Chapter 19

Aquatic Ecology

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19. AQUATIC ECOLOGY

19.1 Introduction

This chapter describes the aquatic ecological values of the region in which the project is proposed. The potential impacts on these aquatic ecological values that may arise during construction, operation, and decommissioning of the project are described and assessed. Management strategies to mitigate these impacts are also presented.

This chapter is based on the Aquatic Ecology Impact Assessment Report provided in **Appendix 20**.

19.2 Methodology

A combination of desktop and field studies were conducted to gather information about aquatic ecological values for the project area. A summary of the methodology used to undertake these tasks is provided below.

19.2.1 Desktop Assessment

The desktop assessment was undertaken in March 2012 and included a review of the following Commonwealth and State databases:

- The Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) Protected Matters Search Tool to identify Matters of National Environmental Significance (MNES) within approximately 20 km of the project area.
- The Department of Environment and heritage Protection (EHP) Queensland Wetlands 2009 and 2011 (WetlandInfo) mapping to determine the classification, extent, and significance of palustrine, lacustrine and riverine systems within the project area
- EHP WetlandInfo Wetland Summary Information (including species listings) for the Burdekin Basin
- The Burdekin Natural Resource Management Region 'Back on Track' Actions for Biodiversity
- Aquatic Conservation Assessments for the riverine and non-riverine wetlands of the Great Barrier Reef catchment: Burdekin region
- Published ecological information on EVNT ('Endangered, Vulnerable or Near Threatened' under the *Nature Conservation Act 1992* (NC Act) or 'Critically Endangered, Endangered, Vulnerable or Conservation Dependent' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)) and special 'least concern' aquatic flora and fauna species.

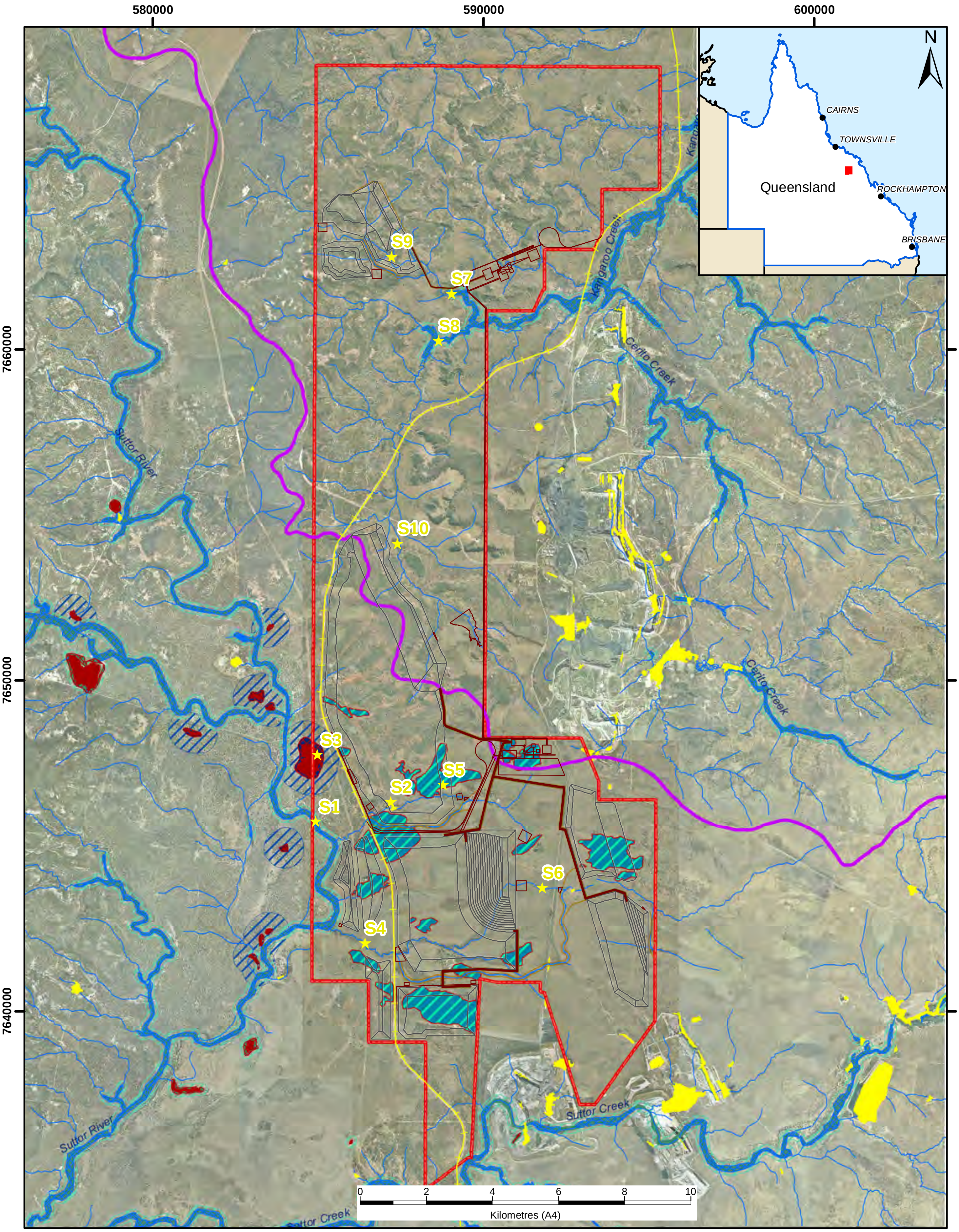
EHP has undertaken site assessment to specifically define drainage features into the categories of watercourses (assessable under the *Water Act 2000*) and drainage lines (not assessable under the *Water Act 2000*). EHP defined watercourses and drainage lines are shown in **Chapter 15**.

19.2.2 Field Survey

The field survey was conducted in May ('late wet' season), approximately 6 weeks after a flood event in the area, during which the Suttor River rose approximately 7 m in 24 hours. A second survey ("early wet season") was conducted in December 2012 the results of which are still being finalised and as such are not presented herein.

19.2.2.1 Site Selection

A total of 10 sites were surveyed within the project area to characterise representative aquatic ecosystems that may be impacted by the project. These consisted of three sites within the Suttor River and its tributaries, four sites within Kangaroo Creek and its tributaries, and three wetland sites (one palustrine wetland, one lacustrine wetland, and one gilgai wetland). Sites within the Suttor River and its tributaries, and Kangaroo Creek and its tributaries, were located both upstream and downstream of the mine. Locations of survey sites are shown in **Figure 19-1**. Detailed information on sampling sites and the samples collected is presented in **Table 19-1**.



Legend

- Project Area
- Waste Rock Dumps and Pits
- Mine Infrastructure
- Catchment Boundary
- GAP Rail Line
- Aquatic Ecology Survey Sites
- Riverine System (Drainage Lines)

Wetland Management Area

- Wetland
- Trigger Area

GBR Wetland Protection Area

- Wetland
- Trigger Area

Water Bodies

- Riverine
- Lacustrine
- Palustrine

Wetland Regional Ecosystem

- Riverine
- Palustrine
- Indicative extent gilgai wetland habitat

Survey Sites, Drainage Features, Wetlands, & Gilgais

Figure 19-1

Byerwen Coal Project

Date: *5/02/2013*

Author: Shahram.Nasiri

Map Scale: 1:150,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

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Table 19-1 Details of Sites and Samples Collected during the Field Survey

Site	Site Code	Date Surveyed	Stream Order	Latitude GDA 1994	Longitude GDA 1994	Macroinvertebrate Samples		Water Chemistry	Habitat Assessment
						Bed Habitat	Edge Habitat		
Suttor River	S1	01/05/2012	5	−21.2883	147.8187	✓	✓	✓	✓
Lacustrine Wetland	S2	02/05/2012	NA	−21.2829	147.8406	✓	✓	✓	✓
Palustrine Wetland	S3	03/05/2012	NA	−21.2700	147.8191	-	✓	✓	✓
Suttor River Tributary	S4	03/05/2012	2	−21.3215	147.8333	✓	✓	✓	✓
Gilgai	S5	04/05/2012	NA	−21.2781	147.8559	-	*	-	✓
Suttor River Tributary	S6	04/05/2012	1	−21.3061	147.8849	✓	✓	✓	✓
Kangaroo Creek Tributary	S7	05/05/2012	3	−21.1440	147.8575	✓	✓	✓	✓
Kangaroo Creek Tributary	S8	05/05/2012	4	−21.1569	147.8538	✓	✓	✓	✓
Kangaroo Creek Tributary	S9	05/05/2012	3	−21.1340	147.8400	✓	✓	✓	✓
Kangaroo Creek Tributary	S10	06/05/2012	2	−21.2123	147.8422	✓	✓	✓	✓

Note *: Limited to sampling of freshwater crab (*Austrothelphusa transversa*) and fairy shrimp (*Branchinella* sp.).

19.2.2.2 Aquatic Habitats

Aquatic habitats were described in accordance with AUSRIVAS protocols for Queensland Streams (DNRM, 2001). This established a general description of the environment of each site and its immediate surrounding (survey reach). The classifications are based on flow level, depth, velocity, width, canopy cover, substrate types, habitat attributes, local catchment erosion, sediment deposits, water colour, algae, water odour, substrate odour, presence of snags and large woody debris, riparian zone width and cover, and general signs of disturbance.

AUSRIVAS protocols suggest a minimum of two survey events in a year. These events should be on a 'seasonal' basis, with at least one undertaken between May and July ('late wet'), and one undertaken between October and December ('early wet').

According to the DNRM (2001), aquatic ecological sampling should be avoided for 4 to 6 weeks following a flood event, unless the impact of flood is being investigated. This is because flood conditions can flush waterways, disbursing sediments and benthic organisms either downstream or across a much broader stream cross-section. The late wet sampling event was undertaken 6 to 7 weeks following the flood event which is in accordance with Queensland AUSRIVAS protocol. An early wet season survey (for which results are not yet available) was completed in December 2012, complying with AUSRIVAS protocols.

19.2.2.3 Water Chemistry

Water quality measurements and water sampling were undertaken at all sites, with the exception of the gilgai (site S5), prior to any disturbance of the surrounding environment. Downstream sites were sampled first to ensure that results were not compromised through disturbance of upstream sampling sites.

Physico-chemical water quality parameters (pH, electrical conductivity, total dissolved solids, turbidity, dissolved oxygen and temperature), were measured and recorded using a calibrated multi-parameter water quality meter.

Water sampling was undertaken in accordance with *AS/NZS 5667.6 - Guidance on sampling of rivers and streams*. Water samples were analysed for the following:

- major cations – calcium, magnesium, sodium, and potassium
- major anions – chloride, sulphate, and alkalinity (carbonate and bicarbonate)
- nutrients – ammonia, nitrite, nitrate, total Kjeldahl nitrogen, total nitrogen, total phosphorus, and reactive phosphorus.

Samples collected for nitrite, major cations, and reactive phosphorus exceeded recommended holding times between sampling and analyses. However, overall data integrity was sufficient to characterise the abiotic environment for the purposes of this aquatic ecology impact assessment.

Water quality was assessed against the guidelines described in **Chapter 15**.

19.2.2.4 Aquatic Flora Survey

Presence/absence surveys of aquatic plants (macrophytes) were undertaken at all 10 sites. For streams, this involved a systematic survey of aquatic plants for a 100 m reach, while for wetlands this involved transects. All aquatic plant specimens collected were identified using available literature and keys. Algae were not surveyed during this assessment.

19.2.2.5 Aquatic Fauna Survey

Macroinvertebrates

The assessment of in-stream aquatic macroinvertebrate communities was undertaken by an accredited AUSRIVAS ecologist and in accordance with AUSRIVAS protocols for Queensland streams (DNRM, 2001). Samples were taken from two distinct aquatic habitats; benthos – benthic (bed) and littoral (edge) fringe. Data was used calculate a number of community descriptors including taxa richness, EPT richness, Stream Invertebrate Grade Number Average (SIGNAL 2) score and AUSRIVAS (which is a prediction system used to assess the biological health of Australian rivers). Further details of these indicators of aquatic ecology health are provided in **Appendix 20**.

Macroinvertebrates specimens were identified by an AUSRIVAS accredited taxonomist. All specimens were identified to family level, except those for which family level identification is not required under the AUSRIVAS protocol.

Fish

Both passive and active sampling techniques were employed to characterise the fish assemblages at survey sites. Passive sampling techniques included baited traps and un-baited fyke nets. Active sampling techniques included seine nets and an LR-24 backpack electrofisher. The methods employed at each site were dictated by the site characteristics.

19.3 Environmental Values – Riverine Systems and Wetlands

19.3.1 Riverine Systems and Draining Lines

The project area encompasses the Upper Suttor River sub-catchment in the south and the Rosella Creek sub-catchment (containing the Kangaroo Creek catchment) in the north (refer to **Figure 19-1**).

In the Upper Suttor River sub-catchment, the broadly defined Queensland Wetland Map (EHP, 2012) shows 15 riverine systems or drainage lines, including:

- One 5th order stream (the Suttor River)
- One 3rd order stream
- Three 2nd order streams
- Ten 1st order streams.

In the Rosella Creek sub-catchment, the project area includes 95 riverine systems or drainage lines mapped by EHP (2012), including:

- One 4th order stream
- Five 3rd order streams
- Sixteen 2nd order streams
- Seventy-three 1st order streams.

The drainage lines within the project area are expected to experience flow only after sustained or intense rainfall in the catchment. Stream flows are highly variable, with most channels expected to dry out during the months of August and September, when rainfall and runoff is historically low. During these times, aquatic fauna are concentrated in senescing pools. As a consequence, physical attributes, water quality, and the composition of aquatic floral and faunal communities, are expected to be highly variable over time.

The Suttor River is the largest waterway that intersects the project area and has a catchment area of approximately 704 km^2. Data from the DNRM gauging station on the Suttor River at Eaglefield (Station No. 120304), approximately 25 km downstream of the project area, indicates that average daily stream flows exceed a median of zero (i.e., flow is encountered more than half the time) only in the wetter months of January, February and March. During other months, this reach of the Suttor River is expected to have low to no flow.

At the time of the site surveys in May 2012, recessional baseflows were encountered on the Suttor River (site S1), and at three stream sampling sites in the Kangaroo Creek catchment (sites S7, S8 and S9). Flows had declined to isolated standing pools at sites S4 and S6 in the Suttor River catchment, and at site S10 in the Kangaroo Creek catchment.

River height data for the Suttor River gauging station at Eaglefield shows that a flood event occurred in March 2012, following intense rainfall and runoff in the catchment. Flood levels in the Suttor River at Eaglefield peaked on 19 March 2012, and again on 21 March, at approximately 8.5 m above the base flow level. It is inferred that intense rainfall is likely to have occurred across the broader project area during this period, including in the northern parts of the project area that fall within the Kangaroo Creek catchment.

19.3.2 Wetlands

An EPBC Act Protected Matters Report did not identify any wetlands of international significance (Ramsar wetlands) within or downstream of the project area.

The closest wetlands of national significance occur downstream of the project area. Birralee-Pelican Creek Aggregation on the Bowen River is 70 km downstream of the project area and the Scartwater Aggregation on the flood plain of the Suttor River is 220 km downstream of the project area. Given the distance from the project area, these wetlands are considered extremely unlikely to be impacted by the project.

19.3.2.1 Palustrine Wetlands

The Queensland Wetlands mapping (EHP, 2012) identifies only one mapped palustrine wetland within the project area which is classified as a High Ecological Significance (HES) wetland.

This wetland (site S3) is situated on a closed depression of the Suttor River floodplain, and is intersected by the western boundary of the project area, but is not within the project footprint. At the time of the surveys, this wetland was a vegetated swamp covering approximately 60 ha (1 km x 0.6 km), with an average depth of 0.5 m (refer **Photo 19-1**). It was dominated by Forest red gums (*Eucalyptus tereticornis*) and emergent macrophytes (**Section 19.4**).

The wetland is likely to be semi-permanent in nature, given that *Eucalyptus tereticornis* is susceptible to impacts of waterlogging and is characteristic of ephemeral wetlands.

The existing GAP rail line already intersects the 500 m buffer to the east of this HES wetland. The railway is <400m from the HES wetland and lies between this HES wetland and the closest project operations (West Pit complex), which are estimated to be 400-500 m from the wetland. The rail infrastructure is likely to have altered the hydrology of the wetland although no baseline data are available to allow an assessment of change over time.

Photo 19-1 Palustrine Wetland (Site S3), May 2012

19.3.2.2 Lacustrine Wetlands

The Queensland Wetlands mapping (EHP, 2012) identifies seven mapped lacustrine wetlands within the project area (refer **Figure 19-1**). Six of these are dammed drainage channels, and the seventh is a topographic depression upslope of a constructed contour in the south-eastern section of the project area. The dam to the west of East Pit 1 and 2 would remain undeveloped, as would the topographic depression. The dam near the south-east corner of South Pit 1 would be incorporated into the drainage diversion; however would remain largely unchanged.

One of the dams (site S2) is positioned within the proposed West Pit 1 (**Photo 19-2**), and would be dewatered as part of the project. This dam had recently (in 2011) been enlarged. At the time of the surveys, the wetted area of site S2 was approximately 5 ha, being approximately 250 m wide at the dam wall, and extending approximately 400 m upstream. Fringing vegetation was dominated by Brigalow (*Acacia harpophylla*) and pasture grasses.

Two dams located to the north of East Pit 1 would remain unaffected by the project, as would the dam located on a tributary to Suttor Creek in the far southeast of the project area.

Photo 19-2 Lacustrine Wetland (Site S2), May 2012

19.3.2.3 Gilgai Wetlands

A number of gilgai wetlands were observed across the project area, all occurring on untilled vertosol soils. The indicative extent of gilgai wetland habitat is shown in **Figure 19-1**. These gilgai wetlands are ephemeral and are expected to fill with water during and following periods of heavy and/or extended rain. **Photo 19-3** shows an example of a gilgai wetland (site S5) observed within the project area during surveys in May 2012. This wetland was approximately 0.7 m deep. Perimeter vegetation was dominated by the annual herb sesbania pea (*Sesbania cannabina*), interspersed with a diversity of macrophytes including; *Juncus sp., Marsilea nutica*, Monochoria (*Monochoria cyanea*), *Cyperus sp*., Cumbungi (*Typha domingensis*) and Smartweed (*Persicaria attenuata*). Brigalow (*Acacia harpophylla*) regrowth dominated the gilgai mounds.

Photo 19-3 Gilgai Wetland (Site S5) May 2012

19.3.2.4 Wetland Physical Habitat Assessment

The physical habitat variables for each of the riverine and wetland sites are presented in **Table 19-2**.

Table 19-2 Physical Habitat Variables of Riverine and Wetland Survey Sites

Habitat Variable	Suttor River and Tributaries			Kangaroo Creek Tributaries				Wetlands	
	S1	S4	S6	S7	S8	S9	S10	S2	S3
Bottom substrate/available cover	G	P	G	G	G	G	G	P	P
Embeddedness	G	P	F	G	F	F	G	G	E
Velocity/depth category	F	P	P	P	F	F	F	P	P
Channel alteration	F	E	F	F	F	P	F	NA	NA
Bottom scouring and deposition	P	F	F	P	F	P	F	E	E
Pool/riffle, run/bed ratio	F	F	F	F	G	F	G	NA	NA
Bank stability	F	P	G	G	F	F	F	E	E
Bank vegetative stability	E	G	G	G	G	G	E	E	E
Streamside cover	E	E	F	E	E	E	E	F	E

P – Poor, F – Fair, G – Good, E - Excellent

The overall habitat condition of each riverine survey site was assessed as being ‘fair’. Most sites exhibited excellent streamside cover. However, overall scores were reduced by factors including:

- evidence of bottom scouring and deposition at most sites – associated with fine substrates, erodible bank materials and intense runoff having previously occurred
- poor velocity/depth categories – with most sites containing only isolated pools and lacking runs or riffles associated with stream flow and connectivity.

The latter is largely a result of seasonality (also modified flow paths, dams, etc.) and is expected to improve substantially in the wetter months of the year. Physical habitat condition is likely to increase to ‘good’ once flows resume in the early wet season.

19.3.3 Water Quality

Water quality data for a range of parameters is provided in **Chapter 15**. The water quality data presented in **Appendix 20** and summarised in **Table 19-3** supplements the data presented in **Chapter 15**.

Table 19-3 Water Quality Data from Aquatic Ecology Survey Sites

Parameter	Site								
	S1	S2	S3	S4	S6	S7	S8	S9	S10
Temperature[5] (˚C)	21.6	24.3	22.3	18.7	22.6	19.0	21.8	24.0	16.6
pH (pH units)	6.8	7.1	7.5	7.0	7.6	8.0	7.9	8.3	8.2
Electrical Conductivity (µS/cm)	174	200	98	98	655	729	1414	145	278
Dissolved Oxygen (% saturation)	79	40	26	39	78	80	74	77	58
Dissolved Oxygen (mg/L)	6.5	3.1	2.0	3.7	6.8	7.2	6.3	6.5	5.6
Turbidity (NTU)	NR	30	81	NR	280	33	10	231	751
Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01
Nitrate as N (mg/L)	0.04	<0.01	<0.01	0.14	0.01	0.02	0.01	0.02	0.14
Nitrite + Nitrate as N (mg/L)	0.04	<0.01	<0.01	0.15	0.01	0.02	0.01	0.02	0.15
Total Kjeldahl Nitrogen as N (mg/L)	0.7	1.2	0.9	0.8	0.8	0.3	0.3	0.6	0.6
Ammonia as N (mg/L)	0.06	0.05	0.05	0.10	0.05	0.04	0.04	0.05	0.06
Total Nitrogen (mg/L)	0.7	1.2	0.9	1.0	0.8	0.3	0.3	0.6	0.8
Reactive Phosphorus (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Phosphorus (mg/L)	0.08	0.13	0.12	0.54	0.13	<0.01	0.06	0.12	0.02
Calcium (Ca)	4	15	2	5	30	29	61	3	11
Magnesium (Mg)	5	7	2	3	19	37	64	4	6
Sodium (Na)	25	9	14	14	70	55	101	13	25
Potassium (K)	2	7	3	2	6	3	5	2	3
Chloride (Cl)	31	6	11	8	86	52	174	15	37
Sulfate (SO_4)	<1	<1	<1	<1	111	<1	<1	<1	<1

Parameter	Site								
	S1	S2	S3	S4	S6	S7	S8	S9	S10
Alkalinity (HCO_3 + CO_3)	38	88	30	50	82	273	448	28	51

The EC levels were variable across the project area, ranging from the 98 µS/cm (fresh) at sites S3 and S4, to 1414 µS/cm (moderately saline) at site S8. The DO concentrations were relatively low across the project area, with poorly oxygenated conditions recorded at sites S2, S3 and S4. The low DO concentrations are indicative of the low to nil flow conditions, which were observed across the project area.

Turbidity was relatively low at the wetland sites, and higher at sites which exhibited flow, and/or where cattle had direct access to the waterway, causing surface erosion. High turbidity is expected in most waterways of the project area (and the broader catchment), where stream banks and beds consist of high percentages of silt and clay, which are more readily held in suspension.

Total Nitrogen (TN) concentrations exceeded QWQG criteria at sites S1, S2, S4, S5, S6, S7, S9, and S10. Ammonia concentrations (NH_3 as N) exceeded the QWQG criteria in all sites, except site S3. High nutrient concentrations (nitrogen and phosphorus) can indicate the potential for excessive weed and algal growth. However, this depends on the bioavailability of nutrients, as well as physical characteristics of the waterway, such as turbidity which can reduce light penetration beneath the water's surface, decreasing photosynthetic rates, and associated weed and algal growth.

Sodium concentrations far exceeded concentrations of all other cations at all sites, except site S2, where calcium concentrations were higher. Concentrations of calcium and magnesium were also high, although not higher than sodium, at sites S6, S7, and S8. Potassium concentrations were low at all sites.

19.4 Environmental Values – Aquatic Flora

19.4.1 Recorded Flora Species

A flora species list generated from Wetland Info (EHP, 2012) identified 157 wetland indicator plants as having been recorded in the broader Burdekin Basin. A total of 13 genera of aquatic plants (macrophytes) were recorded during the survey and are listed in **Table 19-4**.

Table 19-4 Macrophytes Recorded at Survey Sites

Scientific Name	Common Name	Site									
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Cyperus spp.	Sedges	✓		✓	✓	✓		✓			✓
*Echinochloa colona**	Awnless barnyard grass			✓			✓				✓
Eclipta prostrata	White eclipta						✓				
Eleocharis dulcis	**Water chestnut**			✓							
Eleocharis equisetina	Spike rush			✓							
Juncus spp.	Common rush					✓				✓	
Leersia hexandra	**Swamp ricegrass**			✓							

Scientific Name	Common Name	Site									
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Marsilea drummondii	**Nardoo**			✓							
Marsilea mutica	Marsilea			✓		✓					
Monochoria cyanea	Monochoria			✓		✓					
Nymphoides crenata	Wavy marshwort			✓							
Persicaria attenuata	Smartweed		✓			✓					
Philydrum lanuginosum	Frogsmouth			✓							
Typha domingensis	Cumbungi					✓					
Utricularia aurea	Bladderwort			✓							

Notes:
Bold text denotes ACA priority species
* Denotes introduced species.

All wetland indicator plants were of emergent growth form, with the exception of bladderwort (*Utricularia aurea*), which is a submergent form.

The palustrine wetland (site S3), and gilgai wetland (site S5), had the highest diversity of macrophytes. The lacustrine wetland (site S2) and the stream survey sites (sites S1, S4, S6, S7, S8, S9 and S10) all had low macrophyte diversity and abundance. No macrophytes were recorded at site S8, a fourth order tributary of Kangaroo Creek.

The lack of both diversity and abundance in macrophyte cover at the stream survey sites may be indicative of the harsh physical conditions, scouring, and sediment movement associated with the high flow and flood events that occurred in the broader project area in early 2012 (refer **Section 19.3.1**). However, the lack of diversity may also be due to seasonal variation. Seasonal conditions may influence the diversity and/or abundance of macrophytes. For example, community variation may occur through recruitment in response to sustained flows, or through increased temperatures and daylight hours in the warmer months.

19.4.2 Species and Communities of Conservation Significance

An EPBC Act Protected Matters Report did not identify any 'Threatened Ecological Communities' relevant to aquatic ecosystems.

Two threatened aquatic flora species were identified in database searches as occurring in the broader Burdekin basin; the salt pipewort (*Eriocaulon carsonii*), which is 'Endangered' under the EPBC Act and NC Act, and; the frogbit (*Hydrocharis dubia*), which is 'Vulnerable' under the EPBC Act. Both of these listed threatened species are also identified as Priority 'Back on Track' species for the Burdekin NRM region (DERM, 2010). These threatened species were not identified within the project area during the May 2012 survey and were assessed as unlikely to occur in the project area.

In addition, 13 aquatic flora species are listed as Priority species under the Aquatic Conservation Assessments (ACAs) for riverine and non-riverine wetlands of the Great Barrier Reef Catchment (Inglis and Howell, 2009a; Inglis and Howell 2009b).

Threatened and priority aquatic flora species known or likely to occur in the project are presented in **Table 19-5**, along with a preferred habitat description and commentary on the likelihood of occurrence within the project area.

Table 19-5 Priority Aquatic Flora Species Known or Likely to Occur in the Project Area

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell, 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
Eriocaulon carsonii	Salt pipewort	E	E	C/H	R&T	Restricted to saturated soil adjacent to flowing mound springs.	**Unlikely.** Current known distribution is not in proximity to the Project area. Mound springs not known to occur within the Project area. Preferred habitat unlikely to be present within the Project area.		✓		✓	✓
Hydrocharis dubia	Frogbit	V	LC[1]	H/M	R&T	Prefers to grow in small shallow freshwater bodies or swamps.	**Unlikely**. Recorded only from south-east Queensland, and from Ayr and Charters Towers in the northern Burdekin basin. Although suitable habitat occurs within the broader project area, this species has not been recorded from the Bowen or Belyando catchments of the Burdekin basin (i.e., the catchments that encompass the Project site).		✓		✓	✓
arsilea drummondi i	Common nardoo		LC		P	Occurs within or surrounding shallow freshwater depressions, billabongs, swamps, and temporary waterholes. Forms a key threatened macrophyte community on the Burdekin floodplain. It provides bank stability, helps retain surface	**Known**. Recorded during field survey in May 2012 (**Section 7.4**).		✓			✓

[1] As shown for frogbit, a species' conservation status can be different under Commonwealth and State legislation. The status assigned to a species under particular legislation is applicable only to interpretation of that legislation and should not be construed otherwise (e.g. identification of frogbit as a Least Concern species under the NC Act does not diminish its status under the EPBC Act).

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell, 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
						moisture in wetlands during dry periods, and provides habitat for amphibians and invertebrates.						
Ceratopteris thalictroides	Water fern		LC		P	Prefers to grow in muddy environments, submerged or emergent, or free-floating just below the water surface. An indicator of relatively good water quality.	**Likely**. Suitable habitat occurs within the Project site.	✓	✓			✓
Aponogeton queenslandicus			LC		R&T *	An emergent plant that prefers 30–60 cm deep, temporary, freshwater, clay bottom pools, exposed to full sun. It is not usually found in permanent waters.	**Likely**. Suitable habitat occurs within the Project site, including gilgai (**Section 19.3.2.3**).		✓			✓
Eleocharis dulcis	Water chestnut		LC		P	Prefers shallow water lagoons and floodplains on heavy self-mulching soils. Forms large areas of monotypic sedgeland that is a key threatened wetland community in Burdekin Dry Tropics.	**Known**. Recorded during field survey in May 2012.		✓			✓
Eleocharis sphacelata	Tall spikerush		LC		P	Found in coastal and near-coastal regions of Queensland, in areas that are shallowly or deeply inundated. It is often found in areas with muddy substrate. Subject to threatening processes.	**Likely**. Suitable habitat occurs within the Project site.		✓			✓
Hydrilla verticillata	Hydrilla		LC		P	Grows as a submerged aquatic plant that is attached to the bottom by stems up to 2 m in	**Likely**. Suitable habitat occurs within the Project site.	✓	✓			✓

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell, 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
						length. It often forms dense mats just below the water surface. Common in freshwater lakes, pools, and slow-moving streams throughout coastal areas of Queensland.						
Nymphaea gigantea	Giant waterlily	-	LC	-	P	Found in still water to 1.5 m deep, mainly in coastal lagoons, though it does occur in some inland lagoons. It is more commonly found in northern tropical areas than elsewhere in Queensland.	**Possible**. Marginal habitat occurs within the Project site, including farm dams.		✓			✓
Ottelia alismoides	Ottelia	-	LC	-	P	Occurs in slow moving streams, and stagnant pools up to 2 m deep, in coastal Queensland where it is widespread but not usually common. Presence of the species indicates macrophyte communities are in good condition, as this species depends on ideal growing environment such as sunny, shallow margins, and good water quality.	**Possible**. Marginal habitat occurs within the Project site, including farm dams.		✓			✓
Ottelia ovalifolia	Swamp lily		LC		P	Found in still waters of ponds and dams, and in muddy substrates of slow-moving streams. Important food source for fish, vertebrates and waterbirds, especially during winter.	**Likely**. Suitable habitat occurs within the Project site.		✓			✓

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell, 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
Vallisneria nana		-	LC	-	P	Prefers fast-flowing waters of streams, lakes, ponds, and irrigation channels.	**Possible**. Marginal habitat occurs within the Project site.	✓	✓			✓
Hymenachne acutigluma			LC		P	Occurs in north Queensland in shallow water at the margins of swamps and slow-flowing rivers.	**Likely**. Suitable habitat occurs within the Project site.	✓	✓			✓
Leersia hexandra	Swamp rice grass		LC		P	Occurs in, and beside shallow swamps and creeks in the eastern part of Queensland.	**Known**. Recorded during field survey in May 2012.	✓	✓			✓
Pseudoraphis spinescens	Spiny mudgrass		LC		P	Found in shallow water or mud beside creeks and drainage lines throughout Queensland. Threatened through exclusion by para grass (*Brachiaria mutica*) and other exotics in floodplain habitats. It is an indicator of habitat integrity and provides good waterfowl habitat.	**Likely**. Suitable habitat occurs within the Project site.		✓			✓

Notes:

E = endangered, V = vulnerable, LC = least concern, C = critical priority, H = high priority, M = medium priority, P = priority, R&T = rare and threatened.

1 EPBC Act = Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

2 NC Act = Status under the Queensland *Nature Conservation Act 1992*.

3 Back on Track = Status under the DERM (2010) Burdekin Natural Resource Management Region - Back on Track Actions for Biodiversity.

4 ACA = Status under the Aquatic Conservation Assessments using AquaBAMM for riverine and non-riverine wetlands of the Great Barrier Reef catchments (Inglis and Howell 2009a, 2009b).

5 References for information in this column are provided in **Appendix 20**.

* Aponogeton queenslandicus is listed as Rare in AquaBAMM, for the riverine and non-riverine wetlands of the Great Barrier Reef catchment: Burdekin region. However, as of 21 May 2010, this species is a Least Concern species under the NC Act.

19.4.3 Aquatic Weeds

Only one aquatic weed, Awnless barnyard grass (*Echinochloa colona*), was detected during field surveys, at sites S3 and S6. This species is a native of tropical Africa and Asia and is a weed of irrigated areas and soils prone to flooding. It is not listed as a weed of national significance, (WONS) in Australia, nor is it declared under the Queensland *Land Protection (Pest and Stock Route Management) Act 2002* (LP Act).

No other aquatic (or semi-aquatic) weeds were identified during the field survey.

19.5 Environmental Values – Aquatic Fauna

19.5.1 Macroinvertebrates and Stream Health

This section provides a summary of the detailed data analysis on macroinvertebrates and stream health provided in **Appendix 20**.

19.5.1.1 Taxonomic Composition

A total of 1,342 macroinvertebrate individuals, representing 57 taxa, were retrieved from the 18 samples collected during field surveys. Full results of taxonomic classification of all individuals collected are provided in **Appendix 20**.

Edge habitat at all surveys sites had higher taxa richness than bed habitats. Site S3 had the highest taxa richness, while the bed habitat of site S6 had the lowest.

19.5.1.2 SIGNAL 2 Results

SIGNAL 2 scores, which are based on the presence or absence of macroinvertebrate families, can be used to infer the environmental quality of a site, and provide an indication of long-term water quality. The SIGNAL 2 score showed no pattern between bed and edge habitat, with scores higher for the edge habitat at sites S1, S7, S8 and S10 and higher for the bed habitat at sites S4, S6 and S9.

Both bed and edge habitat at site S1, and bed habitat at sites S7 and S10, had SIGNAL 2 scores which indicates a moderately polluted habitat. Bed and edge habitats at sites S4, S6, S8, S9, and edge habitats at site S7 and S10, had SIGNAL 2 scores which indicates more severely polluted habitat. SIGNAL 2 results within the project area are relatively low, indicating that a greater proportion of pollution tolerant taxa are present at survey sites.

The relationships between taxa richness of macroinvertebrates and SIGNAL 2 scores were displayed using a bi-plot, divided into 4 quadrants, each quadrant indicative of particular conditions (**Figure 19-2**). The development of bi-plots is described in **Appendix 20**.

No samples fell within quadrant 1 or quadrant 2. The samples collected from the bed habitat of sites S1, S7, S9 and S10 fell within quadrant 3. Sites within quadrant 3 often display effects of toxicity such as low pH or high concentrations of trace metals. Macroinvertebrates at these sites are often tolerant of pollution. All edge samples, as well as the bed samples collected from sites S2, S4, S6, and S8, fell within quadrant 4. Sites falling within quadrant 4 are generally considered to be suffering from one or more forms of human impact such as urban, industrial or agricultural impacts or downstream effects of dams.

The results of the bi-plots suggest that most of the sites have been under long-term stress from decreased water quality (possibly natural or from past and present land uses), harsh physical conditions (intense seasonal runoff and erosion and deposition and fine sediments) or other anthropogenic effects.

Figure 19-2 The Quadrant Diagram for The Family Version of SIGNAL 2 (Chessman, 2003)

19.5.1.3 AUSRIVAS Model Outputs

Macroinvertebrate data was modelled using the AUSRIVAS (Queensland Regional – Coastal – Autumn) model for the habitats sampled. AUSRIVAS compares site data with regionally relevant reference conditions using predictive models. Results are reported using a standard index, which is used as a measure of biological impairment.

AUSRIVAS scores indicate that most sites surveyed within the project area fell within Band B, referred to as being significantly impaired and lacking in some species that would be expected to occur at the site. The edge habitat at site S1, and the bed habitat at site S10, fell within Band A, which is considered to be roughly equivalent to the reference condition. The bed habitat at site S6 fell within Band C, referred to as severely impaired due to substantial impacts on water and/or habitat quality.

19.5.1.4 EPT Richness

EPT richness, which is a measure of richness based only on the taxonomic orders *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies) and *Trichoptera* (caddis flies). Taxa from the order Plecoptera (stoneflies) were not collected at any site. Samples from the bed habitats generally exhibited a higher percentage of EPT taxa compared to edge samples, with the highest percentage of EPT taxa (28.5%) observed in the bed sample of site S7. Both *Ephemeroptera* (mayflies) and *Trichoptera* (caddis flies) were collected in the all bed samples, with the exception of site S6 where no EPT taxa were recorded. While in edge samples *Ephemeroptera* (mayflies) and *Trichoptera* (caddis flies) were collected at sites S1, S2, S3, S8, S9 and S10. Only one order of EPT taxa (i.e. *Ephemeroptera* -mayflies) was collected in the edge sample of sites S4, S6 and S7.

Bed samples from upstream sites showed lower percentages of EPT taxa compared with downstream sites within both the Suttor River sub-catchment and Kangaroo Creek sub-catchment.

19.5.2 Vertebrate Fauna

A fauna species list generated from Wetland Info (DERM, 2012) identified 49 native fishes, two alien fishes, three semi-aquatic mammals, five turtles, and the saltwater crocodile, *Crocodylus porosus*, as having been recorded in the broader Burdekin Basin. The complete list is provided in **Appendix 20**.

Two species are listed as threatened (‘Endangered’ or ‘Vulnerable’) under the NC Act and/or the EPBC Act; the Australian lungfish (*Neoceratodus forsteri*), which is listed as ‘Vulnerable’ under the EPBC Act, and the estuarine crocodile, which is listed as ‘Vulnerable’ under the NC Act. No species are listed as Near Threatened. The platypus (*Ornithorhynchus anatinus*) is listed as ‘Special Least Concern’ under the NC Act. In addition, 11 aquatic fauna species are listed as ‘Priority’ species under the ACA’s for riverine and/or non-riverine wetlands of the Great Barrier Reef Catchments. One of these species, Irwin’s turtle (*Elseya irwini*), is also listed as a ‘High Priority’ Back on Track species for the Burdekin NRM region.

‘Threatened’, ‘Special Least Concern’ and ‘Priority’ aquatic fauna species identified from the literature review are presented in, along with a preferred habitat description and commentary on the likelihood of individual species occurring within the project area.

Table 19-6 Threatened and Priority Aquatic Fauna Species Known to Occur in the Burdekin Basin

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
Mammals												
Ornithorhynchus anatinus	Platypus	-	SC	-	-	Inhabits freshwater streams, ranging from alpine creeks to tropical lowland rivers; also lakes, shallow reservoirs, and farm dams; preferring areas with steep vegetated banks in which to burrow. Cultural significance.	**Unlikely**. No historical or contemporary reports of platypus presence in the Burdekin River basin, apart from populations at the extreme latitudinal margins. Both of these locations are in regions of cool upland rainforest, while the low-lying area between them is much warmer, more arid and, according to bioclimatic modelling, not suitable for the platypus.					✓
Reptiles												
Crocodylus porosus	Estuarine crocodile	Ma/ Mi	V	-	R&T	Usually inhabits the lower reaches of coastal rivers, swamps, estuaries, and open sea. In Queensland the species is usually restricted to coastal waterways, and floodplain wetlands; however, may also be found hundreds of kilometres upstream.	**Unlikely**. Suitable habitat within the Project area is extremely limited. Waterways of the Project area are of relatively low stream order, and positioned high in the catchment. Substantial barriers/weirs occur on the Suttor River downstream of the Project area and are likely to form physical barriers to the passage of estuarine crocodiles.	✓	✓	✓		✓
Elseya irwini	Irwin's turtle	-	LC	H	P	Endemic to the Burdekin basin. Occurs in clear, well-oxygenated water where flow is continuous (i.e., not seasonal), and substrates which	**Unlikely**. Stream flows in project area are seasonal. The species is only known from an area upstream from the township of Ayr, Queensland; specifically, the Broken River, and	✓			✓	✓

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
						comprise exposed sand and rock.	tributaries downstream from Eungella Dam, as far as, and including, the Bowen River, and part of the Burdekin River. Extent of occurrence is estimated at 25 km^2 (TSSC 2009). The Project site is outside of the known geographic range of this species.					
Fishes												
Neoceratodus forsteri	Australian lungfish	V	LC	-	-	Restricted to SEQ, where it occurs naturally in the Burnett and Mary rivers, and possibly the Brisbane River. Prefers slow-flowing rivers and still water (including reservoirs) with aquatic vegetation on the banks. Most common in deep pools with mud, sand, or gravel substrate.	**Unlikely**. Last recorded sighting in the Burdekin basin was in 1870. Current known distribution not in proximity to the Project site.					✓
Giuris margaritacea	Snake-head gudgeon	-	LC	-	P	Inhabits rivers, swamps, coastal streams, and floodplains. Found over mud bottoms, often amongst dense aquatic vegetation, or under the cover of undercut banks. Most of their lives are spent in freshwater but migrate to the estuarine/ brackish areas to breed (i.e., catadromous). Their presence indicates coastal hydrological	**Unlikely**. Poorly suited to low dissolved oxygen levels, which are expected (and encountered) across the Project site during drier months. Physical barriers inhibit connectivity with the sea and the consequent persistence of this species in waterways upstream of Burdekin Dam.	✓				✓

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
						connectivity. Intolerant of low dissolved oxygen levels.						
Mogurnda adspersa	Southern purple-spotted gudgeon	-	LC	-	P	A widespread species occurring in rivers, creeks, and billabongs, usually quiet or slow-flowing sections, over rocks, or among vegetation. Declining populations and local extinctions are occurring and translocations of the sleepy cod (*Oxyeleotris lineolata*) and golden perch (*Macquaria ambigua*) to upper catchments are placing direct pressure on this species.	**Known**. Recorded during field surveys May 2012.	✓	✓			✓
Philypnodon grandiceps	Flathead gudgeon	-	LC	-	P	Prefers lakes, reservoirs and brackish estuaries, with mud bottoms, often among aquatic vegetation. Less common in gently flowing streams. Restricted in distribution.	**Possible**. In central Queensland, this species has been recorded as far north as the Burdekin River, near Townsville. However, it is considered uncommon, as only a few individuals having been collected from two separate locations.	✓	✓			✓
Kuhlia rupestris	Jungle perch	-	LC	-	P	Prefers fast-flowing streams and rivers, usually in rainforest. Also inhabits rocky pools at the base of waterfalls. Population numbers and extent of distribution has been in decline over recent decades, due to its sensitivity to changes in water quality, reliance on intact	**Unlikely**. Known to have occurred in the Burdekin Catchment; however, has not been recorded there in recent decades. Current known distribution is not in proximity to the Project site, most certainly due to the existence of downstream barriers such as Clare and Collinsville Weirs. Habitat unlikely to occur in Project	✓				✓

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
						riparian vegetation, and dependence on connectivity to other habitats.	site.					
Scortum parviceps	Small-headed grunter	-	LC	-	P	Prefers to swim close to the bottom of swift-flowing streams, near rapids, in clear fresh water. Increasing turbidity thought to be a threat to its habitat range.	**Unlikely**. Recorded only in the upper Burdekin river system. Waterways of the Project site are unlikely to provide adequate flow and clarity to sustain suitable habitat.	✓				✓
Ambassis agrammus	Sailfin glassfish	-	LC	-	P	Prefers rivers and creeks flowing through rainforest. Sometimes occurs in stagnant pools, or slowly flowing rivulets. Also found on the margins of swamps and lakes.	**Unlikely**. Recorded from wetlands of the Burdekin River delta, where it appears to be the southern limit for this species. Widely distributed in the lower reach floodplains, which are highly impacted by agriculture. Current known distribution not in proximity to the Project site.	✓				✓
Strongylura krefftii	Fresh-water longtom	-	LC	-	P	Prefers still or flowing waters of larger rivers, from tidal reaches to far inland. Also occurs in some impoundments. Often shelters amongst overhanging vegetation or submerged roots. Adults sometimes found in coastal marine waters. This species is a floodplain breeder, alienation of floodplain habitat physically, or exposure to low dissolved oxygen is a concern.	**Possible**. Occurs in Burdekin River, penetrating into the Bowen River. Suttor River provides marginal habitat.	✓	✓			✓
Neosilurus	Softspine	-	LC	-	P	Prefers rocky pools in main river channels and larger	**Possible**. Endemic to the Burdekin region with a patchy distribution in	✓				✓

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
mollespiculum	catfish					creeks. Population potentially impacted since 1970s by translocated freshwater catfish (*Tandanus tandanus*).	the Burdekin River catchment. In the upper Burdekin River, it occurs in tributary rivers as well as the main channel. Has been recorded in the north of the project area (Kangaroo Creek and its tributaries). Not previously recorded in the Belyando/Suttor system (southern project area).					
Anguilla obscura	Pacific shortfin eel	-	LC	-	P	Prefers freshwater streams, lakes, and swamps, favouring coastal lagoons and the lower reaches of rivers. Spawning adults occur in marine waters. Presence indicates good habitat connectivity. Evidence suggests the population above Burdekin Dam is in decline. Numbers declining state-wide due to over fishing and fish barriers.	**Unlikely**. The Project site provides only marginal habitat. Poor habitat connectivity likely to limit the success of *A. obscura* in the broader project area.	✓	✓			✓
Anguilla reinhardtii	Longfin eel	-	LC	-	P	Occurs in freshwater streams, lakes, and swamps, with a preference for flowing water. Known to inhabit deep waters of reservoirs well away from the shore. Adults undertake annual spawning migrations to oceanic waters. Populations declining state-wide, due to over fishing and fish barriers.	**Unlikely**. In the Burdekin, generally restricted to the lower reaches downstream of Burdekin Falls Dam. Some large individuals occur upstream of the dam, although numbers are declining as such individuals emigrate at times of high flow and recruitment is denied by the presence of the dam. The Project site provides only marginal habitat. Poor habitat connectivity likely to	✓	✓			✓

Scientific Name	Common Name	Status				Importance and Habitat Description[5]	Likelihood of Occurring within Project area[5]	Data Source				
		EPBC Act[1]	NC Act[2]	Back on Track[3]	ACA[4]			Inglis and Howell, 2009a	Inglis and Howell 2009b	DSEWPAC 2012	DERM 2010	DERM 2012
							limit the success of *A. reinhardtii* in the broader project area.					

Notes:

E = endangered, V = vulnerable, LC = least concern, C = critical priority, H = high priority, M = medium priority, P = priority, R&T = rare and threatened.

1 EPBC Act = Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

2 NC Act = Status under the Queensland *Nature Conservation Act 1992*.

3 Back on Track = Status under the DERM (2010) Burdekin Natural Resource Management Region - Back on Track Actions for Biodiversity.

4 ACA = Status under the Aquatic Conservation Assessments using AquaBAMM for riverine and non-riverine wetlands of the Great Barrier Reef catchments (Inglis and Howell 2009a, 2009b).

5 References for information in these columns provided in **Appendix 20**

* Aponogeton queenslandicus is listed as Rare in AquaBAMM, for the riverine and non-riverine wetlands of the Great Barrier Reef catchment: Burdekin region. However, as of 21 May 2010, this species is a Least Concern species under the NC Act.

19.5.3 Fish

Fish species recorded at each survey site are shown in **Table 19-7**. Eight species of fish were recorded within the reaches surveyed, and were generally restricted to the available pool habitats within these reaches. All eight fish species have previously been recorded in the broader Burdekin basin as per database records.

No threatened (or near threatened) species listed under Commonwealth or State legislation, including the Australian lungish, were found within the project area or are considered likely to occur in the project area.

Of those Priority species identified as having being recorded in the broader Burdekin Basin, only one Priority species, the southern purple-spotted gudgeon (*Mogurnda adspersa*) was recorded during the fauna survey, at sites S1, S3, and S4 in the Suttor River sub-catchment. This purple-spotted gudgeon is considered a Priority for conservation due to declining populations and local extinctions occurring in the broader Burdekin Basin. All other Priority species identified as having been recorded in the broader Burdekin Basin were not assessed as likely to occur in the project area.

Table 19-7 Fish Species recorded at survey sites in the Project area, May 2012

Scientific Name	Common Names	Site								
		S1	S2	S3	S4	S6	S7	S8	S9	S10
Ambassis agassizii	Agassiz's glassfish	✓	✓	✓	✓	✓				
Amniataba percoides	Barred grunter	✓			✓					
Hypseleotris species 1	Midgley's carp gudgeon		✓			✓				
Leiopotherapon unicolor	Spangled perch	✓		✓	✓	✓		✓		✓
Melanotaenia splendida	Eastern rainbowfish	✓		✓	✓	✓		✓		✓
Mogurnda adspersa	**Southern purple-spotted gudgeon**	✓		✓	✓					
Neosilurus hyrtlii	Hyrtl's tandan					✓				
Porochilus rendahli	Rendahl's catfish	✓	✓							

Note: **Bold** text denotes ACA Priority species' (Inglis and Howell 2009a, 2009b)

All eight species (**Table 19-7**) were recorded from survey sites in the Suttor River sub-catchment (sites S1, S2, S3, S4, and S6). Only two of these species, the eastern rainbowfish (*Melanotaenia splendida*), and spangled perch (*Leiopotherapon unicolor*), were recorded from the Kangaroo Creek sub-catchment (sites S7, S8, S9 and S10). Both of these species have been collected from waterways across Queensland displaying a wide range of water quality conditions (Pusey *et al.*, 2004), indicating a general tolerance to environmental degradation or harsh physical conditions.

19.5.4 Turtles

No turtles were observed or caught, during field surveys in May 2012. However, dams throughout the project area are likely to provide suitable habitat for turtles, including breeding habitat, and dry season refuge. This includes site S2. The waterways and gilgai wetlands of the project area, although limited by their ephemeral nature, may provide limited habitat for turtles during wetter times of the year. The palustrine wetland (site S3) may also provide habitat for turtles, although its shallow depth, lack of open water areas and dense emergent macrophytes would limit its use.

19.6 Potential Impacts and Mitigation Measures

19.6.1 Construction

Construction activities have the potential to impact on aquatic ecological values through:

- direct removal of aquatic habitat by diverting natural waterways (stream diversions)
- direct removal of aquatic habitat by de-watering lacustrine wetlands (dam removal)
- vegetation clearing, earthmoving, and vehicle use within, or adjacent to, waterways and wetlands
- unmitigated sediment laden stormwater entering creeks or wetlands as runoff
- creation of waterway crossings for vehicles
- obstruction of surface water flows and aquatic fauna passage
- spills of contaminants such as fuels, oils or chemicals that could migrate into waterways.

19.6.1.1 Removal and Diversion of Waterways

Within the project area, approximately 36.2 km of mapped streams (watercourses and drainage lines) will be directly impacted by clearing activities and stream diversions. In the Upper Suttor River sub-catchment (southern project area), this includes direct impacts on the following streams mapped by EHP:

- 6.2 km of 1st order streams
- 9.2 km of 2nd order streams
- 2.2 km of a 3rd order stream.

In the Rosella Creek sub-catchment (northern project area), the following streams mapped by EHP will be directly impacted:

- 11.6 km of 1st order streams
- 1.9 km of 2nd order streams
- 5.1 km of 3rd order streams
- 50 m of 4th order streams.

Five stream diversion channels are proposed (refer **Chapter 8** and **Chapter 16**); four in the Suttor Creek sub-catchment and one in the Kangaroo Creek sub-catchment. Diversions will be designed so that impacts on hydrology will be negligible to minor.

The design of the diversion channels, represented by the hydraulic characteristics of maximum stream power, velocity and shear stress in the diversion channels, are all within the guideline values for natural watercourses in the Bowen Basin (refer to **Chapter 16**).

Where possible, construction of diversion channels and dewatering of impacted waterways would occur during the dry season, when the extent of wetted habitat in the project area is greatly reduced, and when streams are expected to support the lowest diversity and abundance of aquatic species. Any disturbance to breeding places would be undertaken in accordance with an approved species management program (SMP), damage mitigation permit (DMP), or other relevant authorisation, to ensure compliance with the NC Act. A General Fisheries Permit under the *Fisheries Act 1994* would be obtained to take, remove, or relocate fish during site establishment.

Macrophyte communities will be impacted during establishment of stream diversion channels. However, macrophytes are expected to rapidly colonise the constructed diversion channels. Therefore, impacts to macrophytes during establishment of stream diversion channels are expected to be minor, and short in duration. Diversion channels will be revegetated according to the Rehabilitation Management Plan (RMP), which should minimise erosion by stabilising channel banks and beds, thus reducing sediment loads.

Diversion management will include measures to establish riparian corridors to achieve riparian vegetation continuity along diversion channels. This should allow biogeochemical processes to continue in diversion channels, which will assist in regulating water quality.

It is expected that the diversion channels would be colonised by macroinvertebrate species via mobile adult migration. As a result, the impact on aquatic fauna is likely to be minor in the longer term.

Monitoring of the diversion channels would include the physical condition (e.g., bank stability, erosion, and physico-chemical water quality), and biological condition (e.g., vegetation cover, health, and utilisation by aquatic fauna).

19.6.1.2 Removal of Dams

Two lacustrine water bodies (dams) are likely to be removed as part of the project. One of the dams (Site S2) is approximately 5 ha in area and is located within the proposed West Pit 1. The other dam is approximately 0.8 ha in area and is in the path of the proposed southern-most diversion, and thus would need to be modified as part of diversion’s construction.

The removal of these lacustrine water bodies will potentially have a direct impact on individual fauna, as well as an indirect impact through reduction of potential breeding habitat. Given the small size of these dams in relation to other water bodies in the region, the magnitude of impact is small. Excavation of the dam (S2) would also remove potential breeding habitat for water birds, and a dry season water source for other terrestrial fauna, including the squatter pigeon (*Geophaps scripta*), and black-throated finch (*Poephila cincta* – race not confirmed), which were observed around this dam during field surveys.

The disturbance of these habitats would be undertaken in accordance with an approved SMP, DMP, or other relevant authorisation, to ensure compliance with the NC Act. This is relevant to freshwater turtles. A General Fisheries Permit under the *Fisheries Act 1994* would also be obtained to take/remove fish during site establishment. These measures would minimise impacts on aquatic fauna. In the context of the project area and water bodies in the wider region, impacts on aquatic fauna from removal of these dams are expected to be minor.

19.6.1.3 Indirect Impacts on a Wetland of High Ecological Significance

The HES wetland on the western boundary of the project area (refer **Section 19.3.2.1**) is not within the footprint of project activities. Unmitigated impacts on this wetland may result from:

- development in the catchment of this wetland resulting in detrimental impacts on the hydrological regime of this wetland (refer **Chapter 16**)

- mine affected water or sediment affected water run-off from disturbed areas, entering the wetland, although this will be controlled through the mine water management system described in **Chapter 8**.

This wetland has a catchment area of 4.2 km^2. During mining, the West Pit complex, including waste rock dump, will be developed in this catchment, reducing flow to the wetland. The mine will reduce the catchment area by approximately 43%, to 2.4 km^2 for a period of approximately 16 years, until such time as the West Pit complex waste rock dump is rehabilitated and the wetland catchment reinstated.

There is likely to be a temporary change in plant species composition as hydrological regimes change over time. However, reinstatement of the current hydrological regimes (through rehabilitation of the West Pit complex waste rock dump) is considered likely to see the return of the wetland to its current state over time.

The plant species present within the wetland suggest a semi-permanent nature and as such, the ecosystem would be adapted to periods of wetting and drying and corresponding changes in dominant species, particularly in the ground layer. A decrease in the size of the catchment (and therefore inflows) is likely to increase the proportion of the wetland dominated by terrestrial species over time. Provided that a core area of wetland remains seasonally inundated, a representative suite of plants should persist and enable recolonisation over time as the wetland expands in area.

During the period of time where the effective catchment size is reduced, the impact of feral pigs may be more concentrated on a smaller area of wetland as inflows decrease over time. A culling program will be considered to minimise damage to the wetland areas which are intended to be a seed source for the broader wetland upon its reinstatement.

The remediation strategy for the area will include returning the land to a similar hydrological profile, creating a similar catchment for the wetland.

A suitable baseline assessment and ongoing monitoring will be undertaken to monitor the status of the wetland, including seasonal variation. These monitoring requirements would be included in the receiving environment monitoring program (REMP) (refer **Chapter 15**).

Sediment and erosion control structures will be installed upslope of this wetland prior to the commencement of works to negate sediment laden runoff entering this wetland. These sediment and erosion control structures (described in **Chapter 8**) will be monitored and maintained throughout the site establishment works.

During the 16 year period when the hydrology of the wetland is altered, impacts to the aquatic ecology of the wetland will be minor to moderate. Once the catchment is rehabilitated to a similar pre-development hydrological profile, impacts on the aquatic ecology of the wetland will be negligible.

19.6.1.4 Vegetation Clearing, Earthmoving, and Control of Stormwater Runoff

The establishment of project infrastructure would potentially impact surface water quality through increased erosion of sediments that are exposed after vegetation clearing. If not appropriately controlled, erosion of sediments can lead to increased suspended sediment loads to waterways, which can reduce light penetration and visibility, limiting plant growth, and impeding fish movement. Increased sedimentation can also reduce waterway depths, change drainage patterns, and smother benthic flora and fauna.

The mobilisation and deposition of fine sediments also has the potential to fill downstream pools. This is unlikely to impact significantly on retained minor (first order) tributaries of the project area as these watercourses are expected to only carry runoff for short periods, following intense or sustained rainfall events, and are not expected to provide wetted habitat for extended periods. Sediment deposition in larger watercourses (second order and higher) can reduce habitat diversity, and the number of pools available as refuge habitat in drier times. Although sedimentation (predominately sand) has already limited substrate complexity and associated habitat diversity in the waterways draining the project area (in particular the Suttor River and its tributaries), accelerated sedimentation from project activities could result in a decline in the abundance and diversity of both invertebrate and fish communities in downstream receiving environs.

Aquatic ecosystems within the project area also have the potential to be impacted by nutrients, salts, metals, or other contaminants that are adsorbed onto sediments washed into the waterways. Increased nutrient loads can promote excessive growth of aquatic flora (algae and macrophytes), provided environmental conditions also favour photosynthesis (i.e., light availability). Excessive growth of aquatic flora can reduce oxygen concentrations, which, if severe enough, can lead to mortality of oxygen dependent fauna. Excessive growth of surface aquatic flora can block sunlight for submerged flora, limiting their photosynthetic activity.

Impacts from potential increased nutrient loads to waterways are, however, expected to be minor, providing that adequate sediment and erosion controls are established prior to site clearing, and are maintained throughout the site establishment works. Sediment and erosion controls are described in **Chapter 13**. The mine water management system, including capture of sediment-affected water is described in **Chapter 8**.

Hydrocarbon based leaks or spills from construction equipment represents a potential risk, as most are toxic to aquatic flora and fauna at relatively low concentrations. Runoff of spilt fuels and oils into waterways is only likely to occur if spills occur in close proximity to waterways (natural stormwater channels and constructed diversion channels), or if the spill or leak is left uncontrolled. A fuel or oil spill in excess of ten litres that ends up in a waterway is likely to have more immediate impacts on aquatic flora and fauna. The severity and duration of impacts will be directly related to the quantity of fuel or oil spilt, and the effectiveness of containment measures.

The risk of impacts to aquatic flora and fauna from a fuel or oil spill is lower during the dry season (when watercourses are dry) as spills are likely to be contained before they disperse throughout the waterway.

The following measures will assist in minimising the impacts of sediment and contaminant runoff on aquatic habitats, flora, and fauna:

- Where possible, infrastructure will be located away from the riparian zone of streams. Buffers from streams, measured from the top of the highest bank and on both sides of the stream, are as follows:
  - 10 m for a 1st order stream
  - 20 m for a 2nd order stream
  - 40 m for any 3rd order or greater stream.
- An Erosion and Sediment Control Plan will be developed, the key features of which are described in **Chapter 13** and **Chapter 15**.
- Clearly defined access and work use areas for plant and equipment will be established.
- Areas for vehicle and machinery maintenance, refuelling, and storage of fuels, lubricants, and batteries will be bunded in accordance with AS 1940.
- Maintenance of plant and equipment will minimise the risk of leaks and spills of oils and fuels

- Refuelling will occur in the designated refuelling area.
- Emergency spill kits will be available and readily accessible for all plant and equipment at all times. The kits will include equipment for containment and clean-up of spills on dry soils/sediments, and in water (e.g. floating booms).
- All spills of contaminants (including diesel, hydraulic fluid, oil etc.) will be contained (where safe to do so).

With the implementation of the above mitigation measures impacts on aquatic ecology from the mobilisation of sediments, salts, nutrients or contaminants sediment and spills of hydrocarbons are expected to be minor.

19.6.1.5 Vehicle Stream Crossings and Obstruction of Fauna Passage

The project requires approximately 16 vehicle stream crossings including:

- 6 crossings of 1st order streams
- 2 crossings of 2nd order streams
- 3 crossings of 3rd order streams
- 1 crossing of a 4th order stream (Kangaroo Creek)
- 4 crossings of stream diversions.

Construction of stream crossings can cause both direct and indirect impacts. Direct impacts include a loss of riparian and aquatic habitat due to disturbance of the bed and banks, increased sunlight exposure, and accelerated sedimentation. Indirect impacts include long-term barriers to fish movement, alteration of habitats, and increased pollution.

Many of the fish native to ephemeral or intermittent waterways migrate up and downstream and between different habitats at particular stages of their lifecycle. Bridge crossings of permanent or semi-permanent streams generally pose little problem to these migrating fish if the morphology of the stream-bed and water flow patterns remain largely unaltered. However, causeway and culvert crossings can create major discontinuities in the water flow pattern and bed morphology of a stream, or if there is a tunnel effect created. Fish may be physically unable, or unwilling, to negotiate such discontinuities.

Stream crossings will be designed in a way that maintains or enhances water flows, water quality, stream ecology and existing riparian vegetation. Impacts to the hydrologic, hydraulic, and geomorphic functions of the stream will be minimised.

Stream crossings should be designed in accordance with Queensland Fisheries guidelines for design of stream crossings (FHG 001, Cotterell 1998) and the NSW Office of Water (2010) guidelines for watercourse crossings, which includes:

- minimising construction footprint and extent of proposed disturbances within the watercourse and riparian corridor
- where possible, avoid structured native riparian vegetation
- maintaining existing or natural hydrologic, hydraulic, geomorphic, and ecological functions of the watercourse

- ensuring that where a raised structure or increase in the height of the stream bed is proposed, there will be no detrimental impacts on the natural hydrologic, hydraulic, geomorphic, and ecological functions
- maintaining natural geomorphic processes by:
  - accommodating natural watercourse functions
  - avoiding alterations to natural bank, full, or floodplain flows, or increased water levels upstream
  - avoiding changes to the gradient of the stream bed, except where necessary to address existing bed and bank degradation
  - avoiding increases in flow velocities by, for example, constricting flows
- protecting against scour by:
  - providing any necessary scour protection, such as rock rip-rap and vegetation
  - ensuring scour protection of the bed and banks downstream of the structure is extended for a distance of either twice the channel width, or 20 m whichever is the lesser
- stabilising and rehabilitating all disturbed areas including topsoiling, revegetation, mulching, weed control, and maintenance, in order to adequately restore the integrity of the riparian corridor
- where causeways or bed level crossings are proposed:
  - the deck of the crossing should be at the natural bed elevation
  - the crossing should have a vertical cut-off wall on the downstream side of the crossing to a minimum depth of 1 m and minimum width of 100 mm
- approaches to crossings should be sealed and incorporate roadside drainage, such as stabilised table drains where necessary
- where culverts are proposed on small order streams:
  - box culverts are preferred to pipes
  - culverts should be aligned with downstream channels
  - elevated dry cells and recessed wet cells should be incorporated with the invert at or below the stable bed level
  - the culvert design should be certified by a suitably qualified engineer
  - the design should ensure wet cells have a minimum water depth of 0.2–0.5 m to encourage fish passage
  - the design should minimise changes to the channels natural flow, width, roughness and base-flow water depth.

The majority of stream crossings are of small, ephemeral upper catchment streams with a low sensitivity to impacts from crossings. With the implementation of the above mitigation measures, impacts on aquatic ecology from the construction of stream crossings will be negligible to minor.

19.6.2 Operations

Without appropriate mitigation measures in place the mine operation has potential to impact on aquatic ecological values in the project area and broader catchment through:

- uncontrolled discharge of mine affected water into waterways
- uncontrolled stormwater runoff from disturbed areas entering waterways or wetlands, affecting water and sediment quality
- uncontrolled dust emissions and deposition into waterways or catchment areas
- altering the geomorphology and ecology of a waterway through changes in flow and water quality.

19.6.2.1 Mine Affected Water

The water management system, including capture storage and release of mine affected water is described in **Chapter 8**. Mine affected water will be released to the environment when it meets the release criteria for water quality and flow rates described in **Chapter 8**.

The release criteria have been established in accordance with the Queensland Water Quality Guidelines (QWQG), as described in **Chapter 15.** These are designed to protect existing environmental values including aquatic ecology in receiving waters and have been developed based on a baseline monitoring program.

The QWQG are built around the premise that aquatic ecosystems can tolerate (without significant impact) variation in physico-chemical stressors up to the 80th percentile of the same indicator when assessed against a suitable reference site.

By virtue of the release criteria specified in **Chapter 8**, there is no change to the 80th percentile EC in the Suttor River since no releases would be permitted from the mine when the EC in the Suttor River upstream of the mine is 2,040 µS/cm or above. There is a very slight increase in the modelled EC at percentiles below the 80th percentile, reflecting the effect of the releases. However these are of a very low order (10 µS/cm) and would have negligible impact on the river water quality.

Given that site releases will be strictly regulated and there is no significant change expected to key physico-chemical attributes in the receiving environment, adverse impacts on aquatic ecosystems are expected to be negligible.

A monitoring program will be established to monitor water quality in the mine water management system and in the receiving environment, as described in **Chapter 15**.

Scour protection will be provided at discharge points, where required.

19.6.2.2 Control of Run-off

The mine water management system describing separation of clean water from undisturbed areas and sediment-affected waters is described in **Chapter 8**.

Runoff from undisturbed catchments upstream of the mining area would be diverted around the disturbed area and released directly to the environment.

Areas that drain disturbed areas such as the MIA, coal stockpiles, recently rehabilitated waste rock dumps, access roads and laydown areas have the potential to generate sediment laden runoff. Sediment affected water would pass through sediment dams prior to release to the environment. Sedimentation dams will be utilised until disturbed areas are sufficiently rehabilitated and stabilised.

Control of run-off in the mine water management system is expected to result in negligible impacts to aquatic ecology.

19.6.2.3 Stream Hydrology and Geomorphology

The geomorphology and ecology of natural streams within the project area may be altered by changes in flow and water quality. The project has the potential to alter the hydrology of surface water systems by capturing water in dams, loosing water in the form of dust suppression or pond evaporation, and releasing water during flow events. **Chapter 16** describes that the mine water management system will have negligible impact on the hydrology of the Suttor River and Kangaroo Creek.

Chapter 16 describes that mine water management system is not expected to have significant impacts on the hydrological regime in the Suttor River or Kangaroo Creek.

As described in **Section 19.6.1.3**, the palustrine wetland (a HES wetland) and its catchment would be temporarily affected during mining. Post closure, the remediation strategy for the area will including returning the land to a similar hydrological profile, creating a similar catchment for the wetland. Following remediation it is considered likely that the wetland would be restored to its current condition.

19.6.3 Decommissioning Phase

The areas disturbed by mining will be rehabilitated as per a Rehabilitation Management Plan (refer **Chapter 10**). Four final voids will remain, but as described in **Chapter 11**, these voids are not predicted to overtop and there should be no impacts to aquatic ecology in surrounding waterways and wetlands.

19.6.4 Noise and Vibration – Construction, Operation and Decommissioning Phases

The introduction of significant levels of noise and vibration into the environment under favourable propagation conditions is recognised as a form of potential habitat disturbance. Follow on (secondary or indirect) impacts resulting from this type of habitat disturbance could potentially include behavioural modification to native fauna.

Key project activities which have the potential to propagate noise and vibration include:

- movement of vehicles and plant (all project phases)
- installation of infrastructure (construction phases)
- drilling, blasting and excavation (operation phases).

Analogous data and studies on the specific potential impacts from noise and vibration on inland aquatic fauna are limited, with studies focused more on marine environments. However, under specific conditions potential impacts to fish species as a result of anthropogenic increases in highly percussive noise sources (e.g. pile driving adjacent water bodies) may include disruption or alteration of fish behaviour, hearing, physiology and even injury or mortality in severe cases (Popper & Hastings, 2009).

It should be clearly noted that the existing conditions across the project area are unlikely to present noise and vibration propagation scenarios sufficient to cause any of these noted potential impacts. This is especially the case given the highly ephemeral nature of aquatic habitat within proximity to the project area, which provides a natural mitigation measure. As surface water does not persist for the majority of the hydrological cycle, such potential impacts could only occur to a small portion of aquatic habitat for a small portion of the time. Further reducing the scale of potential impact is the fact that habitat disturbance caused by noise and vibration is expected to be highly localised in the immediate vicinity of project activities.

Overall, potential impacts to aquatic fauna associated with noise and vibrations are expected to be negligible.

19.7 Conclusion

Existing aquatic ecological conditions in the project area, as interpreted from published and collected data, indicate that the waterways transecting the project area incur flow intermittently, and are likely characterised by high inter-annual flow variability. Wetlands within the project area, particularly lacustrine wetlands, provide semi-permanent water. The wetlands, waterways, and associated riparian corridors of the project area provide both aquatic and terrestrial fauna species with opportunities for refuge, foraging and also potential nesting and breeding habitat.

No aquatic 'Threatened Ecological Communities' have been detected in the project area, nor are any expected to occur. The project is unlikely to impact on any wetlands of international significance (Ramsar wetlands) or wetlands of national importance.

A HES, palustrine wetland is located on the western boundary of the project area but is not within the project's disturbance footprint. This wetland has a catchment area of 4.2 km^2. During mining, the West Pit complex, including waste rock dump, will be developed in this catchment, reducing flow to the wetland. The mine will reduce the catchment area by approximately 43%, to 2.4 km^2 for a period of approximately 16 years, until such time as the West Pit complex waste rock dump is rehabilitated and the wetland catchment reinstated. The plant species present within the wetland suggest a semi-permanent nature and as such, the ecosystem would be adapted to periods of wetting and drying and corresponding changes in dominant species, particularly in the ground layer. A decrease in the size of the catchment (and therefore inflows) is likely to increase the proportion of the wetland dominated by terrestrial species over time. Provided that a core area of wetland remains seasonally inundated, a representative suite of plants should persist and enable recolonisation over time as the wetland expands in area. During the 16 year period when the hydrology of the wetland is altered, impacts to the aquatic ecology of the wetland will be minor to moderate. Once the catchment is rehabilitated to a similar pre-development hydrological profile, impacts on the aquatic ecology of the wetland will be negligible.

The project will remove two mapped lacustrine wetlands (dams), comprising approximately 5.8 ha of low to medium value aquatic habitat and some low to medium value gilgai wetland. These impacts would be permanent. In the context of the project area and water bodies in the wider region, impacts on aquatic fauna from removal of these dams are expected to be minor.

No EVNT aquatic flora species are likely to occur within the project area. Macroinvertebrate and fish sampling was undertaken in representative habitats where adequate water was encountered. Macroinvertebrate communities sampled in the late wet season of 2012 were largely dominated by pollution and disturbance tolerant taxa. Overall data from surveys indicate that most sites surveyed were significantly impaired, with one site being severely impaired. Comparison of macroinvertebrate taxonomic richness and biotic sensitivity indices, suggest that most aquatic survey sites had been under long-term stress from decreasing water quality (possibly natural or from past and present land uses), harsh physical conditions (intense seasonal runoff and erosion and deposition of fine sediments), or other anthropogenic effects.

Fish surveys identified eight species of fish, all of which were native. No EVNT or Special Least Concern (platypus) aquatic fauna species, were recorded, or are likely to occur within the project site. A number of Priority fish species are either known, or may occur within the waterways transecting the project site.

However, both direct and indirect impacts on these species through habitat modification are deemed to be short term and confined to the establishment phase of the project. Direct impacts can be reduced by relocating fish in accordance with a General Fisheries Permit where de-watering of water bodies is undertaken. Freshwater turtles are likely to occur within lacustrine wetlands and semi-permanent pools on watercourses. Turtles would need to be relocated from dewatered areas in accordance with a Species Management Program or Damage Mitigation Permit. With the implementation of proposed mitigation measures, impacts on aquatic fauna are expected to be minor.

The project will have both direct and indirect impacts on the aquatic values of Kangaroo Creek and its tributaries, and both direct and indirect impacts on tributaries of the Suttor River. Direct impacts will result from the removal of approximately 36.2 km of riverine habitat, including approximately 18.6 km of riverine habitat in the Kangaroo Creek catchment and 17.6 km of riverine habitat in the Suttor River catchment. These impacts are deemed to be short and medium term only, generally confined to the life of the project.

With the implementation of proposed mitigation measures, the project is expected to result in minor impacts on threatened or Priority aquatic species, aquatic ecological communities or their habitats. The impact to the ecological integrity of the Suttor River, Kangaroo Creek or their downstream receiving environs is expected to be minor.