Central Queensland Coal Project

Chapter 15 – Aquatic Ecology

Environmental Impact Statement

CDM Smith

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Central Queensland Coal Project

Chapter 15 – Aquatic Ecology

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15 Aquatic Ecology

This chapter describes the existing aquatic flora and fauna values within and surrounding the Central Queensland Coal Project, as defined by the boundary of the Central Queensland Coal Mine Lease 80187 (mine ML) and the adjacent ML 700022 on which the train load out facility (TLF) is located (herein referred to as the Project area). The assessment is based on desktop literature reviews of existing background information and site-specific field assessments.

The investigation focuses on habitats within the Project area and wider surrounds, and targets threatened species where necessary. Survey sites were selected in representative locations across the wider area and encompassed the variety of aquatic habitat types present. The Project area together with additional sites visited surrounding the Project area represent the ecological Study area, as referred to in this chapter.

The following chapter assesses the likely impacts of the Project on terrestrial and aquatic flora and fauna Environmental Values (EVs). This chapter collates the results of several ecological technical reports (refer Appendix A9e – Aquatic Ecology Results and A9f – Stygofauna Results) and provides the results of an updated desktop review and an additional site survey. Note that Appendix A9f – Stygofauna Results references the original proponent; Styx Coal Pty Ltd, and the original Project name, Styx Coal Mine Project; however, the Central Queensland Coal Pty Ltd is the new Proponent for the Project and the Project has been renamed as Central Queensland Coal Project to better reflect the change of Proponent. This proponent and title change does not affect the technical studies.

Specific objectives of the aquatic ecology assessment were to:

- Review the relevant background information including databases, mapping and literature;
- Confirm the likely presence / absence of aquatic flora and fauna (and associated habitats) listed under Queensland's *Nature Conservation Act 1992* (NC Act) and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- Characterise the main flow channels associated with the Project area and allow the identification of priority monitoring areas;
- Assess the potential for stygofauna (aquatic groundwater invertebrates) to occur within the Study area;
- Discuss potential direct and indirect impacts to terrestrial and aquatic ecological values as a result of the Project; and
- Propose mitigation measures to protect or enhance aquatic ecological values within the Project area.

The Project's impacts on Matters of National Environmental Significance (MNES) as listed under the EPBC Act are addressed in detail in Chapter 16 - MNES.

15.1 Project Overview

The Project is located 130 km northwest of Rockhampton in the Styx Coal Basin in Central Queensland. The Project will be located within Mining Lease (ML) 80187 and ML 700022, which are adjacent to Mineral Development Licence (MDL) 468 and Exploration Permit for Coal (EPC) 1029, both of which are held by the Proponent.

The Project will involve mining a maximum combined tonnage of up to 10 million tonnes per annum (Mtpa) of semi-soft coking coal (SSCC) and high grade thermal coal (HGTC). Development of the

Project is expected to commence in 2018 and extend for approximately 20 years until the current reserve is depleted.

The Project consists of three open cut operations that will be mined using a truck and shovel methodology. The run-of-mine (ROM) coal will ramp up to approximately 2 Mtpa during Stage 1 (Year 1-4), where coal will be crushed, screened and washed to SSCC grade with an estimate 80% yield. Stage 2 of the Project (Year 4-20) will include further processing of up to an additional 4 Mtpa ROM coal within another coal handling and preparation plant (CHPP) to SSCC and up to 4 Mtpa of HGTC with an estimated 95% yield. At full production two CHPPs, one servicing Open Cut 1 and the other servicing Open Cut 2 and 4, will be in operation.

A new train loadout facility (TLF) will be developed to connect into the existing Queensland Rail North Coast Rail Line. This connection will allow the product coal to be transported to the established coal loading infrastructure at the Dalrymple Bay Coal Terminal (DBCT).

The Project is located within the Livingstone Shire Council (LSC) Local Government Area (LGA). The Project is generally located on the "Mamelon" property, described as real property Lot 11 on MC23, Lot 10 on MC493 and Lot 9 on MC496. The TLF is located on the "Strathmuir" property, described as real property Lot 9 on MC230. A small section of the haul road to the TLF is located on the "Brussels" property described as real property Lot 85 on SP164785.

15.2 Relevant Legislation and Policies

Environmental protection of existing terrestrial wildlife and habitats is governed by several legislative Acts, policies and guidelines which are described in Chapter 1 - Introduction. Those with relevance to terrestrial and aquatic values are outlined below.

15.2.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act regulates activities that may have an impact upon MNES. The Project has the potential to impact upon MNES including listed threatened species, communities and migratory birds and, therefore has been designated as a Controlled Action under the Act. This chapter does not assess the potential impacts on MNES as prescribed under the EPBC Act. As per the Project ToR impacts to MNES are described separately within Chapter 16 – MNES, within this EIS.

15.2.2 Nature Conservation Act 1992

The NC Act provides for the protection and management of native wildlife and habitat that supports native species with particular regard to:

- The clearing of plants protected under the NC Act;
- Activities that may cause disturbance (that is tamper, damage, destroy, mark, move or dig up) to animal breeding places; and
- The taking of fauna.

Subordinate legislation lists protected species and areas to which the regulatory provisions of the NC Act apply including:

- *Nature Conservation (Wildlife) Regulation 2006*: this Regulation lists terrestrial and aquatic plant and animal species presumed extinct, endangered, vulnerable, rare, common, international or prohibited. It recommends management objectives for the protection and maintenance of these species in Queensland, as appropriate; and
- *Nature Conservation (Protected Plants) Conservation Plan 2000*: this Plan provides protection and management of native flora.

15.2.3 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) and subordinate legislation provide regulatory provisions for the protection and management of EVs in relation to mining activities.

15.2.3.1 Environmental Protection (Water) Policy 2009

The EP Act also regulates wetlands in wetland management areas under the subordinate environmental protection policy (EPPs) including the *Environmental Protection (Water) Policy 2009* (EPP (Water)). The EPP (Water) establishes a process for identifying EVs to be protected and states standards for water quality in support of those values. The EPP (Water) provides a framework for:

- Identifying EVs and management goals for Queensland waters;
- Stating water quality guidelines and objectives (WQOs) to protect or enhance the EVs;
- Providing a framework for making consistent, equitable and informed decisions about Queensland waters; and
- Monitoring and reporting on the condition of Queensland waters.

Section 7 of the EPP (Water) specifies the hierarchy of guidelines that are used, to identify water quality objectives in aquatic habitats. The hierarchy (in the order of use) of water quality guidelines for the Project are:

- Queensland Water Quality Guidelines (QWQG) (DERM, 2009a); and
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (herein referred to as the ANZECC guidelines).

The Project is located within the Styx River Basin and EVs / WQOs for the area are detailed in the Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives (EHP, 2014).

15.2.4 Environmental Offsets Act 2014

The *Environmental Offsets Act 2014* (EO Act), Environmental Offsets Regulation 2014 and the Queensland Government Environmental Offsets Policy provides a streamlined framework for environmental offset requirements. Offsets are required where there is an unavoidable impact on significant EVs. In addition, an environmental offset can only be required if impacts from a prescribed activity constitute a significant residual impact as identified through the following guidelines:

- The State guideline that provides guidance on what constitutes a significant residual impact for Matters of State Environmental Significance (MSES);
- The Commonwealth Significant Impact Guidelines for what constitutes a significant residual impact on MNES; and
- Any relevant local government significant impact guideline for Matters of Local Environmental Significance (MLES).

To avoid duplication with offsets required under the EPBC Act, the policy provides that the administering agency must consider other relevant offset conditions which for the same or substantially the same prescribed impact. If duplicating conditions are imposed it allows the proponent to remove the duplication.

15.2.5 Fisheries Act 1994

The *Fisheries Act 1994* (Fisheries Act) provides for the management, protection and conservation of fisheries and fish habitat. Mine developments are required to comply with the Act and minimise impacts to areas of fish habitat which are defined under the Act as: 'Areas of water, land and plants that are associated with the lifecycle of a fish, including those not presently occupied by fish'. Declared fish habitat areas provide long term protection for fish habitats which are deemed essential for sustaining fisheries. Fish habitat areas are protected from physical disturbance and under the Act.

15.2.6 Biosecurity Act 2014

The *Biosecurity Act 2014* (Biosecurity Act) provides legislative measures to manage pests and weeds, diseases and environmental contaminants, to address the impacts they have on the economy, environment, agriculture, tourism and society. The Act commenced on 1 July 2016 and supersedes a range of separate legislative implements previously used to manage biosecurity. This includes the *Land Protection (Pest and Stock Route Management) Act 2002* which previously provided legislative measures to manage damaging pests and weed species.

The Act provides statutory powers to prohibit or restrict the introduction and spread of declared plant and animal pests within Queensland. Weeds and pests pose one of the most significant threats to flora and fauna and agriculture within the study area. Accordingly, a range of management measures will be implemented to restrict the introduction and / or spread of pest species as a means of protecting the viability of local cattle grazing activity.

15.2.7 Planning Act 2016

The *Planning Act 2016* (Planning Act) establishes a new planning system for the state and replaces the *Sustainable Planning Act 2009* (SP Act). The Act provides a planning framework and development assessment system for Queensland. The *Planning Regulation 2017* (Planning Regulation) commenced on the 3 July 2017. Similar to the *Sustainable Planning Regulation 2009,* the Planning Regulation gives effect to a suite of supporting instruments such as the *State Planning Policy 2017* (SPP).

The SPP is a statutory instrument prepared under the Planning Act that relates to matters of Queensland interest. The SPP applies to a range of circumstances under the Planning Act, including for development assessment and when proposed new planning schemes are made or amended. The SPP is applicable to assessable development within Queensland.

The provisions of the SPP may also be considered under the standard criteria of the EP Act which includes ecological matters of State interest including:

- Biodiversity - MSES - Regulated vegetation and MSES - Regulated vegetation (intersecting a watercourse) and waterway barriers; and
- Water Quality - Climatic regions - stormwater management design objectives.

The Act also provides direction for the management of wetlands. The SP Regulation identifies areas designated as 'wetland protection areas' to be protected during operational works development.

In relation to additional ecologically related approvals, Section 4A of the *Mineral Resources Act 1989* precludes the application of the Plannign Act to activities undertaken for purposes of the mining tenure where those activities occur within the mining lease.

15.3 Environmental Objectives and Performance Outcomes

In accordance with the EP Act (Section 125), generally there are three key areas to be identified and addressed through the Environmentally Relevant Activity (ERA) application process regarding land and the associated ecological values:

- Identify the EVs of the site, including any significant flora and fauna associated with the land;
- Identify the possible impacts due to the proposed activity and all associated risks to the EVs; and
- Identify the strategies to mitigate the identified risks to the EVs.

Performance outcomes for the related aquatic EVs identified within the Project area include:

- Activities that disturb land, soils, subsoils, landforms and associated flora and fauna will be managed in a way that prevents or minimises adverse effects on the aquatic EVs of the area including downstream;
- Areas disturbed by Project activities will be rehabilitated to achieve sites that are stable, safe to wildlife and able to sustain an appropriate land use for EVs; and
- The activity will be managed to prevent or minimise adverse effects on the environmental values of land and water due to unplanned releases or discharges.

Any EA applications that have the potential to impact land must describe how environmental objective and performance outcomes for the ERA will be achieved.

The EPP (Water) provides a framework for:

- Identifying EVs and management goals for Queensland waters;
- Stating water quality guidelines and objectives (WQOs) to protect or enhance the EVs;
- Providing a framework for making consistent, equitable and informed decisions about Queensland waters; and
- Monitoring and reporting on the condition of Queensland waters.

15.4 Nomenclature

Flora nomenclature within this chapter follows taxonomy accepted by the Queensland Herbarium and Queensland Museum. Fauna nomenclature follows the Birdlife Australia Rarities Committee checklist (for birds), *The field guide to the freshwater fishes of Australia* (Allen et al. 2003) (for fish) and EHP's WildNet database taxonomy (for all other fauna), unless otherwise noted. All flora and fauna in this chapter will be referred to initially by both their common and scientific names and then for ease of reading only by the common name.

15.5 Study Methodology

The methodology for the terrestrial and aquatic ecology assessment and stygofauna assessment involved a combination of desktop and field based assessment methods, including:

- A desktop review of relevant literature, published ecological studies and Commonwealth and State databases. The desktop review specifically identified suitable vegetation communities to support aquatic fauna and flora species which may exist within the Project area, and the potential presence of stygofauna within the Project area. Stygofauna were targeted as these species live underground in aquifers which have the potential to be impacted by mining operations;
- Two field surveys to assess and confirm the presence of aquatic species and habitat values present in the Project area and surrounds; and
- Groundwater sampling to confirm the presence, or potential presence, of stygofauna within impacted aquifers.

15.5.1 Desktop Review

15.5.1.1 Aquatic Ecology Desktop Review

Desktop studies were undertaken prior to field assessments. The desktop review was used to obtain background information relating to the potential presence and distribution of species and ecological communities (including connectivity across the regional landscape), particularly those listed under the VM Act and NC Act. Desktop studies involved database searches and review of:

- Current RE mapping (V10.0 - Queensland Herbarium 2015);
- Commonwealth EPBC Act Protected Matters Search Tool [Department of the Environment and Energy (DotEE)] (to confirm current legislative status of listed species);

- EHP's WildNet (Wildlife Online) database results;
- Mapping for MSES and Aquatic Conservation Assessment (EHP);
- Wetland and watercourse GIS data (EHP and Geoscience Australia);
- Styx River Catchment Aquatic Baseline Monitoring Program, Waratah Coal Mine Project (ALS Water Resources Group 2011); and
- Draft Stygofauna Survey. Report for Styx Coal South Project EM Plan (GHD Water Sciences July 2012).

Database searches were undertaken over a 50 km radius for State databases and 25 km radius for Commonwealth databases using the central portion of the Project area as a reference point. The EPBC protected matters search tool, whilst based on some species records, primarily relies on modelling of suitable habitats (with mapped boundary constraints accounted for) and is largely a predictive tool. As such, given the site's location (close to the coast) a smaller search radius was used for the search tool in order to avoid the inclusion of marine / coastal species not applicable to the Project area.

Wildlife Online database records are based on records of species from a wide variety of observers and although the records are generally accurate in terms of spatial location, not all records have been verified. Records from EHP's Species Profile Search are generally restricted to sightings from Queensland Government department activities and are considered spatially accurate. Atlas of Living Australia records are largely verified and include specimen records from museum collections across Australia. The database search results for fauna and flora species are provided in Appendix A9c – Ecological Desktop Search Results.

15.5.1.2 Matters of State Environmental Significance

EHP maintains a mapping database of MSES as a guide to assist the planning and development decision-making process. Queensland's SPP includes a biodiversity interest that states 'Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset'. MSES are defined under the SPP as including:

- Lands designated as part of protected areas and marine parks;
- Category B, C and R regulated vegetation;
- REs that intersect with wetlands and watercourses;
- Landscape connectivity areas;
- Habitat for threatened flora and fauna (as listed under the NC Act);
- Strategic Environmental Areas under the *Regional Planning Interests Act 2014*;
- Wetland Protection Areas as shown on the Map of referable wetlands;
- Selected wetlands and watercourses in high ecological value waters defined in the EPP (Water); and
- Legally secured offsets.

15.5.1.3 Aquatic Conservation Assessment

Aquatic Conservation Assessments have been carried out in a number of areas within Queensland including that in which the Project area occurs (Inglis and Howell, 2009). Aquatic Conservation Assessments have been developed using the Aquatic Biodiversity Mapping Method with the intent of identifying conservation values of wetland areas. It provides a robust and objective conservation assessment using criteria, indicators and measures that are founded upon a large body of national and international literature.

The criteria, each of which may have variable numbers of indicators and measures, are naturalness (aquatic), naturalness (catchment), diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness. The results are used to aid decision-making processes for a range of applications such as: prioritising land protection and rehabilitation, local and regional water resource planning, and development impact assessments.

15.5.1.4 Stygofauna Desktop Review

A desktop assessment using published technical reports was undertaken to assess the potential for stygofauna to occur within the Project area and to assess potential impacts on these communities as a result of the Project. The desktop assessment reviewed a number of reports from published EIS documents and scientific literature. The review focussed on literature from within the region surrounding the Project area and the Bowen Basin.

15.5.2 Field Surveys

A detailed aquatic ecology survey was undertaken for the former incarnation of the Central Queensland Coal Project which encompassed a much larger area (EPC 1029). The survey was carried out by ALS Water Sciences over six days from 1 to 6 June 2011 (refer Appendix A9e - Aquatic Ecology Results for technical report).

A second less intensive survey was carried out by CDM Smith in February 2017. The survey focused on freshwater sites previously surveyed in 2011.

Two seasonal surveys of local and Project associated groundwater bores for the presence of stygofauna were carried out by GHD Water Sciences from 21 to 24 November 2011 and 15 to 18 March 2012 (refer Appendix A9f - Stygofauna Results for technical report).

15.5.2.1 Aquatic Ecology - Survey Site Locations

Field assessments were undertaken at nine sites in the wider catchment surrounding the Project during June 2011 (refer Appendix A9e - Aquatic Ecology Results). Survey locations were selected to be representative of the overall aquatic stream environment within the Study area and to provide baseline aquatic ecosystem parameter values.

The local area had experienced wet conditions in the months preceding the surveys including over 500 mm in December 2010 (long-term December average 124 mm) and nearly 300 mm in March 2011 (long-term December average 133 mm). As a result sampling conditions were considered highly suitable with abundant flowing water available in creeks in the area.

Conditions during the February 2017 survey were very hot and dry. Excepting a single day in January on which 212 mm was recorded at St Lawrence (located 74 km north of the Project area), mean rainfall in the area was below average in the months preceding the survey and across the entirety of February. How the January rain event affected the Project site is uncertain as no rain was recorded in Rockhampton on the same day. Nevertheless, although no flow was recorded at the time sizeable waterholes remained which were suitable for sampling.

Water quality samples were collected at each site. The QWQG and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality were used to assess the water quality parameters (ANZECC guidelines; and EHP 2010).

Aquatic organisms were assessed at 9 locations within or surrounding the mine area:

- Three sites on Deep Creek (De1, De2 and De3) sampled in 2011. A fourth site (De4) located upstream of De3 was sampled in 2017 due to lack of site access to De3;
- Two sites on Tooloombah Creek sampled in 2011 and 2017 (To1 and To2);
- Three sites downstream of the Project on Styx River sampled in 2011 (St1, St1b and St2); and
- One site on Granite Creek located 13 km northwest of the Project sampled in 2011 (Gr1).

In addition, a tributary of Deep Creek potentially impacted by the Project (Barrack Creek) was inspected in both 2011 and 2017. Very little water was present on both occasions and no sampling was able to be carried out.

Table 15-1 provides descriptions of the aquatic ecology survey sites which are depicted in Figure 15-1.

Table 15-1 Aquatic ecology survey site descriptions.

De1 – Upper Deep Creek	
Site coordinates	-22.71803, 149.67018
Description	Adjacent to eastern boundary of MLs. Low flow at time of 2011 survey. Evidence of recent flooding – debris noted approx. 7 m above channel. Steep incised banks 7 m above water level. Substrate comprised small cobbles, gravel and sand. Well vegetated riparian zone at all levels with Lantana (*Lantana camara*) dominant in shrub layer. Channel well shaded. Some cattle access evident but likely minor due to steep banks.
Macroinvertebrate Signal score	Riffle – 4.76
Approx. channel size	3 m (riffle) to 6 m (pool)
Mean depth	0.2 m (riffle) to >0.5 m (pool)
De1 pool section – June 2011	**De1 pool section – February 2017**
	
De2 – Deep Creek (below highway)	
Site coordinates	-22.71272, 149.67582

Description	Located north of highway. Substantial pool present. Low flow at time of survey in 2011. Substrate comprised small cobbles, gravel and sand. Bank height approx. 2.5 m above channel. Thin riparian zone with moderate shade cover. Vehicle / cattle crossing point evident. Cattle access evident.
Macroinvertebrate Signal score	Riffle – 5.25
Approx. channel size	7 m (riffle) to 14 m (pool)
Mean depth	0.2 m (riffle), uncertain depth of pool – likely to retain water for extended periods
De1 pool – February 2017	
	
De3 – Lower Deep Creek	
Site coordinates	-22.66108, 149.67363
Description	Adjacent to north-east corner of MLs. Low flow at time of survey. Evidence of recent flooding – debris noted approx. 6-8 m above channel. Steep incised banks 8 m above water level. Substrate comprised largely gravel and sand. Well vegetated riparian zone at all levels. Rubber Vine (*Cryptostegia grandiflora*) dominant in some areas. Channel well shaded. Abundant woody debris observed in channel. Cattle access evident despite presence of exclusion fencing.
Macroinvertebrate Signal score	Riffle – 5.71
Approx. channel size	1.8 m (riffle) to 10 m (pool)
Mean depth	0.3 m (riffle), uncertain depth of pool – likely to retain water for extended periods
De3 riffle site – June 2011	
	
De4 – Lower Deep Creek	
Site coordinates	-22.664023, 149.672344
Description	Located approximately 700 m upstream of De3. No flow observed. Steep incised banks, 8 m above water level on west side. Substrate comprised largely gravel and sand. Well vegetated riparian zone at all levels (Rubber Vine dominant on lower east bank). Channel well shaded. Woody debris observed in channel. No obvious cattle access evident but evidence of pig presence observed.
Macroinvertebrate Signal score	
Approx. channel size	8 m (pool)

Mean depth	uncertain depth of pool – likely to retain water for extended periods
De4 pool – February 2017	
	
St1 – Upper Styx River	
Site coordinates	-22.64, 149.6624
Description	Just downstream of merge of Deep Creek and Tooloombah Creek. Low flow at time of survey. Evidence of recent flooding – debris noted approx. 6 m above channel. Shallow banks 5-7 m above water level. Substrate comprised largely gravel and sand. Very disturbed riparian zone with few tall trees and weed species common (Rubber Vine dominant in some areas). Poor channel shading. Aquatic vegetation present.
Macroinvertebrate Signal score	Riffle – 3.65
Approx. channel size	5 m (run) to 40 m (pool)
Mean depth	0.3 m (riffle area in Tooloombah Creek), main channel uncertain – 0.6 m at edge
St1 pool site – June 2011	
	
St1b – Styx River	
Site coordinates	-22.6232, 149.65187
Description	Located upstream of bridge on Ogmore Connection Road. Substrate dominated by silt / clay. Riparian zone shows evident of infrequent tidal inundation (marine couch present close to channel). Clearing evident with few tall trees present and weed species common. No channel shading. Aquatic vegetation present. Cattle access evident.
Macroinvertebrate Signal score	Riffle – 3.5
Approx. channel size	6 m to 12 m (pool)
Mean depth	Up to 2.5 m in main channel
St2 – Lower Styx River	
Site coordinates	-22.62018, 149.64848

Description	Located downstream of bridge on Ogmore Connection Road. Right bank heavily incised (6 m above channel), left bank floodplain less than 3 m above channel. Substrate dominated by silt / clay. Regular tidal inundation of site and few tall trees present as a result. Weed species common (heavy cover of Noogoora Burr). No channel shading. Aquatic vegetation present.
Macroinvertebrate Signal score	Riffle – 3.52
Approx. channel size	4 m to 10 m (pool)
Mean depth	Up to 1.2 m in main channel
St2 pool site – June 2011	
	
To1 – Tooloombah Creek	
Site coordinates	-22.68923, 149.62985
Description	Located adjacent to bridge over highway (downstream). Moderate flow at time of survey. Evidence of recent flooding – debris noted approx. 6 m above channel. North bank steep (>15 m above channel), gentle slope on south bank. Rocky creek with areas of substrate dominated by bedrock, as well as cobbles / gravel / sand. Well vegetated riparian zone. Channel moderately shaded. Evidence of cattle activity recorded at site.
Macroinvertebrate Signal score	Riffle – 5.77
Approx. channel size	5 m (riffle) to 17 m (pool)
Mean depth	0.3 m (riffle) to >1.5 m (pool)
To1 pool site (upstream of bridge) – June 2011	**To1 pool site (at bridge) – February 2017**
	
To2 – Tooloombah Creek downstream	
Site coordinates	-22.68083, 149.6535
Description	Located adjacent to western boundary of MLs. Moderate flow at time of 2011 survey. North bank relatively steep (7 m above channel), gentle slope on south bank. Substrate dominated cobbles / gravel / sand with large rocks sometimes present. Well vegetated riparian zone in good condition although occurrences of Rubber Vine present. Evidence of cattle activity recorded at site. Channel moderately shaded.
Macroinvertebrate Signal score	Riffle – 5.37
Approx. pool size	2.5 m (riffle) to 35 m (pool)
Mean pool depth	0.3 m (riffle), uncertain depth of pool – likely to retain water for extended periods, creek may be permanent some years

To2 riffle site – June 2011	To2 pool site – February 2017
	

Gr1 - Granite Creek	
Site coordinates	-22.60893, 149.54475
Description	Located downstream of highway and 13 km north-west of MLs. Moderate flow at time of survey. Series of large pools joined by riffle areas. Evidence of recent flooding – debris noted approx. 3 m above channel. Banks gently sloped, north bank approx. 5 m above channel. Substrate dominated by cobbles / gravel / sand. Riparian zone disturbed and substantially narrowed in sections. Weeds common. Channel poorly shaded. Aquatic vegetation present.
Macroinvertebrate Signal score	Riffle – 6.06
Approx. pool size	3 m (riffle) to 25 - 45 m (pool)
Mean pool depth	0.3 m (riffle), 3.8 m in deep section of pool – likely to retain water for extended periods

Gr1 riffle site – 5 June 2011	Gr1 pool site – 5 June 2011
	

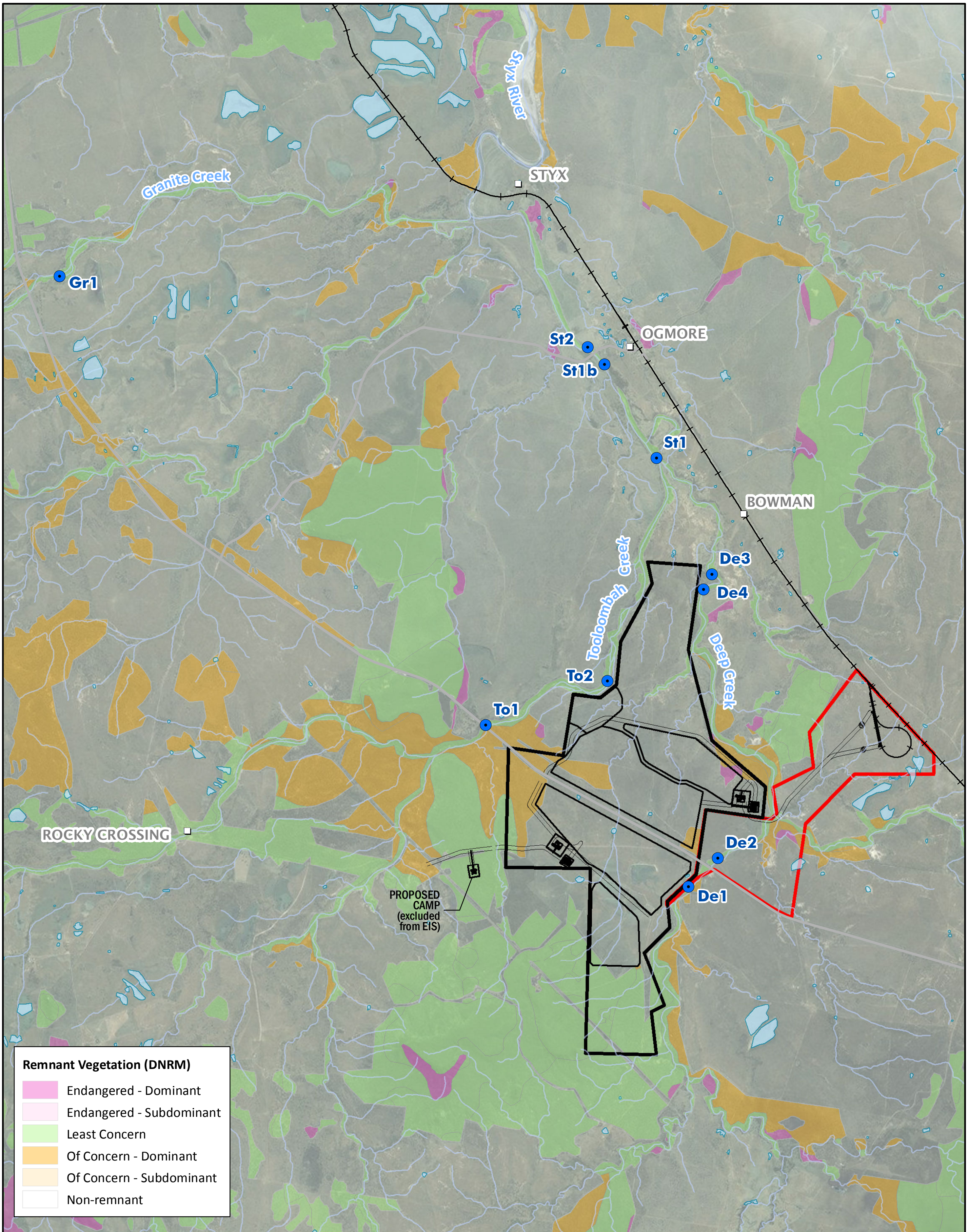

Figure 15-1
Aquatic ecology – survey locations (2011 and 2017)

N

0 1 2 km

Scale @ A4 1:100,000
Date: 21/07/17
Drawn: Gayle B.

Legend

- Aquatic ecology survey location
- ML 80187
- ML 700022
- North Coast Rail Line
- Main road
- Watercourse
- Reservoir

DATA SOURCE
QLD Department of Environment and Heritage Protection, 2016;
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

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Aquatic Habitat Assessment and Water Quality

Aquatic habitat assessment was required at freshwater sites in accordance with the AusRivAS protocols. These field sheets covered Site Description, Site Access, Water Quality, Habitat Data, Substrate data, Reach profile, and Reference Condition data.

In-situ water quality measurements were recorded in June 2011, February and May 2017 using a multi-parameter water quality meter and measurements included water temperature (C), pH, conductivity (mS/cm), and dissolved oxygen (% saturation and mg/L). Water quality meters were calibrated in the laboratory and in the field prior to use. Turbidity was measured separately using a hand-held turbidity meter.

Water samples were collected for laboratory analysis according to procedures outlined in the Department of Environment and Resource Mangement (DERM, 2009) guidelines. Samples were kept chilled in an esky and sent to the ALS laboratory in Brisbane within 24 hr of collection to ensure that they were received within sample holding times. Water samples were tested for the presence of a range of metals (refer to Chapter 9 - Surface Water for a more detailed description).

Flow velocities were assessed to assist with the interpretation of water quality and provided an indication of the relative nature of flow conditions experienced at the time of sampling. Flow measurements were taken where macroinvertebrates or fish were collected. Nonetheless, this process provided some indication of the relative nature of flow conditions experienced at the time of sampling.

Aquatic Macroinvertebrates

Macroinvertebrate sampling methodology followed protocols identified in the 'QLD Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual (DNRW 2001).' At each site, habitat sampled was dependent on habitat availability. Two different habitats were sampled during the 2011 survey, if available, including edge habitat and riffle habitat (with a total of three replicates per site where sufficient habitat was available). For each sample, the collected material was placed into a sorting tray and macroinvertebrates picked *in situ*.

The sample stored in 80% ethanol for later identification. Identification of taxa was performed to Family level except lower Phyla (Porifera, Nematoda and Nemertea), Oligochaetes, Acarina and Microcrustacea (Ostracoda, Copepoda, Cladocera). Chironomids were identified to sub-family.

For the 2017 survey, only edge habitat was sampled as no riffle habitat was available. All collected sample material (including sediment / debris) was stored in ethanol for sorting and identification off-site.

Survey sites were compared to each other using analyses based on the diversity and abundance of indicator fauna present at each site. This included the use of Signal-2 analyses of the macroinvertebrate fauna, taxa richness, and PET richness (Plecoptera, Ephemeroptera and Trichoptera). This methodology follows the National River Health Program (Chessman 2003a, Chessman 2003b, Chessman et al. 2006 and EHP 2010).

The appropriate Queensland AusRivAS models and resulting scores and bandings were utilised to detect any changes in observed and expected macroinvertebrate communities within the study sites (DNRW 2001). AusRivAS generates site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress. The expected fauna from sites with a similar set of physical and chemical characteristics are then compared to the observed fauna, and the ratio derived is used to indicate the extent of impact.

In addition, a number of multivariate analyses were undertaken to identify spatial and temporal trends between sites. The results are presented in detail in the Aquatic Ecology technical report (see Appendix A9e - Aquatic Ecology Results).

Aquatic Vertebrates

During the 2011 survey, fish were sampled at each site using a combination of baited traps and electrofishing (from a boat or backpack dependent on site conditions). The Deep Creek sites were sampled using a back-pack electrofishing unit which was more suited to the relatively narrow and shallow creek habitat. Deep pools that were present on Deep Creek were not sampled for fish as boat access could not be gained and there was evidence of the presence of estuarine crocodiles. The Granite Creek site was sampled with the electrofishing boat as the creek had very wide pools up to 45 m across. For the 2017 survey only baited traps were deployed at each site.

Captured fish were identified to species level on site after which they were released at the point of capture. An analysis of fish species diversity and abundance, community composition and community age structure was carried out at freshwater and estuarine sites in accordance with the Queensland Fish Monitoring Standard (Freshwater) and estuarine methods proposed by ALS (2012). Freshwater fish species were identified using Allen et al. (2003) and estuarine specimens identified using Kuiter (1996).

Freshwater turtles and other aquatic fauna (such as Platypus) were recorded via visual observations and accidental capture during the 2011 survey.

Baited opera house traps were deployed for capturing turtles during the 2017 survey. Traps were left partially submerged in shallow waters for a minimum of two hours before checking.

Aquatic Habitat Assessment

Aquatic habitat assessments were carried out during the 2011 survey as required at freshwater sites and in accordance with the AusRivAS protocols. The field sheets covered site description, site access, water quality, habitat data, substrate data, reach profile, and reference condition data.

15.5.2.2 Stygofauna Assessment

Protocols for sampling stygofauna were designed based on the Western Australia (WA) Guidelines (Guidance for the Assessment of Environmental Factors, Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia Statement No. 54 and Statement Number 54a, WA EPA 2003; and WA EPA 2007). The more recent Queensland *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITIA, 2014) is not specific to Queensland and recommends field sampling regimes as applied under the WA guidelines. The guidelines allow for a pilot study to be conducted where there is considered to be a low likelihood of stygofauna occurrence (based on a desktop review of available information).

The desktop review indicated that stygofauna may have some potential to occur within the shallow aquifers that occur in the mine area. Two seasonal surveys were conducted by GHD Water Sciences in November 2011 and March 2012 which involved collecting groundwater samples to be examined for the presence of stygofauna. A total of 21 groundwater bore locations were sampled in 2011. In 2012, 19 groundwater bores were sampled including nine bores that were not sampled in 2011. Overall a total of 30 bores within the Project area and surrounds were assessed for stygofauna presence (see Table 15-2 and Figure 15-2). This includes 20 bores established specifically for the Project and 10 landholder bores.

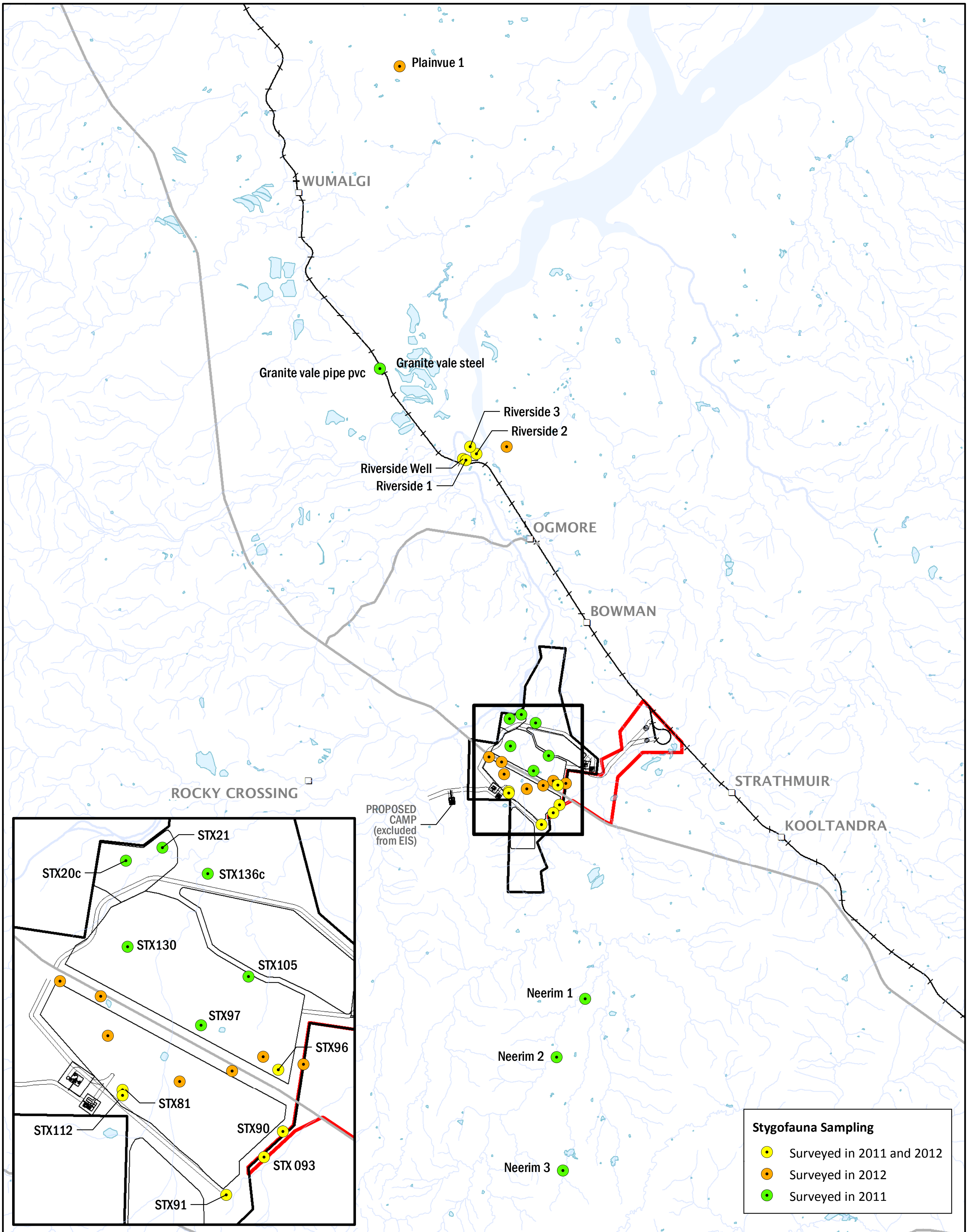
The full water column within each bore was sampled using six hauls of a weighted phreatobiological net (mesh size 50 µm). Samples were preserved in 100 per cent (%) ethanol. A small amount of Rose Bengal, which stains animal tissue pink, was added to each sample to aid sample processing. Samples were transported to the consultant's laboratory where stygofaunal specimens were identified to Order or Family using available taxonomic keys, and then identified to morpho-species within each higher taxon.

Groundwater samples were collected using a bailer lowered to approximately 3 m below the water surface prior to stygofauna sampling. Water was measured for temperature (°C), pH, electrical conductivity (µs/cm) and dissolved oxygen (mg/L and % saturation) using a YSI 556 multi-parameter water quality meter. Groundwater sampling preceded biological sampling to ensure the groundwater contained within the bore was undisturbed.

Table 15-2 Details of groundwater bores sampled for stygofauna

Bore ID	Date sampled	Latitude	Longitude	Standing water level (m)	Bore depth (m)	Bore type/ Lithology
STX 20c	23/11/2011	-22.685598	149.650101	15.5	75.6	Exploration Hole
STX 21	23/11/2011	-22.683998	149.654604	10.3	25.0	Exploration Hole
STX 081	22/11/2011 16/03/2012	-22.71201	149.650172	9.2 9.2	107.5	Exploration Hole
STX 090	21/11/2011 15/03/2012	-22.716497	149.670195	10.7 10.9	40.0 (estimated)	Exploration Hole
STX 091	22/11/2011 15/03/2012	-22.723915	149.663314	10.8 10.7	75.1	Exploration Hole
STX 093	22/11/2011 15/03/2012	-22.719469	149.667898	12.0 11.9	75.0	Exploration Hole
STX 096	21/11/2011 16/03/2012	-22.709395	149.669503	12.4 12.4	74.6	Exploration Hole
STX 097	23/11/2011	-22.704403	149.659803	11.9	74.9	Exploration Hole
STX 105	21/11/2011	-22.698701	149.665599	14.2	74.6	Exploration Hole
STX 112	22/11/2011 16/03/2012	-22.71266	149.650184	9.9 9.4	95.0	Exploration Hole
STX 130	23/11/2011	-22.695503	149.650496	15.6	30.0	Exploration Hole
STX 136c	23/11/2011	-22.6869	149.660302	14.3	74.6	Exploration Hole
Granite vale steel pipe	22/11/2011	-22.558917	149.596782	6.5	8.0 (estimated)	Windmill / Quaternary alluvium
Granite vale pvc pipe	22/11/2011	-22.558926	149.596783	6.6	8.0 (estimated)	Windmill / Quaternary alluvium
Plainvue 1	17/03/2012	-22.448836	149.602438	7.5	17.0 (estimated)	Production with pump attached
Neerim 1	23/11/2011	-22.787002	149.681701	2.1	12.0 (estimated)	Exploration Hole / Quaternary alluvium
Neerim 2	23/11/2011	-22.808396	149.670903	4.4	50.0	Exploration Hole
Neerim 3	23/11/2011	-22.849701	149.674203	4.4	30.0 (estimated)	Exploration Hole
Riverside Well	24/11/2011 17/03/2012	-22.591299	149.629996	7.8 7.1	10.0 (estimated)	Well / Quaternary alluvium
Riverside 1	24/11/2011 17/03/2012	-22.591696	149.631102	7.6 7.3	10.0 (estimated)	Production no pump attached / Quaternary alluvium
Riverside 2	24/11/2011 17/03/2012	-22.589401	149.635103	6.8 6.9	11.0 (estimated)	Exploration Hole

Bore ID	Date sampled	Latitude	Longitude	Standing water level (m)	Bore depth (m)	Bore type/ Lithology
Riverside 3	24/11/2011 17/03/2012	-22.586804	149.632701	5.9 5.3	11.0	Monitoring piezo / Quaternary alluvium
STX 038	16/03/2012	-22.586588	149.647035	9.3	75.1	Exploration Hole
STX 077	16/03/2012	-22.707893	149.667577	13.8	35.0 (estimated)	Exploration Hole
STX 095	16/03/2012	-22.708684	149.672622	13.4	75.7	Exploration Hole
STX 100	16/03/2012	-22.705805	149.648213	6.8	77.7	Exploration Hole
STX 113	16/03/2012	-22.7096	149.663737	11.0	110.0 (estimated)	Exploration Hole
STX 114	16/03/2012	-22.710936	149.657254	9.9	25.0	Exploration Hole
STX 126b	16/03/2012	-22.701281	149.647231	16.6	74.6	Exploration Hole
STX 127	16/03/2012	-22.699613	149.642159	16.1	81.0	Exploration Hole



N

0 2 4 km

Scale @ A4 1:200,000
Date: 24/07/17
Drawn: Gayle B.

Legend

ML 80187
ML 700022
Proposed mine infrastructure
North Coast Rail Line
Main road
Major watercourse
Minor watercourse
Reservoir

Figure 15-2

Bore hole locations – stygofauna sampling

DATA SOURCE
QLD Department of Environment and Heritage Protection, 2016;
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

15.6 The Styx River Catchment - Existing Environment

The Styx River catchment is located on the coast in Central Queensland, approximately 180 km south from Mackay and 150 km north of Rockhampton. The catchment is bordered by the Connors Ranges in the northwest, the Broadsound Ranges to the southwest and empties into Broad Sound near Rosewood Island, south of Saint Lawrence. The Styx catchment represents a transitional zone between the slow-flowing streams of the adjacent and much larger Fitzroy Basin and steep, fast-flowing streams located to the north.

The Styx River Catchment covers approximately 301,300 ha, and the main tributaries include: Deep, Granite, Montrose, Stoodleigh, Tooloombah, Waverly and Wellington Creeks. Many of the creeks are poorly documented and observations from the current survey indicate that many of the smaller waterways are intermittent or ephemeral from the late dry season onward.

The main landuse is agriculture which occupies 78% of the catchment, and cattle grazing is the predominant form of agriculture carried out in the region. Many cleared areas are badly eroded from sheet and gully erosion, particularly in the centre of the catchment and this occurs in association with particular soil types (Melzer et al 2008).

The water quality of rivers and streams within the study area is classified as high and the catchment is classified as being only slightly modified from the natural condition (ANRA 2010 in YEATS 2011). Many of the creeks of the region record high turbidity during periods of high flow due to the erodible and dispersive soils present in the catchment (Melzer et al. 2008).

The mine area and TLF is situated within the lower catchments of Tooloombah Creek and Deep Creek. Both creeks feed directly into the Styx River (2 km north of the Project area) which discharges into the Broad Sound area approximately 33 km northeast of the Project. Deep Creek has a total catchment area of 29,801 ha and Tooloombah Creek has a catchment area of 36,968 ha. The haul road to the TLF crosses Deep Creek and Barrack Creek (which lies within the Deep Creek catchment). Tooloombah Creek and Deep Creek are non-perennial or ephemeral, and largely flow only following heavy rainfall events.

15.6.1 Climate

The Styx region is located about 140 km north of the Tropic of Capricorn and is subject to a seasonally dry tropical climate. Most rainfall occurs between October and April with the driest months being August-September. Mean monthly temperatures are highest in January and February, and the lowest in June-July.

Air temperatures in the study region vary cyclically on a seasonal basis with the lowest mean minimums of around 11 degrees Celsius in winter (July) and the highest mean maximums of around 32 degrees Celsius in summer (December-January period).

The year prior to the June 2011 field survey extending from June 2010 through to May 2011 had extremely high rainfall (refer Figure 2-2 in Appendix A9e - Aquatic Ecology Results). Rainfall from August 2010 through to May 2011 was above mean rainfall in all months except February 2011.

15.6.2 Desktop Results

15.6.2.1 Queensland Wetland and Watercourse Mapping

The majority of mapped drainage lines intersecting the Project are associated with Deep Creek. Existing wetland mapping describes the following drainage system located within the MLs boundary:

- Two 2nd order drainage lines, one each feeding both Tooloombah and Deep Creeks; and
- Eleven 1st order drainage lines associated with Deep Creek and two 1st order drainage lines feeding Tooloombah Creek.

The haul road associated with the TLF crosses:

- Deep Creek as a 5th order drainage line in this area;
- Barrack Creek as a 4th order drainage line; and
- Two un-named tributaries of Barrack Creek as a 3rd order drainage line and a single 1st order drainage line.

The TLF and associated infrastructure intersect two further 1st order drainage line and a single 2nd order drainage line.

Wetland mapping (EHP 2012) indicates two palustrine wetlands (non-riverine vegetated wetlands) and five lacustrine wetlands (wetlands in topographic depressions / dammed areas with little vegetation) are located within the Project boundary. Onsite observations indicate the lacustrine wetlands are farm dams.

The estuarine section of the Styx River north of the Styx rail crossing is classed as High Ecological Value (HEV) waters under the EPP (water) 2009. This area is located 8 km directly north, or 9.7 km downstream of the Project area (see Figure 15-3) and coincides with the boundary of Broad Sound.

15.6.2.2 Wetland Protection Areas

The State Development Assessment Provisions Module 11: Wetland Protection and Wild Rivers provides statutory protection for wetlands within the catchment of the Great Barrier Reef lagoon. The provisions impose limitations to development in areas mapped as Wetland Protection Areas (WPA) which also include a 500 m buffer, or trigger area around the wetland itself. Wetland Protection Areas are also considered as MSES.

There is a single WPA located within the western extent of the Project area boundary (see Figure 15-3). The nearest WPAs outside of the Project area include:

- A single WPA mapped as occurring 10 km to the west of the Project boundary located adjacent to Tooloombah Creek (upstream of the Project area);
- Three WPAs located 14 km north of the Project associated with the floodplain between the Styx River and Stoodleigh Creek; and
- Two WPAs located 12 km and 16 km north-west of the Project area on the floodplain west of the Styx River.

15.6.2.3 Fish Habitat Areas

There is no Fish Habitat Area (FHA) located within the Project area, however Broad Sound is a declared FHA and the southern boundary is located 8 km directly north, or 9.7 km downstream of the Project area. The FHA boundary extends approximately 55 km north to the Clairview area and 76 km northeast to the islands north of Stanage Point on the mainland (see Figure 15-3). FHAs are also considered as MSES and Environmentally Sensitive Areas under the EP Act.

15.6.2.4 Directory of Important Wetlands

Broad Sound is listed in the Directory of Important Wetlands of Australia. The southern boundary of the designated wetland is located 8 km directly north, or 9.7 km downstream of the Project area. The lower Styx River forms part of the catchment of the wetland. It is noted as "A good example of a marine and estuarine wetland complex within a large sheltered embayment adjacent to a broad coastal plain" (DotEE 2017). The Broad Sound wetland encompasses an area of approximately 2,100 km^2 comprising a complex aggregation of tidal marine and estuarine wetlands. These have been formed in a sheltered embayment and have a very large tidal range of approximately 9 m.

The Broad Sound wetland area includes the Torilla Plain, a large marine plain to the east of the Project area formed on the southern side of the Torilla Peninsula. In this area wetlands occur as numerous interconnected pools and channels which may merge into much larger waterbodies in the wet season.

Broad Sound comprises wetland habitats including seagrass beds, lower intertidal and supratidal mudflats, and mangroves. Brackish and freshwater swamps and lagoons occur in adjacent upland areas. The wetland is noted as providing significant habitat for waterbirds including substantial aggregations of a range of migratory shorebirds listed under the EPBC Act (DotEE 2017).

The seagrass beds in the northwest of the Broad Sound area support populations of Dugong (*Dugong dugon*). There is a 'Dugong Protection Area' (administered under the Great Barrier Reef Marine Park Regulations 1983) extending from Carmilla Creek south to Clairview Bluff approximately 55 km north of the Project). Other notable protected marine species known from Broad Sound include Australian Humpback Dolphin (*Sousa sahulensis*) and Australian Snubfin Dolphin (*Orcaella brevirostris*) (CCP 2013).

The extreme tidal range and generally shallow depth in the Broad Sound area has a natural impact on water quality in the area. Constant high turbidity is caused by tidal resuspension of sediments largely due to the currents caused by the ingoing and outgoing tides. Nutrient and chlorophyll concentrations are generally low in this area (De'ath and Fabricius 2008). The turbidity plume extends outwards from Broad Sound to local islands in the Capricorn area of the GBR (such as the Percy Islands group) (Kleypas 1996).

Saltpans and saltmarsh communities occupy 372 km^2 of the Broad Sound wetland area. Current vegetation mapping indicates large areas of saltpans and mudflats with saltbush species along the Styx River beginning approximately 15 km downstream of the Project boundary. These become extensive further downstream extending 5 km to 6 km inland on the northern bank of the river as the channel splits around Rosewood Island. Mangrove communities also occur along the banks of the river beginning 21 km downstream of the Project boundary. Mangroves occupy 216 km^2 within the wetland boundary communities, also becoming more extensive near Rosewood Island. The extent of mangroves and saltmarsh within the wetland area did not decline between 2001 and 2013 (EHP 2017).

Broad Sound (with Shoalwater Bay) is considered one of the five main centres within the Great Barrier Reef (GBR) for mangrove and saltmarsh communities. These are critical habitats for important juvenile marine species such as Barramundi (*Lates calcarifer*), mullet and peneid prawns. In the past, there has been extensive construction of ponded pastures in the Broad Sound area. Bund walls have been constructed to convert saltmarsh into pasture, restricting movements of juvenile fish into these areas (Goudkamp and Chin 2006), but creating additional temporary and brackish wetlands.

Coral reefs

Mapping for the GBRMP area indicates small fringing reefs occur on Turtle Island and Charon Point approximately 35 km north-northeast of the Project boundary. Several small reefs also occur in the Clairview area (approximately 55 km north). A larger reef area occurs on the southwest edge of Long Island (52 km northeast), a continental island adjacent to the west of the Torilla Peninsula.

The structure of coral reefs in the Broad Sound area (including offshore islands such as Peak Island) has been surveyed in the past in order to examine the impact of the naturally turbid conditions and tidal range on reef development. Coral richness in the Broad Sound area is lower than in adjacent regions (De'ath and Fabricius 2008). High turbidity inhibits photosynthesis in symbiotic algae (Thompson 2006) and low tides that allow for extended exposure at low tides are not suitable for most coral species (Kleypas 1996). Kleypas (1996) examined reef systems surrounding the Broad Sound area, including the Percy Islands and Duke Island (90 km and 120 km north-east of the Project respectively). The study found that reefs within or close to Broad Sound were thinner, in shallower waters and comprised species associated with deeper waters. The effects of elevated turbidity in Broad Sound included:

- Decreasing hard coral colony size associated with distance to Broad Sound;
- Decreasing diversity of both soft and hard corals;
- Shifting coral morphology; and
- Lack of reef building (or framework) species (Kleypas 1996).

Seagrass

Seagrass mapping data from the past 30 years has been collated across the GBR area (Carter et al. 2016). There are no mapped seagrass beds known in the broad Sound area. Extensive seagrass beds occur to the northwest in the Clairview area and in Shoalwater Bay, including small patches near the islands off Stanage Bay 70 km north-east of the Project. Seagrasses require suitable light conditions and appropriate nutrient levels. It is likely the extreme tidal range in Broad Sound influences the lack of seagrass likely due to high turbidity levels and prolonged exposure of tidal flats during low tides.

Large marine fauna

The seagrass beds in the northwest of the Broad Sound area support populations of Dugong (*Dugong dugon*). There is a Dugong Protection Area (DPA) (administered under the *Great Barrier Reef Marine Park Regulations 1983*) extending from Carmilla Creek south to Clairview Bluff approximately 55 km north of the Project). A second DPA occurs in the Shoalwater Bay area to the north-west of the Project. Shoalwater Bay DPA is considered the most important Dugong site in the southern area of the GBRMP. Sightings of Dugong are rare in the majority of Broad Sound. In a review of Dugong sighting data by Marsh and Penrose (2001) there are no reported sightings in the Broad Sound area. More recently extensive aerial transect surveys for Dugong and marine turtles which included

Broad Sound recorded no individuals in the sound itself. The nearest reported sightings were individuals in the Clairview and Stanage Bay areas (Sobtzick et al. 2016). Given the lack of seagrass in the majority of Broad Sound it is unlikely the area downstream of the Project provides suitable habitat value for the species.

Humpback Whale (*Megaptera novaehollandiae*) is listed as Vulnerable and Migratory under the EPBC Act. The species is well known to occur in the waters off Shoalwater Bay (although not in the bay itself). There is no indication the species uses the waters of Broad Sound for resting or feeding and it is likely the tidal regime and associated turbid waters are unsuitable for the species.

Other protected marine species recorded from the region include inshore dolphin species including Australian Hump-back Dolphin (*Sousa sahulensis*) and Australian Snubfin Dolphin (*Orcaella brevirostris*), both of which are listed as Vulnerable under the NC Act. Past surveys indicate that both species occur in the Shoalwater Bay area although Australian Snubfin Dolphin occurs in low numbers compared to further south in the Fitzroy River estuary (Cagnazzi 2010, Cagnazzi et al. 2013). During boat-based surveys of Broad Sound carried out over two weeks in 2013 low numbers of both species were detected (seven separate pods detected including two pods of Australian Snubfin Dolphins). All records were located north of the Styx River. Both species were detected in the channel on the western side of Rosewood Island (CQC 2013).

Marine turtles occur in the Broad Sound area and surrounds. There are large nesting aggregations of Flatback Turtles (*Natator depressus*) at Wild Duck Island (74 km north north-east of the Project) and Avoid Island (75 km north of the Project). The species nests at lower levels on many of the islands in the local region and selected mainland beaches (Limpus et al. 2002). Targeted nesting surveys in the region indicate the nearest nest sites for this species were the Carmila area (55 km north including a mainland beach site and nearby Flock Pigeon Island), north-east side of Long Island (67 km north north-east), and in the Stanage Bay area (70 km north-east including mainland sites and Quail Island) (Limpus et al. 2002).

Green Turtle (*Chelonia mydas*) has been recorded nesting on several offshore islands in the region including the Percy Islands group, Curlew Island and islands and mainland beaches in Shoalwater Bay. The Shoalwater Bay sites are the nearest known nesting sites to the Project (66 km north-east) (Limpus et al. 2002). Hawksbill Turtle (*Eretmochelys imbricata*) is also known to nest in low numbers in the Percy Islands group (Limpus et al. 2002). Loggerhead Turtle (*Caretta caretta*) has been reported as foraging in Shoalwater Bay.

Extensive aerial transect surveys for marine turtles which included Broad Sound recorded few individuals in the sound itself. Marine turtles were recorded as individuals adjacent to the west side of Long Island and in the Clairview area. Much higher densities were recorded in Shoalwater Bay (Sobtzick et al. 2016). Green Turtle is known to forage on seagrasses which does not occur in the majority of Broad Sound. The lack of marine turtle observations in the area may be an indicator that the tidal regime in Broad Sound provides low habitat value for marine turtles in general.

15.6.2.5 Great Barrier Reef Marine Park and World Heritage Area

Broad Sound is also incorporated within the boundary of the Great Barrier Reef Marine Park (GBRMP) which is also considered a MNES under the EPBC Act (refer Chapter 16 – MNES). All activities undertaken in the GBRMP are regulated under the *Great Barrier Reef Marine Park Act 1975*.

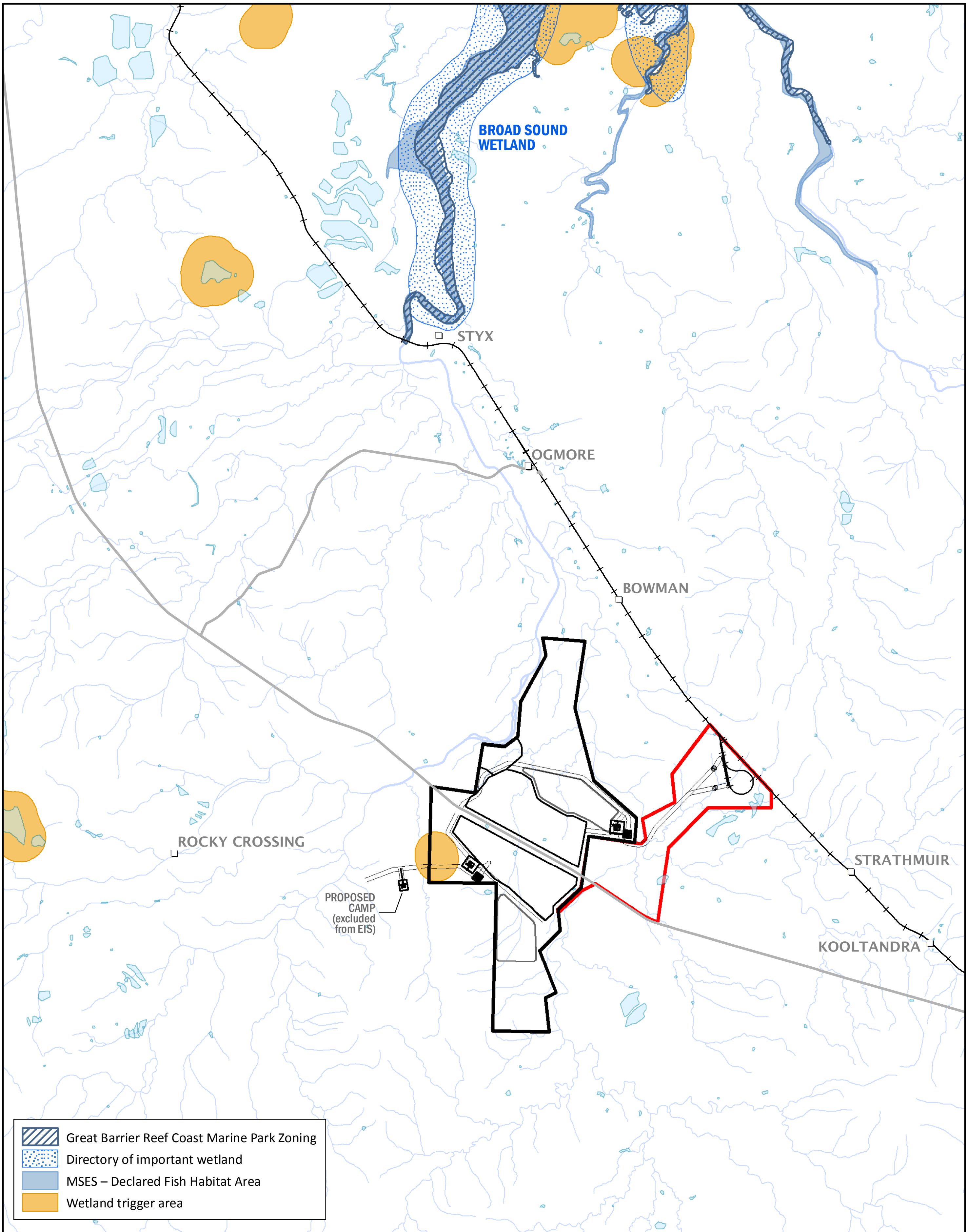
The Styx River portion of Broad Sound is mapped as a 'general purpose use zone' (see Figure 15-3) which provides opportunities for reasonable use, whilst still maintaining conservation values and reflecting the relevant criteria for listing. This zone extends approximately 41 km downstream of the Project area where the Styx River becomes a broad shallow estuary bordered to the west by

Rosewood Island. At this point the waters of much of Broad Sound are mapped as a 'Marine National Park Zone.' These areas are classed as a 'no-take' area and extractive activities like fishing or collecting are not allowed without a permit.

The Great Barrier Reef was inscribed as a World Heritage property in 1981, as it was deemed to meet all the natural heritage criteria for listing. The relevant criteria for the listing were:

- Criterion 7: contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;
- Criterion 8: be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;
- Criterion 9: be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; and
- Criterion 10: contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.

The Great Barrier Reef WHA extends from the low water mark on the coast of Queensland past the continental shelf outside the outer reef. The World Heritage Area boundary aligns with the boundary of the GBRMP and FHA being located 8 km directly north, or 9.7 km downstream of the Project area. The GBRMP is considered as a MSES where designated as a 'highly protected area.' The downstream section of the park closest to the Project is identified as a 'general use zone' and therefore not identified as a 'highly protected area.' The Marine National Park zone is located approximately 33 km northeast of the Project (or 40 km downstream) by which time the Styx River opens into a broad shallow estuary.



Scale @ A4 1:125,000
Date: 19/07/17
Drawn: Gayle B.

Legend

- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Major watercourse
- Minor watercourse
- Reservoir

Figure 15-3
Styx catchment wetland mapping

DATA SOURCE
QLD Department of Environment and Heritage Protection, 2016;
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

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15.6.2.6 Threatened Ecological Communities

The Protected Matters Search Tool identified five listed Threatened Ecological Communities (as listed under the EPBC Act) as having potential to occur in the Project area, none of which are associated with aquatic or wetland communities.

15.6.2.7 Regional Ecosystems

Assessment of current RE mapping identified nine REs occurring within the Project area. A single RE. RE11.3.25 - *Eucalyptus tereticornis* open forest to woodland, occurs within and directly adjacent to the Project area that may be associated with wetland communities. This RE occurs on fringing levees and banks of major rivers and drainage lines of alluvial plains throughout the region.

15.6.2.8 Matters of State Environmental Significance

Current mapping of MSES for the MLs (EHP 2017) indicates the presence of the following features relevant to aquatic ecology:

- 3.4 ha of lands considered to be MSES under 'Criteria 2.1: High Ecological Significance wetlands on the map of Referable Wetlands';
- 4.4 ha of lands considered to be MSES under 'Criteria 4.1: Vegetation Management Wetland Map;' and
- There are also 25.5 km of watercourse vegetation considered to be a MSES under 'Criteria 4.3: watercourses shown on the Vegetation Management Watercourse and Drainage Feature Map.' This is considered very likely to be an overestimate as both banks (rather than the centreline) of larger watercourses where present are mapped by the State, increasing the extent of linear features.

These features encompass two wetland areas within the ML and several mapped watercourse / drainage lines. These features are also represented on Figure 15-4.

15.6.2.9 Aquatic Conservation Assessment

The conservation value of riverine and non-riverine wetlands has been assessed in the Aquatic Conservation Assessments of Great Barrier Reef catchments (Inglis and Howell 2009). Assessment sites are given an overall 'Aquascore' that represents the relative conservation value of the wetland. The Aquascore ratings for the Great Barrier Reef Aquatic Conservation Assessments include:

- Very high: very high values across all criteria, or high representativeness combined with very high values of aquatic and catchment naturalness, threatened or special values. They may also be nominated due to special features by an expert panel;
- High: very high aquatic naturalness or representativeness combined with high or very high values of other criteria;
- Medium: a combination of high to low scores across assessment criteria;
- Low: limited aquatic and catchment naturalness with other medium to low conservation values; and
- Very low: limited or no aquatic or catchment naturalness, and lack any other known significant value. They may also be largely data deficient (Inglis and Howell 2009).

Current EHP reporting and mapping indicates that riverine wetlands within and surrounding the MLs and TLF are considered to be within riverine catchment of High significance. A single non-riverine (palustrine) wetland (located north of Mount Bison Road) mapped within the MLs is of Very High significance and a second wetland is of Medium significance (see Figure 15-4).

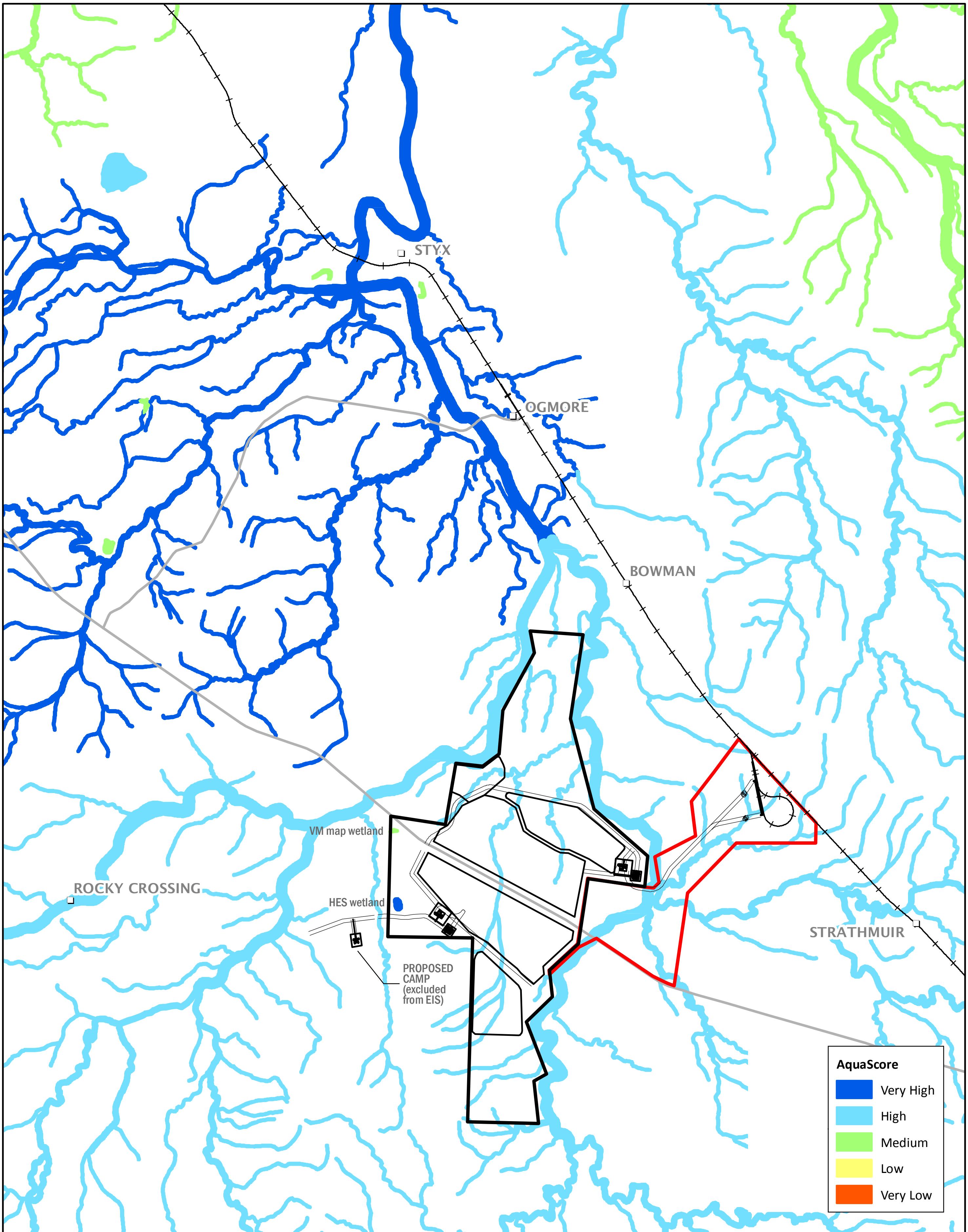

Figure 15-4
Aquatic conservation assessment mapping for the Project area

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

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15.6.2.10 Vertebrate Fauna

The Project area occurs within the Styx River basin which lies outside of, but adjacent to the Fitzroy Basin. Fifty-eight freshwater fish species are known from the wider Fitzroy Basin (Inglis and Howell 2009) but there is no published data available for the much smaller Styx River catchment. Database searches identified 26 freshwater-associated fish species known to occur within a 50 km radius of the Project area. None of the species identified in database searches are listed under the NC Act or EPBC Act. All species identified within database searches can be found in Appendix A9c – Ecological Desktop Search Results.

Database searches also identified five freshwater turtle species recorded in the wider area: Krefft's River Turtle (*Emydura macquarii krefftii*), Fitzroy Turtle (*Rheodytes leukops*), Southern Snapping Turtle (*Elseya albagula*), Snake-necked Turtle (*Chelodina longicollis*) and Saw-shelled Turtle (*Wollumbinia latisternum*).

The Fitzroy Turtle is listed as Vulnerable under the NC Act and EPBC Act. The species is only found in the drainage system of the Fitzroy River and is primarily known to occur in the Fitzroy, Connors, Dawson, and Mackenzie Rivers, Widah Creek and Develin or Marlborough Creek (Cogger 2000). The species prefers large pools and connecting flowing riffle habitats with clear water. It is known to feed on aquatic insect larvae, freshwater sponges and Ribbonweed (*Valisneria* spp.) (Tucker et al. 2001). The nearest database records for this species are located 30 km south of the Project area on Marlborough Creek which lies within the Fitzroy Basin.

The Southern Snapping Turtle is listed as Endangered under the NC Act and Critically Endangered under the EPBC Act. This is one of Australia's larger turtle species and is considered endemic to flowing waters in the Fitzroy, Burnett and Mary River Basins and associated smaller drainages (TSSC 2014). The nearest database records for the species are located 30 km south of the Project area on Marlborough Creek, and 30 km south-west on the Mackenzie River, both of which lie within the Fitzroy Basin.

15.6.3 Aquatic Ecology – Field Survey Results

15.6.3.1 Stream Health and Water Quality

Two parameters from the in-situ water quality variables recorded in June 2011 and May 2017 were outside the WQOs set for the Styx River Basin (refer EHP 2014): Dissolved Oxygen (DO) (%Sat), and pH (Table 15-3). Two further parameters (turbidity and suspended solids) were also outside the WQOs from the data collected in February 2017 (Table 15-4).

DO (%Sat) was slightly lower than the WQOs at two Deep Creek Sites (De1 and De2) and Granite Creek (Gr1) at both riffle and edge habitats, and higher than the WQO value for two Styx River sites (St1b and St2). DO levels recorded in both surveys in 2017 were lower at all sites except To2. Note that DO readings taken in this study represent spot readings recorded at different times of day. Dissolved oxygen levels vary throughout the day, so readings that fell outside guideline levels should not necessarily be considered of concern.

The pH result for site St1 from 2011 was above the WQO for estuarine waters associated with the Styx River with a reading of 9.19. This value was retested after re-calibration of the meter when the pH recorded was 9.8. The pH result for site St1 should therefore be treated with caution. The pH result from To1 and To2 collected in February 2017 was just above the WQO and may have reflected the lack of flow at the time. Neither site was above the WQO in May 2017 when both creeks were flowing. Site Ba1 on Barrack Creek was sampled for the first time in May 2017 and recorded 6.48 which is just below the WQO for this parameter.

Turbidity and suspended solids values recorded in 2011 were all under the associated WQO when flows were observed at all sites. Turbidity at sites on Deep Creek (De2 and De4) sampled in February 2017 were well above the WQO which is considered likely to be a result of the lack of flow at the time as well as the different geological characteristics between the subject creeks. Suspended solids were above the WQOs at DE2 and De 3 in February 2017, and at De4 only in May 2017.

Electrical Conductivity (EC) values recorded in 2011 varied across sites with both Deep and Granite Creek sites having low values in comparison with the Tooloombah Creek and Styx River sites ranging in values from 987 – 1390 µS/cm. Although the EC at the St2 and St1b sites were high this is not surprising given the proximity of these sites to the estuary. EC values recorded in 2017 had decreased in Deep Creek compared to the 2011 results, and substantially increased at To2 and St1 which recorded a value of 13,103 µS/cm in February 2017. Local landholders advised GHD that large tides pushed well up the river above the Ogmore Bridge and may explain the substantial difference between the two surveys.

Broadly the in-situ water quality values recorded in 2011 can be used to separate the sites into two groups:

- Group 1 (Deep and Granite Creek) - EC <500 µS/cm, pH <7.3, DO (%Sat) < 90%, turbidity >7 NTU, alkalinity <50; and
- Group 2 (Tooloombah Creek and Styx River) – EC >500 µS/cm, pH >7.3, DO (%Sat) >90%, turbidity <7 NTU, alkalinity >50.

Laboratory analyses from the 2011 water quality samples confirmed results from the in-situ analyses and supported the water quality groupings outlined above. The laboratory analyses highlighted four analytes that recorded exceedances of the Styx River Basin WQOs (EHP 2014): total nitrogen, total oxidised nitrogen, ammonia, and total phosphorus (Table 15-4).

Total nitrogen and ammonia marginally exceeded the guidelines at the majority of sites. Total oxidised nitrogen exceeded the guidelines at four sites including all the Styx River sites. Total phosphorus exceeded the guidelines at a single site only (St1). No metals recorded dissolved concentrations above the recommended values (refer to Chapter 9 – Surface Water, for further discussion).

Laboratory analyses from the February and May 2017 water quality sampling results confirmed similar results to the 2011 samples for ammonia and total nitrogen (several sites exceeding the WQOs). Total oxidised nitrogen exceeded the WQO at only one site from the May 2017 survey. In contrast total phosphorus recorded exceedances at all of the sampled sites in February 2017 and six out of eight sites sampled in May 2017. A single site recorded a marginal exceedance of the WQO for filterable reactive phosphorus (St1).

Table 15-3 Water quality data – aquatic ecology sites (June 2011)

Water quality parameter	Site								
	De1[2]	De2[2]	De3[2]	St1[3]	St1b[3]	St2[3]	To1[2]	To2[2]	Gr1[2]
Sample date range	2011	2011	2011	2011	2011	2011	2011	2011	2011
Water Temperature (°C)[1]	16.25	16.78	14.79	16.74	19.94	18.49	16.05	15.64	18.3
Dissolved Oxygen (%sat)[1]	82.3	82.7	85.8	90.9	123.4	114.6	94.7	92.1	83.7
pH[1]	6.81	7.16	7.21	9.19	7.61	7.63	7.59	7.4	6.6
Conductivity- base flow (µS/cm)[1]	461	475	447	987	1,366	1,390	866	848	324
Turbidity (NTU)[1]	13.1	12.9	17.2	5.6	5.8	5.4	5.9	1.7	7.4
Suspended solids (mg/l)	6	6	6	<5	<5	<5	<5	<5	6
Ammonia N (mg/l)	0.03	0.03	0.02	0.02	<0.01	0.03	0.02	0.02	<0.01
Total Phosphorus as P (mg/l)	0.04	<0.01	0.1	0.12	<0.01	<0.01	0.03	0.02	0.04
Filterable Reactive Phosphorus (mg/l)	<0.01	<0.01	-	<0.01	-	<0.01	-	-	-
Sulfate (mg/l)	29	28	24	42	66	68	42	41	2
Total Nitrogen (mg/l)	0.7	0.4	0.6	0.5	0.4	0.4	0.4	0.6	0.6
Nitrate (mg/l)	0.03	0.03	0.12	0.04	0.05	0.04	0.03	0.02	0.05
Total Oxidised Nitrogen (mg/l)	0.03	0.03	0.12	0.04	0.05	0.04	0.03	0.02	0.05
Total Alkalinity as CaC03 (mg/l)	89	88	100	190	204	306	212	209	75
Arsenic (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Nickel (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (mg/l)	0.029	0.006	<0.005	0.005	0.010	0.026	<0.005	<0.005	0.014
Mercury (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

1. In-situ water quality measurements
2. WQOs for lowland (< 150 m asl) freshwaters of the Styx River catchment derived from Table 2A of EHP 2014
3. WQOs for middle estuary (moderately disturbed) estuarine waters of the Styx River derived from Table 2A of EHP 2014

Table 15-4 Water quality data – aquatic ecology sites (February and May 2017)

Water quality parameter	Site												
	De1[2]	De2[2]		De3[2]	De4[2]		St1[3]		To1[2]		To2[2]		Ba1[2]
Sample date range	May	Feb	May	May	Feb	May	Feb	May	Feb	May	Feb	May	May
Water Temperature (°C)[1]	19.7	27.1	20.0	20.0	28.7	20.2	29.9	23.7	26.6	22.3	29.5	24.1	22.2
Dissolved Oxygen (%sat)[1]	61.1	37.8	66.7	68.7	36.1	76.3	66.4	65.9	31.5	46.2	108.9	68.1	83.7
pH[1]	7.48	7.65	7.2	6.98	7.51	7.6	8.15	7.09	8.04	7.49	8.1	7.88	6.48
Conductivity- base flow (µS/cm)[1]	380	272	345	356	259	404	13,103	1,127	872	713	2,737	836	1,293
Turbidity (NTU)[1]	23.5	*	28.7	32.9	116	14.0	12.6	12.3	14.5	4.0	3.3	2.5	6.0
Suspended solids (mg/l)	6	1100	<5	15	32	6	13	10	<5	6	<5	8	6
Ammonia N (mg/l)	0.02	0.12	<0.01	<0.01	0.03	0.01	0.05	0.06	0.05	0.02	0.05	0.02	0.03
Total Phosphorus as P (mg/l)	0.16	1.38	0.15	0.15	0.21	0.02	0.16	0.03	0.06	0.22	0.05	0.08	0.02
Filterable Reactive Phosphorus (mg/l)	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sulfate (mg/l)	17	8	15	16	12	16	501	40	12	32	22	33	41
Total Nitrogen (mg/l)	0.2	4.0	0.2	0.3	1.5	0.2	1.2	0.7	0.6	0.2	0.8	0.2	0.1
Nitrate (mg/l)	<0.01	0.05	<0.01	0.2	0.02	<0.01	<0.01	0.06	0.02	<0.01	0.05	<0.01	<0.01
Total Oxidised Nitrogen (mg/l)	<0.01	0.05	<0.01	0.2	0.02	<0.01	<0.01	0.06	0.02	<0.01	0.05	<0.01	<0.01
Total Alkalinity as CaC03 (mg/l)	86	74	76	76	54	87	194	148	122	141	115	140	60
Arsenic (mg/l)	<0.001	<0.01	<0.001	<0.001	<0.01	<0.001	<0.01	0.001	<0.01	<0.001	<0.01	<0.001	<0.001
Cadmium (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	0.002	0.001	0.002	0.003	<0.001	<0.001	0.002	0.002	<0.001	0.018	<0.001	<0.001	<0.001
Nickel (mg/l)	0.001	0.003	0.001	0.002	0.002	0.001	0.001	0.001	<0.001	0.002	<0.001	<0.001	0.001
Lead (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (mg/l)	<0.005	<0.005	<0.005	<0.005	0.012	<0.005	0.025	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Mercury (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0010

*Turbidity not recorded as too high for water quality meter reading

15.6.3.2 Aquatic Flora

No aquatic plants were observed in 2011 other than sedges (*Cyperaceae* sp.) and rushes (*Juncus* sp.). It is likely that most floating, submerged or emergent aquatic plants would have been removed from the waterways during the floods and high flow conditions that occurred in the wet season at that time. Observations during wet and dry season botanical surveys (refer Appendix A9b – Terrestrial Flora Reports) across the wider area in 2011 recorded a number of sedge / wetland plants associated with ephemeral wetlands including *Eleocharis blakeana* and *Juncus polyanthemus.*

Observations in September 2011 at an ephemeral wetland located in the east of the MLs and north of Mount Bison Road (considered as of 'very high significance' under ACA mapping) identified a variety of sedges and a sparse cover of hydrophytes including Swamp Lily (*Otellia ovalifolia*).

Aquatic flora species were relatively sparse again during the February 2017 survey, although dense aquatic algae occurred at the Tooloombah Creek sites. Water Snowflake (*Nymphoides indica*), a floating species, was relatively common on the large pool at To2. Swamp Lily occurred in isolated patches along the edge of De2.

Parthenium (*Parthenium hysterophus*) was observed in the creek bed at To2 during the 2017 survey. This is listed as a Category 3 Restricted Matter (under the State's Biosecurity Act) and a Weed of National Significance, although is not an aquatic plant. Olive Hymenachne (*Hymenachne amplexicaulis*) is an aquatic weed and although not observed at any creek sites, it was observed in the northern extent of the ML at a farm dam (February 2017) and in a water-filled gilgai (May 2017). This species is also listed as a Category 3 Restricted Matter (under the State's Biosecurity Act) and a Weed of National Significance.

15.6.3.3 Vertebrate Aquatic Fauna

A total of 736 fish comprising 28 native fish species were collected across all the sites during the 2011 survey. This included 14 of the 26 species identified from the desktop database search from the wider area. The lack of any records of introduced species from either the desktop review or field results indicates the catchment may be relatively free of introduced taxa such as Tilapia (*Oreochromis* sp.) and Mosquito fish (*Gambusia* sp.). The fish taxa recorded during the June 2011 sampling round are generally typical of what would be expected to occur in a Central Queensland coastal catchment. The most abundant catches were in Deep Creek and Granite Creek. The highest fish diversity for individual sites was recorded from the Styx River at site St2 and at Tooloombah Creek at site To1, which both recorded 15 species (Table 15-5). Both of these sites had large pools that enabled sampling from a boat.

The lowest diversity sites were a Deep Creek site (De1), and a Tooloombah Creek site (To2). Both of these sites were sampled with a back-pack electrofishing unit only. The highest diversity of fish overall was recorded from the Styx River where 22 species were caught over the three sites (Table 15-5). This was well ahead of Tooloombah Creek (15 species from two sites), Granite Creek (12 species from a single site), and Deep Creek (11 species from three sites) and is a result of the estuarine influence in the Styx River.

The taxa recorded were a mix of freshwater and estuarine / marine associated species. Eastern Rainbowfish (*Melanotaenia splendida*) and Empire Gudgeon (*Hypseleotris compressa*) were the most commonly caught in terms of both abundance and distribution across all study sites. Agassiz"s Glassflsh (*Ambassis agassizii*), Spangled Perch (*Leiopotherapon unicolour*), Purple Spotted Gudgeon (*Mogurnda adspersa*) and Barramundi (*Lates calcarifer*) were also relatively common, but these did not occur across all sites. Sixteen of the twenty-nine species recorded in June 2011 were represented by fewer than 10 individuals across all sites. No introduced species were collected in this Project which indicates that the region may be relatively free of introduced taxa.

Two specimens of an unidentified eel were recorded during the 2011 survey. These were tentatively identified as swamp eels of the genera *Ophisternon* (Family: Synbranchidae). At that time, there was no record of this genus or family occurring in the Styx River or the wider region. However, this group of eels has been poorly studied and there is limited taxonomic information available. Swamp eels spend their life living and feeding in burrows within soft sediments and are rarely recorded as a result. Recent information suggests that the Synbranchidae occur as far south as the Moreton Bay region and there are up to three undescribed species from the southern and central coast of Queensland (pers. comm. Dr Jeff Johnson).

Fish sampling in 2017 was limited to bait traps and did not take place at the estuarine sites on the Styx River as occurred during the 2011 survey. A total of 274 fish comprising four species were collected across the five sites that were sampled. By far the highest abundance of fish trapped was at To2 (183 individuals across all four species).

Multivariate analysis of the 2011 fish community data indicated that Deep Creek had a distinct community from that of the other creek systems assessed (refer Figure 5-3, Appendix A9e - Aquatic Ecology Results) reflecting the strong average similarity for Deep Creek sites (73.68%). Fish community composition was more variable in the Styx River and Tooloombah Creek. Further analysis indicated that this related to shallow stream versus deep pool habitat, though further sampling would be required to confirm this. Granite Creek fish fauna most closely matched that of site To1, though this is based on only one sample from that creek system. Further analysis is provided in Appendix A9e - Aquatic Ecology Results.

While most freshwater fish in Australia have some migratory behaviour during their lifespan this can vary substantially from entirely within freshwater systems through to catadromous taxa such as Barramundi which breeds in estuaries but migrates upstream into freshwater as yearlings. The migratory nature of most Australian fish means that connectivity within the rivers and estuaries is important to maintain healthy breeding populations. The migratory aspect of fish observed in the Central Queensland Coal Project in June 2011 is shown in Table 15-5. Connectivity within the waterways of the study area was observed to be generally good.

Two commercially targeted fish taxa were recorded: the Sea Mullet (*Mugil cephalus*), and Barramundi. Sea Mullet was only caught at the two lowest Styx River sites (St1b and St2). This was expected as these sites are in the upper reaches of the estuary and made up of pools over 200 m in length which provide ideal habitat for this species.

A total of 51 Barramundi were caught during the 2011 survey. Barramundi were caught in all creeks sampled except Deep Creek. This is most likely due to the fact that Barramundi were only captured in large pools and no large pools were sampled from within Deep Creek. Barramundi ranged in size from 150 mm to 610 mm with smaller fish (< 500 mm) accounting for 86% of the catch. A key finding is that where Barramundi were recorded, a range of size classes were represented. This indicates that the study area is a nursery area for juvenile Barramundi and that there have been successive cohorts utilising the study area.

The main sightings of aquatic reptiles in 2011 were of turtles which occurred at the following sites: Gr1, De2, De3, To1, and To2. Turtles were most abundant at sites To1 and Gr1 which were both large pools sampled late in the day. These two sites recorded a total of 26 turtles that were observed during routine sampling. Four turtles were caught, photographed and positively identified including Krefft's River Turtle, Eastern Snake-necked Turtle and Southern Snapping Turtle. In 2017 turtles were trapped at a single site (To1) where three Saw-shelled Turtles were caught.

During the June 2011 survey evidence of the presence of Estuarine Crocodile (*Crocodylus porosus*) slides was observed at two Styx River sites (St1b and St2). Anecdotal evidence for the presence of estuarine crocodiles was also noted for the Deep Creek, Granite creek, and the Styx River. Local amateur fishermen observed four crocodiles downstream of St2 in June 2011. It is considered likely that estuarine crocodiles are also present in parts of Tooloombah Creek. No evidence of the presence of Estuarine Crocodile was observed during the February 2017 survey.

Table 15-5 Aquatic fauna species recorded by site (June 2011 / February 2017)

Scientific name	Common name	De1[1]	De2[1]	De3	De4[1]	St1	St1b	St2	To1[1]	To2[1]	Gr1	Habitat and life history (Allen et al. 2003)
Fish												
Ambassis agassizii	Agassiz's Glassfish	20 14	28 2	3	22	4	2	4	4	94	20	Inland freshwaters to estuarine systems
Amnitaba percoides	Barred Grunter	1										Fresh to brackish waters
Anguilla reinhardtii	Marbled Eel		1	1		14	1	4	6	5	13	Catadromous, adults migrate from freshwater to breed in marine waters
Anguilla obscura	Pacific Short-finned Eel						4	1	3	1		Catadromous, adults migrate from freshwater to breed in marine waters
Craterocephalus stercusmuscarum	Fly-speckled Hardyhead								1 65		4	Freshwater only
Elops hawaiensis	Giant Herring							3				Mainly marine, but also lower reaches of freshwater
Gerres filamentosus	Threadfin Silver Biddy							2				Mainly marine, but also lower reaches of freshwater
Glossamia aprion	Mouth Almighty					1						Usually found in still freshwaters with abundant aquatic vegetation.
Glossogobius giurus	Flathead Goby					1	3	3				Freshwater, brackish and estuarine habitats
Hypseleotris compressa	Empire Gudgeon	7 2	12 2	40	7	20	8	2	9 23	3 16	7	Freshwaters to upper estuary
Hypseleotris klunzingeri	Western Carp Gudgeon		1					2				Inland freshwaters to upper estuary
Hypseleotris species 1	Midgley's Carp Gudgeon		7	1		1					8	Mainly freshwater
Lates calcarifer	Barramundi					9	12	8	8		14	Catadromous, spawns in estuarine / coastal areas. Inhabits a variety of fresh, brackish and coastal marine habitats
Leiognathus equulus	Common Ponyfish						4	4				Mainly marine, but also lower reaches of freshwater
Leiopoterapon unicolor	Spangled Perch	16	18	18					6	2	3	Widespread species, freshwater only
Megalops cyprinoides	Oxeye Herring		2	3				2	6		3	Mainly marine, but also lower reaches of freshwater
Melanotaenia splendida	Eastern Rainbowfish	38 8	18 1	20	3	3	20	20	20 5	20 8	19	Freshwaters to upper estuary

Scientific name	Common name	De1[1]	De2[1]	De3	De4[1]	St1	St1b	St2	To1[1]	To2[1]	Gr1	Habitat and life history (Allen et al. 2003)
Mogurnda adspersa	Purple-spotted Gudgeon	20	15	13		1			1	2		Mainly freshwater
Mugil cephalus	Sea Mullet						20	12	1			Marine / estuarine to lower freshwater reaches of streams
Nematelosa erebi	Bony Bream						4	1	8		5	Mostly freshwater, widespread species
Neoarius graeffei	Blue Catfish								1		1	Marine / estuarine to freshwater streams and lagoons
Neosilurus hyrtlii	Hyrtl's Tandan		3	8					2		1	Freshwater only
Pomadasys kaakan	Javelin Fish							1				Marine / estuarine
Pseudomugil signifer	Pacific blue-eye					5						Marine / estuarine to freshwater reaches of coastal streams
Redigobius bikolanus	Speckeld Goby						1					Marine / estuarine to lower freshwater reaches of streams
Scatophagus argus	Spotted Scat						1					Marine / estuarine to lower freshwater reaches of streams
Selenotoca multifasciata	Banded Scat						6					Marine / estuarine to lower freshwater reaches of streams
Potential *Ophisternon* species	Unidentified swamp eel					1			1			Unknown, recorded at estuarine and fresh sites
Total species recorded		**6**	**10**	**9**	**3**	**11**	**13**	**15**	**15**	**6**	**12**	
Other aquatic fauna												
Chelodina longocollis	Eastern Snake-necked Turtle								1			
Elseya albagula	Southern Snapping Turtle			1								
Emydura macquarii krefftii	Krefft's River Turtle								1		1	
Wollumbinia latisternum	Saw-shelled Turtle								3			

1. Numbers in red indicate sampled in February 2017

15.6.3.4 Threatened Aquatic Fauna

There are three freshwater aquatic fauna species listed as conservation significant and predicted to occur in the Study area or surrounds by the EPBC Protected Matters search tool and EHP's Wildnet database. These species are addressed in the following sections – the Fitzroy Turtle (Vulnerable – NC Act and EPBC Act), Southern Snapping Turtle (Endangered – NC Act and Critically Endangered – EPBC Act) and Estuarine Crocodile (Vulnerable – NC Act and Migratory – EPBC Act).

Fitzroy Turtle (*Rheodytes leukops*)

Status: Vulnerable – NC Act and EPBC Act

Ecology and habitat: It possesses enlarged cloacal pouches, allowing it to absorb most of its oxygen needs from the surrounding water (Cann 1998). The species prefers large pools and connecting flowing riffle habitats with clear water. It generally does not move far within its home range. It is known to feed on aquatic insect larvae, freshwater sponges and Ribbonweed (*Valisneria* spp.) (Tucker et al. 2001). The species maintains a home range of between 400 m to 700 m and generally remains sedentary.

Distribution: The species is only found in the drainage system of the Fitzroy River and is primarily known to occur in the Fitzroy, Connors, Dawson, and Mackenzie Rivers, Widah Creek and Develin or Marlborough Creek (Cogger 2000).

Occurrence in the study area: No individuals were recorded within the Project area at any of the sites investigated. The Styx River is isolated from the Fitzroy River basin and the species is not known to occur in the area. The nearest records for the species are located 30 km to the west (Mackenzie River) and 30 km to the south-west (Marlborough Creek). Both of these areas lie within the Fitzroy Basin. Given the species is only known to occur in the Fitzroy River basin itis considered unlikely to occur within the Project area or surrounds. The nearest potential habitat for the species based on current information is in Marlborough Creek to the south.

Southern Snapping Turtle (*Elseya albagula*)

Status: Endangered – NC Act, Critically Endangered – EPBC Act

Ecology and habitat: One of Australia's larger turtle species. It is a slow-growing species that reaches maturity between 15 to 20 years old (Limpus 2008). This species prefers clear, flowing and well-oxygenated waters. Like the Fitzroy Turtle it takes in oxygen through cloacal respiration (Clark et al. 2008). The species still occurs in non-flowing waters but at much reduced densities. The young are largely carnivorous feeding on benthic invertebrates. Older individuals become largely herbivorous feeding on fallen fruits from riparian vegetation and aquatic macrophytes (Limpus 2008; Limpus et al. 2011).

Most available females will breed in each successive year. When breeding, the species is known to travel long distances to known nest site aggregations. In recent years the species has been found to be heavily impacted by nesting failure. Most available females will breed in each successive year, however successful incubation of nest clutches has been heavily impacted by stock trampling and predation with close to 100% of eggs lost (Limpus 2008; Limpus et al. 2011). Turtles sampled at multiple study sites across the three catchments indicate a 'severe depletion' of immature turtles (Limpus 2008; Limpus et al. 2011), and therefore little recruitment into the breeding population.

Distribution: Endemic to flowing waters in the Fitzroy, Burnett and Mary River Basins and associated coastal drainage basins in southeast Queensland.

Occurrence in the study area: A single individual was recorded in Deep Creek (site De3) as an incidental capture during the June 2011 survey. No snapping turtles were captured during the 2017 survey. Based on site observations taken in 2017 (when there was no flow in either creek) there are several large pools along Deep Creek north of the highway crossing that appear relatively permanent, although turbid, which may provide long-term habitat for the species, albeit at low densities. Tooloombah Creek appears to provide better habitat for the species due to the lack of turbidity observed in this system and the presence of dry rainforest species in riparian vegetation that may provide seasonal fruits. A substantial (long and deep) and permanent pool exists adjacent to the southern side of the highway.

Estuarine Crocodile (*Crocodylus porosus*)

Status: Vulnerable – NC Act, Migratory – EPBC Act

Ecology and habitat: Their habitat includes marine habitats such as mangroves, but they also commonly occur in freshwater habitats such as rivers, lakes and swamps. Crocodiles have wide and varied diets which differ between habitats. Prey size increases with the size of the crocodile, with the diet of juveniles consisting of smaller prey such as insects, crustaceans and occasionally small mammals such as rats. Larger crocodiles feed on fish, crabs, turtles, birds and mammals including large prey items such as wallabies, pigs, water buffalo, cattle and horses.

Distribution: Widespread throughout northern Australia and its range includes all of the Gulf of Carpentaria and the Queensland east coast south to the latitude of approximately Gladstone.

Occurrence in the study area: There are no Wildnet database records of the species from the wider area. The nearest ALA database records are from the Fitzroy River approximately 50 km south of the Project. During the June 2011 survey evidence of the presence of estuarine crocodiles was observed at two Styx River sites (St1b and St2) and at De2 on Deep Creek. Anecdotal evidence collected at the time suggested crocodiles have occurred in Deep Creek, Granite Creek as well as the Styx River. No evidence of crocodile presence was observed at any of the aquatic ecology sampling sites in February 2017 and in general habitat conditions appeared less suitable for the species i.e. isolated pools largely with steep banks. However, anecdotal evidence collected in May 2017 suggested an individual was resident in the Styx River in the area of site St1. It is assumed for the purposes of the Project EIS that the species is likely to occur.

15.6.3.5 Aquatic Macroinvertebrates

A total of 46 higher taxa were identified from the nine samples collected in June 2011 (Table 15-6). Macroinvertebrates were sampled from riffle habitats along the creeks and edge habitats were sampled on the Styx River sites. The riffle habitats sampled in Deep, Tooloombah, and Granite Creeks had a total of 31 taxa across all the riffle sites. The highest diversity in the riffle habitats was found on Deep Creek (De2) which had 24 taxa. The lowest diversity for any site was found at Tooloombah Creek (site To1) which had 13 taxa present. The edge habitats sampled along the Styx River had higher diversity than the riffle habitats with a total of 35 taxa collected from all edge sites. The highest diversity at any site was found at St1 which had 26 taxa present.

Overall, macroinvertebrate abundance was much higher at the creek sites than those sampled on Styx River which may be a reflection of the sampling regime (riffle vs edge) and / or saline influence at sites on the Styx River.

The most abundant macroinvertebrate taxa at surveyed creek sites were Diptera species, particularly those of the Families Chironomidae (comprising the subfamilies Chironominae, Tanypodinae and Orthocladinae) and Simulidae. Diptera species have the capacity to tolerate a range of water quality conditions including degraded systems (Odume and Muller 2011; Oliveira et al. 2010). Other fauna found across all or most sites included shrimps of the Family Palaeomonidae, Hydropsychidae (caddis flies - Trichoptera), and Caenidae (mayflies - Ephemeroptera).

PET richness is a measure based on the presence of macroinvertebrate taxa considered to have a low tolerance to poor water quality: the Plecoptera (stone flies), Ephemeroptera (may flies); and Thrichoptera (caddis flies). The PET taxa richness value in the riffle habitats ranged between five and nine taxa. In comparison, the number of PET taxa in the edge habitats ranged between three and five taxa. In general all riffle habitats had higher PET taxa richness than Edge Habitats which is expected as sensitive taxa are generally more abundant in riffle habitats than edge habitats (Boulton and Brock 1999).

Signal-2 analyses are based on the presence and abundance of macroinvertebrate taxa, and can be used to infer habitat quality, stream health and potential disturbance. Each macroinvertebrate taxon is assigned a grade between one and 10 with lower grades indicating more tolerance to poor environmental conditions (Chessman 2003; Chessman et al. 2006).

Results from Signal-2 analyses are presented through a quadrant diagram where:

- Quadrant 1 indicates favourable habitat and chemically dilute waters;
- Quadrant 2 indicates high salinity or nutrient levels (could be natural);
- Quadrant 3 indicates toxic pollution or harsh physical conditions; and
- Quadrant 4 indicates urban, industrial or agricultural pollution.

Signal-2 scores were on average higher in riffle habitats than edge habitats, which is somewhat expected given that riffle habitat tends to host a greater number of PET taxa than edge habitat. Edge habitat Signal-2 scores were broadly similar, albeit that data was only recorded for this habitat at three sites. Signal-2 scores ranged from around 6 from Granite Creek (Gr1) to around 4.7 from Deep Creek (De2). This suggests that site Gr1 riffle habitat hosted the highest ratio of the number of pollution sensitive macroinvertebrate taxa to pollution – tolerant taxa and riffle habitat at site De1 the lowest. The reasons for this are not known, but a Signal-2 score of 4.7 is still relatively high and site De1 had a greater number of taxa than expected, which is not intuitively indicative of a degraded habitat.

The Signal-2 scores across the creek sites (Table 15-6) indicated a relatively healthy habitat with five samples occurring in Quadrant 1 (Figure 15-5). The three Styx River sites occur in Quadrant 2 which may be an indication of estuarine influence (higher salinity) at these sites as well as the impact of sampling type (riffle vs edge). Macroinvertebrate sampling in February 2017 produced substantially poorer results with low abundance and generally few taxa apart from one site on Tooloombah Creek (T02). This may be attributed to several factors. The generally poor and dry conditions causing highly turbid pools in Deep Creek and a lack of flow at the time and hence, lack of instream habitat i.e. there was no riffle habitat to sample at the time. Samples were collected from edge habitat only. The 2017 survey was also carried out at a much reduced survey intensity as only a single sample was collected from each edge site compared to three samples collected in June 2011. No samples were collected from the Styx River.

The Signal-2 scores were all low with the majority (excepting To2) occurring in Quadrant 4 indicating polluted waters. However, given the previous 2011 results and difference in conditions at the time of each survey, this is unlikely to be a fair reflection of instream habitat quality for macroinvertebrates.

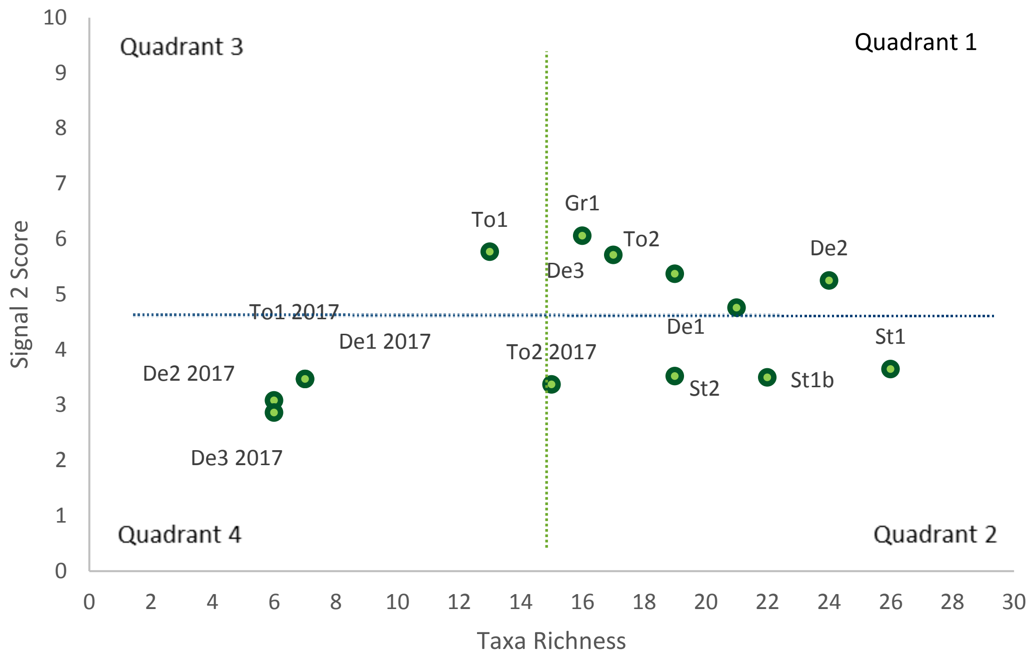

Figure 15-5 Scattergram of signal-2 weighted abundance scores and family richness

Macroinvertebrate habitat condition was measured in terms of the AusRivAS model parameters and associated scores for the 2011 data only. The results are summarised below and presented in further detail in the technical report, as is further multivariate analysis of macroinvertebrate community composition and habitat associations (Appendix A9e – Aquatic Ecology Results).

Under the AusRivAS method the reference condition is defined as 'the condition that is representative of a group of minimally disturbed sites organised by selected physical, chemical and biological characteristics' (Reynoldson et al. 1997). The AusRivAS Model for Coastal Queensland found that nearly all sites had the expected number of macroinvertebrate families expected at a reference riffle site in this area. The only site that failed to have the expected number of macroinvertebrate families was the site To1 which was classified by the model as 'significantly impaired.'

All the edge sites sampled for macroinvertebrates were in similar condition to 'reference condition.' The riffle habitats sampled varied from:

- 'More biologically diverse than reference' (De1, De2, Gr1), meaning taxa richness exceeded the expected number of taxa predicted by the AusRivAS model;
- 'Similar to reference' (De3, To2), where taxa richness is within the range expected at such sites within the model; and
- 'Significantly impaired' (To1), where taxa richness is lower than expected indicating a decline in the health of the river at this location.

These results can be influenced by a range of conditions including the presence of organic pollutants and altered flow patterns, although it could also mean that the AusRivAS model itself requires further calibration, particularly given the macroinvertebrate of the study area has not been subject to much investigation.

Table 15-6 Macroinvertebrate taxa measures for June 2011 and February 2017

Site		De1		De2		De3		St1	St1b	St2	To1		To2		Gr1
Sample		June 2011	Feb 2017	June 2011	Feb 2017	June 2011	Feb 2017	June 2011	June 2011	June 2011	June 2011	Feb 2017	June 2011	Feb 2017	June 2011
Annelida	Oligochaeta	1		2	5	2	2	1						7	
Gastropoda	Bithyniidae								2						
	Corbiculidae							3					1		
	Planorbidae		1				1	1						5	
	Physidae								2						
	Spaeriidae											1			
	Thiaridae							9	12			2	1	1	
Crustacea	Atyidae		6		5		3	4				1		26	
	Palaeomonidae	7		2		2		5	17	9	9		7		1
	Parastacidae	2	1	1										1	
Arachnida	Acari	4		9				1	1	1			2		
Coleoptera	Curculionidae			1											
	Dytiscidae				10		10	4	13	13		4	2	2	
	Elmidae														3
	Gyrinidae			5		6							3		
	Hydrophilidae							1	9	3					
	Hydraenidae	1							1	1					
	Hydrochidae										1				
Hemiptera	Corixidae							7	13	14				4	
	Gerridae			1				1	2	1	1				
	Hydrometridae							1	1						
	Mesovelidae									2					
	Naucoridae							1						1	
	Nepidae							2							
	Notonectidae							11	1	2					
	Pleidae									2					
	Velidae	2		3				1	2	2					
Diptera	Chironominae	13	28	16		8	11	6	1	5	44	53	17	3	1
	Tanypodinae	1	1	4	1			3	1	2					
	Orthocladinae	30	26	31	4	22	7	1	1	1	11	24	24	21	11
	Culicidae								1						

Site		De1		De2		De3		St1	St1b	St2	To1		To2		Gr1
Sample		**June 2011**	**Feb 2017**	**June 2011**	**Feb 2017**	**June 2011**	**Feb 2017**	**June 2011**	**June 2011**	**June 2011**	**June 2011**	**Feb 2017**	**June 2011**	**Feb 2017**	**June 2011**
	Ceratopogonidae				8									6	
	Dolichopodidae	1		6		13							1		
	Simulidae	79		111		57				1	139		113		83
	Tabanidae	1		3		8					1				1
Trichoptera	Leptoceridae	6		8		4		17	9	4			2	1	7
	Ecnomidae													1	
	Hydrobiosidae	3		1		9					5		1		2
	Hydropsychidae	68		85		112				1	92		32		37
	Hydroptilidae			2				1	1		5		3		1
	Calamoceratidae			1											
	Philopotomidae	8		2		6					5		12		77
	Unidentified Trichoptera							1							
Odonata	Gomphidae	1	1			1			2				1	1	1
	Libellulidae	8		7		18		3			10		12		4
	Protoneuridae							2		1					6
Ephemeroptera	Baetidae	20		28		76		2			19		52	3	18
	Caenidae	20		12		8		1	1	1		4	8	1	13
	Leptophlebiidae	8		3		4		3	1						4
Total individuals		284	64	344	33	356	34	93	94	66	342	89	294	84	270
No. of taxa		21	7	24	6	17	6	26	22	19	13	7	19	16	16
Signal 2 score		4.76	3.47	5.25	3.07	5.71	2.85	3.65	3.5	3.52	5.77	3.47	5.37	3.38	6.06
PET richness		7	0	9	0	7	0	5	4	3	5	1	7	4	8

15.6.3.6 Habitat Assessment

Overall, all sampling sites visited in June 2011 as part of the baseline survey were shown to be in a healthy state as evidenced by the generally high water quality results with only marginal exceedances for a few parameters. Cattle access to creeks has the potential to degrade instream habitat conditions through the addition of nutrients from cattle defecation in or close to waterways, increased turbidity through bank erosion and compaction of riffle and edge habitat through trampling, all of which can affect the status of the macroinvertebrate community. In general, the area had very low levels of grazing perhaps due to de-stocking caused by recent drought conditions in the area prior to 2011. Despite this there was evidence of some cattle pugging and droppings in many shallows and riffles, although this did not impact detrimentally on water quality at the time.

Observations from the 2017 survey indicate that substantial cattle access occurs at De2 which likely reflects the poor water quality indicators recorded at this site (refer Table 15-3 and Table 15-4). There was also some evidence of cattle access at To2. The remaining sites appear to be relatively inaccessible for cattle although signs of access by feral pigs was evident at To2 and De4.

Erosion is a major problem in the Styx catchment with many of the soils prone to erosion (Meltzer et al. 2008). Despite this susceptibility, all the 2011 water quality analyses showed very low levels of both turbidity, and suspended solids. Riffles in the Deep, Tooloombah, and Granite Creeks also showed no evidence of siltation from erosion; however, pool habitats in the Styx River did show evidence of sand and silt deposition.

Habitat diversity varied throughout the catchment. The main aquatic habitats noted were rocky pools, sandy pools, rocky runs, sandy runs, riffles, large woody debris, and undercut banks. Rocky pools were found at all sites except one site on Deep Creek (De3), while sandy pools were found at all sites except for Tooloombah Creek (To1), and Granite Creek (Gr1). Rocky run habitats were only found at the Tooloombah sites (To1 and To2). Sandy-gravel runs only occurred on the Styx River at site St1. Large woody debris was found at all sites, indicating there has been little if any de-snagging in the catchment.

All sampling sites within the study area scored highly in terms of physical habitat assessment indicating high structural integrity at both a site and catchment level (refer Table 5-4 in Appendix A9e – Aquatic Ecology Results). This outcome was reflected in the biological and water quality indices which indicated a healthy aquatic ecosystem.

The present habitat condition within the Styx catchment is typically composed of cleared land for grazing with a narrow band of riparian vegetation alongside the creeks and rivers. Despite wide spread erosion throughout the catchment the riparian vegetation was in relatively good condition. Riparian vegetation varied with Deep Creek having medium to large sized *Eucalyptus* and *Melaleuca* species and steep banks that were eroding in some parts of the creek. The shrubs were dominated by Weeping Bottlebrush (*M. viminalis*), the exotic Lantana (*Lantana camara*) and other native sclerophyllous taxa. Along Tooloombah Creek both of the survey sites riparian vegetation along the steep western / northern bank was dominated by rainforest species in close to pristine condition in strong contrast to the right bank which was eroded badly with patchy riparian tree and shrub cover. The riffles at both Tooloombah Creek sites had dense stands of Weeping Bottlebrush.

The Granite Creek site had excellent riparian cover with riffles well shaded and a wide pool that was shaded in parts by large Eucalyptus and Melaleuca trees. The riparian vegetation was relatively poor along virtually all of the Styx River and condition decreased downstream so that at site St2 the majority of riparian vegetation was of Noogoora Burr (*Xanthium occidentale*). It is likely that tidal impact may reduce tree and shrub cover at the lower Styx River Sites.

Noogoora Burr is an annual pest species that is well established along the left bank of the Styx River around site St2. It produces burrs which can tangle in animal coats and produces seeds that are poisonous to stock. Its impact on the riparian vegetation is relatively minor and of nuisance value except to farmers. The main ecological pest weed recorded is Rubber Vine (*Cryptostegia grandiflora*) which is a serious threat to rainforest and in particularly dry-land rainforests. This exotic vine from Madagascar was found along parts of Deep Creek, Tooloombah Creek and the Styx River, as well as the un-named tributary that intersects the northern section of the Project area.

Wetlands

The Project area encompasses a range of natural and artificial wetlands including an ephemeral wetland mapped as High Ecological Value and a Wetland Protection Area. (refer Figure 15-4). This wetland encomapsses approximately 4 ha and was inspected during the February 2017 survey being completely dry at the time. Following heavy rains in late April 2017 the wetland had filled up (Plate 15-1). Cattle were present using the wetland area on both occasions. This community is characterised by a central patch (approximately 2 ha) of Broad-leaved Paperbark (*Melaleuca viridiflora*) surrounded by an open area (subject to inundation). In 2011 a variety of sedges and a sparse cover of of hydrophytes (including *Ottelia ovalifolia*) was present. The wetland is surrounded by intact woodland.

Although the more permanent wetlands, such as farm dams (Plate 15-2) are likely to provide habitat for freshwater turtles and amphibians, it is uncertain to what extent these habitats support strictly aquatic fauna (i.e fish). These habitats are described in more detail in Chapter 14 – Terrestrial Ecology.

Plate 15-1: HEV wetland site within MLs (May 2017)

Plate 15-2: Artificial wetland area within MLs (February 2017)

15.6.4 Groundwater Dependent Ecosystems

While regional-scale hydrogeological systems may provide useful groundwater resources for pastoral or other uses, groundwater also supports surface and subsurface ecosystems, which can themselves be considered to be beneficial users of groundwater resources. The Australian groundwater dependent-ecosystem (GDE) toolbox (Richardson et al. 2011) provides a framework to assist with the identification of GDEs and the management of their water requirements. The toolbox adopts the approach of Eamus et al. (2006) and classifies GDEs based on the role of groundwater in maintaining biodiversity and ecological condition. Three types of GDEs are defined:

- Aquifer and cave ecosystems (Type 1) where groundwater-inhabiting ecosystems (e.g. stygofauna) reside. These ecosystems typically include karst aquifer systems and fractured rock groundwater environments;

- Ecosystems dependent on the surface expression of groundwater (Type 2) including wetlands, lakes, seeps, springs, and river baseflow systems. In these cases, the groundwater extends above the land surface as a visible expression, providing water to support aquatic biodiversity through access to habitat (especially when surface run-off is low) and regulation of water chemistry and temperature; and

- Ecosystems dependent on subsurface presence of groundwater (Type 3) includes terrestrial vegetation which depends on groundwater on a seasonal, episodic or permanent basis in order to prevent water stress and generally avoid adverse impacts to their condition. In these cases, and unlike the situation with Type 2 systems, groundwater is not visible from the earth surface. Type 3 GDEs can exist wherever the water table and capillary fringe is within the root zone of the plants, either permanently or episodically.

There are two sources of information pertaining to the presence of Type 2 and Type 3 GDEs, the National Atlas of GDEs and the Queensland Wetland GDE Layer. The GDE Atlas presents the current knowledge of ecosystems that may depend on groundwater across Australia. The Queensland Wetland GDE Layer presents the current knowledge of ecosystems reliant on groundwater across Queensland. Information pertaining to type 1 GDEs is sourced from existing field survey data. Field surveys undertaken for the Project, while not specifically targeting GDEs, have provided ground-truthing of desktop information including identification of any additional flora and fauna values associated with GDEs.

The identified potential GDEs are shown in Figure 15-6. The results are summarised in the following sections. Further detail is provided in Appendix A6 - Groundwater Technical Report.

15.6.4.1 GDEs – Mine Area

GDEs Reliant on the Surface Expression of Groundwater (Type 2)

The GDE Atlas identifies potential GDEs that are reliant on the surface expression of groundwater (Type 2 GDEs) along extensive reaches of water courses both within and marginal to the Project area (i.e. Styx River, Tooloombah Creek and Deep Creek). Most of these potential Type 2 GDEs are classified as having high potential for interaction with groundwater.

Site observations during dry season sampling suggest tributaries of the Styx River are ephemeral upstream of the confluence of Deep Creek and Tooloombah Creek. However, a field survey in February 2017 identified several pools of water in localised depressions (i.e. at sites De1, De2, De4, To1 and To2) along small reaches of the two creeks that appear to be perennial, indicating that they are potentially groundwater fed. Downstream of the confluence, Styx River is identified as being tidally dominated based on short term water level variations and elevated electrical conductivity measurements (refer to Chapter 9 - Surface Water). These observations suggest that any Type 2 GDEs near the Project area are likely to limited to the localised pools.

The Queensland Government WetlandInfo also shows small areas of riverine, freshwater bodies along Styx River and Tooloombah Creek but the extents of these areas are much smaller than the extent of potential Type 2 GDEs identified by the GDE Atlas. Of particular note, is the HEV wetland that has been identified on the western side of the Project area, which is classified by the GDE Atlas as a potential Type 2 GDE with a high potential for groundwater interaction. However, observations during two field surveys in 2017 suggest that surface water in the wetland (when present) is rainfall dominated. For example, the wetland was dry in February 2017 but was subsequently inundated (Plate 15-1) after heavy rainfall associated with Severe Tropical Cyclone Debbie, which was active in April 2017. Groundwater levels measured in bores near the HEV wetland have also been observed to be approximately 9-10 m bgl (refer Chapter 10 – Groundwater), further indicating that the wetland is unlikely to be an area of active groundwater discharge. This wetland is discussed further in the following section as a potential Type 3 GDE.

It appears that the presence of Type 2 GDEs will be confined to the riverine environments of waterways (Styx River, Tooloombah Creek and Deep Creek) associated with the Project surrounds. Wetlands away from riverine environments are likely not to be connected to the groundwater system. The shallow alluvial aquifers will likely be the dominant source of groundwater for Type 2 GDEs in the area.

GDEs Reliant on the Sub Surface Expression of Groundwater (Type 3)

The GDE Atlas identifies potential GDEs that are reliant on the subsurface expression of groundwater (Type 3 GDEs) along the drainage lines (i.e. riparian zones) associated with Styx River, Deep Creek and Tooloombah Creek (Figure 15-6). At least three of the REs mapped in these areas during field surveys (refer to Chapter 14 - Terrestrial Ecology) have the potential for incorporating some component of groundwater in their water requirements. These include:

- Forest Red Gum woodland fringing drainage lines (RE 11.3.25) – occurs along riparian areas of drainage lines, largely outside of the Project boundary. Vegetation is dominated by Forest Red Gum and Weeping Tea Tree;

- Forest Red Gum woodland on alluvial plains (RE 11.3.4) – occurs in patches across the eastern side of the Project area where it is associated with the alluvial plains adjacent to Deep Creek. Vegetation is dominated by Forest Red Gum, Poplar Gum with Carbeen;

- Poplar Box (*Eucalyptus populnea*) on palustrine wetland (RE 11.5.3b) – this community occurs as an isolated community on a natural depression on the western side of the Project area (i.e. the HEV wetland). The community is characterised by a patch of Broad-leaved Paperbark with a variety of low sedges and forbs on the margin, and hydrophytes in the centre when surface water is present; and

- Areas of semi-evergreen vine thicket occurring adjacent to riparian areas of Tooloombah Creek and Deep Creek.

Of the four vegetation communities, the two Forest Red Gum communities (RE 11.3.25 and RE 11.3.4) and Weeping Tea Tree dominated wetland are most likely to be utilising groundwater in their water use because of the relatively shallower groundwater levels (approximately 2-5 m bgl) (refer Chapter 10 – Groundwater) observed in the alluvial sediments on the margins of the drainage lines. However, these groundwater level measurements were recorded at bores located 1-2 km north of the Project area, where groundwater levels are generally shallower, and no data exist for groundwater levels of alluvial sediments closer to the Project area. In the absence of actual groundwater data, the presence of water tables within the shallow alluvial sediments interacting with the rooting system is considered very likely, and suggests the classification of high potential of groundwater interaction of riparian vegetation to the east of the mine area as appropriate.

The GDE Atlas also identifies areas of potential Type 3 GDEs with low to moderate potential of groundwater interaction on the southwestern margin of the Project area. Measured groundwater levels in these areas have been observed to be approximately 10-12 m bgl (refer Chapter 10 – Groundwater). Groundwater levels have been observed to be even deeper (i.e. approximately 25 m bgl) further away from the southwestern edge of the Project area. Although, these observations do not preclude deep-rooted plant species from potentially using the underlying groundwater, it is likely that groundwater is only a small component of water use during periods of limited soil water availability (i.e. droughts).

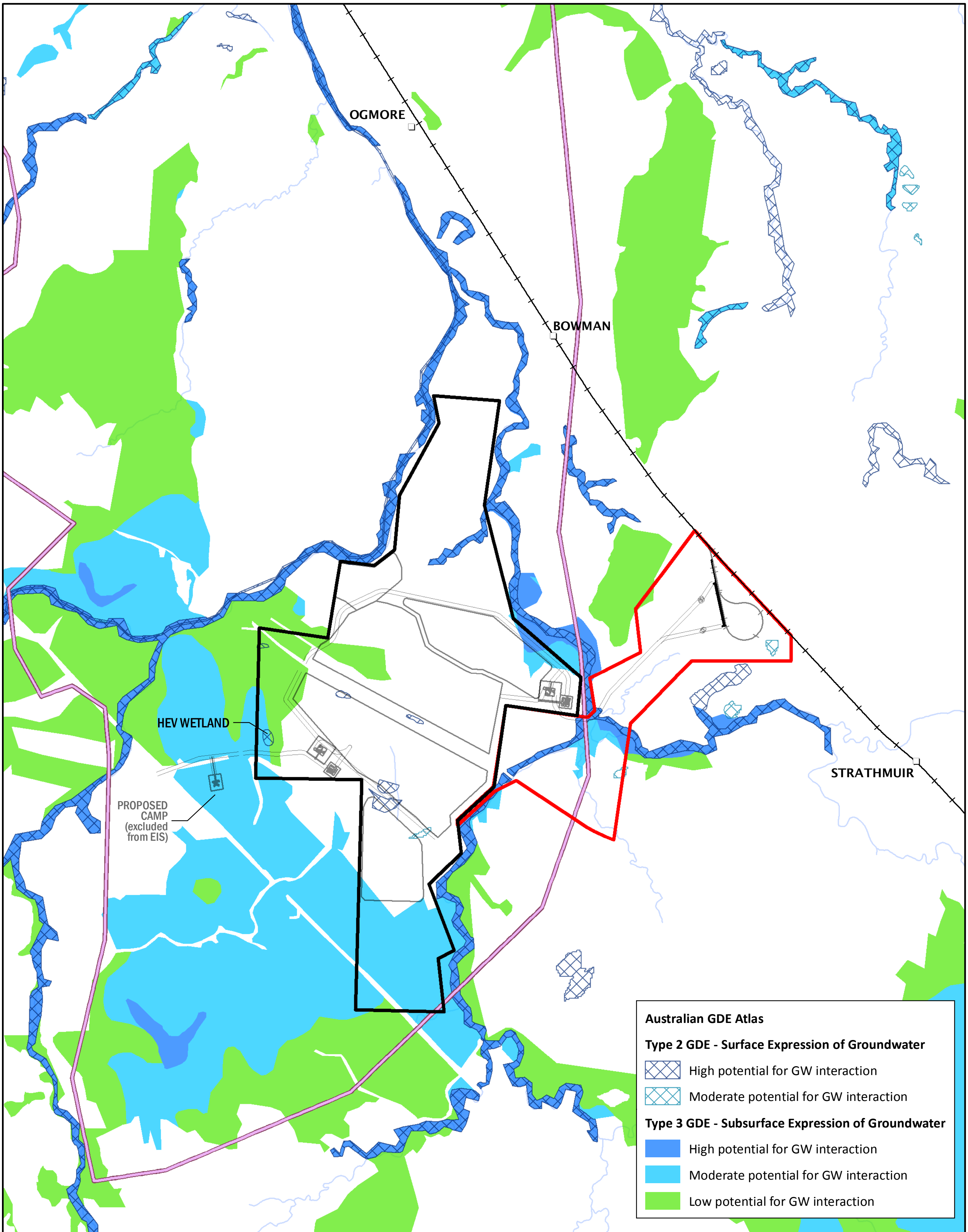

Figure 15-6
Groundwater dependent ecosystems

N
0 0.5 1 km

Legend
- ML 80187
- ML 700022
- Styx Basin
- Proposed mine infrastructure
- Watercourse

Scale @ A4 1:80,000
Date: 21/07/17
Drawn: Gayle B.

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

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15.6.5 Stygofauna Assessment

The following assessment is informed by a desktop review and field studies carried out onsite by GHD Water Sciences in November 2011 and March 2012. The full report is located in Appendix A9f – Stygofauna Results.

15.6.5.1 Desktop Assessment

Stygofauna may be found in a variety of geological formations including: unconsolidated sediments associated with alluvial deposits; limestone karsts; porous sedimentary rocks such as sandstone; and fractured rocks composed of volcanic rocks, metamorphic rocks or limestone permeated with cracks, faults and other voids. Stygofauna require permanent groundwater and are a sign of the long-term residence of a groundwater aquifer. Most stygofauna communities occur close to the surface in shallow aquifers as they rely on connections to the surface to provide food. However, they may occur in any aquifer with sufficient hydraulic connection to the surface allowing food and oxygen transport to the groundwater table.

Stygofauna distribution in eastern Australia is correlated with temperature, specific conductivity, proximity to the water table, the roots of vegetation in the hyporheic zone (the saturated soil and sediment below and adjacent to waterbodies), coarse sediments and hydraulic conductivity (Hancock and Boulton 2008). The preferred conditions for stygofauna habitat are summarised from several Australian studies in Table 15-7.

Table 15-7 Preferred conditions for stygofauna

Parameter	Conditions conducive to stygofauna
Aquifer geology	Cavities, fractures or intersects
Depth to groundwater	Within 0 to 21 m below ground level (bgl)
Groundwater conductivity	Largely under 3200 μScm^{-1}
Groundwater pH	Majority found at pH 6.7 to 7.37; however, species found at pH 4.3 to 8.5

Source: Hancock and Boulton 2008

Geographical extent of stygofauna species is often poorly known and many species are only known from a single area. As a result, there is only a limited amount of publicly available information which is largely restricted to occurrence data and rarely identifies fauna beyond the level of genera (that is to species level) and often only to Family level.

For instance, a species of Parabathynellidae was recorded from three bores in the Burdekin River Alluvial Aquifer in Queensland, with two of these bores located approximately 20 km apart (Cook et al. 2012), suggesting a potential distribution of approximately 400 km^2. Additionally, studies in both Western Australia and Queensland have found evidence that sub-catchment boundaries can demarcate locations of turn-over of stygofaunal species (Finston et al. 2007; Little et al. 2016). Therefore, areas of approximately 400 km^2 to 600 km^2 within a single sub-catchment may represent reasonable estimates of distribution of most stygofaunal species, acknowledging that site-specific factors (e.g. highly confined aquifers) may impose further restrictions on distribution in some cases, or create strong population subdivision within species on smaller spatial scales (Cook et al. 2012; Little et al. 2016).

Stygofauna have the potential to occur in aquifers composed of any geological unit with sufficient pore space to complete their life cycle (Tomlinson and Boulton 2008). Consequently, stygofauna are less likely in geological units with relatively small pore spaces, such as those dominated by mudstone, siltstone and clays. Preliminary discovery rates of stygofauna in Queensland indicate that:

- No stygofauna have been recorded in mudstone and siltstone to date;
- Stygofauna are less common in clay, coal and basalt dominated geologies; and
- Stygofauna are most common in alluvium, granite, gravel, sand, sandstone, silt, and volcanic geological units (Glanville et al. 2016).

The majority of stygofauna tend to be small crustaceans. Approximately 40 species of stygofauna are currently known to occur within Queensland (ALS 2010). Four stygofauna taxa have been previously identified within the Bowen Basin (one Copepod, one Amphipod and two Bathynellacea species) in a study by Hancock and Boulton (2008).

The majority of studies in the Bowen Basin are a result of requirements under EIS ToR which do not require identification below the classification level of Family or Order. As a result, the endemism of the groundwater fauna of the region is poorly known despite widespread sampling.

A review of 13 groundwater studies carried out in the Bowen Basin found 12% of samples (15 of 127 sites) contained stygofauna (4T Consultants 2012). The majority of these were collected in alluvial (shallow) aquifers. In alluvial aquifers in eastern Australia the average number of stygofauna taxa was higher within 6 m of the water table, and where the water table was less than approximately 15 m below the ground (Hancock and Boulton 2008). Other studies have shown similar results, with a statistically lower diversity of stygofauna in deeper aquifers than shallow aquifers (Halse et al. 2014). All of the specimens collected in the Hancock and Boulton Study (2008) were collected from alluvial or shallow sedimentary aquifers, although other types of aquifer (including coal seam aquifers) were not sampled. Such aquifers are hydraulically and ecologically connected to terrestrial ecosystems. The degree of connectivity to other habitats is crucial to the presence of stygofauna, as it allows the transfer of materials, energy and pathways for faunal dispersal (Eberhard et al. 2009). Nevertheless, in Queensland, stygofauna have been recorded from over 60 m below ground (Glanville et al. 2016), indicating that deep groundwater ecosystems can also support stygofaunal communities.

The stygofauna community of coal seam aquifers is poorly known with little published data. GHD (2012) reports a total of eight taxa collected during sampling from coal seam aquifers across Queensland including: four species of water mites (Arachnida), two Copepods, one Amphipod, and a syncarid crustacean of the Bathynellacea order (*Notobathynella* species). Two of these (one each of Amphipoda and Copepoda) were collected from a site in the northern Bowen Basin (GHD 2012).

There is no readily available data related to stygofauna in the region surrounding the Central Queensland Coal Project area. Within the catchment of the Fitzroy River basin the majority of stygofauna surveys have failed to find any taxa, particularly where high salinity groundwater occurs (see AARC 2010). Nevertheless, stygobite taxa (obligate groundwater aquatic fauna) have been found in several shallow aquifers within the Fitzroy River basin (frc environmental 2013).

15.6.5.2 Description of Project Area Aquifers

The Project is in a geological basin comprising early-Cretaceous sediments and coal measures and is referred to as the Styx Basin. The infill sediments of Styx Basin are known collectively as the Styx Coal Measures.

Prior knowledge of the aquifers in the area appears relatively poor. The Bureau of Meteorology's (BoM) National Groundwater Information System reports the Styx River Basin lies outside of declared groundwater management areas, including alluvial aquifer boundaries declared by the DNRM. The BoM database lists the purposes of all bores located within Styx catchment as "unknown." A bore census conducted for the Project in 2011 found that most landholder bores are used for stock watering, with some domestic use (Styx Coal and Fairway Coal 2012). The Groundwater Cartography product of the Australian Hydrological Geospatial Fabric classifies the Styx River Basin as an "unknown" water table aquifer. The shallow hydrogeological units containing the water table are shown to consist mainly of Cenozoic alluvium within surface drainage areas and associated slopes, and fractured rock outcrops along ridgelines and higher areas between the alluvial deposits.

Hydrogeological modelling of the aquifers and the underlying groundwater conditions that occur in the mine area is provided in Chapter 10 – Groundwater. At the broadest level, the basin contains usable groundwater supplies in shallow water-table aquifers that are hosted in the Cenozoic surface deposits, particularly within the alluvial sediments associated with surface drainage, and within fractured and weathered zones of outcropping Cretaceous rocks (Styx Basin) and older Permian rocks. shallow unconfined groundwater flow in Cenozoic sediments and fractured and weathered rocks within Styx River Basin is driven by diffuse groundwater recharge from rain falling within the basin.

The deeper sediments underlying the Cenozoic surface deposits and below the zone of surface fracturing and weathering have much smaller permeability and are not known to yield useable groundwater supplies.

Twenty exploration bore holes were drilled within the Project area boundary targeting the Styx Coal Measures (25 to 100 m hole depth). A coal seam will not generally be classified as an aquifer because of its low hydraulic conductivity; however, within a sequence of coal seams and typical interburden rocks—such as claystone and shale— coal seams are sometimes referred to as 'aquifers' because they are more permeable than the much less-permeable interburden layers (IESC 2014). A further three drill holes are located south of the Project area (Neerim 1, 2 and 3) and a single drill hole is located to the north (Riverside 2) (refer Figure 15-2).

Six landholder bores across the wider area to the north of the MLs were also selected for sampling groundwater and stygofauna. All of the bores are located within, or at the fringes of the mapped Cenozoic deposits which indicates the bores are targeting alluvial groundwater, and possibly groundwater supplied through fracture zones in adjacent and underlying rocks.

Information on the groundwater quality in deeper rocks was limited at the time of the initial works carried out for the Project. Therefore, the precautionary principle was applied and it was considered there was a moderate potential for stygofauna to occur in the Project area given the dominance of shallow aquifers in the area.

15.6.5.3 Field Assessment

Forty samples from 30 different bores were assessed during the surveys for the presence of stygofauna by GHD Water Sciences in November 2011 and March 2012. Eighteen of the bores are located within, or on the boundary of the mine ML and the potential area of predicted groundwater drawdown related to the Project (refer Figure 15-7 and Appendix A6 – Groundwater Technical Report). Of the additional bores, nine are located outside of the likely area of groundwater drawdown impact and may therefore be considered as 'control' survey sites. All of the sampled bores are relatively shallow with the deepest water depth recorded being 16.6 m below ground level.

Groundwater Quality

Average groundwater quality differed between November 2011 and March 2012 (Table 3 in Appendix A9f - Stygofauna Results). In March 2012 pH was generally lower than recorded in November 2011 (by 0.7 of a pH unit), EC was slightly higher (by 800 µS/cm), dissolved oxygen lower (by 7.5% or 0.6mg/L) and water temperature was higher (by 0.4oC). The March 2012 sampling event was preceded by a significant rainfall event across the Styx catchment which lasted a number of days. The data reflects the generally variability in water quality both spatially and temporally across the wider area.

The pH across all groundwater bores was slightly alkaline with mean values of 8.16 in November 2011 and 7.47 in March 2012. These elevated pH values are supported by historic data (YEATS 2011) which shows average pH levels from registered well records in the proximity to EPC 1029 of between 7.5 and 7.7. The highest pH recorded from the current study was 9.77 which occurred at site Stx 105 in November 2011 and the lowest pH was recorded at site Plainvue 1 (6.03) also in November 2011.

Historic data (YEATS 2011) showed average groundwater conductivity levels from registered well records across the wider area range between 1,580 µS/cm (Quaternary alluvium) and 8,000 µS/cm (unconsolidated / consolidated material on terraces and lower slopes). This is in agreement with the data collected during the survey which showed mean values ranging from 6,275 µS/cm in November 2011 to 7,085 µS/cm in March 2012 (Table 3 in Appendix A9f – Stygofauna Results). Ranges in conductivity also reflected the extreme variability in water quality across the survey area with the lowest conductivity recording of 377 µS/cm occurring at site Neerim 2 in November 2011 and the highest EC recording of 30,237 µS/cm occurring at site Plainvue 1 in March 2012. Stygofauna have been reported as preferring an EC concentration of generally less than 5,000 µS/cm and preferably less than 1,500 µS/cm (Boulton and Hancock 2008). Of the groundwater bores sampled for stygofauna across November 2011 and March 2012, 24 bores recorded conductivity concentrations below 5,000 µS/cm and 5 bores recorded concentrations below 1,500 µS/cm.

An updated analysis of current groundwater conditions informed by recent data collected for the Project is located in Chapter 10 – Groundwater.

Stygofauna Presence

Two of the sites surveyed (Riverside 1 and Granite Vale Old Windmill) registered one species at each site in November 2011. Four sites registered five species in March 2012 (Riverside 1, 3 and Well bores and STX 093) (Table 15-8). A total of seven species were collected. The Riverside bores are all located in a concentrated area approximately 8 km north of the MLs. The Old Windmill bore is 13 km northwest of the MLs boundary. The Project specific bore (STX 093) is located on the eastern boundary of the Project area close to Deep Creek (Figure 15-7). Both species can be classed as stygofauna, including obligate groundwater species associated with the hypogean and permanent hyporheic environments (Table 15-8).

Table 15-8 Stygofauna sampling data

Bore site	Sample date	No. of species	Order	Family	Genus	Life habit
Riverside 1	Nov 2011	1 (single individual collected)	Oligochaeta	Capilloventridae	*Capilloventer*	Stygobite
Riverside 1	Mar 2012	1 (single individual collected)	Oligochaeta	Naididae	*Nais*	Stygobite
Granite Vale Steel (Windmill)	Nov 2011	1 (two individuals collected)	Copepoda	Cyclopoidae	Unknown	Phreatobite
STX 093	Mar 2012	2 (one individual and five indivduals collected)	Collembola	Entomodryidae	Unknown	Edaphobite (not stygofauna)
			Astigmata (Class: Acari)	Unknown	Unknown	Stygophile
Riverside Well	Mar 2012	1 (single individual collected)	Oligochaeta	Enchytraeidae	Unknown	Stygobite
Riverside 3	Mar 2012	1 (four indivduals collected)	Syncarida	Parabathynellidae	c.f. *Notobathynella*	Phreatobite

A total of five sites recorded the presence of subterranean fauna with four sites recording subsurface species which can be classed as stygofauna, including obligate groundwater species associated with the hypogean and permanent hyporheic environments. Stygofauna are grouped into one of several classes based on the degree of requirement for subterranean life (Tomlinson and Boulton 2008). Edaphobites are deep soil dwelling (or endogean) species that frequently display troglomorphisms and may sometimes occur in caves. These animals are not classified as stygofauna and the taxa detected at STX 093 is not considered further. For the purpose of this survey, three classes of stygofauna are considered:

- Stygobites are obligate groundwater aquatic fauna with specialised adaptations to underground life and that live within groundwater systems for their entire life;
- Stygophiles are facultative subterranean species, able to complete their whole life cycles both underground and on the surface. Stygophilic species often have populations above and below ground, with individuals commuting between them; and
- Phreatobites are stygobites (obligate subterranean species) restricted to the deep groundwater substrata of alluvial aquifers. All species within this classification have specialised morphological and physiological adaptations.

The shallow water table levels within the riverine bores (Riverside Well, Riverside 1, Riverside 3 and Granite Vale Old Steel Windmill 1) and the presence of Bathynellacea, Syncarida, three families of Oligochaeta and Copepoda suggests a fine to moderate grained unconsolidated alluvial aquifer with direct association / connectivity of the baseflow river system with an interconnected hyporheic zone (Boulton et al. 2008) and moderate to high water quality.

Stygobite Fauna

The hyporheic zone of a river is characterized by being nonphotic, exhibiting chemical / redox gradients, and having a heterotrophic food web based on the consumption of organic carbon sourced from surface waters (Feris et al, 2003). The subsurface fauna collected included three species and families of Oligochaeta. Although occurring within the subterranean environment these three groups have their highest biodiversity within the riverine, hyporheic zones and are classed as members of the "permanent hyporheos' or the community that occurs within the shallow to deep sand and gravel beds associated with areas of groundwater discharge. They typically characterize the transition zone between the permanent shallow hyporheic ecozone and the groundwater hypogean environment (Gilbert et al. 1994).

The Riverside 1 site contained a single Oligochaeta specimen belonging to the family Capilloventridae. This finding suggests that the stratum was a fine to moderate grained unconsolidated substrate with a strong connection to the river as the freshwater species of this family have only been recorded from baseflow sandy bed streams associated with riverine hyporheic zones (Pinder and Brinkhurst 1994). The Capilloventridae is a relatively rare aquatic Oligichaete family that has only previously been recorded in Australia from NSW and Victoria, and one species in south-west WA. As there is almost nothing known of their biology or ecology, little can be said of their environmental requirements except to say that they are found in environments with high water quality and porous sediments.

Stygophile Fauna

Site Stx 093 recorded the presence of water mites. There is little known of the biodiversity and distribution of water mite fauna in Queensland. They have been described by Smit (2007), as typically having a high diversity, and can reach high densities in the substrates of streams and rivers. This taxa has been commonly found in groundwater ecosystems elsewhere in the Bowen Basin (frc environmental, unpublished). The distribution of individual species (morphospecies) within this taxa may be geographically restricted within the Bowen Basin as they are stygobiont, but is likely greater than the survey area.

Phreatobite Fauna

The presence of the obligate groundwater fauna characterised by the Syncarida (Riverside 3) and Copepoda (Granite Vale Old Steel Windmill 1) is an indicator of a permanent flow of water through the interstitial spaces these taxa inhabit. Other interstitial species can be found in both the permanent hyporheic and hypogean whereas the Syncarid and Copepod belong intrinsically to the hypogean (true groundwater) ecosystem. Cyclopoida represent a common group of stygofauna found in association with riverine alluvial aquifers with a strong connectivity between the aquifer and the river (Gibert et al. 1994).

The absence of stygofauna from the remaining groundwater bores sampled for this Project does not indicate that they are not present in the aquifers sampled, rather, it may be due to unsuitable geological conditions (low porosity, low hydraulic conductivity), poor water quality (e.g. high EC or presence of other toxicants) or sampling from a recently drilled bore that has yet to stabilise and attract stygofauna (reduced likelihood of collection).

The results of the two surveys carried out show the majority of the stygofauna community were recorded in the alluvial aquifer associated with the Styx River and located more than 8 km away from the boundary of the Project area. A single taxa (five individuals) was collected adjacent to the Project boundary and Deep Creek. It is; however, considered very unlikely this species will be restricted to the predicted zone of impact (related to groundwater drawdown) from the Project which is relatively minor in overall area. Given the results detailed in Table 15-8 it is considered highly unlikely this morpho-species is restricted to the predicted zone of impact related to the Project.

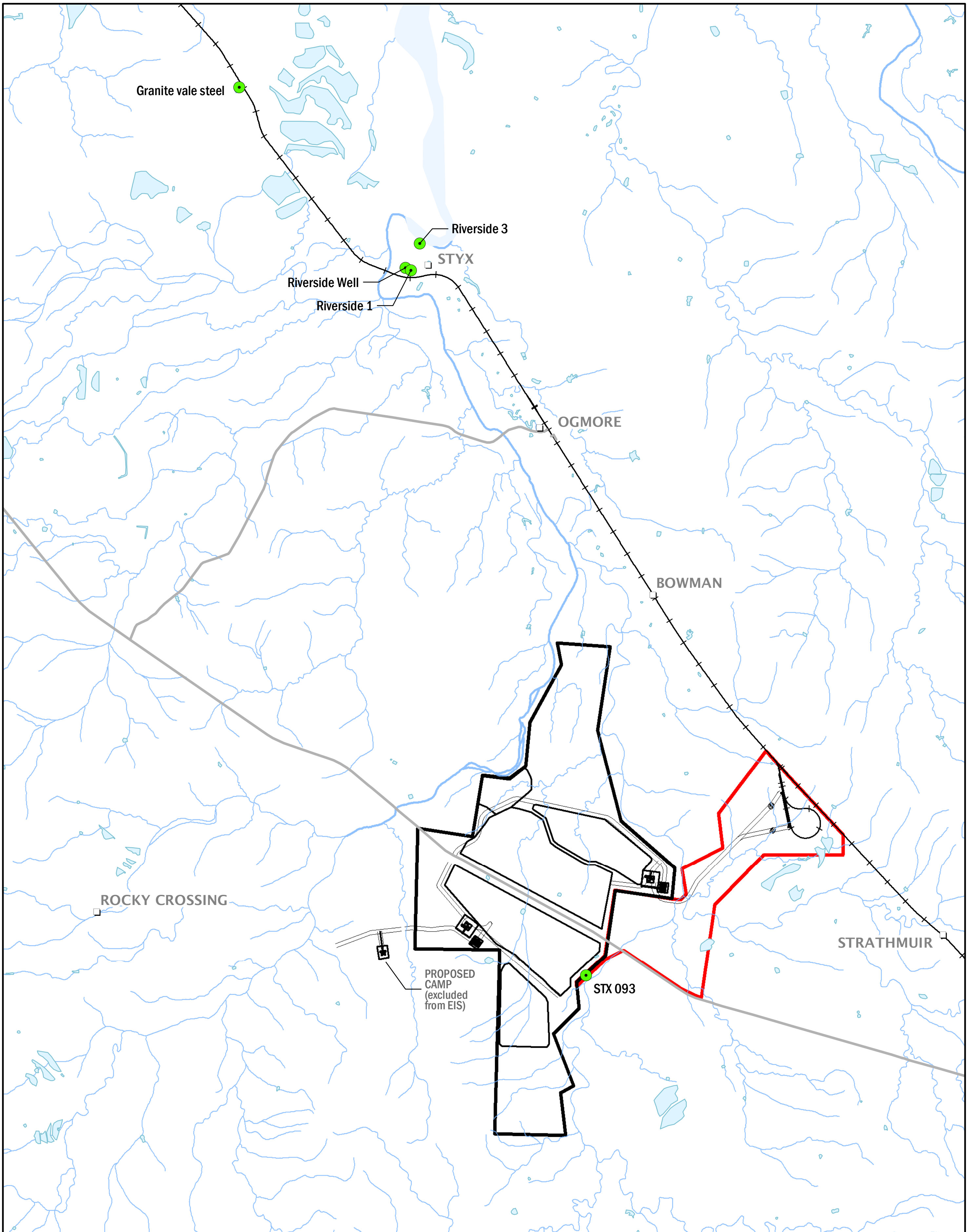

Figure 15-7
Stygofauna locations – (November 2011/March 2012)

N
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Scale @ A4 1:100,000
Date: 24/07/17
Drawn: Gayle B.

Legend
- Stygofauna sampling location
- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Major watercourse
- Minor watercourse
- Reservoir

DATA SOURCE
QLD Department of Environment and Heritage Protection, 2016;
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\Chapter 15 Ecology\BES150160.01 R2 stygofauna locations - Nov-Mar-figure 15-7.mxd 7/24/2017

15.7 Potential Impacts on Environmental Values

The Project has the potential to impact aquatic EVs, including threatened fauna, wetland-associated vegetation communities and other aquatic EVs within the Project area. These include:

- Remnant vegetation (including riparian communities associated with watercourses in the Project area);
- Populations of threatened aquatic fauna – Southern Snapping Turtle and Estuarine Crocodile;
- Habitat for aquatic fauna including natural or man-made wetlands, stream habitat and GDEs;
- Ecological functioning (e.g. riparian habitat connectivity, surface water flow diversions, and flood harvesting); and
- Groundwater drawdown impacts to GDEs and stygofauna communities.

Throughout the construction, operation and decommissioning phases, the Project has the potential to impact on these ecological values through the following activities:

- Removal of remnant vegetation for the mine infrastructure, environmental dams, coal conveyor, waste rock dump areas, TLF and site access and haul roads (refer Figure 15-8);
- Topsoil stripping;
- Construction of open cut pit areas; and
- Stockpiling and transportation of the coal resource by vehicle and conveyor.

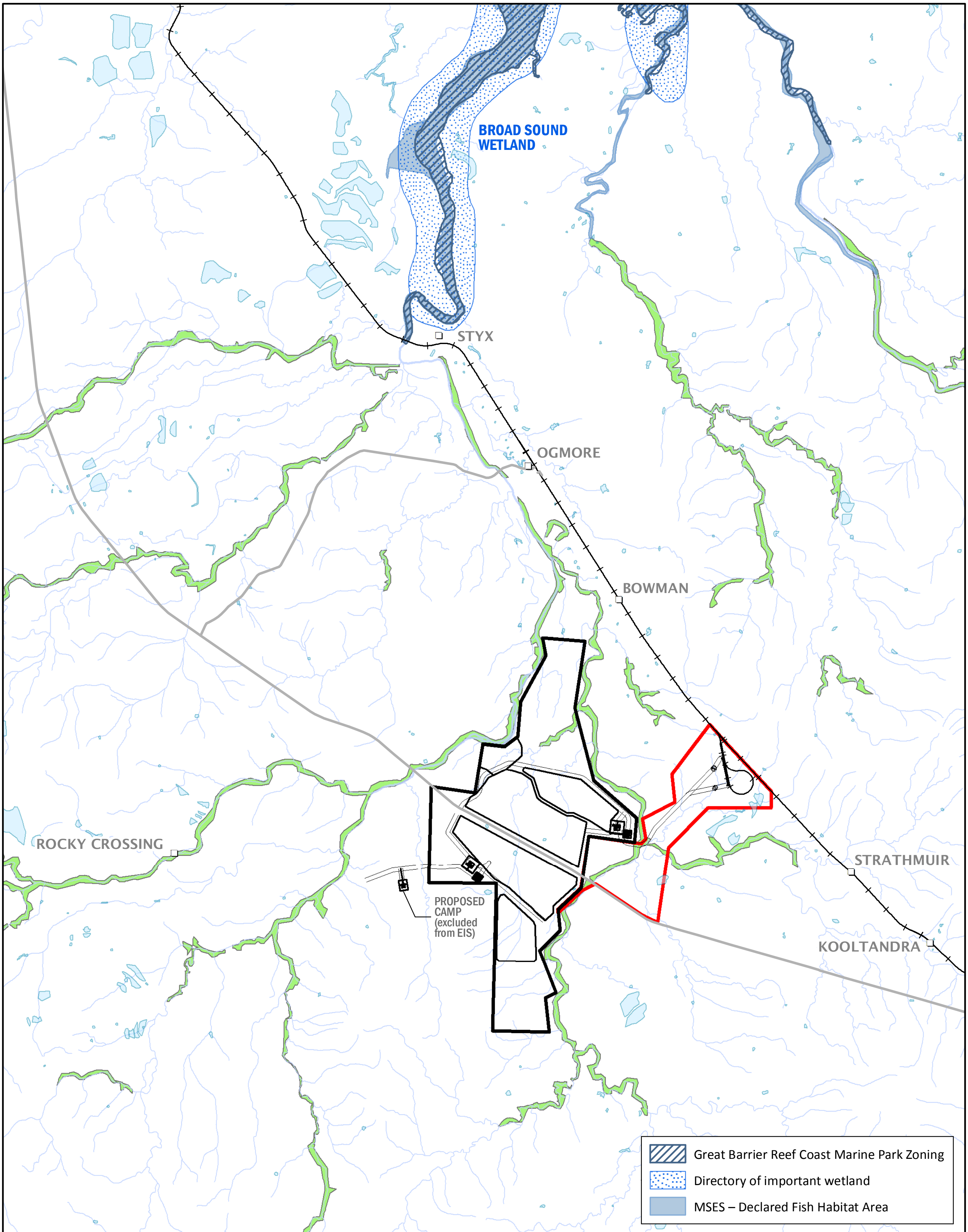
15.7.1 Vegetation and Wetland Clearing

The Project will require the clearing of remnant vegetation for construction of the open-cut mine pits, spoil dump areas, dams, coal conveyors, haul roads and train loadout facility. The layout of the proposed mine, associated infrastructure and the existing remnant vegetation on the site is depicted in Figure 15-8.

The Project will result in clearing of riparian habitat (RE 11.3.25) for the coal conveyor system and haul road along Deep Creek and Barrack Creek. Riparian habitat along a minor tributary of Deep Creek located north of the highway will also be impacted as it lies within the footprint of the Open Cut 2 area and the raw water dam, although this waterway is minor and degraded with a narrow riparian zone surrounded by cleared lands (Figure 15-8).

Remnant riparian vegetation may provide habitat values for aquatic fauna such as shading, bank stability and inputs of instream leaf litter, fallen woody debris and seasonal fruits. There is potential for additional impacts including extended in-stream sediment loads (turbidity) (Crerar et al. 2010), and further riparian vegetation loss and degradation due to bank instability as a result of construction activity at creek crossings.

Two wetlands mapped as matters of state environmental significance (MSES) are located within the site including a single WPA mapped as a HEV wetland (under the ACA), occurs in the western portion of the site. At this stage, no Project infrastructure will intersect the 500 m buffer area applied to this site under the map of referable wetlands. The second wetland located in the western portion of the site will be cleared for the mine pit dewatering dam.



Legend

- Remnant Vegetation (DNRM) RE 11.3.25
- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main Road
- Major watercourse
- Minor watercourse
- Reservoir

0 1 2 km

Scale @ A4 1:125,000
Date: 21/07/17
Drawn: Gayle B.

Figure 15-8
Mine infrastructure layout and existing aquatic values

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\Chapter 15 Ecology\BES150160.01 R1 existing aquatic values-figure 15-8.mxd 7/21/2017

15.7.2 Aquatic Habitat Connectivity

Aquatic habitat connectivity may be disturbed as a result of the Project largely by the potential for obstructing movement of aquatic fauna across Deep Creek and Barrack Creek as a result of the haul road crossing. A minor tributary of Deep Creek within the northern portion of the Project area will be heavily impacted by construction of the raw water dam and Open cut 2 mine area, although it is uncertain whether fish occur in this creek line given it is already heavily disturbed. Site observations during dry season sampling in February 2017 confirm the tributaries of the Styx River are ephemeral upstream of the intersection of Deep Creek and Tooloombah Creek. The only water observed in February 2017 was restricted to isolated, small turbid pools. Deep Creek and Barrack Creek are ephemeral due to the relatively small catchment providing inflows. Flowing conditions were observed during surface water quality investigations in May 2017 following heavy rains in the previous month. A subsequent survey in June recorded no flow and a relatively small and shallow pool at the site of the proposed crossing of Deep Creek.

The Project lies on a relatively flat plain. Flood modelling indicates the Project is unlikely to directly or indirectly increase water velocities within waterways or waterway diversions (refer Chapter 9 – Surface Water) to a level that would prevent fish movement through a structure downstream of the Project area.

15.7.3 Direct Fauna Mortality

Direct mortality of aquatic fauna may occur as a result of the Project during construction works associated with creek crossings and clearing of wetlands / dams. Mortality during riparian habitat clearing and instream works will be managed through the presence of a qualified fauna spotter.

15.7.4 Dust

Increased dust resulting from excavations, topsoil stripping, vehicle movement, open-cut mining activities, construction of infrastructure, coal transport (by road and conveyor) and from coal stockpiles has the potential to impact local flora and fauna values within the Project area throughout construction and operation. Increased dust can result in adverse impacts on plant photosynthesis and productivity (Chaston and Doley 2006), changes in soil properties ultimately impacting plant species assemblages' (Farmer 1993), and mortality and / or decrease in aquatic health on aquatic communities from the toxicity of poor water quality.

The predominant wind directions from the region are as follows: from the north and northeast during spring; north, northeast and southeast during summer; in autumn, the winds are primarily from the southeast; and southerly and southeast winds are more frequent during the winter season (refer Chapter 4 – Climate for more information). Vegetation along Tooloombah Creek and Deep Creek in the vicinity of the Project area has potential to be impacted during construction works for infrastructure (such as access roads and the conveyor), the CHPP / MIA 1 area, and the raw water dam which is located less than 1 km to the south-east of the creek (refer Figure 15-8). Dust impacts during operation may result from activities such as open cut mining, haul and access road use, coal conveyor activity, and from the spoil dump areas. Open Cut 4 is located adjacent to Tooloombah Creek. The larger mine areas (Open Cut 1 and 2) are between 1.2 km and 1.5 km south-east of Tooloombah Creek. The northern waste rock dump is located approximately 200 m east of the creek.

There may be some potential for dust impacts on Deep Creek due to its proximity to mine infrastructure. Deep Creek is located approximately 250 m from the eastern edge of Open cut 1 and the southern waste rock dump. The south-eastern corner of the Open Cut 2 is located 500 m away from Deep Creek and the adjacent waste rock dump is located between 300 m and 400 m from the creek. The northern CHPP / MIA 2 is located approximately 250 m from Deep Creek. The coal conveyor runs adjacent to Deep Creek for approximately 1.3 km including utilising the existing highway bridge. Coal dust spill over from the conveyor may impact the adjacent waterway and riparian vegetation.

The haul road also crosses Deep Creek and Barrack Creek, although there are no large, permanent pools on either creek at, or near, the proposed haul road crossing points. Dust emitted during coal transport may have a minor potential to impact riparian vegetation associated with the creeks where they occur adjacent to the haul road. Refer to Chapter 12 – Air Quality for further information.

15.7.5 Pests and Weeds

Pest and weeds pose one of the most significant threats to aquatic flora and fauna within and adjacent to the Project area. Much of the riparian habitat associated with the creek lines already contains infestations of introduced weed species, particularly Lantana and Rubber Vine. Olive Hymenachne is a semi-aquatic grass species that may infest and choke wetlands and waterways was observed in a farm dam in February 2017 and within a wetland gilgai in May 2017, but not along any creek lines. Parthenium is toxic to cattle and was only observed growing on the bed of Tooloombah Creek at To2. No other infestations of this species were observed within the Project area. All of these weed species are listed under Queensland's Biosecurity Act and as Weeds of National Significance.

A total of 28 fish species were recorded during the 2011 survey (including 18 species in the freshwater sites) indicating a relatively diverse native fish fauna. No introduced fauna species were collected during surveys for the Project which indicates that the Styx River catchment may be relatively free of introduced taxa such as Tilapia (*Oreochromis* sp.) and Mosquito fish (*Gambusia* sp.).

Any potential unmitigated introductions of weeds and pests as a result of Project activities may therefore pose a risk to the productive capacity of wetlands / waterways and may impact the local diversity of the resident fish community. The transportation and operation of construction vehicles and equipment has the potential to introduce weeds into the Project area. Project activities are not considered likely to introduce aquatic pest fauna. Weed and pest management measures will be developed and implemented to manage these risks.

15.7.6 Accidental Release of Pollutants

The release of pollutants into the surrounding environment and waterways has the potential to cause mortality to aquatic fauna, degrade stream habitat quality near the site and degrade downstream stream water quality. Without mitigation, potential exists for several potential contaminants to enter waterways, including the Styx River and further downstream into Broad Sound. Project sources of pollutants include: contaminated mine dewatering runoff; contaminated runoff from waste rock stockpiles; aqueous waste streams including oily waste water (from heavy equipment cleaning); contaminated runoff from chemical storage areas; potentially contaminated drainage from fuel oil storage areas; and general washdown water.

During operations, the creeks are not anticipated to be directly impacted by surface water runoff from Project facilities as runoff will be captured in a number of environmental dams for reuse or treatment.

The majority of the Project lies within the catchment of Deep Creek which is located approximately 250 m from the eastern edge of the Open Cut 1 and 500 m from the south-eastern corner of Open Cut 2. Other potential sources of pollutants include the CHPP / MIA 2 areas which are located approximately 250 m and 500 m from Deep Creek respectively. The southern waste rock dump is located approximately 250 m west of Deep Creek at its closest point and thereby has potential to release contaminated run-off in the creek (refer Figure 15-8).

A mine dewatering dam that will be used throughout the life of the Project will be in the Tooloombah Creek catchment (approximately 800 m east of the creek). The northern spoil dump is located approximately 200 m east of Tooloombah Creek and thereby has potential to release contaminated run-off in the creek.

The dewatering dam will store ground and surface waters pumped from the mine pits. The dam water will be subject to controlled releases into Tooloombah Creek under the strict conditions of the Project Environmental Authority. Dam water is also proposed to be used for coal processing and for general services at the CHPP / MIA areas and for dust suppression on-site.

Contaminated runoff has the potential to impact potential habitat for Southern Snapping Turtle should waterholes on Deep Creek and Tooloombah Creek be impacted. Contaminated runoff also has the potential to enter the Styx River and Broad Sound, temporarily impacting localised coastal habitats such as mangrove and saltmarsh communities and migratory shorebirds. However, given the transient nature of such an event (should it occur) and the large tidal regime in Broad Sound, it is considered any contaminated runoff will be diluted by tidal waters and unlikely to cause any significant or lasting impact to these values.

The proposed detailed design of the water storages and other water infrastructure components associated with the Project is described in detail in Chapter 9 – Surface Water.

15.7.7 Increased Sedimentation of Waterways and Sediment Runoff

During construction and operation sediment can be mobilised and transported by surface water during rainfall events ultimately discharging into drainage lines and watercourses which can result in negative impacts on water quality and aquatic habitats. Specifically, increased suspended sediments can reduce light penetration, decreasing photosynthesis of aquatic flora and decrease dissolved oxygen. Suspended sediments from runoff may contain elevated nitrogen and phosphorus levels due to the agricultural activities on Mamelon Station. Increased nutrients can promote algal growth and in extreme cases result in blooms and surface water deoxygenation within low flow situations.

The Project is largely located in the catchment of Deep Creek, which is therefore considered the watercourse most at risk from increased sedimentation. Surface water observation during the no flow period observed in February 2017 recorded naturally high turbidity levels in Deep Creek sites (refer Table 15-9).

Table 15-9 Water quality data – Project aquatic ecology sites (June 2011)

Water quality parameter	Site								
	De1[2]	De2[2]	De3[2]	St1[3]	St1b[3]	St2[3]	To1[2]	To2[2]	Gr1[2]
Sample date range	2011	2011	2011	2011	2011	2011	2011	2011	2011
Water Temperature (°C)[1]	16.25	16.78	14.79	16.74	19.94	18.49	16.05	15.64	18.3
Dissolved Oxygen (%sat)[1]	82.3	82.7	85.8	90.9	123.4	114.6	94.7	92.1	83.7
pH[1]	6.81	7.16	7.21	9.19	7.61	7.63	7.59	7.4	6.6
Conductivity-base flow (µS/cm)[1]	461	475	447	987	1,366	1,390	866	848	324

Water quality parameter	Site								
	De1[2]	De2[2]	De3[2]	St1[3]	St1b[3]	St2[3]	To1[2]	To2[2]	Gr1[2]
Sample date range	2011	2011	2011	2011	2011	2011	2011	2011	2011
Turbidity (NTU)[1]	13.1	12.9	17.2	5.6	5.8	5.4	5.9	1.7	7.4
Suspended solids (mg/l)	6	6	6	<5	<5	<5	<5	<5	6
Ammonia N (mg/l)	0.03	0.03	0.02	0.02	<0.01	0.03	0.02	0.02	<0.01
Total Phosphorus as P (mg/l)	0.04	<0.01	0.1	0.12	<0.01	<0.01	0.03	0.02	0.04
Filterable Reactive Phosphorus (mg/l)	<0.01	<0.01	-	<0.01	-	<0.01	-	-	-
Sulfate (mg/l)	29	28	24	42	66	68	42	41	2
Total Nitrogen (mg/l)	0.7	0.4	0.6	0.5	0.4	0.4	0.4	0.6	0.6
Nitrate (mg/l)	0.03	0.03	0.12	0.04	0.05	0.04	0.03	0.02	0.05
Total Oxidised Nitrogen (mg/l)	0.03	0.03	0.12	0.04	0.05	0.04	0.03	0.02	0.05
Total Alkalinity as CaC03 (mg/l)	89	88	100	190	204	306	212	209	75
Arsenic (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Nickel (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (mg/l)	0.029	0.006	<0.005	0.005	0.010	0.026	<0.005	<0.005	0.014
Mercury (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

1. In-situ water quality measurements
2. WQOs for lowland (< 150 m asl) freshwaters of the Styx River catchment derived from Table 2A of EHP 2014
3. WQOs for middle estuary (moderately disturbed) estuarine waters of the Styx River derived from Table 2A of EHP 2014

If stormwater runoff is not adequately contained, particularly during the construction of the various mine infrastructure components, there is potential for increased sedimentation and contamination to adversely impact the surface water receiving environments. Erosion and sedimentation during the operation phases is most likely to occur from stormwater runoff from the coal stockpiles, CHPP / MIA areas and ongoing minor earthworks associated with the maintenance of roads and dams.

Impacts to Tooloombah Creek are less likely, as this catchment is relatively isolated from the majority of the Project infrastructure components. However, the dewatering dam has potential to mobilise sediments entering the creek during rainfall periods in the construction period. The diversion of clean stormwater run-off from the site may mobilise sediments to both Deep Creek and Tooloombah Creek during the operation period.

Baseline water quality monitoring results indicated that existing waterways generally have low to moderate turbidity and suspended sediment loads during flow periods (such as sampled in June 2011 and May 2017). During dry periods (as sampled in February 2017) when the waterways are reduced to isolated pools high levels of turbidity and suspended sediment loads were recorded in the lower Deep Creek sites (De3 and De4), although the remaining sites maintained the low levels recorded at other times.

The waters of Broad Sound are subject to a large tidal regime with resulting high turbidity levels. The currents associated with the tides already leads to constant resuspension of sediment in the water column. As a result, conditions supporting the marine habitats directly downstream of the Project, such as coral reefs, seagrass meadows and large marine fauna, appears limited (refer Section 15.6.2.4). Downstream mangrove communities may entrain suspended sediments accidentally released from Project activities contributing to the extension of existing mud banks (Furukawa 1996) in the area, potentially extending mangrove habitat and creating more foraging habitat for local shorebirds, although this effect may be diluted by the large tidal regime in the area. Given the background occurrence of high turbidity in Broad Sound waters it is considered very unlikely that an accidental and temporary release of suspended sediments from Project activities will possibly be of a magnitude that may impact downstream EVs.

The potential impacts of erosion and sedimentation from surface runoff, if not adequately mitigated, could produce medium level impacts on local and downstream water quality and aquatic ecosystem EVs, including the marine environment (and associated recreational fishing values).

15.7.8 Hydrology and Water Flows

The Project activities that may impact surface water hydrology are described in detail in Chapter 9 – Surface Water. The Project will impact on surface water flows as mine infrastructure will decrease the local rainfall catchment area. The Project is largely located within the catchment of Deep Creek. The two major mine pit components (Open Cut 1 and Open Cut 2) will require diversion of two minor drainage lines of Deep Creek (one 1st and one 2nd Order drainage features). Water will be diverted to both Deep Creek and Tooloombah Creek. Diversions will be carried out in a progressive manner as the pits expand. The haul road and other infrastructure will also impact Deep Creek and Barrow Creek including the potential for direct deformation of the stream bed and altering hydraulic flows.

Modelling of local flood levels in Deep Creek and Tooloombah Creek as a result of a reduction in catchment size due to Project activities shows only a very minor reduction in peak flows. Under a 1,000 Average Recurrence Interval rainfall event there is predicted to be a 2 cm reduction in peak flood level at the confluence of Deep Creek and Tooloombah Creek (the Styx River) downstream of the Project. Flood diversions within the Project infrastructure will lead to a predicted localised rise in peak flood levels in Deep Creek of 7 cm, and Tooloombah Creek of 3 cm, with a consequent minor rise in flow rates at these times. Changes of this magnitude to peak flows is considered unlikely to impact on aquatic EVs, particularly as peak flows only occur for short duration of time.

A raw water dam is proposed to be built across a 2nd order watercourse to the north of mining activities (within the mine ML) to supply potable water for the life of the Project. As the upstream catchments will be largely removed due to Project construction, water is to be stored in the dam by pumping water out of Tooloombah Creek during flow events following high rainfall. This is not expected to impact aquatic downstream EVs due to the ephemeral nature of the creek.

Watercourse and creek crossing structures may cause an increase in runoff velocity due to construction of culverts and conveyance features that eliminate natural features such as meanders and increase in slope. However, with appropriately designed stormwater and crossing structures this is unlikely to cause more than localised and very minor changes to surface hydrology.

15.7.9 Changes to Groundwater Table and GDE Impacts

Initial modelling of the potential drawdown effect of the open cut mine operations has been carried out (refer Chapter 10 – Groundwater). At this stage, there is a 'low confidence' in the groundwater modelling results due to a lack of any long-term (time series) groundwater data that would provide insight into the temporal nature of groundwater and surface water connections. Further works are ongoing, including sampling of groundwater bores. For the purposes of the EIS impacts have been assessed based on the results of the initial modelling.

The Project area is dominated by shallow alluvial aquifers. A review of groundwater bore information and groundwater dependent ecosystems in the Project area indicates the water table reaches the rooting depth of riparian vegetation along Tooloombah Creek and Deep Creek (RE 11.3.25) and the alluvial community adjacent to Deep Creek (RE 11.3.4) although there is a lack of understanding around the groundwater environmental requirements of these Type 3 GDEs. Elsewhere it is unlikely that groundwater interacts with terrestrial vegetation.

15.7.9.1 Impacts of Mine Dewatering

Potential impacts on GDEs will depend on the magnitude of the alteration to groundwater connection as well as the positive or negative influences additional drivers have on their condition. The magnitude of dewater ranges up to 100 mbgl and may persist for 100 years. The greatest dewatering (5 to 100 m) occurs within the first 20 years of mine operation, and is centred around the immediate mine area between Tooloombah and Deep Creek (Figure 15-9). The cone of depression is initially steep, reflecting the change in geology from Quaternary sediments to the outcropping Bowen basin units. Further decline in the groundwater levels propagates to the north and south for the following 80 years creating an oval shaped region of impact that is effectively confined to the Quaternary sediments.

Impacts to Type 2 GDEs

The groundwater system associated with the creeks is held within the shallow Quaternary sediments. Recharge to this system will be from direct rainfall, leakage from the creek during surface flow events and from the underlying Bowen basin units. It is likely the dissection of the landscape by stream flow has intercepted the shallow water tables, such that groundwater is exposed as pools, rather than groundwater discharge occurring as flowing springs.

While no long-term groundwater data exists, it is likely upstream of the tidal influence at the confluence of the two creeks, the nature of groundwater connection will vary spatially and temporally depending on the magnitude of the rise and fall of groundwater levels in response to recharge events. The depth to the groundwater associated with both creeks will increase further upstream, away from the coast. The lower reaches of Tooloombah Creek are tidal and likely to be permanently connected. It is likely water ways will be permanently gaining / losing streams. During high surface flow periods, the deep-water column within the streams (>5 m) will recharge the adjacent Quaternary sediment aquifer (losing phase). As the surface flow recedes, there will be a corresponding rise in groundwater levels and during low flow, or no flow periods, the groundwater levels will intercept the base of the stream causing groundwater inflow (gaining phase). During prolonged periods of dry weather with little to no surface flow events groundwater levels will fall, potentially becoming disconnected with the base of the stream.

Within the first 20 years (approximately) there is a predicted draw down of 20 m at sections of Tooloombah and Deep creek closest to the mine area (Figure 15-9). Further up and downstream the change in groundwater levels is less and occurs over longer time frames, up to 80 years. Due to the uncertainty within the drawdown model outputs a simplified approach to considering the impacts of drawdown is undertaken. Any change in groundwater levels of greater than 5 m will inevitably disconnect the Creeks from the groundwater, irrespective of any seasonal recharge that may cause episodic rise in water tables. Changes less than 5 m will cause a shift in the natural cycle of gaining and losing phases, but may or may not cause permanent disconnection.

The disconnection of the streams from the groundwater is not likely to impact surface flow events downstream. The impact is related to the persistence of permanent pools within the riverine environment during low or no flow periods. A surface flow event will fill pools, that when connected to groundwater will persist longer due to the lack of drainage through the stream bed and groundwater inflow volumes. An important note is that groundwater may not provide a measurable volume of water within the pools, but may act to prevent downward leakage.

The change in the persistence and volume (depth) of the pools will adversely impact any present aquatic species. Of most ecological concern if the pools were to become dry, is the Southern Snapping Turtle, which the pools may provide critical habitat for.

What remains unclear is what will be the rate of loss of water from the pool if groundwater levels were to drop and the creek became disconnected, and what is the time required to dry out a pool that is no longer connected to the groundwater. This will help determine the actual impact to aquatic ecosystems and provide information for potential mitigation options. The rate of loss of water is based upon the loss from evaporation plus the volume of leakage through the stream bed, which is currently not known.

Sections of Deep Creek upstream of the immediate mine area are less likely to be connected to the groundwater system (Figure 15-9), with the predicted changes to groundwater levels of only several metres occurring over many decades likely to have little impact to aquatic habitat.

Downstream of the confluence of the two creeks, changes in groundwater levels may be buffered by the tidal influence that may maintain riverine water and support aquatic ecosystem, irrespective of the changing nature of groundwater connection. However, in terms of salt water ingress this may require additional investigation.

Type 3 GDEs

Type 3 GDEs are likely to be confined to the riparian zones of Tooloombah and Deep Creek (RE 11.3.25), where the depth to groundwater will be generally less than 5 m. While several areas of terrestrial GDEs are mapped as having a high potential for groundwater connection, existing bore data suggests the groundwater is around 10 m deep. While it is possible these areas may have deep rooting systems, the dominant source of water will be direct recharge and soil water stores.

In general, there is a substantial data gap regarding the water use patterns of terrestrial ecosystems. The presence of shallow water tables does not necessarily equate to a viable source of water. The complication is that Type 3 GDEs, terrestrial vegetation, can have multiple sources of water, direct rainfall recharge, soil water stores, seasonal soil water from surface water flow and groundwater. The ratio of the water requirements from these four sources to a degree dictates how sensitive these vegetation types are to changes in groundwater levels. To a degree, terrestrial GDEs have a level of reliance greater than Type 2 GDEs, as they have evolved to temporal changes in water sources. Small gradual declines in groundwater levels may not adversely impact the species water requirements, large sudden shifts in groundwater levels will cause water stress depending on the availability of other water sources. For example, if stream flow and rainfall maintain sufficient soil water stores, a change in the groundwater level may be inconsequential, however, if during a dry period, soil water stores were to become depleted and groundwater level were to decline, water stress may occur.

As with Type 2 GDEs, the area of most concern is related to areas of greater than 5 m drawdown. This may result in long-term impacts to the riparian Forest Red Gum communities, and semi-evergreen vine thicket along sections of Tooloombah Creek and Deep Creek located close to open cut mining operations. It is likely these vegetation communities will to some degree suffer adverse impacts in the long-term if groundwater levels decline below the necessary rooting depth required for tree species within these communities. It is uncertain what impact this may have on this community as most species are expected to obtain water requirements from multiple sources.

Based on characterisation of GDEs in the area it is considered likely that permanent waterholes in Tooloombah Creek are connected to the water table. This is less certain for the waterholes in Deep Creek which may only be connected to the water table in very wet conditions and are therefore potentially more resilient to a reduction in the level of groundwater. As a result, groundwater drawdown may also have a localised impact on water levels in permanent waterholes on Tooloombah Creek and Deep Creek potentially reducing habitat in the area for aquatic fauna and flora.

Figure 15-9 indicates the large waterhole observed on Tooloombah Creek (to the south of the highway) and the mapped HEV wetland are unlikely to be impacted by groundwater drawdown.

This may result in long-term impacts to the following aquatic EVs:

- Water levels in permanent waterholes on Tooloombah Creek (and potentially Deep Creek) that are connected to groundwater may decline in those areas closest to open cut mining occurs and drawdowns of 5 m to 50 m are predicted to occur. These waterholes provide habitat for the Southern Snapping Turtle; and
- Riparian Forest Red Gum and semi-evergreen vine thicket habitat in these same areas may also suffer adverse impacts in the long-term if groundwater levels decline below the necessary rooting depth required for tree species within this community.

15.7.10 Stygofauna

Terrestrial vegetation overlying shallow groundwater ecosystems, where the water table intersects the root zone of the vegetation, is thought to provide favourable habitat conditions for stygofauna (Eamus et al. 2006; Hancock and Boulton 2008). Clearing of vegetation may therefore reduce the habitat quality of shallow groundwater ecosystems for stygofauna. However, existing vegetation within the potential impact area located has generally been cleared for cattle grazing, including in the single area where stygofauna was recorded, indicating that the absence of vegetation does not preclude the occurrence of stygofauna.

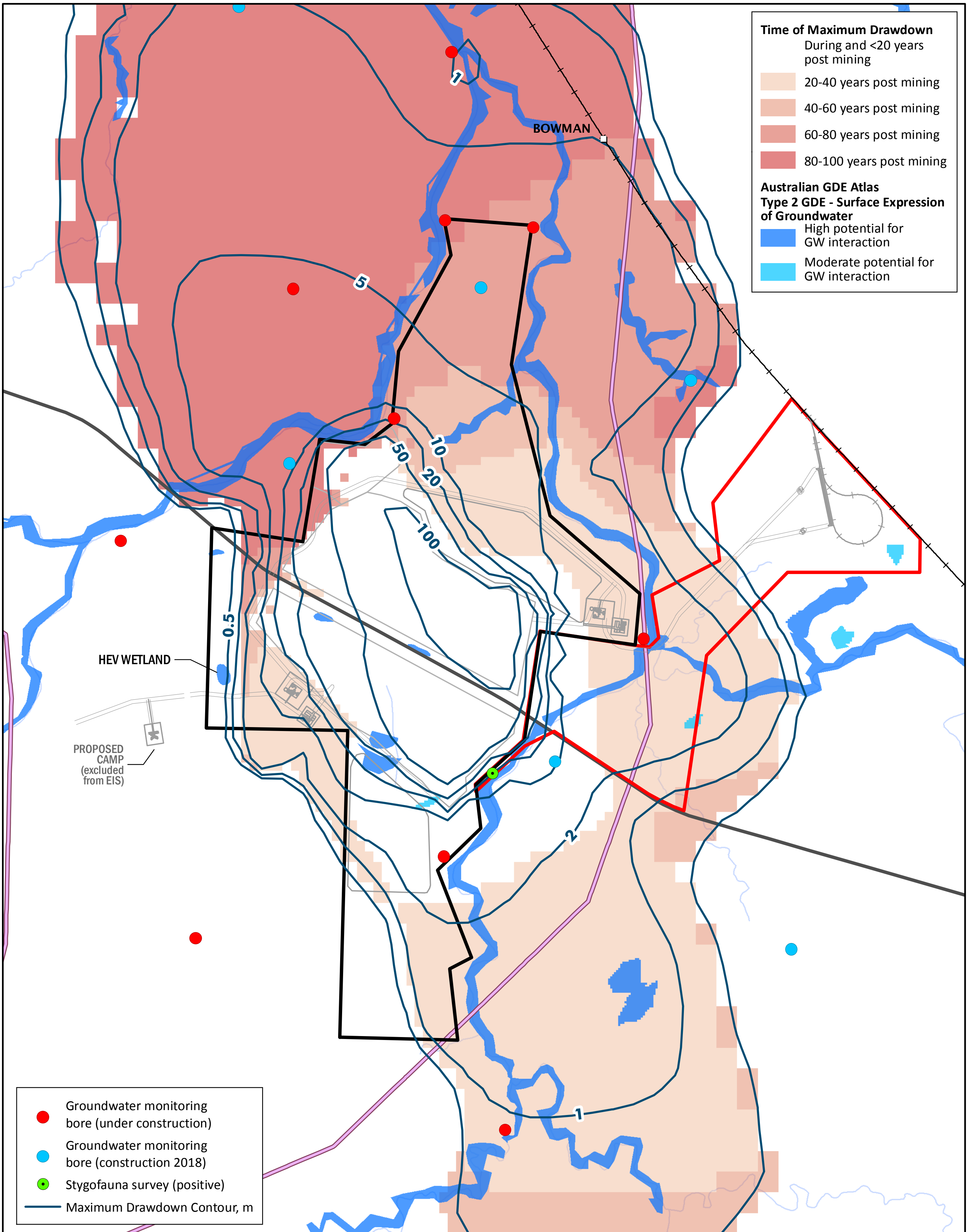
Contamination of groundwater from above ground sources including spills of chemicals or fuels from coal processing areas and for the operation of machinery. Chemicals, fuel and oil are toxic to aquatic flora and fauna at relatively low concentrations. Potential impacts would depend on the magnitude of any chemical, fuel or oil spill, but a small chemical, fuel or oil spill from a processing area or vehicle would likely cause impact on a relatively local scale within the potential impact area.

Mining operations have the potential to impact stygofaunal communities in the Project area by directly disturbing groundwater ecosystems through:

- The removal of top soil, overburden and open cut and underground coal mining;
- Road transportation of coal within the mine area and along the haul road to the east of the mine area, which may lead to localised compression of soils and reduce habitat quality of groundwater ecosystems for stygofauna; and

- Drawdown of the water table and reduction of groundwater pressure. Groundwater drawdown will be greatest close to the mine area itself but also presents to a lesser extent to the north of the mine area.

Six stygofauna morpho-species were identified across the 30 bores, five of which are located out of the predicted zone of groundwater drawdown resulting from the Project. A single morpho-species only was found within the predicted impact area but it is considered highly unlikely this species is restricted to the area of predicted groundwater drawdown itself. Therefore, no stygofaunal species is restricted to the potential impact area.



N
0 0.5 1 km

Scale @ A4 1:60,000
Date: 15/09/17
Drawn: Gayle B.

Legend

- ML 80187
- ML 700022
- Proposed mine infrastructure
- Styx Basin
- North Coast Rail Line
- Main road
- Watercourse

Figure 15-9
Maximum predicted groundwater drawdown impacts on Groundwater Dependent Ecosystems

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\.03 EIS Preparation\BES150160.03-067 R2 drawdown impact on GDEs.mxd 9/15/2017

15.8 Mitigation and Management Measures

Mitigation measures have been developed to minimise impacts associated with construction and operation of the Project. Mitigation strategies have been developed based on the following criteria:

- Avoid potential impacts where possible;
- Minimise the severity and / or duration of the impact; and
- Offset unavoidable impacts.

The potential impacts to aquatic EVs, including impacts to MSES, GDEs, and stygofauna as a result of the activities, and suggested mitigation measures associated with the Project are outlined in the following sections.

15.8.1 Vegetation Clearing

The majority of impacted remnant vegetation is not associated with aquatic habitat. Areas of Least Concern vegetation communities (under the VM Act) associated with riparian habitat (RE 11.3.25) will be impacted by tree clearing and subject to the Project Offsets Delivery Plan (refer Chapter 14 – Terrestrial Ecology).

To ensure the Project does not result in additional unforeseen direct impacts to remnant vegetation, the following mitigation measures will be implemented:

- Prior to construction, Project design may be further altered to avoid or minimise clearing areas of riparian vegetation communities, wetland areas and potential habitat for threatened aquatic species where possible;
- Vegetation located adjacent to the Project construction works will be appropriately marked to avoid unnecessary clearing / vegetation damage;
- Riparian vegetation and creek banks adjacent to culverts that are damaged during construction will be rehabilitated / stabilised; and
- The Project Land Use Management Plan (LUMP) will include monitoring of riparian and HEV wetland vegetation health including associated remnant vegetation considered at risk to mining activities to identify whether indirect impacts are occurring as a result of dust, erosion and mine run-off contamination.

15.8.2 Aquatic Habitat Connectivity

To ensure aquatic habitat connectivity is maintained, Central Queensland Coal commits to undertaking detailed design of the haul road crossings in compliance with:

- Austroads – Guide to Road Design Part 5B – Open Channels, Culverts and Floodways; and
- Design detail requirements of the Code for Self-Assessable Development; Minor Waterway Barrier Works Part 3: Culvert Crossings, Code number: WWWBW01 (April 2013), Department of Agriculture and Fisheries (DAF).

In all cases the following specific conditions will be applied:

- Works will commence and finish within the dry season, and if used during construction, any instream sediment and instream silt control measures associated with the works will be removed within this period;
- This measure eliminates the requirement to construct waterway barriers such as coffer dams to divert water around the construction area;
- Stabilisation of the banks will be done post construction to allow revegetation and reduce scour potential;
- Crossings will have a minimum (combined) culvert aperture width of 2.4 m or span 100% of the main channel width;
- All new and any replacement culvert cells will be installed at or below bed level;
- Internal roof of the culverts will be >300 mm above 'the commence to flow' water level;
- Where the cell is installed at less than 300 mm below bed level, the culvert floor will be roughened throughout to approximately simulate natural bed Ss;
- To the extent possible, box culverts will be used to facilitate fish passage at low flow depths. Footings will be considered over base slabs to maintain the natural bed channel through the culverts;
- Apron and stream bed scour protection must be provided in line with the design requirements of the Code; and
- The culvert will be installed at no steeper gradient than the waterway bed gradient.

Waterway crossings will comprise of box culverts located within the main channel. Box culverts allow the most efficient passage of flows and for preferential fish passage conditions. Furthermore, haul trucks can drive directly on the top of box culverts or link slabs with little to no earth fill required and hence the risk of sediment transport through scour is significantly reduced. Where appropriate, the box culvert height will match the depth of the main channel. This serves to minimise haul road filling on the approach to the culvert crossing whilst maintaining the existing bank full discharge conditions. Box or circular culverts will only be located on the overbank areas where filling is required on approach to the main channel crossing (refer to example crossing design in Figure 15-10). Flows that exceed bank full discharge will overtop the culverts and efficiently pass a floodway section, therefore minimising increases to flood levels upstream (flood afflux).

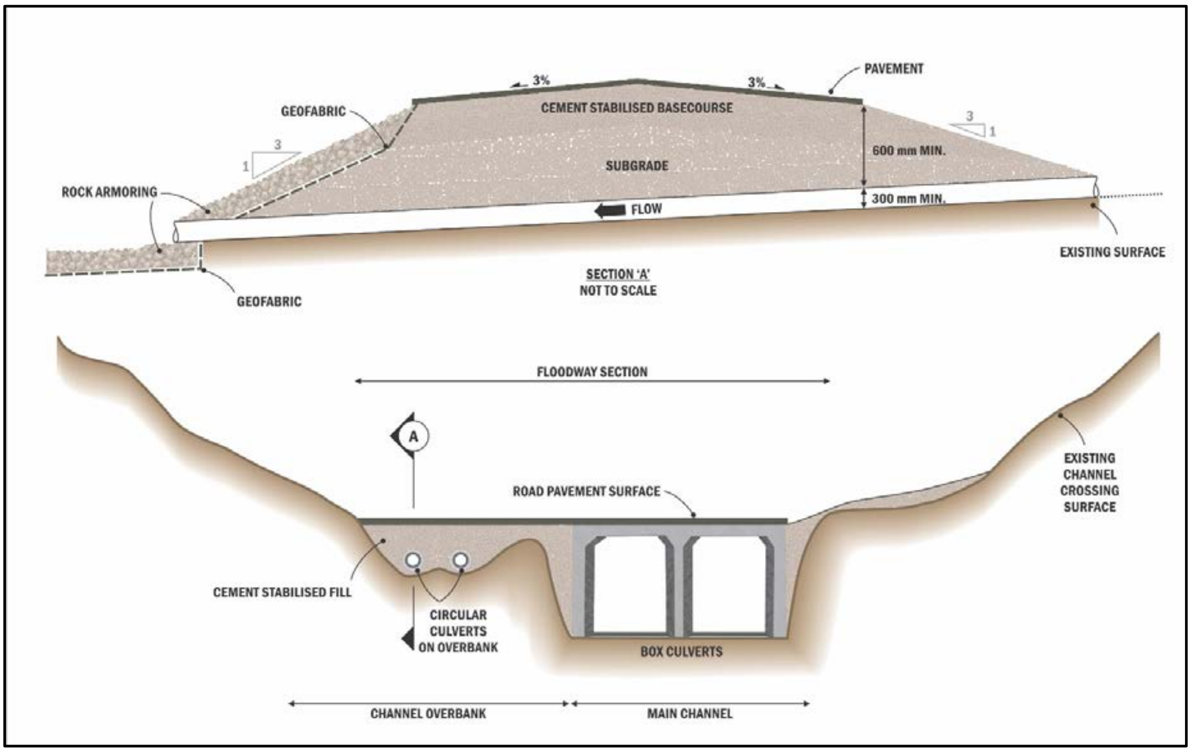


Figure 15-10 Example crossing design

The critical case for flows over the floodway is for events that just overtop the road (i.e. lesser than the 100 year ARI or PMF). This is when the low flow depths result in relatively higher velocities and is where scour potential and hence contamination transport is at its greatest. Scour protection will be designed in accordance with Austroads – Guide to Road Design Part 5B – Open Channels, Culverts and Floodways.

In addition to the above measures it is also important to recognise that all works will be undertaken in the dry season and this will significantly reduce the potential for construction impacts associated with erosion and scour. After construction, the banks will be stabilised and vegetation allowed to establish. There will be no impacts to aquatic connectivity as a result of the Project.

15.8.3 Direct Fauna Mortality

The Project requires the clearing of artificial wetlands (farm dams) and natural wetlands, including a wetland mapped as MSES for the area. Works will also be carried out on creek lines during the construction of the haul road although no permanent water holes are expected to be present at these areas including the crossing at Deep Creek and Barrack Creek.

Fauna management measures will be implemented as part of the Project LUMP and will establish protocols for pre-clearing activities. Prior to emptying any wetland area, a trained ecologist or other qualified environmental specialist will be on site to inspect the wetland and remove aquatic fauna (if required). Aquatic fauna will be transferred to a suitable location as determined prior to the activity occurring. All fauna recorded during pre-clearing surveys will be recorded on a dedicated fauna register.

Significant Species Management Plans will be developed and implemented for those threatened aquatic species known or likely to occur on the site (under the NC Act and EPBC Act). The plan will identify potential impacts on these species (including identified habitat) as a result of Project activities from throughout the life of the Project (construction, operation and decommissioning).

The Plans will detail specific management measures to mitigate the potential impacts and will incorporate adaptive management principles to allow for the adoption of new measures where necessary as the Project progresses.

15.8.4 Dust

Dust is not anticipated to significantly impact aquatic habitat in the area surrounding the Project. However, a vegetation monitoring program will be implemented as part of the Project LUMP and will include measures to monitor the health of adjacent riparian vegetation communities on Tooloombah Creek and Deep Creek within close proximity to the mine, haul road and coal conveyor, and the HEV wetland to the west of the southern mine pit. These areas may be potentially subject to dust accumulation impacts. Results of the vegetation monitoring will be used to inform adaptive management of mitigation measures where impacts are found to be occurring.

A water quality monitoring program will also be implemented under the Project Receiving Environmental Monitoring Program (REMP). This will include monitoring of sites / waterholes identified as potentially impacted by dust such as along Deep Creek adjacent to the coal conveyor.

The following measures have been developed to ensure dust levels resulting from the Project are kept to a minimum:

- The coal conveyor will be covered (although not fully enclosed) and will incorporate ‘spill protectors’ along the sides for the entire length of operation in order to minimise fugitive coal dust emission;
- All areas which have the potential to give rise to airborne dust such as unsealed roads, tracks, spoil areas and coal stockpiles will be wetted down regularly using water from environmental dams;
- Speed limits will be implemented throughout the site to minimise dust generated;
- Areas stripped of topsoil for Project construction will be rehabilitated as soon as practicable where not required during operations;
- Regular cleaning of machinery and vehicles tyres to prevent wheel entrained dust emissions;
- Design haul roads to have a less erodible surface, particularly where adjacent wetland habitat occurs, such as using materials with a lower silt content and / or applying chemical dust suppressants or paving used for haul roads; and
- Further dust suppression mitigation measures are discussed in Chapter 12 - Air Quality.

15.8.5 Pests and Weeds

Weed and pest management will be an important and integral part of proposed site management activities, and will be detailed in the Project LUMP. This Plan will include measures and monitoring to be developed and managed in accordance with the requirements of the Biosecurity Act, and will include the following measures:

- Implementation of sediment control mechanisms to minimise the risk of weed seed washing into waterways;
- Implement control strategies outlined in the Department of Agriculture and Fisheries (DAF) weed and pest animal fact sheets and other relevant government biosecurity management strategies;

- Pre-construction weed mapping should be undertaken to accurately determine the extent of weeds and pests;
- Vehicle wash down procedures;
- Minimise the use of off-road vehicle movements;
- Onsite waste disposal strategies (particularly for food wastes) to be employed that will not encourage the presence of pest fauna;
- Strategies for the storage of construction and operation materials / equipment to be employed that will not encourage the presence of resident pest fauna;
- Regular onsite inspections of site infrastructure / equipment for resident pest fauna and establishment of register for pest sightings; and
- Monitoring and weed and pest inspections particularly in responses to reported outbreaks or from complaints or adjacent property owners.

15.8.6 Accidental Release of Pollutants

The Project design has incorporated the following components as part of the wider Project Water Management Plan (WMP). With these design elements, it is considered the potential impacts from the Project to water quality and hence local aquatic EVs in the vicinity of the site and downstream, are appropriately minimised to the greatest possible extent.

A single mine dewatering dam will be constructed to contain mine groundwater pumped from the open cut pit areas over the life of the Project. The dewatering dam is located outside of any drainage area and will be constructed to store a 1:1,000 Annual Exceedance Probability (AEP) standard flood event (spillway capacity).

Several environment dams are proposed to capture rainfall runoff from the CHPP / MIA areas, TLF and waste rock dump areas. The primary function of the environment dams is to capture sediment laden runoff for sediment removal. The environment dams will be designed to contain 1:100 year AEP storm event.

A large raw water dam will be used to collect water from Tooloombah Creek during flow periods to be used for coal processing and site potable water. The dam will be located on the un-named tributary of Deep Creek which intersects this area.

Surface waters will be managed and monitored according to the Project-specific REMP and WMP. A water release strategy will be developed for the Project. Water quality release limits are set for mine affected water across several parameters as to be conditioned under the Project EA conditions and will be in accordance with EPP water quality objectives for the Styx Basin (refer EHP 2014). Release contaminant trigger investigation levels also apply. Ongoing water monitoring will be undertaken at the environmental dams, mine-affected water dams, discharge locations and locations both upstream and downstream of the Project area as part of the Project REMP. Discharge of mine-affected water will be restricted to flow trigger events in the relevant creek catchments and will also be limited by the quality of water to be released.

Surface water contaminants from industrial pollutants have the potential to impact the local catchment and vegetation communities throughout the Project area. These impacts will be mitigated through:

- Bunding of chemical storage facilities and appropriate storage of chemicals according to AS 1940 'The storage and handling of flammable and combustible liquids;

- Spill containment kits located on site and near likely impacted waterways;
- Locate and design roads and other built infrastructure so that minimal run-off to waterways occurs;
- Retention Basins to allow a pre-treatment of water and wastewater prior to any discharge into the aquatic environment. The discharge of wastewater and stormwater will be similar to water quality of receiving waters and in accordance with EPP water quality objectives for the Styx Basin; and
- Discharge (if any) of treated wastewaters to receiving water will occur during wet periods where possible.

Further details relating to surface water management are discussed in Chapter 3 – Description of the Project and Chapter 9 – Surface Water.

The Project REMP will include monitoring of stream and wetland water quality including associated considered at risk from contaminated run-off / wastewater releases from Project construction and operation to identify whether impacts are occurring.

15.8.7 Increased Sedimentation of Waterways and Sediment Runoff

The Project is located on the Mamelon property. Mamelon encompasses a total area of 6,478 ha of which the Project footprint covers approximately 1,070 ha. CQC have proposed destocking the majority of the property and restricting cattle access to already cleared habitat in the south-west and south of the property. This area encompasses approximately 1,000 ha. The remaining area, including the creek lines which lie adjacent to the mine area, will be managed and allowed to regenerate. This measure will contribute to localised water quality improvements, and contribute to improving the water quality entering Broad Sound and the GBRWHA through the following:

- The long-term restoration of this habitat, and in particular allowing vegetation to regrow along the riparian zones along Deep Creek and Tooloombah Creek (which are presently mostly cleared), will capture / entrain sediment and nutrient run-off from the property;
- The restoration of cleared areas will also reduce soil erosion on cleared areas of the property, thereby reducing the entrainment of sediments entering creek lines during bouts of heavy rainfall; and
- The removal of cattle from much of the property will also remove a source of long-term nutrient input into creek lines following rainfall.

Erosion in active construction or development areas cannot be eliminated. However, impacts can be controlled and with proper mitigation measures, adverse effects to surface waters can be avoided or minimised. The following mitigation measures are proposed to avoid potential sedimentation impacts that could occur as a result of construction and operation activities:

- Surface waters will be managed and monitored according to the Project-specific REMP and WMP;
- Preparation of a certified Erosion and Sediment Control Plan (ESCP) prior to construction and implementation during activities. The ESCP is to ensure construction activities are being undertaken in accordance with best management practices and the International Erosion and Control Association (IECA) Guidelines (2008). Management measures that should be detailed within the plan are outlined in Chapter 5 – Land;
- Land will be surveyed and pegged out prior to clearing to avoid identified areas of significance;

- Vegetation will be preserved with only the minimum amount of land required to operate the Project cleared at any one time;
- Progressive rehabilitation of disturbed areas will be undertaken, where possible; and
- Disturbed land will be returned to pre-existing vegetative habitat condition, including cattle grazing, or native habitat.

In addition, potential contaminant impacts will be reduced via specifically sized and designed sediment containment dams and a controlled release policy. Water management dam sizing and discussion on water releases are provided in detail in Chapter 9 – Surface Water.

15.8.8 Hydrology and Water Flows

Surface waters will be managed and monitored according to the Project specific REMP and WMP. No impacts are expected to result from waterway diversions and flood harvesting. If monitoring detects adverse impacts and assesses that replenishment is required, only water that meets the approved release conditions derived from the site specific water quality monitoring will be released. Using water that meets the approved water quality trigger values will minimise or eliminate adverse impacts to the ecological function of the targeted waterways.

15.8.9 Changes to Groundwater Table and GDE Impacts

15.8.9.1 Groundwater General

A detailed Water Management Plan (WMP) will be established for the Project (refer Chapter 10 – Groundwater). This will include establishing shallow groundwater monitoring bores and monitoring existing landholder bores located within the likely zone of mine influence. CQC is currently installing ten Project-associated bores to expand the knowledge of local groundwater conditions and monitor the potential for future impacts (refer Figure 15-9). Further additional Project bores are planned for installation in 2018. The location / configuration of monitoring bores together with the landholder bores, has been designed to provide sufficient coverage for the Project and surrounding area to detect and monitor groundwater effects from the Project. Based on the information collected during the first few years of mining, a need for expansion or rationalisation of the monitoring network may be identified.

Groundwater monitoring will include the following:

- Mine water inflow monitoring will consist of daily measurements of all water pumped from the mine pit;
- Quarterly field measurements of EC and pH and total petroleum hydrocarbons (TPH) of groundwater from the monitoring bores located on the mine lease and monthly field measurements of the same parameters for water pumped from the mine;
- Quarterly field measurements of EC and pH of groundwater from the monitoring bores located off the mine lease;
- Six monthly sampling of groundwater from monitoring bores and selected landholder bores for laboratory analyses of major ions, TDS and metals using methodologies that are suitable for comparison with the baseline monitoring; and
- Where groundwater quality impacts are identified, monitoring may be intensified to include the analysis of potentially harmful substances associated with oil, fuel and chemical handled onsite (e.g. benzene, toluene, ethylbenzene and xylenes).

The current model of groundwater drawdown is based on limited groundwater data and its results are therefore of 'low confidence. Of note is the lack of time series groundwater level monitoring data and aquifer testing data for the different hydrostratigraphic units that are critical in the development of aquifer properties during the calibration of the groundwater model and to the understanding of groundwater and surface water interactions. While groundwater monitoring of landholder bores has been ongoing, these bores are not located in optimum positions, therefore a further ten Project-related bores are being installed to further inform the modelling that will be done to inform the SEIS and to form part of the ongoing groundwater monitoring regime to be described in the Projects WMP. These bores are strategically located to improve the spatial distribution of groundwater monitoring, with eight of these adjacent water ways.

In the long term monitoring of these bores will allow for a better understanding of local groundwater conditions and observations regarding actual drawdown caused by mining activity. Data collected from the WMP in the first years of mining will be used to verify the groundwater drawdown model predictions and, if necessary, provide a basis for recalibration of the groundwater model. As mining progresses, a need for further model updates will be assessed every twelve months based on quarterly reviews of groundwater monitoring data and findings of impact verification. It is expected the confidence level of model predictions will increase over time as the model is updated to reflect the observed effects on groundwater from the monitoring program.

In the first instance however, data from the bores will provide a critical dataset to assess key assumptions regarding groundwater connection with surface water systems. The assessment of the presence of GDEs is largely based upon existing desktop evaluations of the landscape setting, ecosystem type and hydrology (near permanent pools) and currently suggests there is a groundwater contribution. At this stage, this assumption has not been validated with field based groundwater data.

Groundwater level data from the bores will be used to evaluate the:

1) Hydraulic gradient between the shallow groundwater adjacent the creeks and the surface water level within the creeks. The impact that dewatering may have on the groundwater supply to the GDEs, depends largely on the understanding the nature of groundwater and surface water connection. This process will involve installing gauges within the pools of Tooloombah and Deep Creeks.

   For the permanent pools to be connected to the groundwater a positive gradient from the groundwater to the creek is required. If a negative gradient exists (the elevation of the groundwater is lower than the elevation of the water within the creek) then groundwater inflow is less likely (and this needs to be evaluated both intra- and inter-annually. If a positive gradient exists then groundwater inflow is likely. There are several possible groundwater and surface water connection relationship, they are:

   - The creeks are disconnected from groundwaters in the area of investigation – where groundwater levels remain lower than the creeks, such that there is no connection between the groundwater and the creek bed and an unsaturated zone exists
   - The creeks are connected to the groundwater but receive no groundwater inflow - where groundwater levels are equal to or lower than the creek, such that the movement of water is from the creek into the groundwater and
   - The creeks are connected to the groundwater and groundwater inflow occurs – in this case the creeks may be a) permanently connected such that there always exists a positive hydraulic gradient to the water level in the creek and permanent inflow of

groundwater, or b) the gradient may alternate (+ to -) such that the nature of groundwater connection has a temporal element, switching from gaining to losing depending on climate conditions.

2) The rate of groundwater inflow into the creeks. It is important to note, that determining the nature of groundwater connection (point 1) does not provide actual groundwater inflow volumes, additional information pertaining to aquifer hydraulic properties is required. The rate and volume of groundwater inflow into the creeks is the combination of the existing hydraulic gradient, effective porosity and the hydraulic conductivity of the surrounding aquifer. Testing of aquifer properties of the newly installed bores will enable groundwater inflow calculations to be made.

3) Additional water chemistry sampling and analyses from the groundwater and surface water can assist in identifying the timing of groundwater inflows and the volume of groundwater inflow. It is likely the chemistry of the groundwater and surface water is different. End member analyses, and isotopic signatures (stable and non-stable) can be used to identify groundwater inflow as it mixes with surface waters.

To manage the potential impacts, the following additional mitigation and management measures are listed and expanded upon in Chapter 10 – Groundwater.

Where access to groundwater for stock watering is compromised due to drawdown and this is identified to be due to the Project, the following mitigation measures may be implemented:

- Lowering of the existing pump or fitting with a new pump if sufficient saturated thickness (available drawdown) remains in the bore;
- Deepening or relocation of the bore to an area outside of the area of impact;
- Provision of surplus water from mine dewatering, if the quality is deemed suitable for the current groundwater use;
- Provision of alternative water supply of comparable quantity and quality to the current stock water use;
- Strict management and control measures of potential pollutants and contaminant sources will be maintained to prevent uncontrolled discharge to groundwater; and
- All uncontrolled discharges will be reported to the EHP according to legislative requirements under the EP Act.

15.8.9.2 Groundwater Dependent Ecosystems

Although there is uncertainty in the modelling of groundwater drawdown outputs, and regarding the nature of groundwater connection it remains likely these landscapes comprise GDEs and that access to groundwater will be compromised due to drawdown. This is of most concern within the riverine environments of Tooloombah and Deep Creeks.

The practice of supplementary surface water flows to maintain riparian vegetation health is widely used as a management tool in providing environmental flow requirements to waterways and wetlands across Australia. In most cases, environmental flow programs are established where the ‘natural flow’ of a system has been altered by water diversion, reservoir or dam constructions. The implementation of a supplementary water program for the Project will need to consider the nature of connection between groundwater and the creeks and terrestrial GDEs. This relationship will become more apparent after information has been gathered from the newly installed groundwater bores. Supplementary surface water flows should aim to simulate the natural pattern of environmental flows or offset drawdown of the water table by providing additional recharge to the root zone of riparian vegetation to replenish the shallow groundwater stores at times when groundwater is intermittently accessed by the vegetation. This process would require an evaluation of the frequency and size of flows that would generate sufficient inflow to maintain the depth of the pools within the creek that persisted during low flow periods and infiltration and recharge to the water table, as to maintain appropriate groundwater levels necessary to maintain the riparian condition.

Further understanding of the hydrological function of the identified GDEs in the area is required to develop mitigation measures including the following:

- Environmental water requirements of the GDEs such as minimum water depth and pool size to maintain a healthy aquatic environment, and the likely water demand to riparian vegetation provided by surface flows compared with deeper groundwater;
- Knowledge of the conductance properties of stream bed material will help determine the rate at which pools receive groundwater (during the wet phase) and the rate at which the pools lose water due to leakage to the groundwater (during dry phases) as this depends on the hydraulic properties of the stream beds; and
- The water budget of the pools. Understanding the relationships between the frequency of surface flow events and persistence of in-stream pools is important, as it may indicate that pools can be maintained (irrespective of groundwater inflows) through managed environmental flows. It will also be important to understand if the presence of shallow groundwater provides a volume of water required and / or provides a buffer to stream leakage.

The success of providing supplementary flows can be measured by monitoring the condition of the target 'end point' of the system, in this case the riparian vegetation communities. The hypothesis proposed is that a portion of the water requirements of the riparian vegetation is provided by shallow groundwater, predominantly during dry periods when stream flows are absent. Wetland and stream health and vegetation monitoring will be implemented as part of the LUMP and REMP. This will include at a minimum the following measures:

- Ongoing assessment and monitoring to address the knowledge gaps identified above and allow a greater understanding of GDEs function in the area including a baseline water source study of the riparian vegetation to determine the nature of groundwater uptake. This would require a combination of soil, water and tree analyses to assess water use patterns, and the seasonal source of water;
- Monitoring of the health of the HEV wetland in the mine area;
- Monitoring of water levels and water chemistry in permanent waterholes on Deep Creek and Tooloombah Creek, particularly those identified as potentially impacted by severe groundwater drawdown in the vicinity of mining operations;
- Monitoring of local groundwater levels and chemistry in areas associated with Deep Creek and Tooloombah Creek; and
- Monitoring of riparian vegetation health along Deep Creek and Tooloombah Creek in those areas identified as potentially impacted by severe groundwater drawdown.

As drawdown depends on a range of factors, its impacts will need to be managed adaptively. Adaptive management will involve monitoring groundwater impacts and, based on the severity of impacts, implementing appropriate mitigation measures to minimise impacts on existing groundwater EVs as mining takes place.

With an understanding of the hydrological function of the waterholes in the area and environmental water requirements of the instream ecosystems, as well as ongoing surface and groundwater monitoring, trigger levels will be established for the depth of waterholes that are required to maintain a healthy in stream environment. These levels will incorporate the combination of stream flow inundation and groundwater inputs. It is likely that theses triggers will represent the low flow period of the creeks, when groundwater inputs represent a larger % of the waterholes water budget. Where water levels decline below the trigger it is assumed that this is occurring because of groundwater extraction and dewatering. At this point a Project supplementary water program will be initiated to maintain waterhole depth at a level that will sustain ecological function. Supplementary water is likely to be derived from treated mine water and will be within the water quality objectives set for the lowland waters of the Styx River.

As a last resort, where vegetation communities are found to be unavoidably impacted by groundwater drawdown these areas will be subject to the Project Biodiversity Offsets Delivery Plan.

15.8.10 Stygofauna

Vegetation clearing and soil disturbance will be restricted to only those areas needed for Project construction and operation. Similarly, the haul road and rail connection area will be restricted in extent as much as is possible.

Vegetation located adjacent to the Project construction works will be appropriately marked to avoid unnecessary clearing / vegetation damage. The open cut pit areas will be backfilled and rehabilitated as the mine progresses. Measures will include appropriate storage and stockpiling of topsoil and subsoils to avoid localised soil compaction and maintain soil quality for rehabilitation works.

For mitigation measures relating to chemical or fuel spills refer to those measures described above in Section 15.8.6 - 'Accidental Release of Pollutants.'

Mitigation measures relating to 'Changes to groundwater table' are detailed in the section above and are considered largely applicable to stygofauna. This will include groundwater level monitoring across the existing bore field and implementation of corrective actions resulting from these investigations if required.

15.9 Cumulative Impacts

The area the Project is located within is relatively small. The Tooloombah Creek catchment comprises approximately 36,000 ha and Deep Creek comprises a further 29,000 ha. For the purposes of this cumulative impact assessment on aquatic values we have chosen to restrict the assessment to the overall Styx River catchment as it is inconceivable the Project will have impacts beyond this area. The ranges to the west and south of the Project catchment areas drain into the Fitzroy Basin which remains separate from the Styx River catchment.

The nature of the Styx River catchment is rural with approximately 78% of lands occupied by agriculture dominated by cattle grazing. A review of the latest publicly available information regarding development in the region found no large-scale industrial or mining developments proposed for the catchment other than the Central Queensland Coal Project.

The only major development known from the wider area is the proposed expansion of the Shoalwater Bay Training Area by the Department of Defence. This area lies largely within the adjacent Shoalwater catchment which also drains into Broad Sound to the northeast of the Project area. The original proposal identified a 'likely expansion area' stretching west from the existing training area to the approximate east bank of the Styx River located to the north of the Project. Based on opposition from local communities it has been recently assessed that a reduced expansion area is 'achievable' (DoD 2017). As such, the extent of the proposed expansion and the potential changes to land use are unknown at this stage.

Given there are no other large projects currently known to have identified lands within the Styx River catchment, the Project impacts to aquatic ecology will only add to those impacts that are a result of current land use in the catchment. These background land use impacts are already characterised within this chapter through the identification of local water quality values and aquatic ecology monitoring results. There are no other projects in the catchment or surrounds which the potential Project impacts to aquatic ecology subject to this assessment could conceivably add to.

15.10 Qualitative Risk Assessment

Potential impacts resulting from the current Project on ecological values have been assessed utilising the risk assessment framework outlined in Chapter 1 – Introduction.

For the purposes of risk associated with aquatic EVs risk levels are defined as follows:

- Extreme – Works must not proceed until suitable mitigation measures have been adopted to minimise the risk;
- High – Works should not proceed until suitable mitigation measures have been adopted to minimise the risk;
- Medium – Acceptable with formal review. Documented action plan to manage risk is required; and
- Low - Acceptable with review.

A qualitative risk assessment that outlines the potential impacts, the initial risk, control measures and the residual risk following the implementation of the control measures detailed in the previous sections is shown in Table 15-10

Table 15-10 Qualitative risk assessment

Issue	Potential Impacts	Potential Risk	Control Measures	Residual Risk
Vegetation and wetland clearing	▪ Clearing of wetlands, aquatic habitat and associated vegetation ▪ Degradation of receiving water quality and adverse effect on supported ecosystems ▪ Bank instability and associated follow-on impacts such as further riparian degradation	Extreme	▪ Avoidance of riparian / wetland habitat in Project design; ▪ Avoid unnecessary clearing; and ▪ Rehabilitate riparian habitat and creek banks adjacent to construction works on creek crossings.	High
Aquatic habitat connectivity	▪ Road crossings causing loss of connectivity along creek lines preventing fish movements and changing water flows ▪ Increased flow velocities in creeks due to Project-associated water diversions	High	▪ Appropriately designed culverts informed by DAF guidelines installed at all creek crossings; and ▪ Project water diversions designed to minimise flow velocities in creeks.	Medium
Direct fauna mortality	▪ Mortality of aquatic fauna including threatened species during clearing of artificial wetlands (farm dams) and instream works	High	▪ Where necessary trained ecologist / fauna spotter will inspect waterholes and remove aquatic fauna from ponded areas prior to Project disturbance.	Low
Dust	▪ Impacts of construction-operation related dust settlement on riparian vegetation and wetland habitat ▪ Operational impacts of coal dust settlement on riparian vegetation and instream habitat	High	▪ Incorporate monitoring program to encompass at risk riparian / wetland vegetation within Project LUMP; ▪ Implement water quality monitoring program including sites identified as potentially impacted by dust settlement; ▪ Project mine water to be recycled and used for dust suppression across site; ▪ Vehicle speed limits and regular maintenance enforced to reduce dust emissions; ▪ Coal conveyor designed to minimise fugitive dust emissions (covered and spill collectors featured in design); ▪ Areas stripped of topsoil during construction to be rehabilitated as soon as practical; and ▪ Haul road design to incorporate dust suppression techniques.	Low

Issue	Potential Impacts	Potential Risk	Control Measures	Residual Risk
Pests and weeds	▪ Degradation of aquatic habitats through weed invasion	High	▪ Pest and weed management measures incorporated within Project LUMP; ▪ Carry out pre-construction weed mapping of Project site and implement control strategies as per DAF fact sheets; ▪ Implement weed wash-down procedures and minimise off-road vehicle movements across site; ▪ Implement appropriate strategies to reduce pest occurrence on-site; ▪ Implement regular weed and pest monitoring regime; and ▪ Establish complaints register to report outbreaks on neighbouring lands.	Medium
Accidental release of pollutants	▪ Degradation of instream habitat / water quality including downstream HEV estuarine habitat in the Styx River ▪ Fish mortality events	High	▪ Design and implement Project Receiving Environment Monitoring Program and Water Management Plan; ▪ Controlled release of better quality water in accordance with licensed EA conditions; ▪ Maintenance of Design Storage Allowance on the onset of the wet season to minimise the likelihood of uncontrolled discharges; ▪ Pipeline connectivity between storages to allow water transfer to where there is available capacity; ▪ Establish measures to minimise / control Project-associated chemical spills; ▪ Project design will locate infrastructure to minimise stormwater run-off; and ▪ All waters discharged into adjacent waterways will be treated in retention basins and similar in quality to receiving waters.	Medium
Increased Sedimentation of Waterways and Sediment Runoff	▪ Degradation of instream habitat / water quality including downstream HEV estuarine habitat in the Styx River	High	▪ Design and implement Project Erosion and Sediment Control Plan; ▪ Surface waters managed and monitored under Project Receiving Environment Monitoring Program; ▪ Minimise unnecessary disturbance to vegetated lands; ▪ Progressive rehabilitation of disturbed areas will be undertaken; and ▪ Appropriately designed water management system including sediment containment dams.	Low
Hydrology and water flows	▪ Reduction of inflows to creek lines and consequent reduction in long-term habitat persistence (large waterholes)	High	▪ Design and implement Project Receiving Environment Monitoring Program and Water Management Plan; and ▪ Project design to ensure surface water flows into creeks maintained as close to natural conditions as practical.	Low

Issue	Potential Impacts	Potential Risk	Control Measures	Residual Risk
Changes to groundwater table and GDE impacts	▪ Drawdown of groundwater impacting local GDEs ▪ Drawdown of groundwater impacting long-term habitat persistence in creeks (large waterholes) ▪ Drawdown of groundwater impacting adjacent riparian vegetation communities	High	▪ Design and implement Project Receiving Environment Monitoring Program and Water Management Plan; ▪ Ongoing assessment and monitoring to address knowledge gaps and allow a greater understanding of GDE function; ▪ Regular monitoring of groundwater levels and quality and riparian vegetation health at identified at areas considered at risk of drawdown impacts; ▪ Regular monitoring of wetland health at the identified HEV wetland; ▪ Water Management Plan to include measures to replenish large waterholes in the event of identified impacts; and ▪ Implementation of the Project Biodiversity Offsets Delivery Plan.	High
Stygofauna	▪ Drawdown of groundwater impacting regional stygofauna community	Low	▪ Project footprint reduced as much as possible to avoid surface disturbance; ▪ Progressive rehabilitation of open cut pit areas will be undertaken including appropriate topsoil stockpiling to maintain soil quality for rehabilitation works; ▪ Establish measures to minimise / control Project-associated chemical spills; ▪ Project design will locate infrastructure to minimise run-off; and ▪ All waters discharged into adjacent waterways will be treated in retention basins and similar in quality to receiving waters.	Low

Note: R=Rare, UL= Unlikely, P=Possible, L=Likely, AC=Almost Certain

15.11 MSES Impact Assessment

The assessment has identified potential impacts to MNES fauna and other MNES values associated with the wider area downstream of the Project area, including values associated with the Great Barrier Reef World Heritage Area. Impacts to MNES are addressed in Chapter 16 – MNES.

The Matters of State Environmental Significance (MSES) that are applicable to aquatic EVs associated with the Project as described are compiled in Table 15-11.

Table 15-11 MSES as they apply to the Project

Category	Description	Project applicability
Protected area estates	Includes all classes of protected area (except nature refuges and coordinated conservation areas).	Tooloombah Creek Conservation Park is located 750 m west of the westernmost boundary of the MLs. Bukkulla Conservation Park and Marlborough State Forest are located 17 km east of the ML boundary. Mitigation measures will be implemented to prevent potential off site impacts such as dust settlement. No impacts are expected. Refer Chapter 14 – Terrestrial Ecology.
Marine Parks	Includes 'highly protected areas' of state marine park zones. These zones include: Preservation zones Marine National Park zones Scientific research zones Buffer zones Conservation Park zones	The boundary of the Great Barrier Reef Marine Park is located approximately 8 km north of the Project in the middle estuary of the Styx River. The downstream section of the park closest to the Project is identified as a 'general use zone' and therefore not identified as a 'highly protected area.' The Marine National Park zone is located approximately 40 km downstream of the Project by which time the Styx River opens into a broad shallow estuary. The Project will release treated mine water only during flow events. Other potential impacts resulting from Project activities include increased sedimentation and uncontrolled releases of pollutants. Water quality of released water will be strictly controlled under the Project EA conditions. Mitigation measures to control for such events are described in Section 15.9 and Chapter 9 – Surface Water. No impacts expected.
Fish habitat areas	Includes areas declared as Fish Habitat Area (FHA) A, or Fish Habitat Area B under the *Fisheries Act 1994.*	The Project area is located 8 km south of the boundary of Broad Sound which is listed as declared FHA A. The Project does not require any works within the boundary of the FHA. Not applicable.
Waterway Fish Passage	Includes any part of a waterway that provides for passage of fish. Applies to any structure that may create a barrier or otherwise impact fish habitat quality.	The mine haul road will cross Deep Creek and Barrack Creek. Deep Creek is likely to be used for fish passage when flows occur. Barrack Creek appears largely ephemeral. With appropriate crossing construction including culverts no impacts are anticipated.
Protected wildlife habitat	Includes flora and fauna species listed as Special Least Concern, Vulnerable, or Endangered under the NC Act and includes habitat that supports a listed fauna species (e.g.	There are several terrestrial fauna and flora species listed as Endangered, Vulnerable or Special Least Concern (including bird species listed as Migratory under the EPBC Act) that occur or have potential to occur in the study

Category	Description	Project applicability
	foraging roosting or breeding habitat). Includes areas mapped under the flora survey trigger map	area. These species are detailed in Chapter 14 – Terrestrial Ecology and Chapter 16 – MNES. Two threatened aquatic species are known or likely occur in the waters adjacent to the Project area – Estuarine Crocodile and Southern Snapping Turtle. No impacts are expected. Refer Section 15.9 and Chapter 16 - MNES.
Regulated vegetation	Includes the following under VM Act mapping: REs classified as 'endangered' or 'of concern'; REs classified as 'watercourse'; Habitat mapped as 'essential habitat'; and Wetlands on the VM Act map.	There is a single RE classified as Of Concern, and regulated vegetation intersecting a watercourse that may be impacted by the Project, thereby requiring offsets. Refer Chapter 14 – Terrestrial Ecology.
Connectivity	Includes all remnant vegetation.	The Project impacts to the extent of remnant vegetation in the area have been analysed using EHPs 'landscape fragmentation and connectivity' tool. Refer Chapter 14 – Terrestrial Ecology.
Wild rivers (high preservation areas)	Include the 'high preservation area' in the wild river declaration for the area.	At the time of writing the wild rivers legislation has been repealed and therefore does not apply.
High conservation value wetlands	Includes: Wetlands assessed as 'High Ecological Significance' on the map of referable wetlands; or High Ecological Value (HEV) freshwater and estuarine areas declared under the *Environmental Protection (water) Policy 2009* [EPP (water)].	There is a single HEV wetland considered as a 'Wetland Protection Area' on the map of referable wetlands located in the western portion of the ML. No Project infrastructure will intersect the 500 m buffer area applied to this wetland at this stage. The middle estuary of the Styx River is mapped as HEV under the EPP (water) approximately 8 km north of the Project area. The Project is predicted to release treated mine water only during flows events. Other potential impacts resulting from Project activities include increased sedimentation and uncontrolled releases of pollutants. Water quality of released water will be strictly controlled under the Project EA conditions. Mitigation measures to control for such events are described in Section 15.9 and Chapter 9 – Surface Water. No impacts expected.
Marine Plants	Protected marine plants as regulated under the *Fisheries Act 1994.*	Marine Couch (*Sporobolus virginicus*) was identified along the edge of the Styx River downstream of the site and is considered a marine plant. There are no marine plants within the Project area.
Legally secured offset areas	Includes offset areas legally secured under a registered covenant, easement, conservation agreement or development approval condition.	There are no secured offset areas on or near the Project area. Not applicable.

15.11.1 Potential Impacts to MSES and EVNT Fauna

15.11.1.1 Protected Areas

The boundary of the GBRMP and the Broad Sound FHA (both considered ESAs) is located 8 km north of the Project area in estuarine waters of the Styx River. The boundary of the GBRMP at this point is designated as a 'general purpose zone' and is not considered an MSES. The Broad Sound FHA is considered an MSES at this point. Approximately 40 km downstream of the Project, where the Styx River enters Broad Sound, is designated as a 'marine national park zone' within the GBRMP and is considered as a MSES.

15.11.1.2 Wetlands

There is a single WPA located within the MLs and near the eastern boundary. At this stage, no Project infrastructure will enter the 500 m buffer area located around this ephemeral wetland. Impacts to this area may include dust impacts on wetland health during construction and operation, groundwater drawdown and uncontrolled release of contaminated and / or sediment-laden waters from Project activities.

A second wetland to the north of this area is also on the vegetation management wetland mapping and thereby is considered an MSES. The footprint of the mine dewatering dam largely encompasses the area of this wetland.

15.11.1.3 EVNT Aquatic Fauna

The Project may result in direct and indirect impacts to the two threatened freshwater fauna species considered known or likely to occur: Southern Snapping Turtle (Endangered – NC Act) and Estuarine Crocodile (Vulnerable – NC Act). Given both species will only utilise large permanent pools in the adjacent creeks the potential impacts for both species are likely to be similar. Potential impacts most applicable to these species are localised groundwater level reductions impacting the extent of available habitat, and pollutant and sediment releases which may impact habitat quality.

15.11.1.4 Impacts to MSES

The potential impacts identified on aquatic MSES including EVNT fauna are those associated with water quality impacts (sediment and pollutants), potential groundwater drawdown of permanent waterholes, and potential dust settlement impacts on wetland health. Project impacts associated with the Styx River and downstream MSES are restricted to uncontrolled release of contaminated and / or sediment-laden waters from Project activities.

Mitigations applicable to both of these impacts have already been considered in previous sections (refer Section 15.10.6, 15.10.7 and 15.10.8). These impacts will be mitigated against during the detailed Project design and WMP and REMP will incorporate measures and monitoring that minimise any impacts to the identified values. The GBRMP and FHAs are located well downstream of the Project and no impacts are expected.

15.11.2 Impact Assessment for Threatened Aquatic Fauna

Sections 15.4.7.4 and 15.4.7.5 describe the likelihood of occurrence of threatened (listed under the NC Act and / or EPBC Act) fauna. Species that are considered unlikely or with potential to occur are not considered further and will not be subject to significant residual impacts from Project activities. There are two aquatic fauna species listed as threatened under the NC Act which are considered as likely or known to occur in the Project area or immediate surrounds:

- Southern Snapping Turtle (Endangered under the NC Act, also listed as Critically Endangered under the EPBC Act); and
- Estuarine Crocodile (Vulnerable under the NC Act, also listed as Migratory under the EPBC Act).

There are potential long-term impacts to EVNT fauna or likely habitat (large permanent pools) for Estuarine Crocodile or Southern Snapping Turtle. Initial modelling of a reduction in groundwater levels in the vicinity of open cut mining operations may reduce the level of localised permanent waterholes in these areas including the site where Southern Snapping Turtle was identified in 2011. At this stage, there is a 'low confidence' in the groundwater modelling results and further works are ongoing. Both species will be subject to a Project-specific Species Management Plan. As part of this further targeted surveys for Southern Snapping Turtle will be carried out to ascertain the extent of occurrence of the species in the catchment. The species is known to prefer flowing waters but does occur in ephemeral streams at much reduced densities.

Hydrological impacts resulting from Project activities such as water diversions and flood harvesting are considered very unlikely to impact water levels in likely habitat in either Deep Creek or Tooloombah Creek (refer Section 15.9.8). Mitigation measures relating to 'Accidental Release of Pollutants,' 'Increased Sedimentation of Waterways and Sediment Runoff' and 'Changes to Groundwater Table and GDEs' are detailed in the Sections 15.9.6, Section 15.9.7 and Section 15.5.9 respectively and are considered largely applicable to potential impacts on water quality and levels in the same areas.

Under the Queensland Environmental Offsets Policy: Significant Residual Impact Guideline (SoQ, 2014) the residual impact criteria for assessing the potential impact of a project's activities are essentially the same as that for Vulnerable MNES fauna under the EPBC Act Significant Impact Guidelines 1.1 (DotE, 2013) (refer Chapter 16 – MNES). The significant impact criteria assessment for each of the threatened species listed above is presented in the following table (Table 15-12).

Table 15-12 Assessment against MSES significant impact criteria for threatened species identified

Assessment criterion	Estuarine Crocodile	Southern Snapping Turtle
	Assessment against significance criteria	
Lead to a long-term decrease in the size of a local population of the species	Anecdotal evidence suggests species occurs although the extent of occurrence upstream of the Styx River is uncertain. No direct construction impacts on suitable habitat (large pools) are proposed. Impacts to habitat values that may directly impact individuals or prey species (such as sedimentation and pollutants causing water quality / habitat degradation) will have mitigation measures applied. Hydrologic inflows to likely habitat will not be impacted. Groundwater drawdown may impact permanent waterholes in the vicinity of mining operations but these areas are likely to be of very limited value to this species. Unlikely to lead to a decrease of a local population.	Species recorded in Deep Creek during 2011 aquatic surveys. Likely to occur in low densities in large pools given ephemeral nature of creeks. No direct construction impacts on suitable habitat (large pools) are proposed. Impacts to habitat values that may directly impact individuals or prey species (such as sedimentation and pollutants causing water quality / habitat degradation) will have mitigation measures applied. Hydrologic inflows to likely habitat will not be impacted. Groundwater drawdown may impact permanent waterholes in the vicinity of mining operations including where the species has been recorded. Mitigation measures will include a Significant Species Management Plan, dedicated program to assess the water requirements of GDEs associated with the Project area, monitoring of water levels and quality in at risk sites, and measures to replenish waterholes if necessary. With these measures in place the Project is considered unlikely to lead to a long-term decrease of a local population.

Assessment criterion	Estuarine Crocodile	Southern Snapping Turtle
	Assessment against significance criteria	
Reduce the area of occurrence of the species	Species occurs across much of coastal Queensland. Uncertain if species utilises freshwater habitats adjacent to the Project more than occasionally. The Project will not reduce the area of occurrence.	Known to occur in Fitzroy catchment and Mary / Burnett catchments. Groundwater drawdown may impact permanent waterholes in the vicinity of mining operations however this impact will be localised and mitigation measures will include replenishing impacted areas. The Project will not reduce the area of occurrence.
Fragment an existing population	Overall population is widely dispersed and no subpopulations are recognised. Uncertain if species utilises freshwater habitats adjacent to the Project more than occasionally. The Project is unlikely to fragment an existing population should the species occur upstream of Project activities.	Genetic subpopulations recognised between Fitzroy catchment and Mary / Burnett catchments. Status of Styx River catchment population unknown. Groundwater drawdown may impact permanent waterholes in the vicinity of mining operations and mitigation measures will include replenishing impacted areas. The Project is unlikely to fragment an existing population.
Result in genetically distinct populations forming as a result of habitat isolation	Project design and location within surrounding landscape is unlikely to result in habitat isolation of any species.	
Result in invasive species that are harmful to a vulnerable species becoming established in the species habitat	The LUMP will incorporate weed and pest measures to control the introduction and spread of weed species across the Project area. The LUMP will be in place for the life of the Project, and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered very unlikely to result in invasive species becoming established in the Project area to the detriment of any threatened species' habitat.	
Introduce disease that may cause the population to decline	The LUMP will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause a population of threatened species to decline.	
Interfere with the recovery of the species	The extent of the Project area is relatively small and no individuals of any of either species have been found within the Project site itself. With mitigation of potential Project impacts through surface water management and measures incorporated within the LUMP and REMP, any potential impact on a threatened species, should it occur in the Project area, will be minor and is considered unlikely to interfere with the recovery of the species.	
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	There will be no direct impacts to suitable habitat and indirect impacts will be mitigated. It is unlikely to cause disruption to ecologically significant locations.	Groundwater drawdown may impact permanent waterholes in the vicinity of mining operations and mitigation measures will include replenishing impacted areas. It is uncertain to what extent these areas may be used as breeding habitat as they appear unsuitable and subject to disturbance from known hazards such as the presence of cattle and pigs. With mitigation measures in place the Project is considered unlikely to lead for disruption to ecologically significant locations as a feeding / resting site.
Assessment of potential for significant residual impacts	No significant residual impacts are considered likely to occur.	No significant residual impacts are considered likely to occur.

From the significant impact assessment guidelines for habitat for MSES fauna and flora, no threatened aquatic species are considered to have significant residual impact as a result of Project activities and as a result will not be subject to a biodiversity offsets plan.

15.12 Conclusion

The Project is located within the Styx River basin occupying the lower catchments of two major creek lines – Deep Creek and Tooloombah Creek. The region has experienced a long history of human disturbance largely due to grazing activities which occupies 78% of the Styx River catchment. Deep Creek and Tooloombah Creek lie adjacent to the east and west boundaries of the Project. These creeks are ephemeral, merging two kilometres north of the Project area whereupon it becomes the Styx River. The Styx River is subject to tidal influence almost to the confluence of the two creeks.

The Styx River widens into a large estuary that is located within the wider Broad Sound area 10 km downstream of the Project. Broad Sound is listed as a Fish Habitat Area, is on the Directory of Important Wetlands of Australia, and is part of the great Barrier Reef Marine Park and World Heritage Area.

Aquatic habitats sampled in the area appear to be in good condition when surveyed during flow events despite the impact of cattle grazing in the wider area. Riparian cover along Tooloombah Creek and Deep Creek is largely continuous. Water quality across the catchment recorded generally high values of nutrients including ammonia, nitrogen and phosphorus. Deep Creek was recorded as having significant turbidity levels in some survey areas during no flow conditions. Macroinvertebrate assemblages within survey sites were diverse and representative of healthy aquatic systems when creeks were flowing.

No listed aquatic flora was recorded during the surveys. Observations during wet and dry season surveys across the wider area recorded a number of sedge / wetland plants associated with ephemeral wetlands including Swamp Lily, *Eleocharis blakeana* and *Juncus polyanthemus.* A total of 28 fish species were recorded during site surveys which included the Styx River. The species recorded are generally typical of what would be expected to occur in a Central Queensland coastal catchment. There are no records of introduced species from either desktop information or field surveys indicating the catchment may be relatively free of introduced fish taxa.

Two threatened aquatic species are known or likely to occur in the waters adjacent to the Project. Southern Snapping Turtle (listed as Endangered – NC Act; Critically Endangered - EPBC Act) was recorded at a site in Deep Creek. It is expected to occur in low densities due to the ephemeral nature of creeks in the area. Anecdotal evidence indicates that Estuarine Crocodile (listed as Vulnerable – NC Act; Migratory - EPBC Act) occurs in the Styx River and Deep Creek.

Stygofauna communities were recorded during a comprehensive (seasonal) study sampling from groundwater bores located within the mine lease boundary and the wider area. Five species were identified to the north of the Project. Only a single species was located on the eastern boundary of the mine lease. This species was found within the predicted groundwater drawdown impact area resulting from mine activities. It is considered highly unlikely this species is restricted to the relatively small area of Project groundwater impact. Therefore, no stygofaunal species is considered restricted to the potential impact area and there will be no significant impacts.

Predicted groundwater drawdown impacts close to open cut mining activities has the potential to cause long-term impacts to localised habitat for the Southern Snapping Turtle, and (to a lesser extent) Estuarine Crocodile through reduction of water levels in permanent waterholes. Both species will be subject to Significant Species Management Plans.

The mitigation measures proposed as part of the Project will minimise additional indirect impacts to aquatic EVs within and surrounding the Project area from construction and operational activities.

These measures include monitoring and management measures under the REMP and WMP, to monitor the health of wetlands, streams and riparian vegetation adjacent to the Project for indirect impacts such as water level reductions (in permanent waterholes), dust and surface water contamination. Management measures will include provisions of replenishment in permanent waterholes should water level reductions be detected. With control measures in place indirect impacts to aquatic EVs and aquatic fauna are not expected to be significant.

15.13 Commitments

Table 15-13 Commitments - aquatic ecology

Commitment
Develop and implement a Land Use Management Plan which will establish a vegetation monitoring program, identify pest and weed management controls, fire management measures and principles for managing fauna.
Develop and implement Significant Species Management Plans for managing those threatened species known or likely to occur on the site.
Develop and implement a series of dust mitigation and monitoring measures.
Develop and implement a Receiving Environment Monitoring Program in accordance with EHP Guidelines and periodically update as required throughout the life of the Project.
Fish passage will be maintained at haul road crossing points along Deep Creek and Barrack Creek through incorporating a bridge construction design. At shallower creek crossings culverts designed using guidelines for fish passage will be employed.
Design and implement a Project Erosion and Sediment Control Plan to be certified by a suitably qualified person, prior to construction.
The health of riparian vegetation adjacent to creek crossings will be monitored at least annually throughout construction, operation and decommissioning to identify impacts (such as coal dust accumulation, bank destabilisation and erosion and sediment issues) to environmental values
Prepare and implement a Water Management Plan that outlines the monitoring and management measures for surface water and groundwater.

15.14 ToR Cross-reference Table

Table 15-14 ToR cross-reference

Terms of Reference	Section of the EIS
8.7 Flora and Fauna	
Describe the potential direct and indirect impacts on the biodiversity and natural environmental values of affected areas arising from the construction, operation and decommissioning of the project.	Section 15.7
Consider any proposed avoidance and/or mitigation measures.	Section 15.8
The EIS should provide information based on relevant guidelines, including but not limited to EHP's EIS information guidelines that comver flora and fauna, aquatic ecology, coastal issues, ground-dependent ecosystems, water, matters of national environmental significance, and biosecurity.	Noted
The assessment should include the following key elements: • identification of all significant ecological species and communities, including MSES and MNES, listed flora and fauna species, and regional ecosystems, on the project's site and in its vicinity	Sections 15.6.2 and 15.6.3 and Chapter 14 – Terrestrial Ecology and 16 - MNES
• terrestrial and aquatic ecosystems (including groundwater-dependent ecosystems) and their interactions • biological diversity	Section 15.6 and Chapters 10 – Groundwater and 14 – Terrestrial Ecology
• the integrity of ecological processes, including habitats of listed threatened, near threatened or special least-concern species	Sections 15.6.3.6 and 15.7 and Chapters 10 – Groundwater, 14 – Terrestrial Ecology, and 16 - MNES
• connectivity of habitats and ecosystems	Sections 15.6.5, 15.7, 15.8
• the integrity of landscapes and places, including wilderness and similar natural places	Chapter 14 – Terrestrial Ecology
• chronic, low-level exposure to contaminants or the bio-accumulation of contaminants	Sections 15.7.6, 15.8.6 and 15.10.6 and Chapters 9 – Surface Water, 10 – Groundwater and 14 – Terrestrial Ecology and 16 - MNES
• impacts (direct or indirect) on terrestrial and aquatic species and ecosystems whether due to: vegetation clearing; hydrological changes; discharges of contaminants to water, air or land; noise; etc.	Section 5.7 and Chapters 9 – Surface Water, 10 – Groundwater, 14 – Terrestrial Ecology and 16 - MNES
• impacts of waterway barriers on fish passage in all waterways mapped on the Queensland Waterways for Waterway Barrier Works spatial data layer.	Section 15.7.2 and 15.11

Terms of Reference	Section of the EIS
Describe any actions of the project that require an authority under the *Nature Conservation Act 1992*, and/or would be assessable development for the purposes of the *Vegetation Management Act 1999*[1], the *Regional Planning Interests Act 2014,* the *Fisheries Act 1994* and the *Planning Act 2016.* Features to consider include regional ecosystems, environmentally sensitive areas, wetlands, nature refuges, protected areas and strategic environmental areas.	Section 15.8.2
Propose practical measures to avoid, minimise, mitigate and/or offset direct or indirect impacts on ecological environmental values.	Sections 15.8, 15.10 and 15.11 and Chapters 10 – Groundwater, 14 – Terrestrial Ecology, and 16 - MNES
Assess how the nominated quantitative indicators and standards may be achieved for nature conservation management.	Section 15.8
Address measures to protect or preserve any listed threatened, near-threatened or special least concern species.	Section 15.8
Propose measures that would avoid the need for waterway barriers, or propose measures to mitigate the impacts of their construction and operation.	Section 15.8.2
Assess the need for buffer zones and the retention, rehabilitation or planting of movement corridors. The assessment should take account of the role of buffer zones in maintaining and enhancing riparian vegetation to enhance water quality and habitat connectivity.	Sections 15.6.2.2 and 15.7.1
Propose rehabilitation success criteria, in relation to natural values, that would be used to measure the progressive rehabilitation of disturbed areas. Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed. Proposals for the rehabilitation of disturbed areas should incorporate, in suitable habitat, provision of nest hollows and ground litter.	Chapter 11 - Rehabilitation
Specifically address any obligations imposed by State or Commonwealth legislation or policy or international treaty obligations, such as the China–Australia Migratory Bird Agreement, Japan–Australia Migratory Bird Agreement, or Republic of Korea–Australia Migratory Bird Agreement.	Chapter 16 - MNES
8.7.1 Offsets	
For any significant residual impacts, propose offsets that are consistent with the following requirements as set out in applicable State and Commonwealth legislation or policies: • Where a significant residual impact will occur on a prescribed environmental matter as outlined in the Environmental Offsets Regulation 2014, the offset proposal(s) must be consistent with the requirements of Queensland's *Environmental Offsets Act 2014* and the latest version of the Queensland Environmental Offsets Policy[2].	Chapter 14 – Terrestrial Ecology
• Where the Commonwealth offset policy requires an offset for significant impacts on a MNES, the offset proposal(s) must be consistent with the requirements of the EPBC Act Environmental Offsets Policy (October 2012), the *Offsets Assessment Guide* and relevant guidelines[3] (refer to also Appendix 3 of this TOR).	Chapter 16 - MNES

[1] This is notwithstanding that the Vegetation Management Act 1999 does not apply to mining projects. Refer also to https://www.qld.gov.au/environment/land/vegetation/clearing/

[2] https://www.qld.gov.au/environment/pollution/management/offsets/

[3] http://www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy

Terms of Reference	Section of the EIS
8.8 Coastal environment	
Conduct impact assessment in accordance with the EHP's *EIS information guideline—Coastal*.	Noted
Provide illustrated details of the existing coastal zone that is potentially affected by the project, and describe and illustrate any proposed works in the coastal zone, including a schedule of ongoing maintenance requirements. The description should at least address the following matters: • state or Commonwealth marine parks in the region of the project's site	Section 15.11
• separately mention marine plants and any fish habitat areas protected under the *Fisheries Act 1994*	Section 15.11
Assess the potential impacts of the project's activities in the coastal zone.	Section 15.7
Propose measures to avoid or minimise the potential impacts of the project's activities in the coastal zone. If acid sulfate soils would be disturbed, describe measures to avoid oxidation of the sulfides or to treat and neutralise the acid if it forms.	Section 15.8 and Chapter 5 - Land
Detail any residual impacts that cannot be avoided, and propose measures to offset the residual loss.	Section 15.11
Develop and describe suitable indicators for measuring coastal resources and values, and set objectives to protect them in accordance with relevant State Planning Policy July 2014, guidelines and legislation. Refer to EHP's guidelines on coastal development.	Section 15.8
Detail a monitoring program that would audit the success of mitigation measures, measure whether objectives have been met, and describe corrective actions to be used if monitoring shows that objectives are not being met.	Section 15.8