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WOLEEBEE CREEK TO GLEBE WEIR PIPELINE PROJECT

BIODIVERSITY OFFSET STRATEGY

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Project: P-ASWP-0033-AA-01-02 **File No:** 13-000180/001

Version 11

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1 Introduction

This document comprises a biodiversity offset strategy (BOS) for the purposes of condition 6 of the approval for the Woleebee Creek to Glebe Weir pipeline project under the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**) as well as a vegetation offset strategy for the development permit (vegetation clearing) for the same project under the Queensland *Sustainable Planning Act 2009/Vegetation Management Act 1999*.

1.1 Project background

The Woleebee Creek to Glebe Weir Pipeline project involves the construction and operation of a pipeline to transport up to 113 ML/day of treated coal seam gas (CSG) water from QGC's Woleebee Creek petroleum tenement to the Dawson River at Glebe Weir in southern Queensland. The pipeline is approximately 119 km in length and has a construction easement 30 m wide, creating a construction area of about 435 ha plus small additional areas such as:

- Material stockpile laydown areas;
- Pump station;
- 5ML concrete balance tank;
- Surge tank;
- Air valves (with and without stock offtakes);
- Scour valves;
- Cathodic protection test point;
- Control valve pits;
- Flow meter pits;
- Isolation valves; and
- Metered offtakes.

The pipeline traverses through the Western Downs and Banana Regional Council areas, crossing private farming land, road reserves and mining and petroleum tenures, as well as creeks and roads owned by the State or local government.

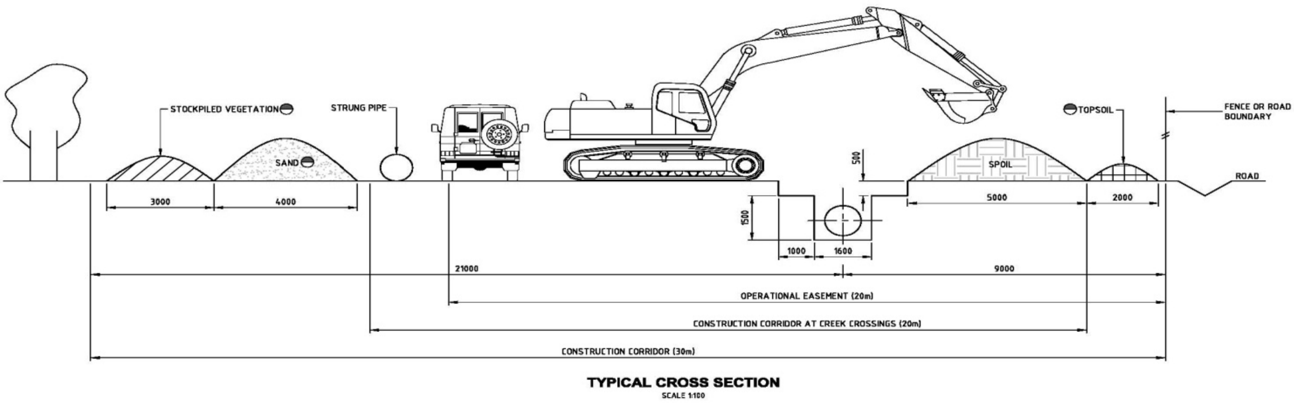
1.2 Pipeline construction activities

The activities associated with the construction of the pipeline include:

- Vegetation clearing of the 30m wide construction easement and lay down areas;
- Topsoil removal and stockpiling;

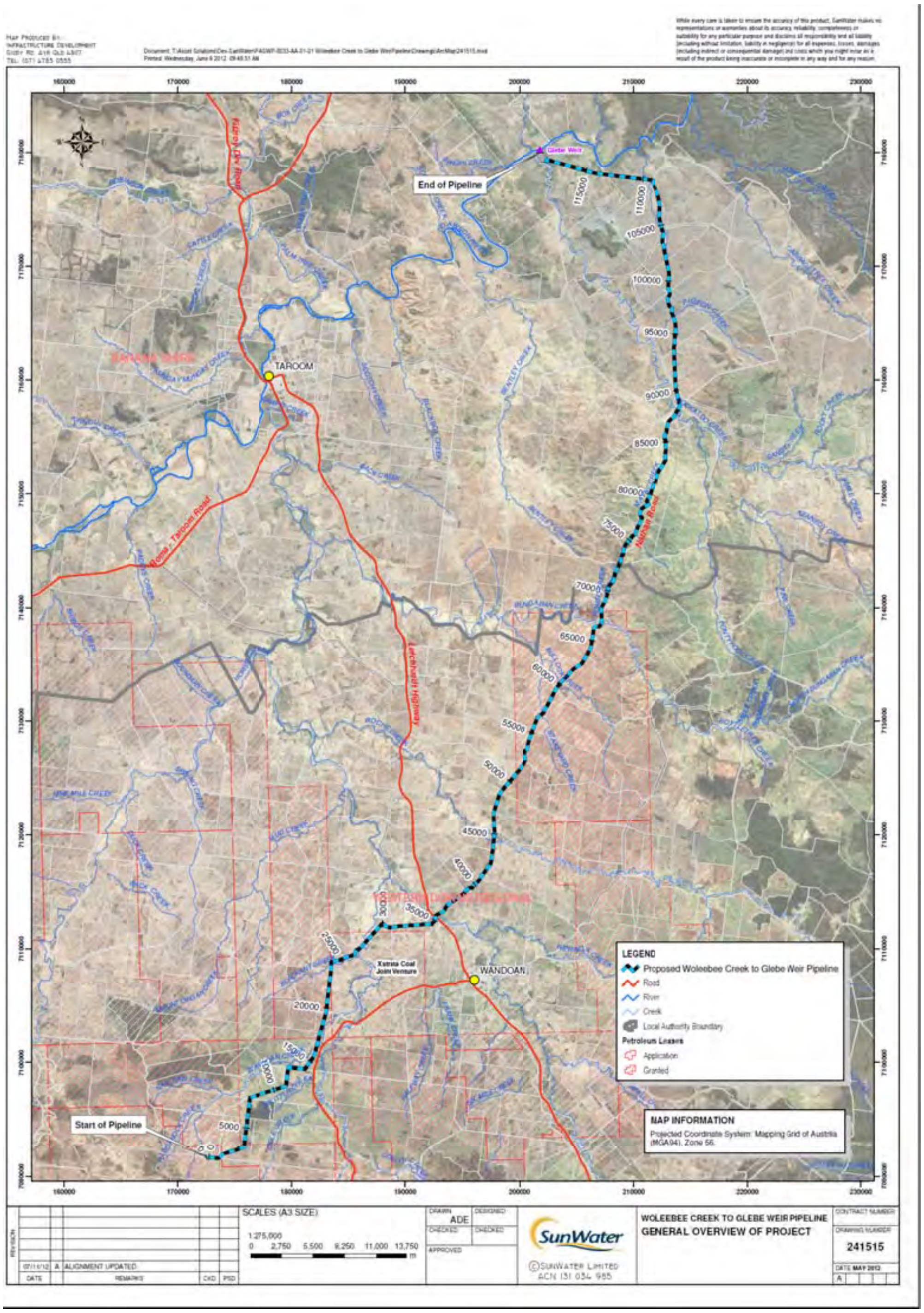
- Construction of access tracks from roads to the construction easement (following existing farm tracks where possible);
- Transport of materials from stockpiles to the easement;
- Trench excavation, pipe laying, backfill and reinstatement of topsoil as shown in **Figure 1**;
- Rehabilitation of the construction easement;
- Construction of pump station and various associated infrastructure;
- Connection of the pipeline to the pump station;
- Connection of metered off-takes from the pipeline to contracted water users; and
- Construction of the outlet works for delivering treated CSG water in to the weir.

Figure 1 - Pipeline construction easement



The construction phase of the project is planned to occur over a 9-12 month period. SunWater is planning for construction to commence in April 2013/early May 2013.

Figure 2 - Woleebee Creek to Glebe Weir Pipeline alignment



1.3 Biodiversity offset strategy purpose and legislative context

The project was determined to be a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**) by the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (**SEWPaC**) on 22 December 2011. The controlling provisions were section 18 and 18A in relation to potential impacts on Listed Threatened Species and Communities.

Condition 6 of the resulting approval required the provision of offsets and the preparation of this Biodiversity Offset Strategy in accordance with the Consultation draft of the *EPBC Act Environmental Offsets Policy*. The offsets to be provided in accordance with this Biodiversity Offset Strategy have been calculated, at the request of SEWPaC, in accordance with the final version of the *EPBC Act Environmental Offsets Policy* (October 2012).

In order to construct and operate the pipeline, clearing of vegetation classified under the Queensland *Vegetation Management Act 1999* as remnant and regrowth vegetation will be required. To meet requirements under the *Vegetation Management Act 1999* (**VMA**), an offset is proposed in accordance with the (Qld) *Policy for Vegetation Management Offsets* (Version 3, 2011) (**PVMO**).

The purpose of the *Policy for Vegetation Management Offsets* (PVMP) is to set the requirements of a proposed offset as a condition of a development permit in order to achieve the purpose of the *Vegetation Management Act 1999* (VMA Act).

The *EPBC Act Environmental Offset Policy* (EPBC Policy) requires that offsets, where applicable, should "maintain or enhance the health, diversity and productivity of the environment as it relates to matters protected by the EPBC Act".

A Biodiversity Offset Strategy (this document) has been developed to describe how the proposed Project offset can meet performance requirements set out in the *Regional Vegetation Management Code for the Brigalow Belt South and New England Tablelands* (Regional VM Code) and satisfies both the PVMO and the EPBC Policy.

Under the both the State and Federal polices, offsetting is considered a last resort and the proponent must demonstrate that all measures have been undertaken to avoid the clearing of vegetation and mitigate impacts of the development on vegetation prior to the consideration of offsets.

As part of the selection of the pipeline route, alternative routes were considered by SunWater based on the following principal considerations:

- Avoiding areas of high environmental value such as endangered ecological communities, national parks, nature reserves and conservation areas;
- Avoiding areas of remnant vegetation or high value re-growth;
- Minimising pipeline route length and the number of properties and existing mining leases impacted;
- Avoiding topographic extremes, hard rock areas and extreme directional changes;
- Utilising co-location opportunities with public and private infrastructure; and

- Minimising river and creek crossings and where these are unavoidable low impact locations have been chosen.

The proposed Project alignment has been selected over shorter and less expensive routes as the current alignment results in:

- Lower impact to remnant vegetation;
- Lower order watercourse crossings; and
- Less area required on private property.

The current alignment has been based on the results of flora and fauna studies, and liaison with individual landholders, as shown in **Annexure F**. Based on the result of these studies the current alignment has been amended with changes in the location of the pipeline to avoid endangered Regional Ecosystems, as follows:

- Location 1 - Realignment of the pipeline to within the road reserve;
- Location 2 - Realignment of the pipeline into private property to avoid vegetation;
- Location 3 – Realignment of the pipeline from the northern to the southern side of Nathan Road;
- Location 4 – Realignment of the pipeline to provide a 10 m separation distance from vegetation;
- Location 5 – Crossing of the road in a skewed direction, normally perpendicular, to avoid vegetation.

In addition to reducing impacts to vegetation, the proposed alignment has been selected due to its reduced impact on existing and proposed land uses. Iterations to the alignment to date have been based on avoiding impact to on-farm operations as much as possible. Consideration has also been given to the location of the alignment within the Surat Basin State Development Area Infrastructure Corridor to ensure no impact on the proposed Surat Basin Rail, a key stakeholder in the State Development Area.

2 Purpose of this Biodiversity Offset Strategy

2.1 Commonwealth EPBC Act

This Biodiversity Offset Strategy has been specifically devised to address the requirements of condition 6 of the EPBC Act approval, as follows:

Table 1 - Approval conditions and sections of Biodiversity Offset Plan addressing those conditions

	Condition	Relevant section of this Report
6.	The person taking the action must develop a Biodiversity Offset Strategy (BOS) to ensure better protection of EPBC Act listed threatened species and communities. The BOS must be submitted to, and approved by the Minister prior to commencement of the action.	This BOS
a.	The BOS must be developed in accordance with the EPBC Act Environmental Offset Policy.	The Offset policy requirements have been addressed in full in sections 5, 7 and 11.
b.	The BOS must include, but should not be limited to, the following:	
i.	Details of the acquisition and ongoing management of vegetation which meets or will meet the definition of the endangered ecological community "Brigalow (*Acacia harpophylla*) dominant and co-dominant";	Sections 8, 9.1 and 10
ii.	Details of the acquisition and ongoing management of vegetation that meets or will meet the definition of the endangered ecological community "Coolibah-Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Region;	Sections 8, 9.2 and 11
iii.	Details of steps to be undertaken to legally secure the proposed offset areas and implement the BOS within 12 months of the commencement of the action;	Section 8.2
iv.	The offset areas for each separate community must be contiguous (that is, the total cannot be comprised of a number of fragments, and must not be located within an existing mining lease or mining lease application areas; and	Section 11.2 and Annexure N
v.	Upon legally securing the offset area, the BOS must be updated with a textual description and map to clearly define the location and boundaries of the offset area. This must be accompanied with the offset attributes and a shapefile.	Section 8.3

2.2 Queensland VMA/SPA

This Biodiversity Offset Strategy has been prepared to include the following in relation to the VMA and the Policy for Vegetation Management Offsets (2011):

- a description of the project and the purpose of this Strategy (section 1 and 2);

- an analysis of the performance requirement of the PVMO and the Regional Vegetation Code which describes the offset requirements of the Project (section 4.2);
- an overview of the Ecological Equivalence Methodology and the components of the work undertaken to execute the methodology (section 6);
- a description of the proposed offset sites (section 9).

3 Clearing Area Description

3.1 Regional Ecosystems located in the project area

Field based regional ecosystem mapping has been produced by Cardno Chenoweth (2012) and described in the 'Post re-alignment surveys' (**Annexure A**). The short description of each RE and their status under the VM Act and EPBC Act is summarised in **Table 1**.

Table 1 - Regional ecosystems in the pipeline easement

RE Code	Description	Vegetation Management Status[1]	EPBC Act Status[2]
11.3.1	Acacia harpophylla and/or Casuarina cristata open forest on alluvial plains	Endangered	Endangered
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Of Concern	-
11.3.3	*Eucalyptus coolabah* woodland on alluvial plains	Of Concern	Endangered
11.3.25	Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines	Least Concern	-
11.5.1	Eucalyptus crebra, Callitris glaucophylla, Angophora leiocarpa, Allocasuarina luehmannii woodland on Cainozoic sand plains/remnant surfaces	Least Concern	-
11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	Endangered	Endangered
11.9.7	*Eucalyptus populnea, Eremophila mitchellii* shrubby woodland on fine-grained sedimentary rocks	Of Concern	-
11.9.10	Acacia harpophylla, Eucalyptus populnea open forest on fine-grained sedimentary rocks	Of Concern	-
11.10.7	*Eucalyptus crebra* woodland on coarse-grained sedimentary rocks	Least Concern	-

[1] Vegetation management status as shown in the Regional Ecosystem Description Database (REDD: Queensland Herbarium 2009).
[2] EPBC Act status of the threatened ecological community comprising the RE.

Clearing of remnant vegetation will occur on properties listed in **Table 2**. Clearing of non remnant vegetation will occur on properties listed in **Table 3**. Properties that have High Value Regrowth are listed in **Table 4**.

Table 2 - Lot descriptions and tenure for clearing of remnant vegetation

Property Description	Tenure	RE	Area (ha)
Lot 14 FT1	Freehold	11.3.25	0.25
		11.3.3	0.11
Lot 1 SP186438	Leasehold	11.3.25	0.13
Lot 28 FT313	Reserve	11.3.25	0.49
Lot 29 FT668	Reserve	11.3.2	0.42
Lot 2 FT734	Freehold	11.3.3	0.35
Lot 2 FT880	Freehold	11.3.25	0.07
		11.10.7	0.39
		11.9.5	0.04
Lot 3 FT733	Leasehold	11.9.7	0.55
Lot 4 SP191511	Leasehold	11.3.2	0.05
		11.3.25	0.06
Lot 8 SP152696	Freehold	11.9.5	0.47
Lot 8 SP152696	Freehold	11.9.10	1.04
Lot 8 SP152696	Freehold	11.10.7	3.82
1 RP123884	Freehold	11.3.25	0.23
21 FT669	Freehold	11.5.1	0.7
		11.9.10	0.3
Bungaban Creek	Unallocated State Land	11.3.25	0.09
Cockatoo Creek	Unallocated State Land	11.3.25	0.09
Cracow Road	Local Road	11.9.10	0.18
Glebe Weir		11.3.3	0.02
Nathan Road	Local Road	11.10.7	0.95
Nathan Road	Local Road	11.3.25	0.62
		11.9.7	0.40
		11.3.2	0.91
Leichhardt Highway	State Controlled Road	11.3.2	0.31
		11.3.25	0.21
Weldons Road	Local Road	11.9.5	0.09
		Total	**13.34**

Table 3 - Lot descriptions and tenure for clearing of non-remnant vegetation

Property Description	Tenure	RE	EPBC	Area (ha)
Lot 14 FT1	Freehold	11.3.3	Non-rem E	0.62
Lot 1 FT861	Freehold	11.3.2		0.49
Lot 1 SP186438	Leasehold	11.9.10		0.53
Lot 28 FT313	Reserve	11.3.2		0.54
Lot 29 FT668	Reserve	11.3.2		0.93
Lot 2 FT734	Freehold	11.9.7		0.28
		11.9.10		0.28
Nathan Road	Local Road	11.9.10		0.01
Lot 10 FT87	Freehold	11.9.5	Non-rem E	0.11
		11.9.10		0.07
Lot 11 FT487	Leasehold	11.9.5a	Non-rem E	0.17
Lot 16 FT1012	Freehold	11.9.5a	Non-rem E	0.18
Lot 50 FT573	Freehold	11.3.25		0.59
Lot 55 FT826	Freehold	11.3.25		0.14
Bundi Road	Local Road	11.9.5	Non-rem E	0.11
Gasby Road	Local Road	11.9.5	Non-rem E	0.51
		11.9.10		0.34
Grosmont Road	Local Road	11.3.25		0.46
Woleebee Creek	Local Road	11.3.25		0.12
		Total		**6.48**

Table 4 - Lot descriptions of properties with high value regrowth

Lot/plan	HVR	Area (ha)	Portion that is within a restricted area
Lot 18 FT880	Containing Endangered regional ecosystems	0.15	0.01
Lot 18 FT880	Containing Of Concern regional ecosystems	0.07	
Lot 18 FT880	Containing Of Concern regional ecosystems	0.03	0.01
Lot 1 FT861	Containing Endangered regional ecosystems	0.05	0.01
Lot 1 FT861	Containing Endangered regional ecosystems	0.05	
Lot 1 FT861	Containing Endangered regional ecosystems	0.55	
Lot 1 SP186438	Containing Of Concern regional ecosystems	0.15	0.17
Lot 2 8FT313	Containing Of Concern regional ecosystems	1.23	0.25
Lot 2 9FT668	Containing Endangered regional ecosystems	0.5	
Lot 2 FT734	Containing Of Concern regional ecosystems	0.22	
Lot 2 FT880	Containing Of Concern regional ecosystems	0.04	0.04
Lot 2 FT880	Containing Of Concern regional ecosystems	1.3	
Lot 2 FT880	Is a Least Concern regional ecosystem	0.26	0.03
Lot 3 FT733	Containing Of Concern regional ecosystems	0.01	
Lot 4 SP191511	Containing Endangered regional ecosystems	0.53	
Lot 8 SP152696	Containing Of Concern regional ecosystems	0.05	
Lot 9 SP152696	Is a Least Concern regional ecosystem	0.38	
Cockatoo Creek	Containing Of Concern regional ecosystems	0.02	0.02
Nathan Road	Containing Endangered regional ecosystems	0.04	
Nathan Road	Containing Of Concern regional ecosystems	0.05	
Nathan Road	Containing Of Concern regional ecosystems	0.19	
Nathan Road	Is a Least Concern regional ecosystem	0.08	
	Total	**5.95**	**0.54**

3.2 Threatened ecological communities located within the clearing area

3.2.1 Brigalow

The ecological community known as "Brigalow (*Acacia harpophylla* dominant and co-dominant)" was listed as Endangered in 2001 under the *Environment Protection and Biodiversity Conservation Act 1999.*

"Brigalow" is the commonly accepted name for the species *Acacia harpophylla* and the vegetation in which this species is dominant or co-dominant, and is used in Queensland to describe the regional ecosystems/vegetation communities that correspond with the listed Brigalow ecological community, as identified in **Table 1**.

The EPBC-listed ecological community is characterised by the presence of Brigalow (*Acacia harpophylla*) as one of the three most abundant tree species. Brigalow is usually dominant in the tree layer or co-dominant with other species such as *Casuarina cristata* (Belah), other species of Acacia, or species of Eucalyptus. Occasionally Belah or Acacia or Eucalyptus species may be more common than Brigalow within the broad matrix of Brigalow vegetation. The structure of the vegetation ranges from open forest to open woodland. The height of the tree layer varies from about 9 metres in low rainfall areas (averaging around 500 mm per annum) to around 25 metres in higher rainfall areas (averaging around 750 mm per annum). A prominent shrub layer is usually present.

A detailed description of this ecological community may be found in the "*Recovery plan for the "Brigalow (Acacia harpophylla dominant and co-dominant) endangered ecological community*".

In Queensland, the listed Brigalow ecological community comprises 16 regional ecosystems, which include the listed regional ecosystem below found at the proposed offset site:

> **RE 11.4.3a** (Palustrine wetland (e.g. vegetated swamp). *Melaleuca bracteata* woodland associated with *Acacia harpophylla* communities on clay plains). May include scattered occurrences of other tree species such as *Eucalyptus tereticornis, E. populnea, Acacia harpophylla* and *Casuarina cristata*. In some instances *E. tereticornis* dominates with other species restricting to a narrow fringe. There may be an understorey of *Damasonium minus, Typha orientalis*, *Cyperus* spp., and other wetland plants associated with ephemeral wetlands. Associated with heavy dark clay soils with very broad and deep gilgai which is seasonally ponded and remain wet for long periods.
>
> **BVG 25a** Open-forests to woodlands dominated by *Acacia harpophylla* sometimes with *Casuarina cristata* on heavy clay soils. Includes areas co-dominated with *A. cambagei* and/or emergent eucalypts.

3.2.2 Coolibah

The ecological community was nominated under the names: 'Coolibah (*Eucalyptus coolabah*) / Black Box (*Eucalyptus largiflorens*) Woodlands of the Darling Riverine Plains and Queensland Brigalow Belt South bioregions' [2008 nomination], and 'Coolibah (*Eucalyptus coolabah*)/ Black Box (*Eucalyptus largiflorens*) Woodlands of the Northern NSW Wheat Belt and Queensland Brigalow Belt' [2005 nomination]. The name is a shortened version of those nominated and accurately reflects the area where the national ecological community occurs. A detailed description of this community may be found in the "*Listing Advice to the Minister for the Environment, Heritage and Arts (1999*)".

The regional ecosystems included in the Coolibah Ecological Community are listed under Queensland's *Vegetation Management Act* (1999) as 'Of-concern' and 'Not of concern' but their tendency for degradation means they are considered 'Of-concern' in terms of their biodiversity status.

The five regional ecosystems of this ecological community include Regional Ecosystem 11.3.3 - *Eucalyptus coolabah* woodland to open-woodland with a grassy understorey. This is both the Regional Ecosystem that will be impacted by the Woleebee Creek to Glebe Weir Pipeline Easement; and the regional ecosystem that is proposed as an offset to the activity.

4 Offset Requirements - Policy for Vegetation Management Offsets and the Regional Vegetation Management Code

4.1 Policy

The Project is located between Woleebee Creek and Glebe Weir, and within the Brigalow Belt South Bioregion. Development applications for the clearing of native vegetation in the Brigalow Belt South Bioregion are assessed against the Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions – Version 2.1 (November 20012) (Regional VM Code).

Under the Regional VM Code, the Project is required to meet the performance requirements for Part P: Requirements for clearing for public safety and infrastructure. The way in which the project will address the performance requirements of the Regional VM Code is set out in "Woleebee Creek to Glebe Weir Pipeline Vegetation Clearing Application".

The performance requirements that are to be satisfied through the use of an offset are described as follows.

Where an Acceptable Solution or Alternative Solution involves the provision of offsets, those offsets are required to comply with the Policy for Vegetation Management Offsets.

The Code and the Offsets Policy, generally require that offsets be land-based.

4.2 Performance requirement P.7 endangered and of concern REs

Clearing of remnant vegetation greater than 10 metres wide or greater than 0.5 hectares (in total) in Endangered or Of Concern REs must be offset. The area of each Endangered and Of Concern RE is listed in **Table 5**. As such, clearing of all vegetation listed in **Table 5** must be offset.

Table 5 - Clearing areas of endangered and of concern REs

BVG	RE	Short Description	VM Act Status	EPBC Act Status	Area (ha)
17a	11.3.2	*Eucalyptus populnea* woodland on alluvial plains	OC		0.05
17a	11.3.2	*Eucalyptus populnea* woodland on alluvial plains	OC		0.42
17a	11.3.2	*Eucalyptus populnea* woodland on alluvial plains	OC		0.53
17a	11.3.2	*Eucalyptus populnea* woodland on alluvial plains	OC	-	0.115
17a	11.3.2	*Eucalyptus populnea* woodland on alluvial plains	OC		0.027
17a	11.3.2	*Eucalyptus populnea* woodland on alluvial plains	OC		0.31
17a	11.3.2	*Eucalyptus populnea* woodland on alluvial plains	OC		0.91
16c	11.3.3	*Eucalyptus coolabah* woodland on alluvial plains	OC		0.11
16c	11.3.3	*Eucalyptus coolabah* woodland on alluvial plains	OC	E	0.35
16c	11.3.3	*Eucalyptus coolabah* woodland on alluvial plains	OC		0.02

BVG	RE	Short Description	VM Act Status	EPBC Act Status	Area (ha)
25a	11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	E	E	0.47
25a	11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	E		0.04
25a	11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	E		0.09
25a	11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	E		0.03
25a	11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	E		0.23
25a	11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	E		0.003
17a	11.9.7	*Eucalyptus populnea*, *Eremophila mitchellii* shrubby woodland on fine-grained sedimentary rocks	OC	-	0.55
17a	11.9.7	*Eucalyptus populnea*, *Eremophila mitchellii* shrubby woodland on fine-grained sedimentary rocks	OC		0.4
17a	11.9.7	*Eucalyptus populnea*, *Eremophila mitchellii* shrubby woodland on fine-grained sedimentary rocks	OC		0.027
17a	11.9.7	*Eucalyptus populnea*, *Eremophila mitchellii* shrubby woodland on fine-grained sedimentary rocks	OC		0.04
25a	11.9.10	*Acacia harpophylla*, *Eucalyptus populnea* open forest on fine-grained sedimentary rocks	OC	-	0.18
25a	11.9.10	*Acacia harpophylla*, *Eucalyptus populnea* open forest on fine-grained sedimentary rocks	OC		0.3
			Total (ha)		**5.202**

Table 6 below summarises the amount of vegetation being cleared under each Broad Vegetation Group (BVG) and the relevant conservation status.

Table 6 - Summary of endangered and of concern vegetation clearing by BVG

BVG	Vegetation Management Status	Area (ha)
16c	Of Concern	0.48
	Endangered	-
17a	Of Concern	3.379
	Endangered	-
25a	Of Concern	0.48
	Endangered	0.863
Total (ha)		5.202

In order to conserve the extent of remnant vegetation a land based offset will be required to maintain the current extent of Endangered and Of Concern REs. Any proposed offset solution will be required to meet the performance criteria detailed in the PVMO Section 8.2.4 (Endangered Regional Ecosystems) and Section 8.2.5 (Of Concern Regional Ecosystems).

Under the PVMO, the offset for the Endangered REs is required to be:

- located in the same bioregion as where the clearing is to occur; and
- an Endangered RE of the same BVG as the vegetation to be cleared.

Under the PVMO, the offset for the Of Concern REs is required to be:

- located in the same bioregion as where the clearing is to occur;
- an Of Concern RE of the same BVG as the vegetation to be cleared; and
- the same or higher conservation status as the area proposed for clearing.

5 Offset Requirements – EPBC Act

5.1 Impacted communities and offset requirements

Condition 6 of the EPBC Act approval for the project requires the development of a Biodiversity Offset Strategy which accords with the *EPBC Act Environmental Offsets Policy – Consultation Draft* (2011) and addresses offsets for the Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community and the Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions ecological community.

As discussed above, this BOS has been prepared in accordance with the final version of the EPBC Act Environmental Offsets Policy.

The extent of the permitted and proposed impacts on threatened ecological communities is set out in **Table 7** below:

Table 7 - Impacts to be offset under EPBC Act approval conditions

Regional Ecosystem to be cleared under Approval	Description	Area allowed to be cleared under Approval (ha)	Area to be cleared (ha)	EPBC Status
11.3.3 (Coolibah)	*Eucalyptus coolabah* woodland to open-woodland with a grassy understorey	1.38	1.38	Endangered
11.3.1 and 11.9.5 and 11.9.10 (Brigalow)	Brigalow (*Acacia harpophylla*) shrubby open forest to woodland	2.08	2.08	Endangered

5.2 Policy

The EPBC Act Environmental Offset policy requires that offsets, where applicable, should "maintain or enhance the health, diversity and productivity of the environment as it relates to matters protected by the EPBC Act". It is understood that offsets are separate from mitigation measures that may occur within the impact area and will be situated on land external to the development area.

Table 8 provides information outlining how the offsets strategy meets the requirements of the EPBC Act Environmental Offsets policy. The EPBC Act Offsets Assessment Guide contained in **Annexure H** incorporates many of the requirements listed below, and has been used to calculate a suitable sized offset area.

Table 8 - EPBC offset policy requirements

Policy Requirement	Strategy
Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of	Offset areas will be secured that contain the protected matters to be impacted, namely the two threatened ecological communities listed in **section 7**. The threatened

Policy Requirement	Strategy
the aspect of the environment that is protected by national environment law and affected by the proposed action	ecological communities will be managed in a way that improves or maintains the viability of the communities. An offsets management plan that sets out specific management goals, objectives, actions, responsibilities and monitoring protocols will be prepared and implemented to minimise risk to the offset areas.
Suitable offsets must be built around direct offsets but may include other compensatory measures	Direct offsets will account for 100% of the offset requirement. An offset broker has identified potential offset areas on private land which are intended to be legally secured for until the earlier of 2052 or until the vegetation in the area is mapped as having achieved remnant status under the Queensland VMA. Monitoring and reporting will also occur in accordance with the offset area management plans.
Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter	The Endangered status of the threatened ecological communities is taken into account by the Offsets Assessment Guide in calculating the area of the offset to be provided (see **section 7**), based on probability of annual extinction for this category of statutory protection.
Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter	The size of the offset has been calculated using the Offsets Assessment Guide. Data regarding the size and quality of the area of threatened ecological communities impacted has been collected through field surveys undertaken by Cardno Chenoweth (2013) and SKM (2012). An analysis against the Offset Assessment Guide is contained in **Annexure H**.
Suitable offsets must effectively account for and manage the risks of the offset not succeeding	The use of direct offsets to satisfy 100% of SunWater's offset obligations will, as contemplated in the Policy, mitigate against the risk of the offsets not succeeding. A high confidence in result can be assumed for achieving a conservation gain in terms of improving the quality of the offset area in relation to the impacted (cleared area). This is because the quality of the impacted area is not high (a score of 5 is considered reasonable for the areas of threatened ecological community impacted) and the potential offset areas contain vegetation of similar condition. Improving the condition of the offset area from a 5 to score of 7 can be achieved by using management measures that reduce the impact of key threats. The key threats impacting upon the Coolibah – Black Box Woodlands ecological community are clearing and fragmentation; altered water flows and patterns; inappropriate grazing regimes; weed invasion (especially Lippia (*Phyla canescens*) and African Boxthorn (*Lycium ferocissimum*)); and the low level of protection in reserves (NSW Scientific Committee, 2009; TSSC, 2010). Key current threats to Brigalow are clearing, fire, plant and animal pests, and lack of knowledge (Butler 2007). The management plans implemented under the proposed voluntary declaration will address and manage for each of the identified key threats.
Suitable offsets must be additional to	Offsets are required under the Queensland Policy for

Policy Requirement	Strategy
what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action)	Vegetation Management Offsets and the EPBC Act will be co-located on properties that are being assessed by SunWater's offset broker. The identified offset areas are not within existing protected areas, are not being funded under any conservation scheme or program and are not being used to offset the impacts of any other project.
Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable	Offsets required under state policy will be aligned with EPBC offsets to maximise efficiency and effectiveness of environmental outcomes. Suitable areas and properties for the location of offsets have been identified by SunWater's offset broker and discussions have commenced with landholders regarding the creation of an offset on their property. See further discussion in **sections 9 to 11** of this BOS.
Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced	An offset management plan including monitoring of performance against clear success benchmarks will be prepared and implemented for the offset area. The offset area management plan will be implemented under the voluntary declaration made by the chief executive of the Department of Natural Resources and Mines as well as under contractual arrangements between SunWater and the landholder.

6 Calculation of Offset Area – VMA and PVMO

6.1 Ecological equivalence

The quantification of the ecological condition is based on the execution of the field and desktop methodologies documented in the **Ecological Equivalence Methodology** (EEM) Guideline (DERM, 2011).

The EEM has been developed in order to assess and demonstrate the ecological equivalence between an area proposed to be cleared (‘**clearing area’**) and an area being offered in exchange for the potential clearing (‘**offset area’**) (DERM, 2011). The results of this assessment for the Project are documented in **Annexure B** and summarised in **Section 6.2.**

Section 6.1 documents the field and desktop methodologies that have been utilised to execute the EEM.

6.1.1 Ecological equivalence fieldwork preparation

The following mapping layers were used in planning the BioCondition fieldwork and developing the assessment units:

- Cardno Chenoweth vegetation mapping (2012);
- Vegetation Management Act Remnant Watercourses Version 2.1 (2011);
- Regional Ecosystem Mapping Version 6.1 (2011);
- Vegetation Management Act Essential Habitat Version 3.1; and
- Vegetation Management Act Great Barrier Reef Wetlands Version 2.1 (2011).

Vegetation to be cleared was grouped into assessment units based on regional ecosystem (RE) type. These assessment units were then assessed in the field to gather BioCondition field data, required for the ecological condition assessment of the impacted vegetation (under the EEM). The number of assessment units was further refined in the field when notable variation was observed in condition between patches of a single RE (**Section 6.1.2**).

6.1.2 Assessment units

Vegetation within the pipeline easement was stratified in to nine homogenous assessment units, covering the REs listed in **Table 1**. BioCondition plots of 1 hectare were then established in each of these assessment units in the field (**Table 9**). One RE, 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains), was found to occur as two different condition classes. Consequently, this RE was separated into two assessment units. Whist undertaking the BioCondition fieldwork surveys it was identified the remnant RE 11.3.1 utilised for the survey was representative of the condition of RE 11.9.5 along the pipeline. Consequently condition data from this patch was considered sufficient to provide an overall ecological condition score for 11.3.1 and 11.9.5.

Table 9 - BioCondition plots

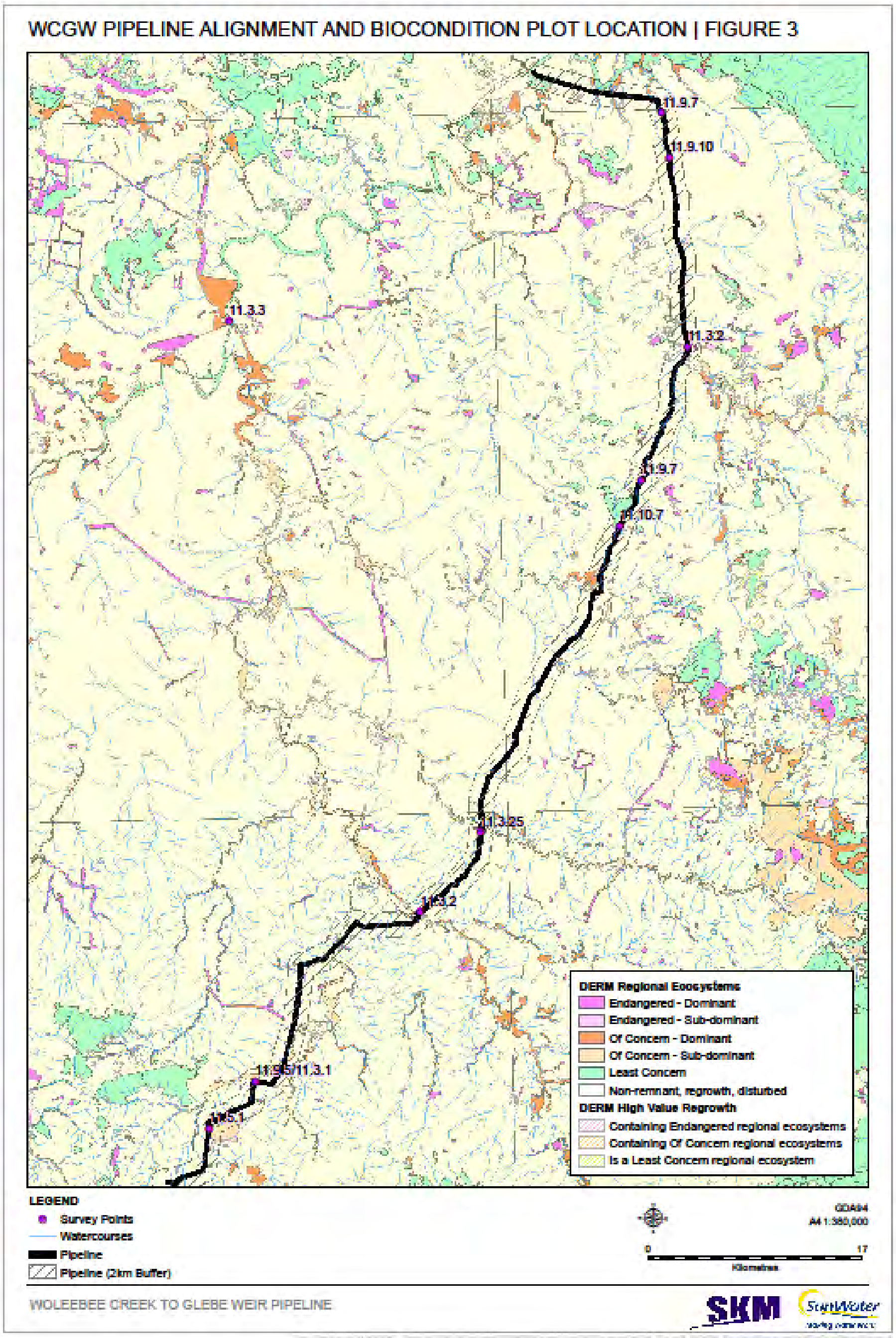
BioCondit ion Plot	Location (GDA 1994; Zone 56)	Property	RE	Reason for BioCondition Assessment
0406B1	192916, 7113052	Lot 2 RP170076	11.3.2 (poor condition)	Of concern
0506B1	197654, 7119341	Lot 60 FT904	11.3.25	Near watercourse
0506B2	176169, 7095875	Lot 160 FTY794	11.5.1	Near watercourse
0606B1	179855, 7099565	Weldons Rd, adjacent Lot 2 RP123884	11.9.5/11.3.1	Endangered
0606B2	208719, 7143649	Lot 2 FT880	11.10.7	Near watercourse
0606B3	210402, 7147298	Lot 8 SP152696	11.9.7	Of concern
0606B4	214079, 7157923	Lot 29 FT668	11.3.2 (good condition)	Of concern
0706B1	212667, 7172902	Cracow Rd, adjacent Lot 3 FT733	11.9.10	Of concern
0706B2	212055, 7176479	Lot 3 FT733	11.9.7	Of concern
0706B3	177773, 7159942	Leichhardt Highway road reserve	11.3.3	Of concern

6.1.3 Ecological equivalence calculation on Lot 14on FT1 and Lot 2 on FT734

Remnant vegetation that will be affected by the pipeline on Lot 14 on FT1 and Lot 2 on FT734 is RE 11.3.3 and 11.3.25. SunWater has not had landholder permission to undertake BioCondition assessments on these properties until recently and it is anticipated to complete the BioCondition assessment in the near future and this offset strategy updated accordingly. In the absence of BioCondition field data the ecological equivalence of remnant vegetation on the two properties, has been conservatively calculated based on the assumption of best condition vegetation. For this purpose an estimate of the BioCondition of vegetation from areas of 11.3.3 and 11.3.25 on nearby properties was used.

Spatial analysis of the special features to calculate the ecological equivalence score was completed using the publically available datasets.

Figure 3 - WCGW Pipeline alignment and BioCondition assessment unit sites



6.2 Ecological equivalence assessment

Tables 10, 11 and 12 provide summary tables of the ecological condition and special feature scores for each assessment unit of the clearing area, respectively.

Table 10 - EEM ecological condition scores

Ecological Condition Indicators	Clearing Area EE Scores							
	11.3.1 & 11.9.5*	11.3.1 Best	11.3.2 Poor	11.3.2 Good	11.3.3 Best	11.9.7	11.9.10	11.9.10 Best
	BVG 25a	BVG 25a	BVG 17a	BVG 17a	BVG 16c	BVG 17a	BVG 25a	BVG 25a
1. Recruitment of woody perennial species	3	5	0	5	5	5	0	5
2. Native plant species richness								
a. Tree species	5	5	5	5	5	2.5	5	5
b. Shrub species	5	5	2.5	5	5	2.5	5	5
c. Grass species	5	5	2.5	5	5	5	5	5
d. Forbs and other species	5	5	2.5	2.5	5	2.5	0	5
3. Tree canopy height	5	5	5	5	5	5	5	5
4. Tree canopy cover	5	5	2	5	5	5	2	5
5. Shrub canopy cover	3	5	0	3	5	3	3	5
6. Native perennial grass cover	5	5	5	5	5	5	5	5
7. Organic litter	3	5	3	5	5	3	3	5
8. Large trees	5	15	0	5	15	10	10	15
9. Coarse woody debris	5	5	2	2	5	5	5	5
10. Weed cover	0	10	5	5	10	5	0	10
11. Size of patch	6	2	5	10	10	2	5	2
12. Connectivity	2.75	2	4	3.5	3	1	1	2
13. Context	2	2	2	2	3	0	1	2
Sum of score	64.75	86.00	45.50	73.00	96.00	61.50	55.00	86.00
Area (ha)	0.97	0.28	0.54	1.25	0.85	0.96	0.49	0.28
Assessment unit ecological condition score	0.63	0.24	0.25	0.91	0.82	0.59	0.27	0.24

*BioCondition data for these two REs was obtained from a remnant 11 3.1 vegetation patch that was found to be reasonably representative of 11.9.5 that occurs in the pipeline easement. Condition data from this patch was considered sufficient to provide an overall ecological condition score for BVG 25a.

Table 11 - EEM special feature scores

Ecological Condition Indicators	Clearing Area Assessment Units							
	11.3.1 & 11.9.5*	11.3.1 Best	11.3.2 Poor	11.3.2 Good	11.3.3	11.9.7	11.9.10	11.9.10 Best
	BVG 25a	BVG 25a	BVG 17a	BVG 17a	BVG 16c	BVG 17a	BVG 25a	BVG 25a
1. Centre of endemism	0	0	0	0	0	0	0	0
2. Wildlife refugia	0	0	0	20	0	0	17	0
3. Disjunct populations	0	0	0	0	0	0	0	0
4. Taxa at limits of geographical range	0	0	0	0	0	0	0	0
5. High species richness	0	0	0	0	0	0	0	0
6. Relictual populations	0	0	0	0	0	0	0	0
7. Regional ecosystems with distinct variation in species	0	0	0	0	0	0	0	0
8. Artificial water body of ecological significance	0	0	0	0	0	0	0	0
9. High density hollow bearing trees	0	0	0	0	0	0	0	0
10. Breeding or roosting areas	0	0	0	0	0	0	0	0
11. Strategic ecological corridor	0	0	17	18.5	18.5	0	0	0
12. Priority species within bioregion	0	0	5	0	0	0	0	0
13. Significance of patch within 1km	4.375	5	2.5	5	3.75	10	6.25	5
14. Protected area estate buffer	0	0	0	0	0	0	5	0
Sum of score	4.38	5.00	24.50	43.50	22.25	10.00	28.25	5.00
Area (ha)	0.97	0.28	0.54	1.25	0.85	0.96	0.49	0.28
Special features score	0.04	0.01	0.13	0.54	0.19	0.10	0.14	0.01

*BioCondition data for these two REs was obtained from a remnant 11 3.1 vegetation patch that was found to be reasonably representative of 11.9.5 that occurs in the pipeline easement. Condition data from this patch was considered sufficient to provide an overall ecological condition score for BVG 25a.

Table 12 - Overall ecological condition and special features scores of the clearing area by BVG

BVG	Ecological Condition Score	Special Features Score
16c	0.816	0.189
17a	1.747	0.257
25a	1.370	0.104

7 Calculation of Offset Area – EPBC Act

Offset areas under the EPBC Act Environmental Offset Policy are calculated in accordance with the offset guide annexed to the Policy.

While condition 6 of the EPBC Act approval requires that offset areas be calculated in accordance with the consultation draft of the Policy, SunWater has (at the Department's request) calculated offset areas in accordance with the version of the assessment guide contained in the final version of the policy.

Assessment guide calculations for both Brigalow and Coolibah are contained in **Annexure H**.

The assessment guide calculations indicate that 18.4ha should be provided at the currently preferred offset area to offset the Brigalow to be cleared. The identified offset area is 20ha in area, which exceeds that requirement.

The assessment guide calculations indicate that 8.7ha should be provided at the currently preferred offset area to offset the Coolibah to be cleared. The identified offset area is 20ha in area, 10ha of which will be provided as an offset for this project with the balance to be retained as a potential advance offset area to be relied upon by SunWater for future projects.

8 Delivery of Offsets

8.1 Appointment of offset broker

SunWater has appointed a third party offset broker, Herron Todd White (Environmental) Pty Ltd trading as Earthtrade Environmental Brokers to deliver the Woleebee Creek to Glebe Weir Pipeline Project offsets. SunWater proposes to obtain SEWPaC's approval of SunWater's appointment of this offset broker for the delivery of the offsets required under its Commonwealth approval as part of the approval of this BOS.

Earthtrade is an environmental broker specialising in:

- Offsets required by Government to meet Environmental Approvals and development application requirements under various Acts.
- Legally binding mechanisms on title to secure the offsets.
- Management plans for offset areas.
- Carbon sequestration projects.
- Project design of offsets to ensure the property has options for other uses.
- Associated Environmental Technical Services1.

Earthtrade will deliver offset areas to satisfy SunWater's offset obligations under its approval under the *Environment Protection and Biodiversity Conservation Act 1999* as well as the offset obligations under its approval to clear vegetation under the Queensland *Sustainable Planning Act 2009* and the *Vegetation Management Act 1999*.

8.2 Mechanism for legally securing offsets

SunWater proposes to legally secure the offsets by way of a voluntary declaration under the VMA. The use of a voluntary declaration to legally secure the offset areas is specifically contemplated in condition 6 of the EPBC Act approval, by way of the definition of 'Legally Secure', and is specifically contemplated as a mechanism for delivering offsets under the Queensland Policy for Vegetation Management Offsets.

Section 19E of the VMA allows an owner of land (including a lessee of state leasehold land) to apply to the chief executive of the Queensland Department of Natural Resources and Mines to have an identified area of their land declared to be an area of high nature conservation value, including where the relevant area contains a vegetation clump or corridor that contributes to the maintenance of biodiversity and/or where the area can make a significant contribution to the conservation of biodiversity.

A declaration of this type (commonly referred to as a 'voluntary declaration') is registered on the title to the land under s19K of the VMA and is binding on successors in title. The voluntary

[1] Earthtrade (2013) HTWE Capability Statement http://www.earthtrade.net.au/

declaration will require the implementation of a management plan which will identify the management outcomes to be achieved in the offset area and the actions to be taken by the landholder to achieve those outcomes. A voluntary declaration will, in this way, deliver long term protection to the offset areas and ensure that the vegetation quality and biodiversity values of the offset areas are enhanced.

The voluntary declaration will then remain in effect until the chief executive determines, under s19L of the VMA, that the management outcomes in the management plan have been achieved. The outcomes of the management plan will include the mapping of each offset area as remnant vegetation under the VMA with the result that the offset areas will, at the end of the process, have a much higher degree of protection under Queensland laws and are, in this way, permanently protected.

SunWater proposes to specify in the management plan that the offset area will remain subject to the voluntary declaration until the earlier of 2052, or the vegetation in the offset area(s) is mapped as having achieved remnant status under the Queensland VMA. Earthtrade's assessment of the quality of the vegetation in the proposed offset areas indicates that remnant status should be achievable in a period well short of 20 years.

8.3 Progress towards delivery of offsets

Earthtrade will deliver SunWater's offset obligations by undertaking the necessary steps to identify potential offset areas, negotiate with landholders to enable SunWater to acquire rights over preferred offset areas and will then ensure that the necessary steps are taken to legally secure the final offset areas. Some of those steps have been completed, or nearly so, other steps remain currently in progress or outstanding.

8.4.1 Acquisition of rights over offset areas

Step 1: Site identification

An offset availability analysis was undertaken by Earthtrade, the results of which are set out in the report entitled 'Offset Obligations & Potential Offset Identification', which is contained in **Annexure G.** The report identified the 13 best offset opportunities within 150km of the project sites.

SunWater and Earthtrade then identified the preferred target sites.

As discussed in more detail below, the preferred target sites are Lot 1 on RP50207 ('Killara) in relation Brigalow and Lot 10 on RP880092 ('Hornet Bank') in relation to Coolibah.

Step 2: Negotiation to acquire

Earthtrade discussed with the landholders of both properties in March 2013 and both have agreed in principle to the use of their properties as offset areas. Letters evidencing the landholders' agreement in principle are contained in **Annexure I.**

Step 3: Field assessment

Earthtrade has now completed a field assessment to identify the ecological values of the proposed offset sites, involving a BioCondition assessment of the vegetation. The results of the field assessment are discussed in detail below.

Step 4: Acquisition

Following the field assessment, each landholder was provided with a draft call option and financial agreement to be entered into between the landholders and SunWater. When executed, those agreements will provide SunWater with the rights to utilise each area as an offset for this project and will establish the process for the offset areas to be legally secured and managed.

The draft call options are contained in **Annexure J**.

Step 5: Legally secure

Once the call option has been entered into, the landholder and Earthtrade will take all necessary steps to finalise the management plan and to proceed towards a voluntary declaration of the offset area as an area of high nature conservation value under the VMA.

It is expected that this process will be finalised within 12 months of the commencement of the action approved under the EPBC Approval.

Step 6: Compliance with condition 6(b)(v)

SunWater expects to have entered into the call options with the landholders and to be in a position, by 3 June 2013, to submit a final offset package which will comply with condition 6(b)(v) of the EPBC Act approval and include:

(i) A report outlining:

(A) the TEC that will be impacted upon by the project;

(B) general information about the proposed offset areas;

(C) the proposed legally binding mechanism;

(D) outcomes of the management plans:

(1) location and boundaries of the offset areas;

(2) timing;

(3) responsibilities and performance criteria;

(4) monitoring and management program;

(5) reporting procedure;

(6) risks and risk management; and

(7) any other legislative or policy requirements that need to be addressed to demonstrate how the proposed offsets meet the policy requirements;

(ii) A copy of the final Offset Area Management Plan for each site;

(iii) A copy of the following maps for each offset area:

(A) Context Map (where property located in landscape);

(B) Qld Regional Ecosystem Map;

(C) Qld PreClear Mapping; and

(D) Offset Area Map;

(iv) Field Verification Reports including an assessment of composition and ecological condition of the impact site and the offset site as well as a ground verification report of the offset site;

(v) Wildlife Online extract for each offset property.

8.4 Contingency planning

While SunWater and Earthtrade expect that the preferred offset sites will be the final offset sites, there are other options which will be pursued in the event negotiations with the landholders of the preferred sites are unsuccessful for any reason.

The Earthtrade report in **Annexure G** identifies additional offset options which will be given further consideration in the event the preferred options do not proceed.

If necessary, Earthtrade will also proceed to generate additional options by, for example, investigating options further from the site of the clearing or sites which were less preferred for other reasons.

As a final option, SunWater may ask for the intervention of the Coordinator-General under the *State Development and Public Works Organisation Act 1971 (Qld)* (**SDPWOA**). The Coordinator-General has the power, under s125 of the SDPWOA, to undertake compulsory acquisition for works to be carried out by a 'local body' such as SunWater where those works are included in a program of works or a 'works regulation' made under Part 6, Division 3 of the SDPWOA. Should it become necessary to do so, SunWater will approach the Coordinator-General to proceed with a program of works or works regulation for this project which includes the offsets necessary for the project. Once that instrument is in effect, the Coordinator-General may compulsorily acquire offset areas required for the project.

9 Proposed Offset Areas

Approximately 5.202 ha of Endangered and Of Concern remnant vegetation cleared for the pipeline easement must be offset in accordance with the PVMO and Regional VM Code (under PR P7).

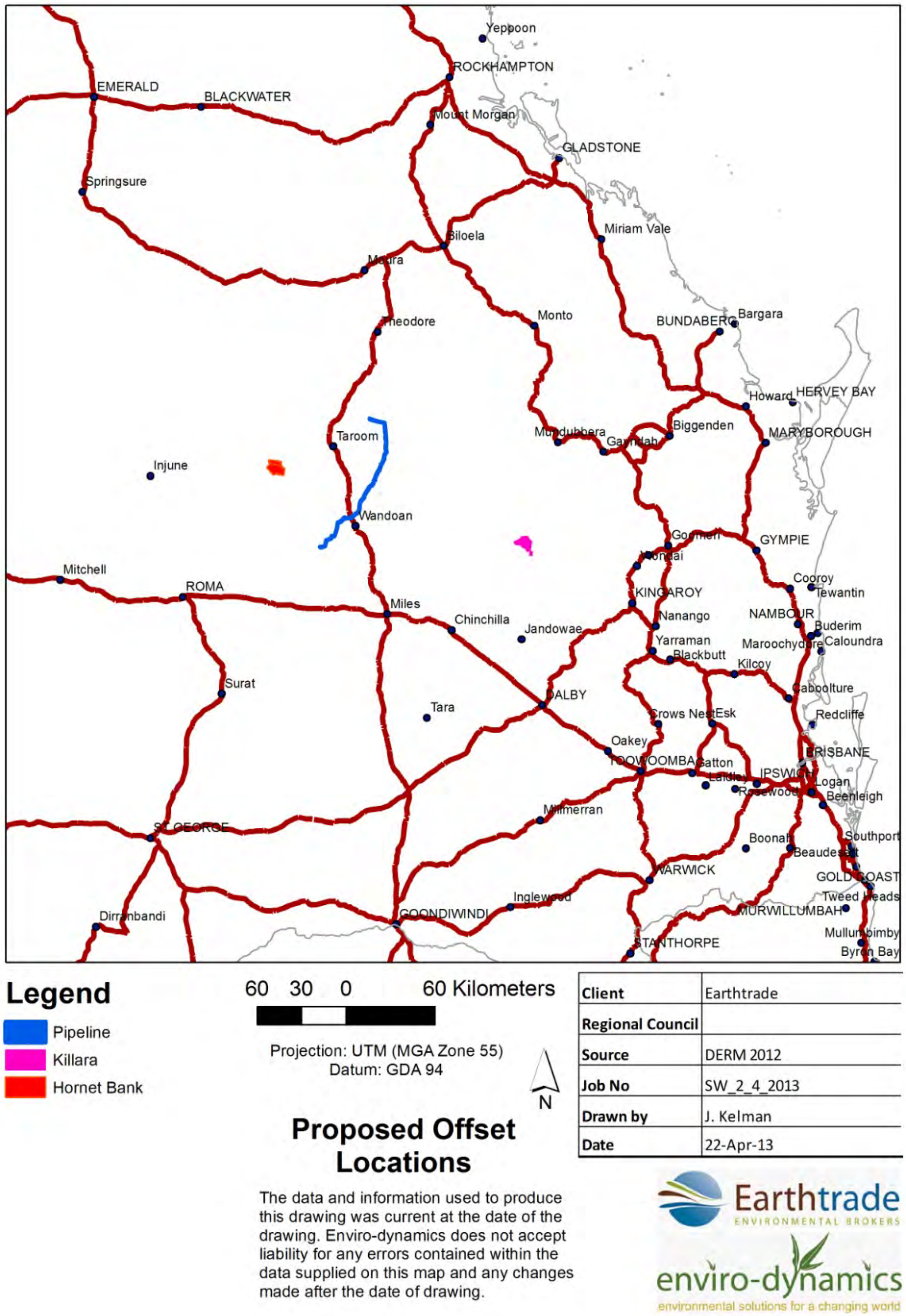
The following areas of threatened ecological community (**TEC**) under the EPBC Act will be cleared and offset under the EPBC Act Environmental Offsets Policy:

- 2.08 ha of Brigalow; and
- 1.38 ha of Coolibah.

Offsets under the EPBC Act will be collocated within the PVMO offset area for PR P7 (Endangered and Of Concern remnant vegetation).

Earthtrade has located potential offset areas for the EPBC Act offsets for Brigalow and Coolibah. Those areas will also satisfy part of the obligations under the Queensland VMA and PVMO, with an additional site to fully satisfy the other state-level requirements.

Figure 4 - Locations of preferred offset areas



9.1 Brigalow

Conditions 6(b)(i) and 6(b)(v) of the EPBC Act approval require that the Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community be offset, in accordance with the EPBC Offset Policy and protected with a legally binding mechanism.

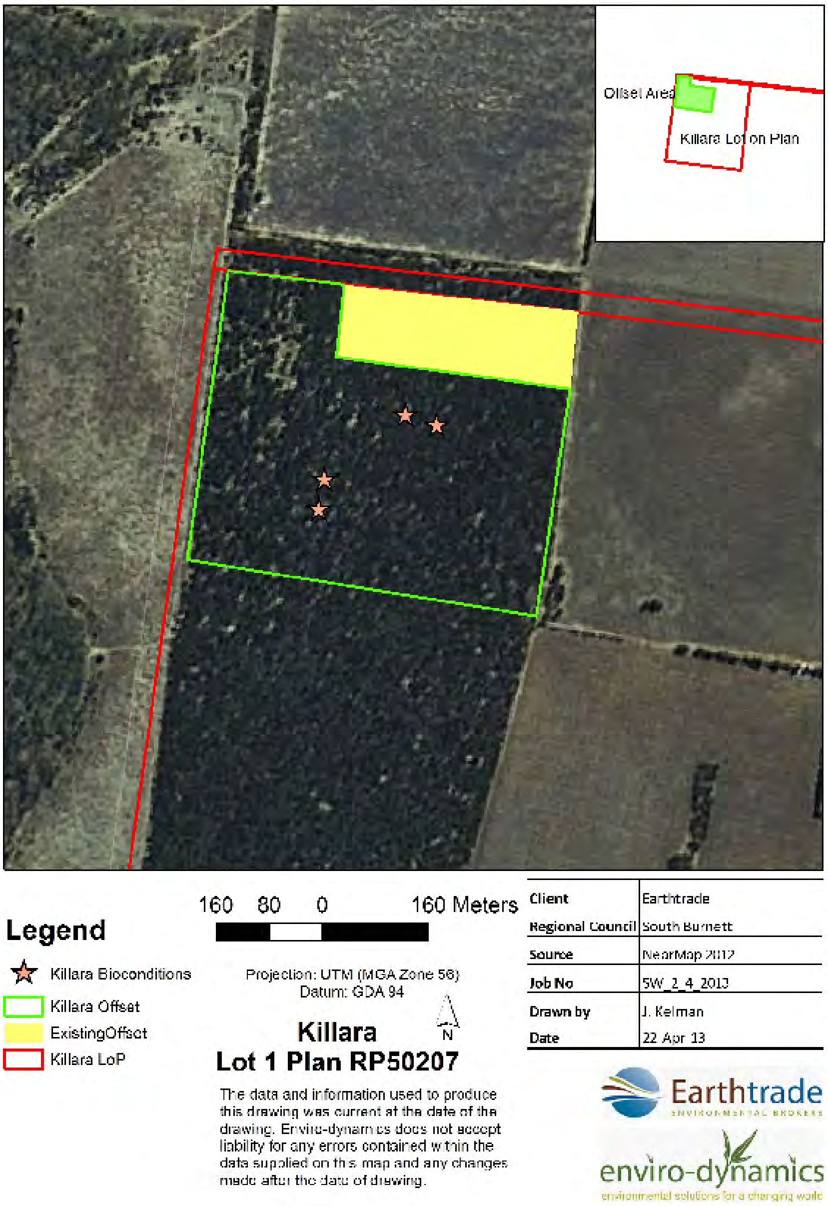
SunWater's offset broker has identified an offset area which will, if agreement is reached with the landholder, satisfy this condition on the property "Killara", which is located approximately 230km north-west of Brisbane, 75 km north-west of Kingaroy and 15 km west of Durong (see **Figure 5**). This is within the Southern Brigalow Belt Bioregion. The location of the Brigalow offset is within a heavily vegetated portion of the property that borders the Baracula State Forest.

The proposed offset area is currently mapped as "Category X" on a Property Map of Assessable Vegetation (**PMAV**). This means that, without protection as an offset, they may be cleared without a development permit under the Queensland SPA/VMA. The area contains vegetation over 20 years of age with the majority of the areas containing vegetation in excess of 25 years. The entire area is in good condition due to the current management practices of the landowner.

9.1.1 Botanical survey of proposed Brigalow offset area

Following a desktop appraisal and an initial reconnaissance survey of the proposed offset area undertaken by Earthtrade in March 2013, a full botanical field survey of the proposed offset area was undertaken in April 2013 (see **Annexure K**). The Field Verification was done via both BioCondition assessment sites and a foot traverse of the proposed Offset Area. **Figure 5** indicates the area surveyed and the location of the BioCondition sites.

Figure 5 - Brigalow offset area map



9.1.2 Results of botanical field survey – Brigalow

A total area of 20 ha of vegetation possessing characteristics of the Brigalow TEC (Regional Ecosystem 11.4.3) was identified within the offset area. The BioCondition sites surveyed within and adjacent to the offset area belong to the regional ecosystem 11.4.3. This community is considered to be part of the Brigalow communities protected under the EPBC and is listed as Endangered in Queensland.

The BioCondition of the non-remnant site for Brigalow community is in a condition class 3, a poor functioning regional ecosystem.

The reason for the offset site not meeting a higher class is mainly due to the high stem density of the regrowth. This has resulted in a lack of large trees, low species richness of shrubs and grasses and a lack of recordable course woody debris. The canopy tree height is lower than the benchmark due to the trees not being mature (see **Figure 6** and **Figure 7**) and there is a small infestation of *Optunia tomentosa* (velvety tree pear) in the woodland. Mostly the site is in a good condition. The offset proposed exceeds Ecological Equivalence (refer to the EEM results sheet at **Annexure L**). Both the offset and cleared site were in a condition 3 class. The area has recognised value as a centre of endemism, as wildlife refugia and represents a disjunct population (please refer to Figure 4.6 in the report at **Annexure K**).

The EPBC Offset Calculator results are also attached at **Annexure H**.

Figure 6 - Acacia harpophylla woodland with melon hole wetlands at Killara

Figure 7 - *Acacia harpophylla* regrowth height at Killara

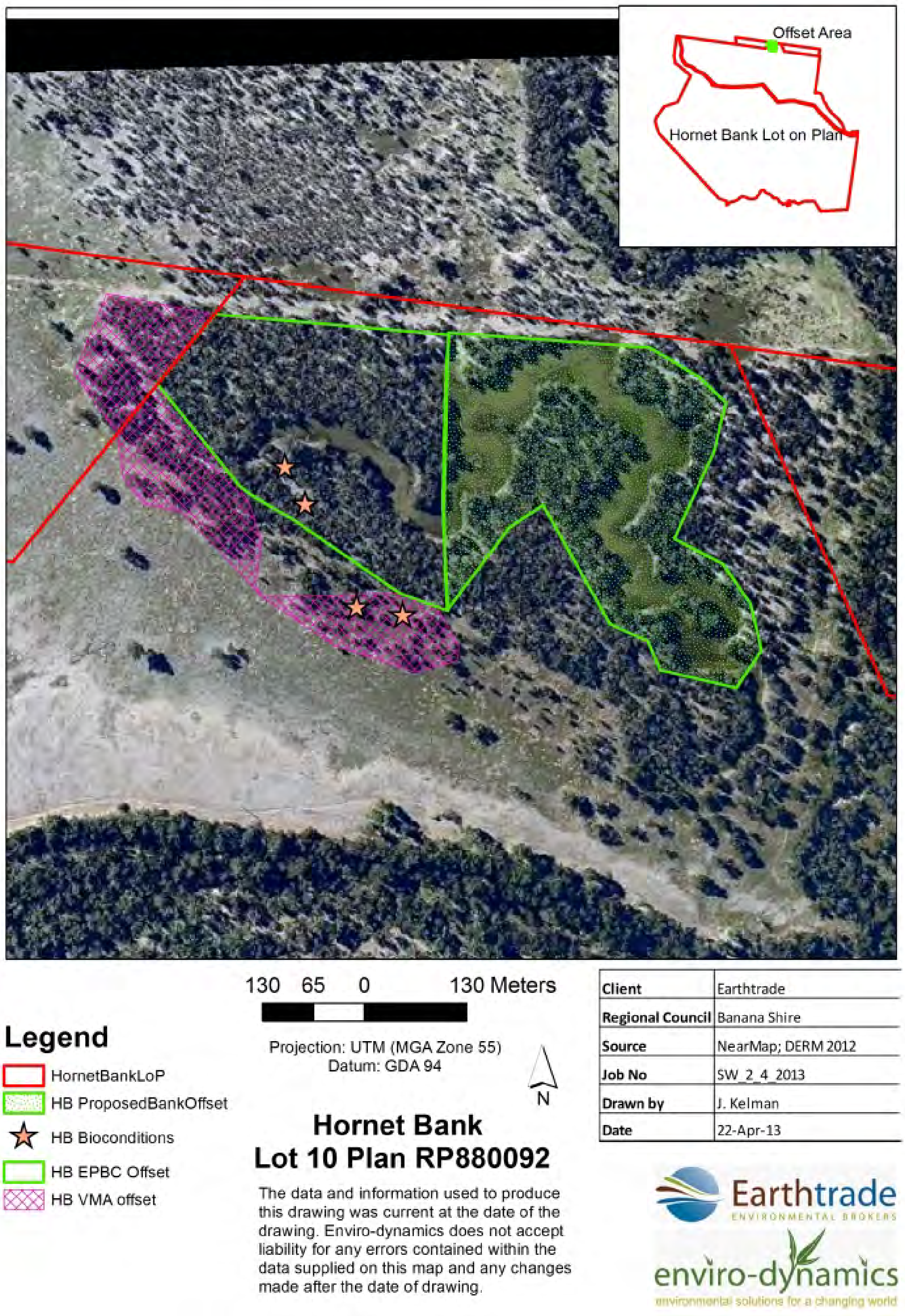
9.2 Coolibah

Condition 6(b)(ii) and (v) of the EPBC Act approval requires that the proponent register a legally binding mechanism over an offset to mitigate the impacts to the Threatened Ecological Community Coolibah-Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions.

The preferred site to satisfy the Coolibah offset is located on “Hornet Bank”. Hornet Bank is 39km west of Taroom and adjoins the Dawson River on both sides. The Dawson River is recognised as a bioregional corridor of State and regional significance.

There are contiguous links of Coolibah that extend from, and through the offset site. The offset site itself strengthens a patch of Coolibah which links to other vegetation thus improving connectedness to the Dawson River system. This enhances the ability for movement for fauna requiring cover across the landscape.

Figure 8 - Coolibah Offset Area Map



9.2.1 Results of botanical field survey - Coolibah

Following a desktop appraisal of the proposed offset area undertaken in March 2013, a full botanical field survey of the proposed offset area was undertaken in early April 2013 (**Annexure K**). This was done via both BioCondition assessment sites and a foot traverse of the proposed Offset Area.

The BioCondition of the remnant offset site for *Eucalyptus coolabah* community shows the community to be in a condition class 2, a mostly functioning regional ecosystem.

The reason for the offset site not meeting the highest class is due to a small infestation of weeds including *Xanthium pungens* (Noogoora burr), *Malvastrum americanum* and *Ludwigia peploides*. Another reason is the lower level of coarse woody debris at the site. On the whole the site is in very good condition. The offset proposed considerably exceeds Ecological Equivalence (refer to the EEM results sheet in **Annexure L**). Both the offset and cleared site were both in condition 2 class. The offset site has significant special ecological features for wildlife refugia and lies within a regional wildlife corridor. (please refer to Figure 4.4 in the report at **Annexure K**).

The EPBC Offset Calculator results are also attached at **Annexure H**.

At Hornet Bank there is an obvious visible difference between the remnant Coolabah woodland and the regrowth Coolabah. In the remnant area there is a mature Coolabah canopy with a sparse grassy understorey. The soil is a silty clay loam. The woodland is intermixed with palustrine wetlands. The regrowth site is connected to the remnant woodland. The canopy is dominated by *Eucalyptus coolabah* with a mid-tree layer of occasional *E. populnea* and *Acacia salicina*. There is a grassy understorey dominated by *Bothriochloa bladhii.* There are clear signs of occasional water inundation. The remnant and non-remnant areas are structurally different in the understorey with considerably more vegetative ground cover in the non-remnant areas due to the lack of canopy cover.

Figure 9 - Remnant Coolibah woodland surrounding palustrine wetlands at Hornet Bank

10 Management of Offset Areas

The offset areas will be managed in accordance with a management plan which will be attached to the voluntary declaration. Draft versions of the management plans for both the Coolibah and the Brigalow offset areas are contained in **Annexure M.** The management plans will be further refined in consultation with the landholders and with the Queensland Department of Natural Resources and Mines during the voluntary declaration process.

The management plans have been specifically developed to address the requirements of condition 6(b)(i) and (ii) of the EPBC Act approval and the EPBC Act Environmental Offsets Policy. The management actions for each area are detailed below.

10.1 Management actions

The intent and outcome of the Management Plan is to undertake:

> *"Management actions to protect and enhance the extent and condition of the endangered ecological communities and threatened species habitat values, including rehabilitation, weed control, fire management, erosion and sediment control, management of livestock and restrictions on access, within the offset areas".*

10.2 Brigalow

The management actions for the proposed Brigalow offset area will be undertaken in accordance with the *Recovery Plan for the Brigalow (Acacia harpophylla dominant and co-dominant) endangered ecological community*. A summary of the draft management actions is contained in **Table 13** below, with a more detailed discussion contained in the draft management plan in **Annexure M**.

Table 13 – Summary of draft management actions for Brigalow offset area Lot 1, RP50207

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
Offset Area: Lot 1 on RP 50207							
Weed Management	Maintain the existing weed monitoring and control program including the use of biological control agents for the Tree Pear to ensure that the weed cover does not exceed 5% cover of the total Offset Area. The Landowner will manually spread the biological control agents.	Biological Control of Tree Pear throughout property to ensure that the weed cover does not exceed 5% cover of the total Offset Area	Maintained for the life of this Management Plan	Landowner	Written records of the landowner as per the landholder's records below. Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns.		3 x per year @ $55/ha = $165/ha Management period = approx. 20 years = $3,300.00
Fire Management	Maintain fire breaks to enhance biodiversity and reduce fuel loads. All practical measures are	Throughout property	Maintained for the life of this Management Plan	Landowner in conjunction with neighbours	Written records of the landowner as per the landholder's records below.		Every second year at $30/ha

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
	maintained to exclude fire from the Offset Area by the maintenance of the road and firebreaks on a biannual basis. The ground cover is to be determined as per Attachment 3: Land Manager's Monitoring Guide, Level 1.				Ground cover is to be recorded in the Landowner Records. Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns.		Management period = approx. 20 years
Thinning by Tordoning	- thinning of *Acacia harpophylla* only - thinning must be conducted by tordoning using the method of applying the poisonous chemical to cut stumps or through stem injection; - thinning must only occur	Areas shown in red polygons on the maps at Attachment 1	Maintained for the life of the agreement	Landowner	Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052.		Thinning by Tordoning 1 treatment for the life of the plan at $430/ha

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
	when data collected from a line plot (in the manner outlined in Attachment 2, shows that the stem count is greater than 10,000 per hectare; - thinning must not reduce the stem count to less than 4,000 per hectare				BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. The stem count result from the line plot is to be recorded in the Landowner Records.		
Biodiversity Management	Allow the accumulation of fallen timber/debris and the establishment of natural undergrowth	Offset Area	Maintained for the life of this Management Plan	Landowner	Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns.		N/A
Restricted Access	The Landowner restricts access to only those invitees, employees and	Offset Area	Maintained for the life of this Management	Landowner	N/A		N/A

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
	subcontractors that are permitted on the entire property.		Plan				
Landowner Records	The Landowner is to maintain records outlining the following: 1. The date in which livestock are put on the paddock to which the Offset Area forms a part and the date in which the livestock are removed; 2. The number of head of livestock that are grazed on the paddock to which the Offset Area forms a part; 3. The type of livestock that is grazed on the paddock (Sheep, Cattle, Dry Cows, Steers, Cows with calves etc); 4. The amount of rainfall that the Offset Area has had for each quarter (Spring, September to November, Summer, December to February, Autumn, March to May, Winter, June to	Offset Area	Maintained for the life of this Management Plan	Landowner	Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns (being the BioCondition Assessment report obtained from SunWater)	As detailed in Section 7	N/A

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
	August); 5. Ground cover specified as a requirement in Section 6.3.1; and 6. Stem count specified as a requirement in Section 6.2.2 before thinning may be conducted.						
Monitoring and Reporting as required by Sections 7 and 8	Refer to Section 7 of this Management Plan	Offset Area	Maintained for the life of this Management Plan	SunWater, its agents, subcontractors or assigns	Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns.		

10.3 Coolibah

The proposed Coolibah offset area is in good condition due to previous management by the owners. Further appropriate and adaptive management of the offset area will enhance the quality of these woodlands, which have good prospects for rehabilitation with the appropriate management actions.

The Management Actions for the woodland offset area have been prepared in accordance with the advice contained in the "Listing Advice for the Coolibah and Black Box Woodlands" and the "Conservation Advice for the Coolibah and Black Box Woodlands". A summary of these draft management actions is provided at **Table 14** below, with further details contained in the draft management plan in **Annexure M.**

Table 14 – Summary of draft management actions for Coolibah offset area on Lot 10, RP880092

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
Offset Area: Lot 10 RP 880092							
Weed Management	Maintain the existing weed monitoring and control program including the use of biological control agents for the *Noogoora burr* to ensure that the weed cover does not exceed 5% cover of the total Offset Area. The Landowner will manually spread the biological control agents.	Biological control of *Noogoora burr* throughout property to ensure that the weed cover does not exceed 5% cover of the total Offset area	Maintained for the life of this Management Plan	Landowner	Written records of the landowner as per the landholder's records below. Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1		3 x per year @ $55/ha = $165/ha Management period = approx. 20 years = $3,300.00

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
					October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns.		
Fire Management	Maintain fire breaks to enhance biodiversity and reduce fuel loads. All practical measures are maintained to exclude fire from the Offset Area by the maintenance of the road and firebreaks on a biennial basis. The ground cover is to be determined as per Attachment 3: Land Manager's Monitoring Guide, Level 1.	Throughout property	Maintained for the life of this Management Plan	Landowner in conjunction with neighbours	Written records of the landowner as per the landholder's records below. Ground cover is to be recorded in the Landowner Records. Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater,		Every second year at $30/ha Management period = approx. 20 years

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
					its agents, contractors or assigns.		
Biodiversity Management	Allow the accumulation of fallen timber/debris and the establishment of natural undergrowth	Offset Area	Maintained for the life of this Management Plan	Landowner	Written records of the landowner as per the landholder's records below. Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns.		N/A
Restricted Access	The Landowner restricts access to only those invitees, employees and subcontractors that are	Offset Area	Maintained for the life of this Management Plan	Landowner	N/A		N/A

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
	permitted on the entire property.						
Landowner Records	The Landowner is to maintain records outlining the following: 1. The date in which livestock are put on the paddock to which the Offset Area forms a part and the date in which removed; 2. The number of head of livestock that are grazed on the paddock to which the Offset Area forms a part; 3. The type of livestock that is grazed on the paddock (Sheep, Cattle, Dry Cows, Steers, Cows with calves etc); 4. The amount of rainfall that the Offset Area has had for each quarter (Spring, September to November, Summer, December to February, Autumn, March to May, Winter, June to August);	Offset Area	Maintained for the life of this Management Plan	Landowner	Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns (being the BioCondition Assessment report obtained from SunWater)	As detailed in Section 7	N/A

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress	Comments	Costs
	and 5. Ground cover specified as a requirement in Section 6.3.1.						
Monitoring and Reporting as required by Sections 7 and 8	Refer to Section 7 of this Management Plan	Offset Area	Maintained for the life of this Management Plan	SunWater, its agents, subcontractors or assigns	Annual monitoring in all Offset Areas for the first six years after the commencement of operations and subsequently every two years until either remnant status is achieved or 1 October 2052. BioCondition monitoring every 7 years, starting at year 7, until either remnant status or 1 October 2052. This monitoring to be undertaken by SunWater, its agents, contractors or assigns.		

11 EPBC Act Environmental Offsets Policy

11.1 Desired outcomes/objectives of management plans

Section 7.8 of the EPBC Offset Policy and condition 6(b)(i) and (ii) require that the Management Plan include *"transparent governance arrangements including being able to be readily measured, monitored audited and enforced".* These management outcomes/intents for the Offset Areas are set out in the draft Management Plans which forms **Annexure M** of this Biodiversity Offsets Strategy.

These draft management plans will be registered on the title of the property in conjunction with the Voluntary Declarations as areas of High Nature Conservation Value. This effectively forms contractual arrangements between the Queensland Government enforceable under the *Vegetation Management Act 1999*.

In summary, these outcomes are:

MANAGEMENT OUTCOMES:

a. The Declared Areas will be managed; restored and protected until the vegetation in the Offset Area achieves a good condition for the Threatened Ecological Communities (i.e. until the site is mapped as remnant vegetation under the VMA) or until 2052 (whichever occurs first). The area will be managed to enhance the presence of characteristic vegetation communities; including:

1. Maintenance and enhancement of natural groundcover
2. Stock management for fuel load reduction
3. Control of weed species
4. Maintenance and enhancement of natural tree and shrub regeneration
5. Exclusion of fire whenever practically possible

b. Habitat values associated with the Areas will be maintained or enhanced and protected through management, including:

1. Retention of habitat trees, including dead and fallen timber,
2. Application of fire management (only as necessary) as per Annex B that enhances the vegetation community
3. Exclusion of fire whenever practically possible

The progress of the offset will be monitored in accordance with section 11.4 below and the methodology for the monitoring will be the use of the BioCondition methodology as developed by the Queensland Herbarium.

The BioCondition methodology is described in Eyre, T.J., Kelly, A.L, Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M.J. and Franks, A.J. (2011). *BioCondition: A Condition Assessment Framework for Terrestrial*

Biodiversity in Queensland Assessment Manual Version 2.1. Department of Environment and Resource Management (DERM), Biodiversity and Ecosystem Sciences, Brisbane.

11.2 Location and boundaries of offset areas

Condition 6.iv and v. of the EPBC Act approval require that the offsets be contiguous and include:

> *"a clear definition of the location and boundaries of the offset areas, through maps and/or textual descriptions as well as an accompanying shapefile".*

The appendices to this Biodiversity Offset Plan include the following:

- Brigalow Offset Area – Map showing location at Schedule 2, Attachment 1 of the Killara Management Plan. The map is reproduced, for ease of reference, at **Annexure N**; and
- Coolibah Offset Area – Map showing location at Schedule 2, Attachment 1 of the Hornet Bank Management Plan. The map is reproduced, for ease of reference, at **Annexure N**.

Shapefiles for each proposed offset area have been provided on an accompanying CD to this document.

11.3 Timing, responsibilities and performance criteria

EPBC Offset Policy clause 7.8 requires that the offset have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

As such, the Management Plans include details of:

- the timing, responsibilities and performance criteria for the management actions;
- details of parties responsible for monitoring, reviewing and implementing the plan.

These details are included in the Schedule of Management Activities attached to the draft Offset Management Plans.

With respect to all offset areas, the landholders will be responsible for implementing the management actions for the life of the management plans, in accordance with an agreement between the landholders and SunWater and the proposed voluntary declarations.

11.4 Monitoring program

To enable the transparent governance of the offset, a monitoring and reporting program has been developed.

This is detailed included at **section 10** of this report and at Annexure A – Management Activities Schedule of the draft Offset Area Management Plan.

Measures to be undertaken include:

- Written records;
- Stock Monitoring;
- Photo point monitoring;
- BioCondition site assessment;
- Annual review of monitoring results; and
- Adaptive management in response to these reviews.

In summary, the OAMP requires annual monitoring in all offset areas for the first six years after the commencement of operations and subsequently every two years until remnant status is achieved or 1 October 2052 (whichever occurs first). BioCondition monitoring every 7 years starting at year 7 until remnant status is achieved or 1 October 2052 (whichever occurs first). This monitoring to be undertaken by SunWater, its agents, contractors or assigns.

until the objectives of the management plan have been achieved.

11.5 Reporting procedure

Section 8 of each draft Offset Management Plan describes the reporting procedure to SEWPaC. Reports to SEWPaC detailing the progress against the proposed management outcomes will be provided until the outcomes are achieved (remnant status) or until 2052, whichever occurs first. Reports will be provided to SEWPaC by:

- 31 July each year for the first 6 years after the agreement comes into effect;
- Then every two years thereafter (to be undertaken by SunWater, its agents, contractors or assigns); and
- A Biocondition report every 7th year, commencing after the first six years.

11.6 Risks and risk management

Section 7.5 of EPBC Act Environmental Offset Policy requires that the risks associated with the success of the individual offsets be assessed and appropriate mitigation actions detailed in the Offset Management Plan.

The most serious risks to the Offset Area Threatened Ecological Communities are exotic weed invasions, and uncontrolled fire. However, these threats will be effectively managed as described above in the section of this Biodiversity Offset Strategy titled “Management Actions”, and Sections 5 and 6 of the draft Offset Management Plan.

Herron Todd White
Independent Property Advisors

Earthtrade
ENVIRONMENTAL BROKERS

Biodiversity Offsets Plan

Prepared for: SunWater Limited

Woleebee Creek to Glebe Weir Pipeline Project

EPBC Act Referral 2011/6181

29th July 2013 **Reference: 20131617**

Document Tracking

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List of Abbreviations

Abbreviation	Description
BOP	Biodiversity Offset Package
BOS	Biodiversity Offset Strategy
BPA	Biodiversity Planning Assessment
BVG	Broad Vegetation Group
DEHP	Dept. of Environment and Heritage Protection
DBH	Diameter at Breast Height
DNRM	Dept. of Natural Resources and Mines
DOA	Deed of Agreement
DSEWPaC	Dept. of Sustainability, Environment, Water, Population & Communities
EA	Environmental Approval
EE	Ecological Equivalence
EEM	Ecological Equivalence Methodology
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EOP	EPBC Offsets Policy
EPBC	Environment Protection & Biodiversity Conservation Act 1999 (Cth)
EPC	Exploration Permit for Coal
ha	Hectares
HVR	High Value Regrowth
km	Kilometres
LBM	Legally Binding Mechanism (on title)
ML	Mining Lease
MLA	Mining Lease Application
ML/day	Mega litres per day
MNES	Matters of National Environmental Significance
Mtpa	Million tonnes per annum
NCA	Nature Conservation Act 1992 (Qld)
OAMP	Offset Area Management Plan
PMAV	Property Map of Assessable Vegetation
QBOP	Queensland Biodiversity Offset Policy
RE	Regional Ecosystem
ROM	Run of mine
SMES	State Matter Environmental Significance
SPA	Sustainable Planning Act 2009 (Qld)
TEC	Threatened Ecological Community
VDec	Voluntary Declaration under the Vegetation Management Act 1999 (Qld)
VMA	Vegetation Management Act 1999 (Qld)

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1. Introduction

1.1. Project

The Woleebee Creek to Glebe Weir Pipeline Project involves the construction and operation of a pipeline to transport up to 113 ML/day of treated coal seam gas **(CSG)** water from Woleebee Creek to the Dawson River at Glebe Weir in southern Queensland.

The pipeline is approximately 119km in length and has a construction easement 30m wide, creating a construction area of circa 435ha.

The pipeline traverses through the Western Downs and Banana Regional Council areas, crossing private farming land, road reserves and mining and petroleum tenures, as well as creeks and roads owned by the State or local government.

1.1.1 Avoidance and Minimisation of Impact

As part of the selection of the pipeline route, alternative routes were considered by SunWater.

The proposed Project alignment has been selected over shorter and less expensive routes as the current alignment results in:

- Lower impact to remnant vegetation;
- Lower order watercourse crossings; and
- Less area required on private property.

The current alignment has been based on the results of flora and fauna studies, and liaison with individual landholders. Based on the result of these studies the current alignment has been amended with changes in the location of the pipeline to avoid endangered Regional Ecosystems, as follows:

- Location 1 - Realignment of the pipeline to within the road reserve;
- Location 2 - Realignment of the pipeline into private property to avoid vegetation
- Location 3 – Realignment of the pipeline from the northern to the southern side of Nathan Road;
- Location 4 – Realignment of the pipeline to provide a 10 m separation distance from vegetation;
- Location 5 – Crossing of the road in a skewed direction, normally perpendicular, to avoid vegetation.

In addition to reducing impacts to vegetation, the proposed alignment has been selected due to its reduced impact on existing and proposed land uses. Iterations to the alignment to date have been based on avoiding impact to on-farm operations as much as possible. Consideration has also been given to the location of the alignment within the Surat Basin State Development Area Infrastructure Corridor to ensure no impact on the proposed Surat Basin Rail, a key stakeholder in the State Development Area.

2. Legislation

2.1. Project approvals

The project was declared a "controlled action" under the *Environment Protection and Biodiversity Conservation Act 1999* **(EPBC Act)** by the Federal Department of Sustainability, Environment, Water, Population and Communities **(DSEWPaC)** on 22 December 2011. The controlling provisions are under Section 18 and 18A, potential impacts on Listed Threatened Species and Communities. The offset was also required by condition 6 of the EPBC Act Referral 2011/6181, dated 27 September 2012

2.2. Purpose of this Biodiversity Offsets Plan

This Biodiversity Offsets Plan has been specifically devised to address the requirements of condition 6 of the EPBC Referral Conditions 2011/6181, as detailed in the following table:

Table 1: Approval Conditions and sections of Biodiversity Offset Plan addressing those Conditions

Condition	Relevant section of this Report
6. The person taking the action must develop a Biodiversity Offset Strategy (BOS) to ensure better protection of EPBC Act listed threatened species and communities. The BOS must be submitted to, and approved by the Minister prior to commencement of the action.	The BOS version 11 dated 1st May 2013 and this report fulfils this condition as detailed below
a. The BOS must be developed in accordance with the EPBC Act Environmental Offset Policy	The Offset policy requirements have been addressed in full in the sections detailed below
b. The BOS must include, but should not be limited to, the following:	
i. Details of the acquisition and ongoing management of vegetation which meets or will meet the definition of the endangered ecological community "Brigalow (Acacia harpophylla) dominant and co-dominant"	Sections 5.1 and 7.2
ii. Details of the acquisition and ongoing management of vegetation that meets or will meet the definition of the endangered ecological community "Coolibah-Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Region	Sections 5.4 and 7.3
iii. Details of steps to be undertaken to legally secure the proposed offset areas and implement the BOS within 12 months of the commencement of the action	Section 6
iv. The offset areas for each separate community must be contiguous (that is, the total cannot be comprised of a number of fragments, and must not be located within an existing mining lease or mining lease application areas; and	Sections 5.1 and 5.4, Figures 2 and 5, and see Appendices 2.1 & 2.2
v. Upon legally securing the offset area, the BOS must be updated with a textual description and map to clearly define the location and boundaries of the offset area. This must be accompanied with the offset attributes and a shapefile.	Figures 2 and 5, and see Appendices 2.1 & 2.2

3. Listed Threatened Species and Communities to be impacted

The vegetation to be cleared within the Woleebee Creek to Glebe Weir Pipeline easement is outlined in ***Table 2*** below. The approval requires that this cleared vegetation be offset.

Table 2: Impacts to be offset as per Approval Conditions

RE to be cleared under Approval	Description	Area allowed to be cleared under Approval (ha)	Area to be cleared (ha)	EPBC Status
11.3.3 (Coolibah)	*Eucalyptus coolabah* woodland to open-woodland with a grassy understorey.	1.38	0.72	Endangered
11.3.1 and 11.9.5 and 11.9.10 (Brigalow)	Brigalow (*Acacia harpophylla*) shrubby open forest to woodland.	2.08	1.34	Endangered

4. Threatened Ecological Communities to be offset

4.1. Brigalow

The ecological community known as "Brigalow (*Acacia harpophylla* dominant and co-dominant)" was listed as Endangered in 2001 under the *Environment Protection and Biodiversity Conservation Act 1999*.

"Brigalow" is the commonly accepted name for the species *Acacia harpophylla* and the vegetation in which this species is dominant or co-dominant, and is used in Queensland to describe the regional ecosystems/vegetation communities that correspond with the listed Brigalow ecological community.

The EPBC-listed ecological community is characterised by the presence of Brigalow (*Acacia harpophylla*) as one of the three most abundant tree species. Brigalow is usually dominant in the tree layer or co-dominant with other species such as *Casuarina cristata* (Belah), other species of Acacia, or species of Eucalyptus. Occasionally Belah or Acacia or Eucalyptus species may be more common than Brigalow within the broad matrix of Brigalow vegetation. The structure of the vegetation ranges from open forest to open woodland. The height of the tree layer varies from about 9 metres in low rainfall areas (averaging around 500 mm per annum) to around 25 metres in higher rainfall areas (averaging around 750 mm per annum). A prominent shrub layer is usually present.

A detailed description of this ecological community may be found in the "*Recovery plan for the "Brigalow (Acacia harpophylla dominant and co-dominant) endangered ecological community*" (which is located at ***Appendix 3.4*** to this Biodiversity Offsets Plan).

In Queensland, the listed Brigalow ecological community comprises 16 regional ecosystems, which include the listed regional ecosystem below found at the proposed offset site.

RE 11.4.3a (Palustrine wetland (e.g. vegetated swamp). *Melaleuca bracteata* woodland associated with *Acacia harpophylla* communities on clay plains). May include scattered occurrences of other tree species such as *Eucalyptus tereticornis, E. populnea, Acacia harpophylla* and *Casuarina cristata*. In some instances *E. tereticornis* dominates with other species restricting to a narrow fringe. There may be an understorey of *Damasonium minus, Typha orientalis, Cyperus* spp., and other wetland plants associated with ephemeral wetlands. Associated with heavy dark clay soils with very broad and deep gilgai which is seasonally ponded and remain wet for long periods.

BVG 25a Open-forests to woodlands dominated by *Acacia harpophylla* sometimes with *Casuarina cristata* on heavy clay soils. Includes areas co-dominated with *A. cambagei* and/or emergent eucalypts.

At Killara, the site is mature regrowth dominated by *Acacia harpophylla* with a sparse understorey. The soil was loamy clay with numerous depressions and melon holes. 11.4.3a was a component of the community but wetland areas dominated by *Melaleuca bracteata* were limited in area and too small to individually map out.

This regional ecosystem constitutes the proposed offset (see ***Section 5.1*** below).

4.2. Coolibah

The ecological community was nominated under the names: "Coolibah (*Eucalyptus coolabah*) / Black Box (*Eucalyptus largiflorens*) Woodlands of the Darling Riverine Plains and Queensland Brigalow Belt South Bioregions" [2008 nomination], and 'Coolibah (*Eucalyptus coolabah*)/ Black Box (*Eucalyptus largiflorens*) Woodlands of the Northern NSW Wheat Belt and Queensland Brigalow Belt' [2005 nomination]. The name is a shortened version of those nominated and accurately reflects the area where the national ecological community occurs. A detailed description of this community may be found in the "*Listing Advice to the Minister for the Environment, Heritage and Arts (1999)*", which forms ***Appendix 3.5*** to this Biodiversity Offsets Plan.

The regional ecosystems included in the Coolibah Ecological Community are listed under Queensland's *Vegetation Management Act* (1999) as 'Of-concern' and 'Not of concern' but their tendency for degradation means they are considered 'Of-concern' in terms of their biodiversity status relevant to the *Environmental Protection Act 1994* (Qld).

The five regional ecosystems of this ecological community include Regional Ecosystem 11.3.3 - *Eucalyptus coolabah* woodland to open-woodland with a grassy understorey. This is both the regional ecosystem that will be impacted by the Woleebee Creek to Glebe Weir Pipeline Easement; and the regional ecosystem that is proposed as an offset to the activity.

The offsets are located within the distribution of the Brigalow and Coolibah and Black Box Woodlands Threatened Ecological Community. See the Distribution Map that accompanies the Listing Advices at ***Appendix 3.7.***

5. Proposed Offset Area

5.1. Brigalow offset

Conditions 6 i. and 6 v. of the Approval Conditions require that the Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community is offset, as per the EPBC Offset Policy dated October 2012, against the impacts of the pipeline easement, and protected via a legally binding mechanism.

An offset area to satisfy this condition has been identified on the property "Killara", located approximately 230km north-west of Brisbane, 75 km north-west of Kingaroy and 15 km west of Durong (see ***Figure 1***). This is within the Southern Brigalow Belt Bioregion. The location of the Brigalow offset is within a heavily vegetated portion of the property that borders the Baracula State Forest.

The proposed offset area is currently mapped as "Category X" on a Property Map of Assessable Vegetation **(PMAV)**. This means that, without protection as an offset, they may be cleared under current Queensland Vegetation Management legislation. The area contains vegetation over 20 years of age with the majority of the areas containing vegetation in excess of 25 years. The entire area is in good condition due to the current management practices of the landowner.

5.2. Botanical survey of proposed Brigalow offset area

Following a desktop appraisal and an initial reconnaissance survey of the proposed offset area undertaken in March 2013, a full botanical field survey of the proposed offset area was undertaken in April 2013. The Field Verification was done via both BioCondition assessment sites and a foot traverse of the proposed Offset Area. ***Figure 2*** indicates the area surveyed and the location of the BioCondition sites.

Figure 1: Project Locality and Proposed Offset Locations

Legend

- Pipeline
- Killara
- Prairie

60 30 0 60 Kilometers

Projection: UTM (MGA Zone 55)
Datum: GDA 94

N

Client	Earthtrade
Regional Council	
Source	DERM 2012
Job No	SW_2_4_2013
Drawn by	s47F
Date	30-May-2013

Proposed Offset Locations

The data and information used to produce this drawing was current at the date of the drawing. Enviro-dynamics does not accept liability for any errors contained within the data supplied on this map and any changes made after the date of drawing.

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Figure 2: Brigalow Offset Area Map

Legend

- ★ Killara Bioconditions
- Killara Offset
- ExistingOffset
- Killara LoP

160 80 0 160 Meters

Projection: UTM (MGA Zone 56)
Datum: GDA 94

N

Killara
Lot 1 Plan RP50207

The data and information used to produce this drawing was current at the date of the drawing. Enviro-dynamics does not accept liability for any errors contained within the data supplied on this map and any changes made after the date of drawing.

Client	Earthtrade
Regional Council	South Burnett
Source	NearMap 2012
Job No	SW_2_4_2013
Drawn by	s47F
Date	22-Apr-13

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5.3. Results of botanical field survey - Brigalow

A total area of 20 ha of vegetation possessing characteristics of the Brigalow TEC (Regional Ecosystem 11.4.3) was identified within the offset area. The BioCondition sites surveyed within and adjacent to the offset area belong to the regional ecosystem 11.4.3. This community is considered to be part of the Brigalow communities protected under the EPBC and is listed as Endangered in Queensland.

The BioCondition of the non-remnant site for Brigalow community is in a condition class 3, a poor functioning regional ecosystem.

The reason for the offset site not meeting a higher class is mainly due to the high stem density of the regrowth. This has resulted in a lack of large trees, low species richness of shrubs and grasses and a lack of recordable course woody debris. The canopy tree height is lower than the benchmark due to the trees not being mature (see ***Figure 3*** and ***Figure 4***) and there is a small infestation of *Optunia tomentosa* (velvety tree pear) in the woodland. Mostly the site is in a good condition. The offset proposed exceeds Ecological Equivalence (refer to the EEM results sheet at ***Appendix 2.5)***. Both the offset and cleared site were in a condition 3 class. The area has recognised value as a centre of endemism, as wildlife refugia and represents a disjunct population (please refer to ***Figure 4.6*** in the report at ***Appendix 2.1***).

The EPBC Offset Calculator results are also attached at ***Appendix 2.3***.

Figure 3: *Acacia harpophylla* woodland with melon hole wetlands at Killara

Figure 4: *Acacia harpophylla* regrowth height at Killara

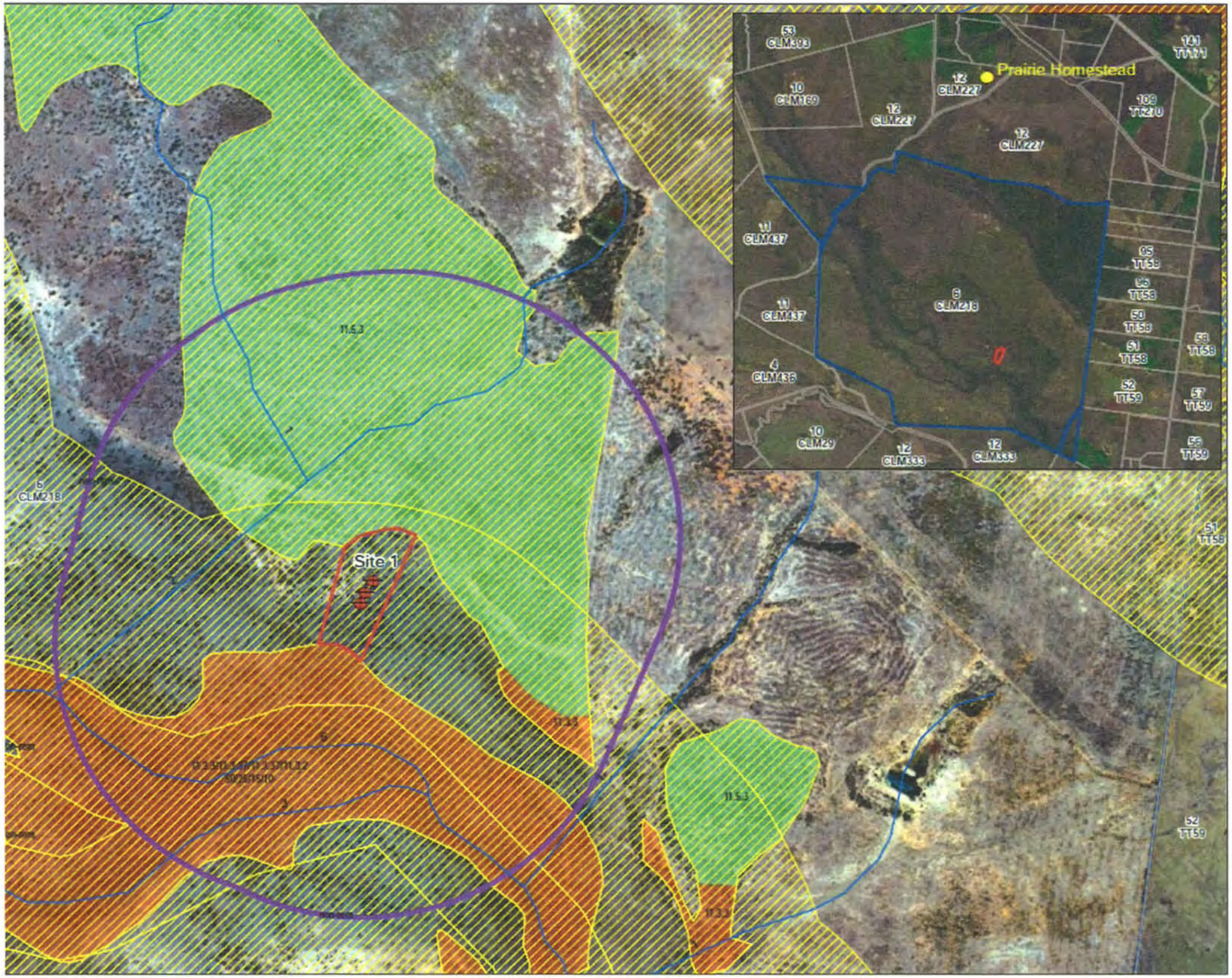
5.4. *Eucalyptus coolabah* (Coolibah) offset

Condition 6 ii. and v. of the Approval Conditions requires that the proponent register a legally binding mechanism over an offset to mitigate the impacts to the Threatened Ecological Community Coolibah-Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions.

The Coolibah offset proposed by the proponent to satisfy Condition 6 i. and v. of the Approval Conditions is located on "Prairie". Prairie is 19km north-west of Capella and links vegetation to the Sandy Creek system that is recognised as a bioregional corridor of State and regional significance.

There are contiguous links of Coolibah that extend from, and through the offset site. The offset site links the Sandy Creek system to a large patch of Coolibah thus improving connectedness to the Sandy Creek system. This enhances the ability for movement for fauna requiring cover across the landscape.

Figure 5: Coolibah Offset Area Map



aurecon

Legend

- Transect
- Drainage Stream Orders
- Proposed Offset
- Proposed Offset 1000m Buffer
- Special features mapping
- DCDB Parcels (Lite)
- Lot Boundary

Regional Ecosystem Mapping (v6.1)

Regional Ecosystem (VM Status)

- Endangered - Dominant
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- Least Concern

Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community.

Date: 3/06/2013 Version: 1

A3 scale: 1:15,000

0 100 200 300 400m

Job No: 236387

Coordinate System: GDA 1994 MGA Zone 55

Earthtrade Prairie Coolibah Biocondition

Figure 5: Proposed Offset

5.5. Results of botanical field survey - Coolibah

Vegetation and habitat quality data for the proposed offset area was recorded at three transect sites on Prairie following the EEM methodology. The transect locations are shown in ***Figure 4***. Upon request the Queensland Herbarium supplied Aurecon with an unpublished benchmark for RE11.3.3 which is due for public release in March 2014, which is addressed in ***Appendix 2.2***. Both the area proposed for clearing and the proposed offset data have been assessed against this benchmark. The final area proposed was delineated from this wider assessment and centres on BioCondition site 1. See ***Figure 5*** above.

The BioCondition of the remnant offset site for *Eucalyptus coolabah* community shows the community to be in a condition class 1, a functioning Regional Ecosystem. The Benchmark for RE 11.3.3 has a Diameter at Breast Height **(DBH)** for large eucalypt species of >45cm. Aurecon were able to analyse the data recorded for the offset site to meet the higher DBH, however the SKM data sheet provided by Earthtrade recorded DBH at >30 cm and >40 cm. Therefore for the purposes of this report the DBH of the large eucalypts at the offset site is >45cm while the DBH of the large eucalypts at the proposed clearing site is >40 cm.

While this is not an ideal situation, having the higher DBH for large eucalypts at the offset site may prove worthwhile as it potentially indicates that there are of more mature large eucalypts at the offset site. On the whole the site is in very good condition. The offset proposed considerably exceeds Ecological Equivalence (refer to the EEM results sheet at ***Appendix 2.6***). Both the offset and cleared site were in a condition 2 class. The offset site has significant special ecological features for wildlife refugia and lies within a regional wildlife corridor. Refer to ***Figure 4.4*** in the report at ***Appendix 2.2***.The EPBC Offset Calculator results are also attached at ***Appendix 2.4***.

Department of Environment and Heritage Protection Ecological Significance mapping was sourced for both the impact and offset sites, which is addressed in ***Appendix 2.2***. The impact site is located on a drainage line mapped as Stream Order 1, which is mapped as an area of High Ecological Significance while the proposed offset site sits within an area mapped as Strategic Rehabilitation Areas between two areas of mapped High Ecological Significance. GIS analysis of the Special Features layer showed no direct impact on Special Features at the area of impact however Indicator 11 (Ecological Corridors) are located within the 1 km buffer zone.

Indicator 11 is also located within the proposed offset site buffer of 1 km. This resulted in the EEM score of 17 for both sites as shown in the EEM calculator located in ***Appendix 2.6***.

Figure 6: Photos of vegetation at Site 1

Facing West -23.1090 S 174.8539 E

Facing East -23.1090 S 174.8539 E

Facing South -23.1090 S 174.8539 E

Facing North-23.1090 S 174.8539 E

6. Legally binding mechanism

The offset areas on "Killara" and "Prairie" will be protected via Voluntary Declarations as Areas of High Nature Conservation Value, made by the land owners under the *Vegetation Management Act 1999 (Qld).* These declarations and maps of the specific areas that they apply to, will be registered on the titles of each property along with the associated Offset Area Management Plan. They will then be binding on all current and future owners until the intent and outcomes of the Management Plan are achieved. The Voluntary Declarations will be in place until 1 October 2052 as per the expiry date of the Approval.

These Draft Requests for Voluntary Declarations are attached as ***Schedule 1*** of this Offset Plan.

7. Management of the Offset Areas

The offset areas will be managed in accordance with the Management Plan, which forms ***Schedule 2*** to this Biodiversity Offsets Plan.

The Management Plan has been specifically developed to address the requirements of Condition 6.b.i. of the Approval Conditions, and Section 7.8 of the EPBC Offsets Policy. The management actions for each Offset Area are detailed below.

7.1. Management Actions

The intent and outcome of the Management Plan is to undertake:

> *"Management actions to protect and enhance the extent and condition of the endangered ecological communities and threatened species habitat values, including rehabilitation, weed control, fire management, erosion and sediment control, exclusion of livestock and restrictions on access, within the offset area"*

7.2. Brigalow

Please refer to the Management Plan for more detailed explanations at ***Schedule 2.1***. The management actions for the Brigalow offset area will be undertaken in accordance with the "Recovery Plan for the Brigalow *(Acacia harpophylla* dominant and co-dominant) endangered ecological community" attached in ***Appendix 3.4***. A summary of these actions is provided at ***Table 3*** below.

Table 3: Schedule of Management Actions Brigalow - Killara

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress
Weed Management	Maintain the existing weed monitoring and control program including the use of Biological Control agents for the Velvety Tree Pear to ensure that the weed cover does not exceed 5% cover of the total Offset Area. Weeds to be controlled via chemical means will be spot sprayed by hand.	Biological Control of Velvety Tree Pear throughout property to ensure that the weed cover does not exceed 5% cover of the total Offset Area. Hand spraying of weeds in the Offset Area as depicted in the map at ***Attachment 1*** cf the Management Plan.	Maintained for the life of this Management Plan	Landowner	Written records of the landowner as per the landholders records below. Annual monitoring in all Offset Areas for the first 6 years after the commencement of operations Subsequently every 7 years until 1 October 2052.
Fire Management	Maintain fire breaks to enhance biodiversity and reduce fuel loads. All practical measures are maintained to exclude fire from the Offset Area by the maintenance of the road and firebreaks on a biennial basis or as required.	Throughout property	Maintained for the life of this Management Plan	Landowner in conjunction with neighbours	Written records of the landowner as per the landholders records below Annual monitoring in all Offset Areas for the first 6 years after the commencement of operations Subsequently every 7 years until 1 October 2052.

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress
Monitoring and Reporting as required by section 7 and 8	Allow the accumulation of fallen timber/debris and the establishment of natural undergrowth	Offset Area	Maintained for the life of this Management Plan	SunWater, its agents, subcontractors or assigns	Annual monitoring in all Offset Areas for the first 6 years after the commencement of operations Subsequently every 7 years until 1 October 2052.
Restricted Access	The Landowner restricts access to only those invitees, employees and subcontractors that are permitted on the entire property.	Offset Area	Maintained for the life of this Management Plan	Landowner	N/A

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress
Landowner Records	The Landowner is to maintain records outlining the following:- 4. The amount of rainfall that the Offset Area has had for each quarter (Spring, September to November, Summer, December to February, Autumn, March to May, Winter, June to August).	Offset Areas	Maintained for the life of this Management Plan	Landowner	Annual monitoring in all Offset Areas for the first 6 years after the commencement of operations Subsequently every 7 years until 1 October 2052.

7.3. Coolibah

The Coolibah Offset Area is in good condition due to previous management by the owners. Further appropriate and adaptive management of the offset area will enhance the quality of these woodlands, which have a good propensity for rehabilitation with the appropriate management actions.

Please refer to the Management Plan for Prairie Offset Area at ***Schedule 2.2***. In summary, the Management Actions for the woodland offset area will be undertaken in accordance with the advice contained in the "Listing Advice for the Coolibah and Black Box Woodlands" (refer ***Appendix 3.5***) and the "Conservation Advice for the Coolibah and Black Box Woodlands" (refer ***Appendix 3.6***). A summary of these actions is provided at ***Table 4*** below.

Table 4: Schedule of Management Actions – Coolibah - Prairie

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress
Weed Management	Maintain the existing weed monitoring and control program including the use of biological control agents for to ensure that the weed cover does not exceed 5% cover of the total Offset Area. When within close proximity to watercourses, weeds to be controlled via chemical means will be spot sprayed by hand.	Hand spraying of weeds in the Offset Area as depicted in the map at ***Attachment 1*** of the Management Plan.	Maintained for the life of this Management Plan	Landowner	Written records of the landowner as per the landholders records below. Annual monitoring in all Offset Areas for the first 6 years after the commencement of operations Subsequently every 7 years until 1 October 2052.
Fire Management	Maintain fire breaks to enhance biodiversity and reduce fuel loads. All practical measures are maintained to exclude fire from the Offset Area by the maintenance of the road and firebreaks on a biennial basis or as required.	Throughout property	Maintained for the life of this Management Plan	Landowner	

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress
Monitoring and Reporting as required by section 7 and 8	Allow the accumulation of fallen timber/debris and the establishment of natural undergrowth	Offset Area	Maintained for the life of this Management Plan	SunWater, its agents, subcontractors or assigns	Annual monitoring in all Offset Areas for the first 6 years after operational commencement. Subsequently every 7 years until 1 October 2052.
Restricted Access	The Landowner restricts access to invitees, employees and subcontractors that are permitted on the entire property.	Offset Area	Maintained for the life of this Management Plan	Landowner	N/A

Management activity	How the activity will be carried out	Where the activity will be carried out	When the activity will be carried out	Who will be carrying out the activity	Progress
Landowner Records	The Landowner is to maintain records outlining the following:- 1. The date in which livestock are put on the paddock to which the Offset Area forms a part and the date in which the livestock are removed; 2. The number of head of livestock that are grazed on the paddock to which the Offset Area forms a part; 3. The type of livestock that is grazed on the paddock (Sheep, Cattle, Dry Cows, Steers, Cows with calves etc); and 4. The amount of rainfall that the Offset Area has had for each quarter (Spring, September to November, Summer, December to February, Autumn, March to May, Winter, June to August).	Offset Areas	Maintained for the life of this Management Plan	Landowner	Annual monitoring in all Offset Areas for the first 6 years after the commencement of operations Subsequently every 7 years until 1 October 2052.

8. Desired outcomes/objectives of implementing the Management Plans

Section 7.8 of the EPBC Offset Policy and Approval Condition 6. i. and ii. requires that the Management Plan include *"transparent governance arrangements including being able to be readily measured, monitored audited and enforced"*. These management outcomes/intents for the Offset Areas are set out in the Management Plan which forms ***Schedule 2.1*** and ***Schedule 2.2*** of this Biodiversity Offsets Plan.

These management plans are registered on the Title of the Property in conjunction with the Voluntary Declarations as areas of High Nature Conservation Value. This effectively forms contractual arrangements between the Landholder and the Queensland Government enforceable under the *Vegetation Management Act 1999.*

In summary, these outcomes are:

MANAGEMENT OUTCOMES:

a. The Declared Areas will be managed; restored and protected until the vegetation in the Offset Area achieves a good condition for the Threatened Ecological Community or until 1 October 2052, whichever comes first. The area will be managed to enhance the presence of characteristic vegetation communities; including:

1. Maintenance and enhancement of natural groundcover
2. Stock management for fuel load reduction
3. Control of weed species
4. Maintenance and enhancement of natural tree and shrub regeneration
5. Exclusion of fire whenever practically possible

b. Habitat values associated with the Areas will be maintained or enhanced and protected through management, including:

1. Retention of habitat trees, including dead and fallen timber,
2. Application of fire management (only as necessary) as per Annexure B that enhances the vegetation community
3. Exclusion of fire whenever practically possible
4. Control of pests

The progress of the offset will be monitored as per ***Section 11*** below and the methodology for the monitoring will be consistent with the BioCondition methodology as developed by the Queensland Herbarium.

The BioCondition methodology is described in Eyre, T.J., Kelly, A.L, Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M.J. and Franks, A.J. (2011). *BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.1.* Department of Environment and Resource Management (DERM), Biodiversity and Ecosystem Sciences, Brisbane.

9. Location and boundaries of offset areas

Approval Condition 6.iv and v. of the Approval require that the offsets be contiguous and include:

> *"a clear definition of the location and boundaries of the offset areas, through maps and/or textual descriptions as well as an accompanying shapefile".*

The appendices to this Biodiversity Offset Plan include the following:

- Brigalow Offset Area – Map showing location at ***Schedule 2, Attachment 1*** of the Killara Management Plan. The map is reproduced, for ease of reference, at ***Appendix 1- Map D*** of this Offset Plan; and
- Coolibah Offset Area – Map showing location at ***Schedule 2, Attachment 1*** of the Prairie Management Plan. The map is reproduced, for ease of reference, at ***Appendix 1- Map G*** of this Offset Plan.

Please note that the respective offset area shapefiles have been provided on an accompanying CD to this document.

10. Timing, responsibilities and performance criteria

EPBC Offset Policy clause 7.8 requires that the offset have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

As such, the Management Plans include details of:

- *the timing, responsibilities and performance criteria for the management actions,*
- *details of parties responsible for monitoring, reviewing and implementing the plan."*

These details are included in the Schedule of Management Activities attached to the Offset Area Management Plan.

With respect to all offset areas, the landholders will be responsible for implementing the management actions for the life of the management plans, in accordance with an agreement between the landholders and SunWater.

Full costs of this will be borne by the proponent in contractual arrangements with the landholder.

11. Monitoring Program

To enable the transparent governance of the offset, a monitoring and reporting program has been developed.

This is detailed included at ***Section 7*** of this report and at ***Appendix A*** – Management Activities Schedule of the Offset Area Management Plan.

Measures to be undertaken include:

- Written records;
- Stock Monitoring;
- Photo point monitoring;
- BioCondition site assessment;
- Annual review of monitoring results for the first six years and every seven years thereafter; and
- Adaptive management in response to these reviews.

In summary, the OAMP requires annual monitoring in all offset areas for the first six years after the commencement of operations and subsequently every seven years until 1 October 2052.

12. Reporting Procedure

Section 8 of the Offset Area Management Plan describes the reporting procedure to DSEWPaC. Reports to DSEWPaC detailing the progress against the proposed management outcomes will be provided until the outcomes are achieved or 2052, whichever occurs first. Reports will be provided to DSEWPaC by 31 July each year for the first 6 years after the agreement comes into effect and thereafter each 7 years until 2052.

SunWater or one of its employees, contractors or authorised representatives will monitor and review the Management Plan, and to undertake reporting procedures. Implementation of the plan activities will be undertaken as shown in the tables in ***Sections 7.2*** and ***7.3*** above.

13. Risks and Risk Management

EPBC Offset Policy clause 7.5 requires that the risks associated with the success of the individual offsets be assessed and appropriate mitigation actions detailed in the Offset Area Management Plan.

The most serious risks to the Offset Area Threatened Ecological Communities are exotic weed invasions, and uncontrolled fire. However, these threats will be effectively managed as described above in the section of this Biodiversity Offset Plan titled "Management Actions", and Sections 5 and 6 of the Offset Area Management Plan at ***Schedule 2***.

14. Conclusion

The Offset Areas proposed in this Biodiversity Offset Plan include:

- 20 ha of "Brigalow (*Acacia harpophylla* dominant and co-dominant) Threatened Ecological Community";
- 10 ha of "'Coolibah (*Eucalyptus coolabah*) / Black Box (*Eucalyptus largiflorens*) Woodlands of the Darling Riverine Plains and Queensland Brigalow Belt South Bioregions Threatened Ecological Community".

These areas will be managed in accordance with the enclosed Management Plan, which addresses the requirements of the EPBC Approval 2011/6181 and the EPBC Offsets Policy dated October 2012.

As such, the Proponent has satisfied the requirements of Condition 6 of EPBC Approval 2011/6181.

sunwater

Glebe End of Waste Scheme

Environmental Performance Report Report

Ref 2011/6181

Final Report
November 2019

An appropriate citation for this paper is:

GEWS Environmental Performance Report

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Document Information

Title	Chinchilla End of Waste Scheme Environmental Performance Report
Subtitle	Ref 2011/6181

Authorisation

	Title	Name	Date
Owner	Principal Aquatic Ecologist	s47F	13/11/2019
Reviewer	Area Operations Manager South		14/11/2019
Approver	Manager Environment		13/11/2019

Contents

Abbreviations

Term	Definition
CSG	Coal Seam Gas
DMP	Discharge Management Plan
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
EPR	Environmental Performance Report

Executive Summary

This report is required by Condition 8b of EPBC Act referral 2011/6181, and assessed Sunwater's compliance against the conditions of the approval.

From 7 February 2019 to 7 August 2019, SunWater discharged 1,061.60 ML of treated CSG water into Glebe Weir. The treated CSG water discharge volume was allocated for take by irrigators (part of the announced allocation process described in the Fitzroy Basin Resource Operations Plan) and was accounted for in the Dawson Valley Water Supply Scheme area.

SunWater undertook monthly monitoring of the receiving environment. The monitoring of the receiving environment and independent assessment of this monitoring did not confirm any new or increased impacts/likely impacts to the receiving environment.

1 EPBC Act 2011/6181 Condition 8b.i

1.1 Condition 8b.i

Within three months of every six month anniversary of commencement of discharge (and until two years after cessation of discharge), the person taking the action must submit to the Minister an Environmental Performance Report (EPR). Each EPR must include, but not be limited to, the following:

i. The results of implementation of the Discharge Management Plan (DMP) required by condition 7.

1.2 Condition 8b.i Compliance

Condition 7 of the approval states:

"The person taking the action must prepare a Discharge Management Plan (DMP). The DMP must be submitted to, and approved by the department prior to commencement of discharge. The DMP must include but should not be limited to, the following:

- Measures to ensure a volume of water equivalent to the volume of discharged Coal Seam Gas water is extracted from the Dawson River prior to the end of the Dawson Valley Water Supply Scheme area; and
- Measures to monitor usage of said volume, including measures to deal with inappropriate usage."

On 23 January 2015 the Discharge Management Plan as required by condition 7 was approved by the Department of the Environment. Discharge of treated Coal Seam Gas (CSG) water from the Woleebee Creek to Glebe Weir pipeline into the Glebe Weir began on 7 February 2015.

From 7 February 2019 to 7 August 2019, SunWater discharged 1,061.60 ML of treated CSG water into Glebe Weir. The treated CSG water discharge volume was allocated for take by irrigators (part of the announced allocation process described in the Fitzroy Basin Resource Operations Plan) and was accounted for in the Dawson Valley Water Supply Scheme area.

The Dawson Valley Water Supply Scheme operational reports are available on SunWater's website:

http://www.sunwater.com.au/schemes/dawson-valley/scheme-information/announced-allocations

2 EPBC Act Referral 2011/6181 Condition 8b.ii

2.1 Condition 8b.ii

Within three months of every six month anniversary of commencement of discharge (and until two years after cessation of discharge), the person taking the action must submit to the Minister an Environmental Performance Report (EPR). Each EPR must include, but not be limited to, the following:

II. The results of regular environmental monitoring required by the Water Quality Management Plan (WQMP).

2.2 Condition 8b.ii Compliance

As per the Water Quality Management Plan (approved by the Department of Environment on 5/02/2015), Sunwater has commissioned monthly independent monitoring of water quality and aquatic ecology in the receiving environment:

- Quarterly Water Quality Monitoring Report, January to March 2019 (Appendix A)
- Quarterly Water Quality Monitoring Report, April to June 2019 (Appendix B)
- Quarterly Water Quality Monitoring Report, July to September 2019 (Appendix C)
- Autum 2019 Sediment Quality and Aquatic Ecology Report (Appendix D)
- Spring 2019 Sediment Quality and Aquatic Ecology Report (Appendix E).

3 EPBC Act Referal 2011/6181 Condition 8b.iii

3.1 Condition 8b.iii

Within three months of every six month anniversary of commencement of discharge (and until two years after cessation of discharge), the person taking the action must submit to the Minister an Environmental Performance Report (EPR). Each EPR must include, but not be limited to, the following:

III. An independent evaluation of the results of the regular environmental monitoring required by the WQMP, and an assessment of any new or increased impacts/likely impacts to the environment

3.2 Condition 8b.iii Compliance

The water quality and aquatic ecology monitoring reports (Appendices A to E) each include an impact assessment section. The impact assessments have concluded, upon assessment of the environmental monitoring data, that overall, the release of treated CS water does not appear to have a negative impact on water quality in the receiving environment.

4 EPBC Act Referral 2011/6181 Condition 8b.iv

4.1 Condition 8b.iv

Within three months of every six month anniversary of commencement of discharge (and until two years after cessation of discharge), the person taking the action must submit to the Minister an Environmental Performance Report (EPR). Each EPR must include, but not be limited to, the following:

IV. Details of appropriate actions taken/to be taken in the event that any new or increased impacts/likely impacts to the environment are identified.

4.2 Condition 8b.iv Compliance

No new or increased impacts/likely impacts to the environment were identified as a result of the discharge of treated CSG water by SunWater into the Dawson Valley Water Supply Scheme. SunWater will continue its monitoring of the receiving environment as detailed in the receiving environment monitoring program.

5 EPBC Act Referral 2100/6181 Condition 10

5.1 Condition 10

Within three months of every 12 month anniversary of the commencement of the action, the person taking the action must publish a Compliance Report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the department at the same time as the compliance report.

a. From first submission of the EPR described in Condition 8, the second of those reports submitted each year can also serve as the Compliance Report required by this condition, as long as the requirements of both conditions are met.

5.2 Condition 10 Compliance

Compliance with Condition 10 is summarised in Table 5.1.

Table 5.1 Condition 10 Compliance

Condition	Compliance
1. The person taking the action must undertake the action in accordance with the Preliminary Documentation dated 2 August 2012, and the conditions of this approval. The conditions of this approval prevail to the extent of any inconsistencies.	All actions undertaken by SunWater in the construction of the Woleebee Creek to Glebe Weir pipeline and operation of the Glebe End of Waste Scheme have been in accordance with the conditions of the approval. This is demonstrated by there being no recorded reportable incidents for the Glebe End of Waste Scheme against the approval.
2. Within 20 business days after the commencement of the action, the person taking the action must advise the department in writing of the actual date of commencement of the action.	SunWater commenced action on 3 May 2013. Written advice of this was provided to the department on 17 May 2013, within the stipulated timeframe of 20 business days

Condition	Compliance
3. The person taking the action must prepare a Construction Environmental Management Plan (CEMP). The CEMP must be submitted to, and approved by the department prior to commencement of the action. The CEMP must be implemented. The approved CEMP must include, but should not be limited to, the following: a. measures to minimise impacts to EPBC Act listed threatened fauna species including measures to care for injured fauna; b. measures to minimise impacts to EPBC Act listed threatened flora, including a vegetation clearing strategy; c. measures to limit the spread of pests and invasive species; d. sediment and erosion controls; e. measures to revegetate and rehabilitate the subject site following construction; and f. measures to implement, monitor, or improve (should deficiencies be identified, either by the person taking the action or by the department) the CEMP.	On 15 April 2013 SunWater received confirmation from the Department of Sustainability, Environment, Water, Population and Communities that the submitted CEMP had been assessed and approved by the department. CEMP previously provided to DoEE, but will be made available upon request.
4. The person taking the action must not destroy by clearing or any other activity, more than 2.08 ha of the endangered ecological community "Brigalow (Acacia harpophylla) dominant and co-dominant," nor more than 1.38 ha of the endangered ecological community "Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions." a. If clearing of more than 2.08 ha of the endangered ecological community "Brigalow (Acacia harpophylla) dominant and co-dominant," or more than 1.38 ha of the endangered ecological community "Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions" is necessary, the person taking the action must: i. undertake pre-clearance surveys of additional areas to be cleared; and ii. submit the pre-clearance surveys to the department for approval prior to clearing. b. Any approved clearing of vegetation must be conducted in accordance with the CEMP, required by Condition 3.	Whilst undertaking the action, 1.25 ha of Brigalow (Acacia harpophylla) dominant and co-dominant, and 0.85 ha of Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions was cleared within the specified limits stated in condition 4. Evidence of this was provided to and acknowledged by the department on 7 March 2014. Whilst under construction, weekly and monthly reports documented any environmental issues or incidents encountered during construction within the applicable reporting period. This enabled any issues to be effectively communicated and addressed, and ensured all clearing undertaken was in accordance with the approved CEMP. Construction reports previously provided to DoEE, but will be made available upon reuest.

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Condition	Compliance
5. The person taking the action must not destroy by clearing or any other activity, more than 22 ha of natural habitat suitable for the vulnerable species: Large-eared Pied-bat {Chalinolobous dwyeri)] Southern-eastern Long-eared Bat {Nyctophilus corbeni)] and Brigalow Scaly-foot [Parademi orientalis). a. If more than 22 ha of natural habitat suitable for the vulnerable species: Large-eared Pied-bat (Chalinolobous dwyeri)] Southern-eastern Long-eared Bat (Nyctophilus corbeni)] and Brigalow Scaly-foot (Parademi orientalis) is necessary, the person taking the action must: i. undertake pre-clearance surveys of additional areas to be cleared; and ii. submit the pre-clearance surveys to the department for approval, prior to clearing. b. Any approved clearing of vegetation must be conducted in accordance with the CEMP, required by Condition 3.	As detailed in SunWater's Woleebee Creek to Glebe Weir Pipeline Vegetation Offset Strategy, and the Atkinson Realignment Flora Investigation report, the total area of natural habitat suitable for the vulnerable species: Large-eared Pied-bat (Chalinolobous dwyeri); Southern-eastern Long-eared Bat (Nyctophilus corbeni); and Brigalow Scaly-foot (Parademi orientalis) cleared was less than 22 ha. During the construction of the Woleebee Creek to Glebe Weir pipeline all work/activities complied with the CEMP.
6. The person taking the action must develop a Biodiversity Offset Strategy (BOS) to ensure better protection of EPBC Act listed threatened species and communities. The BOS must be submitted to, and approved by the Minister prior to commencement of the action. a. The BOS must be developed in accordance with the EPBC Act Environmental Offset Policy. b. The BOS must include, but should not be limited to, the following: i. details of the acquisition and ongoing management of vegetation which meets or will meet the definition of the endangered ecological community "Brigalow {Acacia harpophylla) dominant and codominant"; ii. details of the acquisition and ongoing management of vegetation which meets or will meet the definition of the endangered ecological community "Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions"; iii. details of steps to be undertaken to legally secure the proposed offset areas and implement to BOS within 12 months of the commencement of the action. iv. The offset areas for each separate community must be contiguous (that is, the total cannot be composed of a number of fragments), and must not be located within an existing mining lease or mining lease application areas; and v. Upon legally securing the offset area, the BOS must be updated with a textual description and map to clearly define the location and boundaries of the offset area. This must be accompanied with the offset attributes and a shapefile.	SunWater submitted a BOS to the department on 1 May 2013. A signed letter of approval was provided to SunWater on 2 May 2013, one day prior to the commencement of the action. BOS previously provided to DoEE, but will be made available upon request.

Condition	Compliance
7. The person taking the action must prepare a Discharge Management Plan (DMP). The DMP must be submitted to, and approved by the department prior to commencement of discharge. The DMP must include, but should not be limited to, the following: a. measures to ensure a volume of water equivalent to the volume of discharged Coal Seam Gas water is extracted from the Dawson River prior to the end of the Dawson Valley Water Supply Scheme area; and b. measures to monitor usage of said volume, including measures to deal with inappropriate usage.	SunWater submitted the DMP to the Department on 22 January 2015, before the commencement of discharge on 7 February 2015. SunWater received a letter of approval for the DMP from the department on 23 January 2015. DMP previously provided to DoEE, but will be made available upon request. See also Section 1.2 above.
8. The person taking the action must prepare and submit a Water Quality Monitoring Plan (WQMP), for the Minister's approval. a. The WQMP must include, but not be limited to; i. Measures to conduct regular environmental monitoring within the Dawson River, at a range of locations including, but not limited to: 1. upstream of the discharge point; 2. within Glebe Weir, but downstream of the discharge point; and 3. downstream of Glebe Weir, at least as far as Theodore Weir. ii. details of parameters to be monitored. iii. for each parameter specified in Condition 8(a)(ii); the WQMP must stipulate a threshold limit. iv. The WQMP must specify the guideline, standard, or relevant research for which both the background level within Glebe Weir and the threshold limit has been set, along with a discussion as to why the particular guideline, standard, or relevant research is appropriate. b. Within three months of every six month anniversary of commencement of discharge (and until two year after the cessation of discharge), the person taking the action must submit to the Minister an Environmental Performance Report (EPR). Each EPR must include, but not be limited to, the following: i. the results of implementation of the DMP required by Condition 7; ii. the results of the regular environmental monitoring required by the WQMP; iii. an independent evaluation of the results of the regular environmental monitoring required by the WQMP, and an assessment of any new or increased impacts/likely impacts to the environment are identified. c. If, upon review of an EPR, the Minister is not satisfied that appropriate actions have been taken or will be taken to mitigate any new or increased impacts/likely impacts to the environment identified during the regular monitoring required by this condition, the Minister may direct the person taking the action to reduce or cease discharge. The person taking the action must then undertake an evaluation in accordance with the recommendations of an independent evaluator and submit the report to the department for approval.	On 5 February 2015 a WQMP was submitted by SunWater to the department for the Minister's approval. The discharge commenced on 7 February 2015. SunWater submitted an EPR on 6 November 2015, within the timeframe specified, and have submitted EPRs on a six monthly basis since commencement of discharge. Each EPR also contains the available detailed results from the implementation of the DMP and WQMP. These have shown there has been no adverse environmental impact on the receiving environment as a result of the commencement of discharge (see Appendices A to E for recent monitoring reports).

Condition	Compliance
9. The person taking the action must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the management plans required by this approval, and make them available upon request to the department. Such records may be subject to audit by the department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of the approval. Summaries or audits will be posted on the department's website. The results of audits may also be publicised through the general media.	SunWater records are managed in accordance with SunWater's internal records management policy. The statements and intent of this policy are in accordance with the requirements of condition 9, ensuring all required records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the management plans required by the approval, will be readily available to the department if requested.
10. Within three months of every 12 month anniversary of the commencement of the action, the person taking the action must publish a Compliance Report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the department at the same time as the compliance report. a. From first submission of the EPR described in Condition 8, the second of those reports submitted each year can also serve as the Compliance Report required by this condition, as long as the requirements of both conditions are met.	This Compliance Report shall be available on SunWater's public website www.SunWater.com.au. Documentary evidence of compliance with these conditions has been provided to the Department throughout construction and operation including photos, maps, and surveys.
11. If the person taking the action wishes to carry out any activity otherwise than in accordance with the management plans/strategy as specified in the conditions, the person taking the action must submit to the department for the Minister's written approval, a revised version of that management plan/strategy. The varied activity shall not commence until the Minister has approved the varied management plan/strategy in writing. The Minister will not approve a varied management plan/strategy unless the revised management plan/strategy would result in an equivalent or improved environmental outcome over time. If the Minister approved the revised management plan/strategy that management plan/strategy must be implemented in place of the management plan originally approved.	During the construction of the Woleebee Creek to Glebe Weir Pipeline there was a slight variation in the final alignment of the pipelines from the original alignment communicated to the department. This alignment change and evidence that the impacts were able to be managed through the existing plans and strategies was provided to the department. The department acknowledged receipt of this information on 7 March 2014.

Condition	Compliance
12. If the Minister believes that it is necessary or convenient for the better protection of World Heritage properties (sections 12 and 15A), National Heritage places (sections 15B and 15C), Listed Threatened Species and Communities (sections 18 and 18A), or the Great Barrier Reef Marine Park (section 248 and 24C) to do so, the Minister may request that the person taking the action make specified revisions to the management plan/s/strategy specified in the conditions and submit the revised management plan/s/strategy for the Minister's written approval. The person taking the action must comply with any such request. The revised approved management plan/strategy must be implemented. Unless the Minister has approved the revised management plan/strategy, then the person taking the action must continue to implement the management plan/strategy originally approved, as specified in the conditions.	SunWater has not received any requests from the Minister to make specified revisions to the management plan/s/strategy for the Minister's written approval.
13. Unless otherwise agreed to in writing by the Minister, the person taking the action must publish all management plans referred to in these conditions of approval on their website. Each management plan must be published on the website within one month of being approved.	SunWater has published the Construction Environmental Management Plan, Discharge Management Plan, and Water Quality Management Plan on the SunWater website: www.SunWater.com.au.

Appendix A: Quarterly Water Quality Monitoring Report, January to March 2019

Glebe End of Waste Scheme: Receiving Environment Monitoring Program

Water Quality Monitoring Report, January - March 2019

Prepared for:

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freshwater estuarine marine

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1 Introduction

1.1 Background

SunWater is the proponent of an End of Waste Scheme involving the discharge of reverse osmosis treated coal seam water to Glebe Weir on the Dawson River. As part of the conditions of approval for the scheme SunWater has developed a Receiving Environment Monitoring Program (REMP) that includes monitoring of water, sediment and aquatic ecology in the receiving environment (i.e. Glebe Weir and connected waterways including waters of the Dawson Valley Water Supply Scheme). The REMP includes a control : impact comparison of sites upstream and downstream of the discharge point. Historical baseline data was used to develop project-specific guidelines (local WQGs) for water quality, sediment quality and biological parameters (i.e. macroinvertebrates and fish).

This quarterly REMP report presents the monitoring results for water quality for January – March 2019. It is the twelfth REMP report covering a three-month period (previous to October 2015 reports were provided monthly), and the sixteenth REMP report on water quality since operational discharges commenced on 7 February 2015.

1.2 Scope of Works

The monitoring sites are specified in the REMP Design Report, with the additional site WS09 also monitored for water quality (Table 2.1). The scope of works comprises:

- monthly (ambient) monitoring of water quality measured in situ and laboratory analysis of water samples for parameters specified in the REMP design
- increased frequency of monitoring at times of elevated risk[1]
- an assessment of water quality results against applicable water quality guidelines, noting any trends between sites (especially control and impact sites), and
- an assessment of any potential impact the release of treated CS water has had on water quality in the receiving environment.

The weekly assessment of total and dissolved boron, and water temperature, at selected sites was required under the previous approval, with this monitoring to be discontinued from 30 June 2019

[1] Th s REMP mon tor ng component d d not become effect ve unt June 2019, and thus not app cab e to the current report.

2 Methods

2.1 Site Location Details

Eight sites were surveyed along the Dawson River (Table 2.1); six of these sites are in the receiving environment for GBUS (WS03, WS04, WS05, WS06, WS07 and WS09), and two sites (WS01 and WS02) are control sites upstream of the receiving environment.

Based on the definitions in the *Dawson River Sub–basin Environmental Values and Water Quality Objectives EPP (Water) 2009* (EHP 2013b), there are three water types in the receiving environment of GBUS:

- unregulated reaches of the upper Dawson River (flowing water)
- unregulated reaches of the lower Dawson River (flowing water), and
- regulated reaches of the Dawson River – freshwater lakes / reservoirs (non-flowing water).

The boundary between the lower and upper Dawson River Sub-catchments is Glebe Weir, with four sites in the upper Dawson and three in the lower Dawson. However, the baseline monitoring data indicates that variation in water quality, sediment quality and biological parameters within the lower and upper Dawson River water types, respectively, was often higher than between these two water types. Therefore, for the purpose of GBUS REMP monitoring and local water quality guidelines, all flowing sections of the Dawson River within the receiving environment was considered a single water type (unregulated water).

2.2 Survey Timing

Under the REMP design document, ambient monitoring of water quality for the Glebe End of Waste Scheme (GEWS) is implemented monthly.

Weekly monitoring of total and dissolved boron and water temperature at sites within and downstream of the Glebe Weir pool (WS03, WS04, WS05 and WS06) was required under a previous approval, and will discontinue from 30 June 2019.

The field surveys were completed by suitably qualified persons (professional aquatic ecologists) from frc environmental on:

- 3rd January 2019 (boron and temperature)
- 10th January 2019 (boron and temperature)
- 15th January 2019 (boron and temperature)
- 23rd–24th January 2019 (all parameters at all sites)
- 30th January 2019 (boron and temperature)
- 4th February 2019 (boron and temperature)
- 13th February 2019 (boron and temperature)
- 20th–21st February 2019 (all parameters at all sites)
- 27th February 2019 (boron and temperature)
- 5th March 2019 (boron and temperature)
- 11th March 2019 (boron and temperature)
- 20th March 2019 (all parameters at all sites)
- 27th–28th March 2019 (boron and temperature)

Table 2.1 Location of water quality monitoring sites.

Site	Water Type	Location	Latitude [a]	Longitude [a]
Upstream of Receiving Environment				
Upper Dawson				
WS01	Unregulated	Dawson River at the Old Leichardt Highway crossing at Taroom	-25.644476	149.791877
WS02	Unregulated	Dawson River at Bundulla Road Crossing	-25.572372	149.864464
Receiving Environment				
Upper Dawson				
WS03	Regulated	Dawson River Upstream of Glebe Weir	-25.476944	150.008333
WS04	Regulated	Dawson River Upstream of Glebe Weir	-25.464269	150.033529
Lower Dawson				
WS05	Unregulated	Dawson River Downstream of Glebe Weir	-25.459722	150.043889
WS06	Unregulated	Dawson River Downstream of Glebe Weir	-25.453333	150.055833
WS07	Regulated	Dawson River Upstream of Gyranda Weir	-25.284722	150.181389
WS09	Regulated	Dawson River within Theodore Weir	-24.937778	150.068056

[a] WGS84

2.3 Water Quality Sampling Protocols

All water quality sampling was carried out in accordance with the Department of Environment and Science's *Monitoring and Sampling Manual* (DES 2018).

Water Quality Measured In Situ

Water quality was measured in situ approximately 0.3 m below the water surface using a SmarTroll Water Quality Meter. The water quality meter was calibrated in accordance with

the manufacturer's instructions. Where the water was of suitable depth (i.e. > 2 m), water quality was also measured at 1.0 m intervals through the water column. In shallow water (i.e. < 2 m), water quality was measured at 0.5 m depth intervals.

For the monthly water quality monitoring, the assessed parameters were:

- water temperature (°C) (also measured on boron surveys)
- pH
- dissolved oxygen (mg/L and percent saturation), and
- electrical conductivity (µS/cm).

Turbidity (NTU) was also measured during monthly water quality monitoring approximately 0.3 m below the water's surface using a HACH 2100Q portable turbidity meter.

Collection and Laboratory Analysis of Water Samples

At each site a water quality sample was collected in accordance with the Department of Environment and Science's (DES's) *Monitoring and Sampling Manual 2009* (DES 2018) and the *Procedures for REMP Monitoring and Sampling* (frc environmental 2015b). Water samples were collected using pre-labelled bottles supplied by Symbio Alliance that were appropriate for the suite of parameters being tested. Samples were collected and stored as appropriate for the parameters being tested (e.g. bottles pre-rinsed / not pre-rinsed, bottles filled or not filled to the top, chilled). All of the samples were chilled and transported to Symbio Alliance's NATA-accredited laboratory in Brisbane within the required holding time for each parameter. For monthly monitoring surveys, each sample was analysed for:

- electrical conductivity
- pH
- turbidity
- total hardness (calcium hardness)
- carbonate, bicarbonate, hydroxide
- residual alkalinity (as $CaCO_3$)
- ammonia (as N)
- major cations and anions independently (Ca, Cl, Mg, F, Na, K)
- sulphate (total and dissolved)

- a full total metal scan, including boron and mercury (ICP/MS or ultra-trace as required)
- a full dissolved metal scan, including boron and mercury (ICP/MS or ultra-trace as required)
- chlorophyll *a*, and
- hydrocarbons (C6-C9, C10-C14, C15-C28, C29-C36).

For the weekly monitoring surveys, only total and dissolved boron was analysed.

An additional site replicate and a field blank (i.e. sample filled with deionised water in the field) was collected during each survey, for QA/QC purposes.

The testing methods and Limits of Reporting (LOR) used by the laboratory were based on the 95% ecosystem protection guidelines (ANZECC & ARMCANZ 2000), and specified on the Chain of Custody (COC) forms submitted with each sample batch.

2.4 Quality Assurance and Quality Control

Relative Percent Difference

Relative percent difference (RPD) is a measure of how similar two samples are, with low RPD indicating the samples are very similar[2]. RPD can be used in two ways:

1. comparing *duplicate* samples (i.e. sub-samples of a single sample, taken in the laboratory), which assesses laboratory testing precision and repeatability, and
2. comparing *replicate* samples (i.e. different samples taken at the same site), which tests natural within-site variability.

RPD analyses on *duplicate* samples for the monthly surveys and the weekly boron surveys showed that all laboratory results were within acceptable limits.

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[2] RPD s nf uenced by the magn tude of the va ues be ng compared; for examp e a s ght change between arge numbers g ves a very ow RPD, but a s m ar s ght change between sma numbers g ves a much h gher RPD. Consequent y, n the context of assessment of dup cate samp es n the aboratory, DES spec f es a RPD of 20% for resu ts that are at east f ve t mes the LOR, as a h gher RPD s expected for resu ts c oser to the LOR. There s no thresho d for RPD when compar ng rep cate samp es, as th s s assess ng natura w th n-s te var at on, a though where RPD s h gh between rep cate samp es t s prudent to nterpret resu ts as est mates rather than prec se va ues.

RPD analyses between *replicates* for the monthly surveys showed low variability across the majority of parameters with the exception of one parameter (total nickel) at site WS02 on the January survey. As a result, concentrations of this parameter recorded on that survey should be treated as estimates rather than precise values.

RPD analyses between *replicates* for the weekly surveys showed limited variability in concentrations of total and dissolved boron.

Assessment of LOR for Blank Samples

The laboratory blank sample was below the LOR for all parameters on all surveys.

The field blank sample was below the LOR for all parameters on all surveys, with the exception of the following:

- electrical conductivity – February (5 µS/cm)
- turbidity – January (0.3 NTU), February (0.1 NTU) and March (0.2 NTU)
- barium (dissolved) – February (0.00012 µg/L)
- TPH C6-C9 fraction – January (20 µg/L)
- bicarbonate – January (2 mg/L), February (2 mg/L) and March (2 mg/L)
- total alkalinity (CaCO3) – January (2 mg/L), February (2 mg/L) and March (2 mg/L)
- ammonia as N – January (0.013 mg/L), February (0.018 mg/L) and March (0.017 mg/L)

As a result, concentrations of these parameters should be treated as estimates rather than precise values.

2.5 Comparison with Guidelines

Water Quality

For monthly water quality monitoring, the median of each parameter at each site across the three monthly surveys was calculated and compared to the relevant guideline; raw data for each parameter at each site on each survey was provided to SunWater in an accompanying Excel spreadsheet.

For weekly monitoring of total and dissolved boron and temperature, results for each weekly survey were compared separately to the relevant guideline.

The relevant guidelines were as follows:

- dissolved oxygen, pH, electrical conductivity, turbidity, major ions and nutrients were compared with the Water Quality Objectives (WQOs) to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River (EHP 2013a). This guideline was used because none of the study sites are in High Ecological Value (HEV) areas
- metals and other contaminants were compared with the Australian and New Zealand Guidelines for fresh and marine water quality (ANZECC & ARMCANZ 2000) based on the 95% level of protection of aquatic ecosystems, although mercury was assessed using the guideline for the 99% level of protection of aquatic ecosystems
- all parameters were assessed against local water quality guidelines that were developed using baseline data collected from the receiving environment for GBUS (pre-discharge) (frc environmental 2015a), and
- total and dissolved boron were compared against the Irrigator Notification values listed in Schedule C – Table 1 of the BUA, and the 95% ecosystem level protection guidelines (ANZECC & ARMCANZ 2000).

According to the Queensland Water Quality Guidelines (EHP 2013a) base flow is considered to be when discharge at the time of sampling is less than the 90th percentile of all discharge records. Using this criterion, the base flow thresholds provided by SunWater for this project were:

- Gauging station 130345A (Glebe Weir) – 1177 ML/day
- Gauging station 130305A (Theodore Weir) – 1754 ML/day, and
- Gauging station 130317B (Woodleigh Weir) – 1313 ML/day.

As gauging stations 130345A and 130305A have been decommissioned, flow data was obtained from gauging station 130202A (Dawson River at Taroom) instead.

Flow was in base flow condition at both gauging station on all sampling events.

The published WQO for electrical conductivity varies with flow condition (i.e. high flow versus base flow). As flow was in base flow condition on all surveys, the median electrical conductivity value for the three months was compared to the electrical conductivity WQO for base flow.

Table 2.2 Dawson River stream discharge data (130302A and 130317B gauging stations) for the survey periods from January to March 2019.

Gauging Station	Discharge (mean ML/Day)
130302A Dawson River at Taroom	
Baseflow	**784**
23-24/01/19	2.37 and 2.14
20-21/02/19	0.00 and 0.00
27-28/03/19	9.85 and 11.44
130317B Dawson River at Woodleigh	
Baseflow	**1313**
23–24/01/19	1.49 and 49.27
20–21/02/19	57.47 and 55.68
27–28/03/19	52.43 and 47.43

Grey shad ng denotes h gh f ow cond t on

3 Results

3.1 Monthly Water Quality Monitoring of All Parameters

Temperature, Dissolved Oxygen, Electrical Conductivity, pH and Turbidity

The percent saturation of dissolved oxygen was below the published WQO range at all sites except WS03 and WS07, and was below both the published WQO and the local WQG at site WS02 (Table 3.1). Dissolved oxygen (mg/L) complied with local WQG at all sites, except site WS02[2].

Water temperature was higher than the local WQG range at all sites except site WS09[3] (Table 3.1).

Temperature and dissolved oxygen were not measured in the laboratory.

Electrical conductivity, pH and turbidity were measured both in the field and the laboratory. Measurements for each parameter varied across sites and were similar when measured in the laboratory and in the field (Table 3.1and Table 3.2).

Electrical conductivity was above the published WQO at sites WS02, WS07 and WS09 when measured in the field, but complied at all sites when measured in the laboratory (Table 3.1 and Table 3.2).

Measurements of pH in the field and in the laboratory complied with the published WQO and the local WQG at all sites (Table 3.1 and Table 3.2).

Turbidity was above the published WQO at most sites except WS01 and WS02 when measured in both the laboratory and in situ, but complied with the local WQG at all sites when measured in both the field and in the laboratory (Table 3.1 and Table 3.2).

Results for depth profiles of water quality at each site are presented in Appendix A. Results for water quality below 0.3 m depth were not compared to published WQOs or local WQGs, as these guidelines are based on surface water samples rather than water sampled at depth.

[3] There are no pub shed WQOs for the concentrat on of d sso ved oxygen or water temperature.

Table 3.1 Median water quality measured in situ from January to March 2019 compared to the Water Quality Objectives to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River, and compared to local Water Quality Guidelines.

Site	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO [b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published Default WQO**	**N/A**	**370**	**6.5–8.5**	**N/A**	**85–110**	**50**
	Local WQG	**19.5–26.6**	**654**	**6.5–8.5**	**3.93–7.68**	**45.5–110**	**310**
WS01		31.2	336	7.8	5.21	71.9	18
WS02		30.0	372	7.7	2.47	33.9	25
Lower Dawson River – unregulated waters	**Published Default WQO**	**N/A**	**340**	**6.5–8.5**	**N/A**	**85–110**	**50**
	Local WQG	**19.5–26.6**	**654**	**6.5–8.5**	**3.93–7.68**	**45.5–110**	**310**
WS05		27.6	243	7.6	5.77	76.0	198
WS06		27.3	246	7.5	5.87	74.6	199
Freshwater Lakes / Reservoirs – regulated waters	**Published Default WQO**	**N/A**	**250**	**6.5–8.0**	**N/A**	**90–110**	**1–20**
	Local WQG	**21.0–29.9**	**301**	**6.5–8.0**	**2.42–9.10**	**29.4–110**	**360**
WS03		32.0	216	8.0	6.67	92.2	176
WS04		29.9	224	7.8	6.46	87.8	181
WS07		30.1	257	7.6	6.88	93.7	95
WS09		28.1	274	7.5	3.36	43.6	60

grey shad ng denotes parameters that d d not comp y w th the pub shed WQO but comp ed w th the oca WQG

b ue shad ng denotes parameters that d d not comp y w th the pub shed WQO or the oca WQG

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] water qua ty object ve for base f ow cond t ons app ed

Table 3.2 Median water quality measured in the laboratory from January to March 2019 compared to the Water Quality Objectives to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River, and compared to local Water Quality Guidelines.

Site	Guideline	Electrical Conductivity (µs/cm)	pH	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published Default WQO**	**370**	**6.5–8.5**	**50**
	Local WQG	**654**	**6.5–8.5**	**310**
WS01		300	7.78	14
WS02		350	7.77	17
Lower Dawson River – unregulated waters	**Published Default WQO**	**340**	**6.5–8.5**	**50**
	Local WQG	**654**	**6.5–8.5**	**310**
WS05		230	7.56	200
WS06		230	7.6	200
Freshwater Lakes / Reservoirs / regulated waters	**Published Default WQO**	**250**	**6.5–8.0**	**1–20**
	Local WQG	**301**	**6.5–8.0**	**360**
WS03		210	7.99	180
WS04		210	7.87	190
WS07		230	7.96	96
WS09		240	7.5	58

grey shad ng denotes parameters that d d not comp y w th the pub shed WQO but comp ed w th the oca WQG

b ue shad ng denotes parameters that d d not comp y w th the pub shed WQO or the oca WQG

Metals and Metalloids

Comparisons of results for metals against the ANZECC & ARMCANZ (2000) 95% Ecosystem Protection Level (Table 3.3 and Table 3.4) and local water quality guidelines show that concentrations of:

- total copper exceeded published WQO at sites WS05, WS06, WS07 and WS09, but complied with local WQG at all sites
- dissolved copper exceeded published WQO at all sites, but complied with local WQG at all sites
- total strontium exceeded the local WQG at sites WS01 and WS02
- total and dissolved mercury had a LOR that was higher than the WQO and local WGQ
- all other parameters complied with both the WQO and the local WQG.

Total Petroleum Hydrocarbons

Total petroleum hydrocarbons were less than the LOR at all sites (Table 3.3, Table 3.4).[4]

Major Ions and Nutrients

Comparisons of results for major ions and nutrients with the WQO for 95% Protection of Aquatic Ecosystems in the Upper and Lower Dawson (EHP 2013b) and the local WQGs showed that (Table 3.5 and Table 3.6):

- ammonia was higher than the published WQO and local WQG at site WS02, and higher than WQO at sites WS03, WS04, WS05, WS06, WS07 and WS09; ammonia complied with both the WQO and local WQG at site WS01
- chlorophyll a was higher than published WQO at all sites, and higher than both the published WQO and the local WQG at site WS02
- calcium exceeded the local WQG range at site WS02, but was within the local WQG range at all other sites
- potassium exceeded the local WQG range at sites WS01, WS02, WS05 and WS06, but complied with both WQG and WQO at all other sites
- residual alkalinity had a LOR that was higher than the guideline
- all other parameters complied with both guidelines for their respective water types.

[4] There are no pub shed WQO or oca WQG for tota petro eum hydrocarbons.

Table 3.3 Median concentration of metals, metalloids and total petroleum hydrocarbons at Upper Dawson sites January to March 2019, compared to the ANZECC & ARMCANZ (2000) Guidelines for 95% Aquatic Ecosystem Protection in relation to freshwater streams and the local water quality guidelines.

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Total Metals and Metalloids										
Arsenic	µg/L	0.5	13	13	2.8	6.9	13	13	2.8	2.9
Barium	µg/L	0.1	–	175	95	130	–	132	100	95
Beryllium	µg/L	0.1	–	0.27	<0.1	<0.1	–	0.46	0.2	0.19
Boron	µg/L	5	370	370	63	68	370	370	64	58
Cadmium	µg/L	0.1	0.2	0.2	<0.1	<0.1	0.2	0.2	<0.1	<0.1
Chromium	µg/L	0.5	1	1.76	<0.5	<0.5	–	1.65	0.78	1.2
Cobalt	µg/L	0.1	–	2.01	0.48	2	–	5.77	1	1.3
Copper	µg/L	0.5	1.4	5.53	0.5	1.1	1.4	4.98	3.3	3.7
Iron	µg/L	5	–	3645	380	740	–	3162	2100	2900
Lead	µg/L	0.1	3.4	4.43	0.25	0.24	3.4	6.14	1.6	2.1
Manganese	µg/L	0.5	1900	1900	160	1300	1900	1900	89	92
Mercury	µg/L	0.1	0.06[b]	0.06	<0.1	<0.1	0.06[b]	0.06	<0.1	<0.1
Nickel	µg/L	0.1	11	11	1.3	3.5	11	11	2.8	2.9
Selenium	µg/L	0.5	5[b]	< LOR	<0.5	<0.5	5[b]	< LOR	<0.5	<0.5
Silver	µg/L	0.1	–	< LOR	<0.1	<0.1	–	0.15	<0.1	<0.1

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Strontium	µg/L	0.1	–	418	500	530	–	396	270	280
Tin	µg/L	0.5	–	< LOR	<0.5	<0.5	–	0.5	<0.5	<0.5
Vanadium	µg/L	0.1	–	10.6	2.4	3.2	–	19.1	8.2	8.5
Zinc	µg/L	0.5	8	14	2.5	2.5	8	14.2	6	12
Dissolved Metals and Metalloids										
Arsenic	µg/L	0.5	13	–	2.2	5.3	13	–	1.8	1.9
Barium	µg/L	0.1	–	–	98	95	–	–	53	55
Beryllium	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Boron	µg/L	5	370	–	54	55	370	–	54	49
Cadmium	µg/L	0.1	0.2	–	<0.1	<0.1	0.2	–	<0.1	<0.1
Chromium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Cobalt	µg/L	0.1	–	–	0.24	1.5	–	–	<0.1	<0.1
Copper	µg/L	0.5	1.4	–	<0.5	0.62	1.4	–	1.7	1.6
Iron	µg/L	5	–	–	19	99	–	–	80	110
Lead	µg/L	0.1	3.4	–	<0.1	<0.1	3.4	–	<0.1	0.1
Manganese	µg/L	0.5	1900	–	96	750	1900	–	3.8	3.2
Mercury	µg/L	0.1	0.06[b]	–	<0.1	<0.1	0.06[b]	–	<0.1	<0.1
Nickel	µg/L	0.1	11	–	1	1.6	11	–	1.6	1.5

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Selenium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Silver	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Strontium	µg/L	0.1	–	–	500	480	–	–	220	230
Tin	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Vanadium	µg/L	0.1	–	–	1.4	2.2	–	–	3.6	3.7
Zinc	µg/L	0.5	8	–	0.5	0.5	8	–	0.5	0.5
Total Petroleum Hydrocarbons										
TPH C6-C9 Fraction	µg/L	10	–	–	<10	<10	–	–	<10	<10
TRPH >C10-C16 Fraction	µg/L	50	–	–	<50	<50	–	–	<50	<50
TRPH >C16-C34 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C34-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C10-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] app cab e on y when pH s > 6.5, where pH s < 6.5 there s nsuff c ent data

[b] the 99% eve of spec es protect on was used

Table 3.4 Median concentration of metals, metalloids and total petroleum hydrocarbons at Lower Dawson sites from January to March 2019, compared to the ANZECC & ARMCANZ (2000) Guidelines for 95% Aquatic Ecosystem Protection in relation to freshwater streams and the local water quality guidelines.

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Total Metals and Metalloids										
Arsenic	µg/L	0.5	13	13	2.9	2.9	13	13	2.8	2.8
Barium	µg/L	0.1	–	175	110	110	–	132	69	54
Beryllium	µg/L	0.1	–	0.27	0.23	0.22	–	0.46	<0.1	<0.1
Boron	µg/L	5	370	370	56	56	370	370	49	47
Cadmium	µg/L	0.1	0.2	0.2	<0.1	<0.1	0.2	0.2	<0.1	<0.1
Chromium	µg/L	0.5	1	1.76	1.4	1.3	–	1.65	0.95	0.58
Cobalt	µg/L	0.1	–	2.01	1.6	1.7	–	5.77	0.92	0.44
Copper	µg/L	0.5	1.4	5.53	3.9	3.9	1.4	4.98	2.5	2.4
Iron	µg/L	5	–	3645	2500	3000	–	3162	2300	1200
Lead	µg/L	0.1	3.4	4.43	2.2	2.3	3.4	6.14	1	0.74
Manganese	µg/L	0.5	1900	1900	140	140	1900	1900	130	61
Mercury	µg/L	0.1	0.06[b]	< LOR	<0.1	<0.1	0.06[b]	0.06	<0.1	<0.1
Nickel	µg/L	0.1	11	11	3.4	3.1	11	11	2.2	1.8
Selenium	µg/L	0.5	5[b]	5	<0.5	<0.5	5[b]	5	<0.5	<0.5
Silver	µg/L	0.1	–	< LOR	<0.1	<0.1	–	0.15	<0.1	<0.1

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Strontium	µg/L	0.1	–	418	280	300	–	396	250	250
Tin	µg/L	0.5	–	< LOR	<0.5	<0.5	–	0.5	<0.5	<0.5
Vanadium	µg/L	0.1	–	10.6	8.9	9	–	19.1	5.8	6.9
Zinc	µg/L	0.5	8	14	9	8.3	8	14.2	5.6	2.5
Dissolved Metals and Metalloids										
Arsenic	µg/L	0.5	13	–	1.8	1.7	13	–	1.5	2.3
Barium	µg/L	0.1	–	–	59	60	–	–	52	42
Beryllium	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Boron	µg/L	5	370	–	55	50	370	–	42	39
Cadmium	µg/L	0.1	0.2	–	<0.1	<0.1	0.2	–	<0.1	<0.1
Chromium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Cobalt	µg/L	0.1	–	1.89	0.11	0.15	1.4	–	<0.1	<0.1
Copper	µg/L	0.5	1.4	–	1.6	1.5	1.4	–	1.3	1.1
Iron	µg/L	5	–	–	89	88	–	–	85	64
Lead	µg/L	0.1	3.4	–	<0.1	<0.1	3.4	–	<0.1	<0.1
Manganese	µg/L	0.5	1900	–	26	24	1900	–	33	4.7
Mercury	µg/L	0.1	0.06[b]	–	<0.1	<0.1	0.06[b]	–	<0.1	<0.1
Nickel	µg/L	0.1	11	–	1.6	1.5	11	–	1.3	1

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Selenium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Silver	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Strontium	µg/L	0.1	–	–	220	230	–	–	230	240
Tin	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Vanadium	µg/L	0.1	–	–	3.4	3.5	–	–	2.8	4.2
Zinc	µg/L	0.5	8	–	0.5	0.5	8	–	0.5	0.5
Total Petroleum Hydrocarbons										
TPH C6-C9 Fraction	µg/L	10	–	–	<10	<10	–	–	<10	<10
TRPH >C10-C16 Fraction	µg/L	50	–	–	<50	<50	–	–	<50	<50
TRPH >C16-C34 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C34-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C10-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] app cab e on y when pH s > 6.5, where pH s < 6.5 there s nsuff c ent data

[b] the 99% eve of spec es protect on was used

Table 3.5 Median alkalinity, and concentration of major cations and anions, nutrients and chlorophyll *a* at Upper Dawson Sites from January to March 2019, compared to the Guidelines for 95% Aquatic Ecosystem Protection in the Upper and Lower Dawson River (EHP 2013b).

Parameter	Units	LOR	WQO Upper Dawson River	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Alkalinity										
Bicarbonate	mg/L	1	–	140	125	135	–	115	71	71
Hydroxide	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Carbonate	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Residual Alkalinity	meq/L	1	–	0.75	<1	<1	–	0.67	<1	<1
Total Alkalinity ($CaCO_3$)	mg/L	1	–	140	125	135	–	115	71	71
Hardness	mg/L	1	–	–	93	100	–	–	53	52
Major Cations and Anions										
Calcium	mg/L	0.1	–	14.7 – 27.7	25.0	28.0	–	12.4 – 21.3	14.0	14.0
Magnesium	mg/L	0.01	–	8.38	7.60	7.80	–	6.34	4.30	4.10
Potassium	mg/L	0.2	–	7.40	7.6	9.3	–	9.34	7.5	7.4
Sodium	mg/L	1	–	48.4	27	31	–	31.3	21	22
Chloride	mg/L	2	–	77.1	32	37	–	35.4	18	19
Fluoride	mg/L	0.05	–	0.31	0.19	0.2	–	0.33	0.14	0.14
Sulfate	mg/L	5	5	5.9	0.7	1.2	5	9.3	3.1	2.9
Sulfur	mg/L	0.1	–	–	0.25	0.39	–	–	1	0.96

Nutrients

Parameter	Units	LOR	WQO Upper Dawson River	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Ammonia-Nitrogen	mg/L	0.005	0.02	0.07	0.02	0.12	0.01	0.21	0.049	0.05
Biological										
Chlorophyll *a*	µg/L	1	5	10.2	9.2	26	5	48.9	11	14

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

Table 3.6 Median alkalinity, and concentration of major cations and anions, nutrients and chlorophyll *a* at Lower Dawson Sites from January to March 2019, compared to the Guidelines for 95% Aquatic Ecosystem Protection in the Upper and Lower Dawson River (EHP 2013b).

Parameter	Units	LOR	WQO Lower Dawson River	Local WQG	WS05	WS06	WQO Freshwater lakes / reservoirs	Local WQG	WS07	WS09
Alkalinity										
Bicarbonate	mg/L	1	–	140	71	74	–	115	70	74
Hydroxide	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Carbonate	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Residual Alkalinity	meq/L	1	–	0.75	<1	<1	–	0.67	<1	<1
Total Alkalinity ($CaCO_3$)	mg/L	1	–	140	71	74	–	115	70	74
Hardness	mg/L	1	–	–	56	56	–	–	54	56
Major Cations and Anions										
Calcium	mg/L	0.1	–	14.7 – 27.7	15.0	15.0	–	12.4 – 21.3	14.0	15.0
Magnesium	mg/L	0.01	–	8.38	4.30	4.40	–	6.34	4.40	4.80
Potassium	mg/L	0.2	–	7.40	7.7	7.8	–	9.34	6.9	6.6
Sodium	mg/L	1	–	48.4	24	25	–	31.3	24	26
Chloride	mg/L	2	–	77.1	24	23	–	35.4	27	28
Fluoride	mg/L	0.05	–	0.31	0.14	0.15	–	0.33	0.14	0.15
Sulfate	mg/L	5	25	5.9 [a]	3.4	3.3	25	9.3	4.2	5.2
Sulfur	mg/L	0.1	–	–	1.1	1.1	–	–	1.4	1.7

Nutrients

Parameter	Units	LOR	WQO Lower Dawson River	Local WQG	WS05	WS06	WQO Freshwater lakes / reservoirs	Local WQG	WS07	WS09
Ammonia-Nitrogen	mg/L	0.005	0.02	0.07	0.04	0.04	0.01	0.21	0.03	0.06
Biological										
Chlorophyll *a*	µg/L	1	5	10.2	6	5.8	5	48.9	7.2	5.8

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] the oca WQG s ower than the pub shed WQO for the ower Dawson R ver because t was deve oped to rep ace WQOs for the upper Dawson R ver, wh ch has a ower pub shed WQO than the ower Dawson

3.2 Weekly Water Quality Monitoring of Boron and Temperature

The concentrations of total and dissolved boron were below the BUA Irrigator Notification value, and below the 95% ecosystem protection level, at all sites for all surveys (Table 3.7).

Water temperature ranged from 23.9 ºC to 34.9 ºC and had temperatures above the local WQG range in all weeks surveyed, excluding the last week in March (Table 3.7).

Table 3.7 Results for total and dissolved boron, and water temperature, for GBUS monitoring from January to March 2019.

Parameter	Unit	LOR	BUA Irrigator Notification value	ANZECC & ARMCANZ (2000)	Local Water Quality Guideline	Sites				
						WS03	WS04	WS05	WS06	Blank [a]
3 January 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.045	0.053	0.048	0.048	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.039	0.042	0.038	0.039	<0.005
Temperature	ºC	–	–	–	[b]	30.9	29.4	31.8	32.0	–
10 January 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.047	0.054	0.058	0.061	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.041	0.046	0.049	0.065	<0.005
Temperature	ºC	–	–	–	[b]	28.1	25.9	25.9	26.4	–
15 January 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.050	0.062	0.063	0.059	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.048	0.064	0.047	0.046	<0.005
Temperature	ºC	–	–	–	[b]	34.9	34.8	29.6	33.3	–
30 January 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.051	0.063	0.048	0.057	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.048	0.060	0.047	0.045	<0.005
Temperature	ºC	–	–	–	[b]	28.2	26.7	29.8	31.2	–

Parameter	Unit	LOR	BUA Irrigator Notification value	ANZECC & ARMCANZ (2000)	Local Water Quality Guideline	Sites				
						WS03	WS04	WS05	WS06	Blank [a]
4 February 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.067	0.078	0.067	0.068	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.053	0.069	0.059	0.060	<0.005
Temperature	°C	–	–	–	[b]	29.5	29.0	30.8	32.4	–
13 February 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.061	0.064	0.072	0.084	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.055	0.062	0.065	0.069	<0.005
Temperature	°C	–	–	–	[b]	33.8	31.1	29.8	32.2	–
27 February 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.062	0.073	0.064	0.065	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.053	0.065	0.056	0.061	<0.005
Temperature	°C	–	–	–	[b]	32.5	26.7	28.8	28.6	–
5 March 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.058	0.057	0.055	0.063	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.050	0.050	0.052	0.058	<0.005
Temperature	°C	–	–	–	[b]	28.0	25.5	26.6	30.7	–
11 March 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.059	0.065	0.070	0.063	<0.005

Parameter	Unit	LOR	BUA Irrigator Notification value	ANZECC & ARMCANZ (2000)	Local Water Quality Guideline	Sites				
						WS03	WS04	WS05	WS06	Blank [a]
Dissolved boron	mg/L	0.005	0.5	0.37		0.051	0.058	0.057	0.059	<0.005
Temperature	ºC	–	–	–	[b]	33.0	33.5	30.5	30.9	–
27 March 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.054	0.066	0.069	0.063	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.047	0.055	0.057	0.053	<0.005
Temperature	ºC	–	–	–	[b]	26.8	26.3	25.6	23.9	–

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

[a] the b ank s a samp e of de on sed water that was a quoted to samp e bott es n the f e d for QA/QC purposes.

[b] for temperature the oca WQG for unregu ated water (19.5–26.6ºC) was app ed to s tes WS05 and WS06, and the oca WQG for regu ated water (21.0–29.9ºC) was app ed to s tes WS03 and WS04

4 Impact Assessment

Higher water temperatures measured reflect a seasonal pattern (i.e. summer) and are unlikely to be influenced by the release of CS water, with reference sites WS01 and WS02 also having water temperature higher than the local WQG. It is recommended that the local WQG be amended to have season-specific guidelines (i.e. separate guidelines for each of spring, summer, winter and autumn).

Percent dissolved oxygen saturation was below the local WQG at only reference site WS02. As this is a reference site, upstream, of the release location, this result does not reflect an influence of the release of treated CS water.

Total strontium exceeded the local WQG at references sites WS01 and WS02, but as these sites are upstream of the release location, these results do not reflect an influence of the release of treated CS water.

Calcium was higher than the local WQG range at reference site WS02, but as this site is upstream of the release location, the result does not reflect an influence of the release of treated CS water.

Chlorophyll a was higher than the local WQG at reference site WS02, but as this site is upstream of the release location, the result does not reflect an influence of the release of treated CS water.

Potassium was higher than the local WQG range at reference sites WS01 and WS02, and receiving environment sites WS05 and WS06. However, as site WS04 that is immediately downstream of the release point complied with the local WQG, and sites WS01 and WS02 are reference sites, it is unlikely that these exceedances were a result of the release of treated CS water.

Ammonia was higher than the local WQG at reference site WS02, but as this site is upstream of the release locations, the result does not reflect an influence of the release of treated CS water.

Monthly monitoring of all other parameters indicated they complied with the local WQG and thus reflected ambient baseline conditions. Weekly monitoring of boron showed that concentrations of both total and dissolved boron were below applicable guidelines, including the irrigation trigger level of the BUA.

Overall, the release of treated CS water does not appear to have had an adverse impact on water quality in the receiving environment from January to March 2019.

5 References

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Appendix A Depth Profiles of Water Quality Measured In Situ

Table A.1 Depth profile results of water quality measured *in situ* in January 2019.

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters		**Published WQO**		**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
		Local WQG		**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	24/01/19	14:14	0.3	31.19	322	7.85	4.6	64.3	18
			0.5	29.99	314	7.79	4.2	56.7	–
			1	29.24	314	7.75	3.0	40.5	–
			1.5	28.47	323	7.65	1.2	15.3	–
WS02	24/01/19	13:29	0.3	30.75	372	7.67	3.0	41.1	14
Freshwater Lakes / Reservoirs / regulated waters		**Published WQO**		**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
		Local WQG		**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	24/01/19	11:21	0.3	32.59	207	7.75	6.0	85.4	217
			0.5	31.30	205	7.76	5.3	73.1	–
			1	30.35	207	7.76	5.1	69.8	–
			1.5	29.59	209	7.75	5.1	68.4	–
			2	29.01	210	7.72	4.9	64.8	–
			3	27.92	210	7.60	2.6	33.9	–
			4	26.60	204	7.45	0.4	5.0	–
			5	25.85	203	7.37	0.1	1.2	–
WS04	24/01/19	10:49	0.3	0.3	28.58	213	7.64	5.3	221

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			0.5	0.5	27.73	212	7.64	4.7	–
			1	1	27.49	212	7.63	4.7	–
			1.5	1.5	27.30	213	7.62	4.8	–
			2	2	27.04	214	7.60	4.8	–
			3	3	26.55	211	7.52	3.1	–
			4	4	25.91	206	7.38	1.0	–
Lower Dawson River – unregulated waters		**Published WQO**		**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
		Local WQG		**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	24/01/19	09:05	0.3	27.16	351	7.30	2.0	25.9	198
			0.5	27.09	353	7.28	1.9	23.9	–
WS06	24/01/19	09:50	0.3	28.49	482	7.29	2.3	30.2	141
			0.5	28.08	482	7.28	1.6	21.1	–
Freshwater Lakes / Reservoirs – regulated waters		**Published WQO**		**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
		Local WQG		**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	23/01/19	14:39	0.3	30.14	257	7.64	6.9	93.7	95
			0.5	28.58	250	7.59	4.0	52.9	–
			1	27.98	250	7.57	2.5	32.4	–
			1.5	27.41	250	7.55	2.6	33.3	–
			2	26.84	251	7.52	2.5	32.5	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (μs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			3	25.98	251	7.41	0.9	10.9	–
			4	25.30	255	7.28	0.0	-0.3	–
			5	24.87	268	7.19	0.0	-0.5	–
WS09	24/01/19	06:33	0.3	28.10	233	7.47	3.4	43.6	145
			0.5	27.87	230	7.44	2.6	34.0	–
			1	27.59	228	7.40	1.7	22.4	–
			1.5	27.42	226	7.38	1.4	17.7	–
			2	27.10	212	7.33	0.4	4.6	–
			3	25.88	180	7.20	0.0	-0.5	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Table A.2 Depth profile results of water quality measured *in situ* in February 2019

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published WQO**			**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	21/02/19	14:23	0.3	32.31	336	7.82	5.2	74.5	16
			0.5	30.82	328	7.79	3.4	48.1	–
			1	30.00	329	7.73	1.8	24.0	–
WS02	21/02/19	13:47	0.3	29.98	448	7.79	2.5	33.9	25
Freshwater Lakes / Reservoirs / regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	21/02/19	11:51	0.3	31.95	216	8.09	7.1	101.1	176
			0.5	29.99	210	8.06	5.7	77.3	–
			1	29.24	211	8.02	5.2	69.5	–
			1.5	28.53	212	7.96	4.8	63.1	–
			2	27.90	214	7.89	4.5	58.9	–
			3	27.33	215	7.78	3.9	50.4	–
			4	26.85	215	7.66	3.2	41.6	–
WS04	21/02/19	11:17	0.3	29.85	224	7.80	6.5	87.8	181
			0.5	28.64	220	7.79	5.6	74.0	–
			1	28.11	219	7.78	4.8	63.0	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			1.5	27.59	220	7.74	4.4	56.9	–
			2	27.13	221	7.68	4.2	54.6	–
			3	26.78	222	7.64	4.7	60.0	–
			4	26.52	224	7.60	4.1	52.1	–
Lower Dawson River – unregulated waters	**Published WQO**			**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	21/02/19	10:27	0.3	28.16	223	7.69	5.8	76.0	196
			0.5	27.81	224	7.67	5.8	76.4	–
WS06	21/02/19	09:47	0.3	27.30	228	7.68	5.9	76.5	199
Freshwater Lakes / Reservoirs – regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	20/02/19	14:56	0.3	32.24	262	7.83	9.0	128.1	80
			0.5	29.98	248	7.81	6.5	89.9	–
			1	29.31	247	7.75	3.8	50.8	–
WS09	21/02/19	06:40	0.3	20.87	239	7.70	4.8	50.7	60
			0.5	20.87	238	7.68	4.6	48.4	–
			1	20.67	234	7.64	3.7	36.9	–
			1.5	18.35	225	7.66	4.8	47.7	–
			2	18.72	225	7.62	4.6	44.7	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			3	26.91	259	7.35	0.0	-0.4	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

green shad ng denotes parameters that were non-comp ant w th the oca WQG

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Table A.3 Depth profile results of water quality measured *in situ* in March 2019.

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published WQO**			**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	21/03/19	16:40	0.3	27.92	366	7.80	5.5	71.9	165
			0.5	27.67	365	7.79	5.2	67.9	–
			1	27.01	362	7.75	3.1	39.6	–
			1.5	26.60	362	7.71	1.9	23.9	–
WS02	21/13/19	15:34	0.3	28.33	348	7.67	1.5	19.5	185
Freshwater Lakes / Reservoirs / regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	21/03/19	13:15	0.3	30.84	248	8.03	6.7	92.2	151
			0.5	29.58	243	8.02	5.3	72.0	–
			1	28.42	242	8.00	4.6	60.3	–
			1.5	27.49	244	7.98	4.3	55.6	–
WS04	21/03/19	12:29	0.3	31.79	245	8.32	8.7	122.4	176
			0.5	30.45	241	8.29	7.3	99.4	–
			1	28.95	240	8.25	5.8	77.2	–
			1.5	28.14	238	8.19	5.0	65.3	–
			2	27.41	238	8.11	3.9	50.3	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Lower Dawson River – unregulated waters		**Published WQO**		**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
		Local WQG		**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	21/03/19	11:13	0.3	27.61	243	7.58	5.9	76.2	214
WS06	21/03/19	10:25	0.3	26.67	246	7.50	5.9	74.6	207
			0.5	26.73	245	7.50	5.9	74.6	–
Freshwater Lakes / Reservoirs – regulated waters		**Published WQO**		**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
		Local WQG		**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	20/03/19	15:51	0.3	26.52	244	6.67	4.2	53.4	165
			0.5	26.49	244	6.73	4.1	52.0	–
			1	26.35	243	6.75	3.3	42.3	–
			1.5	26.22	243	6.79	2.3	28.5	–
			2	26.05	244	6.84	1.2	15.0	–
			3	25.87	247	6.88	0.5	5.7	–
			4	25.70	265	6.89	0.1	0.9	–
WS09	21/03/19	06:54	0.3	26.05	275	7.12	4.3	54.4	21
			0.5	26.16	275	7.15	4.3	54.1	–
			1	26.29	274	7.18	4.3	53.8	–
			1.5	26.41	273	7.22	4.2	52.9	–
			2	26.48	273	7.25	4.2	53.2	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			3	26.50	273	7.28	3.8	48.6	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

green shad ng denotes parameters that were non-comp ant w th the oca WQG

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG pub shed QQO

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Appendix B: Quarterly Water Quality Monitoring Report, April to June 2019

Glebe End of Waste Scheme: Receiving Environment Monitoring Program

Water Quality Monitoring Report, April - June 2019

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Sunwater: as PDF .pdf and Word .docx

Contents

Tables

1 Introduction

1.1 Background

Sunwater is the proponent of an End of Waste Scheme involving the discharge of reverse osmosis treated coal seam water to Glebe Weir on the Dawson River. As part of the conditions of approval for the scheme Sunwater has developed a Receiving Environment Monitoring Program (REMP) that includes monitoring of water, sediment and aquatic ecology in the receiving environment (i.e. Glebe Weir and connected waterways including waters of the Dawson Valley Water Supply Scheme). The REMP includes a control : impact comparison of sites upstream and downstream of the discharge point. Historical baseline data was used to develop project-specific guidelines (local WQGs) for water quality, sediment quality and biological parameters (i.e. macroinvertebrates and fish).

This quarterly REMP report presents the monitoring results for water quality for April – June 2019. It is the thirteenth REMP report covering a three-month period (previous to October 2015 reports were provided monthly), and the seventeenth REMP report on water quality since operational discharges commenced on 7 February 2015.

1.2 Scope of Works

The monitoring sites are specified in the REMP Design Report, with the additional site WS09 also monitored for water quality (Table 2.1). The scope of works comprises:

- monthly (ambient) monitoring of water quality measured in situ and laboratory analysis of water samples for parameters specified in the REMP design
- increased frequency of monitoring at times of elevated risk[1]
- an assessment of water quality results against applicable water quality guidelines, noting any trends between sites (especially control and impact sites), and
- an assessment of any potential impact the release of treated CS water has had on water quality in the receiving environment.

The weekly assessment of total and dissolved boron, and water temperature, at selected sites was required under the previous approval, with this monitoring to be discontinued from 30 June 2019

[1] Th s REMP mon tor ng component d d not become effect ve unt   ate June 2019, and thus not app cab e to the current report.

2 Methods

2.1 Site Location Details

Eight sites were surveyed along the Dawson River (Table 2.1); six of these sites are in the receiving environment for GBUS (WS03, WS04, WS05, WS06, WS07 and WS09), and two sites (WS01 and WS02) are control sites upstream of the receiving environment.

Based on the definitions in the *Dawson River Sub–basin Environmental Values and Water Quality Objectives EPP (Water) 2009* (EHP 2013b), there are three water types in the receiving environment of GBUS:

- unregulated reaches of the upper Dawson River (flowing water)
- unregulated reaches of the lower Dawson River (flowing water), and
- regulated reaches of the Dawson River – freshwater lakes / reservoirs (non-flowing water).

The boundary between the lower and upper Dawson River Sub-catchments is Glebe Weir, with four sites in the upper Dawson and three in the lower Dawson. However, the baseline monitoring data indicates that variation in water quality, sediment quality and biological parameters within the lower and upper Dawson River water types, respectively, was often higher than between these two water types. Therefore, for the purpose of GBUS REMP monitoring and local water quality guidelines, all flowing sections of the Dawson River within the receiving environment was considered a single water type (unregulated water).

2.2 Survey Timing

Under the REMP design document, ambient monitoring of water quality for the Glebe End of Waste Scheme (GEWS) is implemented monthly.

Weekly monitoring of total and dissolved boron and water temperature at sites within and downstream of the Glebe Weir pool (WS03, WS04, WS05 and WS06) was required under a previous approval and will discontinue from 30 June 2019.

The field surveys were completed by suitably qualified persons (professional aquatic ecologists) from frc environmental on:

- 2nd–4th April 2019 (all parameters at all sites)
- 8th April 2019 (boron and temperature)
- 15th April 2019 (boron and temperature)
- 23rd April 2019 (boron and temperature)
- 2nd May 2019 (boron and temperature)
- 9th May 2019 (boron and temperature)
- 15th–16th May 2019 (all parameters at all sites)
- 23rd May 2019 (boron and temperatures)
- 29th May 2019 (boron and temperature)
- 10th–11th June 2019 (all parameters at all sites)
- 19th June 2019 (boron and temperature)
- 26th June 2019 (boron and temperature)

Table 2.1 Location of water quality monitoring sites.

Site	Water Type	Location	Latitude [a]	Longitude [a]
Upstream of Receiving Environment				
Upper Dawson				
WS01	Unregulated	Dawson River at the Old Leichardt Highway crossing at Taroom	-25.644476	149.791877
WS02	Unregulated	Dawson River at Bundulla Road Crossing	-25.572372	149.864464
Receiving Environment				
Upper Dawson				
WS03	Regulated	Dawson River Upstream of Glebe Weir	-25.476944	150.008333
WS04	Regulated	Dawson River Upstream of Glebe Weir	-25.464269	150.033529
Lower Dawson				
WS05	Unregulated	Dawson River Downstream of Glebe Weir	-25.459722	150.043889
WS06	Unregulated	Dawson River Downstream of Glebe Weir	-25.453333	150.055833
WS07	Regulated	Dawson River Upstream of Gyranda Weir	-25.284722	150.181389
WS09	Regulated	Dawson River within Theodore Weir	-24.937778	150.068056

[a] WGS84

2.3 Water Quality Sampling Protocols

All water quality sampling was carried out in accordance with the Department of Environment and Science's *Monitoring and Sampling Manual 2009* (DES 2018).

Water Quality Measured In Situ

Water quality was measured in situ approximately 0.3 m below the water surface using a SmarTroll Water Quality Meter. The water quality meter was calibrated in accordance with

the manufacturer's instructions. Where the water was of suitable depth (i.e. > 2 m), water quality was also measured at 1.0 m intervals through the water column. In shallow water (i.e. < 2 m), water quality was measured at 0.5 m depth intervals.

For the monthly water quality monitoring, the assessed parameters were:

- water temperature (°C) (also measured on boron surveys)
- pH
- dissolved oxygen (mg/L and percent saturation), and
- electrical conductivity (µS/cm).

Turbidity (NTU) was also measured during monthly water quality monitoring approximately 0.3 m below the water's surface using a HACH 2100Q portable turbidity meter.

Collection and Laboratory Analysis of Water Samples

At each site a water quality sample was collected in accordance with the Department of Environment and Science's (DES's) *Monitoring and Sampling Manual 2009* (DES 2018) and the *Procedures for REMP Monitoring and Sampling* (frc environmental 2015b). Water samples were collected using pre-labelled bottles supplied by Symbio Alliance that were appropriate for the suite of parameters being tested. Samples were collected and stored as appropriate for the parameters being tested (e.g. bottles pre-rinsed / not pre-rinsed, bottles filled or not filled to the top, chilled). All of the samples were chilled and transported to Symbio Alliance's NATA-accredited laboratory in Brisbane within the required holding time for each parameter. For monthly monitoring surveys, each sample was analysed for:

- electrical conductivity
- pH
- turbidity
- total hardness (calcium hardness)
- carbonate, bicarbonate, hydroxide
- residual alkalinity (as $CaCO_3$)
- ammonia (as N)
- major cations and anions independently (Ca, Cl, Mg, F, Na, K)
- sulphate (total and dissolved)

- a full total metal scan, including boron and mercury (ICP/MS or ultra-trace as required)
- a full dissolved metal scan, including boron and mercury (ICP/MS or ultra-trace as required)
- chlorophyll *a*, and
- hydrocarbons (C6-C9, C10-C14, C15-C28, C29-C36).

For the weekly monitoring surveys, only total and dissolved boron was analysed.

An additional site replicate and a field blank (i.e. sample bottle filled with deionised water in the field) was collected during each survey for QA/QC purposes.

The testing methods and Limits of Reporting (LOR) used by the laboratory were based on the 95% ecosystem protection guidelines (ANZECC & ARMCANZ 2000), and specified on the Chain of Custody (COC) forms submitted with each sample batch.

2.4 Quality Assurance and Quality Control

Relative Percent Difference

Relative percent difference (RPD) is a measure of how similar two samples are, with low RPD indicating the samples are very similar[2]. RPD can be used in two ways:

1. comparing *duplicate* samples (i.e. sub-samples of a single sample, taken in the laboratory), which assesses laboratory testing precision and repeatability, and
2. comparing *replicate* samples (i.e. different samples taken at the same site), which tests natural within-site variability.

RPD analyses on *duplicate* samples for the monthly surveys and the weekly boron surveys showed that all laboratory results were within acceptable limits.

[2] RPD s nf uenced by the magn tude of the va ues be ng compared; for examp e a s ght change between arge numbers g ves a very ow RPD, but a s m ar s ght change between sma numbers g ves a much h gher RPD. Consequent y, n the context of assessment of dup cate samp es n the aboratory, DES spec f es a RPD of 20% for resu ts that are at east f ve t mes the LOR, as a h gher RPD s expected for resu ts c oser to the LOR. There s no thresho d for RPD when compar ng rep cate samp es, as th s s assess ng natura w th n-s te var at on, a though where RPD s h gh between rep cate samp es t s prudent to nterpret resu ts as est mates rather than prec se va ues.

RPD analyses between *replicates* for the monthly surveys showed low variability across all parameters and within acceptable limits.

RPD analyses between *replicates* for the weekly surveys showed limited variability in concentrations of total and dissolved boron.

Assessment of LOR for Blank Samples

The laboratory blank sample was below the LOR for all parameters on all surveys.

The field blank sample was below the LOR for all parameters on all surveys, with the exception of the following:

- electrical conductivity – April (9 µS/cm)
- turbidity – April (0.2 NTU) and May (0.1 NTU)
- barium (dissolved) – April (0.00089 µg/L)
- boron (total) – May (0.0081 µg/L)
- iron (dissolved) – April (0.0053 µg/L)
- TPH C6-C9 fraction – April (170 µg/L)
- bicarbonate – April (4 mg/L), May (2 mg/L) and June (2 mg/L)
- total alkalinity (CaCO3) – April (4 mg/L), May (2 mg/L) and June (2 mg/L)
- ammonia as N – April (0.02 mg/L) and May (0.008 mg/L)

As a result, concentrations of these parameters should be treated as estimates rather than precise values.

2.5 Comparison with Guidelines

Water Quality

For monthly water quality monitoring, the median of each parameter at each site across the three-monthly surveys was calculated and compared to the relevant guideline; raw data for each parameter at each site on each survey was provided to Sunwater in an accompanying Excel spreadsheet.

For weekly monitoring of total and dissolved boron and temperature, results for each weekly survey were compared separately to the relevant guideline.

The relevant guidelines were as follows:

- dissolved oxygen, pH, electrical conductivity, turbidity, major ions and nutrients were compared with the Water Quality Objectives (WQOs) to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River (EHP 2013a). This guideline was used because none of the study sites are in High Ecological Value (HEV) areas
- metals and other contaminants were compared with the Australian and New Zealand Guidelines for fresh and marine water quality (ANZECC & ARMCANZ 2000) based on the 95% level of protection of aquatic ecosystems, although mercury was assessed using the guideline for the 99% level of protection of aquatic ecosystems
- all parameters were assessed against local water quality guidelines that were developed using baseline data collected from the receiving environment for GBUS (pre-discharge) (frc environmental 2015a), and
- total and dissolved boron were compared against the Irrigator Notification values listed in Schedule C – Table 1 of the BUA, and the 95% ecosystem level protection guidelines (ANZECC & ARMCANZ 2000).

According to the Queensland Water Quality Guidelines (EHP 2013a) base flow is considered to be when discharge at the time of sampling is less than the 90th percentile of all discharge records. Using this criterion, the base flow thresholds provided by Sunwater for this project were:

- Gauging station 130345A (Glebe Weir) – 1177 ML/day
- Gauging station 130305A (Theodore Weir) – 1754 ML/day, and
- Gauging station 130317B (Woodleigh Weir) – 1313 ML/day.

As gauging stations 130345A and 130305A have been decommissioned, flow data was obtained from gauging station 130202A (Dawson River at Taroom) instead.

Flows were below the base flow threshold at both gauging station on all sampling events with the exception of April 2019 at gauging station 130302A.

The published WQO for electrical conductivity varies with flow condition (i.e. high flow versus base flow). With the exception of early April at gauging station 130302A, flows in the Dawson river were below the base flow threshold. The median electrical conductivity value for the three months was compared to the electrical conductivity WQO for base flow.

Table 2.2 Dawson River stream discharge data (130302A and 130317B gauging stations) for the survey periods from April to June 2019.

Gauging Station	Discharge (mean ML/Day)
130302A Dawson River at Taroom	
Baseflow	**784**
02–04/04/19	2242.15, 1392.53 and 860.69
15-16/05/19	54.37 and 50.92
10-11/06/19	25.81 and 24.67
130317B Dawson River at Woodleigh	
Baseflow	**1313**
02–04/04/19	42.32, 36.78 and 34.13
15-16/05/19	30.58 and 31.62
10-11/06/19	191.51 and 184.21

Grey shad ng denotes h gh f ow cond t on

3 Results

3.1 Monthly Water Quality Monitoring of All Parameters

Temperature, Dissolved Oxygen, Electrical Conductivity, pH and Turbidity

The percent saturation of dissolved oxygen was below the published WQO range but compliant with the local WQG at sites WS01, WS02 and WS06 (Table 3.1). Dissolved oxygen (mg/L) complied with local WQG at all sites, except site WS05 where the concentration was higher than the 80th percentile of baseline data.

Water temperature was lower than the local WQG range at sites WS05, WS04 and WS07[3] (Table 3.1).

Temperature and dissolved oxygen were not measured in the laboratory.

Electrical conductivity, pH and turbidity were measured both in the field and the laboratory. Measurements for each parameter varied across sites and were similar when measured in the laboratory and in the field (Table 3.1and Table 3.2).

Electrical conductivity was above the published WQO but lower than the local WQG at site WS09 when measured in the field and when measured in the laboratory (Table 3.1 and Table 3.2).

Measurements of pH in the laboratory complied with the published WQO and the local WQG at all sites (Table 3.1 and Table 3.2). Measurements of pH in the field complied with the published WQO and the local WQG at all sites except at site WS09 where pH was slightly below the published and local WQO ranges (Table 3.1).

Turbidity when measured in the field and laboratory was above the published WQO at sites WS01, WS02 and WS07, and above both the published and local WQO at sites WS05, WS06, WS03 and WS04 (Table 3.1 and Table 3.2).

Results for depth profiles of water quality at each site are presented in Appendix A. Results for water quality below 0.3 m depth were not compared to published WQOs or local WQGs, as these guidelines are based on surface water samples rather than water sampled at depth.

[3] There are no pub shed WQOs for the concentrat on of d sso ved oxygen or water temperature.

Table 3.1 Median water quality measured in situ from April to June March 2019 compared to the Water Quality Objectives to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River, and compared to local Water Quality Guidelines.

Site	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO [b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published Default WQO**	**N/A**	**370**	**6.5–8.5**	**N/A**	**85–110**	**50**
	Local WQG	**19.5–26.6**	**654**	**6.5–8.5**	**3.93–7.68**	**45.5–110**	**310**
WS01		19.6	182	7.7	6.07	67.2	150
WS02		21.1	155	7.5	6.62	75.9	234
Lower Dawson River – unregulated waters	**Published Default WQO**	**N/A**	**340**	**6.5–8.5**	**N/A**	**85–110**	**50**
	Local WQG	**19.5–26.6**	**654**	**6.5–8.5**	**3.93–7.68**	**45.5–110**	**310**
WS05		19.4	165	7.3	8.91	97.1	379
WS06		19.7	176	7.3	5.36	59.6	369
Freshwater Lakes / Reservoirs – regulated waters	**Published Default WQO**	**N/A**	**250**	**6.5–8.0**	**N/A**	**90–110**	**1–20**
	Local WQG	**21.0–29.9**	**301**	**6.5–8.0**	**2.42–9.10**	**29.4–110**	**360**
WS03		24.6	135	7.2	5.32	59	505
WS04		20.6	134	7.6	6.28	69.1	492
WS07		20.4	234	7.2	4.85	54.3	174
WS09		21.0	275	6.4	6.98	78.7	11.4

grey shad ng denotes parameters that d d not comp y w th the pub shed WQO but comp ed w th the oca WQG

b ue shad ng denotes parameters that d d not comp y w th the pub shed WQO or the oca WQG

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] water qua ty object ve for base f ow cond t ons app ed

Table 3.2 Median water quality measured in the laboratory from April to June 2019 compared to the Water Quality Objectives to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River, and compared to local Water Quality Guidelines.

Site	Guideline	Electrical Conductivity (µs/cm)	pH	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published Default WQO**	**370**	**6.5–8.5**	**50**
	Local WQG	**654**	**6.5–8.5**	**310**
WS01		200	7.54	140
WS02		170	7.53	210
Lower Dawson River – unregulated waters	**Published Default WQO**	**340**	**6.5–8.5**	**50**
	Local WQG	**654**	**6.5–8.5**	**310**
WS05		170	7.62	380
WS06		180	7.54	400
Freshwater Lakes / Reservoirs / regulated waters	**Published Default WQO**	**250**	**6.5–8.0**	**1–20**
	Local WQG	**301**	**6.5–8.0**	**360**
WS03		150	7.31	470
WS04		150	7.43	470
WS07		240	7.52	140
WS09		280	7.79	10

grey shad ng denotes parameters that d d not comp y w th the pub shed WQO but comp ed w th the oca WQG

b ue shad ng denotes parameters that d d not comp y w th the pub shed WQO or the oca WQG

Metals and Metalloids

Comparisons of results for metals against the ANZECC & ARMCANZ (2000) 95% Ecosystem Protection Level (Table 3.3 and Table 3.4) and local water quality guidelines show that concentrations of:

- total barium exceeded the local WQG at site WS03.
- total beryllium exceeded the local WQG at all sites WS04, WS05 and WS06
- total chromium exceeded the published WQO at site WS01, and the local WQG at sites WS02, WS03, WS04, WS05 and WS06
- total copper exceeded the published WQO at sites WS01, WS02, WS06 and WS07, and the local WQG at sites WS03, WS04 and WS05
- dissolved copper exceeded the published WQO at sites WS03, WS04, WS05 and WS06, but did not exceed the local WQG
- total iron exceeded the local WQG at sites WS03, WS04, WS05, WS06 and WS07
- total lead exceeded published WQO at site WS03, WS04, WS05 and WS06, but did not exceed the local WQG at any site
- total and dissolved mercury had a LOR that was higher than the WQO and local WGQ
- all other parameters complied with both the WQO and the local WQG.

Total Petroleum Hydrocarbons

Total petroleum hydrocarbons were less than the LOR at all sites (Table 3.3, Table 3.4).[4]

Major Ions and Nutrients

Comparisons of results for major ions and nutrients with the WQO for 95% Protection of Aquatic Ecosystems in the Upper and Lower Dawson (EHP 2013b) and the local WQGs showed that (Table 3.5 and Table 3.6):

- ammonia was higher than the published WQO and local WQG at site WS06, and higher than the published WQO at all sites
- calcium was below the local WQG range at site WS01, WS02, WS03, WS04, WS05 and WS06, but was within the local WQG range at all other sites

[4] There are no pub shed WQO or oca WQG for tota petro eum hydrocarbons.

all other parameters complied with both the WQO and the local WQG.

Chlorophyll a

Chlorophyll a was higher than published WQO at sites WS03 and WS09, although all sites complied with the local WQG.

Table 3.3 Median concentration of metals, metalloids and total petroleum hydrocarbons at Upper Dawson sites April to June 2019, compared to the ANZECC & ARMCANZ (2000) Guidelines for 95% Aquatic Ecosystem Protection in relation to freshwater streams and the local water quality guidelines.

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Total Metals and Metalloids										
Arsenic	µg/L	0.5	13	13	1.2	1.4	13	13	1.8	1.9
Barium	µg/L	0.1	–	175	88	91	–	132	140	120
Beryllium	µg/L	0.1	–	0.27	0.15	0.2	–	0.46	0.44	0.47
Boron	µg/L	5	370	370	30	29	370	370	36	39
Cadmium	µg/L	0.1	0.2	0.2	<0.1	<0.1	0.2	0.2	<0.1	<0.1
Chromium	µg/L	0.5	1	1.76	1.2	1.8	–	1.65	2.1	2.3
Cobalt	µg/L	0.1	–	2.01	0.91	1.3	–	5.77	2	2.1
Copper	µg/L	1	1.4	5.53	2.9	4	1.4	4.98	5.6	5.5
Iron	µg/L	5	–	3645	2000	2700	–	3162	4300	5200
Lead	µg/L	0.1	3.4	4.43	1.7	2.3	3.4	6.14	4.1	4.5
Manganese	µg/L	0.5	1900	1900	41	57	1900	1900	80	91
Mercury	µg/L	0.1	0.06[b]	0.06	<0.1	<0.1	0.06[b]	0.06	<0.1	<0.1
Nickel	µg/L	0.5	11	11	1.9	2.7	11	11	4.2	4.2
Selenium	µg/L	0.5	5[b]	< LOR	<0.5	<0.5	5[b]	< LOR	<0.5	<0.5
Silver	µg/L	0.1	–	< LOR	<0.1	<0.1	–	0.15	<0.1	<0.1

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Strontium	µg/L	0.1	–	418	210	250	–	396	190	200
Tin	µg/L	0.5	–	< LOR	<0.5	<0.5	–	0.5	<0.5	<0.5
Vanadium	µg/L	0.1	–	10.6	5.5	7.2	–	19.1	11	12
Zinc	µg/L	5	8	14	5.9	7.3	8	14.2	13	14
Dissolved Metals and Metalloids										
Arsenic	µg/L	0.5	13	–	0.71	0.75	13	–	1.1	1
Barium	µg/L	0.1	–	–	61	53	–	–	47	46
Beryllium	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Boron	µg/L	5	370	–	29	29	370	–	35	43
Cadmium	µg/L	0.1	0.2	–	<0.1	<0.1	0.2	–	<0.1	<0.1
Chromium	µg/L	0.5	–	–	<0.5	<0.5	–	–	1.1	0.97
Cobalt	µg/L	0.1	–	–	0.14	0.2	–	–	0.3	0.27
Copper	µg/L	0.5	1.4	–	0.87	1.4	1.4	–	2.3	2.1
Iron	µg/L	5	–	–	290	310	–	–	1200	1000
Lead	µg/L	0.1	3.4	–	0.18	0.27	3.4	–	0.66	0.65
Manganese	µg/L	0.5	1900	–	8.1	8.9	1900	–	7.1	6.5
Mercury	µg/L	0.1	0.06[b]	–	<0.1	<0.1	0.06[b]	–	<0.1	<0.1
Nickel	µg/L	0.5	11	–	1.2	1.3	11	–	2	1.8
Selenium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Silver	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Strontium	µg/L	0.1	–	–	170	150	–	–	120	120
Tin	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Vanadium	µg/L	0.2	–	–	2.1	2.5	–	–	5	4.8
Zinc	µg/L	1	8	–	<1	<1	8	–	2.8	2.4
Total Petroleum Hydrocarbons										
TPH C6-C9 Fraction	µg/L	10	–	–	<10	<10	–	–	<10	<10
TRPH >C10-C16 Fraction	µg/L	50	–	–	<50	<50	–	–	<50	<50
TRPH >C16-C34 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C34-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C10-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] app cab e on y when pH s > 6.5, where pH s < 6.5 there s nsuff c ent data

[b] the 99% eve of spec es protect on was used

Table 3.4 Median concentration of metals, metalloids and total petroleum hydrocarbons at Lower Dawson sites from April to June 2019, compared to the ANZECC & ARMCANZ (2000) Guidelines for 95% Aquatic Ecosystem Protection in relation to freshwater streams and the local water quality guidelines.

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Total Metals and Metalloids										
Arsenic	µg/L	0.5	13	13	1.8	2.1	13	13	2.6	2.5
Barium	µg/L	0.1	–	175	140	120	–	132	90	49
Beryllium	µg/L	0.1	–	0.27	0.44	0.38	–	0.46	0.13	<0.1
Boron	µg/L	5	370	370	42	45	370	370	49	48
Cadmium	µg/L	0.1	0.2	0.2	<0.1	<0.1	0.2	0.2	<0.1	<0.1
Chromium	µg/L	0.5	1	1.76	2.1	2.1	–	1.65	1.2	<0.5
Cobalt	µg/L	0.1	–	2.01	1.6	1.9	–	5.77	0.78	0.14
Copper	µg/L	1	1.4	5.53	5.6	5.5	1.4	4.98	2.7	1.1
Iron	µg/L	5	–	3645	4200	4000	–	3162	4400	210
Lead	µg/L	0.1	3.4	4.43	4.1	4.2	3.4	6.14	1.3	0.17
Manganese	µg/L	0.5	1900	1900	98	110	1900	1900	88	38
Mercury	µg/L	0.1	0.06b	< LOR	<0.1	<0.1	0.06[b]	0.06	<0.1	<0.1
Nickel	µg/L	0.5	11	11	3.7	3.6	11	11	2.4	1.1
Selenium	µg/L	0.5	5b	5	<0.5	<0.5	5[b]	5	<0.5	<0.5
Silver	µg/L	0.1	–	< LOR	<0.1	<0.1	–	0.15	<0.1	<0.1

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Strontium	µg/L	0.1	–	418	210	220	–	396	210	250
Tin	µg/L	0.5	–	< LOR	<0.5	<0.5	–	0.5	<0.5	<0.5
Vanadium	µg/L	0.1	–	10.6	10	9.7	–	19.1	6.5	3.5
Zinc	µg/L	5	8	14	14	14	8	14.2	7.8	<5
Dissolved Metals and Metalloids										
Arsenic	µg/L	0.5	13	–	1.1	1.2	13	–	1.3	2.4
Barium	µg/L	0.1	–	–	49	52	–	–	49	49
Beryllium	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Boron	µg/L	5	370	–	40	42	370	–	50	41
Cadmium	µg/L	0.1	0.2	–	<0.1	<0.1	0.2	–	<0.1	<0.1
Chromium	µg/L	0.5	–	–	1.2	0.98	–	–	<0.5	<0.5
Cobalt	µg/L	0.1	–	1.89	0.31	0.32	1.4	–	<0.1	<0.1
Copper	µg/L	0.5	1.4	–	2.2	2.1	1.4	–	1.4	0.8
Iron	µg/L	5	–	–	1300	980	–	–	190	28
Lead	µg/L	0.1	3.4	–	0.76	0.58	3.4	–	0.11	<0.1
Manganese	µg/L	0.5	1900	–	14	20	1900	–	6.1	0.96
Mercury	µg/L	0.1	0.06[b]	–	<0.1	<0.1	0.06[b]	–	<0.1	<0.1
Nickel	µg/L	0.5	11	–	2	1.8	11	–	1.3	0.96
Selenium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Silver	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Strontium	µg/L	0.1	–	–	130	140	–	–	220	240
Tin	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Vanadium	µg/L	0.2	–	–	5.3	4.5	–	–	2.5	3
Zinc	µg/L	1	8	–	2.7	1.5	8	–	<1	<1
Total Petroleum Hydrocarbons										
TPH C6-C9 Fraction	µg/L	10	–	–	<10	<10	–	–	<10	<10
TRPH >C10-C16 Fraction	µg/L	50	–	–	<50	<50	–	–	<50	<50
TRPH >C16-C34 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C34-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C10-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] app cab e on y when pH s > 6.5, where pH s < 6.5 there s nsuff c ent data

[b] the 99% eve of spec es protect on was used

Table 3.5 Median alkalinity, and concentration of major cations and anions, nutrients and chlorophyll *a* at Upper Dawson Sites from April to June 2019, compared to the Guidelines for 95% Aquatic Ecosystem Protection in the Upper and Lower Dawson River (EHP 2013b).

Parameter	Units	LOR	WQO Upper Dawson River	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Alkalinity										
Bicarbonate	mg/L	1	–	140	65	55	–	115	44	44
Hydroxide	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Carbonate	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Residual Alkalinity	meq/L	1	–	0.75	<1	<1	–	0.67	<1	<1
Total Alkalinity ($CaCO_3$)	mg/L	1	–	140	65	55	–	115	44	44
Hardness	mg/L	1	–	–	49	56	–	–	40	40
Major Cations and Anions										
Calcium	mg/L	0.1	–	14.7 – 27.7	12.0	14.0	–	12.4 – 21.3	10.0	11.0
Magnesium	mg/L	0.05	–	8.38	4.30	4.80	–	6.34	3.50	3.20
Potassium	mg/L	0.2	–	7.40	5.4	5.6	–	9.34	6	6.2
Sodium	mg/L	1	–	48.4	18	19	–	31.3	14	15
Chloride	mg/L	2	–	77.1	15	13	–	35.4	11	14
Fluoride	mg/L	0.05	–	0.31	0.11	0.1	–	0.33	0.11	0.12
Sulfate	mg/L	0.3	5	5.9	3.2	3.8	5	9.3	3.4	3.3
Sulfur	mg/L	0.1	–	–	1.1	1.3	–	–	1.1	1.1

Parameter	Units	LOR	WQO Upper Dawson River	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Nutrients										
Ammonia-Nitrogen	mg/L	0.005	0.02	0.07	0.07	0.05	0.01	0.21	0.058	0.07
Biological										
Chlorophyll *a*	µg/L	1	5	10.2	4	3.2	5	48.9	8.8	3

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

Table 3.6 Median alkalinity, and concentration of major cations and anions, nutrients and chlorophyll *a* at Lower Dawson Sites from April to June 2019, compared to the Guidelines for 95% Aquatic Ecosystem Protection in the Upper and Lower Dawson River (EHP 2013b).

Parameter	Units	LOR	WQO Lower Dawson River	Local WQG	WS05	WS06	WQO Freshwater lakes / reservoirs	Local WQG	WS07	WS09
Alkalinity										
Bicarbonate	mg/L	1	–	140	51	49	–	115	70	78
Hydroxide	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Carbonate	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Residual Alkalinity	meq/L	1	–	0.75	<1	<1	–	0.67	<1	<1
Total Alkalinity ($CaCO_3$)	mg/L	1	–	140	51	49	–	115	70	78
Hardness	mg/L	1	–	–	45	48	–	–	54	60
Major Cations and Anions										
Calcium	mg/L	0.1	–	14.7 – 27.7	12.0	13.0	–	12.4 – 21.3	14.0	15.0
Magnesium	mg/L	0.05	–	8.38	3.80	4.00	–	6.34	4.40	5.10
Potassium	mg/L	0.2	–	7.40	6.2	6.4	–	9.34	7	6.6
Sodium	mg/L	1	–	48.4	17	18	–	31.3	24	27
Chloride	mg/L	2	–	77.1	18	21	–	35.4	23	32
Fluoride	mg/L	0.05	–	0.31	0.12	0.11	–	0.33	0.14	0.15
Sulfate	mg/L	0.3	25	5.9 [a]	4.2	3.8	25	9.3	4.3	5.3
Sulfur	mg/L	0.1	–	–	1.4	1.3	–	–	1.4	1.8

Parameter	Units	LOR	WQO Lower Dawson River	Local WQG	WS05	WS06	WQO Freshwater lakes / reservoirs	Local WQG	WS07	WS09
Nutrients										
Ammonia-Nitrogen	mg/L	0.005	0.02	0.07	0.06	0.08	0.01	0.21	0.04	0.04
Biological										
Chlorophyll *a*	µg/L	1	5	10.2	1	2	5	48.9	4	5.4

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] the oca WQG s ower than the pub shed WQO for the ower Dawson R ver because t was deve oped to rep ace WQOs for the upper Dawson R ver, wh ch has a ower pub shed WQO than the ower Dawson

3.2 Weekly Water Quality Monitoring of Boron and Temperature

The concentrations of total and dissolved boron were below the BUA Irrigator Notification value, and below the 95% ecosystem protection level, at all sites for all surveys (Table 3.7).

Water temperature ranged from 14.9 ºC to 31.0 ºC and had temperatures above the local WQG in the first week of April and temperatures below local WQG in weeks of 23rd of May, 29th of May, 19th of June and 29th of June (Table 3.7).

Table 3.7 Results for total and dissolved boron, and water temperature, for GBUS monitoring from April to June 2019.

Parameter	Unit	LOR	BUA Irrigator Notification value	ANZECC & ARMCANZ (2000)	Local Water Quality Guideline	Sites				
						WS03	WS04	WS05	WS06	Blank [a]
8 April 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.042	0.038	0.038	0.041	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.042	0.037	0.037	0.037	<0.005
Temperature	°C	–	–	–	[b]	31.0	28.4	24.5	24.1	–
15 April 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.037	0.037	0.037	0.037	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.032	0.032	0.031	0.033	<0.005
Temperature	°C	–	–	–	[b]	26.1	24.5	23.3	23.9	–
23 April 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.034	0.044	0.045	0.042	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.033	0.034	0.037	0.033	<0.005
Temperature	°C	–	–	–	[b]	23.7	23.2	23.1	24.5	–
2 May 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.039	0.047	0.042	0.043	0.011
Dissolved boron	mg/L	0.005	0.5	0.37		0.038	0.037	0.042	0.040	0.010
Temperature	°C	–	–	–	[b]	22.9	22.8	23.0	22.5	–

Parameter	Unit	LOR	BUA Irrigator Notification value	ANZECC & ARMCANZ (2000)	Local Water Quality Guideline	Sites				
						WS03	WS04	WS05	WS06	Blank [a]
9 May 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.039	0.039	0.039	0.042	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.032	0.034	0.035	0.035	<0.005
Temperature	ºC	–	–	–	[b]	25.6	21.3	21.1	21.2	–
23 May 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.034	0.037	0.037	0.038	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.030	0.034	0.034	0.036	<0.005
Temperature	ºC	–	–	–	[b]	21.2	19.4	19.8	19.4	–
29 May 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.032	0.038	0.036	0.033	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.028	0.037	0.032	0.030	<0.005
Temperature	ºC	–	–	–	[b]	19.5	21.6	17.4	17.5	–
19 June 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.031	0.033	0.033	0.031	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.027	0.026	0.029	0.028	<0.005
Temperature	ºC	–	–	–	[b]	16.3	17.1	15.8	15.3	–

Parameter	Unit	LOR	BUA Irrigator Notification value	ANZECC & ARMCANZ (2000)	Local Water Quality Guideline	Sites				
						WS03	WS04	WS05	WS06	Blank [a]
27 June 2019										
Total boron	mg/L	0.005	0.5	0.37	0.37	0.025	0.026	0.031	0.031	<0.005
Dissolved boron	mg/L	0.005	0.5	0.37		0.020	0.021	0.026	0.024	<0.005
Temperature	ºC	–	–	–	[b]	15.1	14.9	16.0	15.9	–

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

[a] the b ank s a samp e of de on sed water that was a quoted to samp e bott es n the f e d for QA/QC purposes.

[b] for temperature the oca WQG for unregu ated water (19.5–26.6ºC) was app ed to s tes WS05 and WS06, and the oca WQG for regu ated water (21.0–29.9ºC) was app ed to s tes WS03 and WS04

4 Impact Assessment

Lower water temperatures measured reflect a seasonal pattern and are unlikely to be influenced by the release of CS water, with reference sites WS01 and WS02 having similar water temperatures to sites in the receiving environment. It is recommended that the local WQG be amended to have season-specific guidelines (i.e. separate guidelines for each of spring, summer, winter and autumn).

The pH of water was lower than the local WQG range at site WS09 (6.4 units), but was within the baseline range for the regulated water type (6.3 – 9.3 units), indicating that the monitoring result is consistent with ambient baseline conditions.

The concentration of dissolved oxygen was higher than the local WQG at site WS05 (8.91 mg/L), but within the baseline range for the unregulated water type (1.6 – 11.0 mg/L), indicating that the monitoring result is consistent with ambient baseline conditions.

The turbidity of water was higher than the local WQG at sites WS03 (505 NTU), WS04 (492 NTU), WS05 (379 NTU) and WS96 (369 NTU). The maximum of baseline data for turbidity (1224 NTU for unregulated waters, and 6000 NTU for regulated waters) is higher than the recorded values, indicating that the monitoring results for turbidity are consistent with ambient baseline conditions.

Total barium exceeded the local WQG at site WS03 (140 µg/L), but was lower than the maximum of baseline data for the regulated water type (1200 µg/L), indicating that the monitoring result is consistent with ambient baseline conditions.

Beryllium was higher than the local WQG range at sites WS04 (0.47 µg/L), WS05 (0.44 µg/L) and WS06 (0.36 µg/L). The maximum of baseline data for total beryllium (0.5 µg/L for unregulated waters, and 2.2 µg/L for regulated waters) is higher than the recorded values, indicating that the monitoring results for beryllium are consistent with ambient baseline conditions.

Chromium exceeded the local WQG at sites WS02 (1.8 µg/L), WS03 (2.1 µg/L), WS04 (2.3 µg/L), WS05 (2.1 µg/L) and WS06 (2.1 µg/L). The maximum of baseline data for total chromium (4.2 µg/L for unregulated waters, and 13.0 µg/L for regulated waters) is higher than the recorded values, indicating that the monitoring results for chromium are consistent with ambient baseline conditions.

Total copper exceeded the local WQG at sites WS03 (5.6 µg/L), WS04 (5.5 µg/L) and WS05 (5.6 µg/L). The maximum of baseline data for total copper (33.0 µg/L for unregulated waters, and 11.0 µg/L for regulated waters) is higher than the recorded values, indicating that the monitoring results for copper are consistent with ambient baseline conditions.

Total iron exceeded the local WQG at sites WS03 (4300 µg/L), WS04 (5200 µg/L), WS05 (4200 µg/L), WS06 (4000 µg/L) and WS07 (4400 µg/L). The maximum of baseline data for total iron (8200.0 µg/L for unregulated waters, and 45000.0 µg/L for regulated waters) is higher than the recorded values, indicating that the monitoring results for iron are consistent with ambient baseline conditions.

Ammonia was higher than the local WQG at site WS06 (0.08 mg/L), but was lower than the baseline maximum value recorded in the unregulated water type (0.77 mg/L), indicating that the monitoring result is consistent with ambient baseline conditions.

Monthly monitoring of all other parameters indicated they complied with the local WQG and thus reflected ambient baseline conditions. Weekly monitoring of boron showed that concentrations of both total and dissolved boron were below applicable guidelines, including the irrigation trigger level of the BUA.

Overall, the release of treated CS water does not appear to have had an adverse impact on water quality in the receiving environment from April to June 2019.

5 References

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Appendix A Depth Profiles of Water Quality Measured In Situ

Table A.1 Depth profile results of water quality measured *in situ* in April 2019.

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published WQO**			**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	4/4/19	11:40	0.3	26.5	95	7.9	5.63	73	>1000
			0.5	24.7	130	7.7	4.98	61	–
			1	23.8	133	7.7	5.11	61	–
			1.5	23.2	134	7.7	5.21	62	–
			2	22.8	135	7.6	5.27	62	–
			3	22.7	136	7.6	5.28	62	–
WS02	4/4/19	8:25	0.3	22.6	156	7.5	5.27	61	>1000
			0.5	22.5	167	7.5	5.18	61	–
			1	22.5	156	7.4	5.18	60	–
			1.5	22.5	156	7.4	5.18	60	–
Freshwater Lakes / Reservoirs / regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	3/4/19	14:25	0.3	25.1	146	7.2	4.28	53	925
			0.5	25.0	146	7.2	4.24	52	–
			1	24.9	146	7.2	4.11	50	–
			1.5	24.6	150	7.2	3.51	43	–
			2	24.1	145	7.2	2.09	25	–
			3	23.6	108	7.3	1.22	15	–
			4	23.0	97	7.2	1.34	16	–
			5	22.7	95	7.1	1.26	15	–
WS04	3/4/19	13:45	0.3	24.1	133	7.6	3.79	46	>1000

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			0.5	23.7	135	7.6	3.74	45	
			1	23.5	136	7.5	3.69	44	
			1.5	23.3	138	7.5	3.48	41	
			2	23.1	111	7.5	2.58	31	
			3	22.6	93	7.4	2.32	27	
			4	22.2	89	7.3	1.57	18	
			5	22.1	104	7.1	1.12	13	
Lower Dawson River – unregulated waters	**Published WQO**			**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	24/1/19	9:05	0.3	24.6	391	7.3	4.02	50	198
			0.5	23.5	368	7.3	1.43	17	–
WS06	24/1/19	9:50	0.3	21.7	284	7.3	2.42	28	141
			0.5	21.7	282	7.3	2.03	23	–
Freshwater Lakes / Reservoirs – regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	2/4/19	9:25	0.3	24.1	248	7.16	3.8	45.5	174
			0.5	24.0	247	7.18	3.6	42.9	–
			1	24.0	247	7.20	3.5	41.8	–
			1.5	24.0	247	7.21	3.5	41.6	–
			2	24.0	247	7.23	3.5	41.4	–
			3	24.0	248	7.24	3.5	41.5	–
			4	24.0	248	7.26	3.5	41.7	–
			5	24.0	248	7.27	3.5	41.8	
			6	24.0	274	7.21	3.5	41.7	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
WS09	2/4/19	6:50	0.3	24.8	275	6.38	4.7	56.7	11
			0.5	25.4	273	6.50	4.5	55.5	–
			1	25.6	272	6.60	4.5	55.2	–
			1.5	25.8	272	6.68	4.4	54.6	–
			2	25.7	270	6.77	2.7	33.7	–
			3	25.6	271	6.86	2.2	27.2	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

green shad ng denotes parameters that were non-comp ant w th the oca WQG

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG and pub shed WQO

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Table A.2 Depth profile results of water quality measured *in situ* in May 2019

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published WQO**			**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	16/5/19	14:30	0.3	19.5	183	6.7	6.07	67	150
			0.5	18.9	184	6.7	6.06	66	–
			1	18.6	184	6.8	6.04	66	–
			1.5	18.4	185	6.8	5.99	65	–
WS02	16/5/19	14:00	0.3	21.2	149	6.6	6.65	76	234
Freshwater Lakes / Reservoirs / regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	16/5/19	10:00	0.3	19.88	135	6.3	5.50	61	505
			0.5	19.50	134	6.4	5.10	56	–
			1	19.24	134	6.4	5.00	54	–
			1.5	19.08	135	6.5	4.90	54	–
			2	18.95	135	6.6	5.00	54	–
			3	18.87	135	6.6	5.00	54	–
			4	18.82	134	6.7	4.90	54	–
			5	18.64	118	6.7	4.20	45	–
			6	18.52	116	6.7	3.90	42	–
WS04	16/5/19	9:20	0.3	19.6	153	6.1	6.76	74	181
			0.5	19.2	152	6.2	5.67	62	–
			1	19.0	151	6.3	5.27	57	–
			1.5	18.9	151	6.4	5.19	56	–
			2	18.8	151	6.5	5.09	55	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			3	18.7	151	6.5	4.95	53	–
			4	18.6	152	6.6	4.77	51	–
			5	18.3	156	6.6	4.23	45	–
Lower Dawson River – unregulated waters	**Published WQO**			**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	16/5/19	11:15	0.3	19.4	155	6.6	8.88	98	525
			0.5	19.3	156	6.7	8.92	98	–
WS06	16/5/19	12:00	0.3	19.7	162	6.7	8.26	91	535
			0.5	19.5	163	6.7	8.31	91	–
			1	19.4	163	6.8	8.32	91	–
Freshwater Lakes / Reservoirs – regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	15/5/19	14:45	0.3	20.3	233	5.8	4.83	54	126
			0.5	20.0	233	6.0	4.70	52	–
			1	19.7	234	6.0	4.50	50	–
			1.5	19.5	234	6.1	4.30	47	–
			2	19.3	236	6.2	4.04	44	–
			3	19.0	238	6.3	3.76	41	–
			4	18.9	239	6.4	3.75	41	–
			5	18.8	240	6.5	3.83	42	–
			6	18.8	240	6.6	3.90	42	–
			7	18.7	240	6.6	3.32	36	–
			8	18.6	256	6.6	2.57	28	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
WS09	16/5/19	6:30	0.3	21.0	274	6.5	6.94	78	10
			0.5	21.1	274	6.5	6.90	78	–
			1	21.1	273	6.5	6.90	78	–
			1.5	21.1	273	6.6	6.94	78	–
			2	21.1	273	6.7	6.08	69	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

green shad ng denotes parameters that were non-comp ant w th the oca WQG

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG and pub shed WQO

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Table A.3 Depth profile results of water quality measured *in situ* in June 2019.

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters		**Published WQO**		**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
		Local WQG		**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	11/6/19	15:25	0.3	16.2	166	7.8	7.12	73	43
			0.5	17.0	279	7.8	7.62	79	–
			1	15.7	275	7.8	7.60	77	–
			1.5	15.3	275	7.8	7.50	76	–
			2	14.8	271	7.8	7.24	72	–
WS02	11/6/19	14:30	0.3	20.5	1	7.6	7.95	89.2	82
			0.5	19.2	212	7.8	8.30	89.4	
			1	17.9	225	7.8	8.37	89.3	
Freshwater Lakes / Reservoirs / regulated waters		**Published WQO**		**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
		Local WQG		**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	11/6/19	12:30	0.3	24.5	32	7.4	8.09	98	393
			0.5	22.2	130	7.7	7.55	87	–
			1	20.3	128	7.7	7.06	78	–
			1.5	19.1	130	7.7	6.93	75	–
			2	18.3	132	7.7	6.67	71	–
			3	17.5	135	7.6	6.64	70	–
			4	16.8	137	7.6	6.59	68	–
			5	16.3	138	7.5	6.08	63	–
			6	16.1	140	7.5	5.82	60	–
WS04	11/6/19	12:00	0.3	20.1	139	7.9	7.97	88	365
			0.5	–	–	–	–	–	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			1	19.2	142	7.9	7.73	84	–
			1.5	18.8	143	7.8	7.65	83	–
			2	18.0	139	7.8	7.42	79	–
			3	16.9	139	7.8	7.02	73	–
			4	16.5	141	7.7	6.86	71	–
			5	16.1	147	7.7	6.58	67	–
			6	15.6	155	7.6	5.98	61	–
Lower Dawson River – unregulated waters		**Published WQO**		**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
		Local WQG		**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	11/6/19	9:45	0.3	–	–	–	–	–	370
			0.5	16.7	165	7.9	9.38	97	
			1	16.8	163	7.9	9.15	95	
WS06	11/6/19	10:30	0.3	–	–	–	–	–	369
			0.5	18.39	176	7.78	8.5	90.8	–
			1	18.34	137	7.80	8.2	87.9	–
Freshwater Lakes / Reservoirs – regulated waters		**Published WQO**		**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
		Local WQG		**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	10/6/19	17:15	0.3	17.6	187	7.2	6.59	70	330
			0.5	17.9	189	7.2	6.69	71	–
			1	17.8	187	7.2	6.60	70	–
			1.5	17.3	187	7.2	6.50	68	–
			2	16.7	189	7.2	5.97	62	–
			3	16.3	189	7.2	5.62	58	–
			4	16.0	188	7.3	5.15	53	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			5	15.8	187	7.3	4.90	50	–
			6	15.6	188	7.3	4.69	48	–
			7	15.5	199	7.1	4.62	47	–
WS09	11/6/19	6:45	0.3	15.8	291	7.9	9.60	97	15
			0.5	16.2	293	8.0	8.82	90	–
			1	16.6	289	7.7	5.98	61	–
			1.5	16.5	287	7.7	5.91	61	–
			2	16.5	286	7.8	6.12	63	–
			3	16.5	284	7.7	5.36	55	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

green shad ng denotes parameters that were non-comp ant w th the oca WQG

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG and pub shed WQO

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Appendix C: Quarterly Water Quality Monitoring Report, July to September 2019

Glebe End of Waste Scheme: Receiving Environment Monitoring Program

Water Quality Monitoring Report, July – September 2019

Prepared for:

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1 Introduction

1.1 Background

Sunwater is the proponent of an End of Waste Scheme (End of Waste Approval ENEW07542518) involving the discharge of reverse osmosis treated coal seam water to Glebe Weir on the Dawson River. To comply with Condition B13 of the End of Waste approval, Sunwater has developed a Receiving Environment Monitoring Program (REMP) that includes monitoring of water, sediment and aquatic ecology in the receiving environment (i.e. Glebe Weir and connected waterways including waters of the Dawson Valley Water Supply Scheme). The REMP includes a control : impact comparison of sites upstream and downstream of the discharge point. Historical baseline data was used to develop project-specific Water Quality Guidelines (local WQGs) for water quality, sediment quality and biological parameters (i.e. macroinvertebrates and fish).

This quarterly REMP report presents the monitoring results for water quality for July – September 2019. It is the fourteenth REMP report covering a three-month period (previous to October 2015 reports were provided monthly), and the eighteenth REMP report on water quality since operational discharges commenced on 7 February 2015.

1.2 Scope of Works

The monitoring sites are specified in the REMP Design Report, with the additional site WS09 also monitored for water quality (Table 2.1). The scope of works comprises:

- monthly (ambient) monitoring of water quality measured in situ and laboratory analysis of water samples for parameters specified in the REMP design
- increased frequency of monitoring at times of elevated risk
- an assessment of water quality results against applicable local WQGs, noting any trends between sites (especially control and impact sites), and
- an assessment of any potential impact the release of treated CS water has had on water quality in the receiving environment.

2 Methods

2.1 Site Location Details

Eight sites on Dawson River were surveyed (Table 2.1); six of these sites are in the receiving environment (WS03, WS04, WS05, WS06, WS07 and WS09), and two sites (WS01 and WS02) are control sites upstream of the receiving environment.

Based on the definitions in the *Dawson River Sub–basin Environmental Values and Water Quality Objectives EPP (Water) 2009* (EHP 2013b), there are three water types in the receiving environment:

- unregulated reaches of the upper Dawson River (flowing water)
- unregulated reaches of the lower Dawson River (flowing water), and
- regulated reaches of the Dawson River – freshwater lakes / reservoirs (non-flowing water).

The boundary between the lower and upper Dawson River Sub-catchments is Glebe Weir, with four sites in the upper Dawson and three in the lower Dawson. However, the baseline monitoring data indicates that variation in water quality, sediment quality and biological parameters within the lower and upper Dawson River water types, respectively, was often higher than between these two water types. Therefore, for the purpose of the REMP monitoring and local water quality guidelines, all flowing sections of the Dawson River within the receiving environment was considered a single water type (unregulated water).

2.2 Survey Timing

Under the REMP design document, ambient monitoring of water quality for the Glebe End of Waste Scheme (GEWS) is implemented monthly.

The field surveys were completed by suitably qualified persons (professional aquatic ecologists) from frc environmental on:

- 16th–17th July 2019
- 6th–7th August 2019
- 9th–12th September 2019

Table 2.1 Location of water quality monitoring sites.

Site	Water Type	Location	Latitude [a]	Longitude [a]
Upstream of Receiving Environment				
Upper Dawson				
WS01	Unregulated	Dawson River at the Old Leichardt Highway crossing at Taroom	-25.644476	149.791877
WS02	Unregulated	Dawson River at Bundulla Road Crossing	-25.572372	149.864464
Receiving Environment				
Upper Dawson				
WS03	Regulated	Dawson River Upstream of Glebe Weir	-25.476944	150.008333
WS04	Regulated	Dawson River Upstream of Glebe Weir	-25.464269	150.033529
Lower Dawson				
WS05	Unregulated	Dawson River Downstream of Glebe Weir	-25.459722	150.043889
WS06	Unregulated	Dawson River Downstream of Glebe Weir	-25.453333	150.055833
WS07	Regulated	Dawson River Upstream of Gyranda Weir	-25.284722	150.181389
WS09	Regulated	Dawson River within Theodore Weir	-24.937778	150.068056

[a] WGS84

2.3 Water Quality Sampling Protocols

All water quality sampling was carried out in accordance with the Department of Environment and Science's *Monitoring and Sampling Manual 2009* (DES 2018).

Water Quality Measured In Situ

Water quality was measured in situ approximately 0.3 m below the water surface using a SmarTroll Water Quality Meter. The water quality meter was calibrated in accordance with

the manufacturer's instructions. Where the water was of suitable depth (i.e. > 2 m), water quality was also measured at 1.0 m intervals through the water column. In shallow water (i.e. < 2 m), water quality was measured at 0.5 m depth intervals.

The assessed parameters were:

- water temperature (°C)
- pH
- dissolved oxygen (mg/L and percent saturation), and
- electrical conductivity (µS/cm).

Turbidity (NTU) was also measured approximately 0.3 m below the water's surface using a HACH 2100Q portable turbidity meter.

Collection and Laboratory Analysis of Water Samples

At each site a water quality sample was collected in accordance with the Department of Environment and Science's (DES's) *Monitoring and Sampling Manual 2009* (DES 2018) and the *Procedures for REMP Monitoring and Sampling* (frc environmental 2015b). Water samples were collected using pre-labelled bottles supplied by Symbio Alliance that were appropriate for the suite of parameters being tested. Samples were collected and stored as appropriate for the parameters being tested (e.g. bottles pre-rinsed / not pre-rinsed, bottles filled or not filled to the top, chilled). All of the samples were chilled and transported to Symbio Alliance's NATA-accredited laboratory in Brisbane within the required holding time for each parameter. For monthly monitoring surveys, each sample was analysed for:

- electrical conductivity
- pH
- turbidity
- total hardness (calcium hardness)
- carbonate, bicarbonate, hydroxide
- residual alkalinity (as $CaCO_3$)
- ammonia (as N)
- major cations and anions independently (Ca, Cl, Mg, F, Na, K)
- sulphate (total and dissolved)

- a full total metal scan, including boron and mercury (ICP/MS or ultra-trace as required)
- a full dissolved metal scan, including boron and mercury (ICP/MS or ultra-trace as required)
- chlorophyll *a*, and
- hydrocarbons (C6-C9, C10-C14, C15-C28, C29-C36).

An additional site replicate and a field blank (i.e. sample bottle filled with deionised water in the field) was collected during each survey for QA/QC purposes.

The testing methods and Limits of Reporting (LOR) used by the laboratory were based on the 95% ecosystem protection guidelines (ANZECC & ARMCANZ 2000), and specified on the Chain of Custody (COC) forms submitted with each sample batch.

2.4 Quality Assurance and Quality Control

Relative Percent Difference

Relative percent difference (RPD) is a measure of how similar two samples are, with low RPD indicating the samples are very similar[1]. RPD can be used in two ways:

1. comparing *duplicate* samples (i.e. sub-samples of a single sample, taken in the laboratory), which assesses laboratory testing precision and repeatability, and
2. comparing *replicate* samples (i.e. different samples taken at the same site), which tests natural within-site variability.

RPD analyses on *duplicate* samples for the monthly surveys showed that all laboratory results were within acceptable limits.

RPD analyses between *replicates* for the monthly surveys showed low variability across all parameters and within acceptable limits.

1 RPD s nf uenced by the magn tude of the va ues be ng compared; for examp e a s ght change between arge numbers g ves a very ow RPD, but a s m ar s ght change between sma numbers g ves a much h gher RPD. Consequent y, n the context of assessment of dup cate samp es n the aboratory, DES spec f es a RPD of 20% for resu ts that are at east f ve t mes the LOR, as a h gher RPD s expected for resu ts c oser to the LOR. There s no thresho d for RPD when compar ng rep cate samp es, as th s s assess ng natura w th n-s te var at on, a though where RPD s h gh between rep cate samp es t s prudent to nterpret resu ts as est mates rather than prec se va ues.

Assessment of LOR for Blank Samples

The laboratory blank sample was below the LOR for all parameters on all surveys.

The field blank sample was below the LOR for all parameters on all surveys, with the exception of the following:

- electrical conductivity – July (5 µS/cm)
- turbidity – July (0.2 NTU) and September (0.3 NTU)
- barium (dissolved) – July (0.56 µg/L)
- bicarbonate – July (2 mg/L), August (2 mg/L) and September (2 mg/L)
- total alkalinity (CaCO3) – July (2 mg/L), August (2 mg/L) and September (2 mg/L)
- ammonia as N – July (0.011 mg/L), August (0.015 mg/L) and September (0.019 mg/L)

As a result, concentrations of these parameters should be treated as estimates rather than precise values.

2.5 Comparison with Guidelines

Water Quality

For monthly water quality monitoring, the median of each parameter at each site across the three monthly surveys was calculated and compared to the relevant guideline; raw data for each parameter at each site on each survey was provided to Sunwater in an accompanying Excel spreadsheet.

The relevant guidelines were as follows:

- dissolved oxygen, pH, electrical conductivity, turbidity, major ions and nutrients were compared with the Water Quality Objectives (WQOs) to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River (EHP 2013a). This guideline was used because none of the study sites are in High Ecological Value (HEV) areas
- metals and other contaminants were compared with the Australian and New Zealand Guidelines for fresh and marine water quality (ANZECC & ARMCANZ 2000) based on the 95% level of protection of aquatic ecosystems, although mercury was assessed using the guideline for the 99% level of protection of aquatic ecosystems

- all parameters were assessed against local water quality guidelines that were developed using baseline data collected from the receiving environment for GBUS (pre-discharge) (frc environmental 2015a).

According to the Queensland Water Quality Guidelines (EHP 2013a) base flow is considered to be when discharge at the time of sampling is less than the 90th percentile of all discharge records. Using this criterion, the base flow thresholds provided by Sunwater for this project were:

- Gauging station 130345A (Glebe Weir) – 1177 ML/day
- Gauging station 130305A (Theodore Weir) – 1754 ML/day, and
- Gauging station 130317B (Woodleigh Weir) – 1313 ML/day.

As gauging stations 130345A and 130305A have been decommissioned, flow data was obtained from gauging station 130202A (Dawson River at Taroom) instead.

Flows were below the base flow threshold at both gauging stations on all sampling events.

The published WQO for electrical conductivity varies depending if the river is in high flow or base flow. As flow on all surveys was below the base flow threshold, the median electrical conductivity value was compared to the base flow WQO.

Table 2.2 Dawson River stream discharge data (130302A and 130317B gauging stations) for the survey periods from July to September 2019.

Gauging Station	Discharge (mean ML/Day)
130302A Dawson River at Taroom	
Baseflow	**784**
16-17/07/19	14.56 and 14.48
6-7/08/19	15.47 and 14.18
9-12/09/19	4.18, 2.98, 3.21 and 3.85
130317B Dawson River at Woodleigh	
Baseflow	**1313**
16-17/07/19	16.36 and 41.42
6-7/08/19	97.24 and 102.02
9-12/09/19	197.88, 195.93, 191.63 and 190.36

Grey shad ng denotes h gh f ow cond t on

3 Results

3.1 Monthly Water Quality Monitoring of All Parameters

Temperature, Dissolved Oxygen, Electrical Conductivity, pH and Turbidity

The percent saturation of dissolved oxygen was below the published WQO range but compliant with the local WQG at all sites (Table 3.1). The concentration of dissolved oxygen (mg/L) complied with local WQG, except sites WS01, WS02, WS05 and WS06, where the concentration was higher than the 80th percentile of baseline data[2].

Water temperature was lower than the local WQG range at all sites[2] (Table 3.1).

Temperature and dissolved oxygen were not measured in the laboratory. Electrical conductivity, pH and turbidity were measured both in the field and the laboratory. Measurements for each parameter varied across sites and were similar when measured in the laboratory and in the field (Table 3.1and Table 3.2).

Electrical conductivity was above the published WQO at site WS09 when measured in the laboratory, but complied with the local WQG at all sites when measured in situ and in the laboratory (Table 3.1 and Table 3.2).

Measurements of pH in the laboratory and in the field complied with the published WQO and the local WQG at all sites (Table 3.1 and Table 3.2).

Turbidity was above the published WQO when measured in the field and laboratory at sites WS03, WS04, WS05, WS06 and WS07, but compliant with the local WQG at all sites when measured in situ and in the field (Table 3.1 and Table 3.2).

Results for depth profiles of water quality at each site are presented in Appendix A. Results for water quality below 0.3 m depth were not compared to published WQOs or local WQGs, as these guidelines are based on surface water samples rather than water sampled at depth.

2 There are no pub shed WQOs for the concentrat on of d sso ved oxygen or water temperature.

Table 3.1 Median water quality measured in situ from July to September 2019 compared to the Water Quality Objectives to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River, and compared to local Water Quality Guidelines.

Site	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO [b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published Default WQO**	**N/A**	**370**	**6.5–8.5**	**N/A**	**85–110**	**50**
	Local WQG	**19.5–26.6**	**654**	**6.5–8.5**	**3.93–7.68**	**45.5–110**	**310**
WS01		15.1	290	7.6	8.29	89.1	10
WS02		16.4	278	7.7	9.96	104.1	19
Lower Dawson River – unregulated waters	**Published Default WQO**	**N/A**	**340**	**6.5–8.5**	**N/A**	**85–110**	**50**
	Local WQG	**19.5–26.6**	**654**	**6.5–8.5**	**3.93–7.68**	**45.5–110**	**310**
WS05		15.3	206	7.6	8.43	83.2	275
WS06		15.1	191	7.5	8.24	83.4	275
Freshwater Lakes / Reservoirs – regulated waters	**Published Default WQO**	**N/A**	**250**	**6.5–8.0**	**N/A**	**90–110**	**1–20**
	Local WQG	**21.0–29.9**	**301**	**6.5–8.0**	**2.42–9.10**	**29.4–110**	**360**
WS03		17.5	125	7.6	7.93	85.1	274
WS04		15.2	127	7.4	8.13	80.6	260
WS07		17.2	164	6.7	8.12	85.9	317
WS09		16.9	246	7.3	8.24	86	17

grey shad ng denotes parameters that d d not comp y w th the pub shed WQO but comp ed w th the oca WQG

b ue shad ng denotes parameters that d d not comp y w th the pub shed WQO or the oca WQG

a EC: e ectr ca conduct v ty

b DO: d sso ved oxygen

c water qua ty object ve for base f ow cond t ons app ed

Table 3.2 Median water quality measured in the laboratory from July to September 2019 compared to the Water Quality Objectives to support the Protection of Aquatic Ecosystems Environmental Value for moderately disturbed aquatic ecosystems in the Upper and Lower Dawson River, and compared to local Water Quality Guidelines.

Site	Guideline	Electrical Conductivity (µs/cm)	pH	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published Default WQO**	**370**	**6.5–8.5**	**50**
	Local WQG	**654**	**6.5–8.5**	**310**
WS01		320	8	7
WS02		330	8	12
Lower Dawson River – unregulated waters	**Published Default WQO**	**340**	**6.5–8.5**	**50**
	Local WQG	**654**	**6.5–8.5**	**310**
WS05		230	7.4	270
WS06		230	7.5	270
Freshwater Lakes / Reservoirs / regulated waters	**Published Default WQO**	**250**	**6.5–8.0**	**1–20**
	Local WQG	**301**	**6.5–8.0**	**360**
WS03		150	7.7	260
WS04		160	7.5	270
WS07		190	7.5	280
WS09		280	7.8	13

grey shad ng denotes parameters that d d not comp y w th the pub shed WQO but comp ed w th the oca WQG
b ue shad ng denotes parameters that d d not comp y w th the pub shed WQO or the oca WQG

Metals and Metalloids

Comparisons of results for metals against the ANZECC & ARMCANZ (2000) 95% Ecosystem Protection Level (Table 3.3 and Table 3.4) and local WQGs show that concentrations of:

- total beryllium exceeded the local WQG at all sites WS05, WS06 and WS07
- total chromium exceeded the local WQG at sites WS03, WS04, WS05, WS06, and WS07
- total copper exceeded the published WQO at sites WS03, WS04, WS05 and WS06 but complied with local WQG; and exceeded local WQG at site WS07
- total iron exceeded the local WQG at sites WS03, WS04, WS05, WS06, and WS07
- total vanadium exceeded local WQG at site WS06
- total zinc exceeded the published WQO at sites WS03, WS04, WS05, WS06, and WS07 but did not exceed the local WQG at any site
- dissolved copper exceeded the published WQO at sites WS03, WS04,WS05, WS06, and WS07, but did not exceed the local WQG at any site
- total and dissolved mercury had a LOR that was higher than the WQO and local WGQ
- all other parameters complied with both the WQO and the local WQG.

Total Petroleum Hydrocarbons

Total petroleum hydrocarbons were less than the LOR at all sites (Table 3.3, Table 3.4).[3]

Major Ions and Nutrients

Comparisons of results for major ions and nutrients with the WQO for 95% Protection of Aquatic Ecosystems in the Upper and Lower Dawson (EHP 2013b) and the local WQGs showed that (Table 3.5 and Table 3.6):

- ammonia was higher than the local WQG at sites WS05 and WS06, and higher than the published WQO at all sites
- calcium was below the local WQG range at sites WS03, WS04, WS05, WS06 and WS07, but was within the local WQG range at all other sites

[3] There are no pub shed WQO or oca WQG for tota petro eum hydrocarbons.

- chloride was higher than the local WQG at site WS09
- residual alkalinity had a LOR that was higher than the WQG
- all other parameters complied with both the WQO and the local WQG

Chlorophyll a

Chlorophyll a was higher than published WQO at sites WS03, WS07 and WS09, although all sites complied with the local WQG.

Table 3.3 Median concentration of metals, metalloids and total petroleum hydrocarbons at Upper Dawson sites July to September 2019, compared to the ANZECC & ARMCANZ (2000) Guidelines for 95% Aquatic Ecosystem Protection in relation to freshwater streams and the local water quality guidelines.

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Total Metals and Metalloids										
Arsenic	µg/L	0.5	13	13	0.54	0.57	13	13	1.6	1.6
Barium	µg/L	0.1	–	175	85	87	–	132	110	110
Beryllium	µg/L	0.1	–	0.27	<0.1	<0.1	–	0.46	0.44	0.44
Boron	µg/L	5	370	370	93	120	370	370	37	38
Cadmium	µg/L	0.1	0.2	0.2	<0.1	<0.1	0.2	0.2	<0.1	<0.1
Chromium	µg/L	0.5	1	1.76	<0.5	<0.5	–	1.65	2.2	2.4
Cobalt	µg/L	0.1	–	2.01	0.15	0.18	–	5.77	1.4	1.6
Copper	µg/L	1	1.4	5.53	0.5	0.5	1.4	4.98	4.7	4.7
Iron	µg/L	5	–	3645	170	200	–	3162	4300	4400
Lead	µg/L	0.1	3.4	4.43	0.11	0.17	3.4	6.14	2.8	2.7
Manganese	µg/L	0.5	1900	1900	18	13	1900	1900	66	61
Mercury	µg/L	0.1	0.06[b]	0.06	<0.1	<0.1	0.06[b]	0.06	<0.1	<0.1
Nickel	µg/L	0.5	11	11	0.57	0.71	11	11	3.2	3.1
Selenium	µg/L	0.5	5[b]	< LOR	<0.5	<0.5	5[b]	< LOR	<0.5	<0.5
Silver	µg/L	0.1	–	< LOR	<0.1	<0.1	–	0.15	<0.1	<0.1

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Strontium	µg/L	0.1	–	418	330	350	–	396	200	190
Tin	µg/L	0.5	–	< LOR	<0.5	<0.5	–	0.5	<0.5	<0.5
Vanadium	µg/L	0.1	–	10.6	1.2	1.6	–	19.1	9.7	9.8
Zinc	µg/L	5	8	14	2.5	2.5	8	14.2	9.8	10
Dissolved Metals and Metalloids										
Arsenic	µg/L	0.5	13	–	<0.5	<0.5	13	–	0.86	0.74
Barium	µg/L	0.1	–	–	83	86	–	–	46	46
Beryllium	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Boron	µg/L	5	370	–	110	110	370	–	38	39
Cadmium	µg/L	0.1	0.2	–	<0.1	<0.1	0.2	–	<0.1	<0.1
Chromium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Cobalt	µg/L	0.1	–	–	<0.1	<0.1	–	–	0.12	0.17
Copper	µg/L	0.5	1.4	–	<0.5	0.73	1.4	–	1.8	1.7
Iron	µg/L	5	–	–	22	15	–	–	460	530
Lead	µg/L	0.1	3.4	–	<0.1	<0.1	3.4	–	0.27	0.24
Manganese	µg/L	0.5	1900	–	6.2	5.3	1900	–	3.4	5.2
Mercury	µg/L	0.1	0.06[b]	–	<0.1	<0.1	0.06[b]	–	<0.1	<0.1
Nickel	µg/L	0.5	11	–	0.25	0.61	11	–	1.4	1.3
Selenium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5

Parameter	Units	LOR	WQO Upper Dawson	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Silver	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Strontium	µg/L	0.1	–	–	320	320	–	–	140	130
Tin	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Vanadium	µg/L	0.2	–	–	0.77	1.1	–	–	3.1	2.8
Zinc	µg/L	1	8	–	0.5	0.5	8	–	0.5	1.6
Total Petroleum Hydrocarbons										
TPH C6-C9 Fraction	µg/L	10	–	–	<10	<10	–	–	<10	<10
TRPH >C10-C16 Fraction	µg/L	50	–	–	<50	<50	–	–	<50	<50
TRPH >C16-C34 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C34-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C10-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] app cab e on y when pH s > 6.5, where pH s < 6.5 there s nsuff c ent data

[b] the 99% eve of spec es protect on was used

Table 3.4 Median concentration of metals, metalloids and total petroleum hydrocarbons at Lower Dawson sites from July to September 2019, compared to the ANZECC & ARMCANZ (2000) Guidelines for 95% Aquatic Ecosystem Protection in relation to freshwater streams and the local water quality guidelines.

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Total Metals and Metalloids										
Arsenic	µg/L	0.5	13	13	1.6	1.6	13	13	2.1	1.6
Barium	µg/L	0.1	–	175	110	120	–	132	130	58
Beryllium	µg/L	0.1	–	0.27	0.46	0.41	–	0.46	0.61	<0.1
Boron	µg/L	5	370	370	45	40	370	370	39	48
Cadmium	µg/L	0.1	0.2	0.2	<0.1	<0.1	0.2	0.2	<0.1	<0.1
Chromium	µg/L	0.5	1	1.76	2.4	2.4	–	1.65	2.6	<0.5
Cobalt	µg/L	0.1	–	2.01	1.6	1.6	–	5.77	1.7	0.1
Copper	µg/L	1	1.4	5.53	4.9	4.6	1.4	4.98	5.1	1
Iron	µg/L	5	–	3645	4600	4700	–	3162	5700	290
Lead	µg/L	0.1	3.4	4.43	3	3	3.4	6.14	3.3	0.11
Manganese	µg/L	0.5	1900	1900	110	95	1900	1900	85	40
Mercury	µg/L	0.1	0.06[b]	< LOR	<0.1	<0.1	0.06[b]	0.06	<0.1	<0.1
Nickel	µg/L	0.5	11	11	3.5	3.5	11	11	3.8	1
Selenium	µg/L	0.5	5[b]	5	<0.5	<0.5	5[b]	5	<0.5	<0.5
Silver	µg/L	0.1	–	< LOR	<0.1	<0.1	–	0.15	<0.1	<0.1

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Strontium	µg/L	0.1	–	418	290	270	–	396	230	270
Tin	µg/L	0.5	–	< LOR	<0.5	<0.5	–	0.5	<0.5	<0.5
Vanadium	µg/L	0.1	–	10.6	10	11	–	19.1	11	2.7
Zinc	µg/L	5	8	14	11	10	8	14.2	12	2.5
Dissolved Metals and Metalloids										
Arsenic	µg/L	0.5	13	–	0.8	0.77	13	–	0.85	1.4
Barium	µg/L	0.1	–	–	60	60	–	–	48	53
Beryllium	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Boron	µg/L	5	370	–	39	39	370	–	40	47
Cadmium	µg/L	0.1	0.2	–	<0.1	<0.1	0.2	–	<0.1	<0.1
Chromium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Cobalt	µg/L	0.1	–	1.89	0.15	0.17	1.4	–	0.1	<0.1
Copper	µg/L	0.5	1.4	–	1.7	1.9	1.4	–	1.6	1.1
Iron	µg/L	5	–	–	170	400	–	–	290	29
Lead	µg/L	0.1	3.4	–	0.32	0.33	3.4	–	0.26	<0.1
Manganese	µg/L	0.5	1900	–	17	15	1900	–	3.3	2.9
Mercury	µg/L	0.1	0.06[b]	–	<0.1	<0.1	0.06[b]	–	<0.1	<0.1
Nickel	µg/L	0.5	11	–	1.4	1.4	11	–	1.3	0.94
Selenium	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5

Parameter	Units	LOR	WQO Lower Dawson	Local WQG	WS05	WS06	WQO Freshwater Lakes / Reservoirs	Local WQG	WS07	WS09
Silver	µg/L	0.1	–	–	<0.1	<0.1	–	–	<0.1	<0.1
Strontium	µg/L	0.1	–	–	130	230	–	–	160	260
Tin	µg/L	0.5	–	–	<0.5	<0.5	–	–	<0.5	<0.5
Vanadium	µg/L	0.2	–	–	2.9	2.8	–	–	2.5	2.2
Zinc	µg/L	1	8	–	0.5	2	8	–	0.5	0.5
Total Petroleum Hydrocarbons										
TPH C6-C9 Fraction	µg/L	10	–	–	<10	<10	–	–	<10	<10
TRPH >C10-C16 Fraction	µg/L	50	–	–	<50	<50	–	–	<50	<50
TRPH >C16-C34 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C34-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100
TRPH >C10-C40 Fraction	µg/L	100	–	–	<100	<100	–	–	<100	<100

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] app cab e on y when pH s > 6.5, where pH s < 6.5 there s nsuff c ent data

[b] the 99% eve of spec es protect on was used

Table 3.5 Median alkalinity, and concentration of major cations and anions, nutrients and chlorophyll *a* at Upper Dawson Sites from July to September 2019, compared to the Guidelines for 95% Aquatic Ecosystem Protection in the Upper and Lower Dawson River (EHP 2013b).

Parameter	Units	LOR	WQO Upper Dawson River	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Alkalinity										
Bicarbonate	mg/L	1	–	140	115	108	–	115	46	44
Hydroxide	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Carbonate	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Residual Alkalinity	meq/L	1	–	0.75	<1	<1	–	0.67	<1	<1
Total Alkalinity ($CaCO_3$)	mg/L	1	–	140	115	108	–	115	46	44
Hardness	mg/L	1	–	–	71	70	–	–	37	38
Major Cations and Anions										
Calcium	mg/L	0.1	–	14.7 – 27.7	19	18	–	12.4 – 21.3	9.7	10
Magnesium	mg/L	0.05	–	8.38	6.2	6	–	6.34	3.2	3.3
Potassium	mg/L	0.2	–	7.40	4.2	4.8	–	9.34	5.6	5.4
Sodium	mg/L	1	–	48.4	32	30	–	31.3	14	14
Chloride	mg/L	2	–	77.1	71	70	–	35.4	22	24
Fluoride	mg/L	0.05	–	0.31	0.11	0.11	–	0.33	0.1	0.1
Sulfate	mg/L	0.3	5	5.9	1.4	1.4	5	9.3	3.2	3.2
Sulfur	mg/L	0.1	–	–	0.46	0.48	–	–	1.1	1.1

Parameter	Units	LOR	WQO Upper Dawson River	Local WQG	WS01	WS02	WQO Freshwater lakes / reservoirs	Local WQG	WS03	WS04
Nutrients										
Ammonia-Nitrogen	mg/L	0.005	0.02	0.07	0.04	0.03	0.01	0.21	0.065	0.11
Biological										
Chlorophyll *a*	µg/L	1	5	10.2	2	2	5	48.9	9	5

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

Table 3.6 Median alkalinity, and concentration of major cations and anions, nutrients and chlorophyll *a* at Lower Dawson Sites from July to September 2019, compared to the Guidelines for 95% Aquatic Ecosystem Protection in the Upper and Lower Dawson River (EHP 2013b).

Parameter	Units	LOR	WQO Lower Dawson River	Local WQG	WS05	WS06	WQO Freshwater lakes / reservoirs	Local WQG	WS07	WS09
Alkalinity										
Bicarbonate	mg/L	1	–	140	46	46	–	115	57	82
Hydroxide	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Carbonate	mg/L	1	–	< LOR	<1	<1	–	< LOR	<1	<1
Residual Alkalinity	meq/L	1	–	0.75	<1	<1	–	0.67	<1	<1
Total Alkalinity ($CaCO_3$)	mg/L	1	–	140	46	46	–	115	57	82
Hardness	mg/L	1	–	–	52	52	–	–	46	58
Major Cations and Anions										
Calcium	mg/L	0.1	–	14.7 – 27.7	14	14	–	12.4 – 21.3	12	15
Magnesium	mg/L	0.05	–	8.38	4	3.8	–	6.34	3.7	4.7
Potassium	mg/L	0.2	–	7.40	5.6	5.8	–	9.34	6.6	7
Sodium	mg/L	1	–	48.4	21	21	–	31.3	17	26
Chloride	mg/L	2	–	77.1	32	33	–	35.4	25	62
Fluoride	mg/L	0.05	–	0.31	0.1	0.1	–	0.33	0.13	0.14
Sulfate	mg/L	0.3	25	5.9 [a]	3.5	3.6	25	9.3	4.4	4.8
Sulfur	mg/L	0.1	–	–	1.2	1.2	–	–	1.5	1.6

Parameter	Units	LOR	WQO Lower Dawson River	Local WQG	WS05	WS06	WQO Freshwater lakes / reservoirs	Local WQG	WS07	WS09
Nutrients										
Ammonia-Nitrogen	mg/L	0.005	0.02	0.07	0.11	0.09	0.01	0.21	0.09	0.09
Biological										
Chlorophyll *a*	µg/L	1	5	10.2	2	2	5	48.9	17	7

grey shad ng denotes parameters that have concentrat ons h gher than the defau t pub shed WQO

b ue shad ng denotes parameters that were not comp ant w th the oca WQG

go d shad ng denotes parameters where the LOR s above the water qua ty gu de ne

[a] the oca WQG s ower than the pub shed WQO for the ower Dawson R ver because t was deve oped to rep ace WQOs for the upper Dawson R ver, wh ch has a ower pub shed WQO than the ower Dawson

4 Impact Assessment

The relatively low water temperatures measured reflect a seasonal pattern and are unlikely to be influenced by the release of CS water, with reference sites WS01 and WS02 having similar water temperatures to sites in the receiving environment. It is recommended that the local WQG be amended to have season-specific guidelines (i.e. separate guidelines for each of spring, summer, winter and autumn).

The concentration of dissolved oxygen was higher than the local WQG at unregulated water type sites WS01 (8.29 mg/L), WS02 (9.96 mg/L), WS05 (8.43 mg/L) and WS06 (8.24 mg/L). This suggests that dissolved oxygen was possibly influenced by water type, and not the release of treated CS water, with both control sites (i.e. sites WS01 and WS02) having relatively high concentrations of dissolved oxygen. Furthermore, all unregulated water sites were within the baseline range for the concentration of dissolved oxygen (i.e. unregulated water baseline dissolved oxygen range = 1.63 – 11.00 mg/L), indicating that the monitoring results for the concentration of dissolved oxygen are consistent with ambient baseline conditions.

Beryllium was higher than the local WQG at sites WS05 (0.46 µg/L), WS06 (0.41 µg/L) and WS07 (0.61 µg/L). The maximum of baseline data for total beryllium (0.5 µg/L for unregulated waters, and 2.2 µg/L for regulated waters) is higher than the recorded values, indicating that the monitoring results for beryllium are consistent with ambient baseline conditions.

Chromium exceeded the local WQG at sites WS03 (2.2 µg/L), WS04 (2.4 µg/L), WS05 (2.4 µg/L), WS06 (2.4 µg/L) and WS07 (2.6 µg/L). The maximum of baseline data for total chromium (4.2 µg/L for unregulated waters, and 13.0 µg/L for regulated waters) is higher than the recorded values, indicating that the monitoring results for chromium are consistent with ambient baseline conditions.

Total copper exceeded the local WQG at site WS07 (5.1 µg/L). However, sites immediately downstream from the release point complied with local WQG, hence it is unlikely that this exceedance was a result of the release of treated CS water.

Total iron exceeded the local WQG at sites WS03 (4300 µg/L), WS04 (4400 µg/L), WS05 (4600 µg/L), WS06 (4700 µg/L) and WS07 (5700 µg/L). The maximum of baseline data for total iron (8200.0 µg/L for unregulated waters, and 45000.0 µg/L for regulated waters) is higher than the recorded values, indicating that the monitoring results for iron are consistent with ambient baseline conditions.

Total vanadium was higher than local WQG at site WS06 (11 µg/L). However, as concentrations of total vanadium complied with WQG at sites immediately downstream from the release point, this is unlikely due to the release of treated CS water.

Ammonia was higher than the local WQG at sites WS05 (0.11 mg/L) and WS06 (0.09 mg/L). The maximum of baseline data for ammonia in unregulated waters (i.e. 0.77 mg/L) is higher than the recorded values, indicating that the monitoring results for ammonia are consistent with ambient baseline conditions.

Calcium was lower than the local WQG range at sites WS03 (9.7 mg/L), WS04 (10 mg/L), WS05 (14 mg/L), WS06 (14 mg/L) and WS07 (12 mg/L). The calcium concentration at most sites was within the baseline range (9.8–53.4 mg/L for regulated waters, and 0.2–101 mg/L for unregulated waters) indicating that concentrations are consistent with ambient baseline conditions. The exception was site WS03, which had a concentration of calcium that was slightly lower (i.e. by 0.1 mg/L) than the baseline range for regulated ranges, although was well within the baseline for unregulated waters, indicating a result that is consistent with water quality of the region.

Chloride was higher than the local WQG at site WS09 (62 mg/L). However, as sites immediately downstream from the release point complied with WQG, this exceedance is unlikely to be a result of the release of treated CS water.

Monthly monitoring of all other parameters indicated they complied with the local WQG and thus reflected ambient baseline conditions.

Overall, the release of treated CS water does not appear to have had an adverse impact on water quality in the receiving environment from July to September 2019.

5 References

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Appendix A Depth Profiles of Water Quality Measured In Situ

Table A.1 Depth profile results of water quality measured *in situ* in July 2019.

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters	**Published WQO**			**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	17/7/19	16:25	0.3	14.53	260	7.5	8.5	85	14
			0.5	13.62	258	7.6	8.1	79.5	–
			1	12.91	261	7.7	8	76.9	–
WS02	17/7/19	15:27	0.3	12.84	261	7.6	10.4	100.4	19
			0.5	12.82	261	7.7	10.5	100.4	–
Freshwater Lakes / Reservoirs / regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	17/7/19	11:07	0.3	14.79	122	7	7.8	78	313
			0.5	14.81	122	7	7.8	77.8	–
			1	14.80	122	7.1	7.8	77.5	–
			1.5	14.77	122	7.1	7.7	77.3	–
			2	14.73	122	7.2	7.7	77.1	–
			3	14.67	122	7.3	7.7	76.8	–
			4	14.52	122	7.3	7.7	76	–
			5	14.45	122	7.4	7.7	75.9	–
			6	14.43	122	7.4	7.6	75.6	–
WS04	17/7/19	10:16	0.3	14.60	125	6.8	8.0	79.7	306
			0.5	14.76	124	6.9	8.0	79.3	–
			1	14.82	124	7	7.9	79	–
			1.5	14.79	124	7	7.9	78.5	–
			2	14.76	124	7.1	7.8	77.9	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			3	14.74	125	7.2	7.7	77.2	–
			4	14.74	125	7.2	7.7	77.2	–
			5	14.58	126	7.3	7.6	75.4	–
			6	14.47	127	7.3	7.5	74.6	–
Lower Dawson River – unregulated waters	**Published WQO**			**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	17/7/19	13:51	0.3	15.03	207	7.6	7.8	78.6	277
			0.5	14.49	208	7.6	7.7	77.1	–
WS06	17/7/19	12:40	0.3	13.64	199	7.1	7.8	76.1	267
			0.5	12.58	198	7.2	7.5	71.3	–
Freshwater Lakes / Reservoirs – regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	17/7/19	7:47	0.3	14.02	151	6.9	7	68.8	392
			0.5	14.09	150	7	7	68.6	–
			1	14.17	151	7	7	68.4	–
			1.5	14.20	151	7.1	6.9	68.4	–
			2	14.21	151	7.1	7	68.4	–
			3	14.23	151	7.2	6.9	68.2	–
			4	14.23	152	7.2	6.9	67.6	–
			5	14.21	152	7.3	6.8	67.1	–
			6	14.20	155	7.3	6.8	66.8	–
WS09	16/7/19	15:40	0.3	16.94	246	6.5	8.2	85.7	11
			0.5	16.94	246	6.6	8.2	85.6	–
			1	16.89	246	6.63	8.1	85.0	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			1.5	16.83	246	6.72	8.0	83.4	–
			2	16.75	246	6.81	7.8	81.2	–
			3	16.65	246	6.89	7.6	78.6	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

green shad ng denotes parameters that were non-comp ant w th the oca WQG

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG and pub shed WQO

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Table A.2 Depth profile results of water quality measured *in situ* in August 2019

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters		**Published WQO**		**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
		Local WQG		**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	7/8/19	15:53	0.3	14.85	291	7.7	9.4	95.2	8.21
			0.5	14.69	290	7.7	9.3	94.2	–
			1	14.48	288	7.7	9.2	92.4	–
			1.5	14.16	287	7.7	8.6	85.3	
			2	14.05	288	7.7	8.2	81.1	–
WS02	7/8/19	15:07	0.3	16.93	275	7.6	9.8	103.6	17.9
			0.5	16.68	276	7.6	9.9	103.8	
Freshwater Lakes / Reservoirs / regulated waters		**Published WQO**		**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
		Local WQG		**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	7/8/19	11:04	0.3	18.17	125	7.5	10.4	112.1	271
			0.5	17.00	120	7.6	9.5	100.2	–
			1	16.02	120	7.5	8.6	88.4	–
			1.5	15.45	121	7.5	8.2	83.1	–
			2	14.96	122	7.5	7.5	75.9	–
			3	14.56	122	7.5	7.0	70.1	–
			4	14.38	122	7.5	6.9	68.5	–
WS04	7/8/19	10:26	0.3	15.88	126	7.4	8.1	83.4	240
			0.5	15.41	124	7.4	7.9	79.9	–
			1	14.96	124	7.4	7.7	77.1	–
			1.5	14.71	124	7.4	7.6	76.5	–
			2	14.52	124	7.4	7.7	77.1	–

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			3	14.38	124	7.4	7.5	74.9	–
			4	14.32	124	7.4	7.3	72.8	–
Lower Dawson River – unregulated waters	**Published WQO**			**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
	Local WQG			**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	7/8/19	13:50	0.3	17.27	119	7.7	8.5	90.8	275
			0.5	16.24	122	7.7	8.8	91.8	–
WS06	7/8/19	12:51	0.3	15.53	126	7.5	9	91.9	305
Freshwater Lakes / Reservoirs – regulated waters	**Published WQO**			**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
	Local WQG			**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	6/8/19	15:38	0.3	18.09	180	6	10.3	111.4	317
			0.5	16.97	178	6.1	8.8	92.3	–
			1	16.21	175	6.1	8.0	83.1	–
			1.5	15.58	176	6.2	7.8	79.6	–
			2	15.09	175	6.2	7.8	78.3	–
			3	14.35	168	6.3	6.0	59.3	–
			4	13.86	165	6.3	5.4	52.9	–
			5	13.68	164	6.3	5.4	52.9	–
			6	13.62	165	6.4	5.4	52.9	–
			7	13.61	172	6.4	5.4	52.9	–
WS09	7/8/19	6:44	0.3	16.92	254	7.7	11.4	118.8	16.7
			0.5	16.87	254	7.7	11.3	118.3	–
			1	16.27	260	7.8	9.1	93.8	–
			1.5	15.48	263	7.7	4.3	43.3	
			2	15.02	263	7.7	3.5	34.9	

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			3	14.72	272	7.6	2.5	25.1	–
			4	14.59	278	7.5	2.0	20.2	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

green shad ng denotes parameters that were non-comp ant w th the oca WQG

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG and pub shed WQO

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Table A.3 Depth profile results of water quality measured *in situ* in September 2019.

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
Upper Dawson River – unregulated waters		**Published WQO**		**–**	**370**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
		Local WQG		**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS01	10/9/19	14:43	0.3	17.72	310	7.5	8.3	88.7	9.82
			0.5	17.66	310	7.5	8.3	88.4	–
			1	17.13	303	7.5	8.2	86.7	–
			1.5	16.86	302	7.6	8.5	88.6	–
			2	16.50	303	7.6	8.1	84.5	–
WS02	11/9/19	14:24	0.3	17.63	332	7.9	11.1	117.9	26.2
Freshwater Lakes / Reservoirs / regulated waters		**Published WQO**		**–**	**250**	**6.5 – 8.5**	**–**	**90 – 110**	**1 – 20**
		Local WQG		**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS03	12/9/19	11:43	0.3	20.52	215	7.6	7.6	85.5	274
			0.5	19.78	216	7.7	7.7	86.0	–
			1	18.20	203	7.8	6.4	68.7	–
			1.5	17.35	206	7.8	6.1	63.7	–
			2	16.88	207	7.7	5.9	61.5	–
			3	16.40	212	7.7	5.5	56.7	–
WS04	12/9/19	9:31	0.3	15.67	209	7.6	6.6	67.1	260
			0.5	15.59	209	7.6	6.6	66.7	–
			1	15.56	210	7.6	6.6	66.5	–
Lower Dawson River – unregulated waters		**Published WQO**		**–**	**340**	**6.5 – 8.5**	**–**	**85 – 110**	**50**
		Local WQG		**19.5 – 26.6**	**654**	**6.5 – 8.5**	**3.93 – 7.68**	**45.5 – 110**	**310**
WS05	11/9/19	8:11	0.3	15.18	212	7.5	8.3	82.5	271
			0.5	15.20	212	7.5	8.3	82.4	

Site	Date	Time (24 h)	Sample depth (m)	Temperature (°C)	EC [a] (µs/cm)[c]	pH	DO[b] (mg/L)	DO [b] % saturation	Turbidity (NTU)
			1	15.20	212	7.5	8.2	82.4	
WS06	11/9/19	9:29	0.3	15.83	216	7.7	8.2	83.4	275
			0.5	15.83	216	7.7	8.2	83.4	–
			1	15.82	216	7.7	8.2	83.3	–
Freshwater Lakes / Reservoirs – regulated waters		**Published WQO**		**–**	**250**	**6.5 – 8.0**	**–**	**90 – 110**	**1 – 20**
		Local WQG		**21.0 – 29.9**	**301**	**6.5 – 8.0**	**2.42 – 9.10**	**29.4 – 110**	**360**
WS07	9/9/19	15:20	0.3	16.93	164	7.4	8.2	86.0	247
			0.5	16.93	164	7.4	8.2	86.0	–
			1	–	–	–	–	–	–
			1.5	16.91	164	7.4	8.2	85.7	–
WS09	10/9/19	7:09	0.3	16.34	201	7.3	7.5	77.5	291
			0.5	16.36	201	7.3	7.5	77.3	–
			1	16.36	201	7.3	7.5	77.3	–
			1.5	16.36	201	7.3	7.5	77.3	–
			2	16.36	201	7.3	7.5	77.3	–
			3	16.38	206	7.3	7.5	77.1	–

grey shad ng denotes parameters that were non-comp ant w th the pub shed WQO

green shad ng denotes parameters that were non-comp ant w th the oca WQG

b ue shad ng denotes parameters that were non-comp ant w th the oca WQG and pub shed WQO

[a] EC: e ectr ca conduct v ty

[b] DO: d sso ved oxygen

[c] base f ow pub shed WQO app ed

– No data

Appendix D: Autumn 2019 Sediment Quality and Aquatic Ecology Report

Glebe End of Waste Scheme: Receiving Environment Monitoring Program

Sediment Quality and Aquatic Ecology, Autumn 2019

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1 Introduction

1.1 Background

Sunwater is the proponent of an End of Waste Scheme involving the discharge of reverse osmosis treated coal seam water to the Dawson River within Glebe Weir pool. As part of the conditions of approval for the scheme, Sunwater have developed a Receiving Environment Monitoring Program (REMP) that includes monitoring of water, sediment and aquatic ecology in the receiving environment (i.e. Glebe Weir and connected waterways including waters of the Dawson Valley Water Supply Scheme). The REMP includes a control : impact comparison of sites upstream and downstream of the discharge point. Historical baseline data was used to develop local guidelines for water quality, sediment quality and biological indicators (i.e. macroinvertebrates and fish).

This report for Autumn 2019 is the ninth REMP report on aquatic ecology since operational discharge of treated coal seam (CS) water commenced on 07 February 2015.

1.2 Scope of Works

The monitoring sites are specified in the REMP design document and are listed in Table 2.1. The scope of works comprises:

- twice yearly monitoring of sediment quality, aquatic habitat, macroinvertebrates and fish
- an assessment of sediment quality and aquatic ecology data against applicable guidelines, noting any trends between sites (especially control and impact sites), and
- an assessment of any potential impact the release of treated CS water has had on the condition of the aquatic ecosystem in the receiving environment.

Water quality is also assessed within the scope of the REMP, with boron and temperature assessed weekly and all other water quality parameters assessed on a monthly basis. Results are presented in quarterly water quality reports.

2 Methods and Quality Assurance

2.1 Site Location Details

Seven sites were surveyed along the Dawson River, with six of these assessed for sediment quality (WS01, WS02, WS03, WS04, WS05 and WS06) and six assessed for aquatic ecology (WS01, WS02, WS03, WS04[1], WS06 and WS07) (Table 2.1). Five of the sites are in the receiving environment for GBUS (WS03, WS04, WS05, WS06 and WS07), and two sites (WS01 and WS02) are control sites upstream of the receiving environment.

Based on the definitions in the *Dawson River Sub–basin Environmental Values and Water Quality Objectives EPP (Water) 2009* (EHP 2013a), there are three water types in the receiving environment of GBUS:

- unregulated reaches of the upper Dawson River (flowing water)
- unregulated reaches of the lower Dawson River (flowing water), and
- regulated reaches of the Dawson River – freshwater lake / reservoirs (non-flowing water).

The boundary between the lower and upper Dawson River Sub-catchments is Glebe Weir, with four sites in the upper Dawson and three in the lower Dawson. However, the baseline monitoring data indicate that variation in water quality, sediment quality and biological parameters within the lower and upper Dawson River was often higher than between these two water types. Therefore, for the purpose of GBUS and local guidelines, all flowing sections of the Dawson River within the receiving environment were considered a single water type (unregulated water) (frc environmental 2015).

2.2 Survey Timing

As a requirement of the End of Waste Approval (ENEW07542518) for the Glebe End of Waste Scheme (GEWS), and the Receiving Environment Monitoring Program (REMP) for the GEWS, sediment quality and aquatic ecology is monitored twice yearly (spring and autumn).

The Autumn 2019 field survey was completed by suitably qualified persons (professional aquatic ecologists) from frc environmental between 2 – 4 April 2019.

[1] S te WS04 was added to the mon tor ng program for aquat c eco ogy n June 2019

Table 2.1 Location of aquatic ecology monitoring sites.

Regulation	Water Type	Site	Location	Latitude [a]	Longitude [a]	Water Quality [b]	Sediment Quality	Aquatic Ecology [c]
Unregulated	Upper Dawson	WS01	Dawson River at the Old Leichardt Highway crossing at Taroom	-25.644476	149.791877	✓	✓	✓
		WS02	Dawson River at Bundulla Road Crossing	-25.572372	149.864464	✓	✓	✓
	Lower Dawson	WS05	Dawson River Downstream of Glebe Weir	-25.459722	150.043889	✓	✓	–
		WS06	Dawson River Downstream of Glebe Weir	-25.453333	150.055833	✓	✓	✓
Regulated	Upper Dawson	WS03	Dawson River Upstream of Glebe Weir	-25.476944	150.008333	✓	✓	✓
		WS04	Dawson River Upstream of Glebe Weir	-25.464269	150.033529	✓	✓	– [d]
	Lower Dawson	WS07	Dawson River Upstream of Gyranda Weir	-25.284722	150.181389	✓	–	✓

[a] WGS84

[b] water qua ty s presented separate y n quarter y reports

[c] aquat c eco ogy nc uded f sh and macro nvertebrate survey, and assessment of aquat c hab tat (aquat c hab tat was assessed at a seven s tes)

[d] S te WS04 was added to the aquat c eco ogy program n June 2019

– s te not assessed for that parameter w th n the scope of the REMP

2.3 Rainfall and Stream Flow

Monthly rainfall data for April 2017 to April 2019 was sourced from the Bureau of Meteorology for the monitoring station at the Taroom Post Office (station number 35070).

Stream flow data was sourced from nearby Department of Natural Resources, Mines and Energy (DNRME) gauging stations to provide information regarding flow conditions in the Dawson River prior to and during the survey to aid in the interpretation of aquatic ecological data. The two stations where flow was assessed are on the Dawson River at Taroom (130302A) and at Woodleigh (130317B) (DNRME 2018).

Volumes of treated CS water discharged from the Woleebee Pump Station were compared to natural river flows at the Glebe Weir headwater gauging station to assess the relative proportion of treated CS water within river flows in the receiving environment.

2.4 Sediment Quality

A single sediment sample was collected at each of the nominated sites (Table 2.1) in accordance with Department of Environment and Science's *Monitoring and Sampling Manual 2009* (DES 2018). Sediment samples were chilled for transportation to Symbio Alliance's NATA-accredited laboratory for analysis of the following metals and metalloids:

- arsenic
- boron
- chromium
- copper
- iron
- lead
- manganese
- nickel
- selenium, and
- zinc.

Metals and metalloids in the sediment were compared to the published national sediment quality guidelines (Simpson et al. 2013) and local sediment quality guidelines (frc environmental 2015).

2.5 Aquatic Habitat

Each nominated site (Table 2.1) was assessed for aquatic habitat attributes using a modified State of the Rivers survey method (Anderson 1993a; b).

A River Bioassessment Score was also calculated for these sites, except if they were dry (DNRM 2001). This score is a numerical index of aquatic habitat condition that enables a direct comparison of habitat quality between sites. Using this method, the quality of habitat is scored (from zero to twenty) for each of nine criteria:

- substrate or available cover
- embeddedness
- water velocity and depth
- channel alteration
- bed scouring and deposition
- pool:riffle and run:bend ratio
- bank stability
- bank vegetative stability, and
- streamside vegetation cover.

The score for each criterion is summed to give the overall score. This overall habitat score is then used to allocate sites to one of four categories (Table 2.2):

- excellent habitat condition (overall score >110)
- good habitat condition (overall score 75 to 110)
- moderate habitat condition (overall score 39 to 74), and
- poor habitat condition (overall score ≤38).

This method is not directly applicable to ephemeral systems in central Queensland because this method was developed for streams with perennial flow in southern Australia. Consequently, even pristine ephemeral systems are rarely classed as being in excellent condition using this method. Nonetheless it is a useful system for comparing between sites within a region.

Each site was also photographed from standard locations.

Table 2.2 Habitat bioassessment scores used to derive overall condition categories.

Habitat Category	**Category Score Range**			
	Excellent	**Good**	**Moderate**	**Poor**
Bed substrate or available cover	16–20	11–15	6–10	0–5
Embeddedness	16–20	11–15	6–10	0–5
Water velocity and depth	16–20	11–15	6–10	0–5
Channel alteration	12–15	8–11	4–7	0–3
Bed scouring & deposition	12–15	8–11	4–7	0–3
Pool:riffle and run:bend ratio	12–15	8–11	4–7	0–3
Bank stability	9–10	6–8	3–5	0–2
Bank vegetative stability	9–10	6–8	3–5	0–2
Streamside vegetation cover	9–10	6–8	3–5	0–2
Total Score	**111–135**	**75–110**	**39–74**	**0–38**

2.6 Fish

All available habitats (e.g. pool, riffle, run, bend, large woody debris) were fished at the nominated sites (Table 2.1) using electrofishing or seine net and box traps. Electrofishing was in accordance with the *Australian Code of Electrofishing Practice 1997*, using a Smith-Root boat 2.5 GPP electrofishing system (BEF) at sites where water was deeper than 1.0 m, and a Smith-Root LR-24 backpack electrofisher (BPEF) in shallower water (Table 2.3).

Table 2.3 Effort used to catch freshwater fish.

Site	Method	Habitat	Date In	Time In	Time Out	Settings	Effort
WS01	boat electrofishing	pool	04/04/19	13:45	14:45	50-1000 V; 4 A; 60 DC; 80%	1015 s
WS02	backpack electrofishing	pool	04/04/19	10:00	10:30	200 V; 40 Hz; 3 ms	406 s
	seine net		04/04/19	8:45	9:05	–	3 x 10 m
	small bait traps (10)		04/04/19	7:00	10:00	–	30 h
WS03	boat electrofishing	pool	03/04/19	14:00	17:00	50-1000 V; 4 A; 60 DC; 80%	1009 s
	small bait traps (10)		03/04/19	15:30	16:15	–	30 h
WS06	seine net	pool	02/04/19	9:45	10:20	–	4 x 10 m
	small bait traps (10)		02/04/19	9:00	11:30	–	25 h
WS07	boat electrofishing	pool	02/04/19	11:15	12:00	50-1000 V; 4 A; 60 DC; 80%	1024 s
	small bait traps (10)		02/04/19	10:30	13:00	–	25 h

The sampling of fishes was conducted under General Fisheries Permit No. 199434 and Animal Ethics Approval No. CA 2018/08/1224 held by frc environmental.

The WQOs and local WQGs for fish are based on a ratio of the number of observed to expected native species, which should be at least 1 (i.e. O/E ≥ 1) (DERM 2011a). The number of expected species is the number of species caught on 50% or more survey events during the baseline studies for each water type.

The number of expected species of native fish in the Lower Dawson is 11, and in the Upper Dawson is 8 (DERM 2011a) (Table 2.4a). That is, to achieve the WQO for the Lower Dawson the observed number of native species is ≥ 11, and in the Upper Dawson is ≥ 8. For the local WQGs, the expected number of native fish for each site is shown in Table 2.4a.

The WQO for the number of species of exotic fish in the Dawson River is no more than 3 exotic species (DERM 2011a). The expected number of exotic fish for each site recorded during the baseline surveys is shown in Table 2.4a.

Table 2.4a Expected number of native and exotic fish species for each REMP monitoring site.

Regulation	Water Type	Site	Expected number of native species	Expected number of exotic species
Unregulated	Upper Dawson	WS01	**4**	**1**
	Upper Dawson	WS02	**2**	**1**
	Lower Dawson	WS06	**3**	**2**
	Lower Dawson	WS05	**4**	**2**
Regulated	Upper Dawson	WS03	**5**	**1**
	Upper Dawson	WS04	**3**	**1**
	Lower Dawson	WS07	**5**	**1**

Source: (frc env ronmenta 2015)

Table 2.5b Expected number of native and exotic fish species for upper and lower Dawson.

Water Type	Expected number of native species	Expected number of exotic species
Upper Dawson	6	1
Lower Dawson	5	1

Source: (frc env ronmenta 2015)

2.7 Macroinvertebrates

Macroinvertebrates were sampled at the nominated sites (Table 2.1) using a Surber sampler that had a square 0.3 m x 0.3 m frame and 250 µm mesh. At each site, five replicate samples were collected from edge habitat with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate was disturbed within the 0.3 m x 0.3 m area, and the sample collected by sweeping the net across the disturbed area.

Macroinvertebrates were identified to the lowest practical taxonomic level (in most instances family) and counted to comply with standard AUSRIVAS methods (Chessman

2003). Quality control procedures were carried out in accordance with the REMP and DES (2018).

The following indices were calculated for each site:

- abundance
- taxonomic richness
- PET richness, and
- SIGNAL-2 scores.

These indices were calculated from the average across the five samples and used to indicate the current ecological condition of the receiving environment by comparing them to the relevant local WQG (frc environmental 2015). Published biological water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in the Fitzroy Basin (DERM 2011a) (Table 2.6) were also presented but are not suitable for comparison in this survey as they apply to macroinvertebrates sampled using AUSRIVAS methods.

Table 2.6 Macroinvertebrate WQOs and Local WQGs for the Dawson River sub-catchment (upper and lower combined).

Habitat	Indicator	WQO[1]	Local WQG[2]
Unregulated Water Type (Flowing Water)			
edge	abundance	–	45.2 – 140.8
	taxonomic richness	23 – 33	9.8 – 33
	PET richness	2 – 5	1.3 – 5.0
	SIGNAL 2 score	3.31 – 4.20	3.31 – 4.20
Regulated Water Type (Lakes/ Reservoirs)			
edge	abundance	–	49.8 – 146.7
	taxonomic richness	–	6.8 – 14.1
	PET richness	–	0.4 – 3.6
	SIGNAL 2 score	–	2.9 – 3.75

1 DERM (2011a)

2 (frc env ronmenta 2015)

Abundance

Abundance is the total number of individuals. In this survey, the abundance of each family, and the overall abundance of macroinvertebrates, was assessed for each site.

Taxonomic Richness

Taxonomic richness is the number of taxa (generally families). Taxonomic richness is a basic, unambiguous and effective diversity measure. However, it is affected by arbitrary choice of sample size. Where all samples are of equal size, taxonomic richness is a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxon, so rare and common taxa are considered equally.

PET Richness

While some groups of macroinvertebrates are tolerant to pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families within sites of good habitat condition and water quality than in sites of degraded condition. PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2007). The lower the PET score (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.

SIGNAL-2 Scores

SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL-2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL-2 scores are weighted for abundance. The scores take the relative abundance of tolerant or sensitive taxa into account (instead of only the presence or absence of these taxa). The overall SIGNAL-2 score for a site is based on:

- the total of the SIGNAL grade
- multiplied by the weight factor for each taxon, and
- divided by the total of the weight factors for each taxon.

2.8 Macrocrustacean Exoskeleton Assessment

Three of the commonly occurring macroinvertebrate species (*Macrobrachium spp., Cherax* spp. and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded. The reproductive status of the specimens was also recorded.

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records of exoskeletons being robust and in good condition, and breeding (i.e. presence of eggs attached to the pleiopods of adult females) recorded in the spring and summer months.

3 Results

3.1 Rainfall

Rainfall for the six months leading up to the survey was mostly below the long-term mean monthly rainfall (except October 2018 and March 2019), overall indicating a dryer than average Summer/Autumn period (Figure 3.1). There was a rainfall event five days prior to survey with a daily maximum of 51.6 mm.

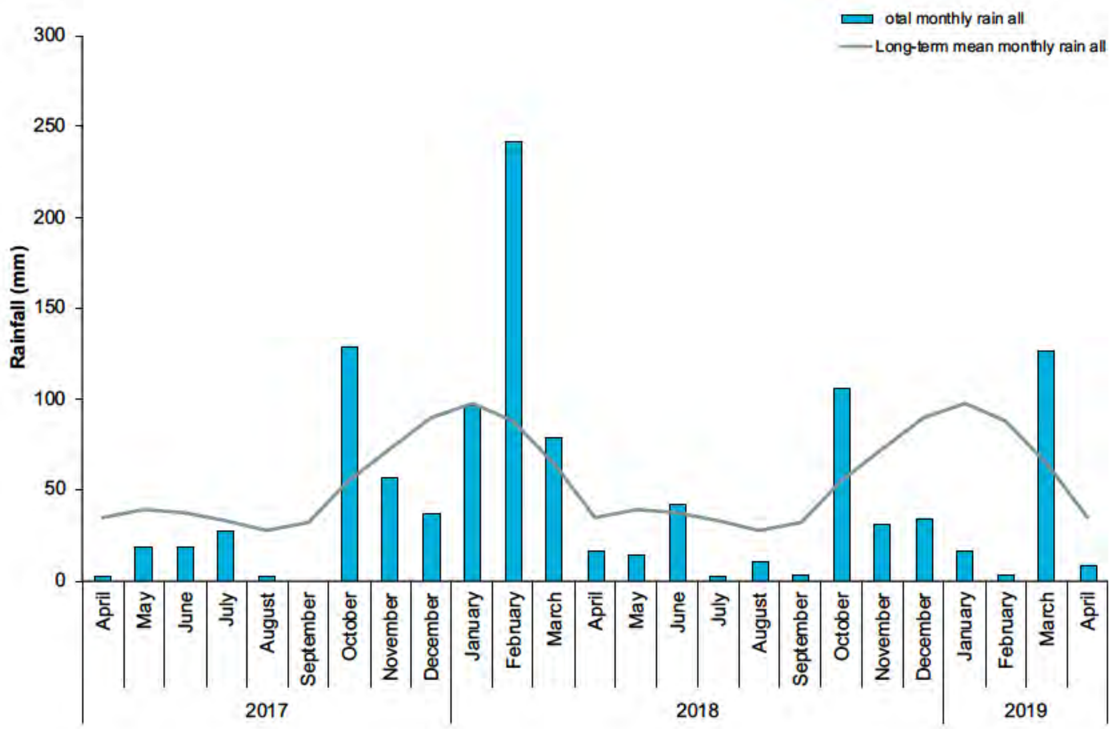

Figure 3.1 Total monthly and mean monthly rainfall (mm) at Taroom post office (station 35070) from April 2017 to April 2019.

3.2 Stream Flow

Dawson River stream flow data from gauging stations 130302A (Dawson River at Taroom) and 130317B (Dawson River at Woodleigh) is shown in Figure 3.2 and Figure 3.3, respectively (DNRM 2017). In the 12 month period, from May 2018 to April 2019, flow patterns were atypical for the region, with larger flows occurring during the spring to early summer months (September – November), coinciding with the above-average rainfall in October 2018. There was little to no rainfall during the summer period from November to February resulting in lower than average flows over the same period. Increased flow was recorded at gauging station 130302A in April 2019 following above average rainfall in March. During the survey period, from the 2nd to the 4th of April 2019, there was 4495 ML of discharge recorded in the Dawson River at the Taroom gauging station. Prior to this, there was little to no flow since December 2018.

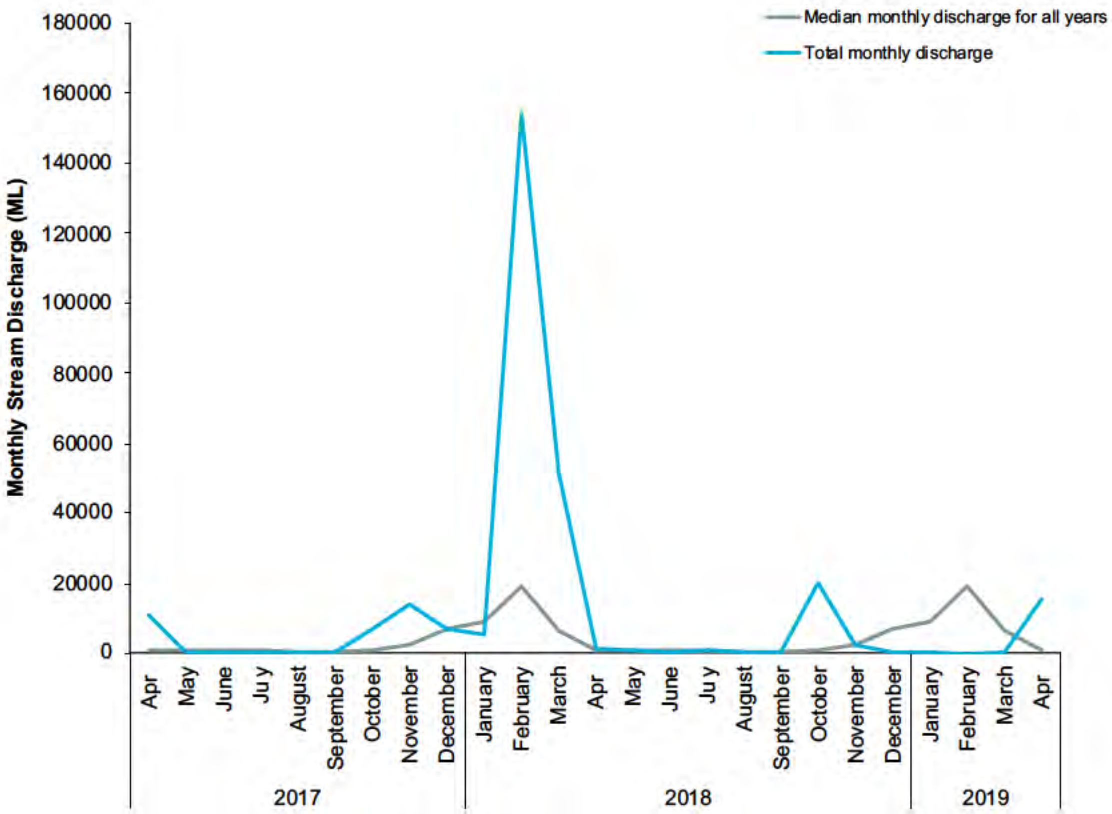

Figure 3.2 Total monthly discharge data for April 2017 – April 2019, and median monthly discharge data for all years, at gauging station 130302A (Dawson River at Taroom).

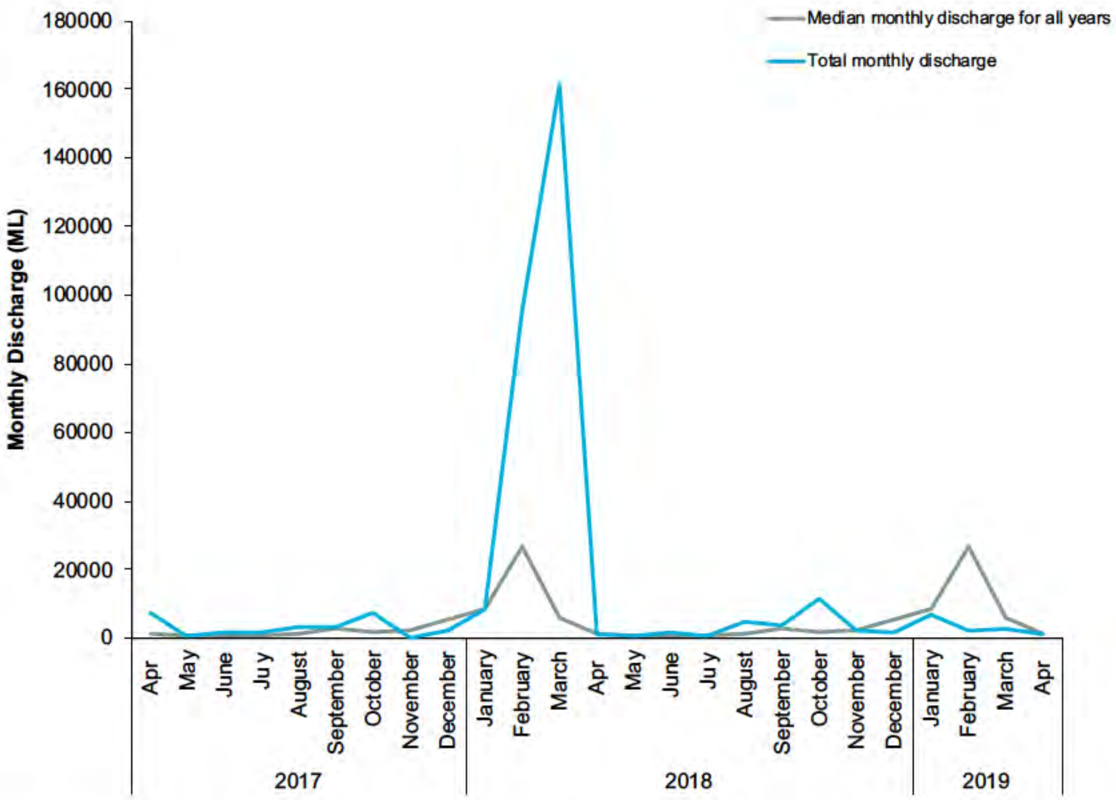

Figure 3.3 Total monthly discharge data for April 2017 – April 2019, and median monthly discharge data, for all years at gauging station 130317B (Dawson River at Woodleigh).

The volume of treated CS water release was greater than Glebe Weir releases for brief periods in 2018, and for a notable period in January / February 2019. However, Glebe Weir Releases were often significantly greater than release volumes at most other times over the past 12 months (Figure 3.4). When compared to natural discharge volumes recorded at the Taroom and Woodleigh gauging stations, the volume of treated CS water released was significantly lower most of the time.

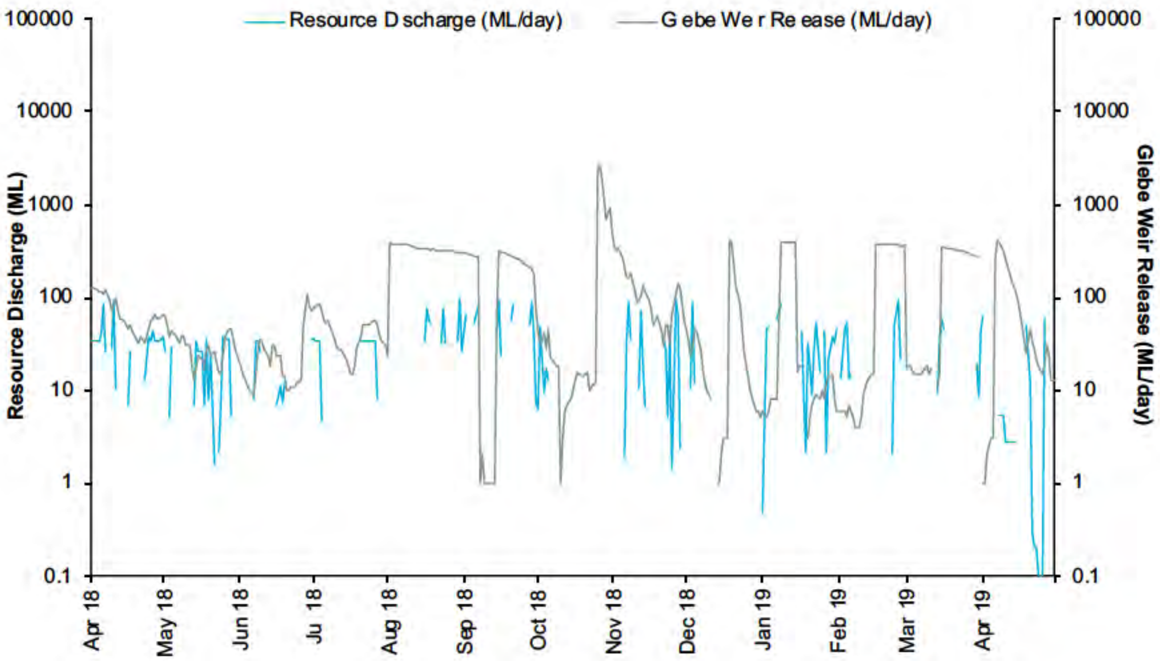

Figure 3.4 Release volumes of treated CS water from Woleebee Pump Station compared to natural river flows in the Dawson River at Sunwater's Glebe Weir headwater gauging station.

3.3 Sediment Quality

The concentration of metals and metalloids in sediment was:

- above the analytical limit of reporting (LOR) for all parameters except arsenic and selenium, which were below the LOR at all sites
- above the local guideline for:
  - iron at all sites, with the values at reference site WS01 higher than the baseline maximum (i.e. 16,800 mg/kg)and
  - manganese at site WS03, but lower than the baseline maximum (i.e.536 mg/kg)
- below the national and local sediment guidelines for all other parameters (Table 3.1)[1].

1 There are no pub shed sed ment qua ty gu de ne va ues for boron, ron, manganese and se en um

Table 3.1 Concentration of metals and metalloids in the sediment compared to the revised ANZECC & ARMCANZ sediment quality guidelines (Simpson et al. 2013) and local sediment quality guidelines (frc environmental 2015).

Parameter	Units	LOR	Default SQG Trigger Value	Default SQG – High	Unregulated Local SQG	WS01	WS02	WS05	WS06	Regulated Local SQG	WS03	WS04
Metals and Metalloids												
Arsenic	mg/kg	5	20	70	20	<5	<5	<5	<5	20	<5	<5
Boron	mg/kg	5	–	–	16	10.3	6.9	6.4	7.7	14.4	7.5	7
Chromium	mg/kg	1	80	370	80	7.4	6.8	5.3	5.2	80	7	4.2
Copper	mg/kg	1	65	270	32	9.9	8.7	6.9	6.7	65	8.9	4.4
Iron	mg/kg	2	–	–	10274	17000	10700	9870	12200	9703	11800	10600
Lead	mg/kg	2	50	220	50	8.7	5.4	8.8	7.8	50	7.5	4.4
Manganese	mg/kg	1	–	–	405	389	173	356	378	268	457	115
Nickel	mg/kg	1	21	52	21	6.3	4.9	5	5.5	21	7.3	3.3
Selenium	mg/kg	5	–	–	1	<5	<5	<5	<5	1	<5	<5
Zinc	mg/kg	5	200	410	200	37.6	27.8	22.2	23.1	200	28.3	13.8

L ght grey shad ng denotes parameters that d d not comp y w th the oca SQG. Go d shad ng denotes resu ts where LOR was h gher than SQG.

3.4 Aquatic Habitat

A detailed description of the habitat at each site is presented in Appendix A.

Aquatic habitat was generally similar to baseline conditions, with:

- substrate dominated by silt and clay at all sites, with site WS02 having a visible fraction of coarser substrate, and WS04 with notable proportion of sand
- bank stability varying between sites, with:
  - site WS06 having unstable banks
  - sites WS01, WS02, WS03, WS04, WS05 and WS07 having banks of moderate stability
  - no sites having high bank stability
- physical habitat, varying degrees of depth variation of water and large woody debris at all sites
- low diversity and cover of aquatic plants in water, and limited aquatic plants adjacent to water at both regulated and unregulated water types.

River bioassessment scores were similar to the baseline surveys, with differences generally related to differences in water levels. Lower scores were typically associated with low substrate type diversity, low water level and existing disturbances. In April 2019, all sites had moderate habitat bioassessment scores with the exception of site WS02, which had a good habitat bioassessment score. The driving factors in determining these scores were due to:

- low to moderate habitat diversity, including variation in the depth of pools and large woody debris, and
- moderate to very high habitat disturbance, including adjacent land uses (urban development, recreational use of bank, grazing).

The groundwater seep at site WS05 that was consistently recorded during the baseline program was visible in April 2019.

Table 3.2 River Bioassessment Scores for each site in April 2019.

Site	Location	River Bioassessment Score
WS01	Dawson River at the Old Leichhardt Highway crossing at Taroom	65 (Moderate)
WS02	Dawson River at Bundulla Road Crossing	79 (Good)
WS03	Dawson River Upstream of Glebe Weir	59 (Moderate)
WS04	Dawson River Upstream of Glebe Weir	69 (Moderate)
WS05	Dawson River Downstream of Glebe Weir	47 (Moderate)
WS06	Dawson River Downstream of Glebe Weir	53 (Moderate)
WS07	Dawson River Upstream of Gyranda Weir	58 (Moderate)

3.5 Fish

Twelve native and one exotic fish species were caught across all sites in April 2019 (Table 3.3). All species recorded in the April 2019 survey were reported in the baseline surveys. A total of eight native species were caught at site WS02 and six native species caught at each of the other sites. Total abundance of native fish ranged from 36 at site WS02 to 385 at site WS06. The most commonly caught native species was carp gudgeon (*Hypseleotris spp.*) and then bony bream (*Nematalosa erebi*). One southern saratoga (*Scleropages leichardti*) was caught at site WS01. All fish caught were in good condition, with no observable lesions or damage.

The pest fish eastern gambusia (*Gambusia holbrooki*) was present at all sites. Additionally, the common goldfish (*Carassius auratus*) was observed at site WS03. Eastern gambusia (*G. holbrooki*) is a restricted biosecurity matter under the *Biosecurity Act 2014*.

Upper and Lower Dawson

The number of observed native species was higher than the number of expected native species at all sites when compared with the local WQG. However, the number of observed native species was lower than the expected native species when compared with the published WQOs, with the exception of site WS02 which was equal to the published WQO's (Table 3.4).

Regulated and Unregulated Reaches

The native fish community was more diverse in the unregulated water type than the regulated water type, with ten and eight native species caught in each type, respectively. All sites were higher than the local WQG, with sites WS02 and WS06 having double, and more than double the number of expected species respectively (Table 3.4).

The local WQG for exotic fish species was met at all sites with the exception of WS03 (Table 3.3), which had twice the amount of pest species than expected due to the occurrence of the common goldfish at this site. The pest species, eastern Gambusia, was caught at all sites (both regulated and unregulated water types). The published WQO for pest fish was not exceeded.

Table 3.3 Total abundance of freshwater fish for each species at each site in April 2019.

Species Name	Common name	Unregulated			Regulated		Total
		Upper Dawson		Lower Dawson	Upper Dawson	Lower Dawson	
		WS01	WS02	WS06	WS03	WS07	
Native species							
Ambassis agassizii	Agassiz's glassfish	0	2	25	4	0	31
Hypseleotris spp.	carp gudgeon	70	20	229	11	0	330
Leiopotherapon unicolor	spangled perch	0	0	0	0	1	1
Macquaria ambigua	yellow belly	3	2	0	0	0	5
Melanotaenia splendida splendida	eastern rainbowfish	14	6	64	21	3	108
Nematalosa erebi	bony bream	15	0	59	82	104	260
Neosilurus hyrtlii	Hyrtl's catfish	0	0	0	0	1	1
Craterocephalus stercusmuscarum	flyspecked hardyhead	0	2	6	5	53	66
Amniataba percoides	barred grunter	0	1	0	0	0	1
Oxyeleotris lineolata	sleepy cod	2	2	2	8	3	17
Scleropages leichardti	southern saratoga	1	0	0	0	0	1
Philypnodon grandiceps	flathead gudgeon	0	1	0	0	0	1
Total abundance of native species		**105**	**36**	**385**	**131**	**165**	**822**
Expected number of native species		4	2	3	5	4	
Number of native species		6	8	6	6	6	12

Species Name	Common name	Unregulated			Regulated		Total
		Upper Dawson		Lower Dawson	Upper Dawson	Lower Dawson	
		WS01	WS02	WS06	WS03	WS07	
Exotic species							
Gambusia holbrooki	eastern gambusia	17	52	1	1	1	72
Carassius auratus	goldfish	0	0	0	6	0	6
Total abundance of exotic species		**17**	**52**	1	**7**	**1**	78
Expected number of exotic species		**1**	**1**	**2**	**1**	**1**	
Number of exotic species		**1**	**1**	**1**	**2**	**1**	**2**

grey shad ng denotes s tes where the number of nat ve spec es s be ow expected

Table 3.4 Ratio of observed/expected native fish in April 2019 for each site.

Regulation	Location	Site	Published WQO	Local WQG	Number of Native Species Observed	O/E (Published WQO)	O/E (Local WQG)
Unregulated	Upper Dawson	WS01	8	≥ 4	6	0.75	1.5
	Upper Dawson	WS02	8	≥ 2	8	1	4.0
	Lower Dawson	WS06	11	≥ 3	6	0.55	2.0
Regulated	Upper Dawson	WS03	8	≥ 5	6	0.75	1.2
	Lower Dawson	WS07	11	≥ 4	6	0.55	1.5

3.6 Macroinvertebrates

The mean abundance of macroinvertebrates ranged from 0.8 (WS03) to 28.0 (WS06), and was below the local WQG range at all sites (Table 3.5), and was lower than baseline range (Appendix B) at all sites except site WS06.

The mean taxonomic richness of macroinvertebrates in edge habitat ranged from 0.8 (WS03) to 6.0 (WS06), and was below the local WQG range at all sites (Table 3.5), and was lower than baseline range (Appendix B) at all sites except site WS06.

Mean PET richness in the edge habitat ranged from 0.0 (WS03) to 0.8 (WS06), and was below the local WQG at all sites (Table 3.5), and was lower than the baseline range (Appendix B) at reference sites WS01 and WS02.

SIGNAL-2 scores ranged from 3.0 (WS03) to 3.5 (WS07), and was below the local WQG at all sites except WS07 which was higher than the local WQG range (Table 3.5). However, all SIGNAL-2 scores were within the baseline range (Appendix B).

3.7 Macrocrustacean Exoskeleton Assessment

The following macrocrustaceans were caught:

- *Macrobrachium australiense* (freshwater prawn): caught at all sites
- *Cherax sp*. (crayfish): caught at site WS01, and
- *Caridina* spp. (freshwater shrimp): caught at sites WS01, WS02 and WS06.

The exoskeleton of all individuals was of same apparent colour, thickness and robustness as recorded for macrocrustaceans on the baseline surveys.

Table 3.5 Mean abundance, taxonomic richness, PET richness and SIGNAL-2 scores in edge habitat for all sites in April 2019.

Water Type	Reach	Site	WQO	Abundance	Taxonomic Richness	PET Richness	SIGNAL-2
Unregulated			**WQO [a]**	**–**	**23 – 33**	**2 – 5**	**3.31 – 4.2**
			Local WQG [b]	**45.2 – 140.8**	**9.8 – 33**	**1.3 – 5**	**3.31 – 4.2**
	Upper Dawson	WS01		12.6	3.8	0.4	3.16
		WS02		7.6	3.4	0.0	3.30
	Lower Dawson	WS06		28.0	6.0	0.8	3.22
Regulated			**WQO [a]**	**–**	**23 – 33**	**2 – 5**	**3.31 – 4.2**
			Local WQG [b]	**49.8 – 146.7**	**6.8 – 14.1**	**0.4 – 3.6**	**2.9 – 3.75**
	Upper Dawson	WS03		0.8	0.8	0.0	3.00
	Lower Dawson	WS07		5.0	2.0	0.2	3.50

a macro nvertebrate water qua ty object ves for Dawson R ver sub-catchment (DERM 2011a); su tab e for compar son on y w th AUSRIVAS samp ng

b macro nvertebrate water qua ty object ves for the GBUS (frc env ronmenta 2015).

grey shad ng nd cates where the average for a g ven ndex was be ow the oca WQG range

b ue shad ng nd cates where the average for a g ven ndex was above the oca WQG range

4 Impact Assessment

The concentration of iron in sediment was higher than the local SQG at all sites, but was lower than the baseline maximum concentration at all sites except reference site WS01. Thus all sites, excluding site WS01 had iron concentrations that were consistent with ambient baseline conditions. As site WS01 is a reference site upstream of the release point, the high concentration of iron in sediment at this site is not related to the release of treated CS water.

The concentration of manganese in sediment at site WS03 was higher than the local SQG, but lower than the baseline maximum, indicating the recorded concentration of manganese in sediment at this site is consistent with ambient baseline conditions.

The aquatic habitat characteristics at all sites in April 2019 were similar to baseline conditions, with all sites being of moderate to good condition, suggesting there was no apparent impact to aquatic habitat condition in the receiving environment due to the release of treated CS water.

Native fish communities were more diverse than expected by the local WQG for native fish at all sites, and the diversity of exotic fish was equal to or lower than expected at all sites except for site WS03 where there were two species of exotic fish observed at this site. However, both pest fish recorded from this site (goldfish and eastern Gambusia) are known from the upper Dawson River, and the published WQO for pest fish species was not exceeded. All native fish caught were in good condition. There was no apparent impact to the fish community due to the release of treated CS water.

All macroinvertebrate indices were lower than the local WQG, and tended to be lower than the baseline minimum, except Signal-2 Scores at site WS07, which was consistent with baseline range. As reference sites WS01 and WS02 had low macroinvertebrate abundance, taxonomic diversity and PET richness, the macroinvertebrate results overall reflect a regional-scale influence, rather than a point-source influence at sites immediately downstream of the release location. The results do not indicate an impact in the receiving environment due to the release of treated CS water.

Overall, there was no evidence of impact from the release of treated CS water to aquatic habitat condition, sediment quality, fish communities or macroinvertebrates in the Dawson River.

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Appendix A Site Habitat Summary Sheets

Site	WS01 Old Leichhardt Highway Bridge Taroom	**Region**	Upper Dawson River Sub-Basin
Reach	Upstream of Receiving Environment	**Water Type**	Unregulated
Date surveyed	04 April 2019	**Habitat Bioassessment Score**	65 (out of 135; moderate)

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	moderate	**Riparian width**	25-10 m
Pattern	mildly sinuous		boulder	0%	**Habitat present**	shallow and deep	**Disturbance**	moderate
Bank stability	moderate		cobble	0%		large woody debris	**Dominant species**	eucalypt
Bank shape	low/convex; low/convex		pebble	10%		macrophytes		melaleuca
Hydrology			gravel	5%				
Flow regime	perennial		sand	5%			**Weed species**	Grasses
Water depth	2 m		silt / clay	80%	**In-stream disturbance**		**Adjacent land use**	Native forest
Wetted width	25 m	**Deposits**	silt		**Flow modification**	downstream causeway		Residential/native vegetation
Flow	moderate (0.10 m/s)	**Bed stability**	moderate aggradation		**Waterway barrier**	downstream causeway and weir		
Channel width	33 m							
Comments:	Site is in a mildly sinuous channel, with a high water level and flowing, very turbid water. The channel 25m from the right bank also has water. There were aquatic plants on the left bank downstream and right bank upstream. Eucalyptus, melaleuca and grasses were extensive on banks. Two bridges over the river and old bridge debris. Land cleared for park and pathway on right bank. Leaf litter extensive on banks.							

Site	WS02 Bundulla Crossing	**Region**	Upper Dawson River Sub-Basin
Reach	Upstream of Receiving Environment	**Water Type**	Unregulated
Date surveyed	04 April 2019	**Habitat Bioassessment Score**	79 (out of 135; good)
No photo		No photo	

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	moderate	**Riparian width**	15-30 m
Pattern	mildly sinuous		boulder	0%	**Habitat present**	run	**Disturbance**	high
Bank stability	high		cobble	2%		deep and shallow	**Dominant species**	Eucalypt
Bank shape	low/convex;		pebble	3%		large woody debris		Melaleuca
	low/convex					macrophytes		
Hydrology			gravel	5%				
Flow regime	perennial		sand	5%			**Weed species**	Grasses
Water depth	1.5 m		silt / clay	85%	**In-stream disturbance**		**Adjacent land use**	Native forest
Wetted width	17 m	**Deposits**	silt		**Flow modification**	–		Grazing
Flow	moderate (0.15 m/s)	**Bed stability**	Moderate aggradation		**Waterway barrier**	bridge (partial barrier)		
Channel width	20 m							

Comments:	Site is in a mildly sinuous channel, with high water level. There was water over the road on the right bank and water over the bridge recently. Water was very turbid and flowing. Fallen tree downstream across 75% of creek. Trees in creek both up and down stream. Build-up of branches (small) on upstream side of bridge. Grasses and trees on banks and some lignum.

Site	WS03 Glebe Weir Pool upstream	**Region**	Upper Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Regulated
Date surveyed:	03 April 2019	**Habitat Bioassessment Score**	59 (out of 135; moderate)

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	15-30 m
Pattern	straight		boulder	0%	**Habitat present**	shallow and deep pool	**Disturbance**	high disturbance
Bank stability	moderate		cobble	0%		large woody debris	**Dominant species**	Eucalypt
Bank shape	low-moderate/convex;		pebble	0%				
	low/convex							
Hydrology			gravel	0%			**Weed species**	Noogoora burr
								grasses
Flow regime	intermittent		sand	10%	**In-stream disturbance**			
Water depth	5 m		silt / clay	90%	**Flow modification**	weir downstream	**Adjacent land use**	grazing
Wetted width	60 m	**Deposits**	silt		**Waterway barrier**	weir downstream		native vegetation
Flow	Not flowing (<0.01m/s)	**Bed stability**	moderate aggradation					
Channel width	70 m							

Comments: Site is located upstream of weir in a mildly sinuous channel. Water level was high with no flow and was very turbid. There were dead trees in the stream from the middle of the river to the right bank and some scattered on the left bank. Eucalypts were extensive on the left and right bank. There was also *Juncus sp.*, weeds and grasses but a lot of bare ground too. Pool of water off to the left upstream.

Site	WS04 Glebe Weir Pool at boat ramp	**Region**	Upper Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Regulated
Date surveyed	03 April 2019	**Habitat Bioassessment Score**	69 (out of 135; moderate)

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	10-30 m
Pattern	Mildly sinuous		boulder	0%	**Habitat present**	shallow and deep pool	**Disturbance**	very high
Bank stability	moderate		cobble	2%		Macrophytes	**Dominant species**	eucalypt
Bank shape	Moderate/ wide lower bench		pebble	3%		Some small woody debris		
	Moderate/convex							
Hydrology			gravel	5%			**Weed species**	Noogoora burr
Flow regime	intermittent		sand	15%				Grasses
Water depth	4 m		silt / clay	75%	**In-stream disturbance**			
Wetted width	50 m	**Deposits**	silt		**Flow modification**	weir (at site)	**Adjacent land use**	camp ground
Flow	Not flowing (<0.01m/s)	**Bed stability**	moderate aggradation		**Waterway barrier**	weir (at site)		grazing
Channel width	70 m							native vegetation

Comments:	Site is located in a mildly sinuous channel. Water level was high but weir was not overtopping. Water was very turbid with no flow. There was minimal woody debris and banks were mostly bare (for 2-3 m) before a line of eucalypts and grasses. Weeds were extensive where aquatic plants were present. Water birds present.

Site	WS05	**Region**	Lower Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Unregulated
Date surveyed:	02 April 2019	**Habitat Bioassessment Score**	47 (out of 135; moderate)
No photo		No photo	

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	30-30 m
Pattern	irregular meander		boulder	0%	**Habitat present**	shallow	**Disturbance**	Moderate
Bank stability	low		cobble	0%		large woody debris	**Dominant species**	Eucalypt
								Lomandra
Bank shape	Steep/concave, moderate/convex;		pebble	0%			**Weed species**	grasses
	Moderate convex							
Hydrology			gravel	0%				
Flow regime	perennial		sand	10%			**Adjacent land use**	grazing
Water depth	5 m		silt / clay	90%	**In-stream disturbance**			native forest
Wetted width	8 m	**Deposits**	silt		**Flow modification**	weir (1 km upstream)		
Flow	slow (<0.01 m/s)	**Bed stability**	moderate aggradation		**Waterway barrier**	weir (1 km upstream)		
Channel width	25 m							
Comments:	Site is located in an irregular meandering channel. Water level very low due to no flow. Water column very turbid. Left bank heavily eroded for a 50 m stretch. Evidence of recent runoff on left bank, including sediment deposit. Fallen tree downstream limiting flow. Other large woody debris and small woody debris present. Grasses, *Lomandra* and eucalypts on banks. Unidentified red substance seeping from left bank.							

Site	WS06 Dawson downstream Glebe	**Region**	Lower Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Unregulated
Date surveyed:	03 April 2019	**Habitat Bioassessment Score**	53 (out of 135; moderate)

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	15-25 m
Pattern	Irregular meanders		boulder	0%	**Habitat present**	shallow pool	**Disturbance**	Very high
Bank stability	low		cobble	0%		large woody debris	**Dominant species**	eucalypt
Bank shape	Moderate/concave; moderate/convex		pebble	0%				
Hydrology			gravel	0%				
Flow regime	intermittent		sand	10%			**Weed species**	grasses
Water depth	3.5 m		silt / clay	90%	**In-stream disturbance**			
Wetted width	6 m	**Deposits**	silt		**Flow modification**	downstream of Glebe Weir	**Adjacent land use**	native forest
Flow	Not flowing (<0.01 m/s)	**Bed stability**	severe aggradation		**Waterway barrier**	nil		grazing
Channel width	15 m							native vegetation

Comments:	Site is located in an irregular meandering channel, with low water level and no flow. Water very turbid. Left bank heavily eroded just upstream of site. Evidence of recent runoff in the form of soil deposits at the bottom of banks and large grooves where it flowed towards the creek. Extensive amount of large and small woody debris. Grasses and eucalypts on banks

Site	WS07 Gyranda Weir	**Region**	Lower Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Regulated
Date surveyed:	02 April 2019	**Habitat Bioassessment Score**	58 (out of 135; moderate)

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	moderate	**Riparian width**	25-15 m
Pattern	mildly sinuous		boulder	1%	**Habitat present**	shallow and deep pool	**Disturbance**	moderate
Bank stability	moderate		cobble	2%		large woody debris	**Dominant species**	eucalypt
Bank shape	Low/convex; moderate/concave		pebble	2%		macrophytes		
Hydrology			gravel	0%				
Flow regime	ephemeral		sand	50%			**Weed species**	grasses
Water depth	4 m		silt / clay	45%	**In-stream disturbance**			
Wetted width	50 m	**Deposits**	silt		**Flow modification**	Weir (at site)	**Adjacent land use**	grazing
Flow	Not flowing (<0.01 m/s)	**Bed stability**	moderate aggradation		**Waterway barrier**	Weir (at site)		
Channel width	65 m							

Comments:	Site is situated at a weir. Water level low and not overtopping weir. No water flow and water turbid. Eucalypts extensive on both banks, with some melaleucas and palms. Persicaria extensive on left bank. Stock grazing on both sides. Evidence of stock presence on right bank. Lower woody debris in the form of dead trees.

Appendix B Macroinvertebrate Indices Baseline Range

The baseline range of the macroinvertebrate indices is presented in Table B1.

Table B1. Macroinvertebrate indices baseline range

Index	Regulated Water		Unregulated Water	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Abundance	26.7	506.8	34.7	624
Taxonomic Richness	5.1	17.4	5.9	23.9
PET Richness	0.0	5.1	0.7	4.9
SIGNAL-2 Score	2.5	4.2	3.0	4.3

Appendix E: Spring 2019 Sediment Quality and Aquatic Ecology Report

Glebe End of Waste Scheme: Receiving Environment Monitoring Program

Sediment Quality and Aquatic Ecology, Spring 2019

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1 Introduction

1.1 Background

Sunwater is the proponent of an End of Waste Scheme (End of Waste approval ENEW07542518) involving the discharge of reverse osmosis treated coal seam water to the Dawson River within Glebe Weir pool. To comply with Condition B13 of the End of Waste approval, Sunwater have developed a Receiving Environment Monitoring Program (REMP) that includes monitoring of water, sediment and aquatic ecology in the receiving environment (i.e. Glebe Weir and connected waterways including waters of the Dawson Valley Water Supply Scheme). The REMP includes a control : impact comparison of sites upstream and downstream of the discharge point. Historical baseline data was used to develop local guidelines for water quality, sediment quality and biological indicators (i.e. macroinvertebrates and fish).

This report for Spring 2019 is the tenth REMP report on aquatic ecology since operational discharge of treated coal seam (CS) water commenced on 07 February 2015.

1.2 Scope of Works

The monitoring sites are specified in the REMP Design Report and are listed in Table 2.1. The scope of works comprises:

- twice yearly monitoring of sediment quality, aquatic habitat, macroinvertebrates and fish
- an assessment of sediment quality and aquatic ecology data against applicable guidelines, noting any trends between sites (especially control and impact sites), and
- an assessment of any potential impact the release of treated CS water has had on the condition of the aquatic ecosystem in the receiving environment.

Water quality is also assessed within the scope of the REMP on a monthly basis, with results presented in quarterly water quality reports.

2 Methods and Quality Assurance

2.1 Site Location Details

Seven sites were surveyed along the Dawson River, with six of these assessed for sediment quality (WS01, WS02, WS03, WS04, WS05 and WS06) and six assessed for aquatic ecology (WS01, WS02, WS03, WS04[1], WS06 and WS07) (Table 2.1). Five of the sites are in the receiving environment (WS03, WS04, WS05, WS06 and WS07), and two sites (WS01 and WS02) are control sites upstream of the receiving environment.

Based on the definitions in the *Dawson River Sub–basin Environmental Values and Water Quality Objectives EPP (Water) 2009* (EHP 2013a), there are three water types in the receiving environment:

- unregulated reaches of the upper Dawson River (flowing water)
- unregulated reaches of the lower Dawson River (flowing water), and
- regulated reaches of the Dawson River – freshwater lake / reservoirs (non-flowing water).

The boundary between the lower and upper Dawson River Sub-catchments is Glebe Weir, with four sites in the upper Dawson and three in the lower Dawson. However, the baseline monitoring data indicate that variation in water quality, sediment quality and biological parameters within the lower and upper Dawson River was often higher than between these two water types. Therefore, for the purpose of the REMP all flowing sections of the Dawson River within the receiving environment were considered a single water type (unregulated water) (frc environmental 2015).

2.2 Survey Timing

As a requirement of the End of Waste Approval (ENEW07542518) for the Glebe End of Waste Scheme (GEWS), and the Receiving Environment Monitoring Program (REMP) for the GEWS, sediment quality and aquatic ecology is monitored twice yearly (spring and autumn).

The Spring 2019 field survey was completed by suitably qualified persons (professional aquatic ecologists) from frc environmental between 9 – 12 September 2019.

[1] S te WS04 was added to the mon tor ng program for aquat c eco ogy n June 2019

Table 2.1 Location of aquatic ecology monitoring sites.

Regulation	Water Type	Site	Location	Latitude [a]	Longitude [a]	Water Quality [b]	Sediment Quality	Aquatic Ecology [c]
Unregulated	Upper Dawson	WS01	Dawson River at the Old Leichardt Highway crossing at Taroom	-25.644476	149.791877	✓	✓	✓
		WS02	Dawson River at Bundulla Road Crossing	-25.572372	149.864464	✓	✓	✓
	Lower Dawson	WS05	Dawson River Downstream of Glebe Weir	-25.459722	150.043889	✓	✓	–
		WS06	Dawson River Downstream of Glebe Weir	-25.453333	150.055833	✓	✓	✓
Regulated	Upper Dawson	WS03	Dawson River Upstream of Glebe Weir	-25.476944	150.008333	✓	✓	✓
		WS04	Dawson River Upstream of Glebe Weir	-25.464269	150.033529	✓	✓	✓
	Lower Dawson	WS07	Dawson River Upstream of Gyranda Weir	-25.284722	150.181389	✓	–	✓

[a] WGS84

[b] water qua ty s presented separate y n quarter y reports

[c] aquat c eco ogy nc uded f sh and macro nvertebrate survey, and assessment of aquat c hab tat (aquat c hab tat was assessed at a seven s tes)

[d] S te WS04 was added to the aquat c eco ogy program n June 2019

– s te not assessed for that parameter w th n the scope of the REMP

2.3 Rainfall and Stream Flow

Monthly rainfall data for September 2017 to September 2019 was sourced from the Bureau of Meteorology for the monitoring station at the Taroom Post Office (station number 35070).

Stream flow data was sourced from nearby Department of Natural Resources, Mines and Energy (DNRME) gauging stations to provide information regarding flow conditions in the Dawson River prior to and during the survey to aid in the interpretation of aquatic ecological data. The two stations where flow was assessed are on the Dawson River at Taroom (130302A) and at Woodleigh (130317B) (DNRME 2018).

Volumes of treated CS water discharged from the Woleebee Pump Station were compared to natural river flows at the DNRME gauging station at Taroom to assess the relative proportion of treated CS water within river flows in the receiving environment.

2.4 Sediment Quality

A single sediment sample was collected at each of the nominated sites (Table 2.1) in accordance with Department of Environment and Science's *Monitoring and Sampling Manual 2009* (DES 2018). Sediment samples were chilled for transportation to Symbio Alliance's NATA-accredited laboratory for analysis of the following metals and metalloids:

- arsenic
- boron
- chromium
- copper
- iron
- lead
- manganese
- nickel
- selenium, and
- zinc.

Metals and metalloids in the sediment were compared to the published national sediment quality guidelines (Simpson et al. 2013) and local sediment quality guidelines (frc environmental 2015).

2.5 Aquatic Habitat

Each nominated site (Table 2.1) was assessed for aquatic habitat attributes using a modified State of the Rivers survey method (Anderson 1993a; b).

A River Bioassessment Score was also calculated for these sites, except if they were dry (DNRM 2001). This score is a numerical index of aquatic habitat condition that enables a direct comparison of habitat quality between sites. Using this method, the quality of habitat is scored (from zero to twenty) for each of nine criteria:

- substrate or available cover
- embeddedness
- water velocity and depth
- channel alteration
- bed scouring and deposition
- pool:riffle and run:bend ratio
- bank stability
- bank vegetative stability, and
- streamside vegetation cover.

The score for each criterion is summed to give the overall score. This overall habitat score is then used to allocate sites to one of four categories (Table 2.2):

- excellent habitat condition (overall score >110)
- good habitat condition (overall score 75 to 110)
- moderate habitat condition (overall score 39 to 74), and
- poor habitat condition (overall score ≤38).

This method is not directly applicable to ephemeral systems in central Queensland because this method was developed for streams with perennial flow in southern Australia. Consequently, even pristine ephemeral systems are rarely classed as being in excellent condition using this method. Nonetheless it is a useful system for comparing between sites within a region.

Each site was also photographed from standard locations.

Table 2.2 Habitat bioassessment scores used to derive overall condition categories.

Habitat Category	Category Score Range			
	Excellent	**Good**	**Moderate**	**Poor**
Bed substrate or available cover	16–20	11–15	6–10	0–5
Embeddedness	16–20	11–15	6–10	0–5
Water velocity and depth	16–20	11–15	6–10	0–5
Channel alteration	12–15	8–11	4–7	0–3
Bed scouring & deposition	12–15	8–11	4–7	0–3
Pool:riffle and run:bend ratio	12–15	8–11	4–7	0–3
Bank stability	9–10	6–8	3–5	0–2
Bank vegetative stability	9–10	6–8	3–5	0–2
Streamside vegetation cover	9–10	6–8	3–5	0–2
Total Score	**111–135**	**75–110**	**39–74**	**0–38**

2.6 Fish

All available habitats (e.g. pool, riffle, run, bend, large woody debris) were fished at the nominated sites (Table 2.1) using electrofishing or seine net and box traps. Electrofishing was in accordance with the *Australian Code of Electrofishing Practice 1997*, using a Smith-Root boat 2.5 GPP electrofishing system (BEF) at sites where water was deeper than 1.0 m, and a Smith-Root LR-24 backpack electrofisher (BPEF) in shallower water (Table 2.3).

Table 2.3 Effort used to catch freshwater fish.

Site	Method	Habitat	Date In	Time In	Time Out	Settings	Effort
WS01	boat electrofishing	channel	10/09/19	16.20	16:50	50-1000 V; 4 A; 120 DC; 95%	1002 s
WS02	backpack electrofishing	channel	11/09/19	15:30	16:30	200 V; 40 Hz; 3 ms	1021 s
WS03	boat electrofishing	channel	12/09/19	13:00	14:00	50-1000 V; 5 A; 120 DC; 90%	1014 s
WS04	small bait traps (10)	channel	12/09/19	8:00	11:00	–	30 h
	boat electrofishing	channel	12/09/19	9:30	10:30	50-1000 V; 5 A; 120 DC; 90%	1003 s
WS06	backpack electrofishing	channel	11/09/19	10:00	11:00	230 V; 35 Hz; 3.4 ms	1034 s
WS07	small bait traps (10)	pool	09/09/19	14:30	16:30	–	20h
	Boat electrofishing	pool	10/09/19	8:00	10:00	50-1000 V; 4-6 A; 120 DC; 90%	1001 s

The sampling of fishes was conducted under General Fisheries Permit No. 199434 and Animal Ethics Approval No. CA 2018/08/1224 held by frc environmental.

The WQOs and local WQGs for fish are based on a ratio of the number of observed to expected native species, which should be at least 1 (i.e. O/E ≥ 1) (DERM 2011a). The number of expected species is the number of species caught on 50% or more survey events during the baseline studies for each water type.

The number of expected species of native fish in the Lower Dawson is 11, and in the Upper Dawson is 8 (DERM 2011a) (Table 2.4a). That is, to achieve the WQO for the Lower Dawson the observed number of native species is ≥ 11, and in the Upper Dawson is ≥ 8. For the local WQGs, the expected number of native fish for each site is shown in Table 2.4a.

The WQO for the number of species of exotic fish in the Dawson River is no more than 3 exotic species (DERM 2011a). The expected number of exotic fish for each site recorded during the baseline surveys is shown in Table 2.4a.

Table 2.4a Expected number of native and exotic fish species for each REMP monitoring site.

Regulation	Water Type	Site	Expected number of native species	Expected number of exotic species
Unregulated	Upper Dawson	WS01	**4**	**1**
	Upper Dawson	WS02	**2**	**1**
	Lower Dawson	WS06	**3**	**2**
	Lower Dawson	WS05	**4**	**2**
Regulated	Upper Dawson	WS03	**5**	**1**
	Upper Dawson	WS04	**3**	**1**
	Lower Dawson	WS07	**5**	**1**

Source: (frc env ronmenta 2015)

Table 2.5b Expected number of native and exotic fish species for upper and lower Dawson.

Water Type	Expected number of native species	Expected number of exotic species
Upper Dawson	6	1
Lower Dawson	5	1

Source: (frc env ronmenta 2015)

2.7 Macroinvertebrates

Macroinvertebrates were sampled at the nominated sites (Table 2.1) using a Surber sampler that had a square 0.3 m x 0.3 m frame and 250 µm mesh. At each site, five replicate samples were collected from edge habitat with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate was disturbed within the 0.3 m x 0.3 m area, and the sample collected by sweeping the net across the disturbed area.

Macroinvertebrates were identified to the lowest practical taxonomic level (in most instances family) and counted to comply with standard AUSRIVAS methods (Chessman 2003). Quality control procedures were carried out in accordance with the REMP and DES (2018).

The following indices were calculated for each site:

- abundance
- taxonomic richness
- PET richness, and
- SIGNAL-2 scores.

These indices were calculated from the average across the five samples and used to indicate the current ecological condition of the receiving environment by comparing them to the relevant local WQG (frc environmental 2015). Published biological water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in the Fitzroy Basin (DERM 2011a) (Table 2.6) were also presented but are not suitable for comparison in this survey as they apply to macroinvertebrates sampled using AUSRIVAS methods.

Table 2.6 Macroinvertebrate WQOs and Local WQGs for the Dawson River sub-catchment (upper and lower combined).

Habitat	Indicator	WQO[1]	Local WQG[2]
Unregulated Water Type (Flowing Water)			
edge	abundance	–	45.2 – 140.8
	taxonomic richness	23 – 33	9.8 – 33
	PET richness	2 – 5	1.3 – 5.0
	SIGNAL 2 score	3.31 – 4.20	3.31 – 4.20
Regulated Water Type (Lakes/ Reservoirs)			
edge	abundance	–	49.8 – 146.7
	taxonomic richness	–	6.8 – 14.1
	PET richness	–	0.4 – 3.6
	SIGNAL 2 score	–	2.9 – 3.75

1 DERM (2011a)

2 (frc env ronmenta 2015)

Abundance

Abundance is the total number of individuals. In this survey, the abundance of each family, and the overall abundance of macroinvertebrates, was assessed for each site.

Taxonomic Richness

Taxonomic richness is the number of taxa (generally families). Taxonomic richness is a basic, unambiguous and effective diversity measure. However, it is affected by arbitrary choice of sample size. Where all samples are of equal size, taxonomic richness is a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxon, so rare and common taxa are considered equally.

PET Richness

While some groups of macroinvertebrates are tolerant to pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families within sites of good habitat condition and water quality than in sites of degraded condition. PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2007). The lower the PET score (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.

SIGNAL-2 Scores

SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL-2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL-2 scores are weighted for abundance. The scores take the relative abundance of tolerant or sensitive taxa into account (instead of only the presence or absence of these taxa). The overall SIGNAL-2 score for a site is based on:

- the total of the SIGNAL grade
- multiplied by the weight factor for each taxon, and
- divided by the total of the weight factors for each taxon.

2.8 Macrocrustacean Exoskeleton Assessment

Three of the commonly occurring macroinvertebrate species (*Macrobrachium spp., Cherax* spp. and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded. The reproductive status of the specimens was also recorded.

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records of exoskeletons being robust and in good condition, and breeding (i.e. presence of eggs attached to the pleiopods of adult females) recorded in the spring and summer months.

3 Results

3.1 Rainfall

Rainfall for the six months leading up to the survey was mostly below the long-term mean monthly rainfall (except March and June 2019), overall indicating a dryer than average Winter/Spring period (Figure 3.1).

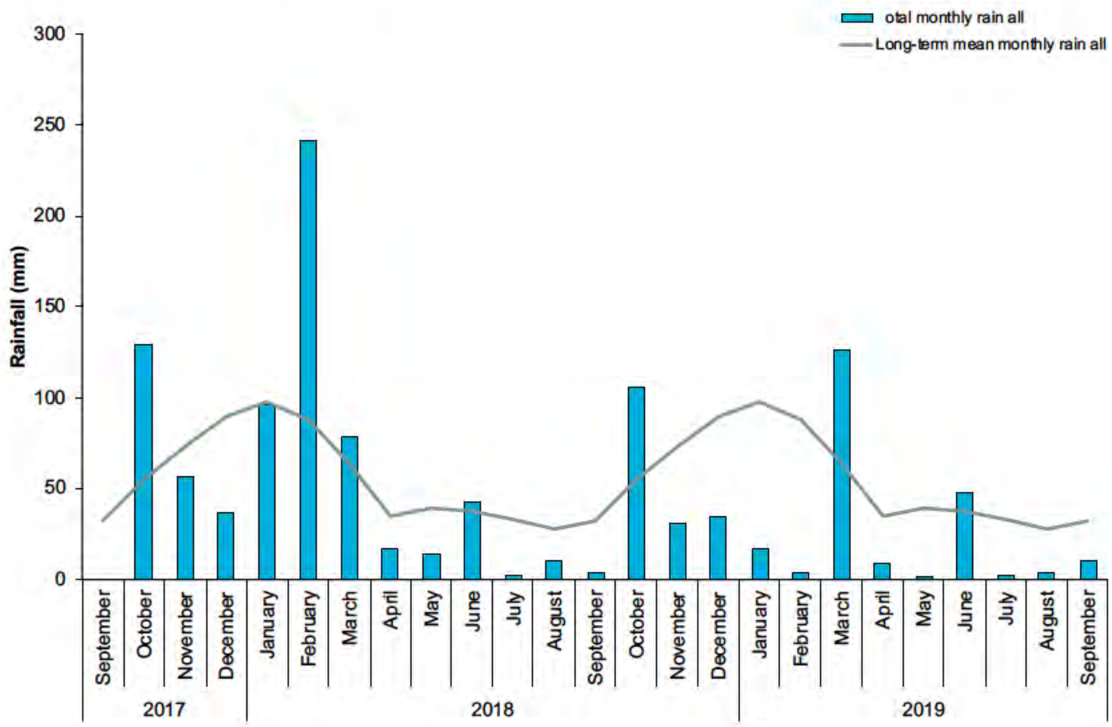

Figure 3.1 Total monthly and mean monthly rainfall (mm) at Taroom post office (station 35070) from September 2017 to September 2019.

3.2 Stream Flow

Dawson River stream flow data from gauging stations 130302A (Dawson River at Taroom) and 130317B (Dawson River at Woodleigh) is shown in Figure 3.2 and Figure 3.3, respectively (DNRM 2017). In the 12 month period, from May 2018 to April 2019, flow patterns were atypical for the region, with larger flows occurring during the spring to early summer months (September – November), coinciding with the above-average rainfall in October 2018. There was little to no rainfall during the summer period from November to February resulting in lower than average flows over the same period. Increased flow was recorded at gauging station 130302A in April 2019 following above average rainfall in March. During the survey period, from the 2nd to the 4th of April 2019, there was 4495 ML of discharge recorded in the Dawson River at the Taroom gauging station. Prior to this, there was little to no flow since December 2018. In the period between May and September 2019, below-average rainfall was exhibited in all months except June 2019, which had slightly above-average rainfall. During this period there was little to no flow recorded at gauging stations 130302A or 130317B.

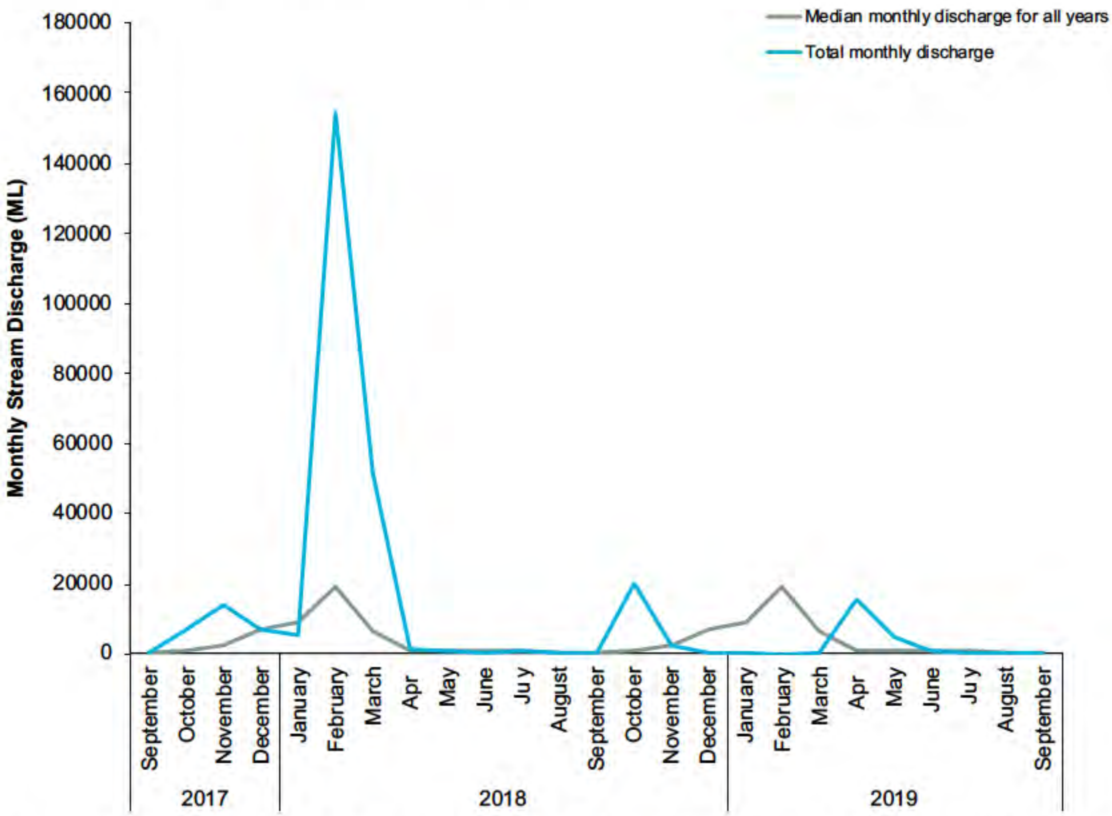

Figure 3.2 Total monthly discharge data for September 2017 – September 2019, and median monthly discharge data for all years, at gauging station 130302A (Dawson River at Taroom).

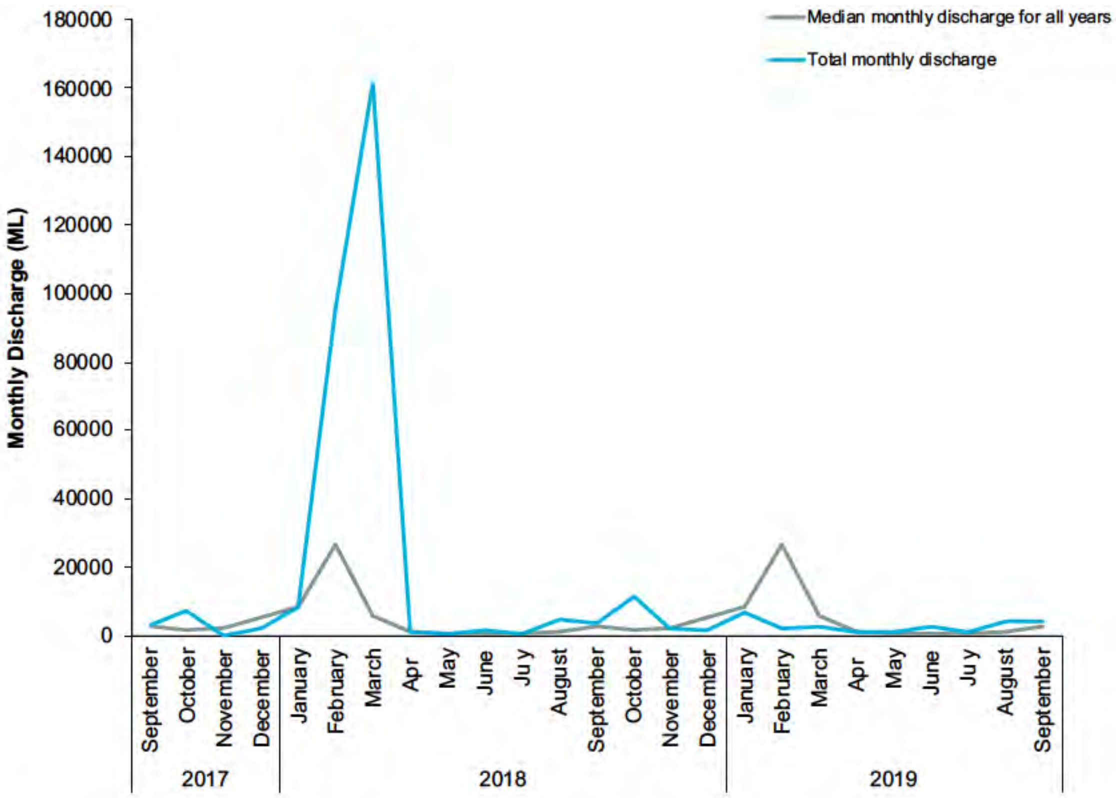

Figure 3.3 Total monthly discharge data for September 2017 – September 2019, and median monthly discharge data, for all years at gauging station 130317B (Dawson River at Woodleigh).

The volume of treated CS water released to Glebe Weir was sometimes higher than natural river flows at Taroom, however several large flow events in the Dawson River were several orders of magnitude larger than the release (Figure 3.4) (median daily release = 0 ML and maximum daily release = 97 ML; median river flow at Taroom = 15 ML and maximum river flow = 5056 ML).

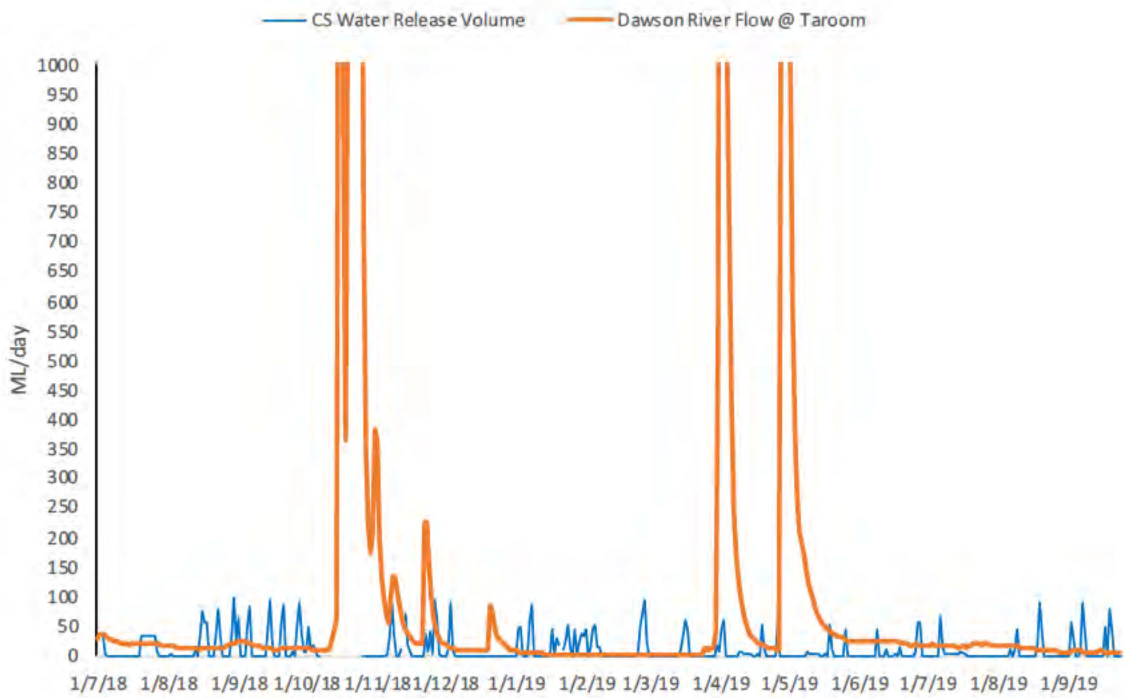

Figure 3.4 Release volumes of treated CS water from Woleebee Pump Station compared to natural river flow in the Dawson River at DNRME gauging station 130302A (Dawson River at Taroom) (note three river flow events truncated at 1000 ML/day).

3.3 Sediment Quality

The concentration of metals and metalloids in sediment was:

- above the analytical limit of reporting (LOR) for all parameters except arsenic and selenium, which were below the LOR at all sites
- above the local guideline for:
  - iron at sites WS02 and WS03, but lower than the baseline maximum (i.e. 16,800 mg/kg), and
  - manganese at sites WS02, WS03, WS05 and WS06, but lower than the baseline maximum (i.e.536 mg/kg)
- below the national and local sediment guidelines for all other parameters (Table 3.1)[1].

1 There are no pub shed sed ment qua ty gu de ne va ues for boron, ron, manganese and se en um

Table 3.1 Concentration of metals and metalloids in the sediment compared to the revised ANZECC & ARMCANZ sediment quality guidelines (Simpson et al. 2013) and local sediment quality guidelines (frc environmental 2015).

Parameter	Units	LOR	Default SQG Trigger Value	Default SQG – High	Unregulated Local SQG	WS01	WS02	WS05	WS06	Regulated Local SQG	WS03	WS04
Metals and Metalloids												
Arsenic	mg/kg	5	20	70	20	<5	<5	<5	<5	20	<5	<5
Boron	mg/kg	5	–	–	16	10.3	6.9	6.4	7.7	14.4	7.5	7
Chromium	mg/kg	1	80	370	80	4.8	5.3	5.7	4.8	80	6	5
Copper	mg/kg	1	65	270	32	10	6.7	8.5	7.6	65	9.9	8.3
Iron	mg/kg	2	–	–	10274	8280	10800	9430	8830	9703	9920	9190
Lead	mg/kg	2	50	220	50	6.5	5.7	8.2	7.9	50	7.1	6
Manganese	mg/kg	1	–	–	405	177	392	460	427	268	402	212
Nickel	mg/kg	1	21	52	21	4.8	4.4	6.2	5.2	21	6	4.6
Selenium	mg/kg	5	–	–	1	<5	<5	<5	<5	1	<5	<5
Zinc	mg/kg	5	200	410	200	33.3	22.6	26.8	23.5	200	27.8	26.4

L ght grey shad ng denotes parameters that d d not comp y w th the oca SQG. Go d shad ng denotes resu ts where LOR was h gher than SQG.

3.4 Aquatic Habitat

A detailed description of the habitat at each site is presented in Appendix A.

Aquatic habitat was generally similar to baseline conditions, with:

- substrate dominated by silt and clay at all sites, with site WS02 having a visible fraction of coarser substrate, and WS01 with notable proportion of sand
- bank stability varying between sites, with:
  - site WS05 and WS06 having unstable banks
  - sites WS02, WS03, WS04, WS05 and WS07 having banks of moderate stability
  - site WS01 having high bank stability
- physical habitat at all sites comprising:
  - varying degrees of depth variation of water
  - large woody debris at all sites
  - low to moderate diversity and cover of aquatic plants in water, and
  - limited aquatic plants adjacent to water at both regulated and unregulated water types.

River bioassessment scores were similar to the baseline surveys, with temporal differences at a site generally related to differences in water levels. Sites with overall lower scores were typically had low substrate type diversity, low water level and existing disturbances. In September 2019, sites WS01, WS03 and WS04 had moderate habitat bioassessment scores. Sites WS05, WS06 and WS07 had poor habitat assessment scores, while site WS02 had a good habitat bioassessment score.

The groundwater seep at site WS05 that was consistently recorded during the baseline program was visible in September 2019.

Table 3.2 River Bioassessment Scores for each site in September 2019.

Site	Location	River Bioassessment Score
WS01	Dawson River at the Old Leichhardt Highway crossing at Taroom	74 (Moderate)
WS02	Dawson River at Bundulla Road Crossing	79 (Good)
WS03	Dawson River Upstream of Glebe Weir	44 (Moderate)
WS04	Dawson River Upstream of Glebe Weir	40 (Moderate)
WS05	Dawson River Downstream of Glebe Weir	25 (Poor)
WS06	Dawson River Downstream of Glebe Weir	36 (Poor)
WS07	Dawson River Upstream of Gyranda Weir	38 (Poor)

3.5 Fish

Thirteen native and two exotic fish species were caught across all sites in September 2019 (Table 3.3). All species recorded in the September 2019 survey were reported in the baseline surveys. A total of nine native species were caught at site WS07 and between five and seven native species caught at each of the other sites. Total abundance of native fish ranged from twelve at site WS02 to 396 at site WS07. The most commonly caught native species was bony bream (*Nematalosa erebi*) and then carp gudgeon (*Hypseleotris spp.*). One southern saratoga (*Scleropages leichardti*) was caught at site WS01, and one at site WS07. All fish caught were in good condition, except for one bony bream caught at site WS03 which had lesions on its caudal fin.

The pest fish eastern gambusia (*Gambusia holbrooki*) was present at sites WS01, WS02 and WS06. Additionally, the common goldfish (*Carassius auratus*) was caught at site WS07. Eastern gambusia (*G. holbrooki*) is a restricted biosecurity matter under the *Biosecurity Act 2014*.

Upper and Lower Dawson

The number of observed native species was higher than the number of expected native species at all sites when compared with the local WQG. However, the number of observed native species was lower than the expected native species when compared with the published WQOs at all sites (Table 3.4).

Regulated and Unregulated Reaches

The native fish community was equally diverse in the unregulated and regulated water types, with eleven native species caught in each type. All sites were higher than the local WQG, with sites WS02 and WS07 having double, and more than double the number of expected species, respectively (Table 3.4).

The local WQG for exotic fish species was met at all sites (Table 3.3). The pest species, eastern Gambusia, was caught at sites WS01, WS02 and WS02 (unregulated water types only). The published WQO for pest fish was not exceeded.

Table 3.3 Total abundance of freshwater fish for each species at each site in September 2019.

Species Name	Common name	Unregulated			Regulated			Total
		Upper Dawson		Lower Dawson	Upper Dawson		Lower Dawson	
		WS01	WS02	WS06	WS03	WS04	WS07	
Native species								
Ambassis agassizii	Agassiz's glassfish	1	1	0	4	50	29	85
Amniataba percoides	barred grunter	0	1	0	1	0	15	17
Hypseleotris spp.	carp gudgeon	20	8	27	28	36	47	166
Leiopotherapon unicolor	spangled perch	0	1	0	0	0	2	3
Macquaria ambigua	yellow belly	1	0	0	5	0	0	6
Melanotaenia splendida splendida	eastern rainbowfish	0	0	1	14	19	42	76
Nematalosa erebi	bony bream	0	0	13	247	45	206	511
Neosilurus hyrtlii	Hyrtl's catfish	0	0	1	0	0	0	1
Oxyeleotris lineolata	sleepy cod	5	0	5	0	1	16	27
Philypnodon grandiceps	flathead gudgeon	0	0	0	1	0	0	1
Scleropages leichardti	southern saratoga	1	0	0	0	0	1	2
Tandanus tandanus	freshwater catfish	1	1	0	0	0	0	2
Craterocephalus stercusmuscarum	flyspecked hardyhead	0	0	0	0	0	38	38
Total abundance of native species		**29**	**12**	**47**	**300**	**151**	**396**	**935**
Expected number of native species		**4**	**2**	**3**	**5**	**3**	**4**	

Species Name	Common name	Unregulated			Regulated			Total
		Upper Dawson		Lower Dawson	Upper Dawson		Lower Dawson	
		WS01	WS02	WS06	WS03	WS04	WS07	
Number of native species		6	5	5	7	5	9	13
Exotic species								
Gambusia holbrooki	eastern gambusia	22	2	4	0	0	0	28
Carassius auratus	goldfish	0	0	0	0	0	1	1
Total abundance of exotic species		**22**	**2**	4	**0**	**0**	**1**	**29**
Expected number of exotic species		**1**	**1**	**2**	**1**	**1**	**1**	
Number of exotic species		**1**	**1**	**1**	**0**	**0**	**1**	**2**

grey shad ng denotes s tes where the number of nat ve spec es s be ow expected

Table 3.4 Ratio of observed/expected native fish in September 2019 for each site.

Regulation	Location	Site	Published WQO	Local WQG	Number of Native Species Observed	O/E (Published WQO)	O/E (Local WQG)
Unregulated	Upper Dawson	WS01	8	≥ 4	6	0.75	1.5
	Upper Dawson	WS02	8	≥ 2	5	0.625	2.5
	Lower Dawson	WS06	11	≥ 3	5	0.45	1.67
Regulated	Upper Dawson	WS03	8	≥ 5	7	0.875	1.4
	Upper Dawson	WS04	8	≥ 3	5	0.625	1.67
	Lower Dawson	WS07	11	≥ 4	9	0.82	2.25

3.6 Macroinvertebrates

The mean abundance of macroinvertebrates ranged from 61.2 (WS04) to 222.0 (WS02), and was within or above the local WQG range at all sites (Table 3.5), and was within the baseline range (Appendix B) at all sites.

The mean taxonomic richness of macroinvertebrates in edge habitat ranged from 5.2 (WS04) to 17.4 (WS01), and was below the local WQG range at sites WS03 and WS04 (Table 3.5). However, taxonomic richness was within the baseline range (Appendix B) at all sites.

Mean PET richness in the edge habitat ranged from 0.6 (WS03 and WS04) to 3.6 (WS07), and was within the local WQG range at all sites (Table 3.5).

SIGNAL-2 scores ranged from 3.18 (WS06) to 3.73 (WS02), and were within the local WQG range at all sites except WS06 which was lower than the local WQG range (Table 3.5). However, all SIGNAL-2 scores were within the baseline range (Appendix B).

3.7 Macrocrustacean Exoskeleton Assessment

The following macrocrustaceans were caught:

- *Macrobrachium australiense* (freshwater prawn): caught at all sites
- *Cherax sp*. (crayfish): caught at site WS02
- *Caridina* spp. (freshwater shrimp): caught at sites WS01 and WS07.

The exoskeleton of all individuals was of same apparent colour, thickness and robustness as recorded for macrocrustaceans on the baseline surveys.

Table 3.5 Mean abundance, taxonomic richness, PET richness and SIGNAL-2 scores in edge habitat for all sites in September 2019.

Water Type	Reach	Site	WQO	Abundance	Taxonomic Richness	PET Richness	SIGNAL-2
Unregulated			**WQO [a]**	**–**	**23 – 33**	**2 – 5**	**3.31 – 4.2**
			Local WQG [b]	**45.2 – 140.8**	**9.8 – 33**	**1.3 – 5**	**3.31 – 4.2**
	Upper Dawson	WS01		168.2	17.4	3.4	3.71
		WS02		222.0	14.2	3.0	3.75
	Lower Dawson	WS06		94.8	11.2	1.4	3.18
Regulated			**WQO [a]**	**–**	**23 – 33**	**2 – 5**	**3.31 – 4.2**
			Local WQG [b]	**49.8 – 146.7**	**6.8 – 14.1**	**0.4 – 3.6**	**2.9 – 3.75**
	Upper Dawson	WS03		72.4	5.4	0.6	3.53
		WS04		61.2	5.2	0.6	3.40
	Lower Dawson	WS07		203.0	13.0	3.6	3.66

[a] macro nvertebrate water qua ty object ves for Dawson R ver sub-catchment (DERM 2011a); su tab e for compar son on y w th AUSRIVAS samp ng

[b] macro nvertebrate water qua ty object ves for the GBUS (frc env ronmenta 2015).

grey shad ng nd cates where the average for a g ven ndex was be ow the oca WQG range

b ue shad ng nd cates where the average for a g ven ndex was above the oca WQG range

4 Impact Assessment

The concentration of iron in sediment was higher than the local SQG at sites WS02 and WS03, but was lower than the baseline maximum concentration at all sites. Thus all sites, had iron concentrations that were consistent with ambient baseline conditions.

The concentration of manganese in sediment at site WS02, WS03, WS05 and WS06 was higher than the local SQG, but lower than the baseline maximum, indicating the recorded concentration of manganese in sediment at this site is consistent with ambient baseline conditions.

The aquatic habitat characteristics at all sites in September 2019 were similar to baseline conditions, with sites WS01, WS02, WS03 and WS04 being of moderate to good condition. Sites WS05, WS06 and WS07 were characterised as being in poor condition, however the factors driving this were seasonal low water levels and low flow regimes, suggesting there was no apparent impact to aquatic habitat condition in the receiving environment due to the release of treated CS water.

Native fish communities were more diverse than expected by the local WQG for native fish at all sites, and the diversity of exotic fish was equal to or lower than expected at all sites. All native fish caught were in good condition, except for one bony bream caught at WS03 which had lesions on its caudal fin. There was no apparent impact to the fish community due to the release of treated CS water.

All macroinvertebrate indices were within or higher than the local WQG range, except taxonomic richness scores at WS03 and WS04, and Signal-2 Scores at site WS06, which was consistent with baseline range. The results do not indicate an impact in the receiving environment due to the release of treated CS water.

Overall, there was no evidence of impact from the release of treated CS water to aquatic habitat condition, sediment quality, fish communities or macroinvertebrates in the Dawson River.

5 References

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Appendix A Site Habitat Summary Sheets

Site	WS01 Old Leichhardt Highway Bridge Taroom	**Region**	Upper Dawson River Sub-Basin
Reach	Upstream of Receiving Environment	**Water Type**	Unregulated
Date surveyed	09 September 2019	**Habitat Bioassessment Score**	74 (out of 135; moderate)

Downstream view

Upstream view

Channel Morphology	
Stream order	7
Pattern	mildly sinuous
Bank stability	high
Bank shape	moderate/convex; moderate/convex

Hydrology	
Flow regime	perennial
Water depth	2.5 m
Wetted width	20 m
Flow	moderate (0.01m/s)
Channel width	30 m

Substrate		
Composition	bedrock	0%
	boulder	0%
	cobble	0%
	pebble	0%
	gravel	0%
	sand	10%
	silt / clay	90%
Deposits	Silt and sand	
Bed stability	Bed stable	

Aquatic Habitat	
Habitat diversity	moderate
Habitat present	deep pool
	large woody debris
	macrophytes

In-stream disturbance	
Flow modification	downstream causeway
Waterway barrier	downstream causeway and weir

Riparian Zone	
Riparian width	10-15 m
Disturbance	moderate
Dominant species	eucalypt
	melaleuca
Weed species	Parthenium, yellow flower
Adjacent land use	Native forest
	Residential/native vegetation

Comments:	Site is in a mildly sinuous channel, with a high water level and slow flowing, relatively clear water. There were several different species of aquatic plants on the left bank downstream and right bank upstream. Eucalyptus, melaleuca and grasses were extensive on banks. Area past both banks cleared. Two bridges over the river and large woody debris downstream from old bridge.

Site	WS02 Bundulla Crossing	**Region**	Upper Dawson River Sub-Basin
Reach	Upstream of Receiving Environment	**Water Type**	Unregulated
Date surveyed	11 September 2019	**Habitat Bioassessment Score**	79 (out of 135; good)

Downstream view

Upstream view

Channel Morphology

Stream order	7
Pattern	mildly sinuous
Bank stability	moderate
Bank shape	flat/convex; low/convex

Hydrology

Flow regime	perennial
Water depth	0.5 m
Wetted width	8 m
Flow	moderate (0.02 m/s)
Channel width	20 m

Substrate

Composition	bedrock	0%
	boulder	0%
	cobble	2%
	pebble	5%
	gravel	10%
	sand	20%
	silt / clay	63%
Deposits	Silt and sand	
Bed stability	Bed stable	

Aquatic Habitat

Habitat diversity	moderate
Habitat present	macrophytes
	shallow
	large woody debris

In-stream disturbance

Flow modification	Weir downstream
Waterway barrier	bridge (partial barrier)

Riparian Zone

Riparian width	4-5 m
Disturbance	high
Dominant species	Eucalypt
	Melaleuca
Weed species	Grasses, mex. poppy
Adjacent land use	Native vegetation
	Grazing
	road

Comments: Site is in a mildly sinuous channel, with low water level. Water has moderate flow rate, with clear water upstream of bridge. Evidence of periods of high flow. Fallen tree downstream across 75% of creek. Trees in creek both up and down stream. Build-up of branches (small) on upstream side of bridge. Grasses and trees on banks and some lignum. Most of immediate bank vegetated. Evidence of cattle access to water.

Site	WS03 Glebe Weir Pool upstream	**Region**	Upper Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Regulated
Date surveyed:	12 September 2019	**Habitat Bioassessment Score**	44 (out of 135; moderate)

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	2-2 m
Pattern	straight		boulder	0%	**Habitat present**	deep pool	**Disturbance**	Very high disturbance
Bank stability	moderate		cobble	0%		large woody debris	**Dominant species**	Eucalypt
Bank shape	moderate/convex;		pebble	0%				
	low/convex							
Hydrology			gravel	0%			**Weed species**	
Flow regime	perennial		sand	0%	**In-stream disturbance**			
Water depth	4 m		silt / clay	100%	**Flow modification**	weir downstream	**Adjacent land use**	grazing
Wetted width	50 m	**Deposits**	silt		**Waterway barrier**	weir downstream		Native vegetation
Flow	low (0.01m/s)	**Bed stability**	Bed stable					
Channel width	200 m							

Comments:	Site is located upstream of weir in a straight channel, with water only occupying the left hand side of the channel. Water level was moderate low flow and was very turbid. There were dead trees in the stream from the middle of the river to the right bank and some scattered on the left bank. Eucalypts were extensive on the left and right bank. There was also *Juncus sp.* as the only riparian aquatic plant species, with a lot of bare ground on banks. Evidence of cattle accessing low water line.

Site	WS04 Glebe Weir Pool at boat ramp	**Region**	Upper Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Regulated
Date surveyed	12 September 2019	**Habitat Bioassessment Score**	40 (out of 135; moderate)

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	3-5 m
Pattern	straight		boulder	0%	**Habitat present**	shallow pool	**Disturbance**	very high
Bank stability	moderate		cobble	0%			**Dominant species**	eucalypt
Bank shape	low/convex; low-flat/convex		pebble	0%				
Hydrology			gravel	0%			**Weed species**	
Flow regime	perennial		sand	2%				
Water depth	0.5 m		silt / clay	98%	**In-stream disturbance**			
Wetted width	80 m	**Deposits**	silt		**Flow modification**	weir (at site)	**Adjacent land use**	camp ground - recreation
Flow	slow (0.1m/s)	**Bed stability**	Bed stable		**Waterway barrier**	weir (at site)		grazing
Channel width	250 m							native vegetation

Comments: Site is located in a straight channel. Water level was very low and weir was releasing water. Contours of the river bed were visible. Water was very turbid with slow flow. Width of riparian vegetation was very short, and there was low species diversity of aquatic plants. Riparian zone is moderately dense, but quickly becomes cleared land.

Site	WS05	**Region**	Lower Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Unregulated
Date surveyed:	11 September 2019	**Habitat Bioassessment Score**	25 (out of 135; poor)

Downstream view

Upstream view

Channel Morphology	
Stream order	7
Pattern	irregular meander
Bank stability	low
Bank shape	vertical/concave; Moderate convex

Hydrology	
Flow regime	perennial
Water depth	1.5 m
Wetted width	15 m
Flow	moderate (0.1 m/s)
Channel width	20 m

Substrate		
Composition	bedrock	0%
	boulder	0%
	cobble	0%
	pebble	0%
	gravel	0%
	sand	2%
	silt / clay	98%
Deposits	silt	
Bed stability	Severe erosion	

Aquatic Habitat	
Habitat diversity	low
Habitat present	deep
	large woody debris

In-stream disturbance	
Flow modification	weir (0.5 km upstream)
Waterway barrier	weir (0.5 km upstream)

Riparian Zone	
Riparian width	1-5 m
Disturbance	Moderate
Dominant species	Eucalypt
	lomandra
Weed species	
Adjacent land use	grazing
	native forest

Comments: Site is located in an irregular meandering channel. Water level moderate with moderate flow rates due to release upstream. Water column very turbid. Left bank heavily eroded for a 50 m stretch, with roots of trees exposed and deposits of fallen dead trees. Very little vegetation on left bank. More grasses and some aquatic plants on right bank. Grasses, *Lomandra* and eucalypts on banks. Left bank has washouts from run-off, as well as leeching present.

Site	WS06 Dawson downstream Glebe	**Region**	Lower Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Unregulated
Date surveyed:	11 September 2019	**Habitat Bioassessment Score**	36 (out of 135; poor)

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	7	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	2-2 m
Pattern	Mildly sinuous		boulder	0%	**Habitat present**	deep	**Disturbance**	high
Bank stability	low		cobble	0%		large woody debris	**Dominant species**	eucalypt
Bank shape	Moderate/concave; steep/convex-concave		pebble	0%				
Hydrology			gravel	0%				
Flow regime	perennial		sand	0%			**Weed species**	grasses
Water depth	1 m		silt / clay	100%	**In-stream disturbance**			
Wetted width	25 m	**Deposits**	silt		**Flow modification**	downstream of Glebe Weir	**Adjacent land use**	native forest
Flow	Slow flow (0.01 m/s)	**Bed stability**	Moderate erosion		**Waterway barrier**	nil		grazing
Channel width	30 m							native vegetation
Comments:	Site is located in a mildly sinuous channel, with moderate water level and slow flow. Water very turbid. Large amounts of cattle tracks and severe erosion on left bank, with fallen trees in the creek. Very few aquatic plants on the left bank, with the right bank being slightly more vegetated. Evidence of washouts.							

Site	WS07 Gyranda Weir	**Region**	Lower Dawson River Sub-Basin
Reach	Receiving Environment	**Water Type**	Regulated
Date surveyed:	9 September 2019	**Habitat Bioassessment Score**	38 (out of 135; poor)

Downstream view

Upstream view

Channel Morphology	
Stream order	7
Pattern	mildly sinuous
Bank stability	moderate
Bank shape	moderate/concave; low/convex

Hydrology	
Flow regime	intermittent
Water depth	1.5 m
Wetted width	100 m
Flow	slow (<0.01 m/s)
Channel width	130 m

Substrate		
Composition	bedrock	0%
	boulder	0%
	cobble	0%
	pebble	0%
	gravel	2%
	sand	8%
	silt / clay	90%
Deposits	silt	
Bed stability	moderate aggradation	

Aquatic Habitat	
Habitat diversity	moderate
Habitat present	deep pool
	large woody debris
	macrophytes

In-stream disturbance	
Flow modification	Weir (at site)
Waterway barrier	Weir (at site)

Riparian Zone	
Riparian width	20-10 m
Disturbance	high
Dominant species	eucalypt
Weed species	grasses
	Mexican poppy, daisy
Adjacent land use	grazing

Comments: Site is situated at a weir. The weir was dry and water not overtopping. Weir was discharging at time of survey. Slow water flow and water turbid. Eucalypts extensive on both banks. Persicaria extensive on left bank, but mostly dead. Evidence of cattle present on both banks. Large woody debris in the form of dead trees in channel.

Appendix B Macroinvertebrate Indices Baseline Range

The baseline range of the macroinvertebrate indices is presented in Table B1.

Table B1. Macroinvertebrate indices baseline range

Index	**Regulated Water**		**Unregulated Water**	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Abundance	26.7	506.8	34.7	624
Taxonomic Richness	5.1	17.4	5.9	23.9
PET Richness	0.0	5.1	0.7	4.9
SIGNAL-2 Score	2.5	4.2	3.0	4.3