/night work	Musculoskeletal injuries, slips, trips, falls	H6	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Adhere to PPE checklist	M13

Risk	Hazard	Impact	Risk Rating (Inherent)	Risk Mitigation Measures	Risk Rating (Managed)
				• Wear sturdy shoes, check visibility/take a torch if required • First aid kit to be carried at all times and equipped • All staff will have current first aid qualifications.	
Aquatic surveys	Boat usage	Hypothermia, become wet during cold conditions, drowning, damage and injuries.	H7	• Field staff to have boat licence • All field staff to wear inflatable vest when operating boat • Boat to be equipped with all safety items listed under NSW legislation (Flare/beacon, light, oars, first aid kit) • Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Two person project team, only one person in deep water at any time • All staff will have current first aid qualifications.	M14
	In-stream/wetland/ bank surveys	Slip / trip leading to injury, being swept downstream, collision with in-stream debris, stuck in mud, drowning.	H7	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Wear appropriate shoes if working prolonged periods in inundated wetlands • Two person project team, only one person in deep water at any time. • First aid kit to be carried at all times and equipped • All staff will have current first aid qualifications.	M14
Hazardous substances	Diesel or Ethanol use and handling	Inhalation, ingestion, contact with skin	Medium	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • MSDS to be carried at all times • First aid kit to be carried at all times and equipped • Adhere to PPE checklist	L24
Ergonomic	Manual handling (lifting, bending, reaching, carrying)	Musculoskeletal injuries and back strain, joint injury	H7	• Safe Work Methods Statement to be completed prior to trip and onsite Toolbox Talks prior to commencing work • Job rotation • Manual handling training and refresher undertaken	M15

10.4 Quality assurance

This Quality Assurance Plan has been developed by the MER Providers for the Warrego-Darling Selected Area, being the project team (the University of New England (UNE) and 2rog Consulting (2rog)). UNE has its own Quality Assurance System (QA System), based on AS/NZS ISO 9001: 2000. This Plan has been developed based on this QA System in accordance with relevant standards including AS/NZS ISO 10005:2006 and ANZECC (2000). The objective of this Quality Assurance Plan is to document quality control and quality assurance (QA/QC) procedures for monitoring activities in the Warrego-Darling Selected Area, including:

- A table of methods for field equipment
- Data collection QA/QC requirements
- Data storage and management (Section 11)
- Document management (Section 11)
- Training
- Auditing

10.4.1 Field Equipment

A table listing field equipment required to collect data relevant to Basin-scale evaluation is provided in Table 10-8, together with specific methods such as calibration requirements and maintenance and calibration logs. A maintenance log sheet is provided in Appendix E.1 and a Chain-of-Custody Form is provided in Appendix E.2.

Table 10-8 Field equipment and methods QA/QC – Warrego-Darling Rivers Selected Area.

Monitoring indicator	Field Equipment	QA/QC
Ecosystem Type	GPS and spare batteries Field vegetation guide Maps, including assessment site information SOP Datasheets	
Vegetation Diversity	GPS and spare batteries Compass Maps, including assessment site information 100 m surveyor's measuring tape(s) DBH tape Plastic cattle tags or stamped metal tags pre-prepared as unique identifiers of surveyed trees Permanent marker pens Digital camera, spare battery SOP DECC field data sheets and/or field computer	
Fish (Channel)	DPI Fisheries are undertaking all field work and data analysis for this indicator. Relevant maintenance records and equipment calibration procedures will be undertaken as per NSW Department of Primary Industries' protocols	
Frogs	Torch or spotlight with a minimum of 300 Lumens Notebook- Pocket notebooks are far easier to manage than A4 datasheets for general surveys Callipers (for size measurement) Disposable gloves GPS Watch (record start and finish times) Disinfectant (see NSW OEH hygiene protocol for frogs)	All surveyors must adhere to the NSW OEH hygiene protocol for frogs, or other state approved hygiene protocol. http://www.environment.nsw.gov.au/animals/HygieneProtocolForFrogs.htm
Stream Metabolism	Sample containers and appropriate preservatives (sourced from laboratory) 0.2 µm filters and suitable filtering device (e.g. syringe filter) for dissolved nutrients and carbon 47 mm glass fibre (GFC) filters and suitable filtering device for chlorophyll-a Water quality meter(s) with pH, turbidity and electrical conductivity probes Deionised water for sample blanks Eskies and ice for sample preservation and storage Datasheets and/or field computer	Prior to deployment in the field, the probe(s) must be calibrated according to manufacturers' instructions and results of calibration entered into a calibration log.
Waterbird Diversity	Field guide GPS Camera Watch	

Monitoring indicator	Field Equipment	QA/QC
	Maps of Selected Area including assessment site information 2B pencils, sharpener and eraser Hand held tally counter Binoculars or Telescope and tripod SOP Field note book or datasheets	
Microinvertebrates	Benthic corer (50 mm diameter x 120 mm long, 250 mL volume) and rubber backed spatula Small (4L) bucket with lid for settling benthic cores 63um mesh sieve Squirt Bottle 70% ethanol with Rose Bengal stain Storage jars Data sheets SOP Data sheets	Consistent make/model of corer/sampler among selected areas using microinvertebrate method. Consistent level of taxonomic identification/keys used among selected areas.
Water quality	Hydrolab DS5-X logger (the DS5-X multi-probe logger includes a self-cleaning system to reduce fouling of probes and is designed for long-term submersible deployment). Water quality sensors and loggers. Preferably as a multi-parameter probe, but separate probes for each parameter are acceptable. Note that dissolved oxygen probe must have an optical (fluorescence) sensor. Tool kit and spare parts for the multi-parameter probe; including spare batteries and calibration fluids Metal star pickets and star picket driver or mallet. Means to attach probe to star picket or permanent structure. GPS Probe calibration log Field sheets Laptop and data cables for connecting to probes / logger SOP Data sheets	Sensors placed in location with continuous flow. Sensor placed in the vicinity of NPWS homesteads at 'Acuna' and 'Yanda' for security. Calibration and maintenance of sensors and loggers at a maximum 6 week interval. Data correction procedures will be used to account for sensor drift or fouling following periodic calibration. The initial sensor readings (before cleaning) are compared to a calibrated field meter before removing the monitor sonde for servicing. This initial sensor reading becomes the ending point of the data record since the last servicing, and the field meter reading provides a sense of the reasonableness of the monitor readings and an indication of potential drift and fouling. If the readings of the monitoring sensor are outside the range of acceptable differences, recalibrating the sensor and/or servicing are required.
Hydrology (River)	n/a	

11. Data management

11.1 Confidentiality and Intellectual Property

The UNE/2rog team will align and comply with CEWO's contract and requirements for confidentiality. All personnel will be aware of confidentiality and communication management requirements. Ownership of information generated for this project belongs to CEWO.

UNE will develop and maintain an intellectual property register for the duration of the project. UNE will obtain and abide by all licences and agreements for all complimentary data obtained and used for the MER Project. This will also be tracked in the Intellectual Property register.

11.2 Data collection

This section specifies QA/QC arrangements relating to data collection will ensure that the data collected are of a high quality (Table 11-1). The CEWO has developed the LTIM data standard to ensure that data collected for the LTIM and MER Projects is done so in a structured and consistent manner. The LTIM data standard defines the specific data requirements for the LTIM and MER Projects that will be managed by the LTIM and MER Monitoring Data Management System (MDMS) (Brooks & Wealands 2014). The MER project will comply with this data standard to maintain consistency.

Staff will follow the SOPs for each indicator (Appendix B). A training log sheet is provided in Appendix E.3. This training log will be kept with each SOP and a copy provided to the Project Manager.

Table 11-1 Data collection QA/QC – Warrego-Darling Selected Area.

Monitoring indicator	QA/QC – data collection
Ecosystem Type	GIS analysis by experienced GIS staff Field survey by qualified ecologist/environmental scientist
Vegetation Diversity	All surveys will be led by experienced ecologists. Where possible the same team will be used for each survey to reduce surveyor bias.
Fish (River)	DPI Fisheries are undertaking all field work and data analysis for this indicator. DPI Fisheries will obtain the necessary specific fisheries and ethics permits prior to undertaking any sampling. Copies of these permits shall be provided to the Project Manager prior to any field work taking place.
Frogs	All surveys will be led by experienced ecologists. Where possible the same team will be used for each survey to reduce surveyor bias. All surveyors will adhere to the NSW OEH hygiene protocol for frogs, or other state approved hygiene protocol. http://www.environment.nsw.gov.au/animals/HygieneProtocolForFrogs.htm
Waterbird Diversity	All Waterbird Diversity assessments within a Selected Area, where possible, will be undertaken by the same experienced observers during the LTIM project to maintain consistency over time. All observers will undergo training prior to undertaking monitoring surveys, including calibration against experienced observers to ensure standardisation of measurements. Training and calibration procedures must be documented in the MEP and relevant records maintained. Identification of difficult species will often differ between observers. To minimise the variance associated with different observers, a minimum of two staff are assigned to Waterbird Breeding assessments. Where there are significant differences in original observer scores, observers will discuss their rationale and where appropriate adjust scores to mutually agreed values.

Monitoring indicator	QA/QC – data collection
Microinvertebrates	Standardisation of microinvertebrate sampling equipment. Requirements for NATA accreditation for water quality sampling – all samples will be processed by the NSW OEH Lidcombe laboratories. Field duplicate and blank samples will be collected following the Standard Method. Preservation and transport of water quality samples will follow the procedures provided by the processing laboratory. Entire samples should be preserved individually in 70% ethanol.
Water quality and Metabolism	Calibration and maintenance of sensors and loggers is required at a maximum 6 week interval Data correction procedures will be used to account for sensor drift or fouling following periodic calibration
Hydrology (River)	Data will be sourced from existing WaterNSW gauging stations
Hydrology (Floodplain)	Data will be sourced from existing data sets (LiDAR) as well as from water level sensors deployed at the site.
Hydrology (Northern tributaries)	Data will be sourced from existing WaterNSW gauging stations
Hydrology (Channel)	Data will be gained from existing WaterNSW gauging stations and water level recorders deployed at the site. Surveying will be undertaken by experienced personnel to tie all water level recorders in to a common benchmark.
Hydrology (Habitat)	Observers with geomorphological experience will be used to identify and map in-channel habitat.

11.3 Data and Document Management

All MER Project files will be stored on UNE's cloud.UNE server and/or 2rog's server. The data-centre underlying cloud.UNE is located on UNE's Armidale campus and copied weekly to a data centre in Sydney. 2rog utilises a common data backup rotation scheme. Backup rotation schemes allow immediate storage of data in a secure location.

- On return from the field, copies of data sheets will be scanned onto the server and hard copy records kept. At a minimum, 5% of all data entered will be checked for consistency and accuracy.
- As much as possible, data storage will be undertaken in a way to be complimentary to the CEWO MSDS.
- All files will be stored according to the existing file naming protocol (Table 11-2) used for LTIM.
- All derived data submitted for shared evaluation needs will adhere to LTIM data standards and be traceable to raw data. Data that supports shared evaluation needs will be submitted/uploaded within one month of collection, and according to the protocols established by CEWO.

UNE will store and manage access to primary data for the duration of the MER Project.

All data will be entered onto UNE's research server (cloud.UNE) as soon as practically possible upon return from the field.

The document control processes outlined below are based on UNE's Quality Control Process, which confirms to the requirements of the AS/NZS ISO 9001:2008 Quality management system.

A document control process has been developed for both internal and external MER documents (Table 11-2). Internal documents will primarily relate to the project and outcomes reporting requirements to CEWO. Each document will follow the specified CEWO reporting templates. All external documents will follow the process outlined below, and in addition:

- All external written documentation to be submitted to CEWO (not including emails) will be reviewed by the MER Provider (Directors) prior to submission
- The Approved Branding specification will be adhered to
- The delivery of external documents will align and comply with CEWO's contract and requirements for confidentiality

The MER Providers will develop and maintain an intellectual property register for the duration of the MER Project.

Table 11-2 Document management procedures.

Step	Description
1. When to make changes	**MER Reporting Documents** • Changes to a document will be made in response to an audit or request by CEWO Project Management Team or MER Advisers • The MER Provider Team will refer to the Document & Authority Register to determine who is responsible for document changes and approval • Changes cannot be made until a new copy of the document is saved. The current version will be retained until changes are finalised (and approved, if required) • WHS Documentation (includes Safety procedures, plans, registers and forms) are only undertaken by the MER Provider team, in collaboration with their WHS Manager to ensure compliance with relevant legislation
2. Changing and approving changes to a document	All members of MER Provider Team can make changes to a document. Approval of changes to a document can only be undertaken by the MER Provider Leads (UNE/2rog) Any major changes will be discussed with CEWO Project Management Team
3. Control versions at point of use	The MER Provider Team will save all new versions of a document using the file naming system outlined in Step 4 Document required by CEWO will follow the relevant CEWO reporting templates and include a version control register Communicate changes to relevant project personnel and re-issue documents, if required Printed copies of documents are uncontrolled and should be treated as non-current
4. Legible and readily identifiable	The MER Provider Team will initiate a project folder and file naming system • Documents for internal use should be in the form "Brief name of document]_[date]_[initials]", e.g. "Draft MER Plan_172014_XX" • Version number – this is shown in the Document Tracking box of the report and in the file name: • Use v0, v1, v2 etc to indicate changes in report versions that are sent to the client. Use v0 for the first draft before it goes to the client as v1. Do not restart the numbering when you change from draft to final report status

Step	Description
	• Use an alphabetical suffix for internal revisions e.g. v1a, v1b, v1c. Do not send files that have the alphabetical suffix to the client • If there are a number of people working on a document simultaneously, add the initials of the author to differentiate documents e.g. v1a_sm
5. Review of documents	A record of the review will be documented on a **Document Register** within the document
6. Archival documents & data	All archival documents & data to be retained for legal or knowledge preservation purposes are to be identified (Archival file) and stored on under nominated folder i.e. driver:\MER project\OLD

11.4 Training

Training logs will be maintained for all training undertaken as required for monitoring indicators. These logs will be provided in each SOP as required, and copies maintained by the Project Manager. Any training required under the WHS Plan will also be logged. A training log template is provided in Appendix E.3.

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Appendix A. Work Health and Safety Plan

Warrego-Darling Selected Area MER Project

Item	Details
UNE Project Number	A19/467
Project Director/s	Paul Frazier, Darren Ryder
Project Manager	Sarah Mika
Prepared by	Sarah Mika, Paul Frazier, Darren Ryder

This document is the Work Health and Safety Plan for the CEWO LTIM Project for the Warrego-Darling Selected Area. It is to be read in conjunction with the Monitoring, Evaluation and Research Plan for the above project.

Any reviews or changes to this Work Health and Safety Plan must be recorded in the tables below.

Document control

Version	Date	Reviewed by	Approved by
1	24 May 2019	Darren Ryder, Paul Frazier	Darren Ryder
2	28 May 2019	Darren Ryder, Paul Frazier	Darren Ryder

Version	Change since previous issue
2	Minor editing and formatting

Contents

Abbreviations

Abbreviation	Description
2rog	2rog Consulting
CEWO	Commonwealth Environmental Water Office
JSEA	Job Safety and Environment Assessment
LTIM	Long-Term Intervention Monitoring
MER Plan	Monitoring and Evaluation Plan
MER Providers	Monitoring and Evaluation Providers
OEH	(NSW) Office of Environment and Heritage
PPE	Personal Protective Equipment
QA/QC	Quality Assurance / Quality Control
SOP	Standard Operating Procedure
UNE	University of New England
WHS	Work Health and Safety

Induction Register

All field team members are to sign below acknowledging they have read and understood their roles and responsibilities as documented within this WHS Plan.

Name	Signature	Date

A.1 Introduction

This document is the Work Health and Safety Plan (WHS Plan) for the Commonwealth Environmental Water Office (CEWO) MER Project for the Warrego-Darling Selected Area. It is to be read in conjunction with the Monitoring, Evaluation and Research Plan for the above project.

This WHS Plan has been developed by the MER Providers for the Warrego-Darling Selected Area, being the project team lead by the University of New England (UNE) and 2rog Consulting (2rog).

A.1.1 Plan objectives

The objectives of this WHS Plan are to:

- Identify and address risks to health, safety and the environment that may arise from monitoring activities undertaken during the MER Project in the Warrego-Darling Selected Area (Contract A19/467), including the provision of job safety and environment assessments (JSEAs)
- Identify roles and responsibilities
- Provide emergency preparedness and response procedures, including incident reporting
- Detail communication and consultation processes as they related to WHS
- Describe the process for the review of this WHS Plan and subsequent reporting.

A.1.2 Scope

The scope of this WHS Plan is to address activities that will be undertaken for all monitoring indicators as part of the Warrego-Darling MER Project, including travelling to and from site.

Locations for field work are nominated in the Standard Operating Procedures (SOPs) prepared for each monitoring indicator (Appendix B), and are not replicated in this document.

A.1.3 Identifying legal and other requirements

This WHS Plan has been developed in accordance with the Commonwealth *Work Health and Safety Act 2011*, *Work Health and Safety Regulations 2011* and the Work Health and Safety Codes of Practice 2011, and the relevant NSW legislation.

Related documents

This WHS Plan is supported by UNE's Environment, Safety and Quality Management System (ESQMS) that conforms to:

- AS/NZS ISO 14001: 2004 Environmental management systems – Requirements with guidance for use
- AS/NZS 4801:2001 Occupational Health & Safety management systems – Requirements with guidance for use
- AS/NZS ISO 9001:2008 Quality management system – Requirement.

Where existing UNE procedures and documents are referred to, these documents are provided as an attachment to this MER Plan.

A.2 WHS Risks

Risk management is an integral part of this WHS Plan and good management practice. It is an iterative process consisting of steps, which, when undertaken in sequence, enable continual improvement in decision-making.

UNE has established, implemented and maintained documented procedures for the identification, assessment and control of hazards and risks through its Audit and Risk and WHS Directorates. The process for analysing and managing hazards and risks includes:

- Establishing the context, including acceptability criteria for the risk analysis
- Hazards/aspects identification to determine risk scenarios and select a suitable level of risk evaluation
- Evaluating risks by qualitative or quantitative assessment(s) and assigning risk ownership
- Recording the risk analysis in the UNE Risk Register
- Managing risks according to their classification of High to achieve levels that are deemed to be as low as reasonably practicable
- Utilising the following hierarchy of control:
    - Eliminate the risk scenario
    - Substitution
    - Engineering and process controls
    - Administrative controls or management strategies
    - The use of personal protective equipment (PPE)
- Developing and agreeing on further actions or monitoring of the risks, taking into account the hierarchy of controls
- Verifying the completion of actions
- Re-evaluating the risk and classification as appropriate
- Reviewing and updating the UNE Risk Register over time
- Documenting, reporting and communicating the risk information.

A.2.1 Risk identification and assessment

The risk management process, including the identification of risks and the risk assessment/control process, is outlined above and in Chapter 10 of the MER Plan.

The risk assessment method undertaken for the MER Project is compliant with the Australian/New Zealand AS/NZ 31000:2009: Environmental Risk Management – Principles and Process (Standards Australia 2009), and aligns with the principles of Australian Standard AS/NZS 4360:2004 Risk Management (Standards Australia 2004).

Risk assessment was provided in Section 10.3 of the MER Plan and follows UNE's *WHS OP008 Risk Assessment Operating Procedure* and *WHS F020 Risk Assessment*.

A.2.2 Risk register

A risk register has been developed for monitoring, evaluation and research activities to identify potential project risks. This risk register identifies key personnel responsible for control measures to ensure that the register and associated controls are current, implemented and communicated.

Potentially high risk activities associated with the MER Project are listed below (Table A-1). Further details are provided in Section 10.3.

Table A-1 Potentially high risk activities identified for the MER Project – Warrego-Darling Selected Area.

Potential risk	Site/activity specific
Exposure to the elements, weather conditions	Generic
Vehicles and driving hazards (including remote access, fatigue, towing etc.)	Generic
Terrain hazards and general site hazards (e.g. slips, trips and falls)	Generic
Hazards from flora and fauna, including dead livestock	Generic
Hazards to flora and fauna	Generic
Water borne illnesses	Generic
Manual handling and lifting	Generic
Handling and storage of chemicals and equipment	Activity specific
Remote surveys	Generic – limited coverage at most sites in the Warrego-Darling Selected Area
Bushfire hazards	Generic

A.3 Safe Work Procedures

Safe work procedures have been provided for potentially high risk activities and form part of this WHS Plan. Safe work procedures provide directions on how a particular aspect of work is to be carried out safely. They identify hazards and clarify what must be done to eliminate or minimise risks.

Written work safe procedures should be prepared for all potentially hazardous tasks performed and must list any required PPE. The process of developing a written safe work procedure for a hazardous task includes the following four steps:

- Determine the overall task that requires a safe work procedure
- Break down the task into its basic steps
- Identify the hazards associated with each step, and ways to eliminate or minimise the risk to workers from these hazards
- Write the safe work procedure – the list of actions that workers must do when performing the task.

Safe work procedures and protocols have been developed for the following activities and can be provided upon request:

1. Fatigue management
2. Manual handling
3. Bogged vehicle retrieval
4. Heat/cold induced illnesses and injuries
5. Hazardous chemicals
6. Fauna related diseases
7. Bushfire safety
8. Personal protective equipment
9. Safe driving.

These procedures will be updated or added too, should any deficiencies or non-conformances be identified during the project (see Section 10.3).

A.3.1 Procedure for site visits

Prior to any field-based activities, a review of WHS risks shall be carried out using the *WHS F020 Risk Assessment* and the *WHS F010 Fieldwork Planning Guide and Checklist* forms.

A copy of this WHS Plan will be carried by all field teams, and is to be used in conjunction with the *WHS F014 Safe Work Method Statement (SWMS)* and *SWMS - Toolbox Talk*.

The *WHS F014 SWMS* will be completed and reviewed prior to undertaking any fieldwork by all personnel including consultants and sub-contractors. The SWMS includes call-in/call-out procedures and emergency contacts.

Toolbox talks must be completed daily on-site. Any new risks identified as part of the Toolbox Talks are to be sent to the Project Manager for inclusion on the risk register.

The following standard practices shall be applied prior to undertaking any fieldwork:

1. All vehicles should be checked for serviceability prior to leaving (*Remote Location Vehicle Checklist*). Vehicle Emergency Box and First Aid Kits are to be carried in company vehicles at all times during field trips. Non company vehicles are not to be used for fieldwork.
2. A personal first aid kit must be carried by an individual at all times when away from the vehicle.
3. All members of the team undertaking site visit or field trip must be senior first aid qualified.
4. Drivers must have a current drivers' licence eligible in Australia and be authorised to drive company vehicles.
5. The most recent update of this WHS Plan must be carried in the field folder in the vehicle.
6. The completed *WHS F010 Fieldwork Planning Guide and Checklist, WHS F014 SWMS* and blank copies of the *SWMS - Toolbox Talk* must be carried in the field folder. Completed copies must scanned and electronically saved in project file and hard copies placed on the project folder.

A list of first aid equipment is contained in each first aid kit. The field team leader or designated project officer will be responsible for checking the first aid supplies of each kit prior to field work.

All field vehicles carry a Field based First Aid Kit and also an emergency equipment box that includes various supplies and consumables (bottled water and non-perishable food) in the event of an emergency.

A.4 Emergency Responses and Reporting

A.4.1 Emergency response

The safety of all persons is the immediate priority.

All members of the Project Team must report all injuries or incidents (inclusive of lost time and no lost time) to the Project Manager and UNE's/2rog WHS Manager within 24 hours and fill in an Injury / Incident Report.

Hazards and near miss incidents are to be reported on UNE's WHS software SkyTrust within one business day for an investigation to be undertaken. Serious hazards or near miss incidents should be reported immediately to the Project Manager and UNE WHS team.

A.4.2 Notifiable incidents

The Work Health and Safety (WHS) Act requires that UNE must notify the regulator of any notifiable incidents that arise out of the conduct of the business or undertaking. The primary purpose of incident notification is to enable the regulator to investigate serious incidences and potential contraventions of the WHS Act, as soon as possible.

In the event of a notifiable incident it is the responsibility of the person with management or control of the workplace to ensure, so far as is reasonably practicable, that the site is not disturbed until an inspector arrives or otherwise directs.

The Project Manager and Project Directors are to be notified immediately following a notifiable incident. The Project Manager will notify the relevant agency of the incident within the required timeframe for notification.

What is a notifiable incident?

A notifiable incident is an incident involving the *death of a person, serious injury or illness of a person or a dangerous incident*. To assist in determining what type of incident must be notified, 'serious injury or illness' and 'dangerous incident' are defined in the *WHS Act*:

A *serious injury or illness* is one that requires a person to have:

- Medical treatment within 48 hours of exposure to a substance
- Immediate treatment as an in-patient in a hospital
- Immediate treatment for a serious injury or illness such as a serious head injury, a serious burn or a spinal injury and a number of other injuries listed in the WHS Act.

Importantly, it does not matter whether a person actually received the treatment referred to in this definition, just that the injury or illness could reasonably be considered to warrant such treatment.

A *dangerous incident* is an incident in a workplace that exposes a worker or any other person to a serious risk to their health or safety emanating from an immediate or imminent exposure to a number of risks. These risks include an uncontrolled escape, spillage or leakage of a substance, an electric shock, a fall from a height or the collapse of a structure.

Notification to Regulator

Immediately after the occurrence of a notifiable incident, the UNE WHS Manager must notify the regulator (relevant State/Territory) by telephone or in writing, by fax or email, whichever is faster. The notification must provide the information required by the regulator. If telephone notification is made, the regulator may request written notice to be provided within 48 hours.

Incident Site Preservation

In the event of a notifiable incident, it is the responsibility of the person with management or control of the workplace to ensure, as far as is reasonably practicable, that the site (including any plant, substance, structure or thing associated with the incident) is not disturbed until an inspector arrives or otherwise directs.

This does not prevent the person taking any action to assist an injured person, remove a deceased person, take action that is essential to make the site safe or to minimise the risk of a further notifiable incident occurring, or any action associated with a police investigation or action for which an inspector or the regulator has given permission.

A.4.3 Non-notifiable / First aid incidents

Personnel must report all injuries/incidents and near misses to their Manager and the WHS Manager within 24 hours and fill in an Injury / Incident Report using UNE's SkyWatch software. All first aid treatment will be recorded on a First Aid Treatment Log that is stored within the Vehicle First Aid Kit.

A.4.4 Incident investigation and reporting

All accidents and dangerous events will be investigated. Investigations must however, be kept objective, factual and free from any attempt to assign blame. The principal benefit of incident investigation is the prevention of a further accident, but there are other advantages such as:

- Improved morale by corrective actions that may be implemented
- Reduction in lost time, delays and business interruption
- Reduction in damage to product and plant
- Good documentation as legal preparation.

Carrying out an investigation aimed at identifying the underlying causes of an accident or near miss will require the asking of some basic questions. The importance of concentrating upon the underlying cause(s), rather than the outcome is important. An examination of the workplace and its work procedures and methods will be required as well as the collection of background information. All investigations will be documented by UNE's WHS team.

A.5 WHS Roles and Responsibilities

A.5.1 Project manager

The Project Manager (of the UNE/2rog team) is responsible for the safety relating to all personnel (including sub-contractors/ sub-consultants) engaged in the MER Project for the Warrego-Darling Selected Area.

The Project Manager is responsible for ensuring that the following conditions are met by any sub-contractors/ sub-consultants:

- A Sub-consultant Contract and Subcontractor's Statement is provided for the duration of the MER Project
- The sub-contractor / sub-consultant are competent for the tasks to be undertaken, suitably trained, licensed and experienced
- The sub-contractor / sub-consultant and their employees carry out the work in a safe manner, using proper and safe plant and substances, employing systems of work that are safe and environmentally sound, and in which there has been adequate instruction, training and supervision.
- The sub-contractor / sub-consultant are able to demonstrate an awareness of the relevant WHS legislative requirements appropriate to the work to be undertaken and commit to this.

Any sub-contractors/ sub-consultants engaged on the project must submit to the Project Manager, for review and approval, a project-appropriate Safe Work Method Statement (SWMS) and safe work procedures. Certificates of Currency for all relevant insurances must also be provided.

The Project Manager must monitor the performance of any sub-contractors / sub-consultants against their SWMS and any safe work procedures and work practices.

A.5.2 Field staff

All personnel undertaking any field-based activities for the MER Project in the Warrego-Darling Selected Area are responsible for:

- Understanding and agreeing to comply with the requirements of this WHS Plan, including wearing of PPE as nominated
- Advising the Project Manager as they become aware of any hazards/risks
- Comply with any actions required to reduce risks, taking into account the hierarchy of controls.

A.5.3 Sub-contractors / Sub-consultants

Sub-contractors / sub-consultants are responsible for the management of their employees and the implementation of their WHS Plans. Sub-contractors / sub-consultants must prepare an appropriate WHS Plan and/or SWMS and submit to Project Manager for their review and approval. Alternatively, sub-contractors / sub-consultants may agree to operate under this WHS Plan and associated safe work procedures.

Sub-contractors / sub-consultants must attend a project start-up meeting with Project Manager to ensure all the WHS issues have been communicated and are understood.

A.6 Training and Competency

Training needs, and evidence of completion, will be documented and appropriate records maintained for the duration of the MER Project. This training needs assessment is to ensure that training required for the safe working of the project is provided to enable field personnel to competently undertake monitoring activities in a safe manner.

A.6.1 WHS induction

All project staff visiting or working on site are required to be provided with induction training prior to commencing work. This induction will be undertaken by the Project Manager or their nominated representative.

Induction training should be documented and appropriate records maintained (see Induction Register, page A4 of this WHS Plan).

A.6.2 Skills and competency

Project personnel either visiting or working on site shall be provided with appropriate WHS skills training. Where activities with potentially significant safety or environmental risk are to be undertaken, specialised training in accordance with the Job Safety Environment Analysis (JSEA) shall be provided.

All project staff will have the necessary licences to drive, operate equipment and undertake specialised work as required by law.

Training conducted and training certificates, licences etc. shall be documented and appropriate records maintained.

A.6.3 Sub-contractors

Sub-contractors are responsible for the communication of the WHS Plan and safe work methods to their employees. Sub-contractors shall ensure appropriate records are kept of all inductions, training etc.

Copies of training records and induction logs shall be made available to the Project Manager upon request.

A.7 Monitoring and Reviews

The WHS Plan should be reviewed regularly to ensure its currency, and that any new risks are captured and adequate mitigation measures provided and existing controls evaluated. Scheduled reviews are nominated in Table A-2; however, a review can take place at any time.

When this WHS Plan is reviewed, the document shall be controlled, and all staff previous inducted shall be provided with a copy of the new WHS Plan.

Table A-2 WHS Plan Review.

What	When	Who	Audit/review procedure
Review WHS Plan	At the completion of the first round of monitoring	Project Manager (with Team Leader for each indicator as required)	• Review risks and controls • Review incidences or non-conformances • Identify any deficiencies in existing controls • Discuss with CEWO as necessary
	Receipt of feedback (CEWO, Landholders, Stakeholders etc)	Project Manager	• Identify any deficiencies in data • Discuss with Project Director/s and raise with CEWO as necessary • Update plans as necessary
	Receipt of non-conformances, complaints etc	Project Manager	

A.8 Risk Register

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
Weather Conditions	Thermal risk- Extreme Heat	Sunburn, skin cancers, hyperthermia	Likely	Fatality/serious illness/injuries	**HIGH**	Appropriate PPE, suitable scheduling and rostering of activities	Project Director, Project Manager, Project staff			**MODERATE**	Working in extreme conditions
	Thermal risk- Extreme Cold	Hypothermia, skin burns and frost bite.	Likely	Fatality/serious illness/injuries	**HIGH**	Appropriate PPE, suitable scheduling and rostering of activities	Project Director, Project Manager, Project staff			**MODERATE**	
	Prolonged Heavy Rain / Flash flooding	Drowning and physical injury from debris slips and falls.	Likely	Fatality/serious illness	**HIGH**	Record any areas of potential flash flooding on the SWMS_Toolbox Talk. Check for any flooding alerts prior to entering site	Project Director, Project Manager, Project staff			**LOW**	
	Storms-lightning strikes	Burns and Shock, (potentially fatal)	Very unlikely	Fatality/serious illness/injuries	**MODERATE**	Do not enter site until 1 hour after the storm passes If on-site vacate the area and/or seek shelter immediately.	Project Director, Project Manager, Project staff			**MODERATE**	
	High winds	Struck from falling objects and vehicle control.	Very unlikely	Fatality/serious illness/injuries	**MODERATE**	Take cover during periods of high winds away from overhead trees/branches. Reduce speed if driving in high winds	Project Director, Project Manager, Project staff			**LOW**	
Vehicles and Driving Hazards	Vehicle accident on route to or return from survey	Death, permanent impairment, lost time injury	Unlikely	Fatality/serious illness/injuries	**HIGH**	Safe Driving Policy, Safe Work methods statements, prior risk analysis of each project, 4WD first Aid Kit, all field staff have current First Aid qualifications. Emergency First Aid Box	Project Director, Project Manager, Project staff			**MODERATE**	
	Vehicle accident on site	Permanent impairment, death, injury, isolation	Unlikely	Fatality/serious illness/injuries	**HIGH**	Sat phone, 4WD Car First Aid Kit, Emergency First Aid Box, All staff have current first aid qualifications. Site induction in high risk sectors. SWMS and onsite Toolbox Talks prior to commencing work	Project Director, Project Manager, Project staff			**MODERATE**	
	Vehicle breakdown/ bogged	Isolation, thermal stress, dehydration, hunger	Unlikely	Fatality/serious illness/injuries	**HIGH**	Safe Operating Procedures- Vehicle recovery, 4 WD recovery Kit in all Field based 4WD's, 4WD training for field staff, Safe Driving Policy, Emergency First Aid Box (includes consumables and bottled water, Sat phones, trialling Spot tracker, Safe Work Methods Statement (SWMS), on site Toolbox Talks	Project Director, Project Manager, Project staff			**MODERATE**	Vehicle recovery
	Driving long distances - Fatigue	Wide ranging physical injuries, potentially fatal and vehicle damage	Likely	Fatality/serious illness/injuries	**HIGH**	Safe Operating Procedures- Vehicle recovery, 4WD recovery Kit in all Field based 4WD's, 4WD training for field staff, Safe Driving Policy, Emergency First Aid Box (includes consumables and bottled water, Sat phones, trialling Spot tracker, Safe Work Methods Statement (SWMS), on site Toolbox Talks	Project Director, Project Manager, Project staff			**MODERATE**	

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
	Towing trailers and boats	Injury, accident, Collision, loss of trailer equipment	Unlikely	Short term illness/injury/First Aid	**MODERATE**	Safe Driving Policy, Emergency First Aid Box (includes consumables and bottled water, Sat phones, Safe Work Methods Statement (SWMS)	Project Director, Project Manager, Project staff			**LOW**	Manual handling, Operating a Boat
	Encountering wildlife e.g. kangaroos	Car accident (with either wildlife, or other vehicles)	Unlikely	Fatality/serious illness/injuries	**HIGH**	Safe Driving Policy, Emergency First Aid Box (includes consumables and bottled water, Sat phones, Safe Work Methods Statement (SWMS)	Project Director, Project Manager, Project staff			**MODERATE**	
Terrain hazards	Rocky, uneven or slippery terrain resulting in falls/trips.	Injury – musculoskeletal / soft tissue injury (sprains etc)	Unlikely	Short term illness/injury/First Aid	**MODERATE**	First aid kit, Emergency First Aid Box (includes consumables and bottled water)mob/sat phones, Safe Work Methods Statement (SWMS)	Project Director, Project Manager, Project staff			**LOW**	
	Bushfires	Burns, smoke inhalation, potentially fatal	Unlikely	Fatality/serious illness/injuries	**HIGH**	SWMS, regular updates from BOM website and advice from RFS, field work policy.	Project Director, Project Manager, Project staff			**MODERATE**	Bushfire management
Flora and Fauna	Plant and insect Allergens and poisons	Allergic reactions (skin/eye) Hay Fever, respiratory reactions, anaphylactic shock	Unlikely	Fatality/serious illness/injuries	**HIGH**	Ensure staff know who their colleagues are with severe allergic reactions, implement allergy management response plan, ensure Epipen or other relevant medication is on hand at all times, be aware of nearest hospital for treatment and have communications available. Don't expose staff with known allergies to projects where these risks are unaccepted to their personal health issues	Project Managers, theme team managers and staff			**MODERATE**	
	Venomous Fauna	Poisoning, potentially fatal	Unlikely	Fatality/serious illness/injuries	**HIGH**	SWMS, Wildlife survey procedures, onsite Toolbox talks, Snake bandages, All staff are qualified in first aid, 2 persons in the field, PPE.	Project Director, Project Manager, Project staff			**MODERATE**	
	Bats / flying foxes	Australian Bat Lyssavirus (ABL)	Very unlikely	Fatality/serious illness/injuries	**MODERATE**	Ensure you are vaccinated if you are required to work with flying-foxes/bats regularly. Avoid handling flying-foxes/bats or coming into close contact with them. Suitable clothing and PPE.	Project Director, Project Manager, Project staff			**MODERATE**	
	Ticks, mosquitoes and leeches	Bites, infection and illness	Likely	Short term illness/injury/First Aid	**MODERATE**	SWMS, proper clothing and applying permethrin to clothing, performing daily tick checks and removing ticks as soon as they are detected	Project Director, Project Manager, Project staff			**MODERATE**	
	Walking through vegetated areas	Trampling of flora and fauna, potential weed spread, potential spread of soil fungus	Likely	Minor environmental damage	**MODERATE**	Avoid trampling areas that do not need inspection. Clean mud and weeds off shoes, clothing, bags, and the gear and vehicle tyres prior to leaving an area.	Project Director, Project Manager, Project staff			**MODERATE**	

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
	Loss of or damage to biodiversity	Impacts on flora	Likely	Minor environmental damage	**MODERATE**	Minimise trampling and avoid areas that do not need survey. Follow requirements of land owner/ manager, incl. government bodies. A scientific licence is required for the picking or possession of protected flora, incl. marine plants. Where possible identify flora species in the field. If a sample is required, take only that needed for identification. Take photos where a sample would affect survival of the individual. If a new location is discovered for a threatened species, note its position and take care not to unnecessarily disturb its root system or habitat. Clean mud and weed propagules off shoes, clothing and vehicle tyres prior to leaving an area (particularly where noxious weeds were identified). Works should be programmed to consider seeding periods and weed locations. This is particularly important when weeds such as Giant Parramatta Grass, St John's Wort, Fireweed, African Lovegrass, and Chilean Needle Grass are seeding.	Project Director, Project Manager, Project staff			**MODERATE**	
	Fish survey work	Ecological impacts	Likely	Environmental damage	**MODERATE**	Ensure field staff are listed either on the NSW DPI Scientific Collection Permit or a project specific fisheries permit. Ensure field staff are trained in trapping and handling aquatic fauna. In NSW, additional approvals are required for fish survey works in all Marine Parks or Aquatic Reserves. Conduct works per permit requirements.	Project Director, Project Manager, Project staff, subcontractors			**MODERATE**	
General Site Hazards	Site security - intruders	Physical harm - assault	Very unlikely	Long term illness or serious injury	**MODERATE**	SWMS, Toolbox talks, engagement of security, client representation where required, emergency procedures	Office Managers, staff			**LOW**	
	Community consultation	Aggressive behaviour from people, assault	Very unlikely	Long term illness or serious injury	**MODERATE**	SWMS, Toolbox talks, engagement of security, client representation where required, emergency procedures	Project Director, Project Manager, Project staff			**LOW**	
	Dumped rubbish - asbestos and needles	Inhalation of asbestos fibres and needle stick injuries	Very unlikely	Long term illness or serious injury	**MODERATE**	SWMS, PPE.	Project Director, Project Manager, Project staff			**LOW**	
	Working with others in remote areas	Harassment- sexual, bullying, inappropriate behaviour	Very unlikely	Long term illness or serious injury	**MODERATE**	SWMS, 2 person project team, Toolbox talks, spot tracker, mob/sat phone. Prior discussion with client if required.	Project Director, Project Manager, Project staff			**LOW**	

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
	Working in Isolation / Remote area surveys	Injury to personnel due to no access to emergency contacts or first aid. Slow response time from external source/services to an injury or incident	Unlikely	Fatality/serious illness/injuries	**HIGH**	SWMS, 2 person project team, Toolbox talks, spot tracker, mob/sat phone. Prior discussion with client if required. Call in/out procedure.	Project Director, Project Manager, Project staff			**MODERATE**	
	Field Equipment use (e.g. traps)	Muscle and back strain, joint injury, lacerations and other Injury from equipment	Unlikely	Long term illness or serious injury	**MODERATE**	Safe operating procedures, Risk assessment, PPE, Tool box talks, regular, scheduled equipment servicing, and manual handling training.	Project Manager, Project staff			**LOW**	Manual handling
	Heavy machinery operating on site	Injury/ potently fatal	Unlikely	Fatality/serious illness/injuries	**MODERATE**	SWMS, 2 person project team, Toolbox talks, signage, mob/sat phone.	Project Director, Project Manager, Project staff			**MODERATE**	
	Boat usage, debris, shoreline, sand bars, exposure, sinking, accidental collision.	Hypothermia, Become wet during cold conditions, drowning, explosion, damage and injuries.	Very unlikely	Fatality/serious illness/injuries	**MODERATE**	SWMS, 2 person project team, Toolbox talks, mob/sat phone.	Project Director, Project Manager, Project staff			**LOW**	To be addressed under subcontractor WHS Plan
	In-stream/on bank aquatic surveys	Slip / trip leading to injury, being swept downstream, collision with in-stream debris, drowning.	Unlikely	Fatality/serious illness/injuries	**HIGH**	SWMS, 2 person project team, Toolbox talks, mob/sat phone.	Project Director, Project Manager, Project staff			**MODERATE**	Working around water
	Aquatic animals	Sting or bite e.g. fish, platypus	Unlikely	Fatality/serious illness/injuries	**HIGH**	SWMS, 2 person project team, Toolbox talks, mob/sat phone.	Project Director, Project Manager, Project staff			**MODERATE**	
	Fatigue: field survey work- long hours/night work	Musculoskeletal injuries, slips, trips, falls	Likely	Short term illness/injury/First Aid	**MODERATE**	Effective rostering, maximum work hours. Additional rest breaks. Fatigue Management Plan	Project Director, Project Manager, Project staff			**LOW**	Fatigue Management Plan
Hazardous substances	Chemical use and handling	Inhalation	Likely	Short term illness/injury/First Aid	**MODERATE**	Safe Operating Procedures- safe use, handling and storage of chemicals, SWMS, Chemicals register, MSDS on site, Tool box talks, First Aid Kits, spill kits, PPE	Project Director, Project Manager, Project staff			**LOW**	
		Ingestion	Unlikely	Short term illness/injury/First Aid	**MODERATE**					**LOW**	
		Contact with skin	Likely	Short term illness/injury/First Aid	**MODERATE**					**LOW**	
	Chemical storage	Explosion, spills	Unlikely	Short term illness/injury/First Aid	**MODERATE**					**LOW**	
Ergonomic, Manual Handling and Vibration	Manual handling - (lifting, bending, reaching, carrying)	Musculoskeletal injuries and back strain, joint injury	Unlikely	Fatality/serious illness/injuries	**HIGH**	Safe Operating Procedures for use of equipment, SWMS, pre start checklist, ensure machinery is regularly services, PPE, job rotation, manual handling training and refresher undertaken	Project Manager, Project staff			**MODERATE**	Manual handling

Mechanism	Risk Title	Hazards	Occurrence Likelihood	Consequences	Inherent Risk Class	Control measures	Responsibility for control actions	Due Date	Sign off	Residual risk class	JSEA Number
	Vibration	Use of Quad bike etc	Unlikely	Fatality/serious illness/injuries	**HIGH**	Safe Operating Procedures for use of equipment, SWMS, pre start checklist, ensure machinery is regularly services, PPE, Regular job rotation with maximum use limits imposed, Manual handling policy, manual handling training and refresher undertaken	Project Director, Project Manager, Project staff			**MODERATE**	
	Over use of field equipment	Hand injury /strains- use of nets	Unlikely	Long term illness or serious injury	**MODERATE**	Safe operating procedures developed for all of this equipment, job rotation, work at own pace, SWMS, PPE, tool box talks, Manual Handling training	Project Director, Project Manager, Project staff			**LOW**	
Employee Selection, Training and Competence	Selection and engagement of employees or sub-contractors who are unsuitable for the position or do not appropriate skills, experience and qualifications to undertake tasks	Potential injury to employees, others sub - contractors or others	Unlikely	Long term illness or serious injury	**MODERATE**	Position descriptions accurately reflecting skills, experience, qualifications required. Merit based EEO selection process undertaken with reference checking. Pre placement medical examinations where required. Annual performance reviews undertaken, Individual and corporate training plan developed annually, staff and subcontractors participate in induction on 1st day of employment. Subcontractor Management Plan and induction process, Project scope accurately identifies tasks and requirements	Human Resource Manager Project Director, Project Manager, Project staff			**LOW**	
Noise	Use of equipment and machinery -	Noise from quad bike - potential hearing loss	Likely	Long term illness or serious injury	**HIGH**	SWMS, Risk assessment prior to commencing work, Tool box talks, PPE, job rotation, PPE examinations	Project Manager, Project staff			**LOW**	
	Climbing/Falling from a ladder	Musculoskeletal injuries, Slip/trip/fall from height, eye injury from vegetation / branches, Ladder collapsing / falling over Electric shock from lightning Interaction with ladder	Unlikely	Fatality/serious illness/injuries	**HIGH**	Conduct toolbox talk before commencing the task, SWMS, 2 person team with one person always bracing the ladder while in use, use appropriate lifting techniques for carrying, extending, raising and lowering the ladder.	Project Director, Project Manager, Project staff			**MODERATE**	
	Carrying a ladder	Musculoskeletal injury – carrying ladder	Unlikely	Long term illness or serious injury	**MODERATE**	Conduct toolbox talk before commencing the task, SWMS, 2 person team with one person always bracing the ladder while in use, use appropriate lifting techniques for carrying, extending, raising and lowering the ladder.	Project Director, Project Manager, Project staff			**LOW**	
	Falling branches or nest boxes - striking support staff below	Head injuries, scratches, broken limbs	Unlikely	Long term illness or serious injury	**MODERATE**	Wear hard hats - PPE, maintain communications with team, risk assess the tree prior to work being undertaken. Ensure nest boxes are secured to rope.	Project Director, Project Manager, Project staff			**LOW**	

A.9 Job Safety Environmental Analysis (JSEA)

The purpose of the Job Safety Environmental Analysis (JSEA) is to assess the work tasks and consider what the safest way to complete it is. It is a documented process of risk management.

A JSEA is a systematic examination of each job step to identify potential hazards, assess risks and evaluate control measures. It integrates safety, health and the environment into the planning of work and work related activities.

Conducting JSEAs allows the team to gather information to identify hazards associated with each job step, to determine what could potentially go wrong, what are the controls that are currently in place (if any), and what is the level of risk associated with the identified hazards. In addition, preparing a JSEA will determine if safe work procedures are required.

When conducting/preparing a JSEA the following process should be adopted:

1. Break the activity down into logical steps that are required to complete the job
2. Consider what may cause injury - identify the hazards
3. Document controls currently in place to manage the identified hazards
4. Calculate risk based on exiting controls in place
5. Consider each hazards and ascertain the consequence of an incident
6. Determine the likelihood of the consequence occurring (based on existing controls in place)
7. Calculate the risk of each hazard (combination of consequence and likelihood)
8. Establish new controls (if required) appropriate for the risk determined
9. Calculate residual risk based on new and existing controls
10. Establish additional or supplementary controls (where required) to achieve appropriate level of risk.

A template for preparing a JSAE is provided next.

JOB SAFETY ENVIRONMENT ANALYSIS (JSA) TEMPLATE					
Company name:		**Date:**		**JSA Number:**	
Site name:		**Supervisor name:**		**Permit to work required?**	**Yes / No**
Plant / Area:			**Location:**		
Scope of JSA:					
JSA team member names:					
Overall risk associated with JSA: *Highest residual risk – this can only be determined after the rest of the JSA is complete*					
Approved by: *Have the appropriate approval levels been obtained?*		**Position of approving person:**		**Date:**	

JOB SAFETY ANALYSIS (JSA) TEMPLATE				
Activity *Provide a step-by-step breakdown of the task*	**Hazards** *List all hazards associated with each step*	**Inherent Risk** *Risk associated with each hazard before any control measures are put in place*	**Controls** *Measures that need to be taken to eliminate or minimise the risk associated with each hazard*	**Residual Risk** *Remaining risk associated with each hazard once the control measures have been put into place*

Source: Training Services Australia

Fieldwork Checklist

When	Action	Responsibility	Completed (y/n)
Fortnight prior to Fieldwork	**Landholder/s contacted (as required)**	Project Manager or their delegate	
Day Before Fieldwork	**Daily Weather / Bushfire Checklist (Form 2)** Bureau of Meteorology 1900 969 900 OR www.bom.gov.au OR www.eldersweather.com.au AND Rural Fire Service 1800 679 737 OR www.rfs.nsw.gov.au	Team Leader or their delegate	
	Daily Trip Plan and Contact Sheet Email to _____	Team Leader or delegate	
	Check all gear is packed	Team Leader or delegate	
Day of Fieldwork	**Vehicle inspection**	Designated driver	
ON SITE	**Complete** Toolbox Talk prior to undertaking site work **Monitor** site conditions (weather, fire, hazards). Cease work if dangerous or no suitable control measures **Report** near miss/safety incidents/accidents t **Complete First Aid Record Form for first aid incidents**	Team Leader or delegate	
POST-FIELDWORK	**Contact** Project Manager to inform team has left site, daily update (new hazards, incidents, site details)	Team Leader or delegate	
	Report incidents or near missed (with 24 hours)	Team Leader or delegate	
	Update JSEA if required	Project Manager	
	Check equipment and batteries – charge if required	Team Leader and all team members	

SWMS

Aquatic Ecology and Restoration RESEARCH GROUP	SWMS – High Risk	Document No. WHS F014_AquaticLab
	Version No: 2 / Date Approved:	Approved By: Darren Ryder

Note: Fill in these sections and communicate with field staff prior to any field work as part of the SWMS - Toolbox Talk process and take a copy into the field			
Project #:		**Project Title:**	
Description of Task:			
Date:		**Project Manager:**	

PPE Requirements (Please List)	Training/ Licences/ Permits Required	Special Tools or Equipment Required
Hazardous Materials	**Reference Documents**	**Fire/ Emergency Equipment**

PROJECT TEAM

Personnel Name	Project Role
	Project Director Project Manager

Client Terms and Conditions	☑	**Subcontractor Terms and Conditions**	☑ or n/a	**Subcontractor Work Method Statement**	☑ or n/a
Licences/Approvals/Permits	☑ or n/a	**Survey in line with Lab ecological survey procedures**	☑ or n/a	**Consistent with Lab project management procedures**	☑ or n/a

I confirm the above documents have been reviewed, understood and are signed and in the project file.

I agree this project team is competent and trained to complete this project and this form will be used in conjunction with the *WHS F010 Fieldwork Planning Guide and Checklist* and *SWMS-Toolbox Talk* by the team in the field.

This form has been prepared & all team members have been informed of the project planning requirements:

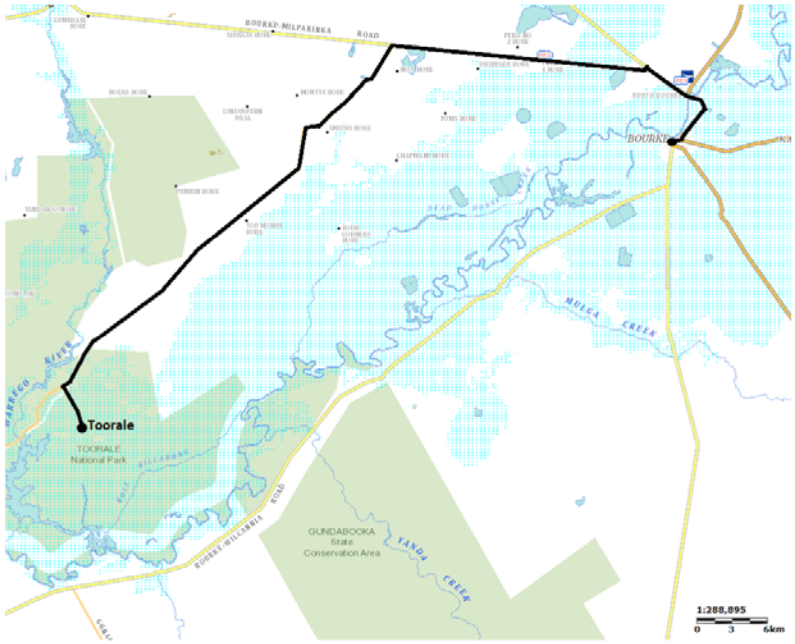
Project Manager/ Project Director Name:	**Signature and Date:**

NEAREST HOSPITAL

The nearest hospital is 80 km to the east of the site.

Hospital Name: Bourke District Hospital	Phone: (02) 6870 8888
Street Address: 26 Tarcoon Street Bourke NSW	

Insert a map showing route between site and hospital (if required)



EMERGENCY CONTACTS

UNE Safety and Security	(02) 6773 2099 – 24 hours
UNE HR Manager	(02) 6773 3705 (bh)
UNE WHS Manager	0459 281 880 – Darren Stevenson
UNE Vehicle Management Services	0419 490 145 – 24 hours
UNE Project Manager	0439 600 554 – Sarah Mika
Project Directors 0457 513 296 – Darren Ryder	0488 000 842 – Paul Frazier
Police/ Ambulance/ Fire	000
Rural Fire Service	1800 679 737 (press '2' for current fire information)
Local Council	(02) 6830 8000 – Moree Shire Council
Essential Energy (Emergencies)	13 20 80
Telstra (Faults and Service)	13 22 03
NSW Environmental Protection (EPA)	131 555
NSW Department of Lands	www.nsw.gov.au
Bourke National Parks and Wildlife	(02) 6830 0200
Western Local Land Services (Western LLS)	02 6870 8600 (Bourke)
WIRES	13 000 94737 (NSW Regional Branches)
Others	

RISK ASSESSMENT MATRIX – Use this matrix to assess the level of WHS and Environmental risk.

MATRIX	LIKELIHOOD			
CONSEQUENCES	**Very Likely** (could happen at any time)	**Likely** (could happen sometime)	**Unlikely** (could happen but very rarely)	**Very Unlikely** (could happen but generally never will)
Fatality or permanent disability. Or property, or environmental damage over $50,000	H 1	H 2	H 3	M 7
Long term illness or serious injury. Or property, or environmental damage between $5,000 and $50,000	H 4	H 5	M 8	M 9
Short term illness or injury. Or property, or environmental damage between $500 and $5,000	H 6	M 10	M 11	L 14
First aid needed. Or property, or environmental damage up to $500	M 12	M 13	L 15	L 16

LEGEND	RISK ASSESSMENT MATRIX
1-6 H	Top priority – deal with the hazard immediately. Must deal with the cause(s) now.
7-13 M	Deal with the hazard as soon as possible. Must fix the cause(s) in 1 month. Regularly monitor the cause(s) and hazard until rectified.
14-16 L	Must fix the hazard and cause(s) when time and resources permit but within 3 months. Regularly monitor the cause(s) and hazard until rectified.

Source: Workcover- AS/NZS 4360

DESKTOP RISK ASSESSMENT – Project Manager to complete **prior** to works.

Step In Process	**Hazard Identified** (potential source of harm)	**Risk Analysis** (what could happen)	**Risk Rating***	**Solution/ Control Measure** (consider hierarchy of control)	**New Risk Rating***
1. Driving to and from site	Driving in traffic/ long distance	Car accident	High	• Rapid visual inspection of car- currently registered and serviced • Plan trip- suggest breaks every 2 hours, avoid driving when fatigued. • Share driving whenever possible- only drive when sufficiently rested and alert to do so • Drivers must have a current drivers licence • Ensure the first aid kit is fully stocked • Field ecologists to have UNE 4wd accreditation	Low
	Use of motor vehicle	Air pollution Fuel consumption Environmental damage	L15	• Choose vehicles appropriate to the terrain, i.e. off road (4WD) or on road (smaller car) • Practice fuel efficient driving • Ensure street directory is in the vehicle and plan the trip route prior to departing • Vehicles should use existing tracks where possible, to minimise disturbance	L16
	Onsite vehicle control – uneven ground, potholing & slippery conditions.	Vehicle crashes – wide range of physical injuries.	Moderate	• Maintain safe driving speed (speed limits) • Take care in route selection. • Consult landowners over risks on property. • Reduce speed when livestock/native animals are in the vicinity. • Use 4WD vehicle with high ground clearance. • Field ecologists to have UNE 4wd accreditation	Low
	Vehicle breakdown/bogged	Isolation Thermal stress Dehydration Hunger	Moderate	• Ensure the First Aid kit and Emergency First Aid Box are fully stocked and carry mobile phone • Choose vehicles appropriate to the terrain, i.e. off road (4WD) • Field ecologists to have UNE 4wd accreditation • 4 WD recovery kit in all field based 4WD's	Low

Step In Process	Hazard Identified (potential source of harm)	Risk Analysis (what could happen)	Risk Rating*	Solution/ Control Measure (consider hierarchy of control)	New Risk Rating*
	Road conditions – Gravel, Dirt & Sand (unsealed)	Wide ranging physical injuries, potentially fatal & vehicle damage	High	• Observe all warning signs on unpaved roads • Staff should have completed 4WD course or competent to drive in these conditions. • Travel at a sensible speed, observe the speed limit and drive to the conditions of the road on the day. • Slow down when approaching corners to prevent skidding.	Moderate
	Encountering wildlife e.g. kangaroos	Car accident (with either wildlife, or other vehicles)	High	• Remain alert when travelling through areas likely to house wildlife i.e. bushland areas or outback roads • Avoid driving between dusk and dawn where possible. If you must drive during this time keep an eye on the sides of the road and reduce speed to allow brake time if necessary • Take note of road signs. Wildlife black spots usually feature signs such as 'Kangaroos next 30km' to alert drivers to potential hazards • If wildlife runs onto the road DO NOT SWERVE to avoid it. Swerving will increase the chance of a serious accident • If you hit or encounter an injured animal, stop only if it is safe for you to do so. Wildlife can become aggressive when scared or injured. Contact the relevant agency on page 2 of this WMS • If the animal is dead, and you can safely do so, drag it to the roadside to reduce risk to other motorists	Low
2. Conduct field work	Slip/trip	Injury – musculoskeletal / soft tissue injury (sprains etc)	Moderate	• Wear sturdy shoes, check visibility/take a torch if required • Remain aware of surroundings- watch where you walk	Low

Step In Process	Hazard Identified (potential source of harm)	Risk Analysis (what could happen)	Risk Rating*	Solution/ Control Measure (consider hierarchy of control)	New Risk Rating*
2. Conduct field work	Venomous Fauna	Allergic reaction/death	High	• Remain aware of surroundings • Avoid wherever possible likely habitats, e.g. holes, under rocks • Wear appropriate PPE (gloves , long trousers, covered sturdy shoes) • Communicate known allergies to other persons on site and carry medication (anti-histamines) • Carry 2 snake bandages per person and first aid kit • Carry mobile phone at all times • Ensure manager is aware of your whereabouts and expected time back in office	Low
	Plant Allergens and poisons	Allergic reactions (skin/eye) Hay fever, respiratory reactions Anaphylactic shock	Low	• Communicate known allergies to other persons on site and carry medication (anti-histamines) • Avoid poisonous plants • Wear appropriate PPE (gloves, long trousers) • Ensure 2 Epi-pens are in the first aid kit	Low
	Adverse weather (Lightning, Bushfire, Rain, Hail, Gale force winds)	Struck by lightning Struck by falling branches/ objects Smoke inhalation/ death	High	• Postpone site inspection in event of adverse weather. • Avoid working under large trees during strong winds • Check weather updates regularly to ensure risk is managed	Moderate
	Outdoor exposure	Dehydration Sunburn/Sunstroke Heat exhaustion Skin cancers Hypothermiaa	High	• Regular rest, drink and snack breaks in shade as required • Apply sunscreen 20 minutes before exposure • Avoid inspections in the hottest part of day • Wear appropriate PPE, e.g. light cotton clothing, broad brim hat, sunglasses or warm clothing • Carry first aid kit and mobile phone	Moderate

Step In Process	Hazard Identified (potential source of harm)	Risk Analysis (what could happen)	Risk Rating*	Solution/ Control Measure (consider hierarchy of control)	New Risk Rating*
	Heavy machinery operating on site	Injury/ death	Moderate	• Undertake site inspection with a supervisor and follow site specific safety induction • Wear a high visibility vest • When moving is close to heavy machinery, make sure driver has waved at you • Follow relevant Safe Operating Procedures (where provided) by site for working near plant and machinery	Low
	Walking through vegetated areas	Trampling of flora and fauna Potential weed spread Potential spread of soil fungus	Moderate	• Avoid trampling areas that do not need inspection. • Take care to avoid eye-poke injury. • Assess risk of die back or spread of other diseases. If required provide for protocol of brushing down or wash off of boots or vehicles	Low

Step In Process	Hazard Identified (potential source of harm)	Risk Analysis (what could happen)	Risk Rating*	Solution/ Control Measure (consider hierarchy of control)	New Risk Rating*
	Impacts on flora	Loss of or damage to biodiversity	Moderate	• Minimise trampling and avoid areas that do not need survey. Follow requirements of land owner/ manager, incl. government bodies. • A scientific licence is required to pick, hold or study native flora, incl. marine plants. • Where possible identify flora species in the field. If a sample is required, take only that needed for identification. Take photos where a sample would affect survival of the individual. • If a new location is discovered for a threatened species, note its position and take care not to unnecessarily disturb its root system or habitat. • Clean mud and weed propagules off shoes, clothing and vehicle tyres prior to leaving an area where possible (particularly where noxious weeds were identified). • Works should be programmed to consider seeding periods and weed locations. • Field personnel should be aware of potential impacts of the soil borne water mould *Phytophthora cinnamomi* for its capacity to invade and destroy the function of root systems in a wide range of plants. Good hygiene must be used when conducting field activities in areas known to contain *Phytophthora*. Assess risk and where required provide for protocol of brush down or wash of boots or vehicles	Low

Step In Process	Hazard Identified (potential source of harm)	Risk Analysis (what could happen)	Risk Rating*	Solution/ Control Measure (consider hierarchy of control)	New Risk Rating*
	Impacts on fauna	Loss of or damage to biodiversity	Moderate	• Minimise trampling and avoid areas that do not need survey. • Use minimum impact survey techniques as per survey procedure and required by animal ethics permit/ • In areas known to be habitat for threatened species of frogs, hygiene practices are used to avoid the introduction and/or spread of Amphibian Chytrid Fungus. Use the frog hygiene protocol in the EMS - Wildlife Survey Procedure. • Observe quarantine notices (verbal or written) to prevent the spread of animal diseases (e.g. Bovine Johne's Disease, Ovine Johne's Disease, Equine Influenza, and Newcastle Disease). • Assess risk of spread of disease. If required provide for protocol of brush down and wash off boots and vehicle.	Low
	Damage to items of cultural or archaeological heritage	Loss of or damage to cultural heritage	Moderate	• Do not disturb any potential Aboriginal or cultural artefacts • If any new artefacts are suspected during works, the find must be reported immediately to the client and relevant government heritage agency	Low

Step In Process	Hazard Identified (potential source of harm)	Risk Analysis (what could happen)	Risk Rating*	Solution/ Control Measure (consider hierarchy of control)	New Risk Rating*
	Working in isolation with other subcontractors /clients – potential risk of inappropriate conduct/harassment	Inappropriate conduct/harassment Individual /special needs not considered which may compromise their OHS & wellbeing Bullying	Moderate	• Employees to raise any potential issues or concerns with project manager prior to field work • Be familiar with UNE's Code of Conduct policies and undertake annual refresher courses • Where escorts are provided to accompany field personnel, the project manager will liaise with clients in advance of field work to ensure appropriate escorts are provided, who will ensure the health, safety and wellbeing of UNE employees whilst on site. Special considerations or needs of UNE employees are to be highlighted and provided for at this stage (e.g. employees who are pregnant, female, employees with any physical impairment) • Report any instances of inappropriate/unwelcome or threatening conduct to Project Manager/Project Director who will escalate to Human Resources Manager and Client. Alternatively contact Human Resources Manager directly. • Advise the Client /subcontractor how their behaviour makes you feel and the impact on you. Ask them to modify their behaviour.	Low

Step In Process	**Hazard Identified** (potential source of harm)	**Risk Analysis** (what could happen)	**Risk Rating***	**Solution/ Control Measure** (consider hierarchy of control)	**New Risk Rating***
3. Surveys	In-stream/on Bank aquatic surveys	Slip/trip leading to injury Being swept downstream Collision with in-stream debris Drowning	High	• Staff to work in pairs and maintain visual contact at all times • Staff to assess stream flow and depth prior to survey. Post-pone survey if current flowing too swiftly or large in-stream debris moving downstream • Staff to identify potential downstream exit points to be used if swept downstream • Avoid steep and/or slippery stream bank where possible. • Staff to check stream for (potential) presence of dangerous animals. Where there is a risk of dangerous animals present - postpone surveys and seek advice from PM.	Low
4. Ergonomic, Manual Handling and Vibration	Manual handling –(lifting, bending, reaching, carrying)	Musculoskeletal injuries Back strain Joint injury	Moderate	• Job rotation • Manual handling training and refresher undertaken	Low
5. Other					

*See Risk Matrix at the beginning of this document.

RISK ASSESSMENT & WORK METHOD STATEMENT ACCEPTANCE

I have read and understood and agree to comply:

Name: _____

Signature: _____

Date: _____

I have read and understood and agree to comply:

Name: _____

Signature: _____

Date: _____

I have read and understood and agree to comply

Name: _____

Signature: _____

Date: _____

I have read and understood and agree to comply:

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I have read and understood and agree to comply:

Name: _____

Signature: _____

Date: _____

I have read and understood and agree to comply:

Name: _____

Signature: _____

Date: _____

SWMS – Toolbox Talks

SWMS – Toolbox Talk		Approved By: UNE Project Director
Version No: 1	Date Approved: 01 July 2013	Document: LabAdmin/WHS/FieldworkForms/SWMSToolboxTalkV1

Step 1. To be completed daily with all staff in the field prior to commencing work. To be used in conjunction with the SWMS form for that fieldtrip.

Step 2. Identify, discuss and document in the table below any hazards relevant to the site, or that were not included in the SWMS; include any relevant additional controls not included in the *F010 Fieldwork Planning Guide*.

Step 3. Assess the risk of any additional controls with the controls in place using the Risk Matrix in the *F010 Fieldwork Planning Guide*. Use the comment section below to include relevant information.

Step 4. All field staff sign and date the form to confirm that they have read and agree to comply with this document.

Project: _____	**Site:** _____	**Date:** _____

Category	ID	Additional Controls	Risk Rating

Comments:

Note: scan and add to project folder upon return from fieldwork. Notify the Project Manager of any new hazards identified.

I have read, understood and agree to comply with this SWMS:

Name: _____ **Sign:** _____ **Date:** _____

Name: _____ **Sign:** _____ **Date:** _____

Name: _____ **Sign:** _____ **Date:** _____

Name: _____ **Sign:** _____ **Date:** _____

Name: _____ **Sign:** _____ **Date:** _____

Name: _____ **Sign:** _____ **Date:** _____

Vehicle Inspection Checklist – pre fieldwork

Vehicle Make		Registration No.		
Odometer		Date of Inspection		
Inspection by:				
	NAME (print)	**SIGNATURE**		
Tick Box Applicable		**YES**	**NO**	**Comments**
1.	Brakes:			
	- Foot brake operating			
	- Hand brake operating			
2.	Light operating and clean			
3.	Indicators working and clean			
4.	Steering – excessive play/vibration			
5.	Windscreen wipers operating			
6.	Windscreen washers operating			
7.	Windscreen/windows damaged			
8.	Windscreen/windows clean			
9.	Horn operating			
10.	Seat belts satisfactory			
11.	Mirrors in good condition			
12.	Tyres:			
	- Correctly inflated			
	- Sufficient tread			
	- Damaged			
13.	Body damage			
14.	Jack and handle			
15.	Wheel brace			
16.	Spare wheel			
17.	Fire extinguisher fitted and charged			
18.	Engine Oil/Hydraulic Oil at Correct Level			
	- Water – Radiator Full			
	- Battery- Secure and water level OK			
19.	Windscreen Washers water containers full			
20.	First Aid Kit Provided and In Good Condition			
21.	Registration Current			
22.	Petrol			
Comments				

Appendix B. Standard Operating Procedures for Monitoring Indicators

Contents

B.1 SOP – Hydrology (Northern Tributaries)

B.1.1 Objectives

The aim of the Hydrology (Northern Tributaries) indicator is to document the relative contribution of upstream end-of-system Commonwealth water for the environment to discharge through the Darling River zone of the Selected Area.

B.1.2 Related indicators

The Hydrology (Northern Tributaries) indicator links to Hydrology (River, Channel, Habitat), and Food Webs (Water Quality, Metabolism, Microinvertebrates and Macroinvertebrates) indicators.

Monitoring of Hydrology (Northern Tributaries) sources and analyses hydrological data to understand the system hydrology and character of Commonwealth water for the environment and other water for the environment deliveries. This indicator assists with understanding hydrological connectivity and duration for the other indicators nominated above.

B.1.3 Locations for monitoring

The Hydrology (Northern Tributaries) indicator will use WaterNSW gauges located in upstream tributaries that best reflect the contribution of each tributary to flows entering the Selected Area (Table B-1, Figure B-1).

Table B-1 WaterNSW gauging stations within upstream tributaries.

Gauge no.	Gauge Name	Tributary	Latitude	Longitude
416001	Barwon River @ Mungindi	Border Rivers	-28.9762	148.9848
417001	Moonie River @ Gundablouie	Moonie	-29.1671	148.6305
416027	Gil Gil Creek @ Weemelah	Gwydir	-29.0488	149.1599
418055	Mehi River @ Collarenebri	Gwydir	-29.5130	148.7241
419091	Namoi River @ US Walgett	Namoi	-30.0279	148.1529
420020	Castlereagh River @ Gungalman	Castlereagh	-30.3088	147.9999
421012	Macquarie River @ Carinda (Bells Bridge)	Macquarie	-30.4347	147.5696
421107	Marra Creek @ Billybongbone Br	Macquarie	-30.4032	147.1710
421023	Bogan River @ Gongolgon	Bogan	-30.3472	146.8978
422006	Culgoa River @ DS Collerina	Condamine Balonne	-29.7735	146.5179
423001	Warrego River @ Fords Bridge	Warrego	-29.7526	145.4276
423002	Warrego River @ Fords Bridge Bywash	Warrego	-29.7568	145.4408
425003	Darling River @ Bourke Town	Darling	-30.0861	145.9387
425004	Darling River @ Louth	Darling	-30.5347	145.1151

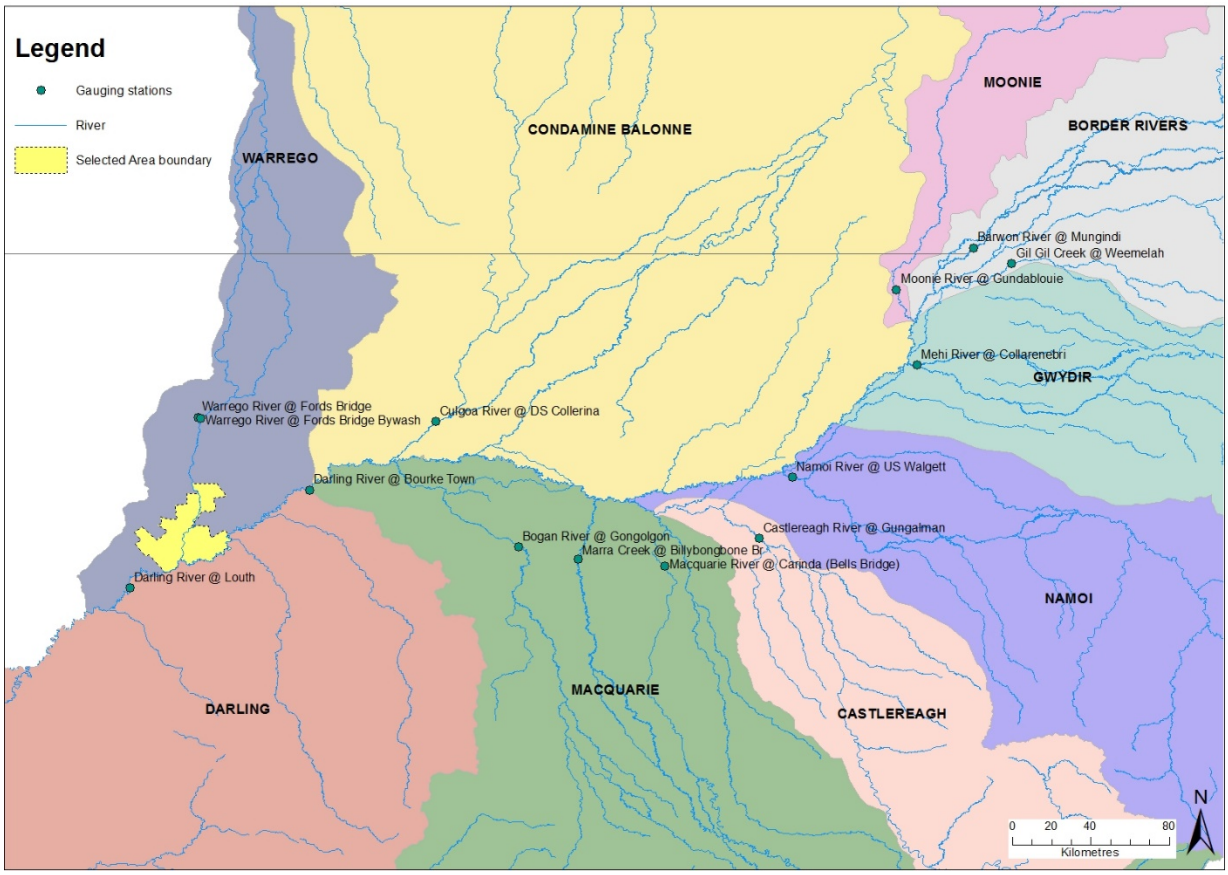

Figure B-1 WaterNSW gauging stations in upstream tributaries.

B.1.4 Timing and frequency

Ongoing throughout the MER Project.

B.1.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. Experienced technicians will undertake data collation and analysis under the direction of the Project Manager.

B.1.6 Detailed methods

The influence of Commonwealth water for the environment at the Selected Area is dependent on unregulated, and to a lesser extent regulated flows from a number of upstream tributaries (Gawne et al. 2013). Given the relatively short period of time that Commonwealth entitlements have been available in the northern Basin, the relative influence of flows from each tributary in contributing to different flow components, and how best to 'shepherd' these environmental flows through the system for maximum benefit remains an issue for interpreting data.

The Hydrology (Northern Tributaries) indicator will inform this, by quantifying the relative contributions of the end of system flows coming out of each upstream tributary to hydrological connectivity (frequency and duration of flows) within the Selected Area. We will continue the model of flow contributions established in the LTIM Project.

B.1.7 Data analysis and reporting

Standard hydrological analysis will be used to determine relationships between end-of-system Commonwealth water for the environment flows out of upstream tributaries and flows entering the Selected Area. These relationships will inform a basic working hydrological model of upstream inputs of Commonwealth water for the environment from upstream tributaries to the Selected Area. This indicator will also provide context for a number of other indictors.

B.1.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the MER Plan (CEWO 2014).

B.1.9 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Gawne B., Brooks S., Butcher R., Cottingham P., Everingham P. & Hale J. 2013. *Long-term Intervention Monitoring Project: Monitoring and Evaluation Requirements: Junction of the Warrego and Darling rivers*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 01.2/2013.

B.2 SOP – Hydrology (River)

B.2.1 Objectives

The Hydrology (River) monitoring protocol will provide fundamental hydrological information for Basin-scale and Selected Area evaluation questions and survey timing.

B.2.2 Related indicators

This Hydrology (River) indicator links to Vegetation Diversity, Fish (Channel), Food Webs (Stream Metabolism, Water Quality, Microinvertebrates and Macroinvertebrates), Hydrology (Northern tributaries, Floodplain, Channel, Habitat).

Monitoring of Hydrology (River) sources and analyses of hydrological data will help to understand the system hydrology and character of Commonwealth water for the environment entering the site. This indicator assists with understanding hydrological connectivity and duration for the other indicators nominated above.

B.2.3 Locations for monitoring

This indicator will use a number of WaterNSW gauging stations and water level recorders in close proximity to the Selected Area (Category I method; Table B-2, Figure B-2). The gauge network maintained by WaterNSW in and adjacent to the rivers Selected Area has sufficient distribution and quality to ensure that no additional gauge stations are required for the delivery of the project.

Table B-2 Gauges and water level sensors within zones, Junction of Warrego and Darling rivers Selected Area.

Zone	WaterNSW Gauge Number	Gauge/sensor name	Latitude	Longitude	Datum
B	423001	Warrego @ Fords Bridge	−29.7526	145.4276	GDA94
B	423002	Warrego @ Fords Bywash	−29.7568	145.4408	GDA94
B	423008	Warrego @ Boera Dam	−30.09945	145.4278	GDA94
C	425003	Darling @ Bourke Town	−30.0861	145.9387	GDA94
C	425037	Darling @ D/S Weir 19A	−30.2326	145.6957	GDA94
C	425004	Darling @ Louth	−30.5347	145.1150	GDA94
A	Water level sensor	Site 1 WF	-30.1210	145.4229	GDA94
A	Water level sensor	Site 2 WF	-30.1311	145.4204	GDA94
A	Water level sensor	Site 3 WF	-30.1513	145.4158	GDA94
A	Water level sensor	Site 4 WF	-30.1737	145.4163	GDA94
A	Water level sensor	Site 5 WF	-30.3268	145.2650	GDA94
C	Water level sensor	Weir 19A	-30.2335	145.7119	GDA94
C	Water level sensor	Hells Gate	-30.2901	145.5616	GDA94
C	Water level sensor	Acuna Homestead	-30.4098	145.3345	GDA94
C	Water level sensor	Weir 20A	-30.4764	145.2593	GDA94

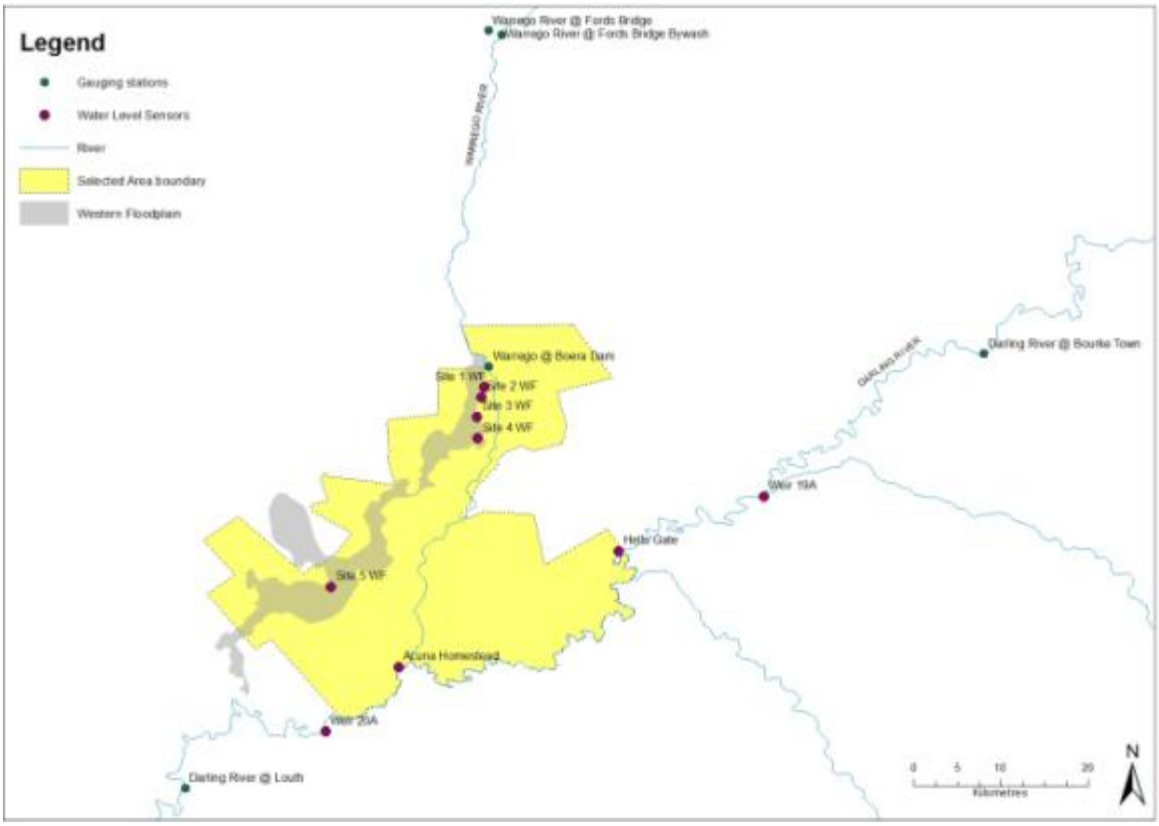

Figure B-2 Hydrological gauge network – Junction of the Warrego and Darling rivers Selected Area.

B.2.4 Timing and frequency

On-going for the duration of the MER Project.

B.2.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. Experienced technicians will undertake data collation and analysis under the direction of the Project Manager.

B.2.6 Detailed methods

No new gauging stations are to be established. Data will be downloaded from the WaterNSW hydrological data site (https://realtimedata.waternsw.com.au/water.stm) or directly from WaterNSW.

B.2.7 Data analysis and reporting

A suitable hydrological modelling package will be used to calculate the following river water regime parameters:

- Daily mean river 'stage' water height (mASL)
- Daily mean river discharge (ML/day)
- Travel time (days).

All data provided for this indicator will conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

Hydrology (River) data will be used to assess the level of hydrological connectivity throughout the Selected Area. Relationships between upstream and downstream gauges in each monitoring zone determined via the LTIM project will be refined in the MER phase of monitoring. These relationships will be used to assess the movement of Commonwealth water for the environment between these gauges and the duration and volume of Commonwealth water for the environment moving through the site will be quantified each year. Comparing these flows to other flows in the Selected Area each year, the additional hydrological connectivity provided by Commonwealth water for the environment will be determined. Relationships between WaterNSW gauging stations and water level loggers present throughout the Selected Area will also be refined to provide for a more accurate assessment of hydrological connectivity within the Selected Area.

B.2.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

B.2.9 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Gawne B., Brooks S., Butcher R., Cottingham P., Everingham P. & Hale J. 2013. *Long-term Intervention Monitoring Project: Monitoring and Evaluation Requirements: Junction of the Warrego and Darling rivers*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 01.2/2013.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

B.3 SOP – Hydrology (Channel)

B.3.1 Objectives

The aim of the Hydrology (Channel) indicator is to document the degree of connectivity resulting from Commonwealth water for the environment along the Warrego River channel.

B.3.2 Indicators

Hydrology (Channel) monitoring will map the flow paths along the Warrego River channel and determine the hydrological connectivity as a result of the delivery of Commonwealth water for the environment. The hydrodynamic model developed through the LTIM Project will continue to be refined.

The Hydrology (Channel) indicator links to Waterbird Diversity, Hydrology (River, Floodplain), Fish (Channel), Food Webs (Water Quality, Stream Metabolism, Microinvertebrates and Macroinvertebrates) and Frogs indicators.

B.3.3 Locations for monitoring

Hydrology (Channel) monitoring will be undertaken in the Warrego River zone. Long-term gauging stations operated by WaterNSW in the Warrego River upstream of the Selected Area at Fords Bridge on the Warrego, and also at Boera Dam at the northern end of the Selected Area will inform the amount of Commonwealth water for the environment entering the zone (Figure B-3).

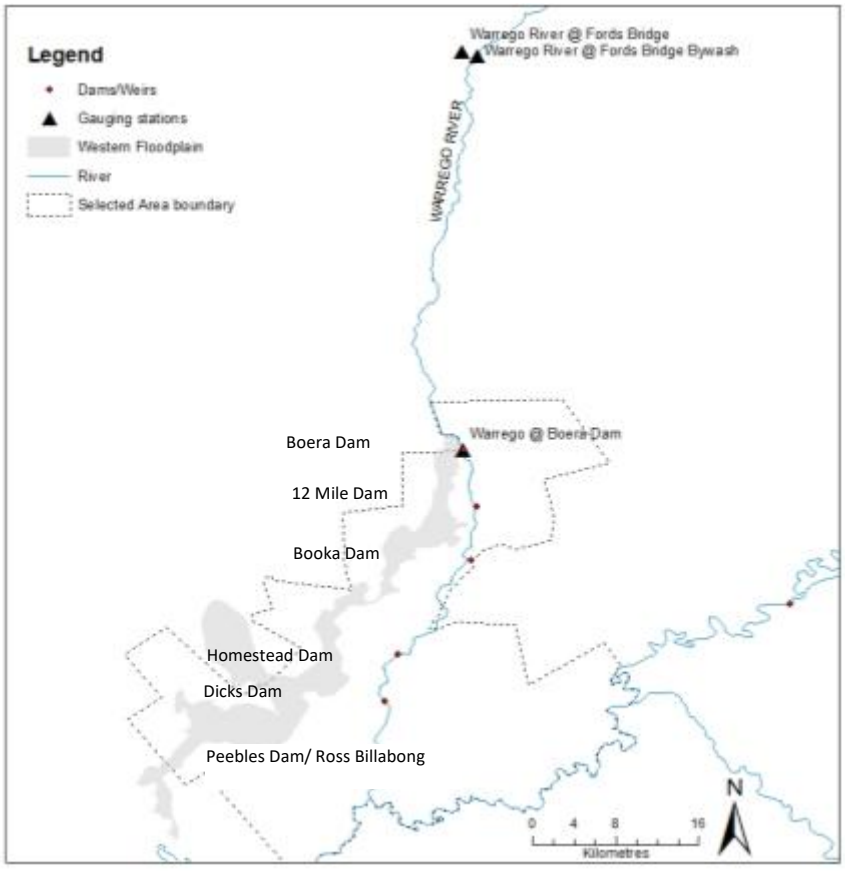

Figure B-3 Gauging stations and Dams located on the Lower Warrego River channel.

B.3.4 Timing and frequency

Ongoing throughout the MER Project.

B.3.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. Experienced technicians will undertake data collation and analysis under the direction of the Project Manager.

B.3.6 Detailed methods

The lower Warrego River takes on an anastomosing channel form, with multiple channels and by-washes carrying water through the system. These primary and secondary flow pathways will be determined via image analysis linked to key flow periods.

The hydrodynamic model will be refined to better determine the hydrology of the channel network by utilising a number of existing water level loggers and known levels (dams/weirs) throughout the system. Additional water level loggers may be implemented to improve the relationships with flow and connectivity in this system. Waterhole permanence will also be determined using water level loggers, cameras, imagery and field validation.

The hydrodynamic model developed in the LTIM Project will continue to provide an important tool for the MER Project. Other data on inundation extent and frequency from previous work (Cox et al. 2012; Holz et al. 2008, Aurecon 2009) and the work currently being undertaken via OEH will be used to assist in developing the known and expected hydrological connectivity through the Warrego River channel during flow events.

B.3.7 Data analysis and reporting

Selected Area scale hypotheses

At the Selected Area scale a number of hypotheses that relate to the outcomes of delivery of Commonwealth water for the environment are possible. Selected Area scale hypotheses include:

1. Hydrological connectivity in the channels of the lower Warrego River will increase with Commonwealth water for the environment.
2. The persistence of waterholes in the lower Warrego River will increase with Commonwealth water for the environment.

Selected Area scale analyses

Quantitative analyses will be applied at the Selected Area scale to document temporal shifts in the presence and connectedness of water in periods that Commonwealth water for the environment is delivered each year. Long-term year on year trends can be analysed based on periods with and without the delivery of Commonwealth water for the environment.

Short-term and long term responses:

- Hypotheses 1-2 – Relative increases in the persistence and connections provided with the addition of Commonwealth water for the environment, compared to times without.

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

B.3.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

B.3.9 References

Aurecon 2009. *Toorale Station Decommissioning Plan Volume 1*. Prepared for the Department of Environment, Water, Heritage and Arts.

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Cox, S.J., Thomas, R.F. & Lu, Y. 2012. *Flooding patterns of Toorale: the confluence of the Warrego and Darling rivers.* Office of Environment and Heritage, Sydney. Unpublished report.

Holz, L., Barma, D. & Wettin, P. 2008. Warrego River Scoping Study. WMA Water, Sydney.

B.4 SOP – Hydrology (Floodplain)

B.4.1 Objectives

The aim of the Hydrology (Floodplain) indicator is to document the extent of inundation resulting from Commonwealth water for the environment.

B.4.2 Indicators

Hydrology (Floodplain) monitoring will model and map the inundation extent resulting from the delivery of Commonwealth water for the environment on the Western Floodplain using the hydrodynamic model established in the LTIM Project.

The Hydrology (Floodplain) indicator links to Vegetation Diversity, Waterbird Diversity, Hydrology (River and channel), Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates) indicators.

B.4.3 Locations for monitoring

Hydrology (Floodplain) monitoring will be undertaken in the Western Floodplain zone (Figure B-4).

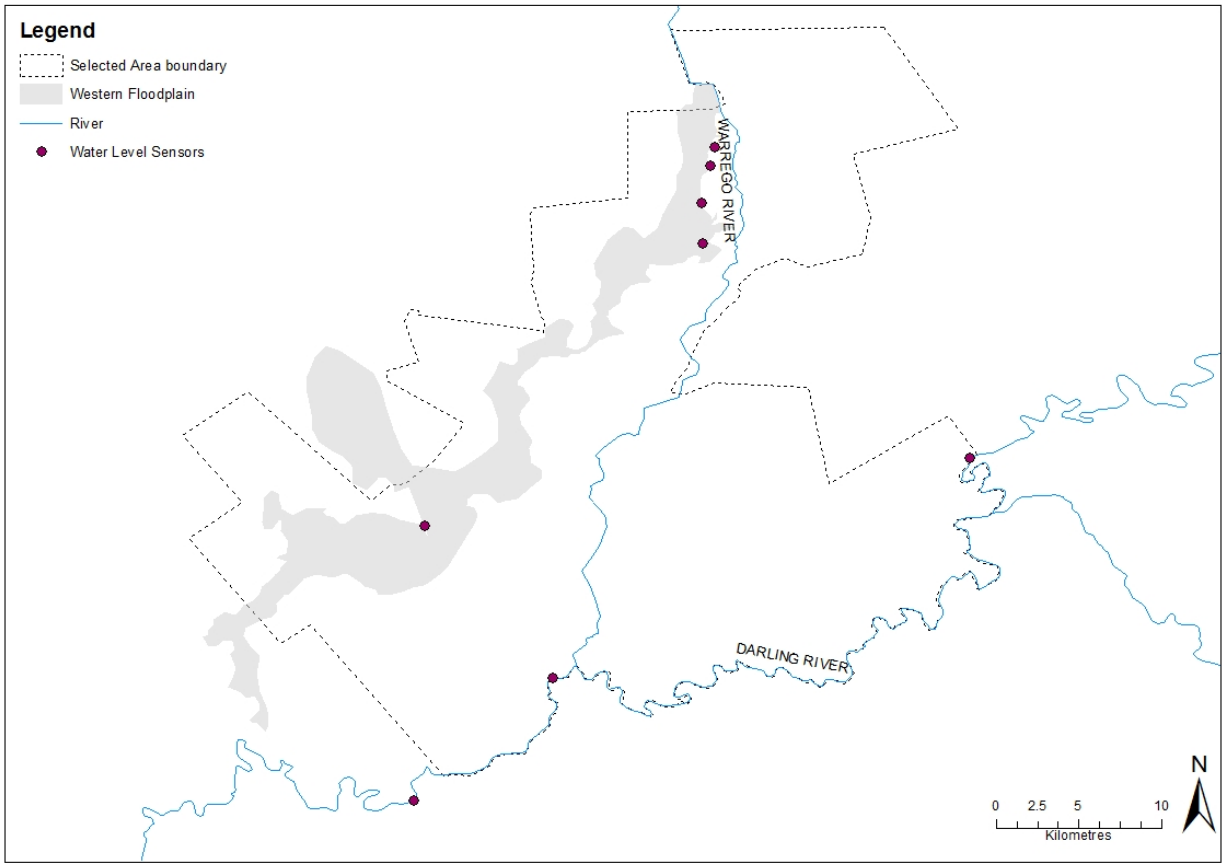

Figure B-4 Location of the Western Floodplain zone in the Selected Area. Water sensors are shown as red circles.

B.4.4 Timing and frequency

Ongoing modelling linked to flow using the hydrodynamic model and satellite image captures.

B.4.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. A team of GIS officers will complete the data analysis under the direction of the Project Director (Paul Frazier).

B.4.6 Detailed methods

Data on inundation extent and frequency from previous and ongoing work (e.g. OEH), will be used to assist in developing the known and expected inundation extent and volume from given flow events.

A number of water depth recorders will be maintained on the Western Floodplain to increase the coverage of water level monitoring within this system. Water level information from this network of gauges will then be linked to the hydrodynamic model and satellite image captures to allow for an estimation of the extent and volume of water on the Western Floodplain at any given time.

B.4.7 Data analysis and reporting

GIS based analysis to determine the relationship between inundation event (volume) and inundated area, and volume in relation to mapped soil and vegetation regions.

The Hydrology (Floodplain) method reports m^2 ANAE typology and vegetation community inundated from Commonwealth environmental water. The proposed indicator will document the m^2 of inundated ANAE and vegetation hydrology and will facilitate the scaling of potential Food Webs (Microinvertebrates and Macroinvertebrates) and Vegetation Diversity to the Selected Area.

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

B.4.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

B.4.9 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

B.5 SOP – Hydrology (Habitat)

B.5.1 Objectives

The aim of the Hydrology (Habitat) indicator is to document the degree of connection of in-channel habitat resulting from Commonwealth water for the environment.

B.5.2 Indicators

Hydrology (Habitat) monitoring will quantify the connection of in-channel habitats within the Darling River channel.

The Hydrology (Habitat) indicator links to Hydrology (River and Northern tributaries), and Food Webs (Water quality, Stream Metabolism, Microinvertebrates and Macroinvertebrates) indicators.

B.5.3 Locations for monitoring

Hydrology (Habitat) monitoring will be undertaken in the Darling River zone within the Selected Area. Long-term gauging stations operated by WaterNSW located in the Darling River at Bourke, Weir 19A and Louth will be used to quantify river flows through the zone. In addition, there are several water level sensors that have been placed along the Darling River within the Selected Area that are being maintained by WaterNSW staff (Figure B-5).

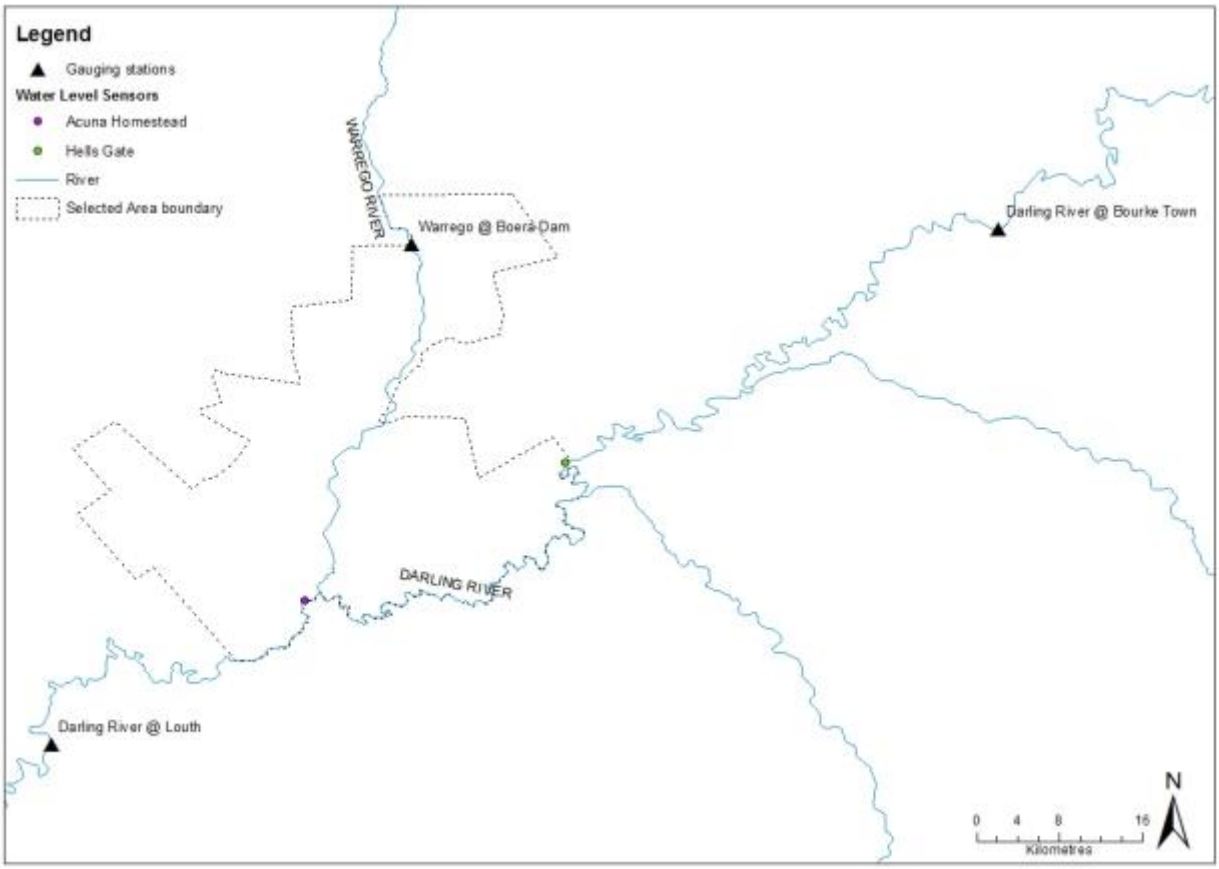

Figure B-5 Location of gauging stations and water level sensors along the Darling River zone.

B.5.4 Timing and frequency

Throughout the MER Project.

B.5.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. Experienced technicians will undertake field data collection and data analysis under the direction of the Project Manager.

B.5.6 Detailed methods

The habitat mapping developed in the LTIM Project will continue to be used to link flow to habitat inundation and river processes. Flow stage data within the reach will be analysed to determine habitat inundation periods and concomitant production for each water year.

There are several ongoing projects funded under the MDBA's Northern Basin strategy that will generate information relevant to this indicator. The project team is keen to collaborate with these projects to maximise the outcomes of all projects and minimise duplication of effort.

B.5.7 Data analysis and reporting

Selected Area scale hypotheses

At the Selected Area scale a number of hypotheses that relate to the outcomes of delivery of Commonwealth water for the environment are possible. Selected Area scale hypotheses include:

1. The inundation of in-channel bench surfaces along the Darling River channel will increase with the delivery of Commonwealth water for the environment
2. The inundation of large Woody Debris within the Darling River channel will increase with the delivery of Commonwealth water for the environment
3. The hydrological connection of anabranch channels along the Darling River will increase with the delivery of Commonwealth water for the environment.

Selected Area scale analyses

Quantitative analyses will be applied at the Selected Area scale to document temporal shifts in the connection of habitats in periods that Commonwealth water for the environment is delivered each year. Long-term year on year trends can be analysed based on periods with and without the delivery of Commonwealth water for the environment.

Short-term and long term responses:

- Hypotheses 1-3 – Basic descriptive statistics comparing the amount of connected habitat with the addition of Commonwealth water for the environment, compared to times without.

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

B.5.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

B.5.9 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Boys CA 2007, *Fish habitat association in a large dryland river of the Murray-Darling Basin Australia.* PhD Thesis, University of Canberra, Australia.

Southwell MR 2008, *Floodplains as Dynamic mosaics: Sediment and nutrient patches in a large lowland riverine landscape.* PhD Thesis, University of Canberra, Australia.

B.6 SOP – Ecosystem Type

B.6.1 Objectives

This is a monitoring protocol to validate the interim Australian National Aquatic Ecosystems (ANAE) classification.

B.6.2 Indicators

The monitoring of Ecosystem Type will help to validate the interim ANAE mapping.

The interim ANAE framework has been applied to aquatic ecosystems across the MDB using the best available mapping and attribute data (Brooks et al. 2013).

B.6.3 Locations for monitoring

Validation will be carried out for each ecosystem type that falls within an assessment unit for all new on-ground monitoring sites in the Selected Area. Where a site has not been mapped, the typology developed by Brooks et al. (2013) will be used to assign an ecosystem type.

B.6.4 Timing and frequency

This validation mapping will occur as and if new sites are added. Desktop mapping will occur prior to field work. Verification or assignation of a classification will occur after field work.

B.6.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. Desktop mapping and updating of any ecosystem type will be undertaken by a GIS Officer. Ground-truthing and validation will be undertaken by an ecologist.

B.6.6 Detailed methods

Interim ANAE classification shall be undertaken as per the standard methods described in the LTIM Standard Methods (Hale et al. 2014). The typology used to assign ecosystem types is described in the LTIM Standard Methods (Hale et al. 2014).

There are a number of complementary datasets that will be used to aid in identifying aquatic ecosystem types prior to the field validation:

- Mapping output from Brooks et al. (2013)
- Any regional sources with updated feature mapping
- Fine-scale resolution vegetation mapping and/or remote sensed data
- Satellite imagery (e.g. SPOT6 – panchromatic resolution 1.5 m, multispectral resolution 8 m)
- NVIS41_MDB vegetation mapping (NVIS v4.1 updated with CMA mapping by Brooks et al. 2013).

For the purposes of the MER Project, aquatic ecosystems are described as rivers, floodplains and wetlands. This is a simplification of four ecosystem classes into three common terms. For the validation protocol the terminology defined by the interim ANAE classification (Aquatic Ecosystem Task Group 2012) is to be applied. The ecosystem classes relevant to the MER Project are as follows:

- Lacustrine systems (lakes) are open-water dominated systems, characterised by deep, standing or slow-moving water with little or no emergent vegetation (<30% cover) (note this ecosystem class is included as wetlands in LTIM Project Logic and Rational Document, Gawne et al. 2013).
- Palustrine systems are primarily shallow, vegetated, non-channel environments, including billabongs, bogs, swamps, springs, soaks etc. (Included as wetlands in Logic and Rational document).
- Riverine systems are those that are contained within a channel and its associated streamside vegetation. This definition refers to both single channel and multi-channel systems e.g. braided channel networks. The beds of channels are not typically dominated by emergent vegetation, may be naturally or artificially created, periodically or continuously contain moving water, and may form a connecting link between two bodies of standing water (Aquatic Ecosystem Task Group 2012).
- Floodplain systems are those aquatic systems that are either seasonally or intermittently flooded flat areas that are outside the riverine channels or palustrine/lacustrine systems but that display characteristics of hydric soils or vegetation that are characteristically adapted to the seasonal or intermittent presence of water.

B.6.7 Data analysis and reporting

No data analysis is required for this indicator. All data provided for this indicator will be reported following the requirements outlined in the LTIM Project Standard Protocol: Section 2 Ecosystem Type (Hale et al. 2014) and must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014). The data standard provides a means of collating consistent data that can be managed within the LTIM Monitoring Data Management System (MDMS).

Each site ANAE classification will be recorded and provided to the CEWO.

B.6.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

B.6.9 References

Aquatic Ecosystem Task Group. 2012. Aquatic Ecosystems Toolkit: Module 2, Interim Australian National Aquatic Ecosystem Classification Framework. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Brooks S., Cottingham P., Butcher R., & Hale J. 2013. *Murray-Darling Basin aquatic ecosystem classification: Stage 2 report*. Peter Cottingham & Associates report to the Commonwealth Environmental Water Office and Murray-Darling Basin Authority, Canberra.

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water

Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Gawne B., Brooks S. Butcher R., Cottingham P., Everingham P., Hale J., Nielson D., Stewardson M. & Stoffels R. 2013a. *Long Term Intervention Monitoring Project: Logic and Rationale Document*. V1.0. MDFRC Publication 01/2013.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

B.7 SOP – Fish (Channel)

B.7.1 Objectives

To assess the contribution of Commonwealth water for the environment to fish survival, resilience and diversity at the Selected Area scale.

B.7.2 Indicators

The Fish (Channel) indicator links with Food Webs (Water Quality, Stream Metabolism, Microinvertebrates and Macroinvertebrates) and Hydrology (River and Channel) indicators.

Fish sampling will be undertaken before and after water for the environment events using modified Sustainable Rivers Audit (SRA) protocols (Davies et al. 2010). All fish will be identified, counted, measured (maximum of 50 individuals per species per site). Individuals (maximum of 50 individuals per species per site) of two or three "periodic" species will be weighed to assess changes in relative condition.

Dependent variables include:

- Relative abundance estimation
- Population structure for target species
- Length-weight (total length or fork length, weight (g)

B.7.3 Locations for monitoring

Fish (Channel) monitoring will be undertaken in the Warrego River and Darling River zones. The overall design for the Fish (Channel) indicator will provide Selected Area specific information. Given the uncertainty of the timing of water for the environment releases in the system, the Fish (Channel) sampling will target specific flow events within pools behind structure within the Warrego River, at the confluence of the Darling and Warrego Rivers, and at 5 locations in the Darling River zone within the Selected Area. Warrego channel sites may include Boera Dam, 12 Mile Dam, Booka Dam, Homestead Dam, Dicks Dam and Peebles Dam/Ross Billabong (Figure B-6) dependent on inundation. These sites provide the most permanent refugia within this zone and also include some sites which have been previously sampled by DPI Fisheries.

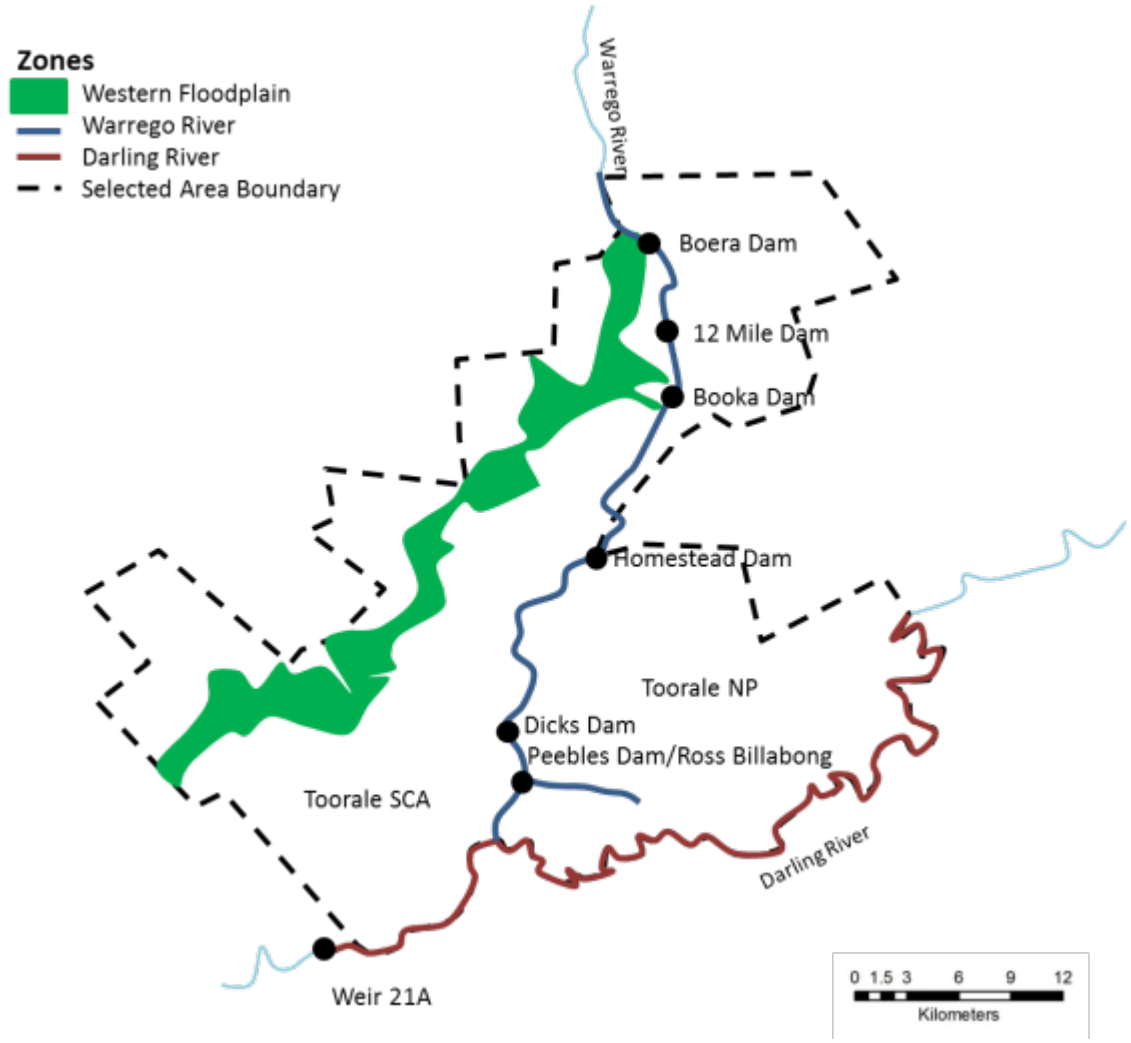

Figure B-6 Fish (Channel) sampling sites and zones.

B.7.4 Timing and frequency

All sampling is event-based and will be undertaken within the Selected Area before (where possible) and after Commonwealth water for the environment events. DPI Fisheries will be contracted to undertake Fish (Channel) monitoring in a minimum of two events within the three-year MER Project. Each event will comprise two samples (pre-event or existing condition and post-event). The current flow and inundation event in the Warrego (from May 2019 onwards), may mean the initial survey may be undertaken as soon as possible in the 2019-20 water year and represent the existing connected and inundated condition at that time.

B.7.5 Responsibilities

DPI Fisheries will be sub-contracted by UNE to undertake Fish (Channel) monitoring.

B.7.6 Detailed methods

Sampling will be undertaken using modified Sustainable Rivers Audit (SRA) protocols (Davies et al. 2010). Fish will be sampled at sites (number of sites determined by water levels) aligned to two flow events. Sampling will involve a combination of boat electrofishing, un-baited bait traps and fyke nets (n = 6). Boat electrofishing will involve 12 x 90 second shots and bait traps (n = 10) will be soaked for up to two hours concurrently during electrofishing operations. Three each of two sizes of double-winged fyke nets (small mesh and large mesh) will be set overnight at each site. Seine netting (where possible) will also be undertaken as required to capture young-of-year at or near sample sites. All fish (up to maximum of 50 individuals at the one site) captured within samples will be identified, counted, and measured. Individuals (maximum of 50 individuals per species per site) of two or three periodic species (golden perch and bony herring and/or spangled perch) will also be weighed to assess relative condition before and after watering events. DPI Fisheries are also undertaking fish sampling as part of an MDBA funded fish monitoring program. There are several sites in this program that are located within the Selected Area.

B.7.7 Data analysis and reporting

Selected Area scale hypotheses

Short-term (event-based) responses:

1. Mean Total length, Fork length, Mass and Condition for each of the two or three target taxa (golden perch, bony herring and/or spangled perch) will be greater following the release of Commonwealth water for the environment within the selected area.
2. SRA metrics "Expectedness", "Nativeness", and "Recruitment" of native fish communities will be higher post release of Commonwealth water for the environment within the selected area
3. A greater abundance of young-of-year will be present following the release of Commonwealth water for the environment within the selected area.

Selected Area scale analyses

To accommodate for the ephemeral nature of the Warrego system which limits the potential area available to sample (particularly for 'before' samples), a finite population correction (fpc) factor will applied to the data before analysis to allow for the potential that greater than 5% of the population was captured. The fpc factor is used to adjust a variance estimate for an estimated mean or total, so that this variance only applies to the portion of the population that is not in the sample.

The fish community data will then be summarised using the three main SRA Indicators:

1. "Expectedness" - a comparison of the existing catch composition with that of historical fish distributions,
2. "Nativeness" - the proportion of native versus alien fishes, and
3. "Recruitment" - the recent reproductive activity of the native fish community.

Quantitative analyses will then be applied using a counterfactual approach based on an historical 'reference' condition represented by a pre-European fish assemblage (developed by Fisheries NSW). Multi-sample analyses will be based around the repeat application of models. Models outputs will be compared between samples around events to assess the immediate effect of Commonwealth water for the environment releases, and also where applicable, among years to determine if there are changes across longer temporal scales.

Relative body condition of each of the target species will be calculated using the length and weight data collected for individual fish. Changes in relative condition will be then examined around watering events (before and after samples) as well as among events. Fish with high body condition are typically more resistant to negative environmental factors and have greater reproductive potential.

Short-term (Annual) responses:

- Hypotheses 1, 2 and 3 – Univariate analysis (e.g. ANOVA - main effect – time) for all taxa, each target taxa, each life history guild, taxa reference richness/diversity.
- Hypotheses 2 - (diversity-abundance) multivariate analysis (e.g. Permanova, MDS, PCA - factors – time, target taxa, life history guilds, native/exotic, taxa reference composition).

Data for the Warrego Selected Area will be reported following the requirements outlined in the LTIM Data Standard and conform to the LTIM Data Standard (Brooks & Wealands 2014).

B.7.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

QA/QC activities specific to this protocol include:

- Electrofishers must be experienced operators of units. They should be supervised by Senior Operators on-site, and have obtained their electrofishing certificates through a reputable course.
- Monitoring and Evaluation Providers must have relevant boat licenses.
- It is the responsibility of the Monitoring and Evaluation Providers to have specific fisheries and ethics permits with them while sampling.
- Fyke nets will be checked for holes in either wing- or cod-ends prior to every field trip. Any net with a hole will be repaired or replaced.

B.7.9 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Davies, P. E., Harris, J. H., Hillman, T. J., & Walker, K. F. (2010). The sustainable rivers audit: assessing river ecosystem health in the Murray–Darling Basin, Australia. *Marine and Freshwater Research*, *61*(7), 764-777.

B.8 SOP – Vegetation Diversity

B.8.1 Objectives

This monitoring protocol aims to assess the contribution of Commonwealth water for the environment to floodplain vegetation diversity, condition and extent.

B.8.2 Indicators

This Vegetation diversity indicator links to Ecosystem Type, Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates), and Hydrology (Selected Area) indicators.

B.8.3 Locations for monitoring

Sites will be located as per the LTIM Project in target wetland communities within the Western Floodplain zone (Figure B-7, Table B-3). The northern section of the Western Floodplain will be targeted as these areas represent the sites most likely to be influenced by Commonwealth water for the environment. Sites selection are based on both wetland vegetation community and flooding frequency.

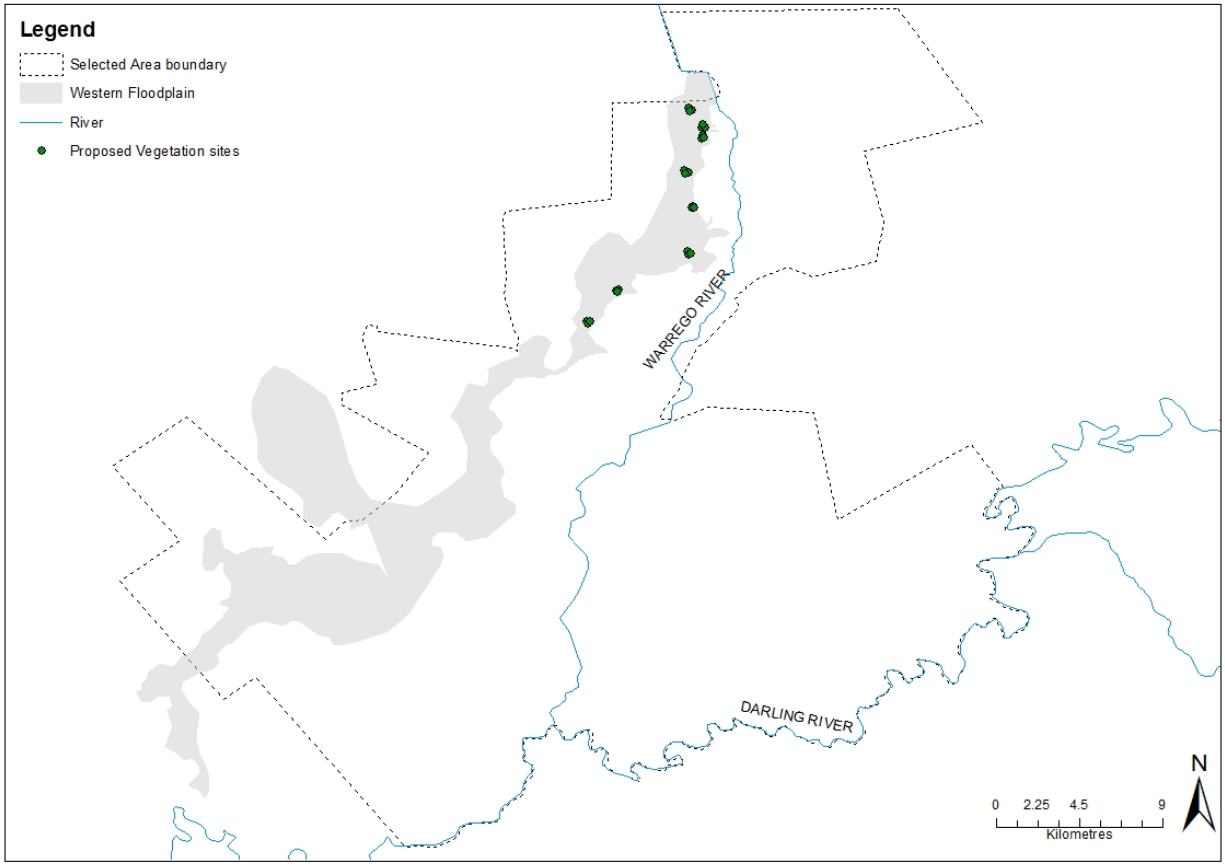

Figure B-7 Vegetation Diversity sites within the Western Floodplain.

Table B-3 Vegetation Diversity - monitoring site locations.

Site Name	Target vegetation community	Target inundation frequency (years)	Longitude	Latitude
WD1.1	Coolibah-River Cooba-Lignum woodland	High (<1)	-30.1052	145.4143
WD1.2	Coolibah-River Cooba-Lignum woodland	High (<1)	-30.1042	145.4127
WD1.3	Coolibah-River Cooba-Lignum woodland	High (<1)	-30.1058	145.4131
WD2.1	Coolibah-River Cooba-Lignum woodland	Low (2-5)	-30.1176	145.4195
WD2.2	Coolibah-River Cooba-Lignum woodland	Low (2-5)	-30.1191	145.4189
WD2.3	Coolibah-River Cooba-Lignum woodland	Low (2-5)	-30.1187	145.42
WD3.1	Chenopod shrubland	High (<1)	-30.1925	145.3787
WD3.2	Chenopod shrubland	High (<1)	-30.1927	145.3777
WD3.3	Chenopod shrubland	High (<1)	-30.1934	145.3783
WD4.1	Chenopod shrubland	Low (2-5)	-30.1735	145.412
WD4.2	Chenopod shrubland	Low (2-5)	-30.1753	145.4124
WD4.3	Chenopod shrubland	Low (2-5)	-30.1746	145.4136
WD5.1	Coolibah woodland wetland	High (<1)	-30.209	145.3638
WD5.3	Coolibah woodland wetland	High (<1)	-30.2078	145.3632
WD5.2	Coolibah woodland wetland	High (<1)	-30.208	145.365
WD6.1	Coolibah woodland wetland	Low (2-5)	-30.1346	145.4108
WD6.2	Coolibah woodland wetland	Low (2-5)	-30.1355	145.4128
WD6.3	Coolibah woodland wetland	Low (2-5)	-30.1359	145.4112
WD7.1	Lignum shrubland wetland	High (<1)	-30.152	145.4147
WD7.2	Lignum shrubland wetland	High (<1)	-30.1528	145.4143
WD7.3	Lignum shrubland wetland	High (<1)	-30.1527	145.4154
WD8.1	Lignum shrubland wetland	Low (2-5)	-30.1139	145.4192
WD8.2	Lignum shrubland wetland	Low (2-5)	-30.114	145.4207
WD8.3	Lignum shrubland wetland	Low (2-5)	-30.1124	145.4197

B.8.4 Timing and frequency

Vegetation diversity monitoring shall be undertaken twice annually; twice in 2019, and then before and after inundation events (generally August-October and March-June) in Years 2 to 3. The exact timing of sampling will be largely dependent on the target vegetation communities and expected lag time for response to watering.

B.8.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. Field surveys and data analysis will be undertaken by experienced field botanists.

B.8.6 Detailed methods

Survey methods conform to with the Standard Methods as a Category II indicator (Hale et al. 2014).

Surveys will target at least 8 monitoring sites that incorporate Coolibah - River Cooba - Lignum woodlands, Coolibah open woodlands, Lignum shrublands and Chenopod low open shrublands in the Western Floodplain. These sites have been established to directly target zones where environmental watering is likely to be delivered. At each site, three 20 x 20m plots will be sampled. The 0.04 ha plot size is standard for surveying floristics (Sivertsen 2009) and is consistent with previous vegetation monitoring within the Selected Area (Gowans et al. 2012).

At each site, measures of species abundance, structure, tree recruitment, and site flooding will be measured (data sheets below). Projected foliage cover will be used to define cover (Hale et al. 2014). In addition the LTIM data a comprehensive survey of vegetation distribution and condition was undertaken in 2012 by Cowans et al. (2012). Information from this survey will be used as a comparative baseline throughout the MER Project.

B.8.7 Data analysis and reporting

Data analysis methods will follow those defined in Section 4: Vegetation Diversity of the LTIM Standard Methods ((Hale et al. 2014).

Selected Area scale hypotheses

Short-term (Annual) responses:

1. The delivery of Commonwealth water for the environment to wetland and floodplain areas in the Western Floodplain will lead to increased cover and/or richness of wetland vegetation communities.

Long-term responses:

2. The delivery of Commonwealth water for the environment to wetland and floodplain areas in the Western Floodplain and will lead to increased year-on-year cover and/or richness of wetland vegetation communities.

Selected Area scale analyses

Analyses based on aggregation will be applied at the Basin and Selected Area scales for cover and richness of wetland vegetation communities. Quantitative analyses will be applied at the Selected Area scale to document increased cover and richness of wetland vegetation communities at sites receiving Commonwealth environmental water. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model. The placement of survey sites has been strategically undertaken to permit quantification of the hydrologic connection and inundation metrics and lead to reduced uncertainty the delivery of Commonwealth water to these sites.

Short-term (Annual) responses:

- Hypotheses 1 - univariate analysis (main effect – location, inundation, time) cover and richness and multivariate analysis (factors – location, inundation history, time).

Long-term (5 year) responses:

- Hypotheses 2 - univariate analysis (main effects – location, inundation history, year, time) and multivariate analysis (factors – location, inundation history, year, time).

Linking wetland vegetation community extent to Commonwealth water for the environment inundation extent should permit extrapolation of the response to the Selected Area.

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Standard Methods (Hale et al. 2014). All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

B.8.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

B.8.9 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Gowans, S., Milne, R., Westbrooke, M. & Palmer, G. 2012. *Survey of Vegetation and Vegetation Condition of Toorale*. Prepared for the NSW Government Office for Environment and Heritage. University of Ballarat, Mt Hellen. 199pp.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

Sivertsen, D. (2009) *Native Vegetation Interim Type Standard*. Department of Environment, Climate Change and Water, NSW Sydney.

Field Data Sheets

Note – iPads or similar will be used in the field to record all data under the following headings.

Species abundance

Site Number	Collect	Common name	Scientific name	% Cover	Mean Height	Upper Height	Exotic	waypoint	Photo SW from NE	Photo N from S	Photo NE from SW	Photo S from N	Grazing	Notes

Community structure

Site Number	Sample date	Veg community	>5m canopy % cover	1-5m understory % cover	<1m ground % cover	Litter % Cover	Lichen/moss % cover	Bare ground % cover	Fallen timber (0.04 ha)	Av length of fallen logs

Tree Recruitment

Site no	Species	No ind. 0.2-0.5m tall (0.04 ha)	No ind. 0.5 1.3m tall (0.04 ha)	No ind. 1.3-3m tall (0.04 ha)	No ind. 0.2-0.5m tall (0.1 ha)	No ind. 0.5 1.3m tall (0.1 ha)	No ind. 1.3-3m tall (0.1 ha)	No dead trees (0.4 ha)	No live trees (0.4 ha)	comments

Site flooding data

Site No	Date	% Plot flooded	% Plot wet	% open water	Water depth (cm)	%submerged veg	bare ground submerged (%)	Submerged litter (%)	bare ground (%)	litter (%)	Time since previous flood	Time flooded (weeks)	notes

B.9 SOP – Waterbird Diversity

B.9.1 Objectives

The Waterbird Diversity monitoring protocol aims to assess the contribution of Commonwealth water for the environment to waterbird survival and diversity.

B.9.2 Indicators

This indicator links to Vegetation Diversity, Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates) and Hydrology (River, Channel, Floodplain) indicators.

B.9.3 Locations for monitoring

Waterbirds will be monitored at 3 sites along the Warrego River zone; Boera Dam, Booka Dam and Peebles Dam/Ross Billabong, in association with other Category III indicators (Figure B-8).

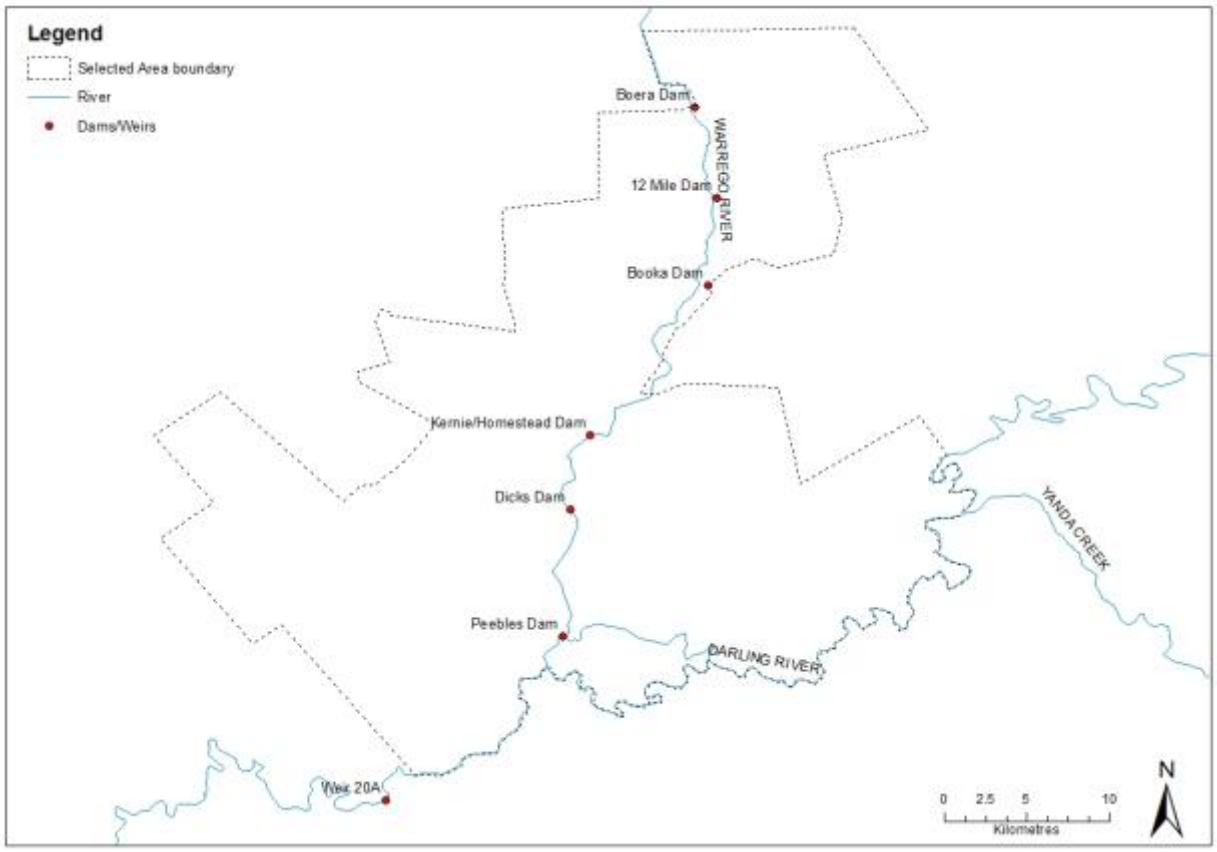

Figure B-8 Location of Dams within the Warrego River. Waterbirds will be monitored in Boera Dam, Booka Dam and Peebles Dam/Ross Billabong.

B.9.4 Timing and frequency

Surveys will typically occur in February and May but will be responsive to inundation conditions. Sampling will occur three times per event (before, during and after) for two events within the MER Project and opportunistically on the Western Floodplain during inundation events (Contingency Monitoring).

B.9.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. The field surveys will be led by experienced bird ecologists.

B.9.6 Detailed methods

Surveys will be undertaken on both foot and from a vehicle using observation points or transects depending on the size and shape of the wetland.

Foot surveys will be undertaken by moving around the wetland and observing from various points that are generally spaced so as to be out of sight of each other. At each point all birds are observed and recorded. New birds are recorded en route to new points and their species and number noted. During the survey, as much of each wetland as possible is accessed, and the percentage of the total wetland observed is recorded. Surveys are undertaken for at least 20 minutes but no more than 1 hour at each wetland, in order to gain a representative no necessarily complete, count of all waterbirds in the wetland.

For large or linear wetlands with good vehicular access, transect surveys will be used. Counts of species observed are recorded as a running tally as the vehicle travels along the transect. The start and end points and times are recorded on the datasheet.

Data from additional sources and monitoring programs may be used to contribute in whole or part to this monitoring protocol. For example, the Eastern Aerial Waterbird Survey (EAWS) may pass over assessment sites and be used to augment ground surveys. There may also be local aerial or ground surveys undertaken under other monitoring programs that should be considered as supplementary data.

B.9.7 Data analysis and reporting

For ground surveys, the total abundance of each species per wetland and per hectare will be calculated and reported (Section 10, Hale et al. 2014).

Selected Area scale hypotheses

Short-term (Annual) responses:

1. The delivery of Commonwealth water for the environment will lead to increased waterbird survival.

Long-term responses:

2. The delivery of Commonwealth water for the environment will lead to larger waterbird populations.
3. The delivery of Commonwealth water for the environment will lead to increased waterbird diversity.

Selected Area scale analyses

Analyses based on aggregation will be applied at the Basin and Selected Area scales for abundance, richness and diversity of waterbirds. Quantitative analyses will be applied at the Selected Area scale to document increased abundance, richness and diversity of waterbirds at sites receiving Commonwealth water for the environment. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model. The placement of water level devices at key location to quantify hydrologic connection and inundation metrics will improve uncertainty in quantifying the delivery of Commonwealth water for the environment to target sites.

Short-term (Annual) responses:

- Hypotheses 1 and 2 - univariate analysis (main effect – site, time) abundance, richness, diversity
- Hypotheses 2 - (diversity-abundance) multivariate analysis (factors – site, time).

Long-term (5 year) responses:

- Hypotheses 2 and 3 - univariate analysis (main effects – target site, year, time)
- Hypotheses 3 - (diversity-abundance) multivariate analysis (factors – target site, year, time).

The standard method for Waterbird Diversity reports m^2 ANAE area surveyed inundated from Commonwealth water for the environment. The proposed indicator Hydrology (Floodplain) will document the m^2 of inundated ANAE and vegetation and will facilitate the scaling of potential colonial waterbird rookery sites.

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

B.9.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

QA/QC requirements specific to this protocol include:

- All Waterbird Diversity surveys will be undertaken by the same experienced observers, where possible, over time to maintain consistency
- Observers will undergo training prior to undertaking monitoring surveys, including calibration against experienced observers to ensure standardisation of measurements. Training and calibration procedures will be documented in the MEP and relevant records maintained.

B.9.9 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Gawne B., Hale J., Butcher R. Roots J., Brooks S., Cottingham P., Stewardson M. & Everingham P. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Evaluation*

Plan. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29/2014.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

Warrego-Darling LTIM WATER BIRD DIVERSITY DATA SHEET

Date: / / **Time started**(24hr):_____ **Time finished:** _____ **Sheet No:**____ of ____

Site name/code:_____ **Survey No:** _____

Observer name(s):_____

Site location, including survey points: *(UTM, GDA94 datum)*

Survey Point	*Zone*	*EASTING*	*NORTHING*	*Photo Numbers*

Type of survey: ☐ Point(s) ☐ Transect ☐ Area (100x200m)

Survey site description

Weather conditions:

Temperature (℃) (est.) ☐

Rain (circle) None / Light / Heavy

Cloud cover ⅛ ☐

Wind speed (circle) Still / Light / Gusty / Gale

Wind direction (from) ☐

Total size of wetland (ha) ☐

Site coverage %: ☐ (Estimate % of total wetland area surveyed)

Habitat assessment:
Estimate % coverage of each habitat type that makes up area observed from your survey point (complete for first survey only)

Survey point No:					
Open water					
Aquatic floating veg					
Mudflat					
Dry bare ground					
Low-growing aquatic veg. eg. nardoo					
Aquatic emergent veg. <1m eg. rushes					
Aquatic emergent veg. >1m eg. reeds					
Terrestrial ground cover					
Estimate % total canopy area — Tree canopy					
Estimate total number — Dead standing timber					

Water level: Flooded Area (est %) ☐

Gauge height (m) (where available) ☐

Disturbance: (e.g. vehicles, feral species, people, machinery)

_____

_____

_____

_____

Additional comments:_____

_____

_____

_____

_____

Warrego-Darling LTIM WATER BIRD DIVERSITY DATA SHEET

Date: ____ / ____ / ____ **Site name/code:** ______________________________ **Sheet No:** ____ of ____

Survey Pt. No.	Time	Common Name	Count	Notes	Veg. hab. Type*	Breed (Y/N)

* Vegetation habitat types include:

- Open water (No vegetation) – OW
- River red gum forest – RRGF
- River red gum woodlands – RRGW
- Black box forest – BBF
- Black box woodland – BBW
- Coolibah – C
- River Cooba – RC
- Freshwater grasses – FG
- Paperbark - P
- Lignum - L
- Other Shrub - OS
- Saltmarsh - S
- Tall emergent aquatic - TEA
- Aquatic - A
- Sedge/Grass/Forb – S/G/F
- Freshwater forb - FF

B.10 SOP – Frogs

B.10.1 Objectives

The Frogs monitoring protocol aims to assess the contribution of Commonwealth water for the environment to frog recruitment, survival and diversity.

B.10.2 Indicators

This indicator links to Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates) and Hydrology (River and Channel) monitoring indicators.

B.10.3 Locations for monitoring

Frogs will be monitored at 3 sites along the Warrego River zone; Boera Dam, Booka Dam and Peebles Dam/Ross Billabong, and opportunistically on the Western Floodplain in association with other Category III indicators (Figure B-9).

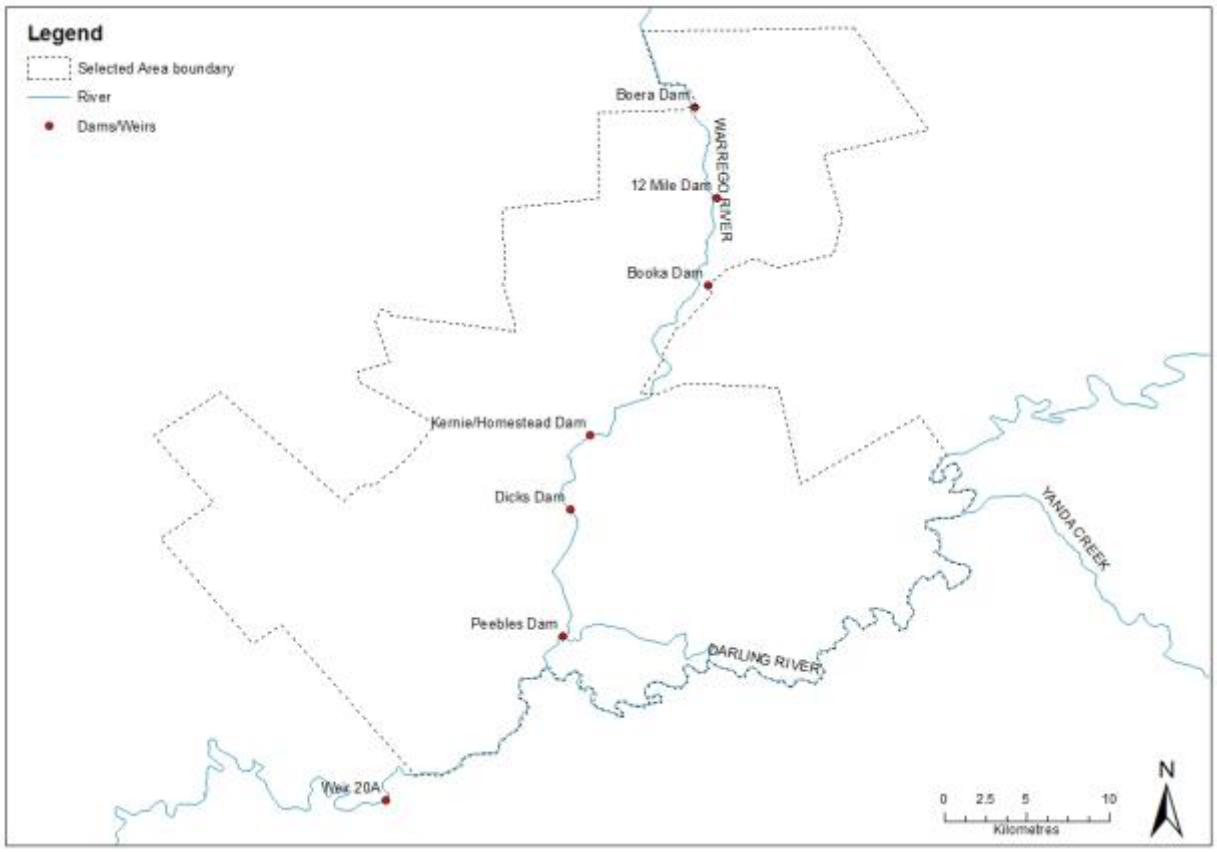

Figure B-9 Location of Dams within the Warrego River. Frogs will be monitored in Boera Dam, Booka Dam and Peebles Dam/Ross Billabong.

B.10.4 Timing and frequency

Surveys will typically occur in February and May but will be responsive to wetland conditions. Sampling will occur three times per event (before, during and after) for two events within the MER Project and opportunistically on the Western Floodplain during inundation events (Contingency Monitoring).

B.10.5 Responsibilities

The Project Manager is responsible for overseeing this procedure. The field surveys will be led by experienced ecologists.

B.10.6 Detailed methods

Event based surveys will be undertaken, as per the LTIM Standard Methods reported in the Murrumbidgee LTIM document (Wassen et al. 2014). Here, adult frogs and metamorphs will be surveyed at each site after dark using a 2x20 minute visual encounter (person minutes) and a 6 x 1 minute audio survey. Start and finish times will be recorded to allow for frog abundance to be standardised as frogs/minute. All individuals observed will be identified to species and the number recorded.

A 15-30 watt spotlight or torch will be used to search for frogs along the wetland edge and into the surrounding terrestrial habitats. All individuals observed will be identified to species and the number recorded (it is possible to identify individuals without capture).

Audio surveys involve listening for the distinct calls of resident frog species. General estimates of the number of calling individuals will be determined using the methodology described in (Wassens et al. 2011).

B.10.7 Data analysis and reporting

Selected Area scale hypotheses

Short-term (Annual) responses:

1. The delivery of Commonwealth water for the environment will lead to increased frog species diversity.
2. The delivery of Commonwealth water for the environment will stimulate frog breeding.

Long-term (5 year) responses:

3. The delivery of Commonwealth water for the environment will lead to larger frog populations.
4. The delivery of Commonwealth water for the environment will lead to increased frog diversity.

Selected Area scale analyses

Analyses based on aggregation will be applied at the Selected Area scale for abundance, richness and diversity of frogs. Quantitative analyses will be applied at the Selected Area scale to document increased abundance, richness and diversity of frogs at sites receiving Commonwealth water for the environment. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models.

Short-term (annual) responses:

- Hypotheses 1 and 2 - univariate analysis (main effect – site, time) abundance, richness, diversity.

Long-term responses:

- Hypotheses 3 and 4 - univariate analysis (main effects – target site, year, time).
- Hypotheses 4 - (diversity-abundance) multivariate analysis (factors – target site, year, time).

All data provided for this indicator must conform to the data structure defined in the LTIM Data Standard (Brooks & Wealands 2014).

B.10.8 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014).

QA/QC requirements specific to this protocol include:

- All frog surveys will be undertaken by the same experienced observers, where possible, over time to maintain consistency
- Observers will undergo training prior to undertaking monitoring surveys, including calibration against experienced observers to ensure standardisation of measurements. Training and calibration procedures will be documented in the MEP and relevant records maintained.

B.10.9 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Junction of the Warrego and Darling rivers Selected Area*. Commonwealth of Australia.

Gawne B., Hale J., Butcher R. Roots J., Brooks S., Cottingham P., Stewardson M. & Everingham P. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Evaluation Plan*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29/2014.

Wassen S., Jenkins K., Spencer, J., Theim, J., Bino, G., Lennon, E., Thomas, R., Kabyashi, T., Baumgartner, L., Brndis, K., Wolfenden, B, Hall, A., Watson, M. & Scott, N. 2014. *Murrumbidgee Selected Area: Monitoring and Evaluation Plan.* Commonwealth of Australia.

Wassens, S., Watts, R., Howitt, J., Spencer, J., Zander, A. and Hall, A. 2011. Monitoring of ecosystem responses to the delivery of environmental water in the Murrumbidgee system. Report to DSEWPaC. Albury, Institute of land, Water and Society. Report 1.

Field Data sheets

Warrego-Darling Frog Data sheet		
Site:		**Date:**
Observer:	**Time start:**	**Time end:**

Visual Encounter

Species	Count	Count/minute

Calling

Species	Count

B.11 SOP – Food Webs (Water Quality)

B.11.1 Objectives

The Food webs (Water Quality) monitoring protocol seeks to assess the contribution of Commonwealth water for the environment to improved water quality.

B.11.2 Indicators

Dependant variables:

- Temperature
- pH
- Turbidity
- Salinity
- Dissolved oxygen.

B.11.3 Location for monitoring

Monitoring sites for Food webs (Water Quality) will be located in three target areas in the Selected Area, the Warrego channel, Western Floodplain, Darling channel. *In situ* logging and spot sampling of DO (metabolism), temperature, EC, pH, turbidity and chlorophyll *a* will be undertaken at multiple sites throughout the Selected Area aligned to Food web and Fish (Channel) sites. Two sites at Akuna and Yanda (upstream and downstream of the Warrego confluence) will be maintained for *in situ* monitoring of long term DO and temperature. Collection and analysis of water quality samples for laboratory analysis (chlorophyll *a*, dissolved organic carbon, inorganic and organic nutrients) will be collected from all Food web sample locations.

B.11.4 Timing and frequency

Monitoring of dependant variables and covariates will align with the commencement, delivery and cessation of Commonwealth water for the environment delivery.

B.11.5 Specific Equipment

- D-Opto dissolved oxygen loggers; HOBO Tidbit temperature loggers; YSI multi-probe

B.11.6 Responsibilities

The Project Manager is responsible for overseeing this procedure. A field scientist/technician will be responsible for the monitoring and maintenance of loggers and collation of data under the direction of Project Director (Ryder), who will conduct the analyses and reporting.

B.11.7 Complementary monitoring and data

Hydrological measures of stream discharge are used to inform the interpretation of stream water quality. The existing stream gauges at Bourke and Louth in the Darling River will be used to quantify discharge (ML/day).

B.11.8 Detailed methods

Measurement of the Water Quality indicator will follow the field and laboratory procedures outlined in the LTIM Standard Methods (Hale et al. 2014).

B.11.9 Data analysis and reporting

Selected Area scale hypotheses

At the Selected Area scale a number of hypotheses that relate to the outcomes of delivery of Commonwealth water for the environment are possible. Selected Area scale hypotheses include:

1. Mean daily water temperature, and daily range in water temperature will decrease during the delivery of Commonwealth water for the environment.
2. Mean daily pH, and daily range in decrease during the delivery of Commonwealth water for the environment.
3. Mean daily turbidity will increase during the delivery of Commonwealth water for the environment.
4. Mean daily EC will decrease during the delivery of Commonwealth water for the environment.
5. Mean daily DO concentrations will decrease during the delivery of Commonwealth water for the environment.

Selected Area scale analyses

Quantitative analyses will be applied at the Selected Area scale to document temporal shifts in water quality in periods that Commonwealth water for the environment is delivered each year. Long-term year on trends can be analysed based on periods with and without the delivery of Commonwealth water for the environment.

Short-term and long term responses:

- Hypotheses 1 to 5 – Replication derived from randomised daily means of data periods within/outside delivery of Commonwealth water for the environment. One-way ANOVA (WQ variables as dependant variable) comparing among flow periods, and two-way ANOVA (flow period, years) for long term dataset.

Data for the Basin-scale will be reported following the requirements outlined in the LTIM Data Standard (Hale et al. 2014) and conform to the LTIM Data Standard (Brooks & Wealands 2014).

B.11.10 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed for the M&E Plan (CEWO 2014). In addition, this method requires a number of QA/QC procedures:

- Calibration and maintenance of sensors and loggers is required at a maximum 6 week interval
- Data correction procedures will be used to account for sensor drift or fouling following periodic calibration.

B.11.11 References

Brooks S. & Wealands S.R. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard*. Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre. MDFRC Publication 29.3/2013 Revised Jan 2014.

Commonwealth Environmental Water Office (CEWO). 2014. *Long Term Intervention Monitoring Project Gwydir River System Selected Area*. Commonwealth of Australia.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2014. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

B.12 SOP – Food Webs (Microinvertebrates and Macroinvertebrates)

B.12.1 Objectives

The Food webs (Microinvertebrates and Macroinvertebrates) monitoring protocol seeks to assess the contribution of Commonwealth water for the environment to improved invertebrate diversity and resources to food webs.

B.12.2 Indicators

- Microinvertebrate relative abundance (density/L)
- Microinvertebrate community assemblage
- Macroinvertebrate relative abundance (density/m^2)
- Macroinvertebrate community assemblage

B.12.3 Locations for monitoring

Monitoring sites for Food Webs (Microinvertebrates and Macroinvertebrates) will be located in the Warrego Channel, Darling River and Western Floodplain zones.

Sampling locations for the Warrego Channel and Darling River zones will be undertaken at locations aligned with Category 3 Fish (Channel) sampling in the Warrego and Darling River channels to provide explicit links among these indicators and provide an assessment of a functional ecosystem response.

Sampling on the Western Floodplain will sample within representative sites in each of the dominant wetland vegetation communities inundated by Commonwealth water for the environment. The Hydrology (Floodplain) indicator will facilitate the scaling-up of site based invertebrates data (density/L/vegetation type) to the entire inundated area of the Western Floodplain. The focus is on the invertebrate response to the inundation of the Western Floodplain.

This design will allow Basin-scale reporting for river channel and floodplain habitats and alignment with Fish (Channel) and Vegetation Diversity where relevant.

B.12.4 Timing and Frequency

Sampling in channel locations will occur pre- (where possible), during and post-connection events for a minimum of 2 events. At each floodplain site, three sample events are planned to track the inundation and contraction cycle, sampling as soon as possible after inundation, at peak area inundation, and during the drying cycle. The current inundation of the Western Floodplain and connection of the Warrego channel will mean this indicator will be sampled as soon as possible in Stage 2 (July 2019) to capture the current conditions.

The rationale underlying this approach is to seek as much synergy as possible between the components monitoring other vertebrates and wetland fish that also prey on Microinvertebrates and Macroinvertebrates. For Microinvertebrates, a single composite sample (comprised or either 5 benthic cores or 5 pelagic buckets) is taken from each site or flow-habitat within a site. This will reduce the overall number of samples for laboratory processing. Similarly, for Macroinvertebrates, three replicate 10 linear metre kicknet samples will be collected at each site.

B.12.5 Specific Equipment

- Benthic corer (50 mm diameter x 120 mm long, 250 mL volume) and rubber backed spatula;
- 63µm plankton net
- 250µm kicknet
- Small (4L) bucket with lid for settling benthic cores;
- 63µm and 250µm mesh sieve;

B.12.6 Responsibilities

The Project Manager is responsible for overseeing this procedure under the direction of Project Director (Ryder), who will conduct the analyses and reporting.

B.12.7 Detailed Methods

Monitoring Design

This design will allow Basin-scale reporting for river channel and floodplain habitats and alignment with Fish (River) and Vegetation Diversity where relevant.

Microinvertebrates

Two different microinvertebrate sampling gear will be used within the Selected Area: benthic corer and a pelagic bucket. Five benthic cores will be randomly allocated within the slackwater habitats along a 150m section of river and placed in a single bucket to yield a single 'benthic' composite sample from the site. Five pelagic buckets should be randomly allocated within flowing edge habitats along a 150m section of river and then poured through a net to yield a single 'flowing pelagic' composite sample from the site.

The sampling procedure is the same for floodplain and river channels. Benthic corers should be modified slightly from King (2004), the details of which can be found in (Morris 2008). The benthic cores within each site should be collected either in the afternoon or the morning to tie in with other sampling. Collection times should be recorded on the data sheet.

Composite samples (each pelagic and benthic) will be collected at each site. Benthic samples will be collected with a corer (50 mm diameter x 120 mm long, 250 mL volume). At each site, five cores will be collected from random locations within each site with replicates spaced along a 150 m transect. The corer is placed onto the sediment surface, the top is then sealed with a plastic cap and the sediment and overlaying water extracted with the aid of a hardened rubber trowel. The contents of the corer are be emptied into a 4 litre bucket and allowed to settle for at least one hour. Once settled, the supernatant will be poured through a 63 µm sieve to retain microinvertebrates. The retained sample will be washed into a sample jar and stored in ethanol (70% w/v) with Rose Bengal. To assess the pelagic microinvertebrate community, a composite sample consisting of 10 x 10 litre buckets will be collected at each site. Each bucket should be poured through a plankton sampler (63 µm mesh). Retained samples are stored in ethanol (70 % w/v) with Rose Bengal until time of enumeration.

Macroinvertebrates

Macroinvertebrate samples from each site will be collected with a 250µm mesh kicknet as a 10 metre linear sweep sample. River channel habitats will integrate each 10 metre sweep sample across major habitat features (bare ground, vegetated, logs etc). In floodplain habitats, each 10 metre sweep sample

will integrate dominant inundated vegetation communities. Samples will be immediately placed in jars or ziplock bag with 70 % ethanol preservative.

Laboratory sample processing – microinvertebrates and macroinvertebrates

Entire samples should be preserved individually in 70 % ethanol and returned to the laboratory for microinvertebrate and macroinvertebrate identification and enumeration. Whole samples should be examined in trays and the contents identified to Class, Order and family level.

B.12.8 Data analysis and reporting

Short-term (one-year) and long-term questions:

1. What did Commonwealth water for the environment contribute to microinvertebrate and macroinvertebrate productivity?
2. What did Commonwealth water for the environment contribute to microinvertebrate and macroinvertebrate community composition?
3. What did Commonwealth water for the environment contribute to resilience of microinvertebrate and macroinvertebrate egg banks (comparing multiple years)?
4. What did Commonwealth water for the environment contribute to the timing of microinvertebrate and macroinvertebrate productivity, composition and presence of key species in relation to numbers of fish in river channels?
5. What did Commonwealth water for the environment contribute to the timing of microinvertebrate and macroinvertebrate productivity, composition and presence of key species in relation to diversity of fish communities in river channels?
6. What did Commonwealth water for the environment contribute to the timing of microinvertebrate and macroinvertebrate productivity, composition and presence of key species in relation to watercourse hydrology metabolism and water chemistry?
7. What did Commonwealth water for the environment contribute to connectivity of microinvertebrate and macroinvertebrate and vegetation communities in floodplain watercourses?

Quantitative analyses will be possible for microinvertebrate and macroinvertebrate density and community composition for time since watering, with multivariate analyses such as nMDS (and modules including Simper, BioEnv, DISP, PCA) will be used to explore patterns among dependant and covariate variables such as Food Webs (Water Quality) and Fish (Channel).

Basin and Selected Area scale reporting will conform to the LTIM Data Standard (Brooks and Wealands 2014) to facilitate data management within the LTIM Monitoring Data Management System (MDMS).

B.12.9 Quality assurance/quality control

Quality control and quality assurance protocols are documented in the Quality Plan developed as part of the MEP for all Selected Areas. This method requires a number of QA/QC procedures outlined below:

- All staff will follow the Safe Work Method Statement for field and laboratory work
- Standardisation of microinvertebrate and macroinvertebrate sampling equipment
- Sample exchange between Murrumbidgee and Warrego-Darling teams
- Water chemistry samples will have a QA/QC check via 10 % sample exchange with NATA laboratory at the NSW OEH Lidcombe laboratories
- Field duplicate and blank samples will be collected following the Standard Method
- Holding times for water quality samples will follow the procedures provided by the processing laboratory
- Preservation and transport of water quality samples will follow the procedures provided by the processing laboratory.
- Data management will follow the Warrego-Darling QA/QC protocols.

B.12.10 References

Brooks S and Wealands S (2014) *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Data Standard.* Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.3/2013 Revised Jan 2014, 29pp.

Hale J., Stoffels R., Butcher R., Shackleton M., Brooks S. & Gawne B. 2013. *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project – Standard Methods*. Final Report prepared for the Commonwealth Environmental Water Office by The Murray-Darling Freshwater Research Centre, MDFRC Publication 29.2/2014, January, 182 pp.

B.13 SOP – Food Webs (Stream Metabolism)

B.13.1 Monitoring

Stream Metabolism will be conducted in the Darling River zone at two locations - near the 'Yanda' homestead (-30.34906, 145.57685) and near the 'Akuna' homestead (-30.40978, 145.33438; Figure B-10). These are sites representative of the zone and were selected due to their proximity to NPWS residences to allow for ease of access and sample collection. The Akuna site is located downstream of the Warrego confluence and can be used to assess the influence of Warrego River flow to the water chemistry of the Darling River. Their location will also allow frequent and/or event based monitoring of the stations by NPWS staff. Category III Water quality will also be undertaken at all these sites.

Category III Stream Metabolism will be carried out at three locations in the Warrego River. D-Opto loggers will be placed in Boera Dam, Booka Dam, and Peebles Dam/Ross Billabong. A weather station measuring light (PAR) will be established at the Toorale Homestead within the Selected Area. Category III Metabolism will follow the standard methods outlined in Hale et al. (2013) through periodic deployment of D-Opto DO loggers. Water chemistry will be collected at least every 6 weeks for Category I, or at the commencement and completion of each incubation period for Category 3. Water samples will be processed in accredited laboratories.

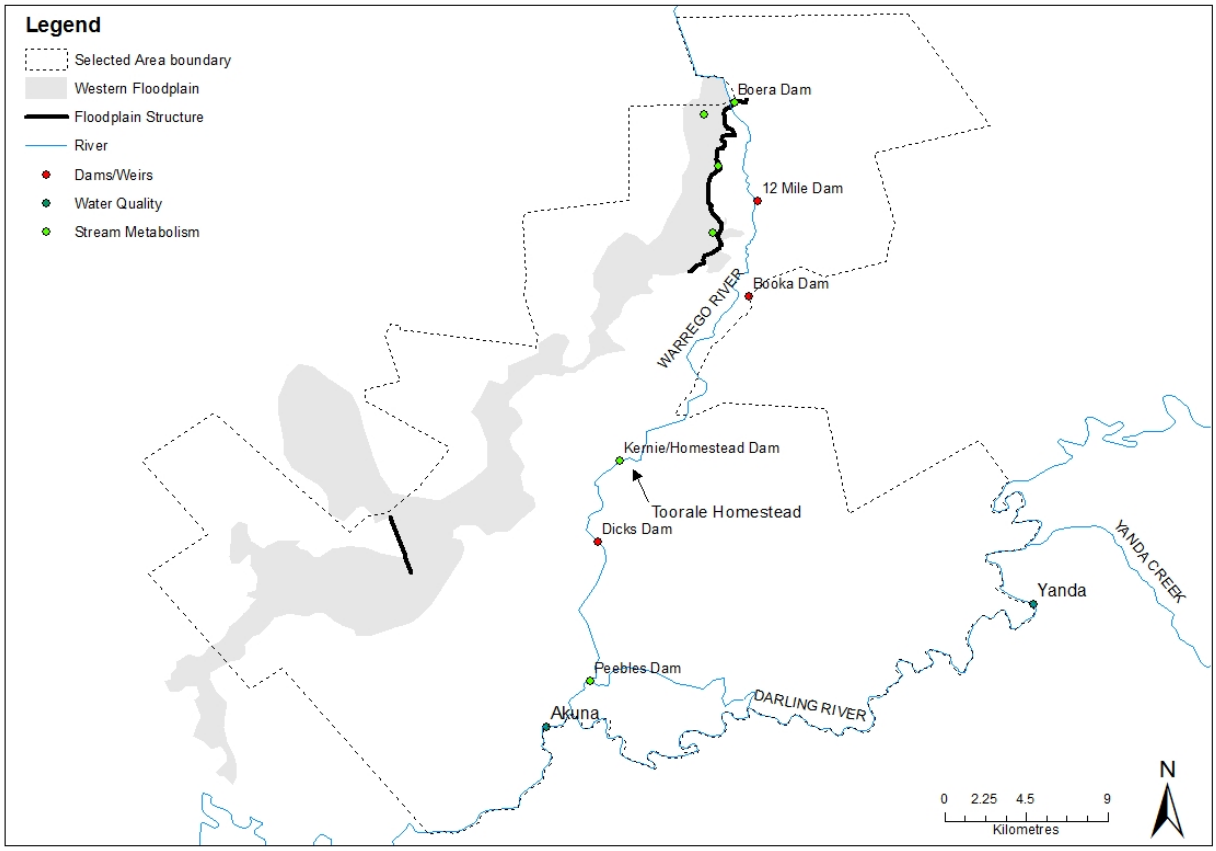

Figure B-10 Location of Water Quality sensors and sampling sites for the Metabolism indicator.

B.13.2 Evaluation

Selected Area evaluation questions

Short-term (annual) and long-term questions:

1. What did Commonwealth water for the environment contribute to patterns and rates of decomposition?
2. What did Commonwealth water for the environment contribute to patterns and rates of primary productivity?

Approach to evaluation

This indicator links to Fish (Channel), Food Webs (Water Quality, Microinvertebrates and Macroinvertebrates) and Hydrology (River) indicators. There are two Selected Area hypotheses that relate to the outcomes of delivery of Commonwealth water for the environment:

- The delivery of Commonwealth water for the environment will influence the rates of primary production and decomposition.
- The delivery of Commonwealth water for the environment will increase whole-of-system trophic dynamics (biological productivity, interaction among species, interaction between the system and its biotic and abiotic surroundings).

Statistical analyses

Quantitative analyses will be applied at the Selected Area scale to test predicted changes in dissolved oxygen, nutrients, decomposition and primary productivity. Data will be reported as mgDO/L/day and gC/L/day. Multi-year analyses will be quantitatively assessed based on year-on-year repeat application of annual models outlined in the Selected Area conceptual model.

Replication derived from randomised daily means of data periods within/outside delivery of Commonwealth water for the environment (Basin scale) and pre-, during- and post-delivery for event-based sampling (Selected Area scale). One-way ANOVA (GPP, ER, NPP, water chemistry as dependant variables) comparing among flow periods, and two-way ANOVA (flow period, years) for long term dataset for Basin scale assessment. Selected Area scale assessment will be determined by one-way ANOVA comparing among flow periods (pre-, during- and post-flow delivery), and two-way ANOVA (flow period, years) for long term dataset.

Appendix C. Progress Report Template

Quarterly Project Progress Report

Warrego-Darling MER Project

Project Manager:

Report period:

Decisions from Selected Area Working Group meeting (date)

Attended by:

-
-
-

Key achievements

-
-
-

Significant problems encountered

Risk / issue	Action

Summary of project progression

Activities completed in the previous period
Please include a summary of activities completed in the previous period in relation to the activities outlined in the MER plan. This may include but not be limited to, an update on sampling, analysis, early findings, stakeholder engagement and reporting.

Monitoring activities

Waterbird diversity surveys

Vegetation diversity

Water quality and invertebrate sampling

Fish diversity sampling

MDMS data upload

Research activities

Additional Collaboration activities

-

Stakeholder Engagement
SAWG meeting

Reporting
Quarterly progress reports

Activities to be undertaken in the upcoming period

Please include a summary of planned activities for the upcoming period, including an estimate of effort and time required to complete the activities.

Monitoring activities
Waterbird Diversity surveys
Vegetation Monitoring
Water quality/invertebrate sampling
Fish diversity sampling
Frog sampling
MDMS

Research activities

Additional collaboration activities

Stakeholder Engagement
Warrego-Darling MER SAWG

Reporting
Quarterly progress report

Summary of progress of each project element

Project Element	Due Date	% Complete	Comment
Completion of scheduled core monitoring and evaluation activities			
Completion of approved contingency monitoring activities			
Completion of approved research activities			
Communications and Meetings			
Reporting			

Critical risks and issues

Risk / issue	Action

External communications for the services

In kind contributions

Additions to digital media database

Appendix D. Warrego-Darling Selected Area Working Group

Terms of Reference

UNE (led by Professor Darren Ryder) and 2rog Consulting (led by Dr Paul Frazier) have been engaged to prepare and implement the Monitoring, Evaluation and Research Plan for the Junction of the Warrego and Darling Rivers Selected Area. This document provides the Terms of Reference for the MER Project.

D.1 Purpose

The Warrego-Darling Selected Area Working Group will provide a forum for the exchange of information and knowledge that supports the implementation of the MER Project, through effective coordination of environmental watering and monitoring and evaluation.

D.2 Objectives

The Warrego-Darling Selected Area Working Group will facilitate:

- Effective coordination between water for the environment delivery partners and other relevant monitoring and evaluation projects
- Communication to water for the environment managers of any information that would improve water for the environment management
- Exchange of information and knowledge relevant to improving the implementation of the MER Project, as well as improve the efficacy of environmental watering activities to support adaptive management on both a short-term (preliminary observations during watering events) and longer-term (evaluation outcomes)
- The identification, communication and management of any issues, risks or opportunities relevant to the MER Project.

D.3 Membership

The Warrego-Darling Selected Area Working Group includes agencies involved in the delivery of the Warrego-Darling MER Project. It includes organisations directly and indirectly responsible for delivering MER Project deliverables and representatives from organisations involved in water for the environment planning and delivery.

The Warrego-Darling Selected Area Working Group comprises the following members who have been nominated in the LTIM project or who are replacing nominated members (Table D-1). Basin-scale Team members as well as relevant people from the CEWO Water Use Section may be invited by the CEWO to attend meetings.

The MER Project team will seek advice from Jason Wilson, Brad Moggridge and the JMAC regarding JMAC and NBAN representation in the SAWG membership.

Table D-1 Membership of the Warrego-Darling SAWG.

Name	Agency/position/role
Paul Frazier	Warrego-Darling MER Project Director (2rog Consulting) Chair
Darren Ryder	Warrego-Darling MER Project Director (UNE)
Sarah Mika	Warrego-Darling MER Project Manager (UNE)
Michael Peat	CEWO (Northern Basin Section) MER Project Area lead for the Warrego-Darling
Elizabeth Webb	CEWO
Hilary Rossow	CEWO
Jason Wilson	CEWO
Bernard Davis	NPWS
Christopher Ghirardello	NPWS
Sonya Ardill	OEH
Carmen Amos	OEH
Gavin Butler	DPI Fisheries (Scientific Officer, Aquatic Ecosystems Research)
Anthony Townsend	DPI Fisheries (Senior Fisheries Manager, Murray-Darling)
Andrea Prior	DNRME, Qld
Jonathan Marshall	DES, Qld
Ryan Woods	DES, Qld
Justin McClure	Floodplains Assoc.
Jennifer Azevedo	Western LLS

D.4 Terms of Reference

The Warrego-Darling Selected Area Working Group is responsible for supporting strategic direction of the MER Project and exchanging information and intelligence to support the MER Project and adaptive management. It will:

- Actively support and promote the MER Project within partner organisations
- Review (where appropriate) key project documentation, including evaluation reports
- Exchange operational intelligence relevant to the MER Project, including intelligence on upcoming watering or monitoring activities
- Exchange intelligence relevant to adaptive management of environmental water, including operational observations, monitoring outcomes and evaluation outcomes
- Consider stakeholder expectations (where appropriate) of the MER Project
- Exchange intelligence on any risks, actual or perceived, to the MER Project

- Communicate key messages of the MER Project to organisations involved in water for the environment planning and delivery
- Document key discussion points and outcomes of Warrego-Darling Selected Area Working Group meetings and distribute these to members (including the CEWO) in the form of minutes.

D.5 Authority

The Warrego-Darling Selected Area Working Group will be organised, operated and Chaired by UNE from July 2019.

The Warrego-Darling Selected Area Working Group has no executive powers, supervisory functions or decision-making authority in relation to the MER Project. It is an operational group tasked with a general support and advisory role.

D.6 Operations

The Warrego-Darling Selected Area Working Group will operate in alignment with the following requirements:

D.6.1 Meetings

Selected Area Working Group meetings were held twice during Stage 1 (2019) and can be attended either via phone or in person, or via earlier comment in both Stage 1 and Stage 2 of the MER project.

Meeting schedule	Date	Location
Meeting 1	27 March 2019	Armidale / phone
Meeting 2	15 May 2019	Armidale / phone

D.6.2 Agendas and minutes

UNE will prepare and distribute meeting agendas and minutes. Agendas and minutes from the previous meeting will be distributed no later than five days prior to the meeting.

Where practical, meeting papers will be distributed no later than five days prior to the meeting, and will include:

- Agenda
- Previous meeting minutes
- Any papers for consideration.

Meeting minutes and action items will be distributed within two weeks of the meeting. Immediate actions may be circulated earlier.

D.6.3 Agenda items

The following table lists the standard agenda items for the Selected Area Working Group. Members can submit additional items to be included on the agenda at the discretion of the Chair.

Item	Responsibility
Review and accept minutes from last meeting	2rog (Chair)
Update on action items from last meeting	Chair and members
Update on planned watering activities	Delivery partners, water for the environment planning organisations
Update on planned monitoring activities	UNE
Update on monitoring observations and evaluation outcomes to support adaptive management	UNE
Update on community engagement	2rog
Other business	All
Confirmation of next meeting	2rog (Chair)

D.7 Grievances

Grievances identified within the Selected Area Working Group will be mediated by the Chair. Where a grievance is deemed significant, a member or members of the Selected Area Working Group may be removed from the Selected Area Working Group, at the discretion of the CEWO.

Appendix E. Proformas

E.1 Meter maintenance log sheet

This Log Sheet to be kept with Meter at all times.

Meter Maintenance Log Sheet

Owner of Meter:	Serial number:
Make and model:	Date of Last Service:
Date of purchase (if known):	Meter Number:

Date	Time	Field Officer	Standard/Reagent Expiry date or lot number	Calibration 1 (auto or manual; one or multi-point)	Parameters calibrated	Comments (variation in values/drift)

E.2 Chain-of-Custody Form

Chain-of-Custody Form

Field sampling staff:		
Project name/ID and location:		
Sample dates included:		
Sample sites included:		
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
SAMPLES SENT BY:		
Date:	**Time:**	**am/pm**
Location:		
Sample quantity:	**Samples unaltered: yes/no**	
Fixative/Preservative used:		
Signed:		
Courier company:		
RECEIVING LABORATORY		
Receipt of sample by laboratory from sampling officer or courier:		
Date:	**Time:**	**am/pm**
Location:		
Sample quantity:	**Samples unaltered: yes/no**	

E.3 Training Log

Training Log

Monitoring indicator	Location Training undertaken	Date	Trainer		Trainee		Comments
			Name	Signature	Name	Signature	

Appendix F - Schedule 6 –Work Order

Order

The parties have agreed in accordance with clause 7 the Agreement that the Provider will provide the Additional Project Services specified in this Work Order.

Item	Description	Clause	Details
1.	**Agreement description**	**N/A**	Agreement for Additional Project Services in respect of ***Junction* of *the Warrego and Darling Rivers Selected Area: additional communication and engagement projects* (Work Order number 1)** dated November 2019
2.	**Names of Parties to the Agreement**	**N/A**	The Commonwealth of Australia as represented by the Department of the Environment and Energy ABN 34 190 894 983 University of New England ABN: 75 792 454 315
3.	**Additional Project Start Date**	**1.1**	The date this agreement is signed by the last party.
4.	**Additional Project Timeframe**	**1.1**	From the Additional Project Services Start Date until 31 December 2020
5.	**Category of Services**	**7**	Engagement
6.	**Additional Project Services**	**7**	See Attachment A that includes details of services, deliverables and milestones. Service levels are as per the signed agreement and/or as outlined in the 'Communication and Engagement Plan' and 'Quality Assurance' sections of the Monitoring, Evaluation and Research Plan (2019-2022).
7.	**Subcontractors**	**6.5**	2rog consulting Pty Limited ABN 91 619 296 221 NSW Department of Primary Industries - Fisheries (DPI Fisheries) ABN 72 189 919 072 NSW Department of Planning, Industry and Environment (DPIE) ABN 20 770 707 468

			Debus, Stephen John Stewart ABN 36 753 055 798
8.	**Progress meetings and reports**	**11**	Details of reporting requirements, progress meetings and reports are outlined in Attachment A.
9.	**Performance Criteria**	**12**	Must be in accordance with the Work Order and/or the Monitoring, Evaluation and Research Plan (2019-2022). Must be completed to a professional standard. Must be undertaken in accordance with the dates and timeframes specified in the Work Order (or where agreed in writing ahead of time with the Project Manager) Must demonstrate how the activities undertaken have increased opportunities for understanding and engagement by key stakeholders (including Aboriginal people, organisations and communities) and the community around water for the environment and ecological responses to flow and/or other drivers in the Warrego-Darling Selected Area Must include recommendations for how communication and engagement around Commonwealth water for the environment in the Warrego-Darling Selected Area can be improved, and examples of best practice and other learnings to directly inform adaptive management. Must address relevant feedback previously provided by the Department.
10.	**Project Officers**	**1.1**	**Department** Name: Michael Peat Position: Assistant Director for Warrego-Darling Water Delivery, Northern Basin Section Fax: 02 274 2524 Email: Michael.Peat@environment.gov.au **Provider** Name: Sarah Mika and Mark Southwell Position: Senior Research Fellows in Aquatic Ecology, School of Environmental and Rural Science Fax: 02 6773 2769 Email: sarah.mika@une.edu.au, msouthw2@une.edu.au
11.	**Specified Personnel**	**1.1 and 13**	Dr Paul Frazier and Dr Darren Ryder (University of New England) (Project Directors)

			Dr Sarah Mika and Dr Mark Southwell (University of New England) (Project Managers) Dr Gavin Butler (NSW DPI - Fisheries) Dr Yoshi Kobayashi (NSW DPIE) Dr Jennifer Spencer (NSW DPIE)
12.	**Department Material**	**1.1**	**Not applicable**
13.	**Pre-existing Material of the Provider**	**1.1**	**Not applicable**
14.	**Payment Schedule**	**7 and 16**	Payment Schedule for payment of the Additional Project Service (Year 1) is in Attachment A. The Payment Schedule specifies the payment dates and amounts.
15.	**Expenses**	**16**	**No change**
16.	**Other**	**N/A**	**No change**

ATTACHMENT A

REVISED Work Order #01 (Communications & Engagement July 2020 to december 2020)

This communication and engagement strategy will guide the Warrego-Darling MER team to communicate the purpose of, and outcomes from, management of Commonwealth water for the environment.

This work order is prepared for the approval by our client, the CEWO.

The objectives of the strategy are to:

- support the CEWO to develop and maintain trusting relationships, including by supporting the CEWO's northern Local Engagement Officers to provide interesting, accurate and timely information to the community;
- help to explain the role of water for the environment to key stakeholders:
    - Warrego-Darling community, including Aboriginal people, schools, fisher groups, the irrigation industry and local/regional broader community;
    - the broader Australian community, including those who may never visit Toorale;
    - Government agencies; and
    - the science community, particularly those with an interest in the northern Murray-Darling Basin;
- Develop an Aboriginal wetland resources table or document which can later be tested with the Aboriginal community within the Warrego-Darling Selected Area.
- work effectively with partners to include outputs and outcomes in the Warrego-Darling into integrated communication products across the MER program; and
- engage professionally, thoughtfully, respectfully, and early by providing timely, relevant and interesting information in an authentic way; engage in a way that demonstrates that the MER team and the CEWO value knowledge and desire to share it; and respect cultural and local knowledge and contexts.

Engagement approaches have been defined for key audiences in the table on the following page. There is an emphasis on face-to-face activities, as these work best in the northern Basin.

The COVID-19 pandemic has affected travel and face to face meetings. These restrictions have particular relevance for at risk communities such as elderly groups and Aboriginal communities. The Warrego-Darling Selected Area Communication and Engagement Strategy for 2020 had a considerable focus on face to face, on country engagement activities. Until the pandemic is better controlled, the approach to communication and engagement for this project has been altered for the final 6 months of the program. The original work order (which was for the period December 2019 – December 2020) has been amended to reflect changes to deliverables as a result of COVID-19. This revised work order is for the period July 2020 - December 2020.

Audience	Comment	Stakeholder(s)	Knowledge-base	Engagement approach
Local and regional community	Place-based activities from conversations to field days and local media Content for written communication products	LLS; Aboriginal groups; Australian Floodplain Association; Barwon-Darling Water; Bourke Shire Council; fishing club at Bourke; local landholders around Toorale; communities generally; bird watching group	• **no** assumed knowledge of water • **no** assumed knowledge of riverine ecology	• Provide clear and audience specific presentations to key groups • Local media, field days, in the relevant local/regional area. • Presentations at relevant meetings. • Communicate new discoveries
Other government agencies	An audience group that provides considerable extension of the LTIM/MER network to other stakeholders. Often activities can be shared and/or co-planned.	Cth Department of Agriculture	• **sophisticated** knowledge of water • **sophisticated** knowledge of riverine ecology	• Targeted presentations, research forum. • Respond to questions as appropriate
		NPWS		• Targeted presentations, research forum. • Include events with the ECA OAC.
		DPIE Water, EES, and Fisheries; WaterNSW; MDBA		• Targeted presentations, research forum. • Products may be picked up and shared through these agencies (e.g. MDBA Regional Engagement Officers)
		Industry – including irrigation, dryland farmers and graziers (i.e. riparian and floodplain landholders)	• **sophisticated** knowledge of water • **no** assumed knowledge of riverine ecology	Local media, field days where appropriate, conversations
Aboriginal people, organisations and communities	(In addition to the engagement with the Aboriginal community as part of the local and regional community) JMAC and other groups. Critical link with Jane Humphries, Jason Wilson and Brad Moggridge	Aboriginal community including Toorale JMAC; Aboriginal Land Councils at Bourke and Louth	• **no** assumed knowledge of water • **no** assumed knowledge of riverine ecology • **knowledge** of cultural significance of rivers, wetlands and country	Work with the Aboriginal communities to build and share knowledge.
All community	Those reached by social media, many who value the existence of Toorale but may not visit	All community – including individuals and groups located far away	• **no** assumed knowledge of water • **no** assumed knowledge of riverine ecology	• Twitter and other platforms for regular presence

Academia	Adds and tests program scientific validity	Academics	• **no** assumed knowledge of water management arrangements • **sophisticated** scientific knowledge and experience	• Northern Basin Research Forum • Some effort for publications and conference presentations (although the majority of the effort would be under the broader MER contract).
MER teams	Linked to academia item above	Selected area and basin scale	• **reasonable** understanding of water management arrangements • **sophisticated** scientific knowledge and experience	• Sharing of approaches, issues and solutions including for communications.

Deliverables and milestones for December 2019 - December 2020

Period	Original Deliverables	COVID 19 Amended Deliverables (July 2020 – Dec. 2020)
Every three months (starting December 2019)	Teleconference (or face to face meeting if possible) with CEWO team including the northern LEOs, and any other representatives of government agencies or the community nominated by the CEWO (e.g. possibly DPIE EES and MDBA Regional Engagement Officers)	Frequency increased to monthly for the broader team. Increased to fortnightly with LEOs and monthly including MDBA REOs.
	Regular flow of photographs that can be used in CEWO products (such as 'updates') and which include people and researchers in some photographs. This would include unusual species – possibly Hyrtl's tandan - or charismatic species such as brolgas and magpie geese.	Unchanged
Every three months (starting March 2020)	Selected Area newsletter (as per the Basin-scale contract)	Unchanged
Jan-Dec 2020	Northern Basin Research workshop	Delivered for 2020
	Participate in a community event / knowledge sharing / field day (or events) led by the CEWO or other agencies	Partly undertaken – alternative activities focused on engagement through development and distribution of web-based stories (4 per month).
December 2020	Annual communications and engagement report	Unchanged
March/April 2020 and September/ October 2020	Planning meeting with northern Local Engagement Officers, probably face to face in Armidale (or elsewhere if mutually convenient), to share progress, receive feedback	Increased to fortnightly meetings – video conferencing (measure – meetings undertaken)
On going	Contribute to the Basin scale web site	Unchanged
	Curriculum development (in conjunction with the northern LEOs)	Unchanged
	Aboriginal engagement planning and delivery – including through listening with Jason Wilson and others. Draft plan that has ownership by Aboriginal groups by 30 March 2020.	Partly undertaken – alternative activities focused on development of Aboriginal wetland resources document which can later be tested with the Aboriginal community within the Warrego-Darling Selected Area
	Regular press releases linked to key events or outcomes	Unchanged
	Regular conversations with the northern LEO's to discuss opportunities	Unchanged

As requested / arranged	Meetings and field events (at least 6)	Partly undertaken – alternative activities focused on engagement through development and distribution of web-based stories and radio interviews.
	Academic events (conference presentations and papers)	Conferences postponed in 2020, papers ongoing.

Budget for year 1 (December 2019-31 December 2020)

Note this work order #01 for the communication and engagement component is for the December 2019 to end of December 2020 calendar year to allow for full implementation of a twelve month work program. A further work order for communication and engagement services in the Warrego-Darling Selected Area will be developed by early 2021 through to the end of the current MER Warrego-Darling River Selected Area service agreement (31 December 2022).

Grouping	Original Activities	COVID-19 Amended Activities
Local events and engagement activities	Local events - Support field days and help to run a CEWO led field day at Toorale day/night. Offer of presentation to local groups identified previously - northern Local Engagement Officers would be informed and probably involved in setting up the meetings. At least 6 local events annually in the region nominated by the northern LEOs.	Engagement through development and distribution of web-based stories. In collaboration with CEWO staff, participate in radio interviews.
Supporting Aboriginal engagement	Development of an Aboriginal engagement and communication action plan (including a listening process). Work with Jane Humphries, Jason Wilson and others; participate in and present to JMAC (planned in conjunction with the NPWS)	Develop an Aboriginal wetland resources table or document which can later be tested with the Aboriginal community within the Warrego-Darling Selected Area. Key steps undertaken to complete the wetland resources table or document will include: • Compiling species (plants and animals) found during the LTIM and MER projects into a list. • Creating a table from the literature for each key species, noting key habitat and lifecycle details. • Researching the available cultural uses and importance of each species and where possible finding stories that relate to the species.
Contribution towards the broader portal	Contribute to the Basin scale MER portal as required (note that the plan is yet to be approved or communicated)	Unchanged

being set up for water for the environment		
Products (Northern Basin focus)	Press releases & social media	Unchanged
	Regular provision of recent photos to the CEWO that can be used for various purposes	Unchanged
	Selected Area newsletters	Unchanged
	Annual Communications and Engagement Report - 2-4 page summary following team workshop of what happened and what worked	Unchanged
	Curriculum development - work with UNE outreach and CEWO northern Local Engagement Officers to develop specific MER items for schools	Unchanged
Northern Basin Research Forum	Northern Basin Research Forum - Annual workshop of key research agencies and programs in the northern basin (in conjunction with the Gwydir MER)	Unchanged
	Possible interview on research findings on local radio	Unchanged

Appendix G - Schedule 6 –Work Order

Order
The parties have agreed in accordance with clause 7 the Agreement that the Provider will provide the Additional Project Services specified in this Work Order.

Item	Description	Clause	Details
1.	**Agreement description**	**N/A**	Agreement for Additional Project Services in respect of ***Junction of the Warrego and Darling Rivers Selected Area: additional research projects*** **(Work Order #02)** dated December 2019
2.	**Names of Parties to the Agreement**	**N/A**	The Commonwealth of Australia as represented by the Department of the Environment and Energy ABN 34 190 894 983 University of New England ABN: 75 792 454 315
3.	**Additional Project Start Date**	**1.1**	The date this agreement is signed by the last party.
4.	**Additional Project Timeframe**	**1.1**	From the Additional Project Services Start Date until 30 June 2022
5.	**Category of Services**	**7**	Research
6.	**Additional Project Services**	**7**	See Attachment A that includes details of services, indication of the research, deliverables, milestones, and basis of payments.
7.	**Subcontractors**	**6.5**	2rog consulting Pty Limited ABN 91 619 296 221 NSW Department of Primary Industries - Fisheries (DPI Fisheries) ABN 72 189 919 072

			NSW Department of Planning, Industry and Environment (DPIE) ABN 20 770 707 468 Debus, Stephen John Stewart ABN 36 753 055 798
8.	**Progress meetings and reports**	**11**	Details of reporting requirements, progress meetings and reports are outlined in Attachment A.
9.	**Performance Criteria**	**12**	Must be in accordance with the Work Order and/or the Monitoring, Evaluation and Research Plan (2019-2022). Must be completed to a professional standard for audiences of CEWO staff, and community members. Must be undertaken in accordance with the dates and timeframes specified in the Work Order (or where agreed in writing ahead of time with the CEWO Project Manager). Must demonstrate how the activities undertaken have addressed key knowledge and information gaps for the Warrego-Darling Selected Area around water for the environment and ecological responses to flow and/or other drivers in the Warrego-Darling Selected Area Must include recommendations for how research around Commonwealth water for the environment in the Warrego-Darling Selected Area can be improved, and examples of best practice and other learnings to directly inform adaptive management. Must address feedback previously provided by the Department.
10.	**Project Officers**	**1.1**	**Department** Name: Michael Peat Position: Assistant Director for Warrego-Darling Water Delivery, Northern Basin Section Fax: 02 6274 2524 Email: Michael.Peat@environment.gov.au **Provider** Name: Sarah Mika and Mark Southwell Position: Senior Research Fellows in Aquatic Ecology, School of Environmental and Rural Science Fax: 02 6773 2769 Email: sarah.mika@une.edu.au, msouthw2@une.edu.au

11.	**Specified Personnel**	**1.1 and 1.3**	Dr Paul Frazier and Dr Darren Ryder (University of New England) (Project Directors) Dr Sarah Mika and Dr Mark Southwell (University of New England) (Project Managers) Dr Gavin Butler (NSW DPI - Fisheries) Dr Yoshi Kobayashi (NSW DPIE) Dr Jennifer Spencer (NSW DPIE)
12.	**Department Material**	**1.1**	**Not applicable**
13.	**Pre-existing Material of the Provider**	**1.1**	**Not applicable**
14.	**Payment Schedule**	**7 and 16**	Payment Schedule for payment of the Additional Project Services (January 2020-June 2022) is in Attachment A. The Payment Schedule specifies the payment dates and amounts.
15.	**Expenses**	**16**	**No change**
16.	**Other**	**N/A**	**No change**

ATTACHMENT A
WORK ORDER #02 - JUNCTION OF THE WARREGO AND DARLING RIVERS SELECTED AREA CONTINGENCY RESEARCH (JANUARY 2020 TO JUNE 2022)

Introduction

This Work Order will guide the Warrego-Darling MER team to deliver research additional to the core MER program from 1 January 2020 to 30 June 2022. The Warrego-Darling contingency research program will provide additional evidence to improve the understanding of how water for the environment is helping maintain, protect, and restore the ecosystems and native species in the Warrego-Darling catchment and other catchments, particularly in the northern Murray-Darling Basin. The Warrego-Darling contingency research program will provide knowledge on biodiversity, ecosystem function, and resilience. It will demonstrate outcomes, inform management of Commonwealth water for the environment and help meet the legislative reporting requirements of the CEWO through to June 2022.

The Warrego-Darling contingency research program will endeavour to produce knowledge for several different flow bands - very low flow, baseflow, freshes, bankfull and overbank, depending partly on what flow bands occur during the implementation of the Work Order. Each flow band supports different functions in the three water-dependent ecosystem types occurring in the Warrego-Darling catchment - river, wetland, and floodplain, and provides different research opportunities. These research opportunities/elements are explained in this Work Order.

The Warrego-Darling contingency research program has the following elements:

3. Modelling inundation extent and duration of inundation for floodplain and wetland habitats (including the Warrego Western floodplain)
4. Finalising the Warrego hydrodynamic model
5. Building resilience: understanding ecological thresholds in low flow refugia, including duration/persistence of key refuge river pools and waterholes
6. Developing a model to predict food web responses to water for the environment delivery
7. Developing a regime for assessing the condition of lignum in the Warrego-Darling Selected Area.
8. Contribution of in-channel benches and bars to high flow events in the Darling channel of the Warrego-Darling Selected Area.
9. Biodiversity responses to Commonwealth water for the environment

Indication of the research

Element	Indication of research associated with the element
Modelling inundation extent – Warrego Western Floodplain	This research element will involve working with Geoscience Australia and MDBA to access the Geoscience Australia Data Cube and wetland/water related indices; develop a range of products specifically for the Western Floodplain, incorporating field data, local knowledge, data from Long-Term Intervention Monitoring derived system maps, depth loggers and vegetation communities; capture a set of high resolution satellite or aerial images to compare against the derived data cube products; and provide a quantitative accuracy assessment of products derived from the data cube.
Hydrodynamic model finalisation	This research element will refine the Warrego hydrodynamic model (Western Floodplain and Warrego channel) developed through the Long-Term Intervention Monitoring project, including improved bathymetric profiles of the key waterholes along the Warrego River. Once surveys are completed this information can then be incorporated into the model which should improve model accuracy.
Building resilience: understanding ecological thresholds in low flow refugia	This research element will define, identify and describe biophysical and water chemistry characteristics of refuge habitats as they fill and recede. This element also will characterise biogeochemical processes and food web and target species they support, and how these change over time with refuge maintenance, or disconnection, contraction and then reconnection.
Developing a model to predict food web responses to environmental water delivery	This research element will link management decisions on environmental watering to the trophic carrying capacity of rivers in the northern Basin, particularly in the Warrego and Darling catchments and including successful larval fish recruitment. This research element in the Warrego-Darling will develop a channel-based foodweb model, complementing a floodplain wetland foodweb model developed as part of the Environmental Water Knowledge and Research project. This element also contributes directly to the MER Basin scale diversity, food web and modelling themes to contribute northern Basin data.
Developing a method to assess lignum condition in the Warrego-Darling Selected Area	This research element will investigate current methodologies for monitoring lignum, and developing a monitoring regime for incorporation into the MER project to provide detailed information on the specific condition of lignum in the Warrego-Darling Selected Area. This regime would then be undertaken in association with other vegetation diversity monitoring throughout the MER project.
Contribution of bars and in-channel benches during high flow events (Darling)	This research element will investigate how the inundation regimes of in-channel benches and bars contribute to the nutrient and carbon budgets of rivers. The research will use mesocosm experiments to determine nutrient release upon inundation from in-channel benches and bars; characterise emerging microinvertebrate communities and identify the food sources used for their growth. Outcomes will provide robust estimates of nutrient and carbon 'loads' resulting from e-water deliveries, and an estimate of the food web that it will support in the Darling channel.
Biodiversity responses to environmental water	The focus of this research element is on biodiversity responses to flow and inundation in the Warrego-Darling. It extends the core MER research program by adding other species and relationships to the knowledge base. The program also links with our broader strategy for MER projects to expose PhD students to multi-disciplinary, management relevant projects with stakeholder engagement, and includes substantial financial and in-kind contributions by UNE. The topics of research will be confirmed by 30 March 2020, and is likely to include: • turtle tracking; • frog diversity, recruitment and responses to inundation; and

	• acoustic analysis of biodiversity responses to wetland inundation.

Appendix H - Schedule 6 –Work Order

Order

The parties have agreed in accordance with clause 7 the Agreement that the Provider will provide the Additional Project Services specified in this Work Order.

Item	Description	Clause	Details
1.	**Agreement description**	**N/A**	Agreement for Additional Project Services in respect of ***Junction of the Warrego and Darling Rivers Selected Area: contingency monitoring*** **(Work Order #03)** dated December 2019
2.	**Names of Parties to the Agreement**	**N/A**	The Commonwealth of Australia as represented by the Department of the Environment and Energy ABN 34 190 894 983 University of New England ABN: 75 792 454 315
3.	**Additional Project Start Date**	**1.1**	The date this agreement is signed by the last party.
4.	**Additional Project Timeframe**	**1.1**	From the Additional Project Services Start Date until 30 June 2022
5.	**Category of Services**	**7**	Monitoring
6.	**Additional Project Services**	**7**	See Attachment A that includes details of services, deliverables, milestones, and distribution of funding.
7.	**Subcontractors**	**6.5**	2rog consulting Pty Limited ABN 91 619 296 221 NSW Department of Primary Industries - Fisheries (DPI Fisheries) ABN 72 189 919 072 NSW Department of Planning, Industry and Environment (DPIE) ABN 20 770 707 468

			Debus, Stephen John Stewart ABN 36 753 055 798
8.	**Progress meetings and reports**	**11**	Details of reporting requirements, progress meetings and reports are outlined in Attachment A.
9.	**Performance Criteria**	**12**	Must be in accordance with the Work Order and/or the Monitoring, Evaluation and Research Plan (2019-2022). Must be completed to a professional standard for audiences of CEWO staff, and community members. Must demonstrate how the activities undertaken have addressed key knowledge and information gaps for the Warrego-Darling Selected Area around water for the environment and ecological responses to flow and/or other drivers in the Warrego-Darling Selected Area Must include recommendations for how contingency monitoring around Commonwealth water for the environment in the Warrego-Darling Selected Area can be improved, and examples of best practice and other learnings to directly inform adaptive management. Must be undertaken in accordance with the dates and timeframes specified in the Work Order (or where agreed in writing ahead of time with the CEWO Project Manager). Must address feedback previously provided by the Department.
10.	**Project Officers**	**1.1**	**Department** Name: Michael Peat Position: Assistant Director for Warrego-Darling Water Delivery, Northern Basin Section Fax: 02 6274 2524 Email: Michael.Peat@environment.gov.au **Provider** Name: Sarah Mika and Mark Southwell Position: Senior Research Fellows in Aquatic Ecology, School of Environmental and Rural Science Fax: 02 6773 2769 Email: sarah.mika@une.edu.au, msouthw2@une.edu.au
11.	**Specified Personnel**	**1.1 and 1.3**	Dr Paul Frazier and Dr Darren Ryder (University of New England) (Project Directors) Dr Sarah Mika and Dr Mark Southwell (University of New England) (Project Managers)

			Dr Gavin Butler (NSW DPI - Fisheries) Dr Yoshi Kobayashi (NSW DPIE) Dr Jennifer Spencer (NSW DPIE)
12.	**Department Material**	**1.1**	**Not applicable**
13.	**Pre-existing Material of the Provider**	**1.1**	**Not applicable**
14.	**Payment Schedule**	**7 and 16**	Payment Schedule for payment of the Additional Project Service (Jan 2020 to June 2022) is in Attachment A. The Payment Schedule specifies the payment dates and amounts.
15.	**Expenses**	**16**	**No change**
16.	**Other**	**N/A**	**No change**

ATTACHMENT A
WORK ORDER #03 - JUNCTION OF THE WARREGO AND DARLING RIVERS SELECTED AREA CONTINGENCY MONITORING (JANUARY 2020 TO JUNE 2022)

Introduction

This Work Order will guide the Warrego-Darling MER team to deliver monitoring additional to the core MER program from 1 January 2020 to 30 June 2022.

The Warrego-Darling contingency monitoring program will provide evidence to improve the understanding of how water for the environment is helping maintain, protect, and restore the ecosystems and native species in the Warrego-Darling catchment and other catchments, particularly in the northern Murray-Darling Basin. The Warrego-Darling contingency monitoring program will provide knowledge on biodiversity, ecosystem function, and resilience. The monitoring program will demonstrate outcomes, inform management of Commonwealth water for the environment and help meet the legislative reporting requirements of the CEWO through to June 2022.

The Warrego-Darling contingency monitoring program will endeavour to produce knowledge for several different flow bands - very low flow, baseflow, freshes, bankfull, and overbank, depending partly on what flow bands occur during the implementation of the Work Order. Each flow band supports different functions in the three water-dependent ecosystem types occurring in the river, wetland and floodplain system of the Warrego-Darling catchment and provides different monitoring opportunities. These monitoring opportunities/elements are explained in this Work Order. Each year in June, based on the likely use of water for the environment in the year ahead, likely monitoring elements will be identified and outlined in an annual plan.

The Warrego-Darling contingency monitoring program will also be responsive to opportunities that present within a year. The broad aim is to spread the monitoring out reasonably evenly over years (work order quarterly payments), and to provide clear incentive to provide information in a timely way whilst there is a higher degree of relevance and community interest (annual plan milestone payments).

The Warrego-Darling contingency monitoring program includes the following six monitoring elements: connectivity events, Western Floodplain biodiversity, waterbird recruitment, fish recruitment, low flow refuges in the Warrego and Darling Rivers and incident response monitoring.

By 30 June of each year, based on likely environmental watering actions and antecedent conditions in the coming watering year, an annual plan of contingency monitoring will be submitted by UNE and approved by CEWO. The annual plan will set out proposed monitoring activities and associated reporting requirements for each monitoring activity proposed to be undertaken across the water year. The annual plan will identify completion dates for each identified Milestone.

Should changes in proposed environmental watering actions or antecedent conditions during a water year necessitate changes to be made to an annual plan, proposed changes would need to be agreed to by UNE and the CEWO. These changes may include adjusting milestone payments in the annual plan.

Indication of elements of the Warrego-Darling contingency monitoring program

Element	Indication of monitoring
Connectivity events	Contingency monitoring of multiple indicators before, during and after flow events will provide information on flows needed to influence channel habitats; improve water quality; and provide for longitudinal connectivity (particularly important for fish) in the Warrego-Darling Selected Area. This will improve understanding of short-term environmental outcomes from flow management in the Warrego-Darling, including trade-offs between connecting the Warrego channel to the Darling River and/or the inundation of the Western floodplain by Commonwealth water for the environment.
Western Floodplain biodiversity	This contingency monitoring element will monitor abundance of key faunal groups on the Western floodplain not captured through current monitoring programs (e.g. small bodied fish, frogs, snakes and turtles) and how their response changes with inundation timing, frequency, spatial extent and duration of watering. This information will allow the CEWO to better target environmental water to the Warrego Channel or Western floodplain.
Waterbird recruitment	The Western Floodplain has extensive lignum and macrophyte communities that may be important habitat for waterbird breeding. These rookery areas will be the target of event-driven survey effort. Surveys of colonial bird breeding events and fledging success are proposed using standard methods. Surveys will be initiated by confirmed commencement of bird breeding events.
Fish recruitment	Monitoring of fish recruitment could occur in any year. Additional fish methods and evaluation over and above standard methods will target event-based fish recruitment in the Warrego-Darling (including the Western Floodplain, connection of Warrego channel with the Darling and the role of refuge habitats). Monitoring will track inundation events and the potential for breeding and potential recruitment of native fish (with a focus on Golden Perch). Monitoring will include length, weight, condition and otolith (age and chemistry – research linked to MER Basin Scale) to link to flow triggers in the upstream Darling or Warrego reaches.
Low flow refuges in the Warrego and Darling Rivers	The focus of this monitoring of refuges will be in drier years. This monitoring will consider the duration of cease to flow events at waterholes in the Warrego and Darling, and monitor how the habitat and food changes (focus on native fish such as golden perch and Murray cod). This project will contribute to the evidence base for the CEWO to better target environmental water to the Warrego Channel or Western Floodplain.
Incident response monitoring	This monitoring could happen in any year. Opportunistic monitoring can be undertaken for water quality (spot measures and samples) or ecological indicators (fish, frogs, turtles, birds, mussels, other) as agreed between UNE and the CEWO.