NEW HOPE GROUP

8. Aquatic Ecology

Contents

8. Aquatic Ecology

8.1. Introduction

This Chapter describes the existing environment for aquatic ecology that may be affected by the revised Project and the measures required for the mitigation of these potential impacts. The revised Project requires mine development in areas adjacent to Lagoon Creek and the development of infrastructure as described in **Chapter 3**.

8.2. Purpose of the Aquatic Ecology Assessment

The tasks and objectives of the aquatic ecology assessment were as follows:

- describe the aquatic flora and fauna species, including fish, crustaceans and aquatic invertebrates, present or likely to be present, in the areas affected by the revised Project;
- describe any species of endangered, vulnerable and near-threatened (EVNT) aquatic species;
- describe any wetlands listed by DEHP as areas of national, state or regional significance;
- describe any exotic and pest aquatic organisms;
- describe the habitat requirements and the sensitivity of aquatic species to changes in flow regime, water levels and water quality in the aquautic ecology study area;
- describe aquatic plants, including native, exotic and weed species, and aquatic substrate;
- describe habitat upstream and downstream of the revised Project;
- discuss the potential impacts of the revised Project on the aquatic species and ecosystems and describe proposed mitigation actions; and
- outline strategies to avoid, minimise, mitigate and offset potential impacts of the revised Project on aquatic flora and fauna values.

8.3. Legislation

Relevant Commonwealth and Queensland policies and legislation applicable to the management of aquatic values for the revised Project are summarised below. In addition, a full list of legislation relevant to the revised Project is located in **Chapter 1** and further examined within the revised Project's Regulatory Approvals Plan located in **Appendix C**.

8.3.1. Commonwealth Legislation and Relevant Guidelines

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The MNES that are considered in this aquatic ecology assessment for the revised Project are National Heritage place, Wetlands of International Importance, listed threatened (EVNT) species and ecological communities and listed migratory species.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000)

These guidelines provide an Australian standard framework for assessing water quality and protecting environmental values by setting water quality objectives. These guidelines have been applied for the

assessment of water quality data with regard to the protection of the aquatic ecosystem environmental value of the revised Project.

8.3.2. State Legislation and Relevant Guidelines

Environmental Protection Act 1994 (EP Act)

The objective of the EP Act is to protect Queensland's environment by promoting ecologically sustainable development. The *Environmental Protection Regulation 2008* provides a mechanism to enforce the EP Act and allows for an assessment of the risk that an ERA poses to environmentally sensitive areas (ESAs) in proximity to the revised Project.

Environmental Protection (Water) Policy 2009 (EPP Water)

This policy is subordinate legislation to the EP Act and governs the discharge of wastewater to land, surface water and groundwater. The EPP (Water) sets water quality objectives to provide guidance to protect environmental values. The values for aquatic ecology are closely related to those of groundwater and surface water resources and have been assessed as part of the revised Project.

Fisheries Act 1994

This Act provides for the management, use and protection of fisheries resources in Queensland. The main purpose of the Act is to provide for the use, conservation and enhancement of the community's fisheries resources and fish habitats in a way that seeks to apply and balance the principles of ecologically sustainable development. Waterway barriers may be required for the construction of watercourse crossings for the revised Project. This will be determined during the detailed design phase of the revised Project.

Nature Conservation Act 1992 (NC Act)

This Act prohibits the taking or destruction, without authorisation, of protected flora and fauna species in the wild. All native plants and animals in Queensland are protected under Section 71 of the Act. This Act also provides for an integrated and comprehensive approach to conserving nature. It provides a legislative basis for research, community education, dedicating, declaring and managing protected areas, and protecting native wildlife and its habitat. Section 41 of the *Nature Conservation (Protected Plants) Conservation Plan 2000* describes that a clearing permit is not required if the disturbance happens in the course of activity under a mining lease.

Nature Conservation (Wildlife) Regulation 2006 (NC Regulation)

These regulations list the plants and animals considered extinct, endangered, vulnerable, near threatened, least concern, international and prohibited. The regulation discusses their significance and states the declared management intent and the principles to be observed in any taking and use for each group.

Queensland Water Quality Guidelines 2009

These guidelines provide a framework for assessing water quality and protecting environmental values by setting regionally based water quality objectives for Queensland. These guidelines have been applied to the revised Project for the assessment of water quality data with regard to the protection of the aquatic ecosystem environmental value.

Water Act 2000

This Act provides the framework to deliver sustainable water planning, allocation management and supply processes to ensure the improved security of water resources. The revised Project lies within the region covered by the *Water Resource (Condamine and Balonne) Plan 2004*.

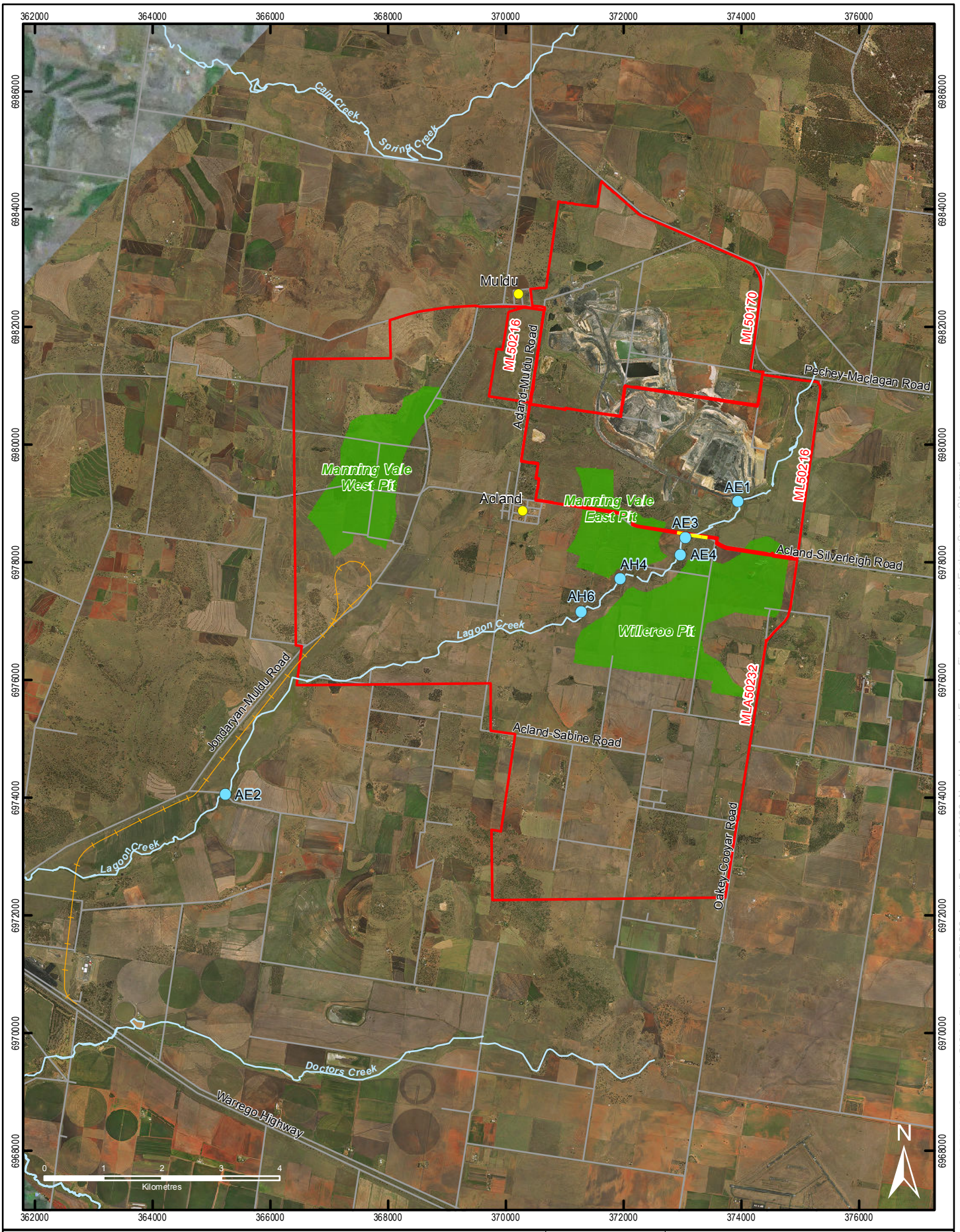
8.4. Existing Environment

8.4.1. Methodology

The methodology adopted for the aquatic ecology assessment of the existing environment involved the following stages:

- desktop review of background information including reports, available database search results, maps and satellite imagery;
- field surveys of aquatic habitats, fauna and flora to verify information collected in the desktop review; and
- assessment of potential impacts of the revised Project on aquatic values and identification of strategeis to avoid, minimise and mitigate potential impacts.

The aquatic ecology study area is the section of Lagoon Creek adjacent to the revised Project site and is located between the survey sites AE1 and AE2, shown in **Figure 8–1**. Survey sites were selected upstream and downstream of the revised Project, concentrating on sections of the watercourse closest to proposed mining activities.



LEGEND

- Towns and Localities
- Survey Sites
- Proposed Rail Spur
- Roads
- Creeks
- Proposed Haul Road Crossing
- Mining Tenements
- Stage 3 Pit Areas

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NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 8-1 - Aquatic Ecology Survey Sites

Scale 1:85,000 on A4

Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 21/08/2013 Path: I:\QENV2\Projects\QE06644\SpatialArcGIS\01_Figures\01_SEIS\08_AquaticEcology\130430_NewHope_AquaticEcology_Figure8-1_AquaticEcdogySurveySites.mxd

Desktop Review

Database searches were conducted within a 25 km radius of the aquatic ecology study area, which included larger watercourses with permanent surface water, for example Oakey Creek. Reviews of literature were conducted to determine the distribution of aquatic fauna and flora, EVNT species, special least-concern species, and protected areas including wetlands and sensitive environments. The following resources were used for the review:

- EPBC Act Online Protected Matters database;
- EHP Wildlife Online database;
- Queensland Museum database;
- Australian Wetlands Database, and EHP Wetlands Maps;
- State of the Rivers Report, Upper Condamine River and Major Tributaries, (Phillips and Moller 1995);
- Aquatic Conservation Assessments (ACA), using AquaBAMM, for the wetlands of the Queensland Murray-Darling Basin.(Fielder et al. 2011);
- relevant publications, including scientific papers and literature; and
- aerial photography and satellite imagery.

Field Surveys

Two separate field surveys were conducted at survey sites along Lagoon Creek. The first survey was conducted in January 2008 during warm and dry conditions with little preceding rainfall, and evaluated aquatic values (habitat, flora and fauna) in the available surface water habitats. The second survey was conducted in March 2013 following a period of substantial rainfall, and evaluated aquatic habitat in the channel sections of Lagoon Creek during stream flow, but did not include surveys for aquatic flora and fauna. Both surveys are detailed below.

Dry Season Aquatic Ecology Survey

Aquatic ecology surveys were conducted on the 23 and 24 January 2008 during dry conditions at three sites upstream AE1, AE3, and AE4, and one site downstream AE2, of the revised Project's mining areas as shown in **Figure 8–1** and described in **Table 8–2**. Site selection was limited to creek reaches where surface water was present; they were all located in sections of Lagoon Creek upstream of earthen impoundments constructed for farm dams and causeways, which provide the only aquatic habitats that persist in drier periods.

Table 8–1 Survey Site Locations

Survey and Year	Site Code	Site Location
Dry season survey (January 2008)	AE1	Upstream of the Manning Vale East Pit and Willeroo Mine Pit
	AE2	Downstream of the Willeroo Mine Pit
	AE3	Upstream of the Manning Vale East Pit and Willeroo Mine Pit
	AE4	Upstream of the Manning Vale East Pit and Willeroo Mine Pit

Habitat Description

The aquatic habitat at each survey site was assessed using the Australian River Assessment System (AusRivAS) rapid assessment protocol (Parsons et al. 2002). This approach broadly defines the stream morphology, available aquatic habitats, measures of water quality and observed land use impacts.

Macroinvertebrates

Macroinvertebrate samples were collected during the field survey using Queensland AusRivAS protocols (DERM 2009a). The sampling area at each survey site was determined as a 100 m reach of the watercourse. At each survey site macroinvertebrate samples were collected from edge habitats which included sub-habitats (leaf litter, fine sediment deposits and overhanging bank vegetation). Riffle habitats, which consist of broken water with rapid current, were absent. Samples were collected from 10 m of representative edge sub-habitats using a dip net (0.25 mm mesh size) to dislodge and collect macroinvertebrates. All sub-habitats at each survey site were represented within the sample. All macroinvertebrates were live picked, preserved in 70 % ethanol and identified to a taxonomic resolution of family level or higher in a laboratory using a dissecting microscope.

Aquatic Flora

Each of the 100 m reaches selected for the macroinvertebrate sampling was visually surveyed for the presence of aquatic macrophyte species. The macrophyte species present were identified according to Sainty and Jacobs (2003) and the percentage of area in the reach covered by each macrophyte species was visually estimated.

Fish and Macrocrustaceans

Two bait traps (45 cm x 25 cm x 25 cm) were deployed at each survey site for a minimum of 16 hours. Bait or light sticks were not used in the traps. Within each survey site, the traps were positioned near available instream habitat (e.g. woody debris, aquatic vegetation, or instream aquatic macrophytes). All fish were identified to species level and the total count recorded.

Turtles

During the field based aquatic surveys, the available in-stream habitat including edge, bank, macrophyte beds and riparian habitat at each survey site was inspected for the presence of turtles, nests or pathways. These inspections were conducted during daylight hours. There were no dedicated turtle trapping methods conducted at the survey sites.

Macroinvertebrate Analysis

SIGNAL scores are a biotic index system that allocates a value to each macroinvertebrate family based largely upon their sensitivity to pollution (a value of 10 indicates high sensitivity, 1 represents high tolerance) (Chessman 1995). Weighted SIGNAL2 is a revised index which weights the SIGNAL scores of taxa by their abundance, relative to the overall abundance of all taxa. Based upon the presence or absence of macroinvertebrate families, the environmental quality of a survey site can be assessed and provide an indication of long term water quality (Chessman 2003).

Identified macroinvertebrate data were entered into the AusRivAS modelling program. The program uses mathematical models to predict the aquatic macroinvertebrate fauna expected to occur at locations with similar habitat which have minimal or no impact from human activity (reference condition) and compares these results with the fauna actually collected, providing a measure of biological impairment. Predictor variables (which can include physical habitat variables, latitude, longitude, altitude, and slope and distance from source) are used to determine a reference stream of similar type against which macroinvertebrate assemblages can be compared.

Wet Season Habitat Survey

Additional surveys along Lagoon Creek were conducted on 7 March 2013 at two sites within the aquatic ecology study area to assess aquatic habitat within the watercourse channel following recent rainfall events in the catchment and during a period of flow. Site AH4 was adjacent to the proposed Manning Vale and Willaroo resource areas, and site AH6 was downstream of the revised Project as shown in **Figure 8–1** and described in **Table 8–2**. The survey sites were selected from analysis of aerial photography where the watercourse was not impounded, and the channel and riparian vegetation were visibly present.

The surveys recorded channel habitat type (pool, run or riffle), wetted width, reach length, substrate types, per cent instream cover (macrophytes, woody debris), riparian width and vegetation characteristics (per cent canopy and ground cover), and assessed habitat condition using the AusRivAS Physical Assessment Protocol (Parsons et al. 2002). Photographs were taken at each survey site, and observations of existing impacts and disturbance were also recorded. The wet season assessment did not include targeted surveys of aquatic fauna (macroinvertebrates, macrocrustaceans and fish).

Table 8–2 Survey Site Locations

Survey and Year	Site Code	Site Location
Wet season survey (March 2013)	AH4	Adjacent to Manning Vale East Pit and Willeroo Mine Pit
	AH6	Downstream of Willeroo Mine Pit

Risk Assessment

The risk assessment method is consistent with Australian standards (AS/NZS 4360 2004). The revised Project activities (e.g. earthworks in waterway channel) and the potential impacts that could exert a detrimental effect on aquatic ecology values (e.g. increased sediment run-off) were identified.

The likelihood of a potential impact occurring and the consequence of the impact on the ecological values was determined according to the categories in **Table 8–3** and **Table 8–4**.

Table 8–3 Likelihood Categories

Likelihood	
Likely	The impact is expected to occur
Possible	The impact may occur at some time
Unlikely	The impact is unlikely to occur

Table 8–4 Consequence Categories

Category	**Consequence**
Low	Negligible to Minor, short term stress on the environment with rapid recovery, no disruption to breeding cycles. Ecosystem processes and community structure remain largely unchanged. No breach of legal or other obligations (e.g. EPBC Act, State Acts). Ecosystem is resilient to impacts and only simple, low cost rehabilitation works are required, if any.
Medium	Environment stress observed, short term disruption to breeding cycles and ecological processes. Minor breach of legal or other obligation, prosecution unlikely, internal management response required. Ecosystem resilience is reduced and moderately difficult rehabilitation is required.
High	Significant damage to the environment observed, including impact on threatened species and shift in underlying ecosystem processes. Breach of legal or other obligations, regulator investigation with possibility of prosecution. Ecosystem resilience is substantially compromised and difficult, long term or high cost rehabilitation is required.

Preliminary risk (i.e. before mitigation measures) and residual risk (after mitigation measures) were calculated based on the risk matrix shown in **Table 8–5**.

Table 8–5 Risk Matrix for Combining Likelihood and Consequence

Likelihood	**Consequence**		
	High **Widespread environmental damage, irreversible**	**Medium** **Environmental stress observed.** **Minor breach of government guidelines**	**Low** **None to minor, short term only impacts on environment**
Likely	High	High	Medium
Possible	High	Medium	Low
Unlikely	Medium	Low	Low

8.4.2. Results

Regional Catchment Overview

The aquatic ecology study area is located in the Condamine River catchment which is at the headwaters of the Murray-Darling Basin in Southern Queensland and covers an area of 87,300 km^2 (CBWC 2002). The climate in the Condamine River catchment ranges from sub-tropical in the east to semi-arid in the west and rainfall can be highly variable both inter-annually and seasonally, with 60% to 70% of rainfall occurring between October and March (CBWC 2002).

Stream flow is almost entirely due to rainfall run-off during storm events and consequently the flow regime is unpredictable. River flows are intermittent; the larger watercourses have permanent water although flows can cease during drier periods resulting in isolated waterholes, and smaller ephemeral watercourses will dry completely. The construction of numerous weirs and dams, and extraction of water for irrigation has greatly altered the hydrology of watercourses in the Condamine River catchment (Coffey Environmental 2011).

The upper Condamine River catchment was surveyed as part of the Queensland Government State of the Rivers (SoR) Report series, and included the Oakey Creek subcatchment (Phillips and Moller 1995). Whilst Lagoon Creek was not surveyed, the report does provide a general overview of the environmental condition of aquatic habitats in watercourses within the subcatchment. The following is a summary of the main findings of SoR Report for the Oakey Creek subcatchment relating to the aquatic habitat condition.

- Banks were mostly stable or very stable with the predominant bank process identified as erosion, which occurred along 87 % of stream length.
- Habitat types included pool (56 %) and riffles (44 %) with some runs, backwaters and glides also recorded.
- Riparian vegetation was recorded as mostly very poor with a mean width of 15.8 m.
- Aquatic flora was rated as very poor and included submerged, floating and emergent forms. Rushes and sedges were the most commonly represented plants.
- The condition of the aquatic habitat was generally very poor, with limited cover and channel habitat types and depths.

Ecological surveys have been conducted in Gowrie Creek in the Oakey Creek subcatchment (Aquateco 2011) and in other nearby subcatchments of the lower Condamine basin, including Wilkie Creek (SKM 2012), and Charleys Creek (Hydrobiology 2010). These reports provide information of aquatic values for intermittently flowing tributaries of the Condamine River, with the Gowrie Creek, Wilkie Creek and Charleys Creek survey sites located approximately 27 km southeast, 70 km west and 100 km north west of the aquatic ecology study area, respectively. The surveys are referred to in the description of aquatic values of Lagoon Creek for comparative purposes and were conducted in environments that share similar hydrology. The surveys in Wilkie Creek and Charleys Creek were also in subcatchments impacted by in-stream barriers and with agricultural land use practices similar to the Oakey Creek subcatchment (Condamine Alliance 2012). There were no existing mining

activities upstream from the study areas subject to the surveys in Gowrie Creek, Charleys Creek and Wilkie Creek.

At the location of the survey sites the upstream catchment area and stream order (Strahler 1957) was greater for Gowrie Creek (stream order 4), Wilkie Creek (stream order 4) and Charleys Creek (stream order 5) than for the aquatic ecology study area of Lagoon Creek (stream order 2). The natural channels of watercourses with higher stream orders provide larger, deeper and more permanent surface water environments, higher variation of aquatic habitat and they can support a higher diversity of aquatic fauna and flora than lower stream order watercourses.

Aquatic Ecology Study Area

Lagoon Creek is located in the Oakey Creek subcatchment in the northeast of the upper Condamine River catchment. Land-use in the Oakey Creek subcatchment is predominantly grazing with some cropping (Condamine Alliance 2012). Lagoon Creek is an ephemeral watercourse that flows south west past Jondaryan and drains into Oakey Creek, located south of Bowenville. Sections of Lagoon Creek within the aquatic ecology study area differ considerably from higher stream order waterways within the broader Condamine River catchment, by virtue of their ephemeral flow regime, low diversity of aquatic habitats and minimal coverage of riparian vegetation.

The aquatic ecology study area is located downstream of the Mine, and receives discharges from the Mine as part of the Water Infrastructure Management system, which are regulated by the conditions set out in the Mine's EA. Discharges from the Mine are not common and mainly occur in periods of high flow in Lagoon Creek. Water quality monitoring has been conducted at survey sites upstream and downstream of the Mine in accordance with the EA and these data provide information on the condition of water quality in Lagoon Creek. From the literature review undertaken there were no assessments of aquatic ecology identified for Lagoon Creek, aside from the 2008 and 2013 surveys carried out as part of this EIS.

The location of Lagoon Creek within the Oakey Creek subcatchment was rated with a riverine AquaScore of medium in the Aquatic Conservation Assessments (ACA) for the wetlands of the Queensland Murray-Darling Basin (Fielder et al. 2011). The assessment covers a range of criteria including aquatic naturalness, EVNT species, diversity and connectivity. The assessment is at a catchment scale, and consequently values of Lagoon Creek were not specifically assessed.

Aquatic Habitat

Dry Season Survey

The survey sites for the dry season aquatic habitat survey conducted in January 2008 were restricted to locations where surface water was present; these were reaches of Lagoon Creek where in-stream impoundments provide aquatic environments that persist during dry periods.

Site AE1, as shown in **Photograph 8-1,** was an in-stream farm dam located upstream of the revised Project site. This survey site was highly disturbed by modification of the stream channel and disturbance from cattle accessing the dam. The substrate was fine silt and mud. The substrate assemblage has been modified due to sedimentation of fine particles present in surface water run-off during flow events. There was evidence of bank erosion, most of which was located directly upstream of the dam. The presence of macrophytes, filamentous algae and woody debris was recorded. No

overhanging vegetation was present at the survey site. Site AE1 was assessed to be highly disturbed due to very substantial modification of the watercourse channel and cleared riparian vegetation.

Photograph 8-1Site AE1 In-stream Farm Dam

The Lagoon Creek channel upstream of the survey site was dry as presented in **Photograph 8-1**, and consisted of narrow braided channels draining into the farm dam. These channels would flow during substantial rainfall events and would provide aquatic habitat when inundated.

Photograph 8-2 Views of the Channel Upstream of Site AE1

Site AE2, as shown in **Photograph 8-3**, was located downstream of the revised Project site. The waterbody at this survey site was approximately 250 m long and 8 m wide and formed by a downstream impoundment. This survey site was moderately disturbed with no riparian or overhanging vegetation present. The substrate at this survey site was compacted sand and silt with macrophytes present. Evidence of bank erosion was visible downstream, although no other waterbodies were identified. The surrounding land use is dominated by cropping (upstream) and cattle grazing (downstream). Site AE2 was assessed to be moderately disturbed due to the modification of the watercourse channel and the removal of riparian vegetation.

Photograph 8-3 Site AE2 Downstream Views

Site AE3 as shown in **Photograph 8-4,** was located upstream of the revised Project site. The channel was modified due to a downstream impoundment. This survey site provided aquatic habitat with abundant macrophytes and large woody debris, and variations in depth. Overhanging vegetation was provided by trees, fringing ground cover and macrophytes. The substrate at this survey site was a combination of sand and silt. Erosion and reduced bank stability were prevalent around the edges of the waterbody due to cattle access along the riparian zone. Site AE3 was assessed to be moderately disturbed due to modification of the watercourse channel and the removal of riparian vegetation.

Photograph 8-4 Site AE3 Downstream View

Site AE4 as presented in **Photograph 8-5** was located approximately 300 m downstream of Site AE3. This waterbody was a large instream farm dam that backed up water for approximately 150 m. A small amount of overhanging vegetation was present and was represented by a large tree and macrophytes. Riparian vegetation was very limited. The substrate at this survey site was a combination of sand and silt. The only visible aquatic habitat was macrophytes that were located around the edges of the waterbody. Site AE4 was assessed to be moderately disturbed due to modification of the watercourse channel and the removal of riparian vegetation.

Photograph 8-5 Site AE4 Downstream View

Wet Season Survey

The wet season aquatic habitat survey was conducted in March 2013 following substantial rainfall and catchment run-off. The survey provided information on the habitat values in the channel of Lagoon Creek during a period of flow. As discussed previously, Lagoon Creek is an ephemeral watercourse and therefore surface water does not persist in these reaches during dry periods. Results of the habitat survey are summarised in **Table 8–6** and **Table 8–7**.

Table 8–6 Lagoon Creek Watercourse Habitat Assessment: Survey Site AH4

Survey Site AH4		
Stream flow classification:		Intermittent flow
Aquatic and riparian habitat condition:		Good – 54 % (Refer to site description below)
Permanent surface water habitat:		No
Channel characteristics		
Reach length (m)	70	 Upstream view
Channel habitat	Run	
Average wetted width (m)	5	
Maximum Depth (m)	< 1	
Flow	Yes	
Dominant substrate in reach (%)	Silt (95)	
Instream cover (%)	Large woody debris (5)	
Riparian characteristics		
Canopy cover (%)	Lhb = 15 Rhb = 30	
Riparian width (m)	Lhb = 15 Rhb = 10	
% native/exotics trees	100/0	
% native/exotics ground cover	0/100	
 Cross section view		 Downstream view
▪ Channel habitat: flowing shallow run located between upstream and downstream grassed riffles; low amount of instream cover, predominantly large woody debris. ▪ Riparian zone and banks: canopy dominated by native trees, partially intact on both banks; some bank erosion; ground cover dominated by exotic species. ▪ Watercourse impacts: barriers to fish and turtle movement from instream impoundments. ▪ Land use and impacts: agriculture including cattle grazing; cattle tracks, pugging and slumping on banks.		

Riparian data are provided for left hand bank (Lhb) and right hand bank (Rhb)

Table 8–7 Lagoon Creek Watercourse Habitat Assessment: Survey Site AH6

Survey Site AH6		
Stream flow classification:		Intermittent flow
Aquatic and riparian habitat condition:		Fair – 45 % (Refer to site description below)
Permanent surface water habitat:		No
Channel characteristics		
Reach length (m)	70	 Upstream view
Channel habitat	Run	
Average wetted width (m)	1	
Maximum Depth (m)	< 1	
Flow	Yes	
Dominant substrate in reach (%)	Silt (95)	
Instream cover (%)	Large woody debris (10)	
Riparian characteristics		
Canopy cover (%)	Lhb = 5 Rhb = 15	
Riparian width (m)	Lhb = 20 Rhb = 50	
% native/exotics trees	100/0	
% native/exotics ground cover	3/97	
 Cross section view		 Downstream view
▪ Channel habitat: narrow braided shallow run; low amount of instream cover, predominantly large woody debris. ▪ Riparian zone and banks: canopy dominated by native trees, partially intact on the right hand bank, substantially cleared on the left hand bank; some bank erosion; ground cover dominated by exotic species. ▪ Watercourse impacts: barriers to fish and turtle movement from instream impoundments. ▪ Land use and impacts: agriculture including cattle grazing; cattle tracks, pugging and slumping on banks.		

Riparian data are provided for left hand bank (Lhb) and right hand bank (Rhb)

Aquatic Habitat Values

The desktop review of existing information and field surveys completed during dry and wet season conditions have identified that Lagoon Creek is a moderate to highly disturbed ephemeral creek, which flows during, and immediately following, periods of moderate to high rainfall. During the dry season, Lagoon Creek does not flow and surface water contracts into a series of temporal pools. Similar conditions predominate in the ephemeral watercourses of the broader Condamine catchment and are interspersed with periods of flow when substantial rainfall and run-off events occur.

The majority of survey sites within Lagoon Creek were rated as moderately disturbed (AE2 - AE4) or highly disturbed (AE1), primarily due to channel modification and previous clearing of riparian vegetation. The channel has been impacted by numerous instream impoundments which can reduce connectivity and serve as barriers to the movement of aquatic fauna. However, the impoundments have also resulted in surface water habitats that persist during dry periods for longer than natural pool habitats, particularly considering Lagoon Creek is an ephemeral water course with a stream order of 2. Consequently the impounded habitat provides refugia for aquatic flora and fauna during the dry periods. In addition to channel modification, some sections of the creek (Sites AE1-AE4) were impacted by extensive removal of riparian trees. The removal of the riparian zone in these locations has resulted in an absence of canopy shading, invasion by exotic weeds on the creek banks and within the channel, and highly reduced input of large woody debris resulting in low instream habitat complexity (SKM, 2011).

The value and extent of aquatic habitats of the Lagoon Creek channel were assessed to improve during periods of flow, with the condition of Site AH4 rated as good and the condition of Site AH6 rated as fair during wet season field assessments. Channel habitat had some variability during periods of flow, consisting of temporary pools and riffles. The water depths recorded in pools during the survey were shallow (< 1 m), but provided connectivity between permanent surface water habitat, which allows for the movement and dispersal of aquatic flora and fauna. Instream cover within the channel was not abundant and substrate was dominated by silt. However, the presence of intact sections of riparian vegetation at sites AH4 and AH6 indicated some functionality of the system including input of woody debris, shade and the presence of edge habitat.

Relevant historical water quality monitoring for Lagoon Creek is limited, with NAC completing routine water quality monitoring of temperature, dissolved oxygen, electrical conductivity, pH, and analysis of sulphate and suspended sediments from 2009 to 2011. Prior to this, a single water quality sampling event was completed in January 2008 (as part of the dry season aquatic ecology survey), with temperature, dissolved oxygen, electrical conductivity, and pH measured using a water quality probe. More recently (March 2013), a similar water quality assessment was completed at two sites within Lagoon Creek as part of the wet season aquatic habitat assessment, but this included additional chemical analysis of water samples for total and dissolved metals, nutrients, total petroleum hydrocarbons, total suspended solids and pesticides. A comprehensive description of previous water quality monitoring and a water quality assessment have been undertaken for the Revised Project and are presented in **Chapter 5**, **Section 5.6**.

The results of water quality monitoring show that pH and EC were higher during the dry season survey and exceeded the relevant water quality guidelines (DERM 2009b). Dissolved oxygen was

substantially lower during the wet season sampling and was below the guidelines (DERM 2009b) at most sites. Water quality at selected dry season and wet season sites for Lagoon Creek is summarised in **Table 8–8**. The March 2013 water quality assessment found that nutrients were present in Lagoon Creek at high concentrations, with total and filterable fractions of nitrogen and phosphorus exceeding the Australian Water Quality Guidelines (ANZECC 2000) for aquatic ecosystems protection at all sites during the period of flow, as outlined in **Table 8–8** for selected sites, and provided in **Chapter 5**, **Section 5.6.2**. Dissolved concentrations of metals were below guidelines (ANZECC 2000) with the exception of copper, which was detected at all sites and exceeded the relevant guideline (ANZECC 2000) at Site AE2. This site also had a notably higher concentration of Manganese than at other sites. Concentrations of pesticides and hydrocarbons were below the laboratory detection limits at all sites.

Water in the Condamine catchment is generally high in total phosphorus and has high turbidity (CBWC 1999). This is indicative of catchments that are highly affected by agriculture. The revised Project site has been impacted by land uses including grazing, dry-land cropping and mining. These land-use practices have affected the surrounding waterways including Lagoon Creek. The high concentrations of nutrients in Lagoon Creek during the flow period indicate mobilisation of inorganic and organic forms of nitrogen and phosphorus from catchment run-off, possibly from a variety of diffuse point sources such as agricultural activities**.**

The high concentration of ammonia represents a risk to aquatic fauna and was at concentrations that could be toxic to fish at the established water quality monitoring (LCU1) site located upstream of the Mine as shown in **Table 8–8** and described in **Chapter 5**, **Section 5.6.2**. The low concentrations of dissolved oxygen during the period of flow, possibly due to the decomposition of suspended and dissolved organic matter in the rainfall run-off, also represents a risk to fish species.

Wilkie Creek, a watercourse in the Condamine catchment which is impacted by similar agricultural land practices also has high nutrient concentrations, including ammonia, and low dissolved oxygen concentrations (SKM 2012) and is compared to Lagoon Creek in **Table 8–8**. Whilst EC is high in Lagoon Creek and Oakey Creek, the turbidity is low in comparison to other subcatchments of the Condamine River basin, including Wilkie Creek, where high turbidity has been identified as a major influencing and limiting factor for the environmental values (EV's), including protection of the aquatic ecosystem (CBWC 1999). Additionally, previous studies of the broader catchment have shown that median pH and EC values from the Fairview gauging station on Oakey Creek exceeded the *Queensland Water Quality Guidelines* (DERM 2009b), as did EC recorded in Gowrie Creek (Aquateco 2011) which drains into Oakey Creek. Such water quality characteristics may be a feature of the Oakey Creek subcatchment, possibly due to the high alkalinity and salinity of soils.

Table 8–8 Seasonal and Spatial Variation of Water Quality

		Wet season		Dry season		
		Lagoon Creek				Wilkie Creek
Variable	WQOs	LCU1 (US)	AH4 (DS)	AE4 (DS)	AE2 (DS)	WC
Flow	na	Yes	Yes	No	No	No
Temperature* (°C)	-	23.9	21.9	26.89	26.34	11.3
Dissolved oxygen (%)	90-110%	15.0	44.3	65.61	95.23	50.0
pH	6.5-7.5	7.0	7.6	8.52	8.91	7.0
Electrical conductivity (µS/cm)	<500	240	240	642.1	463.1	111.5
Turbidity (NTU)	<25	8.6	19	20.45	33.35	401.5
Total nitrogen (mg/L)	<0.25	1.400	1.200	nd	nd	2.150
Ammonia (mg/L)	<0.010	0.350	0.060	nd	nd	0.065
Dissolved inorganic nitrogen (mg/L)	<0.015	0.020	0.020	nd	nd	0.205
Total phosphorus (mg/L)	<0.030	0.150	0.310	nd	nd	0.270
Filterable reactive phosphorus (mg/L)	<0.015	0.052	0.180	nd	nd	0.025

Note – 'na' indicates not applicable, 'nd' indicates no data available. All water quality objectives (WQOs) apply to the protection of slightly to moderately disturbed aquatic ecosystems (ANZECC 2000, DERM 2009). Red values indicate exceedances of the relevant guideline, or outside of guideline range. US indicates the site is upstream of the Mine on Lagoon Creek, DS indicates the site is downstream of the Mine on Lagoon Creek. Lagoon Creek data is sourced from Chapter 5. Wilkie Creek data is sourced from SKM (2012).

A full summary water quality for Lagoon Creek and surrounds is provided in **Chapter 5**, **Section 5.6.2**.

Aquatic flora

A total of 16 species of aquatic flora were identified from the desk top review as being potentially present within the aquatic ecology study area, three of which are submerged forms and the remainder are emergent forms as described in **Table 8–9**. Three of these macrophyte species are introduced and the remaining 13 are native. None of the species are listed as EVNT species or as special least-concern species. Five species were recorded at Lagoon Creek; all are emergent macrophytes, four of which are native species, and one, the pickerel weed (*Pontederia cordata),* is introduced. Macrophytes were observed at all of the survey sites and were most abundant at Site AE2 where the shallow water depth of the pool provided the most suitable conditions for emergent macrophytes. The presence of macrophytes at all of the survey sites indicated the persistence of surface water and the provision of refugia for aquatic flora and fauna in these sections of Lagoon Creek during drier periods.

Macrophyte diversity was variable during surveys of larger tributaries of the Condamine River (Hydrobiology 2010, Aquateco 2011). Six species were recorded at Gowrie Creek in the Oakey Creek subcatchment, and only a single species, the water primrose (*Ludwidgia* spp.) recorded at Charleys Creek as described in **Table 8–9**.

Table 8–9 Aquatic Flora Recorded from the Aquatic Ecology Study Area and Broader Catchment

Species	Common name	Status, form	Recorded from the Study Area	Source
Bolboschoenus fluviatilis	Marsh clubrush	N, e	No	WO, GC
Cyperus eragrostis	Umbrella sedge	I, e	No	WO
Cyperus exaltus	Giant sedge	N, e	No	GC
Damasonium minus	Starfruit	N, e	No	GC
Eleocharis acuta	Common spike-rush	N e	Yes	WO, LC
Eleocharis cylindrostachys	Unknown	N, e	No	WO
Eleocharis sphacelata	Tail spike-rush	N, e	Yes	LC
Fimbristylis dichotoma	Common fringe-rush	N, e	No	WO
Juncus bufonius	Toad rush	I, e	No	WO
Juncus flavidus	Rush	N, e	No	WO
Juncus polyanthemus	Unknown	N, e	No	WO
Juncus subglaucus	Unknown	N, e	No	WO
Juncus subsecundus	Finger rush	N, e	No	WO
Juncus usitatus	Common rush	N, e	Yes	WO, LC
Leptochloa digitata	Umbrella canegrass	N, e	No	GC
Ludwigia spp.	Water primrose	N, e	Yes	WO, LC, CC
Persicaria attenuata	Unknown	N, e	No	GC
Phragmites australis	Common reed	N, e	No	
Pontederia cordata	Pickerel weed	I, e	Yes	LC
Potamogeton crispus	Curly pondweed	N, s	No	WO
Potamogeton perfoliatus	Perfoliate pondweed	N, s	No	WO
Ruellia simplex, R. tweediana	Ruellia, Mexican bluebell	I, e	No	WO
Rumex crispus	Curled dock	I, e	No	GC
Vallisneria nana	Ribbon weed	N, s	No	WO

N indicates taxon is native to the Study area. I indicates that the taxon is introduced to Queensland and has naturalised. e indicates emergent form. s indicates submerged form. WO indicates record sourced from Wildlife online database search. LC refers to Lagoon Creek field survey (this study), CC refers to Charleys Creek (Hydrobiology 2010), GC refers to Gowrie Creek (Aquateco 2011).

In general, macrophyte richness and abundance is low in the Condamine catchment (Hydrobiology 2010). Ephemeral waterways typically support a lower diversity and coverage of macrophytes than in perennial waterways, and communities are dominated by emergent species including introduced weed species such as para grass (*Urochloa mutica*) (Hydrobiology 2010). Ephemeral waterways do not offer good habitat for submerged macrophytes, as these plants are sensitive to desiccation and die

when ephemeral waterways dry out (Hydrobiology 2010). Similarly, ephemeral watercourses in the Condamine catchment are generally characterised by high turbidity (CBWC 2002), which may not allow sufficient light penetration through the water column for the growth of macrophytes on the substrate. Where surface water can persist between flow events in intermittently flowing catchments, either within large natural pools or waterholes or within impoundments, the stable and permanent aquatic environment may be colonised by emergent, floating and submerged macrophytes, particularly where these waterways have lower turbidity.

Despite the intermittent flows and small upstream catchment area of Lagoon Creek, the in-stream impoundments have provided surface water environments that support emergent macrophyte communities. Important functions of emergent macrophytes include bank stabilisation, food and refugia for aquatic fauna, nutrient uptake and recycling, decreased evaporation, and in some cases reduced turbidity due to slowing flow (Sainty and Jacobs 2003).

Macroinvertebrates

The presence/absence of aquatic macroinvertebrates across the four sites assessed is shown in **Table 8–10**. The figures presented in **Table 8–10** represent the sum of the number of specimens collected at each survey site and indicate the relative abundance of taxa per site during the dry season survey. A total of 31 family or higher level taxa were recorded over the four sites. None of the macroinvertebrate species recorded have local or regional significance, or were listed as EVNT species.

Table 8–10 Macroinvertebrate Presence/Absence and SIGNAL2 Scores for Survey Sites

Family Name	Site AE1	Site AE2	Site AE3	Site AE4
Hydridae (2)			2	30+
Bithyniidae (3)		2		
Thiaridae (4)	30+			30+
Physidae (1)	1			4
Planorbidae (2)		25		
Lymnaeidae (1)			1	2
Ancylidae (4)				4
Sphaeriidae (5)	3			16
Corbiculidae (5)				1
Atyidae (3)				30+
Parastacidae (4)			4	1
Acarina (6)	1	14		
Baetidae (5)	1	1	15	30+
Caenidae (4)		2		1
Aeschnidae (4)			13	2
Libellulidae (4)		4	2	5
Coenagrionidae (2)		2	30+	30+

Family Name	Site AE1	Site AE2	Site AE3	Site AE4
Nepidae (3)			2	
Notonectidae (1)	15		30+	30+
Corixidae (2)	30+	7	30+	30+
Pleidae (2)		1		
Psephenidae (6)	1			
Curculionidae (2)		1		
Dytiscidae (2)	3	22	3	1
Haliplidae (2)		2		
Hydrophilidae (2)	1		2	6
Tipulidae (5)		1		
Culicidae (1)			7	1
Chironomidae (3)	13	13	30+	30+
Ceratopogonidae (4)	1		3	
Leptoceridae (6)		30+	30+	30+
No. of Taxa	12	15	16	21
Total Signal Score	41	50	46	65
Av. Signal Score	3.42	3.33	2.88	3.10

Note: Figures in brackets denote SIGNAL2 values following Chessman (2003); In line with suggested protocols a maximum of 30 specimens only of any taxon were counted.

It must be noted that the Queensland sampling protocol for AusRivAS requires a minimum of two sample sets in one year (one in autumn and one in spring). Due to annual rainfall patterns, the ephemeral nature of these creeks and timeframes, the spring sample set was unable to be obtained. As such the results are limited to one season only and therefore the interpretation of data reflects this approach.

Average SIGNAL values may range from 1 to 10 to reflect the disturbed or undisturbed nature of the freshwater environment respectively. Values less than 5 usually indicate some form of environmental perturbation. The numerical dominance of a few taxa and the low SIGNAL scores associated with the majority of the taxa (most less than 5) indicates low environmental sensitivity and high adaptability, and sites would typically be impacted by environmental disturbance. Low SIGNAL scores are common in macroinvertebrate communities surveyed in watercourses of the Condamine basin and this has been attributed to a range of impacts occurring in these catchments including river regulation, agriculture, clearing of vegetation and urban development (Hydrobiology 2010). The SIGNAL scores for Lagoon Creek were similar to those from surveys of Wilkie Creek (3.37 and 3.83, SKM 2012) and for Charleys Creek (3.3, Hydrobiology 2010) both of which are larger watercourses in subcatchments north of Lagoon Creek. However SIGNAL values can vary considerably over time and within subcatchments, and a substantially higher SIGNAL score of 6.10 was recorded from an earlier survey at Wilkie Creek and at Gowrie Creek in the Oakey Creek subcatchment (Aquateco 2011). The

diversity of macroinvertebrate communities in watercourses of the Condamine basin is also affected by flow events with surveys following large flow events recording lower diversity than surveys during the dry season (Australia Pacific LNG 2010).

Macrocrustaceans

Macrocrustaceans captured in bait traps in Lagoon Creek during the dry season survey were freshwater crayfish (*Cherax* spp.) at sites AE1 and AE3, and the Australian freshwater prawn, (*Macrobrachium australiense*) at site AE4. Both taxa are common and widely distributed and are often recorded from aquatic fauna surveys in the Condamine catchment including disturbed aquatic habitats (Hydrobiology 2010).

Freshwater crayfish are omnivorous, and feed on decaying plant matter, aquatic invertebrates and fish. They are able to aestivate in their burrows (which may be up to 2 m deep) to survive droughts (Gooderham and Tsyrlin 2002). Freshwater crayfish are moderately tolerant of poor water quality (Chessman 2003), including low concentrations of dissolved oxygen, which allows them to survive in ephemeral streams that are impacted by surrounding land-uses.

Freshwater prawns (*Macrobrachium* spp.), unlike freshwater crayfish, are not resistant to desiccation and therefore mostly inhabit permanent waterbodies (Williams 1980). Freshwater prawns feed on decaying organic matter (Gooderham & Tsyrlin 2002).

Fish

A total of 14 species of fish were identified as potentially occurring within the aquatic ecology study area as presented in **Table 8–11**. Two fish species are introduced (common carp *Cyprinus carpio* and Mosquitofish *Gambusia holbrooki*) and are declared pest species under the *Fisheries Act 1994.* The remaining twelve species are native to the Condamine catchment. One species, the Murray cod (*Maccullochella peelii*), is an EVNT species and listed as vulnerable, and may occur or may have habitat that occurs within the aquatic ecology study area. There were no species listed as special least-concern or aquatic migratory.

Two native fish species (spangled perch *Leiopotherapon unicolor*, and gudgeon *Hypseleotris* spp.) and one exotic fish species (Mosquitofish *Gambusia holbrooki*) were captured in Lagoon Creek using bait traps during the survey. The results of previous surveys conducted at Gowrie Creek, and Charleys Creek were also reviewed, given that substantially more sampling effort was applied at these locations, and a range of gear types were used, including backpack electrofishing, fyke nets, seine nets and multiple survey sites or repeated surveys (Hydrobiology 2010, Aquateco 2011). The watercourses were considerably larger (stream order 4 - 5) than Lagoon Creek (stream order 2) and included channel habitat that was not directly modified by instream impoundments (unlike Lagoon Creek). It is highly likely that the species present in Lagoon Creek will be constrained to those that can tolerate degraded conditions including poor water quality, multiple barriers to fish movement, impounded dry season aquatic habitat, low instream cover complexity and minimal riparian functionality.

Table 8–11 Fish Recorded from Aquatic Ecology Study Area and Broader Catchment

Species	Common name	Status	Recorded from Study Area	Likelihood of occurrence	Source
Fish					
Ambassis agassizii	Agassiz's glassfish	N	No	Unlikely	WO
Carasius auratus	Goldfish	I	No	Likely	CC, WC
Craterocephalus stercusmuscarum	Flyspecked hardyhead	N	No	Possible	WO, QM, GC
Cyprinus carpio	Common carp	I	No	Likely	WO, CC, WC, GC
Gambusia holbrooki	Mosquitofish	I	Yes	Observed	WO, LC, CC, GC
Gadopsis marmoratus	River blackfish	N	No	Unlikely	WO, GC
Hypseleotris spp.	Gudgeon	N	Yes	Observed	LC, CC
Hypseleotris species 1	Midgley's carp gudgeon	N	No	Unlikely	WO
Hypseleotris klunzingeri	Western carp gudgeon	N	No	Unlikely	WO, QM, WC
Leiopotherapon unicolor	Spangled perch	N	Yes	Observed	WO, LC, GC
Maccullochella peelii	Murray cod	N, V	No	Unlikely	WO
Macquaria ambigua	Golden perch	N	No	Unlikely	WO
Melanotaenia duboulayi	Crimsonspotted rainbowfish	N	No	Unlikely	WO
Melanotaenia fluviatilis	Murray River rainbowfish	N	No	Possible	WO, QM
Mogurnda adspersa	Purple-spotted gudgeon	N	No	Unlikely	
Nematalosa erebi	Bony bream	N	No	Unlikely	
Retropinna semoni	Australian smelt	N	No	Possible	
Tandanus tandanus	Eel-tailed catfish	N	No	Unlikely	

N indicates taxon is native to the surrounds of the Study area. I indicates that the taxon is introduced to Queensland and has naturalised. V Indicates the taxon is listed as vulnerable under the EPBC Act. WO indicates record sourced from Wildlife online database search. QM indicates record sourced from Queensland Museum database search. LC refers to Lagoon Creek field survey (this study), CC refers to Charleys Creek (Hydrobiology 2010), WC refers to Wilkie Creek (SKM 2012), GC refers to Gowrie Creek (Aquateco 2011).

Existing potential water quality impacts on fish were particularly evident during the wet season monitoring from the high concentrations of total and dissolved nitrogen and phosphorus, and low

dissolved oxygen concentrations. High nutrient concentrations can often drive low dissolved oxygen concentrations due to aerobic decomposition of dissolved and suspended organic matter. High concentrations of dissolved inorganic nitrogen and phosphorus also promote algal blooms which can result in depleted concentrations of dissolved oxygen during night-time respiration and during the decomposition of algal biomass. Potential water quality impacts on fish also involve ammonia, which was recorded at concentrations far exceeding those for the protection of moderately disturbed aquatic ecosystems. Ammonia toxicity to fish increases when temperature and pH are high (i.e. pH >8.5, temperature >25 °C, US Environmental Protection Agency 1991) and these conditions were recorded at most sites during the 2008 dry season survey. A comprehensive water quality assessment has been undertaken and is located in **Chapter 5**, **Section 5.6**.

The series of in-stream impoundments along the length of Lagoon Creek (including within the aquatic ecology study area) have been the result of earthen farm dams and causeways, and have greatly modified the channel. Whilst connectivity in Lagoon Creek is sustained during high flow events, the impoundments will reduce connectivity during the rising and falling stages of the flow event. The duration of connectivity is also limited by the area of the upstream catchment; for a watercourse with a stream order of 2, such as Lagoon Creek, the catchment area is generally small and flow events following rainfall are consequently flashy and relatively short-lived. Fish species that require sustained periods of connectivity for movement and migration are therefore unlikely to persist in Lagoon Creek.

The impounded aquatic habitat that persists during the dry season is likely to be simplified by silt deposition. The historical removal of riparian tress from most sites has reduced the complexity of edge habitat and the availability of shade. The loss of variation and complexity of aquatic habitat at the Lagoon Creek sites will limit fish species to those that are tolerant of a simplified habitat.

Fish that can tolerate the degraded aquatic conditions in Lagoon Creek include the species described below:

- Common carp (*Cyrpinus carpio*) show a preference for slow flowing waters, including billabongs and backwaters. The species is omnivorous, feeding mainly on aquatic insects, crustaceans, annelids, molluscs, weed and tree seeds, aquatic plants and algae; mainly by foraging in sediments (Allen et al. 2002). Common carp is abundant in degraded and impounded environments of the Murray-Darling basin. This species was not recorded during surveys in the Study area.
- Goldfish (*Carasius auratus)* is a species capable of tolerating high water temperatures and low oxygen concentrations and widely distributed in the Murray-Darling, and is not known to migrate (McDowall 1996). This species was not recorded during surveys in the Study area.
- *Mosquitofish (Gambusia holbrooki)* is a tolerant species capable of handling a wide range of temperature and salinity extremes. The species is found in a variety of habitats including still or slow-moving aquatic habitats in large lowland floodplain rivers, upland rivers and streams, and small coastal streams (Allen et al. 2002). This species was recorded during surveys in the Study area.
- Gudgeon (*Hypseleotris* spp.) is group of species found in slow-flowing or still waters, normally associated with aquatic vegetation. Although experimental data are not available, tolerances for low dissolved oxygen and high turbidity are inferred from distributional studies (Aquateco 2011).

While originally thought to be a relatively sedentary species, recent studies have shown that large numbers of *Hypseleotris* attempt to move through fishways; whether these movements reflect local dispersal or foraging movements is unknown (Baumgartner 2003). This species was recorded during surveys in the Study area.

- Murray River rainbowfish (*Melanotaenia fluviatilus*) is generally found in the lowland slow-flowing rivers, wetlands and billabongs. Until recently the species was considered to be largely sedentary, however recent studies have shown substantial movement through fishways (Baumgartner 2003). This species was not recorded during surveys in the Study area.
- Spangled perch (*Leiopotherapon unicolor)* has been shown to exhibit tolerance to a wide range of salinities within inland systems, with the upper tolerance approaching that of seawater (35%), which is beneficial in enabling the species to survive in pools that evaporate to near dryness (Pusey et al. 2004). Although experimental data are not available, tolerances for low dissolved oxygen and high turbidity are inferred from distributional studies. It is a relatively fast swimming species and is capable of swimming through quite shallow water in order to colonise expanding habitat such as floodplains and ephemeral streams during storm events (Pusey et al. 2004). This species was recorded during surveys in the Study area.
- Flyspecked hardyhead (*Craterocephalus stercusmuscarum*) is typically found around the margins of large, slow-flowing lowland river, lakes and billabongs. It prefers habitats with aquatic vegetation and sand, gravel or mud substrates (Allen et al. 2002). This species was not recorded during surveys in the Study area.
- Australian smelt (*Retropina semoni*) is tolerant of poor water quality and habitat degradation, with specimens caught over a wide range of water quality conditions in a number of studies. Upstream migrations may occur in low or high flow periods (Pusey et al. 2004). This species was not recorded during surveys in the Study area.

The native species likely to be present in environments such as Lagoon Creek are all small bodied species, which are considered to be generalist in their habitat requirements with wide distributions and often high abundance. Whilst several species demonstrate migrating behaviour, they are all able to persist in impounded environments. Larger species such as river blackfish *Gadopsis marmoratus* and golden perch (*Macquaria ambigua ambigua*) are unlikely to persist in the aquatic ecology study area and similar environments due to a strong preference for complex in-stream structural habitat, particularly woody debris, and in the case of golden perch a requirement for extensive migratory movements.

Other species unlikely to be present in Lagoon Creek due to their inability to tolerate the disturbed conditions are the eel-tailed catfish (*Tandauns tandanus*), Agassiz's glassfish (*Ambassis)* and the Murray cod (*Maccullochella peelii*).

The following information on Murray cod, the single EVNT fish species identified within the region, was derived from the SEWPaC (2011) website, Kearney and Kildea (2001) and Allen et al. (2002). The Murray cod is the largest freshwater fish found in Australia and occurs in the Murray-Darling Basin. It is a long lived ambush predator species that is highly territorial and aggressive, feeding mainly on fish, frogs and crayfish. It occurs in a variety of habitats that range from clear, rocky streams to slow flowing turbid rivers and billabongs and is generally associated with deep pools in rivers with instream cover

such as rocks, undercut banks and structural woody habitat. Major threats to the Murray cod include habitat disturbance through the impoundment of natural riverine habitat by dams and weirs and loss of instream woody habitat in the waterways of the Murray–Darling Basin. Murray cod have been regularly stocked in the Condamine River; the closest stocking site to the revised Project site is Loudoun Weir near Dalby, which is approximately 50 km distant via river channel. Lagoon Creek does not provide suitable habitat for the Murray cod.

Turtles

Three turtle species identified from the desk top review as being potentially present within the aquatic ecology study area and surrounds, were the Murray turtle (*Emydura macquarii*), the Eastern snake-necked turtle (*Chelodina longicollis*) and the broad-shelled river turtle (*Chelodina expansa*) as described in **Table 8–12**. None are listed as EVNT species or as special least-concern species. During the dry season survey the presence of turtles was confirmed from sightings at site AE1, although the species was not identified. During the wet season habitat survey an Eastern snake-necked turtle was identified on the bank of Lagoon creek adjacent to a shallow flowing run section, approximately 0.7 km upstream of site AH4 as shown in **Photograph 8-6**.

Table 8–12 Turtle Species Identified in the Surrounds of the Study Area

Species	Common Name	Status	Recorded from project site	Likelihood of occurrence	Source
Chelodina expansa	Broad-shelled river turtle	N	No	Unlikely	WO
Chelodina longicollis	Eastern snake-necked turtle	N	Yes	Observed	WO, LC
Emydura macquarii	Murray turtle	N	No	Unlikely	WO

N indicates taxon is native to the aquatic ecology study area and surrounds. WO indicates record sourced from Wildlife online database search. LC refers to Lagoon Creek field survey (this study).

Photograph 8-6 Lagoon Creek Channel and Eastern Snake-Necked Turtle Upstream of AH4

The single turtle species observed along the Lagoon Creek Channel, inhabits slow moving water bodies from farm dams to major rivers and lakes. Due to their ability to move over land to find water, they are able to inhabit shallow lakes and ephemeral waterbodies (Chessman 1988). The broad-shelled river turtle has a preference for aquatic habitat with structured vegetation including emergent and submerged macrophytes, submerged logs, dead trees and root system (Ercolano 2008). The low availability of structural habitat and cleared riparian vegetation and absence of submerged macrophytes suggests Lagoon Creek is unlikely to support populations of the broad-shelled turtle. The Murray turtle is highly unlikely to be found in the aquatic ecology study area due to its habitat preference for large river and permanent lakes (Chessman 1988) both of which are not present in the Study area. Turtle species were not reported in the surveys of Charleys Creek (Hydrobiology 2010), Gowrie Creek (Aquateco 2011) and Wilkie Creek (SKM 2012) although these larger water courses are likely to have potential habitat for all three species.

Regional Ecosystem Wetlands

Regional ecosystems in which wetlands may be present (1 % - 50% by area) were identified approximately 24 km downstream of the revised Project site, adjacent to Oakey Creek (DEHP Wetlands mapping). For DEHP mapping purposes, wetlands are defined as areas of permanent or periodic/intermittent inundation, with water that is static or flowing.

8.5. Impact Assessment

The activities of the revised Project that may potentially affect aquatic ecology values include the following:

- continuation of the existing mining activities using current open cut mining techniques to progressively extend to parts of the Manning Vale and Willaroo resource areas within MLA 50232, located to the south and west of the current MLs 50170 and 50216 which are adjacent to Lagoon Creek;
- develoment of a haul road crossing across Lagoon Creek for access to and from the Willaroo resource area;
- continued use of a mine surface water management system involving seven new water management structures (including two flood levees) staged to accommodate the revised Project requirements and based on the principles of diverting clean water and capturing and reusing dirty water from disturbed areas; and
- construction of a new 8 km rail spur line and balloon loop from the Western Line onto MLA 50232 which passes through the flood plain of Lagoon Creek.

A comprehensive description of the revised Project is presented in **Chapter 3**, **Section 3.3**.

The potential impacts to aquatic ecology as a result of the construction, operation and decommissioning of the revised Project are:

- changes to water quality;
- alteration of flow regimes;
- changes to habitat for aquatic flora and fauna; and
- introduction and spread of pests and weeds.

The revised Project activities and their potential impacts upon aquatic ecosystem values are described below with consideration of existing and proposed management of these potential impacts.

8.5.1. Removal of Terrestrial Vegetation

Removal of terrestrial vegetation will occur for the development of open-cut pits in the Manning Vale and Willaroo resource areas within MLA 50232, which are adjacent to Lagoon Creek as shown in **Figure 8–2**. The removal of terrestrial vegetatation in locations that drain into water courses can result in impacts on aqautic values, particularly related to erosion during periods of high rainfall run-off. The following are potential impacts on the aquatic ecoystem:

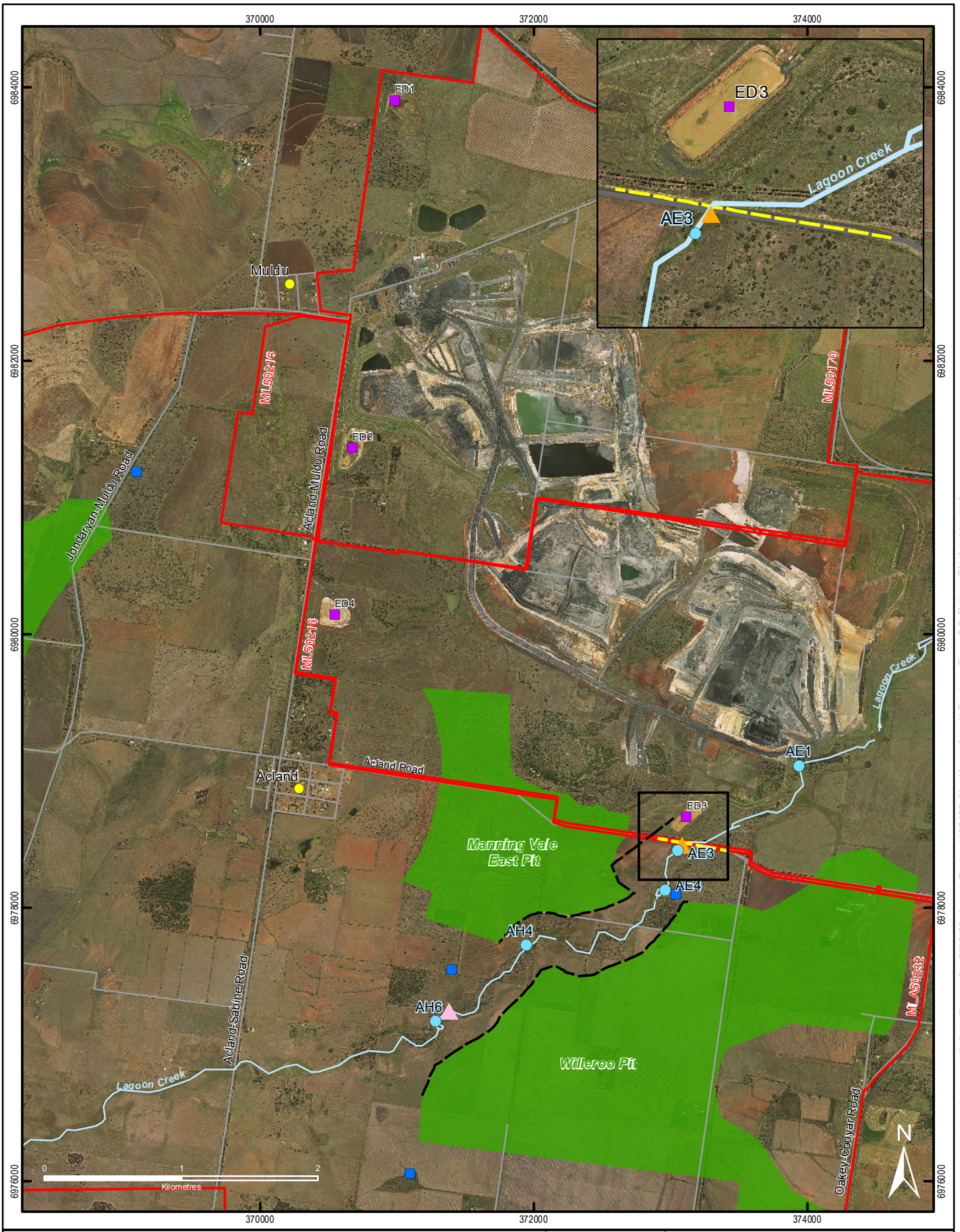
- water quality decline with increased suspended sediments and turbidty, water temperature and nutrients, and reduced dissolved oxygen concentration;
- reduced light penetration and benthic primary production;
- stimulation of algla blooms from increaed nutrients; and
- silt depostion causing the smothering of benthos and simplification of substrate habitat.

These impacts can potentially affect aquatic values identified in the aquatic ecology study area, which are already significantly modified and subject to moderate to high levels of disturbance. Existing aquatic values within Lagoon Creek are compromised by high nutrient levels, sediment runoff and the loss of riparian vegetation and associated habitat values. The aquatic values remaining that will be at greatest threat are those in close proximity to vegetation removal works, such as sections of Lagoon Creek immediately downstream of clearing works. The level of potential impact can be predicted to decrease with distance downstream from vegetation clearing activities. Impacts on the diversity and abundance of native fish, macrocrustaceans and macroinvertebrate communities are likely to be influenced mostly by low dissolved oxygen concentrations and from the smothering of benthic habitat areas with sediment. Fauna that depend upon aquatic production for food resources within the creek may also be impacted, such as the Eastern snake-necked turtle population. In this context, some additional impacts upon the aquatic ecology values are expected to add to what is an already degraded aquatic ecosystem. Riparian buffer zones maintained to a minimum of 50 m on either side of Lagoon Creek (which has a stream order of two) will minimise the impact of vegetation clearing on Lagoon Creek.

The water management principles of the revised Project that relate to potential impacts on aquatic values due to removal of terrestrial vegetation include the following:

- diversion of clean water away from disturbed areas; and
- revegetation of disturbed areas no longer required for operational use to promote progressive rehabilitation.

Flood levees will be constructed between the Manning Vale East and Willaroo resource areas, that will contain up to the PMF rainfall event. Erosion management will be undertaken in the areas with infrastructure development that is potentially affected by run-off and flood plain indundation. A comprehensive flood assessment for the revised Project is located in **Chapter 5**, **Section 5.10** and **Section 5.11**. These management actions are outlined in the mitigation section below. The locations of the proposed release points, flood levees and haul road crossing are shown shown in **Figure 8–2**.



LEGEND

- Towns and Localities
- Proposed Dam
- Environment Dam (ED)
- Survey Sites
- Existing Release Point
- Proposed Release Point
- Proposed Haul Road Crossing
- Proposed Flood Levee
- Roads
- Creeks
- Mining Tenements
- Stage 3 Pit Areas

NEW HOPE GROUP

SKM

NEW ACLAND COAL MINE STAGE 3 PROJECT

Figure 8-2 - Existing& Proposed Release Points & Proposed Flood Levee

Scale 1:36,580 on A4
Projection: Australian Geodetic Datum – Zone 56 (AGD84)

Produced: 21/08/2013 Path: I:\QENV2\Projects\QE06644\Spatial\ArcGIS\01_Figures\01_SEIS\08_AquaticEcology\130430_NewHope_AquaticEcology_Figure8-2_ReleasePts_Levees.mxd

8.5.2. Water Management and Infrastructure

Water management for the Mine and the revised Project will be conducted in accordance with the Water Resource Management Plan (WRMP) which provides for integrated operation of the water mangement infrastructure in a manner that complies with the conditions set out in the Projects EA.

The potential impacts on aquatic values in the Study area from the water management infrastructure are associated with the retention and transfer of site water and controlled and uncontrolled releases of water from the storages. The location of the current water release point from the Mine into Lagoon Creek is at the Environmental Dam 3, upstream of the revised Project site, as shown in **Figure 8–2**. The proposed location for water releases from the revised Project is likely to be positioned between the survey sites AH4 and AH6 as shown in **Figure 8–2**. Impacts on aquatic values resulting from water management primarily relate to the alteration of catchment run-off and the quality, quantity, and timing of releases.

Potential impacts on aquatic values due to the water quality of discharges relate to controlled and uncontrolled dischages as a result of excessive rainfall and flooding. Controlled discharges will be regulated within the integrated water management system in accordance with the current approved water quality targets for revised Project. The potential for uncontrolled releases is unlikely given the location of the disturbance footprint in relation to the catchment topography. The on-site water storage capacity and WRMP has been designed to reduce the likelihood of uncontrolled discharges. This is discussed in detail in the **Chapter 5**, **Section 5.13** and **Appendix J.4**.

The water management principles adopted for the revised Project are consistent with the existing mine and include:

- capture or adequate treatment of mine-affected water that may be discharged off-site to ensure it complies with the Mine's EA conditions for releases;
- design and construction of all water management structures using practical hydraulic parameters based on an appropriate risk based rainfall event, catchment size, slopes, discharge design and soil types; and
- preferential use of water stored in environmental dams as a supplemental water source for coal washing, dust suppression and other activities to minimise the likelihood of off-site water discharges.

The potential impacts on aquatic ecology values from a controlled release within the receiving waters will depend on a suite of factors including the water quality and the duration, timing and magnitude of releases. Evaluation of the impacts requires reference to the outputs of **Chapter 5**, **Section 5.6**.

Aquatic ecology values may be impacted by altered flow regimes as a result of development and operation of the revised Project. Altered flow regimes may include increased or decreased flow volumes, altered flow patterns and changed flow duration. These potential impacts are summarised as follows:

- decreased flow volumes may occur due to a reduction in catchment run-off into Lagoon Creek resulting from alteration of topography, or the retention of catchment run-off into the revised Project's storages;

- increased flow volumes may occur if waters generated and stored during operation are discharged into waterways; and
- altered flow patterns due to changes of the magnitude, timing, duration and frequency of the natural flow regime may occur due to activities that increase or decrease flow volumes.

The application of the water management principle for the diversion of clean water away from disturbed areas will result in reduction of catchment area and run-off in Lagoon Creek Catchment during rainfall events and thereby potentially reduce flows in Lagoon Creek during these events. The maximum reduction of total catchment area is 5 %. This is expected to have a negligible effect on flows in Lagoon Creek. The aquatic values in Lagoon Creek are therefore unlikely to be affected by decreased flows. The predicted reduction in the flow exceedance curve for Lagoon Creek is provided in **Chapter 5**, **Section 5.4**.

There are several species of fish likely to occur in the aquatic ecology study area that have been observed to move or migrate in response to flows, and these include spangled perch, Murray River rainbow fish, gudgeons, and Australian smelt. Fish movement and migration is often associated with reproduction, recruitment, movement and dispersal, all of which can be disrupted if unseasonal changes to the flow regime occur (Bunn and Arthington 2002). Other fauna present in Lagoon Creek may also be affected by such impacts on flow including macroinvertebrate diversity and abundance, and movement patterns of macrocrustaceans and the Eastern snake-necked turtle.

The results of the surface water modelling predict that there will be no significant change in daily flows as a result of the water management and therefore impacts on aquatic values resulting from reduced or increased flows and changes to seasonal flow patterns are not expected. The change in the flow duration curve without inclusion of releases in Lagoon Creek is very minimal and a very slight reduction of flow is predicted at the MLA downstream boundary. This reduction of flow is even slighter at the confluence with Oaky Creek. The flow duration curve shows that the number of cease to flow days will not increase and the seasonal pattern of flows will remain.

Releases will be restricted to periods during flow events or immediately after a flow event and this strategy minimises the risk of unseasonal changes of flows. It is expected that the revised Project will be managed according to the *Model Water Conditions for Coal Mines in the Fitzroy Basin* (DERM 2012). The management of releases in accordance with DERM (2012) stipulates that for no/low flow stream conditions, releases are made at a time when flow is on the tail end of an event above a specified flow trigger and limited to four weeks, and for medium flow stream conditions releases can only occur during a flow event which is above base/low flow. In the case of Lagoon Creek, flow percentiles are only calculated from days when a minimum flow occurred, thus discounting cease to flow days.

The rules for releases may result in increased magnitude and duration of flow events that could extend for up to a maximum of four weeks beyond the cessation of natural flows. Whilst such releases can potentially affect flow magnitude and duration they are not considered to constitute an alteration to the seasonal patterns of the flow regime. The potential increased magnitude of flow events and extended tail of flow events is not considered to represent a disruption to aquatic values in Lagoon Creek. At their most extreme the effect of these changes to flow may include increased extent and duration for

seasonal movement of fish, turtle and macrocrustaceans, and an extended period prior to the re-establishment of macrophyte and macroinvertebrate communities following wet season flow disturbances.

Uncontrolled releases could occur due to infrastructure failure, and could potentially affect aquatic values through unseasonal flow events and deteriorated water quality. Both of these impacts could disturb aquatic values in Lagoon Creek by disruption of seasonal movement and reproductive patterns, and by impacts upon health due to poor water quality, which can particularly affect aquatic fauna. The potential of these impact is addressed through the integrated water management strategy which incorporates the design and construction of all water management structures using practical hydraulic parameters based on an appropriate risk based rainfall event, catchment size, slopes, discharge design and soil types. Details of the revised Project's WRMP is presented in **Appendix J.4**.

8.5.3. Groundwater

Based on the studies undertaken for groundwater, a comparison of groundwater levels and stream bed levels indicates that groundwater does not contribute to surface water flow within the Lagoon Creek system. After significant rainfall events which result in run-off to surface water drainage lines, it is anticipated that a component of surface flow will infiltrate, and a small amount will reach the Quaternary Alluvial aquifer which is generally several tens of metres below the stream beds. The majority of the infiltrated water is likely to be lost by direct evapotranspiration along the stream banks. These findings indicate that surface water pools in Lagoon Creek persisting during dry periods are separated from groundwater and that groundwater drawdown will not impact upon water levels of surface water in Lagoon Creek.

8.5.4. Construction of Waterway Crossings

Waterway crossings on Lagoon Creek are proposed for the access road to the Willaroo resource area, adjacent to the existing Acland-Silverleigh Road crossing as shown in **Figure 8–2,** and for the rail spur, approximately 3 km downstream of the site AE3 as shown in **Figure 8–1**.

The construction and operation phases of the rail spur and road crossings could potentially impact on aquatic values through the following aspects:

- degradation or loss of riparian and instream habitat may occur due to earthworks and other activities that involve vegetation clearing and alteration of channel morphology at the location of the creek crossing;
- decline in water quality, with increased suspended sediments and turbidty, and water temperature, nutrients and reduced dissolved oxygen;
- instream barriers as a result of the installation of temporary or permanent structures; and
- death of fauna species could occur during construction and operation phases due to activities including vehicle movement, vegetation clearing and earthworks.

The potential for these impacts to occur and their implications for aquatic ecosystems should be assessed in the context of the existing moderate to highly disturbed nature of Lagoon Creek. The presence of only minimal riparian vegetation along sections of the creek and the existing degraded water quality conditions mean that any additional impacts on aquatic values arising from construction and operation of the rail spur and road crossings are likely to be relatively minor. In this context, there

are also several existing in-stream barriers to fish migration within Lagoon Creek, including numerous in-stream farm dams, road crossings at Childs Road and the Warrego Highway, and within the broader catchment, weirs are located downstream in the Condamine River.

The construction of new crossings has the potential to impact upon fish and turtle passage, riparian vegetation, bank stability and water quality. The construction of temporary and permanent barriers in watercourses can restrict the passage of fish and other aquatic fauna, particularly during periods of low flow. Several of the fish species likely to be present in Lagoon Creek are known to migrate (e.g. spangled perch) and the distribution, access to food resources and reproductive strategies of such species can be further impacted by the construction of additional barriers to movement.

The loss of riparian vegetation, particularly trees, can reduce the complexity of the edge habitat, the availability of shade and the inputs of woody debris, and can affect diversity and abundance of aquatic fauna. The potential impact on riparian trees is likely to be limited at the proposed crossing locations due to the existing degraded riparian condition.

The water managent principles of the revised Project that relate to potential impacts on aquatic vlaues due to waterway crossings include the following:

- diversion of clean water away from disturbed areas;
- revegetation of disturbed areas no longer required for operational use to promote progressive rehabilitation; and
- Appropriately designed crossings that consider the hydrualic behaviour of Lagoon Creek.

8.5.5. Movement and Operation of Vehicles and Machinery

The movement and operation of vehicles and machinery during the construction phase, for example clearing and extraction activities, may potentially affect aquatic values where they occur within or adjacent to Lagoon Creek. Potential impacts are likely to be predominantly associated with locations used for the construction of the creek crossings but may occur at other locations and include the following:

- introduction and spread of weeds; and
- accidental chemical and fuel spillage during resulting in pollution impacts in Lagoon Creek.

The spread of weeds can impact upon aquatic ecology values in Lagoon Creek by impeding macrophyte communities. Such changes to the existing macrophyte community can reduce the quality of environment for aquatic fauna by altering the availability of refugia and food resources, and by decreasing hydraulic habitat and habitat complexity. Water quality declines due to toxins entering waterways from chemical and fuels spills are likely to impact upon fish and aquatic invertebrates.

The principles of water management relating to vehicle and machinery and movement include the following:

- temporary or permanent bunding of all significant quantities of hydrocarbon and chemical products stored on-site;
- use of spill capture and retention devices for refuelling and similar areas; and

- revegetation of disturbed areas no longer required for operational use to promote progressive rehabilitation.

8.6. Mitigation Measures

The mitigation and monitoring measures outlined below have been developed based on the potential impacts identified in **Section 8.5**. The assessment of impacts assumes that industry standard management practices (e.g. for management of construction projects and storage of fuels, lubricants, dangerous goods and wastes) will be applied as baseline mitigation controls. The following proposed mitigation measures will assist in protecting and, where possible, enhancing the aquatic values potentially impacted by the revised Project.

8.6.1. Management of Cleared Vegetetation Zones

- Construction of flood levees to prevent floodwaters entering resource operation areas and to prevent run-off from resource operations entering Lagoon Creek. Flood levees to be constructed adjacent to the Manning Vale and Willaroo resource areas. Flood levees will be an average of 100 m from the top of the banks area and designed to control flood water up to a PMF rainfall event.
- The flood levee will be a fully engineered structure and will be constructed using compacted clay lifts, and top soiled and grass covered to minimise the potential for erosion. The flood levee will be constructed in accordance with the (formerly) DERM's *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams,* 2012. Flood Levee sections that may be prone to erosion during flood events will be reinforced using appropriate stabilisation methods and materials (e.g. rip-rap).
- Riparian buffer zones maintained to a minimum of 50 m on either side of Lagoon Creek (which has a stream order of two). Buffer zones adopted are based on the Regional Vegetation Management Code for Brigalow Belt and New England Tablelands, which designate buffer widths based on stream order.
- Preparing and implementing an Erosion and Sediment Management Plan including installing and maintaining sediment control devices to be installed around exposed areas and earthworks adjacent to aquatic habitats and watercourses. This will be required for the development of all access roads and buildings where run-off could enter watercourses.
- Implementing the management measures described in the FLURP for areas no longer required for operational use to promote stabilisation and progressive rehabilitation. The FLURP for the revised Project is presented in **Appendix J.2**.

8.6.2. Water Management and Infrastructure

- Development and operation of the integrated water management system to manage clean and dirty water transfer and storage, water reuse, and the controlled releases of water within approved water quality targets (e.g. Environmental Authorities and Final Model Water Conditions for Coal Mines in the Fitzroy Basin). The revised Project's WRMP is located in **Appendix J.4**.
- Release water from Environmental Dams during natural flow events in accordance with approved release strategies (e.g. Environmental Authorities and Final Model Water Conditions for Coal Mines in the Fitzroy Basin) to maintain seasonal flow regime and minimise potential disruption to aquatic values from increased flow magnitudes and extended tail flow following flow events.

- Management of potential for uncontrolled releases through the development and operation of the water management infrastructure which incorporates the design and construction of all water management structures using practical hydraulic parameters based on an appropriate risk based rainfall event, catchment size, slopes, discharge design and soil types.
- Monitoring and assessment of aquatic values in Lagoon Creek at sites upstream and downstream of the Mine and downstream of the revised Project site. Monitoring locations are required to evaluate condition of aquatic and riparian habitat, water quality, aquatic flora and fauna to account for seasonal variation and for assessing potential cumulative impacts. This can be incorporated into a Receiving Environment Management Plan (REMP) for the revised Project, as specified by DEHP (2012).
- Culverts to be constructed for the rail spur in the area of the Lagoon creek flood plain to allow for overland flow of run-off.

8.6.3. Construction of Waterway Crossings

The following proposed mitigation measures will assist in protecting and where possible enhancing the aquatic ecology values potentially impacted by the rail and road crossings at Lagoon Creek.

- Construct the road and rail spur watercourse crossings in accordance with the Queensland code of environmental compliance for exploration and mineral development projects.
- Locate creek crossings at established road crossing sites where possible.
- Minimise the width of the rail and road crossings, associated infrastructure, and workspace areas, so as to reduce the length of bank and channel at the crossing of Lagoon Creek affected by the construction and operation activities.
- Restrict construction within and around the creek channel to the dry season where possible and complete stream bed and bank restoration before the onset of flow.
- Provide passage for aquatic fauna under the rail line and haul road where it crosses Lagoon Creek. The permanent structures will be in accordance with the minor waterway barrier works self-assessable code (DEEDI, 2010a) including the provision of appropriate hydraulic conditions across a range of low to high flow events, and appropriate levels of natural light. Temporary barriers will be in accordance with temporary waterway barrier works (DEEDI 2010b).
- Monitoring and maintaining water quality in accordance with Queensland Water Quality Guidelines (DERM 2009b) during and after construction.
- Monitoring of aquatic flora and fauna before, during and after construction to provide assessment of impacts on community structure.
- The Conservation Zone Management Plan located in **Appendix J.6** describes the appropriate rehabilitation and bank stabilisation measures that will be implemented for the revised Project. Revegetation of riparian zones will use locally endemic species and include the identification and marking of exclusion areas to protect adjacent riparian communities where applicable.

8.6.4. Movement and Operation of Vehicles and Machinery

- A Pest and Weed Management Plan is located in **Appendix J.9** for the revised Project. The Plan outlines monitoring procedures for pests and weeds, and describes the application of appropriate control measures.
- Bunded fuel and chemical storage procedures will be applied to minimise risk of accidental chemical release or spillage.

8.6.5. Decommissioning

- The stability of the dams will be enhanced (where necessary) by buttressing with inert rock material to create safe final slopes that are resistant to erosion and will be rehabilitated in accordance with the post-mine land use.
- A self-sustaining vegetation cover will be grown to provide long term stabilisation. Appropriate measures to assist vegetation growth will include, amongst other things, topsoil covering and appropriate erosion protection and drainage.
- Rehabilitated land will be monitored on a bi-annual basis until monitoring data confirms successful achievement of the agreed rehabilitation performance criteria. NAC will continue this monitoring regime until the total disturbed area is fully rehabilitated and relinquishment of the revised Project's MLs can be completed. A final landform assessment is presented in **Chapter 4**. The Final Landform Technical Report is located in **Appendix G.1.10**.

8.7. Risk Assessment

Environmental risks from the revised Project to aquatic ecology values are described in **Table 8–13** and were assessed as low following the implementation of mitigation measures. In summary, Aquatic habitats are subject to moderate to high levels of existing disturbance and mitigation measures will minimise the extent and duration of any impacts from the revised Project.

Table 8–13 Risk Assessment for Aquatic Ecology Values

Activity	Likelihood of Impact	Consequence	Preliminary Risk	Key Mitigation Actions	Likelihood of Impact	Consequence	Residual Risk
Extending mining activities to the edge of Lagoon Creek	Possible	Low	Low	Flood levees constructed Riparian buffer zones maintained Erosion and sediment management plan	Unlikely	Low	Low
Construction of haul road crossing at Lagoon Creek	Possible	Medium	Medium	Minimise width of crossing Conduct works around creek during dry season Install temporary barriers to minimise disturbance to flows Monitor crossing rehabilitation	Possible	Low	Low
New water management structures	Possible	Medium	Medium	Controlled discharges to be regulated Design based upon risk assessment Maximum reduction of total catchment area 5% Apply water management strategy	Possible	Low	Low
Rail spur and balloon loop through flood plain of Lagoon Creek	Unlikely	Low	Low	Flood levees constructed Riparian buffer zones maintained Erosion and sediment management plan	Unlikely	Low	Low

8.8. Conclusion

8.8.1. Aquatic Values

The Lagoon Creek catchment has a long history of disturbance from activities including grazing and mining. As a result, riparian and aquatic vegetation, as well as channel diversity and bank stability have been highly impacted and exotic weeds are now prevalent (SKM, 2011). The ecological and physical status of Lagoon Creek as part of the lower Oakey Creek sub-catchment was classed as 'poor' to 'very poor' in all the key parameters surveyed in the SoR Report for the Upper Condamine River catchment (Phillips and Moller 1995).

During dry periods, flows cease in Lagoon Creek and surface water contracts into temporal pools. These conditions predominate in the ephemeral watercourses of the Condamine catchment and are interspersed with periods of flow when substantial rainfall and run-off events occur in the catchment. The aquatic habitats that persist during dry periods are limited to temporal pools formed from in-stream earthen impoundments. During the wet season the channels provide shallow but varied habitat and connectivity within the watercourse.

Water quality was found to be generally poor; low dissolved oxygen concentrations and high nutrient concentrations occurred during the wet season survey in 2013, with high pH and electrical conductivity occurring during the dry season. Values frequently exceeded the guidelines for the protection of moderately disturbed aquatic ecosystems.

At the dry season survey sites riparian trees have been cleared, often to the watercourse edge. Some of the upper locations of Lagoon Creek exhibit sections of intact riparian vegetation including trees and shrubs, and this was observed at the two sites visited during the wet season survey. In the lower section, where the proposed rail crossing is located, the riparian vegetation has been cleared and vegetation is limited to ground cover dominated by grasses.

Macrophyte diversity in Lagoon Creek is low, with fringing sedges and rushes the most dominant forms. Macrophytes are likely to be restricted to the permanent waterbodies and were not observed in the channel habitats during the flow period.

Lagoon Creek supports a low diversity of macroinvertebrates, which is similar to other systems impacted by high levels of disturbance from clearing and agricultural land use (SKM, 2011).

Fourteen fish species are known to occur in the surrounds of the aquatic ecology study area. Of these, the EVNT species Murray Cod (*Maccullochella peelii*) or its potential habitat was identified within a 25 km radius. However, within the Lagoon Creek itself, only three species of fish have been recorded: spangled perch (*Leiopotherapon unicolor*), gudgeon (*Hypseleotris* spp.), and the introduced Mosquitofish (*Gambusia holbrooki*). These three species are widely distributed and tolerant of disturbed environments. Furthermore, the degraded aquatic habitat and connectivity, and land use impacts in Lagoon Creek are likely to restrict the presence of fish species to those with high tolerance of degraded habitats and water quality. The distribution of fish species that are strongly associated with high quality habitats and abundant woody debris (e.g. Murray Cod) (Schiller and Harris 2001) are highly unlikely to extend upstream into such disturbed environments as Lagoon Creek.

The single turtle species observed during the survey was the Eastern snake-necked turtle which inhabits slow moving water bodies from farm dams to major rivers and lakes. Due to their ability to move over land to find water, they are able to inhabit shallow lakes and ephemeral waterbodies. The Murray turtle is highly unlikely to be found in the aquatic ecology study area due to its habitat preference for large river and permanent lakes both of which are not present in the aquatic ecology study area.

During and following substantial rainfall and catchment run-off events, the flows in the channels of Lagoon Creek provide connectivity within the watercourse and to floodplains and off-stream aquatic environments. These periods of flow provide opportunities for dispersal and movement of aquatic flora and fauna, which are often accompanied by reproductive strategies and increased availability of nutrients and food resources. Whilst the aquatic environment of Lagoon Creek has been substantially impacted, the wet seasons flows are important for maintaining the aquatic values present in this system.

The application of the mitigation strategies for management of water quality, altered flows, aquatic habitat, watercourse crossings and the introduction and spread of weeds associated with the revised Project have been developed with respect to the existing environment of the aquatic ecology study area. The proposed mitigation strategies provide a suite of management actions to avoid or minimise the potential impacts of the revised Project and to maintain the aquatic values of Lagoon Creek.

8.8.2. EVNT Species

Murray cod

The potential presence of Murray cod in Lagoon Creek in the reach associated with the Study area is considered to be very unlikely due the abundance of instream barriers downstream, the limited and moderately disturbed aquatic environment, limited instream habitat and the degraded water quality. The potential impacts of the revised Project on water quality, alteration of hydrology, instream barriers, aquatic habitat and downstream environmental values are considered to be minimal with the implementation of the mitigation measures and are extremely unlikely to have a detrimental effect on the distribution of Murray cod in the Oakey Creek subcatchment. A comprehensive assessment of water quality is presented in **Chapter 5**, **Section 5.6**.

8.8.3. Protected Areas

Regional Ecosystem Wetlands

It is considered that that potential impacts associated with the revised Project will not extend to the Regional ecosystem identified approximately 24 km downstream of the Study area. Given this distance downstream, the likely ephemeral nature and offstream location of the possible wetland, and the proposed mitigation strategies and management actions for the revised Project, the risks of potential impacts on water quality are very low.

8.9. Summary of Mitigation Measures and Commitments

Table 8–14 Summary of Mitigation Measures and Commitments

Project Activity	Mitigation measures
Removal of terrestrial vegetation for development of resource areas and infrastructure including roads and rail spur	Flood levees to be constructed adjacent to the Manning Vale and Willaroo resource areas resource operations. Flood levees will be an average of 100m from the top of the banks area and designed to control flood water for up to a PMF event. Reinforce flood levee sections that may be prone to erosion during flood events. Riparian buffer zones maintained to a minimum of 50 m on either side of Lagoon Creek Preparing and implementing an Erosion and Sediment Management Plan including installing and maintaining sediment control devices to be installed around exposed areas and earthworks adjacent to aquatic habitats and watercourses. Implementing the management measures described in the FLURP.
Water management and infrastructure	Controlled discharges are to be regulated within the integrated water management system in accordance with the WRMP and approved water quality targets.
Water management and infrastructure	Design and construction of all water management structures using practical hydraulic parameters based on an appropriate risk based rainfall event, catchment size, slopes, discharge design and soil types.
Water management and infrastructure	The maximum reduction of total catchment area is 5 %. And will have a negligible effect on flows in Lagoon Creek based upon the results of the surface water modelling and accordingly, aquatic values would not be affected by decreased flows.
Water management and infrastructure	Application of the Water Management strategy and regulatory requirements will avoid disruption to the seasonal patterns of the flow regime. The potential increased magnitude of flow events and extended tail of flow events is not considered to represent a significant disruption to aquatic values in Lagoon Creek.
Removal of riparian vegetation at waterway crossings.	Minimise areas of vegetation to be cleared by selecting crossing locations which require minimal clearing of established vegetation. Implementing the management measures described in the FLURP and the Conservation Zone Management Plan. Monitor riparian vegetation on banks to review and refine riparian management and rehabilitation strategies.

Project Activity	Mitigation measures
Earthworks and construction within the channel and banks for watercourse crossing	Minimise width of the rail and road crossing and locate workspace areas away from creek banks, so as to reduce the disturbance to riparian vegetation, bank and channel affected by construction. Restrict construction within and around the creek channel to the dry periods and rehabilitate areas of disturbed channel bed and banks. Design and construct temporary barriers in waterways to minimise disturbance to environmental flows. Monitor the effectiveness of waterway crossing rehabilitation.
Movement and operation of vehicles and machinery.	Implement the Pest and Weed Management Plan. The plan will include required vehicle wash-down, monitoring of pests and weeds, and application of appropriate control measures and is presented in **Appendix J.9**.
Movement and operation of vehicles and machinery.	Procedures should be applied to minimise the risk of accidental release or spillage. Do not conduct refuelling operations within the waterway crossing. Ensure spill kits are available for all refuelling operations.
Decommissioning and rehabilitation	The stability of the dams will be enhanced by buttressing with inert rock material (where appropriate) to create safe final slopes that are resistant to erosion and which may then be rehabilitated in accordance with the post-mine land use. Implement the management measures outlined in the FLURP.