17B AQUATIC ECOLOGY

17B.1 INTRODUCTION

This chapter examines the existing environment, potential impacts and mitigation measures associated with aquatic ecology. The purpose of the chapter is to:

- describe the aquatic flora and fauna occurring and likely to occur in areas affected by the Project (including wetlands and matters of National Environmental Significance identified in the *Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act))*
- discuss potential direct and indirect effects of the Project on aquatic flora and fauna
- if potential impacts to rare or threatened species are identified, propose strategies for protecting these species (including any obligations under legislation or policies of the Queensland and Australian Governments).

Further information on the aquatic ecology assessment for the Project is provided within the technical report associated with this chapter is TR 17B-1-V1.5. Note that figures/documents with numbering ending in V1.5, for example, refer to figures/documents contained in Volume 1, Book 5 of the EIS.

17B.2 METHODOLOGY OF ASSESSMENT

17B.2.1 RELEVANT LEGISLATION

Commonwealth Legislation

Environment Protection and Biodiversity Conservation Act 1999

Any actions that are likely to have a significant impact on a Matter of National Environmental Significance (MNES) are subject to assessment under the EPBC Act approval process. MNES include:

- World Heritage properties
- National Heritage places
- wetlands of International importance
- threatened species and ecological communities
- migratory species
- Commonwealth marine areas
- nuclear actions.

Where relevant, MNES are further described below.

World Heritage Properties (Great Barrier Reef)

The EPBC Act regulates actions that will have, or are likely to have, a significant impact on the World Heritage values of a World Heritage property. This includes relevant actions that occur outside the boundaries of a World Heritage Area.

The Fitzroy Basin drains to the Great Barrier Reef World Heritage Area, approximately 600 km downstream from the Project area. The Project is not expected to result in a significant impact on the values of the Great Barrier Reef World Heritage Area.

Wetlands of International Importance (Ramsar Wetlands)

The EPBC Act regulates actions that will have, or are likely to have, a significant impact on the ecological character of a Ramsar wetland. This includes relevant actions that occur outside the boundaries of a Ramsar wetland.

There are no Ramsar wetlands or wetlands of national importance in the Project area. The Fitzroy Basin drains into the Shoalwater and Corio Bays Ramsar site, a Wetland of International Significance (Department of Environment, Water, Heritage and the Arts (DEWHA) 2008a). The Ramsar wetland is approximately 620 km downstream from the Project area. The Project is not expected to result in a significant impact on these areas.

Threatened Ecological Communities and Species

Boggomoss Communities

On the Dawson River, approximately 100 km downstream from the watercourses of the Project area, mound springs from the Great Artesian Basin (Boggomoss Areas 1 & 2) are listed on the Register of the National Estate. The boggomoss communities are dependent on natural discharge of groundwater from the Great Artesian Basin and are listed as an Endangered Ecological Community under the EPBC Act.

The boggomoss snail (*Adclarkia dawsonensis*), or Dawson River snail, is listed as Critically Endangered under the EPBC Act. This snail lives in the boggomoss habitat on the Dawson River (DEWHA 2008b).

Potential impacts of the Project on these species and communities are addressed in Section 17B.5.10.

Fitzroy River Turtle

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act. Its distribution is restricted to the Fitzroy Basin, and it has been recorded from the Dawson River (EPA 2007b).

Potential impacts of the Project on this species are addressed in Sections 17B.5.9 and 17B.5.10.

Queensland Legislation

Water Act 2000

The *Water Act 2000* provides for the sustainable management of water and other resources. Under section 266, a Riverine Protection Permit is required from the Department of Natural Resources and Water (NRW) to:

- destroy vegetation in a watercourse
- excavate in a watercourse
- place fill in a watercourse.

Creek diversions are required in the MLA areas, and the MLA areas and gas supply pipeline alignment crosses a number of watercourses. Permits will therefore be required for works associated with these diversions and crossings, including submitting an Application for License to Interfere with the Course of Flow for creek diversions.

Additionally, where waters are to be taken from a watercourse, lake, spring or underground water (e.g. for use in dust suppression during construction works), a Water Permit may be required pursuant to section 237.

Fisheries Act 1994

All waters of the State are protected against degradation by direct or indirect impact under section 125 of the *Fisheries Act 1994* (Fisheries Act).

Under Division 8 of the Fisheries Act, a Waterway Barrier Works Approval is needed to build any structure across a freshwater waterway. The purpose of this part of the Act is to provide a balance between the need to construct dams and weirs and the need to maintain fish movement. Such structures include culverts and road crossings, which will be constructed as a part of the Project. The Chief Executive (Department of Primary Industries and Fisheries (DPI&F)) may direct the building of a specified fishway for the barrier, if required.

Nature Conservation Act 1992

The Fitzroy River turtle (*Rheodytes leukops*) is also recognised as vulnerable under the *Nature Conservation Act 1992* (NC Act), as listed in the Nature Conservation (Wildlife) Regulation 2006 (NCWR).

Potential impacts of the Project on this species are addressed in sections 17B.3.6 and 17B.5.10.

17B.2.2 DESCRIPTION OF STUDY AREA

The study area includes:

- the waterways of the MLA area
- waterways immediately upstream of the MLA area
- Juandah Creek downstream of the MLA area (to approximately 60 km downstream, just upstream of its confluence with the Dawson River)
- waterways crossed by the gas supply pipeline alignment. Figures 17B-1-V1.3 and 17B-2-V1.3 show the study areas of the MLA areas and gas supply pipeline.

The waterways of the MLA area are a part of the upper Dawson River Catchment (Southern Tributaries or 'Taroom' subcatchment). The major creeks include:

- Spring Creek and Mud Creek (MLA50229)
- Halfway Creek, Frank Creek, Two Mile Creek and Juandah Creek (MLA50230)
- Blackant Creek, Wandoan Creek and Woleebee Creek (MLA50231).

The major creeks (and their tributaries) crossed by the gas supply pipeline include:

- Stakeyard Creek
- Roche Creek
- Juandah Creek.

Both palustrine and lacustrine wetlands have been identified in the Environmental Protection Agency's (EPA's) recent wetland mapping program. Lacustrine wetlands within the study areas are likely to be farm dams. None of the wetlands within the study areas are recognised by the EPA as being of National, State or Regional Significance.

17B.2.3 STUDY METHODOLOGY

Survey timing

Surveys were undertaken separately for the MLA and gas supply pipeline areas.

For the MLA areas, aquatic floral and faunal surveys and collection of water quality data was undertaken during the late wet season (10 – 14 March 2008). The weather was fine during the survey. In the months preceding the survey, there had been between 129 and 185 mm of rainfall per month in December 2007, January 2008 and February 2008 (based on rainfall records from the Taroom Post Office, BOM 2008). No rain had fallen in the week prior to the survey (BOM 2008).

For the proposed gas supply pipeline area, aquatic flora and fauna surveys and collection of water quality data was undertaken during the late dry season (19 to the 28 August 2008). The weather was fine and cool during the survey. Rainfall was relatively low during the months prior to the survey (between 0 mm in April, to 74 mm in July at the Taroom Post Office) (BOM 2008). No rain had fallen in the three weeks preceding the survey. However, there was relatively heavy rainfall on the 24th of July 2008 (recorded at the Taroom Post Office, BOM 2008).

For both the MLA areas and gas supply pipeline, in order to describe seasonal patterns in aquatic flora and fauna abundance, and the likely presence of species throughout the year, a second survey is planned for the 2008/2009 wet season, after the first significant rainfall event of the season.

Study sites

Site selection for the MLA areas survey was based on data collected during an initial field trip undertaken in August 2007. The final ten sites selected were considered representative of the range of aquatic habitats found in the region, and included sites that may be either directly or indirectly impacted by the Project, such as waterways that will be diverted, or those downstream of the Project area that may receive mine runoff/discharge, and comparison sites that are not likely to be either directly or indirectly impacted by the Project (refer Figure 17B-1-V1.3).

Seven waterways crossed the gas supply pipeline alignment, with surveys completed at the proposed crossing location whenever possible (refer Figure 17B-2-V1.3). Due to property access restrictions, some creeks were assessed at nearby road crossings. Aquatic flora and fauna surveys were completed at the only three sites that held water during the survey.

Methods

Aquatic habitat

Sites were described and scored using AusRivAS protocols (NRM 2001).

Regionally, the quality of streams and creeks in the Southern Tributaries subcatchment of the Dawson River was described via literature review.

Water quality

Water quality data was collected on water temperature, electrical conductivity, pH, and dissolved oxygen.

No Water Quality Objectives (WQOs) have been prescribed for the waterways within the study area, therefore the sites have been compared to Queensland Water Quality Guidelines (QWQG) values for upland (altitude greater than 150 m) streams in the central coast region (EPA 2007a).

Aquatic flora

Aquatic flora data was recorded for each site as follows:

- the presence of all native and exotic macrophytes and their growth form
- the percent cover of each species at each site (cover may exceed 100% due to overlap).

Aquatic Macro-invertebrate Communities

At each site, a macro-invertebrate sample from each aquatic habitat found was collected in accordance with the Queensland AusRivAS Sampling Manual (NRM 2001).

Samples were frozen and returned to frc environmental's Brisbane benthic laboratory for processing.

At each study area site and for regional data available from NRW, taxonomic richness, PET richness and stream invertebrate grade number average level (SIGNAL) 2 scores were calculated.

Fish Communities

Fish communities were surveyed using a combination of backpack electrofishing, seine and set nets, baited traps and dip nets. Electrofishing was attempted at all sites where conditions were appropriate.

At each site, the presence and abundance of each species by life history stage (juvenile, intermediate, adult) and the apparent health of individuals was recorded.

Sampling of fishes was conducted under General Fisheries Permit No. 54790 and Animal Ethics Approval No. CA 2006/03/106.

Taxonomic richness, total abundance, abundance of rare and threatened species, abundance of exotic species and the abundance of each life history stage was determined.

Turtles

Turtles were sampled by trapping or by incidental observation and identified to species level.

Other Aquatic Vertebrate Communities

The likely presence of other aquatic vertebrates in the study area and throughout the region was described through literature review and database searches, specifically: the Commonwealth Protected Matters Search Tool (DEWHA 2008a); and the State Wildlife Online database (EPA 2007b).

17B.3 EXISTING ENVIRONMENT

17B.3.1 AQUATIC HABITAT

The sites surveyed within the MLA areas typically had moderate River Bioassessment Program habitat assessment scores whereas those in the gas supply pipeline alignment typically had poor to moderate scores. These relatively low scores were generally related to low habitat variability (no riffles observed), moderate to extensive bank erosion and substrates dominated by finer sediments (e.g. sand and silt).

The notable exception to this was a tributary to Mud Creek (initial field trip site 13, shown in Figure 3.1 of TR 17B-1-V1.5), which had the highest score of all of the sites surveyed. This site included a variety of substrate types and it would contain riffle habitats when flowing. It was not adversely affected by channel alteration or scouring and had relatively stable banks. Although canopy cover was relatively low, there were fallen logs in the channel that would provide in-stream habitat for fauna.

Higher order streams generally scored higher due to more riparian vegetation and a higher proportion of large trees in the riparian zone.

Reach environs

Overall, the reach environs of the creeks surveyed have been moderately impacted by human activities. Land use is dominated by cattle grazing on native and improved pastures and some cropping. There has been some riparian vegetation clearing, although large trees still grow on the banks at many sites (and in particular at sites on higher order streams). Cattle accessing creeks has also caused some disturbance.

Road crossings were a mix of gravel crossings (fords) without culverts, bitumen/concrete crossings with culverts and bridges. Road crossings are likely to alter flow patterns and may restrict aquatic fauna passage.

Bridge crossings and crossings with large culverts (e.g. Frank Creek at Jackson-Wandoan Road) are generally less of a barrier to aquatic fauna movement. During flood events however, pylons and large culverts can alter flow patterns and trap debris that can potentially restrict fish and other fauna movements. Fences also cross several sites and may restrict water flows, fish passage and movement by other aquatic fauna if blocked by debris.

Riparian vegetation

Riparian zones were generally 5 – 15 m wide but varied significantly (e.g. less than 2 – 20 m). Grasses typically dominated although shrubs and trees also grew at most sites.

Riparian vegetation was dominated by native species, although exotic grasses were found at all sites. Prickly pear, a declared Class 2 pest in Queensland, was noted at several sites in the MLA areas (e.g. sites 4, 5 and 8). Giant sensitive tree (*Mimosa pigra*), a declared Class 1 pest, was noted along roadsides throughout the study area. The Class 2 declared pest parthenium (*Parthenium hysterophorus*) is likely to grow adjacent to Mud and Juandah Creeks and tributaries, in the north of the MLA area. Further details on declared plants are provided in Chapter 17A.

Bank stability

There was some bank erosion at each site, apart from very small first order streams with very low banks.

Bed and bar stability

Overall, stream beds throughout the study area were relatively stable.

Channel diversity

Channel diversity was extremely low, with isolated pools being the dominant habitat category. No run or riffle habitat was observed.

Aquatic habitat

The overall aquatic habitat condition of the creek systems was moderate, with some physical aquatic habitat found at most of the sites. Mostly, habitat consisted of undercut banks, trailing bank vegetation and some overhanging vegetation.

Regional perspective

Reach environs

Most subcatchment streams are reportedly in poor to moderate condition. Most of the land adjacent to the sites surveyed in NRW's State of the Rivers assessment had been cleared and converted to native pasture for cattle grazing. Other disturbances included road infrastructure and forestry activities.

Bank stability

Most stream banks in the subcatchment were rated as stable. Cattle, land clearing, infrastructure, scouring and eroded walking tracks have negatively affected bank stability.

Bed and bar stability

Factors reducing stream bed stability throughout the subcatchment included the presence of stock, bank erosion and bed deepening. Fallen trees, rock outcrops and man-made structures provided stream bed stabilisation.

Channel diversity and habitat types

Channels across the subcatchment lacked diversity (diversity ratings ranged from low to moderate).

Sediments in the upper banks and stream beds of the subcatchment varied from boulders to fine silt, while lower banks were composed of sand and fine silt.

Riparian vegetation

Across the subcatchment, riparian vegetation was dominated by grasses (97%), trees 10 – 30 m (85%), trees less than 10 m (81%), rushes (62%) and herbs and forbs (59%). Native species included *Eucalyptus* spp., cypress pines (*Callitris* spp.), *Lomandra* spp., *Acacia* spp., *Melaleuca* spp., *Brigalow* spp. and *Callistemon* spp.

Most of the riparian zones in the subcatchment were in very poor condition due to agricultural clearing and grazing. Weed species were recorded from most sites.

Aquatic habitat

Most aquatic habitats in the subcatchment were rated as poor or very poor.

Conservation values

Only 2% of sites were deemed to have aquatic habitats of very high conservation values and no sites were regarded as very high value for riparian habitat or wildlife corridors. Approximately 40 – 46% of sites were deemed to be of low conservation value for aquatic habitat, riparian habitat or as wildlife corridors.

Overall, 7% of the subcatchment was in very poor condition, 23% was in moderate condition, 7% was in good condition and no sites were regarded as being in very good condition.

Summary

All sites surveyed within the MLA and gas supply pipeline study areas were scored as poor to moderate using the River Bioassessment Program habitat assessment protocol. Poor to moderate habitat assessment scores reflect low habitat variability, moderate to extensive bank erosion, and substrates dominated by finer sediments such as sand and silt.

Overall, reach environs have been moderately affected by land use activities. Cattle grazing dominated the surrounding land use, with cattle access to creeks having caused some disturbance. There has been some riparian vegetation clearing across the study area, although large trees still grow on the creek banks at many sites. Roads and fences crossings creeks in the study area are likely to alter flows and restrict fish and other aquatic fauna passage. Similar impacts were observed throughout the Southern Tributaries subcatchment.

Riparian zone condition throughout the study area and regionally was poor. Riparian zones were generally 5 – 10 m wide and dominated by native species, although exotic species were found at all sites. Erosion of waterways is common throughout the region and at most sites in the study area. However, a relatively high cover of bank vegetation of predominantly grasses often maintained bank stability.

Stream beds were relatively stable, however there was some scouring at bends or downstream of obstructions and some sedimentation in pools or upstream of obstructions. Bars forming around obstructions or channel points are also a common feature of the streambeds in the region. Channel diversity is generally low to moderate in the region and was extremely low across the study area, with isolated pools being the dominant habitat category.

In-stream physical habitat was typically in the form of undercut banks and terrestrial debris. In-stream habitat diversity was highest at sites with a higher cover of trees in the riparian zone and a higher cover of overhanging bank vegetation. Throughout the region, disturbances to the riparian zone have led to a reduction in the cover and diversity of in-stream habitat.

17B.3.2 WATER QUALITY

Study areas

Water temperature

In the MLA area, water temperature ranged between 20.8 °C (site 7) to 33.6 °C (site 9), with the majority of sites of between 22.7°C and 29.1°C, due to sampling being conducted in the warmer month of March 2008. Water temperatures along the gas supply pipeline alignment were between 11.5 and 13.4 °C as sampling was conducted in winter.

There are no guidelines available for water temperature (ANZECC & ARMCANZ 2000; EPA 2007a).

Dissolved oxygen

Within the MLA survey area, dissolved oxygen (DO) concentrations were highly variable between sites. Only sites 5 and 6 were compliant with the DO concentration range (90 – 110% saturation) recommended in the Queensland Water Quality Guidelines (QWQG) (EPA 2007a). Sites outside of the MLA areas (sites 7 – 10) had the lowest DO concentrations (between approximately 20 and 40% saturation).

For the gas pipeline survey area, DO levels were within the QWQG range in the anabranch of Roche Creek (site 4b) but were below the QWQG range in the main channel of Roche Creek (site 4a). Juandah Creek (site 7) levels exceeded the QWCG range, which may have been due to photosynthesis by periphyton and water column algae that was observed at this site. DO levels were below the QWQG values in Juandah Creek in March 2008 which suggests that DO levels within the creek may fluctuate seasonally and may rarely be within the QWQG range.

pH

pH was fairly similar across sites, and for most sites was compliant with the QWQG pH range (6.5 - 7.5) (EPA 2007a).

Electrical conductivity

Within the MLA survey area, conductivity ranged from 129 to 528 μS/cm. Conductivity at sites 2, 4, 5, and 9 exceeded the (preliminary) QWQG upper limit value of 340 μS/cm (EPA 2007a) while site 6 had relatively low conductivity.

Conductivity at each of the sites along the gas supply pipeline alignment was below the preliminary QWQG upper limit. Conductivity was particularly low (approximately 10 μS/cm) in the anabranch of Roche Creek (site 4b).

Turbidity

Turbidity was highly variable across sites, ranging from 21 to 2,500 nephelometric turbidity units (NTU). Site 7 was the only site below the QWQG upper limit value of 25 NTU (EPA 2007a). Several sites were extremely turbid – site 4 was 100-times the QWQG value; site 10 was 30-times the QWQG value; and sites 2 and 3 were 20-times the QWQG value.

No turbidity measurements were recorded at waterways along the gas supply pipeline alignment due to no turbidity meter being available at the time of sampling.

Nutrients

Nitrogen and phosphorus concentrations in the waterways of the MLA areas exceed guideline values, and are indicative of the surrounding land-use. Further discussion on nutrients and water quality are provided in Chapter 11 Water Supply and Management.

Contaminants

Heavy metal concentrations in the waterways of the MLA areas are elevated, and the concentration of some metals exceeds the relevant trigger level. Organophosphorus pesticide concentrations are also elevated within the waterways of the MLA areas. Further discussion on contaminants and water quality are provided in Chapter 11 Water Supply and Management.

Regional perspective

The waterways of the study areas are a part of the upper Dawson River Catchment (Southern Tributaries or 'Taroom' Subcatchment). The Dawson River is the largest tributary in the Fitzroy River basin, which eventually feeds into the Great Barrier Reef (GBR) Lagoon.

Dawson River catchment

Agricultural land uses occupy approximately 84% of the Dawson River catchment (EPA 2001). In comparison with other Dawson River subcatchments, the Taroom subcatchment is a moderate emitter of phosphorus and a light emitter of nitrogen (EPA 2001). Estimates indicate a total nitrogen (TN) emission rate of approximately 0.95 kg/ha/year and a total phosphorus (TP) emission rate of approximately 0.33 kg/ha/year (EPA 2001). It is estimated that the Taroom subcatchment contributes only 1.6% of the TN and 1.4% of the TP exported out of the Dawson River catchment annually.

Fitzroy River catchment

Water quality in this catchment is compromised by:

- pesticide and herbicide contamination, particularly in irrigation areas
- erosion and runoff increasing sedimentation and nutrients levels in waterways and the GBR
- high risk of blue-green algal bloom in still waters
- rising salinity, particularly in streams between Theodore and Rockhampton

- acid mine drainage in localised areas including Blackwater Creek, Crinum Creek, Don River and Dee River
- heavy metal contamination, mostly from cadmium and copper in parts in of the Mackenzie, Nogoa and lower Dawson catchments
- substantial areas of poor riparian vegetation cover, particularly in the Dawson catchment and Central Highlands (Meecham 2003).

Land use in the Fitzroy River catchment is primarily agricultural (grazing - 90%; cropping - 6% (Noble et al 1996)). Accordingly, levels of TN and TP are elevated and exceed the QWQG values at times (Noble et al, 1996; EPA 2007a), especially during periods of moderate and high flows.

The results of aquatic invertebrate sampling suggested that the streams within the catchment possessed relatively diverse invertebrate communities. Noble (et al 1996) concluded that life within the river system was fairly healthy, but that the significant flow events moved millions of tonnes of soil, and hence any nutrients and pesticides present in the soil, into the GBR lagoon.

Central Queensland

Overall, Central Queensland's water quality is in moderate condition. Key issues that require attention include (Meecham 2003):

- erosion and runoff increasing sedimentation, nutrient, pesticide and herbicide levels
- toxic blue-green algae blooms in still waters
- contamination or pollution in industrial and mining areas
- rising salinity
- poor riparian vegetation cover
- changes to river flows.

Summary

Across the study areas, DO concentrations and turbidity levels did not generally comply with the QWQG. Low DO concentrations were probably due to high biochemical oxygen demand and low mixing of the waters. High turbidity was probably related to sediment-laden runoff associated with clearing of riparian vegetation, sloped / steep banks and the preceding flood. By their nature, ephemeral streams such as those in the study area are commonly subject to a range of severe (natural) stresses, and as such the water quality of the creeks within the study area may be characterised by elevated turbidity, salinity and nutrient enrichment (Chessman, B. [Centre for Natural Resources NSW] pers. comm. 2003, 21 October).

Regionally, water quality is also characterised by high turbidity and fluctuating DO concentrations. Due to surrounding land uses, waterways within the region are impacted by relatively high inputs of nutrients, pesticides and other contaminants. The Taroom subcatchment, in which the MLA and gas supply pipeline study areas are located, only contributes 1.6% of the TN and 1.4% of the TP exported out of the Dawson River catchment each year.

17B.3.3 AQUATIC FLORA

Within the MLA study area, sixteen species were recorded across the ten sites surveyed.

At most of the MLA sites, two to four species covered ≤ 15% of the site (with the exception of sites 5, 7 and 8). The most common emergent macrophyte was *Alternanthera denticulata* (lesser joyweed) which grew at all ten sites. Sedges (Family Cyperaceae) and rushes (Family Juncaceae; *Juncus usitatus*) were relatively common and grew at most sites. Less common species included *Persicaria decipiens* (smartweed), *Lomandra* sp. (rush), *Paspalum distichum* (water couch), *Phragmites australis* (common reed) and *Eragrostis elongata* (clustered lovegrass).

The limited cover of macrophytes, in particular the lack of submerged species, is probably related to the ephemeral nature of the waterways and turbid water, allowing insufficient light penetration for the growth of macrophytes.

Within the gas supply pipeline study area, macrophytes were only recorded in Roche Creek (sites 4a and 4b). This may be related to the timing of the survey in winter (typically dry season). A similar range of species to those recorded in the MLA study area was found in the gas supply pipeline study area.

Filamentous and mat algae grew at MLA sites 8 and 9, although it was less common during the field surveys than during the initial field trip in August 2007. The overall reduction in algal growth is probably associated with recent flushing of the creeks.

Regional perspective

Very little information is available regarding macrophytes of the region.

Most State of the Rivers (Telfer 1995) sites in the subcatchment were dry at the time of sampling, while sites with water did not support macrophytes. Similar observations were made during the initial field trip of the study area in August 2007.

A recent study in the upper Dawson River catchment (frc environmental 2007) reported a similar result to the MLA and gas supply pipeline study area survey. frc environmental (2007) reported ten different species of macrophyte from seven sites, with richness ranging from zero to eight species at any one site. All macrophytes had an emergent growth form.

17B.3.4 AQUATIC MACRO-INVERTEBRATE COMMUNITIES

Macro-crustaceans (freshwater prawns and crayfish), diving beetles water bugs and non-biting midge larvae dominated the invertebrate communities of the MLA study area, whereas diving beetles, water bugs, mayfly nymphs and non-biting midge larvae dominated the macro-invertebrate communities of the sites within the gas supply pipeline study area.

The calculated index scores indicate the following:

- within the MLA survey area, taxonomic richness was generally higher in edge habitats (7 – 18 taxa recorded) than in bed habitats (2 – 15 taxa recorded)

- by contrast, taxonomic richness within the gas pipeline study area ranged from 7 to 10 in edge and bed habitats at the sites surveyed and was generally similar across sites and habitat type
- PET richness for both bed and bank habitats was low and indicative of degraded or moderate water and habitat quality
- SIGNAL 2 results suggest that the surveyed waterways are probably impacted by agricultural pollution associated with surrounding land uses.

Macro-Crustacean communities

Across the ten MLA sites surveyed, three macro-crustaceans species were positively identified (refer Table 17B-1). All three species of macro-crustacean were captured at most sites. Richness was lowest at site 8, where only orange-fingered yabbies were captured.

Table 17B-1: Abundance of macro-crustaceans at each site (all survey methods combined)

Family	Scientific Name	Common name	Site									
			1	2	3	4	5	6	7	8	9	10
Atyidae	*Caradina* sp.	freshwater shrimp	25	6	28	8	33	20	9	—	4	2
Palaemonidae	*Macrobrachium* sp.	river prawn	20	2	23	4	83	—	25	—	2	54
Parastacidae	*Cherax depressus*	orange-fingered yabby	46	53	42	35	76	17	13	12	38	2

Four species of macro-crustacean were recorded at the three gas supply pipeline sites surveyed (refer Table 17B-2).

Table 17B-2: Abundance of macro-crustaceans at each site surveyed in the gas supply pipeline study area

Family	Scientific Name	Common Name	Site		
			4a	4b	7
Atyidae	*Caradina sp.*	freshwater shrimp	0	14	2
Atyidae	*Paratya sp.*	freshwater shrimp	1	13	0
Palaemonidae	*Macrobrachium sp.*	river prawn	2	7	3
Parastacidae	*Cherax depressus*	orange fingered yabby	6	28	3

Regional Perspective

Species Richness

Sandy pool habitats surveyed by NRW in the Dawson River supported between seven and eighteen macro-invertebrate families per sample, while rocky pool habitats supported between ten to twenty-five families per sample. These sites were therefore more diverse (richer) than bed habitats surveyed in the present study.

Similarly, edge habitats in the Dawson River also supported a higher number of taxa (17 – 32) than the edge habitats sampled during the present study.

In contrast, results for Juandah Creek (eighteen in June 1997 and eleven in May 2000) indicates that Juandah Creek may have lower habitat and/or water quality than the Dawson River.

PET Richness

The PET richness of bed and edge habitats in the Dawson River at Taroom was indicative of moderate to good habitat and/or water quality and was generally higher than the PET richness during the present MLA and gas pipeline surveys.

In contrast, zero to two PET families were sampled by the NRW at Juandah Creek (NRW 2007) and no PET families were sampled from this site during the present study.

SIGNAL 2/Family Bi-plots

The SIGNAL 2 results for communities sampled from the Dawson River are indicative of fair to good habitat and water quality in the Dawson River at Taroom. However, the macro-invertebrate communities may be affected by high nutrient or salinity levels, urban or agricultural pollution and/or harsh physical conditions.

Macro-Crustacean Communities

Macro-crustaceans were abundant in a recent study in the upper Dawson River catchment (frc environmental 2007), where a variety of Australian river prawns, freshwater shrimps and orange-fingered yabbies were caught.

Aquatic Macro-invertebrate Summary

Aquatic macro-invertebrate community structure within the MLA and gas supply pipeline study areas was generally indicative of poor to moderate habitat and/or water quality. Differences in macro-invertebrate community structure appeared to be related to site-specific differences in habitat availability and diversity. Crayfish and prawns/shrimp were common in the study area.

In general, the macro-invertebrate communities of the downstream Dawson River were more diverse and contained more taxa sensitive to pollution and disturbance than corresponding communities within the study area. Sites on the Dawson River at Taroom are likely to have permanent water and therefore offer more stable habitat for macro-invertebrates. In contrast, the communities of the study area are influenced by harsh physical conditions, such as the drying of pools.

17B.3.5 FISH COMMUNITIES

In total, eight species were captured across the ten MLA sites surveyed (refer Table 17B-3). Four species were captured across the three gas pipeline sites surveyed (refer Table 17B-4).

Life History Stages

Within the MLA study area, all life history stages (juvenile, intermediate and adult) were captured for all species except sleepy cod (one adult was captured at site 10 only). Across the study area, intermediate was the most abundant life stage for most species (bony bream, eastern rainbowfish, golden perch, Hyrtl's tandan and spangled perch). Juvenile was the most abundant Agassiz's glassfish life stage, while adult was the most abundant carp gudgeon life stage. The largest species (on average) was bony bream and the smallest species (on average) was Agassiz's glassfish.

For the gas pipeline study area, each life history stage (juvenile, intermediate and adult) was captured for carp gudgeons only. Intermediate was the most abundant life stage for goldfish, while juvenile was the most abundant carp gudgeon and spangled perch life stage. The largest species (on average) was the goldfish and the smallest species (on average) was the carp gudgeon.

Indicators of Stream Health

No introduced species or listed Threatened species were captured in the MLA study area. Some spangled perch had lesions which may be due to the fungal disease Epizootic Ulcerative Syndrome (EUS or red spot disease), though no testing was done to confirm this. This condition affects a range of native fish species in Queensland, Northern Territory, New South Wales and Western Australia; however causative factors are unclear (Humphrey & Pearce 2004). All other fishes appeared healthy.

By contrast, goldfish, an introduced species (listed as non-indigenous under the under the Fisheries Regulation 2008) were captured in the gas pipeline study area. They are omnivorous and are able to withstand high summer temperatures and low DO levels (Allen et al. 2002).

No listed Threatened species were captured during the survey.

Table 17B-3: Abundance of fish species at each site in the MLA study area (all survey methods combined)

Family	Latin Name	Common name	1	2	3	4	5	6	7	8	9	10
Ambassis	*Ambassis agassizii*	Agassiz's glassfish	11		2		50					
Clupeidae	*Nematalosa erebi*	bony bream										15
Eleotridae	*Hypseleotris* sp.	carp gudgeon	4			2	16	7	6			
Eleotridae	*Oxyeleotris lineolata*	sleepy cod										1
Melanotaeniidae	*Melanotaenia splendida*	eastern rainbowfish	1		1		6		3		2	
Percichthyidae	*Macquaria ambigua*	golden perch									3	4
Plotosidae	*Neosilurus hyrtlii*	Hyrtl's tandan				2			1		3	20
Terapontidae	*Leiopotherapon unicolor*	spangled perch	19	4	10	26	7	6	8	8	4	1
		unidentified juvenile							1			

Table 17B-4: Abundance of fish species at each site surveyed along the gas supply pipeline route (all survey methods combined)

Family	Latin Name	Common name	4a	4b	7
Ambassis	Ambassis agassizii	Agassiz's glassfish	1	1	–
Cyprinidae	Carassius auratus	Ggoldfish	–	–	10
Eleotridae	Hypseleotris sp.	Carp gudgeon	–	10	3
Terapontidae	Leiopotherapon unicolor	Spangled perch	3	–	–

Regional Perspective

The results of studies undertaken by Berghuis & Long (1999), frc environmental (2007) and Ecowise (2008) are listed in Table 17B-5.

Table 17B-5: Number and species of fish caught in the upper Dawson River catchment during previous studies

Family *Species*	Common name	Study		
		Berguis and Long (1999)	frc environmental (2007)	Ecowise 2008
Ambassidae				
Ambassis agassizii	Agassiz's glassfish	52	0	3
Antherinidae				
Craterocephalus stercusmuscarum	Fly-specked hardyhead	88	0	2
Clupeidae				
Nematolosa erebi	Bony bream	214	196	211
Cyprinidae				
Carassius auratus	Goldfish	0	0	5
Eleotridae				
Hypseleotris sp. A	Midgley's gudgeon	89	8	2
Hypseleotris klunzingeri	Western carp gudgeon	23	0	20
Mogurnda adsepersa	Purple-spotted gudgeon	0	0	8
Oxyeleotris lineolata	Sleepy cod	0	4	8
Philypnodon grandiceps	Flathead gudgeon	0	0	3
Melanotaeniidae				
Melanotaenia s. splendida	Eastern rainbowfish	224	3	26
Osteoglossidae				
Scheropages Leichhardti	Southern saratoga	0	0	4
Percichthyidae				
Macquria ambigua oriens	Golden perch	16	0	20
Plotosidae				
Neosilurus hyrtlii	Hyrtl's tandan	0	8	22
Porochilus rendahli	Rendahl's catfish	0	0	1
Tandanus tandanus	Eel-tailed catfish	6	1	9
Poecillidae				
Gambusia holbrooki	Mosquitofish	0	16	32

Family *Species*	Common name	Study		
		Berguis and Long (1999)	frc environmental (2007)	Ecowise 2008
Pseudomugilidae				
Pseudomugil signifer	Pacific blue eye	56	0	0
Terapontidae				
Leiopotherapon unicolor	Spangled perch	7	31	76
Scortum hillii	Leathery grunter	0	0	13

Berghuis & Long (1999) did not report any exotic species in the Dawson Catchment, although *Poecilia reticulata* (guppy) and goldfish were recorded in the Fitzroy Basin. Since then, goldfish have been caught in Juandah Creek and the Dawson River (present study, Ecowise 2008), and *Gambusia holbrooki* (mosquitofish) have been captured in the Dawson River in November 2007 (frc environmental 2007). Mosquitofish are declared noxious species in Queensland under the Fisheries Regulation 2008.

Fish Movement

Of the fish likely to be found in the study areas, most undertake freshwater migrations. Adult golden and spangled perch move upstream to spawn while juveniles move downstream for dispersal. This movement is typically triggered by large flow events (Cotterell 1998). Glassfish, rainbowfish and gudgeons move within freshwaters to disperse to new habitats. This movement also typically occurs following flow events and in the case of the study area, could only occur when the creeks are flowing.

The habitat preferences, diet and migrations of each of the fish species captured in the study area are described in Appendix 17B-1-V1.4. Each of the native fish species found in study area requires some physical in-stream habitat to provide shelter or suitable spawning habitat. A variety of physical aquatic habitat such as woody debris and substrate diversity also support diverse macro-invertebrate communities, which are prey to many of the fish found in the study area.

Most of the species that were captured from the study area can tolerate a large range of water quality conditions. The common fish species in the study area (spangled perch, glassfish, Midgley's carp gudgeons and eastern rainbowfish) are tolerant species that can live in water characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity.

17B.3.6 TURTLE COMMUNITIES

Across the MLA study area, turtle traps were set at six of the ten sites (sites 1, 3, 6, 7, 8 and 10). Turtle traps could not be set at the other sites within the MLA areas and along the gas supply pipeline route, due to insufficient water depths. Only one species of turtle was captured or observed throughout the study areas, and this was at one site only. Seven

Emydura macquarii krefftii (Krefft's river turtle) were captured in Juandah Creek, downstream of the MLA areas (MLA site 10): two adults, one intermediate and four juveniles. Juveniles were the most abundant life history stage, although no obvious turtle nesting banks were observed at this site, or across the study areas.

Regional Perspective

Only Krefft's river turtle were captured from the MLA study area and during a recent survey of the upper Dawson River catchment (frc environmental 2007). During the frc environmental (2007) survey, adult turtles were more abundant than intermediate or juveniles. Krefft's river turtle inhabits rivers, creeks and lagoons through eastern Queensland from just north of Brisbane to Princess Charlotte Bay (Wilson & Swan 2008).

Other freshwater turtle species that may occur in the Dawson Catchment include the eastern snake-necked turtle (*Chelodina longicollis*) and the saw-shelled turtle (*Elseya latisternum*) (Cogger 1996). The eastern snake-necked turtle has been recorded from within 20 km of the MLA areas (EPA 2007b) but as they generally only inhabit larger waterways (Cogger 1996), they are considered unlikely to be abundant in the ephemeral creeks of the study area.

Fitzroy River turtles (*Rheodytes leukops*) are only found in the Fitzroy River and its tributaries. This species is listed as 'vulnerable' under the NC Act, the EPBC Act and the International IUCN Red List of Threatened Species 2007 (IUCN 2007).

Fitzroy River turtles are found in shallow, fast-flowing riffle zone habitats characterised by well-oxygenated water (Cann 1998, Tucker et al. 2001). Female Fitzroy River turtles nest on sandy banks with a deep layer of sand and a low vegetative cover. Nests are typically laid in deep chambers (up to 170 mm) situated from 1 – 4 m above the water level, and have been observed up to 15 m back from the waters edge (Cogger et al. 1993, Cann 1998).

No fast-flowing habitats or turtle nesting banks were observed during surveys of the MLA and gas supply pipeline study areas. Due to a lack of suitable habitat, the Fitzroy River turtle is unlikely to occur within the study areas. However, this species may be present downstream in the upper Dawson River as it has previously been recorded in the Dawson River (EPA 2007b).

17B.3.7 OTHER AQUATIC VERTEBRATES

This survey did not target other aquatic vertebrates. A semi-aquatic keelback snake (*Tropidonophis mairii*) was caught in the set net at Juandah Creek, downstream of the MLA area (MLA site 10). An unidentified snake was also observed crossing the creek at Spring Creek (MLA site 6).

No conservationally significant aquatic amphibians or reptiles have been recorded from, or are likely to occur in, the study area (DEW 2007a; EPA 2007b).

17B.3.8 SUMMARY OF AQUATIC ENVIRONMENTAL VALUES

The biological values of aquatic ecosystems within the study areas are relatively low and consistent with those of the wider catchment. Environmental values are influenced primarily by the ephemeral nature of the waterways and agricultural development within the region which has significantly influenced water quality and the physical characteristics of aquatic habitat (Telfer 1995). Degraded creeks in the study area and regionally are characterised by riparian vegetation loss, erosion, invasion of weed species, poor water quality and sedimentation (Telfer 1995).

Water quality is generally poor and is characterised by high turbidity and variable dissolved oxygen levels, which are typical of the region. Biodiversity is relatively low, with only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabiting the study areas. Nevertheless, creeks within the MLA areas and along the gas supply pipeline alignment do provide 'upstream' dispersal habitat for the fish species that were recorded in the study areas (and possibly breeding habitat for some species).

No Rare or Threatened species of aquatic flora or fauna have been recorded from, or are likely to occur in, the waterways of the study areas.

17B.4 DESCRIPTION OF PROPOSED DEVELOPMENT

The coal resources of the Project will be developed by open cut mining and associated infrastructure, including a gas supply pipeline from the existing Peat-Scotia Lateral Gas Line. Construction and mining activities have the potential to impact on aquatic ecology through activities including:

- the operation of mining equipment and vehicles, and other plant and equipment
- vegetation clearing and earth moving
- management of stormwater runoff and worked water, including creation of sediment, environmental, raw water, catchwater and tailings dams
- management of sewage
- construction of creek crossings for the access road, haul roads, conveyors, rail spur and the gas supply pipeline
- seven creek diversions resulting in a loss of riparian and aquatic habitat, including:
  - a 2,500 m diversion of Spring Creek, commencing construction in Year 9
  - a 970 m diversion of an unnamed tributary of Spring Creek, commencing construction in Year 9
  - a 9,100 m diversion of Woleebee Creek, which will also carry water from Wandoan Creek and Blackant Creek, commencing construction in Year 10
  - a 5,400 m diversion of an un-named tributary to Woleebee Creek (at the east of Mud Creek Pit on MLA 50229) commencing construction in Year 14
  - a 2,900 m diversion of Frank Creek, commencing construction in Year 15, proposed in two stages
  - a diversion of Mud Creek, commencing construction in Year 17
  - a diversion of Mount Organ Creek, commencing construction in Year 18
- the loss of catchment area.

The general layout of the site is shown on Figures 6-26-V1.3 to 6-30-V1.3 with discussion of site features provided in detail in Chapter 6 Project Operations.

17B.5 POTENTIAL IMPACTS

17B.5.1 OPERATION AND MAINTENANCE OF VEHICLES AND EQUIPMENT

Fuel Spills

Fuels and oils are toxic to aquatic flora and fauna at relatively low concentrations.

The risk to aquatic ecology from a spill within the MIA is likely to be very low, due to bunding of the storage and maintenance areas.

Spilt fuel is most likely to enter the creeks via an accidental spill on the roads near creek crossings or when there are construction activities adjacent to creeks. Roads cross the major creeks in the area and a significant fuel spill to any of these creeks is likely to have a significant impact on both flora and fauna.

The risk to aquatic flora and fauna is reduced as the creeks are ephemeral and therefore many spills could be effectively cleaned up before they can disperse throughout the waterways.

Maintenance of Vehicles and Equipment

Litter and waste associated with vehicle maintenance has the potential to entangle larger fauna and contribute to the degradation of water quality. However, with appropriate waste management controls in place, the risk to aquatic ecology from spilt litter and waste from the MIA is likely to be very low.

17B.5.2 VEGETATION CLEARING AND EARTHMOVING

Without mitigation, there is a high potential for soil erosion and sedimentation following vegetation clearing and earth moving, as outlined in the following sections:

Construction Activities and Timing

Construction Years -2 and -1, and Operational Years 1 to 5

During this period, construction of access roads, haul roads, rail spur, conveyor, and gas supply pipeline will pose the greatest threat to aquatic ecology. These features cross the major waterways of the MLA areas (Frank Creek and Woleebee Creek) and the gas supply pipeline (Juandah and Roche Creeks) and construction will require vegetation clearing and earthmoving in the riparian zones. Construction of levee banks along Frank Creek could impact on aquatic ecology via increased turbidity and nutrient levels in these waterways, as well as alteration of aquatic habitats.

Where an appropriate erosion and sediment control plan is followed, vegetation clearing and earthmoving associated with construction of accommodation facilities, the gas fired power station, MIA, pits and dumps are unlikely to pose a significant threat to aquatic ecology. These features are situated away from the main creeks and protection measures such as levee banks (where a pit is at the Q_{100} flood level) and sediment or environmental dams will be constructed.

Years 5 to 10

During this period, development of the Frank Creek, Austinvale, Woleebee, Mud Creek and Summer Hill Pits will continue and the Spring Creek diversion will be constructed. Appropriately sized and located sediment, environmental and tailings dams will be constructed. Where an appropriate erosion and sediment control plan is implemented, vegetation clearing and earthmoving is unlikely to pose a significant threat to aquatic ecology.

Years 10 to 20

Major activities during this period include expansion of mine pits, construction of further levee banks along Frank Creek, use of the Austinvale pit as a rejects disposal area, and construction of the Frank, Woleebee, Mud/Mount Organ and Unnamed Creek diversions.

Where an appropriate erosion and sediment control plan is implemented, vegetation clearing and earthmoving associated with expansion of mine pits is unlikely to pose a significant threat to aquatic ecology.

However, construction of levee banks adjacent to Frank Creek and earthworks associated with the creek diversions (particularly the Woleebee Creek diversion), could lead to impacts on aquatic ecology via increased turbidity and nutrient levels and alteration of aquatic habitats.

Potential impacts of the creek diversions are discussed specifically in Section 17B.6.6.

Years 20 to 30

Major activities during this period include further expansion of mine pits. Provided appropriate erosion and sediment control plans are implemented, vegetation clearing and earthmoving associated with the construction activities described above is unlikely to pose a significant threat to aquatic ecology.

Increased Turbidity

Vegetation clearing and/or ground disturbance can result in increased sediment runoff and elevated turbidity in onsite and downstream waterways. Increased turbidity may impact on aquatic flora and fauna. Reduced light penetration, caused by increased turbidity, can also lead to a reduction in temperature throughout the water column (DNR 1998).

Based on survey results, waterways within the study area are generally highly turbid with substrates dominated by silt. No submerged macrophytes were found in the study areas and few have been found in the catchment (Telfer 1995). Aquatic fauna communities of the study area are adapted to living in turbid water. Given these background conditions, small increases in turbidity would be unlikely to have a significant impact on aquatic ecology. However, significant increases in turbidity could have an impact on some species.

Input of Nutrients or Contaminants

Aquatic biota could also be impacted by nutrients or contaminants washed into the waterways. Nutrient inputs can lead to algal or macrophyte blooms, which may lead to harmful DO 'crashes' during the night.

Nutrient-laden runoff from the Project is likely to be low compared to that associated with agricultural practices, as fertilisers will only be used in association with rehabilitation and revegetation of disturbed areas. In any case, the highly turbid water of the creeks is likely to prevent significant algae blooms for much of the year. Eutrophication of the waterways is therefore considered to be a low risk to aquatic ecology.

Alteration of Aquatic Habitat

The deposition of fine sediments has the potential to decrease stream bed roughness and fill in existing pools. Within the minor (first order) tributaries throughout the MLA areas, this would be unlikely to have a significant impact as these streams generally only carry flood flows. However, in larger watercourses (second order and higher) such as Spring Creek, Mud Creek, Wandoan Creek, Woleebee Creek and Frank Creek, sediment deposition would lead to a decline in habitat diversity and a reduction in the number of pools available as refuge habitat in the dry season. These impacts would lead to a decline in the abundance and diversity of both invertebrate and fish communities.

17B.5.3 WASTEWATER AND STORMWATER

A Water Management System (WMS), designed to achieve no planned pit or process water discharge, will be developed for the Project.

Stormwater

Overflow or failure of the sediment dams has the potential to allow sediments, nutrients and contaminants to enter onsite and downstream waters. However, the WMS will be designed to divert clean water around disturbed areas and dirty water into sediment dams. Sediment will be allowed to settle out before the water is discharged to the environment through a low level pipe outlet, if the water is of acceptable quality.

Release of water of an acceptable quality would not be expected to have a negative impact on aquatic ecology. The impact of small discharges in the wet season would not be significant given the magnitude and frequency of natural flows. Release(s) in the dry season may result in the creation of additional (or larger) pools (providing 'refuge habitat') and may also trigger fish movement and spawning. This may result in an overall increase in fish abundance and diversity. Where practicable, timing of discharges to coincide with natural flows may help to mitigate the impacts of a loss of catchment area and streams due to the construction of mine pits.

Sediment dams will be designed to remove coarse sediment in accordance with the Department of Mines and Energy Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland as recommendations for discharge of uncontaminated water to non-environmentally sensitive receiving waters. Low level outlets will be sized to ensure retention times are sufficient to ensure the turbidity of overflowing water will not significantly influence the character of receiving waters (which would be naturally highly turbid during a flow event). The dams will discharge via the spillway only following significant rainfall that exceeds the design storage capacity (dams will retain runoff from a 10 year ARI time of concentration storm).

Industrial Wastewater

Environmental dams will be sized to ensure the risk of discharge is small. Water balance modelling, as discussed in Chapter 11 Water Supply and Management, indicates the preliminary capacities would results in no discharges under historical climate extremes. As the contributing catchments to these dams are small, the size of any discharge would be small compared to flows in the receiving waters. Minor spills from environmental dams AU-E1, MC-E2, SH-E3, and WS-E1 as identified in Figure 11-18-V1.3 would not be expected to have a significant impact on aquatic ecology, as these dams are situated away from major creeks, and as the volume of the overflow would be reduced by infiltration before the water reached any major creeks. However, the tailings dams and environmental dams AU-E2, W-E2, AU-E4 (and the raw water storage dam) as identified in Figure 11-18-V1.3 are in close proximity to Woleebee Creek. A spill from these dams would be expected to have localised impact on the aquatic flora and fauna of this creek, and potentially some nearby reaches of Juandah Creek downstream. However, the flora and fauna of downstream waters including the Dawson River are unlikely to be impacted given the associated dilution and dispersion.

The overall level of risk to aquatic ecology from the overflow of these dams is low, as these dams will be designed in accordance with NRW and EPA guidelines. Water used in coal preparation will be recycled in a closed-loop system and will not be discharged into the natural environment. Water from the environmental dams is not intended to be discharged, and will be used for dust suppression and in the CHPP.

Domestic Wastewater

Unplanned discharges and spills of domestic effluent prior to treatment at the Wandoan WWTP have the potential to introduce nutrient-rich discharge(s) into the natural receiving environment. Sewage has the potential to be accidentally discharged to either Woleebee, Frank or Juandah Creeks at the two proposed pump stations.

Nutrient inputs can lead to algal or macrophyte blooms, which may lead to harmful DO ‘crashes’ during the night.

However, within the study area, the highly turbid water of the creeks is likely to prevent significant algae blooms for much of the year. The impacts of nutrient enrichment and any algal blooms due to a sewage spill would also be likely to be short-lived and not widespread. Impacted aquatic flora and fauna communities are expected to rapidly recover.

The Wandoan WWTP will be upgraded as a part of the Project, improving treated effluent quality, with some treated sewage used to irrigate adjacent areas. No impacts to aquatic ecology due to upgraded sewage processing at the Wandoan WWTP are expected.

17B.5.4 WATER SUPPLY

Potable Water Supply

Potable water requirements will be met by upgrading the potable water system from the Wandoan Township. The potable water requirements of the Project will not expected to exceed the current GAB allocation for the Wandoan Town Water Supply.

There will be a short-term impact due to installation of potable water supply pipelines across creeks. Where construction of the potable water pipeline from Wandoan follows the mitigation measures for pipeline construction and creek crossings presented in relation to the gas supply pipeline (refer section 17B.6.7), no long-term impacts to surface waters are expected.

Glebe Weir – Dawson River

No exotic species were recorded from within the MLA study area. However, raw water supply from the Dawson River and the creation of dams on the site may significantly increase the opportunity for exotic species to become established. *Gambusia holbrooki* (mosquitofish) and *Carassius auratus* (common goldfish) have been captured in the Dawson River (frc environmental 2007, Ecowise 2008) and goldfish were captured in Juandah Creek (upstream of the MLA study area) during the survey of the gas supply pipeline study area. *Poecilia reticulata* (guppy) have also been recorded in the Fitzroy Basin (Berghuis & Long 1999). This risk is discussed further in Chapter 12 of Volume 4 Glebe Weir Raising and Pipeline.

Coal seam methane by-product water

Overall, raw water supply from CSM water is unlikely to have a significant impact on the aquatic ecology of the natural waterways within the study area. However, CSM water may be sourced from the Condamine Power Station and the declared noxious fish, carp (*Cyprinus carpio*) is known from this catchment. If carp establish a presence in the raw water storage dam at the power station, the pipeline presents a conduit for carp to be transferred to the study area and thus the Fitzroy Basin, where they do not currently occur. Refer to Volume 2, Chapter 17B Aquatic Ecology for a description of the risk of this impact and suggested mitigation measures.

Discharge from raw water storage dam

The raw water storage dam would only be expected to overflow during periods of significant rainfall. Accidental discharge from the raw water storage dam would flow to Woleebee Creek. Water quality in the raw water dam is expected to be similar to that of the study area if water is sourced from the Dawson River, but high in total dissolved solids (TDS) if sourced from CSM by-product water. However if this water were discharged during a rainfall event, the TDS concentrations would be expected to dilute quickly. Therefore, discharge from the raw water dam would not be expected to have a discernable impact on aquatic ecology.

17B.5.5 LOSS OF CATCHMENT AREA

By Year 30 of the Project, the growth of the mine will result in runoff from approximately 8,500 ha of catchment area being captured in the site water management system for reuse. Combined with changes to the catchment runoff characteristics, this will reduce flows to some creeks that currently drain the MLA areas. Based on water balance modelling, the reduction in mean annual runoff from the MLA areas is expected to be a maximum in Year 30 of between 9% and 38% (or between 2% and 7% of Juandah Creek streamflow at Windamere).

Excavation of pits will also result in the loss of some minor waterways, with higher order creeks being diverted. Again, this has the potential to negatively impact on riparian and aquatic habitat diversity and biodiversity both on-site and downstream.

Changes to upper catchment area (approximately 0.6% of Southern Tributaries Catchment) due to the creation of mine pits are unlikely to have a regionally significant impact. Locally, a reduction in flows to creeks has potential to impact on flushing and cues for faunal migration and reproduction. This could have an impact on the abundance and diversity of macrophytes, macro-invertebrate and fish populations within creeks in the study areas. However, this would not be expected to have an impact on the aquatic communities of Juandah Creek or downstream waterways.

17B.5.6 CREEK DIVERSIONS

The diversion of creeks around the pits will ensure that the waters of the creeks avoid disturbed areas, and maintain downstream flows as much as possible. The diversions will, however, result in the replacement of the existing natural ephemeral watercourses with artificial channels.

Proposed creek diversions will result in the loss of portions of natural watercourses. Levee banks will be constructed between creek diversions and the mining areas where required, in order to maintain separation of clean (natural) waters and 'dirty' (mine) waters during flood events. Creek diversions will be constructed in accordance with the NRW Central West Regional Office guideline document Watercourse Diversions – Central Queensland Mining Industry. Creek diversions will be constructed two years prior to opening them to flows, in order to allow sufficient time for vegetation to establish.

As there are approximately 2,258 km of similar natural waterways within the Southern Tributaries Catchment of the Dawson River (Telfer 1995), the proposed creek diversions are unlikely to have a regionally significant impact on aquatic ecosystems.

Local aquatic flora and fauna are generally tolerant of a range of habitat and water quality. If the diversion channels are well engineered to maintain fish passage and replicate the aquatic habitat found in the natural creeks, the loss of natural ephemeral watercourse is highly unlikely to result in the loss (even locally) of any species.

The construction of the diversion channels will require clearing and ground disturbance, which provides the potential for increased soil erosion and sedimentation and water turbidity.

Diversion of flows from the existing channels to the completed diversion channels may leave fish and other fauna such as turtles stranded unless appropriate mitigation measures are implemented, as discussed in Section 17B-6.6.

17B.5.7 CREEK CROSSINGS

Construction of creek crossings

Construction of creek crossings will disturb sediments, leading to potential increases in localised turbidity and sediment deposition. When construction is carried out during the dry season, these impacts will be minimal or absent, although a highly localised loss of aestivating crustaceans may be expected within the construction footprint. The impacts of disturbance to habitat will be highly localised and are considered acceptable in both a local and regional context, given the existing disturbed nature of the creeks.

When construction of creek crossings is carried out in the wet season, there will be a temporary impact to fish passage during construction activities. Impacts to water quality will not be significant in a local or regional context if appropriate erosion and sediment control measures are in place.

Obstruction of fish passage

Stream crossings can create waterway barriers that prevent or impede movements of aquatic fauna such as fish and turtles. Fish passage is already restricted in the MLA study area due to existing infrastructure. Poorly-designed fish crossings associated with the Project have the potential to further impact on fish movement within the study area. Adoption of best practicable design will avoid this potential impact.

Pipeline crossings

Pipeline crossings will disturb bed and bank stability, potentially leading to increased localised erosion and increased turbidity and sedimentation downstream. After construction, the newly formed bed and banks may continue to erode, given the high flows that can occur in the wet season. This may result in an increase in channel width and a loss in channel definition, which could lead to a decrease in downstream flow. The impacts of decreased bed and bank stability will be localised, but the impacts may be unacceptable in a local context if not remediated.

17B.5.8 BITING INSECTS

Within the study area, creeks, farm dams, stock water troughs and other areas of standing water (for example along roads or in backyards of domestic dwellings) currently have the potential to provide breeding habitat for mosquitoes and biting midges.

Construction and operational activities that result in pooled water will potentially provide an increase in mosquito and biting midge breeding habitat in the study area. An increase in the population of mosquitoes and biting midges has the potential to impact on human health.

17B.5.9 SIGNIFICANT CONSERVATION HABITAT

There is no significant conservation habitat located within, or immediately downstream of, the MLA or gas pipeline study areas.

The Project is not likely to impact on boggomoss springs, as there are no springs within, or in the immediate vicinity of, the MLAs or gas supply pipeline routes (DEWHA 2008a).

The Great Barrier Reef World Heritage Area and the Shoalwater and Corio Bays Ramsar site are unlikely to be impacted by the Project, as they are over 300 km to the north-east and water quality that far downstream of the MLA and gas supply pipeline study areas will not be impacted by the Project.

17B.5.10 THREATENED SPECIES AND ECOLOGICAL COMMUNITIES

As discussed in section 17B.3.6, it is unlikely that the Fitzroy River turtle inhabits the ephemeral creeks within the MLA or gas pipeline areas. The Project is unlikely to have a significant impact on this species.

The boggomoss snail (*Adclarkia dawsonensis*) is found associated with boggomoss habitat located approximately 100 km downstream of the MLA and gas supply pipeline study areas, on the Dawson River. Boggomoss communities are unlikely to be impacted by construction and operational activities associated with the MLA areas and gas supply pipeline.

17B.6 MITIGATION MEASURES

17B.6.1 OPERATION AND MAINTENANCE OF VEHICLES AND EQUIPMENT

Risks associated with the spillage of fuels and other contaminants will be substantially reduced where:

- vehicle maintenance areas and storage of fuels, oils and batteries within the MIA is undertaken within bunded areas designed and constructed in accordance with Australian Standard AS 1940 – The storage and handling of flammable and combustible liquids
- portable refuelling stations, for refuelling of machinery in the field, are bunded to meet AS 1940 and placed above the Q_{100} flood level of nearby waterways and dams
- all spills of contaminants (such as diesel, oil, hydraulic fluid etc.) are immediately reported to the Project's Environmental Officer
- appropriate spill containment kits are available, and used for the cleanup of spills in the field. Equipment that is susceptible to spills and/or leakages should have a spill kit onboard or within 5 m of the equipment at all times. The kits should contain equipment for clean-up of both spill on land or in dry creek beds, and spills to water (such as floating booms).

17B.6.2 VEGETATION CLEARING AND EARTHMOVING

Risks associated with the clearing of vegetation will be substantially reduced where an Erosion and Sediment Control Plan (ESCP) is developed (as a part of the EM Plan and Plan of Operations) to minimise the quantity of sediment run off into waterways during construction and operation of the Project. This ESCP will incorporate the following elements where possible and practicable:

- construction of the pipeline in the dry season
- staging of earth moving and vegetation clearing
- use of erosion controls technologies as appropriate
- rehabilitation of vegetation after clearing, including the establishment of ground cover
- rehabilitation of instream aquatic habitat after clearing, including bed and bank rehabilitation.

Timing

Vegetation clearing and earthworks will be done in stages over the life of the mine. During each stage of construction, sediment and environmental dams and levee banks will be constructed to protect natural waterways from sediment-laden runoff.

The risk of sediment runoff impacting nearby waterways will be further reduced where the timing of clearing and earthworks within 100 m of a major waterway (e.g. Frank, Woleebee, Wandoan, Blackant, Mud, Mount Organ and Spring Creeks) is done in the dry season. However, this will be subject to the overall mine schedule and duration of activities adjacent to watercourses.

Erosion control and sediment control

During and after construction and other land disturbance during operations, water quality and ecosystem health of nearby waterways will be protected where practicable by:

- erosion control matting (or mulch), placed along ditches and drainage lines running from all cleared areas, especially on slopes and levee banks
- contour banks, ditches or similar formed across cleared slopes to direct runoff towards surrounding vegetation and away from creeks
- monitoring water quality of creeks.

Further discussion on erosion and sediment control measures is provided in Chapter 9 Geology, Mineral Resources, Overburden and Soils and the associated technical report.

Rehabilitation of vegetation

After construction and other land disturbance during operational activities, water quality and ecosystem health of nearby waterways will be protected by rehabilitation of the landscape by:

- salvaging and appropriately storing and maintaining selected native grass, shrubs and trees prior to clearing
- use of native vegetation of local provenance for replanting where possible

- replanting along creek margins (e.g. following construction of creek crossings). The width of the replanted riparian vegetation should match the existing riparian vegetation. However, 5 m should be the minimum width. Planted trees in the riparian zone should provide canopy cover and have root systems that can stabilise the banks and disturbed area.

17B.6.3 WASTEWATER AND STORMWATER

The quality of waters released from the MLAs area, unless designated as clean stormwater, should be similar to that of the receiving waters. As a guide, Table 17B-6 presents preliminary discharge water quality objectives, based on the water quality recorded during the current studies and published environmental tolerances.

When possible, the discharge of water from the sediment dams to the natural environment should be managed to coincide with natural flow events, minimising disruption of cues for reproduction and/or migration of aquatic fauna.

Table 17B-6: Preliminary water quality objectives for the discharge water quality required to maintain the natural fish communities of the region

Parameter	Range Required to Sustain the Fish Communities Sampled During this Study
Temperature (º C)	< 34
Dissolved Oxygen (mg/L)	1.5 – 10.0
pH	6.0 – 8.5
Electrical conductivity (µS/cm)	19.5 – 650
Turbidity (NTU)	< 100*

* However most species found in this study have been recorded from waterways with much higher turbidity (typically <200 NTU, but up to 600 NTU; frc environmental pers obs.)

17B.6.4 WATER SUPPLY

Transfer of exotic fish species

The use of water from Glebe Weir during the Project could increase the opportunity for mosquitofish and goldfish to become more widely distributed through the region. The significance of this impact is being considered as a part of the Glebe Weir Raising and Pipeline impact assessment (Volume 4 of the EIS). The requirement for screens on the pipeline intake to prevent the transfer of exotic fish will be subject to negotiations with DPI&F.

The WJV will ensure that the dams on the MLAs area are free from noxious species on a regular basis.

17B.6.5 LOSS OF CATCHMENT AREA

The loss of catchment area could reduce the magnitude of freshwater flows to the receiving environment. This may be mitigated through:

- Not discharging treated stormwater to the natural receiving environment during dry periods, to minimise potential local impacts to the timing, duration and magnitude of flows in the creeks, which can each be important cues for reproduction and/or migration of aquatic fauna.

Regional impacts from a loss of catchment are not expected.

17B.6.6 CREEK DIVERSIONS

To effectively mitigate the loss of on site aquatic and riparian habitat, diversions will be designed and constructed to provide bed and bank habitat of a similar character to that of natural watercourses within the region. Key considerations include:

- diversion low flow channels will provide a stable, sinuous channel, of dimensions similar to the existing natural channel, and that will maintain a similar flow to the existing natural channel. Bends and varying depth contours in particular are important in maintaining habitat diversity and refuge areas for fish and other fauna during periods of high flow. Other important physical features of a creek to replicate include sediment type, in-stream habitat availability (e.g. tree roots, logs, boulders etc.) and riparian vegetation. This may include the placement of boulders or logs and branches from vegetation clearing into the channel.
- Diversions will only be opened to flows once geotechnical stability and vegetation requirements have been satisfactorily established. Until this time, the existing channels will continue to function normally.
- Designing diversions channel to have water velocities of ≤0.3 m/s facilitate passage of all native fish species (Cotterell 1998). During flood flows, the time that the channel has water velocities of >1 m/s should be minimised as this will likely impede all fish passage (Cotterell 1998).
- Where practicable, diversion channels will only be initially opened to flows in the dry season (May – September). This will minimise any impacts to fish movement and reproduction that may be occurring in the sections of creeks to be diverted.

Prior to construction of the creek diversions, approvals will be required from the EPA under the *Environmental Protection Act 1994*, the NRW under the *Water Act 2000* and the DPI&F under the *Fisheries Act 1994*. Preliminary recommendations for the design and construction of each creek crossing are presented below. However, these are based on preliminary information only from the survey of one or two sites on each creek.

For further details associated with creek diversion mitigation measures, refer to Sections 7.6.1 and 7.6.2 of the technical report TR 17B-1-V1.5.

Stranding of fish and other aquatic fauna

Opening any diversion channels in the dry season (May – September) will minimise the number of fish that are likely to become stranded in the section of creek to be diverted.

If pools remain in the section of creek to be diverted, fish and other aquatic fauna will become stranded once the section is isolated. Once flow is diverted from the existing channel, stranded fish will be captured and translocated to either the diverted creek or upstream of the diverted creek, following the DPI&F Fish Salvage Guidelines (DPI&F 2004), which recommend that:

- fish should be captured from the creek to be diverted using gear appropriate to the waterways and species present
- translocation should be done in the cooler months if possible, to minimise stress to the fish
- fish should be removed from the existing channel before water flow is isolated from the channel
- fish should be handled, transported and released so as to minimise damage to the fish.

The capture of fish using electrofishing, traps, bait nets or cast nets requires a General Fisheries Permit, issued by the DPI&F. The capture, handling and translocation of fish and other fauna will also require an Animal Ethics approval.

In large pools, traps will be set to capture turtles. If caught, turtles should also be transported and released to a relatively permanent waterhole in the study area, in accordance with ethical handling procedures.

17B.6.7 CREEK CROSSINGS

Construction of permanent creek crossings

Impacts associated with the construction of permanent creek crossings by roads, the rail spur, conveyors, or other linear infrastructure will be minimised if:

Dry season

- crossings are located to result in minimal disturbance to vegetated areas
- construction is undertaken during the dry season, thereby minimising the likelihood of rainfall and runoff carrying sediment and other pollutants into the creeks
- stormwater, and erosion and sediment control measures are implemented
- crossing construction methods minimise disturbance to aquatic habitat and fish passage.

Wet season

Where practicable, the workspace is isolated, irrespective of if there is an isolated pool or flowing water. The isolation will be designed such that:

- it is completed within one work-day, to minimise the impact on aquatic fauna
- upstream and downstream dams are installed on the edge of the temporary workspace, to maximise the workspace. These dams should:
  - be constructed of an appropriate material for each creek (e.g. steel plates, flumes, sand bags or aquadam)
  - be made impermeable by using polyethylene liner and sand bags

- if flowing water is present, 100% downstream flow is maintained by using appropriately sized pumps
- pump intakes must have a screen, with openings no larger that 2.54 mm, to ensure that no fish are entrapped
- fish must be salvaged from the isolated workspace and translocated
- the upstream dam is slowly removed, to allow water to flush the sediment from the workspace area
- sediment-laden water should be pumped into sumps or onto vegetation
- operation of the clean-water pump to sustain partial flow below the downstream dams must be continued until the downstream dam is removed.

Construction of temporary vehicle creek crossings

Impacts associated with the construction of temporary road crossings will be minimised if crossings:

- are constructed during the dry season
- follow the guidelines presented above for permanent creek crossings
- have bed and bank habitat rehabilitated after removal of the temporary crossing.

Rehabilitation of instream aquatic habitat

Prior to and following land disturbance of creek crossings, impacts will be mitigated by:

- Salvaging existing bed material prior to construction and placing it back into the creek at completion of construction. If the existing bed material is unable to be salvaged, a comparable sediment size material is recommended to cover the bed and should be approximately 10 cm thick. If the sediment is fine (mud and/or silt), it is recommended that the bed material be replaced with sand, to prevent future erosion. If the sediment is coarser (gravel, cobble, pebbles and/or boulder), new material must be washed prior to placing in the creek, as usually new coarse substrate is covered in a fine dust, which will become suspended in the water.
- Rehabilitation of the bed and bank structure such that original dimensions and shape of the creek are achieved. Bank recontouring will include stabilisation methods, such as crib walls or soil wraps, where appropriate.
- Revegetation of creek banks.
- Aquatic habitat structures are replaced within the channel. Prior to construction, any instream structures (woody debris, large cobbles) should be salvaged where practicable. Felled trees should also be placed into creeks to create woody debris habitat.

Obstruction of fish passage

Ford crossings can be used for crossings of small gullies and first order streams without having major impacts on fish movement throughout the study areas.

Where practical, bridges are preferred to culverts for crossings of the larger streams in the MLA areas (e.g. Frank, Woleebee, Wandoan, Blackant, Mount Organ, Mud and Spring Creeks).

Where culverts are used, their design and installation will potentially significantly influence fish passage. DPI&F will be consulted during stream crossing design, siting and maintenance. DPI&F guidelines for the design of culverts state that culverts should be designed such that they are:

- located at least 100 m from any other waterway barrier on the creek (e.g. road crossing and, dam) in order to minimise the cumulative effects of fish barriers as short and wide as possible, whilst allowing the passage of anticipated flood volumes, associated debris and enough water depth to facilitate fish movement (estimated at greater than 0.5 m depth for the fish species likely to be present)
- open-bottomed if possible, to retain the natural morphological features of the stream. If this is not possible, culverts should be countersunk below the stream bed and natural materials such as rocks secured to the base of the culvert to increase roughness and reduce water velocity (water velocities of less than or equal to 0.3 m/s are likely to facilitate passage of all native fish species; velocities of greater than 1 m/s will likely impede all fish passage)
- constructed without a 'drop off' at the culvert outlet, as this impedes fish migration upstream
- constructed with minimum disturbance to the outer banks on stream bends, as these are usually the most unstable and prone to erosion
- surrounded by riparian vegetation (that is planted after construction if necessary) to stabilise banks, provide food and habitat for fauna and prevent predation of aquatic fauna by birds.

Where practicable, culverts will be installed at the driest time of year (preferably in the dry creek bed, avoiding pools), in order to minimise erosion and to reduce the impacts of construction on fish migrations (which, within the study area, are likely to be triggered by rain and the onset of corresponding flows). During the wet season, isolation methods should be in accordance with those outlined in Section 17B.6.7.

Culverts will be maintained so that there is regular removal of debris or plant growth.

Gas supply pipeline

The guidelines presented in Section 17B.6.7 apply to the temporary disturbance of the creeks associated with the installation of the gas supply pipeline. Appendix 17B-2-V1.4 contains specific mitigation measures for the pipeline crossing of each waterway. Fish salvage methods are described in Section 17B.6.6 and water quality monitoring is described in Section 17B.6.10.

17B.6.8 BITING INSECTS

Minimisation of Breeding Habitat

Mosquito breeding habitat should be minimised through:

- minimising the area of standing water and ensuring drainage within 4 days
- grading to ensure sufficient drainage

- during construction, routinely filling incidental depressions and holes that may hold standing water
- regularly clearing drainage lines to ensure that water continues to flow and no ponded areas are created
- constructing dams and water storages intended to contain stormwater and wastewater with steep edges in order to minimise the extent of shallow water, which can provide breeding habitat.

Design and engineering

Mosquitoes are less likely to pose a health risk where:

- there is more open window area on the windward side of buildings (rather than the leeward) which passively 'pressurises' a building and reduces opportunities for biting insects to enter from the preferred leeward side
- buildings are fully screened to prevent insect entry
- ceiling fans or air conditioning are installed to increase airflow.

Control of biting insect populations

Natural control using native fish

Where water quality is acceptable and practicable to do so, native larvivorous fish can be stocked into sediment dams and the raw water storage dam on-site to assist mosquito control (water quality in the tailings dam and the environmental dams is unlikely to support fish). Suitable local fish species include Agassiz's glassfish (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*) and carp gudgeons (Hypseleotris sp.).

These fish can be obtained from some aquariums and from registered fish hatcheries (DPI 2004). Previous studies have suggested that fish stocking densities of around 1 fish per m^2 of potential breeding habitat (i.e. shallow habitat around the margin of a waterbody that may support aquatic macrophytes) should be sufficient to control mosquito populations (frc environmental 2002).

In order for stocked fishes to effectively control mosquito breeding, they must be allowed to develop sufficiently abundant populations and must be able to get to locations used by mosquitoes for breeding. In effect, this requires permanent and relatively stable water quality and sufficient depth of water to allow the fish access to potential breeding habitats.

Chemical control of mosquitoes

Chemical mosquito control is based principally on the application of larvicides. These larvicides are relatively target-specific, and are appropriate for use in the Project area.

Complaints by Mine employees or surrounding residents should primarily determine the requirement for application of larvicides in breeding habitats. If complaints are received, breeding habitats should be determined by conducting a survey of breeding habitat, by dipping for larvae along the margins of waterbodies on the site. When a high abundance of mosquito larvae are found in a dip sample (greater than 10 larvae per dip), treatment of the waterbody with a commercial larvicide, such as Altosid 30 day briquettes, may be warranted.

Chemical control of midges

Biting midges cannot be treated by chemical means within breeding areas due to the toxicity of midge adulticides (such as Bifenthrin) to other organisms. Control of biting midges needs to include site specific studies of where midge populations are coming from before control measures such as barriers/fences (which may be treated with 'Bistar', a midge adulticide containing Bifenthrin) can be effectively implemented.

17B.6.9 THREATENED SPECIES AND ECOLOGICAL COMMUNITIES

The Project associated with the MLA areas and gas supply pipeline is highly unlikely to have an impact on any threatened aquatic species or ecological communities as none are likely to occur in the waterways of the MLA areas or along the gas supply pipeline.

17B.6.10 MONITORING REQUIREMENTS

Turbidity monitoring

Monitoring of turbidity levels in the creeks will occur at least:

- on a monthly basis in waterways throughout the MLA areas and in the creeks crossed by the gas supply pipeline immediately prior to pipeline installation, in order to determine background turbidity levels
- during periods of rainfall in creeks that are within 500 m of vegetation clearing earth moving activities
- daily when constructing permanent or temporary creek crossings.

Turbidity levels should not exceed 10% above background during construction. If turbidity levels exceed 10% of background concentrations, construction will cease, and stormwater and erosion and sediment control measures be revised prior to re-commencement of construction.

Other water quality monitoring mitigation measures are further discussed in Chapter 11 Water Supply and Management, and the associated water quality technical report.

Aquatic ecology monitoring

A long-term aquatic ecological monitoring program will be required to monitor the impacts of the Project of the waterways within and downstream of the Project area and to contribute to the ongoing improvement and effectiveness of the Project's environmental management plan. The monitoring program should be designed to detect changes to the physical environmental and ecological communities within the waterways, thereby providing the opportunity to prevent further damage if impacts are detected.

Monitoring will occur at approximately five sites within the MLA areas five sites downstream of the MLA areas, and five comparison (reference) sites that will not be impacted by the Project. Each site should be approximately 100 m in length. Sites should also be established on the diversion channels once they are commissioned. Two monitoring events should be completed each year, one in the early wet season and one in the late wet season. At least two baseline survey events should be completed prior to the commencement of construction.

The monitoring program will include quantitative, replicated monitoring of water quality, aquatic habitat, macrophytes and aquatic fauna (focussing on macro-invertebrates and fish).

Water quality and aquatic habitat

Water quality and aquatic habitat will be assessed in accordance with AusRivAS protocols. The percent cover of each macrophyte species present will also be assessed at each site. This information will be compared among creek sections (within the MLA areas, downstream of the MLA areas and comparison sites) for each survey event using one-way Analysis of Variance (ANOVA). This information may also be used in multi-variate analyses of fish communities.

Macro-invertebrates

A statistically valid monitoring program, as described in TR 17B-1-V1.5 Section 7.10.2, should be developed in order to assess impacts on macro-invertebrate communities.

Fish communities

Fish communities will be surveyed using gear types appropriate to the conditions at each site. This may involve the use of one, or a combination of, the following gear types:

- backpack or boat electrofishing units
- seine nets (approximately 10 mm mesh size); gill nets (75 mm and 150 mm mesh)
- baited traps (of 2 mm and 20 mm mesh)
- dip nets (of 2 mm mesh).

Any electrofishing will be conducted strictly in accordance with the Australian Code of Electrofishing Practice. General Fisheries and Animal Ethics permits will be required to complete the monitoring.

At each site, the species captured and the abundance of each species by life history stage (juvenile, intermediate, adult) will be recorded, along with the apparent health of individuals. Specimens which cannot be identified in the field should be euthanised and preserved for later identification.

The richness, total abundance, abundance of ‘key’ species and abundance of each life history stage should be compared among creek sections for each survey event.

The relationships between fish communities among different creeks and within the habitats present at each site should be determined.

Monitoring of dams for exotic species

The dams on-site (in particular the raw water storage dam) will be monitored for the establishment of exotic species. This can be done in conjunction with the aquatic ecology monitoring program. Fish will be surveyed using a combination of boat-based electrofishing, set traps and seine nets. If exotic species are discovered, management will be addressed and implemented as part of the Pest Management Plan, as further described in Chapter 17A Terrestrial Ecology.

17B.7 RESIDUAL IMPACTS

17B.7.1 OPERATION AND MAINTENANCE OF VEHICLES AND OTHER EQUIPMENT

Where fuel storage and handling activities are undertaken in accordance with AS1940 Storage and Handling of Flammable and Combustible Liquids – encompassing spill containment and response protocols and appropriate spill kits are carried in the field, the risk from a fuel spill to aquatic ecology is considered to be very low. The risk to aquatic ecology from spilt litter and waste from the MIA and accommodation is also likely to be very low.

17B.7.2 VEGETATION CLEARING AND EARTHMOVING

Where the mitigation measures are adopted, an appropriate Construction Management Plan is followed and turbidity is routinely monitored in the creeks, it is considered unlikely that construction-related increases in turbidity or nutrients in the waterways of the study area will have a significant ecological impact.

17B.7.3 WASTEWATER AND STORMWATER

Stormwater

Release of water of an acceptable quality from the sediment dams is not expected to have a negative impact on aquatic ecology. The impact of small outflows in the wet season would not have a discernable impact when compared to the naturally occurring flows. Release in the dry season may result in the creation of permanent pools that act as refuge habitat in the creeks and may also trigger fish movement and possibly spawning in the creeks.

Industrial wastewater

Contaminants will be unlikely to impact on aquatic ecology where the Water Management System (WMS) is successful in ensuring that there is no mine water discharge from the site.

Accidental spills from environmental dams AU-E1, MC-E2, SH-E3, and WS-E1 would not be expected to have a large impact on aquatic ecology as these dams are situated away from major creeks and any overflow would be subject to infiltration before the water reached any major creek. However, the tailings dams and environmental dams AU-E2, W-E2, and AU-E4 are in close proximity to Woleebee Creek. A spill from these dams would be expected to have localised impact on the aquatic flora and fauna of this creek and (potentially) some nearby downstream reaches of Juandah Creek. However, no impacts would be expected to waterways further downstream, such as the Dawson River, due to dilution and dispersion of the contaminants.

Domestic wastewater

Sewage has the potential to be accidentally discharged to Woleebee, Frank or Juandah Creeks from the two pump stations. The impacts of nutrient enrichment and any algal blooms due to a sewage spill would also be expected to be short-lived and affected aquatic communities would be expected to recover from such an impact. Therefore, eutrophication of the waterways due to a sewage spill is considered to be a low risk to aquatic ecology.

17B.7.4 WATER SUPPLY

Potable water supply

There will be a short-term, reversible impact to aquatic ecology where pipelines are installed across creeks. Where construction of the potable water pipeline from Wandoan follows the mitigation measures for pipeline construction and creek crossings, no long term impacts to surface waterbodies are expected from the use of Great Artesian Basin water for potable purposes.

Glebe Weir – Dawson River

Where screens are fitted to the intake pipe and are regularly maintained and tested, the opportunity for exotic species to become established within the study area will not be significantly increased above the current situation, as mosquitofish and goldfish are already established within the catchment.

Coal seam methane by-product water

Water supply from CSM by-product water is unlikely to have a significant impact on the aquatic ecology of the natural waterways within the study area. Chapter 17B Aquatic Ecology of Volume 2 describes the risk and mitigation measures necessary to prevent transfer of the declared noxious carp (*Cyprinus carpio*) from the Condamine catchment.

Discharge from raw water storage dam

The raw water storage dam would only be expected to overflow during periods of significant rainfall. Discharge from the raw water storage dam would not be expected to have a discernable impact on aquatic ecology.

17B.7.5 LOSS OF CATCHMENT AREA

The diversion of runoff from approximately 8,500 ha of upper catchment area to the site water management system due to the creation of pits is unlikely to have a regionally significant impact. Locally, a reduction in flows to the creeks could negatively impact on the abundance and diversity of macrophyte, macro-invertebrate and fish populations within the creeks of the MLAs. However, this would not be expected to have an impact on aquatic communities of Juandah Creek or waterways further downstream, such as the Dawson River.

17B.7.6 CREEK DIVERSIONS

At least 20 km of natural watercourse will be lost, including reaches of Spring, Mt Organ, Mud, Woleebee and Frank Creeks and an un-named tributary of Juandah Creek. However, if the diversion channels are well engineered to maintain fish passage and replicate the aquatic habitat found in the natural creeks, this loss of natural ephemeral watercourse is highly unlikely to result in the local loss of any species of aquatic flora or fauna.

The proposed diversions are unlikely to have a regionally significant impact on the abundance of aquatic flora and fauna, on the diversity of aquatic communities, or on aquatic ecosystems functioning.

17B.7.7 CONSTRUCTION OF CREEK CROSSINGS

Construction of creek crossings will result in a temporary disturbance to aquatic and riparian habitat. If these habitats are appropriately rehabilitated, there will be no permanent local or regional impact.

When there is water present in the channel, there will be a temporary impact to fish passage during construction activities. There may also be impacts to water quality; however, these will not be significant in a local or regional context if appropriate erosion and sediment control measures and monitoring are put in place.

17B.7.8 BITING INSECTS

Construction and operational activities that result in pooled water will potentially provide an increase in mosquito and biting midge breeding habitat in the study area. During the operational phase, dams have the potential to provide additional breeding habitat for these organisms. An increase in the population of mosquitoes and biting midge has the potential to impact on human health. However, the impact of mosquitoes and biting midges on human health can be minimised through appropriate education, breeding control, engineering and building design.

17B.7.9 SIGNIFICANT CONSERVATION HABITATS

The Project MLA areas and gas supply pipeline will not impact on any significant aquatic conservation habitats, including those that are listed under State or Commonwealth legislation.

17B.7.10 THREATENED SPECIES AND ECOLOGICAL COMMUNITIES

The Project MLA areas and gas supply pipeline are highly unlikely to have a significant impact on any listed threatened species or communities that are listed under State or Commonwealth legislation.

17B.8 CONCLUSIONS

The biological values of aquatic ecosystems within the study areas are relatively low and consistent with those of the wider catchment. Environmental values are dictated primarily by the ephemeral and intermittent nature of the region's waterways; although surrounding land uses, including vegetation clearing, cattle grazing and cropping, have negatively impacted the aquatic habitat of the study area and the wider catchment. Water quality is relatively poor, and reflects the predominantly agricultural nature of the region and the ephemeral nature of the creeks. However, the aquatic habitat of the study areas are considered to be in a moderate condition overall, with many of the sites surveyed supporting large trees in the riparian zone and characterised by a variety of aquatic microhabitats.

Biodiversity in the study area is slightly lower than that found in the more permanent waters of the region (such as the Dawson River). Only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabit the study area; that is, communities typically have a low sensitivity to changes in water levels and water quality. However, macro-invertebrate and fish communities found within the MLA areas are likely to contribute to the success of downstream populations through movement/migration. Flow is an important cue for migration and reproduction in many of the species recorded in the study areas. One species of freshwater turtle (the Krefft's river turtle) was found downstream of the MLA areas in Juandah Creek. However, turtles are unlikely to be abundant in the ephemeral creeks of the study areas at any given time. No rare or threatened aquatic floral or faunal species were found in the study areas, or are considered likely to occur, based on the habitats present.

The coal resources of the Project will be developed as an open-cut mine and related local infrastructure. Construction and mining activities, including the operation of vehicles and other equipment, vegetation clearing and earth moving, creation of wastewater in association with the required infrastructure, management of stormwater runoff, creation of dams; construction of creek crossings, creation of stream diversions, and the loss of catchment area, each have the potential to impact on aquatic ecology.

The potential impacts of fuel handling, vegetation clearing, dam operation and stormwater discharge on the creeks within the study areas (and downstream waterways) can be minimised if current best practicable practice environmental management programs are followed.

The Project MLA areas and gas supply pipeline are highly unlikely to have an impact on boggomoss springs, the Great Barrier Reef World Heritage Area or the Shoalwater and Corio Bays Ramsar site. The Project MLA areas and gas supply pipeline are unlikely to impact on any threatened aquatic species or ecological communities (as listed under State or Commonwealth legislation), as these species and communities are unlikely to occur in the waterways of the MLA areas or along the gas supply pipeline.

In summary, the Project MLA areas and gas supply pipeline are not likely to impact on MNES with respect to aquatic ecology.

Of the potential impacts of the Project MLA areas and gas supply pipeline on the creeks of the study areas, the diversion of creek channels, and the construction of creek crossings (which can affect fish movement) could result in the greatest impact to the aquatic environment. However, the significance of any potential impacts can be reduced if appropriate mitigation measures are followed. In particular, the channel morphology and aquatic habitats of the creeks to be diverted should be surveyed in detail, so that the diversion channels can be constructed so that they replicate the natural channels in terms of channel morphology, sediment type, instream physical habitat and riparian vegetation. Creek crossings should be constructed in accordance with the recommendations in the

DPI&F Fish Habitat Guideline FHG 001, Fish Passage in Streams, Fisheries guidelines for design of stream crossings (Cotterell 1998).

Taking into account the low existing biological values of the aquatic environments of the study area, in general, the impact assessment demonstrates that there will be only a low magnitude of impact to the local aquatic environments of the MLA areas and gas supply pipeline alignment, and negligible regional impacts. However, future water quality and aquatic ecology monitoring will be required to determine the impact of the Project on aquatic ecology, in order to inform adaptive management of the Project.

17B.9 SUMMARY OF COMMITMENTS AND MITIGATION MEASURES

Mitigation measures to avoid, minimise and mitigate potential impacts of the Project MLA areas and the gas supply pipeline to aquatic flora and fauna, as previously detailed in this chapter, are summarised below:

- Fuel storage areas will meet AS 1940, to contain any fuel spills or the runoff of other contaminants. Appropriate spill containment kits will be available and used for the cleanup of spills.
- Mobile fuel stations, for refuelling of machinery in the field, will bunded to meet AS 1940, and placed above the Q_{100} flood level of nearby waterways and dams.
- An erosion and sediment control management plan will be developed (as a part of the EM Plan) to prevent excess sediment from running off into the creeks during earth moving and vegetation clearing related to construction and operation of the mine.
- Where practical, clearing and earthworks within 100 m of a major waterway (Frank, Woleebee, Wandoan, Blackant, Mud, Mount Organ and Spring Creeks) will be done within the dry season.
- Erosion control matting (or mulch), placed along ditches and drainage lines running from all cleared areas, especially on slopes and levee banks.
- Contour banks, ditches or similar will be formed across cleared slopes to direct runoff towards surrounding vegetation and away from creeks
- Monitoring water quality of creeks will be undertaken
- After construction, native vegetation will be replanted where possible, and along creek margins where riparian vegetation has been cleared, to a width that matches the existing riparian vegetation (but at least 5 m). Species planted should be the same as the plants naturally found in the riparian zone, and should provide canopy cover and have root systems that can stabilise the banks and disturbed area.
- Where practicable, water should only be released from sediment dams during periods of rainfall and flow in the natural waterways. Water quality of the released water should be maintained at levels similar to those recorded naturally in the study area during periods of rainfall.
- When possible, the discharge of water from the sediment dams to the natural receiving environment should be managed to coincide with natural flow events.

- The creek diversions should be designed and constructed to provide bed, bank and in-stream habitat of a similar character to that of natural watercourses within the region.
- Prior to diversion, the sections of creeks to be diverted will be surveyed in detail, and used as a basis for designing bends, pools, bars in detailed design of each diversion. Where possible, the natural channel features of each creek will be incorporated into the diversion design.
- The success of rehabilitation and erosion and sediment control methods will be monitored, and the diversions will only be opened to flows once geotechnical stability and vegetation requirements have been satisfactorily established.
- Construction of the Woleebee Creek diversion is proposed in three stages, starting in Year 10 and finishing in Year 12. Sufficient time must be allowed for the habitats within the entire diversion channel to establish prior to commissioning (estimated to be at least two years). That is, if construction finishes in Year 12, the channel should not be opened to flows until at least Year 14.
- The channels of Blackant and Wandoan Creeks will remain open during the construction of the Woleebee Creek diversion, with the diversion channel being built either side of the banks. These banks will only be redesigned to direct flows into the new diversion channel immediately prior to opening it to flows. Reinforcing the banks of Blackant and Wandoan Creeks with hard structures such as crib walls or riprap if required in these locations would be acceptable.
- Once flow is diverted from the existing channel, stranded fish and turtles will be captured and translocated to either the diverted creek or upstream of the diverted creek, following the DPI&F Fish Salvage Guidelines (DPI&F 2004) and ethical handling procedures.
- Where practicable, construction of road and rail crossings will be undertaken during the dry season. However, stormwater and erosion and sediment control measures will still be put in place during construction.
- In the detailed design phase, where practicable, the exact location of the crossings will be sited so that the minimum number of riparian trees needs to be cleared. Trees that are cleared will be anchored into the stream bed (for example by partial burial of the use of boulders), to enhance in-stream habitat in the creek.
- After removal of a temporary crossing, the rehabilitated bed and bank structure should mimic the existing dimensions and shape of the watercourse.
- At the completion of construction, banks will be recontoured to the original shape and revegetated. Bank recontouring should include stabilisation methods (crib walls or soil wraps) where appropriate.
- Where practicable, existing bed material will be salvaged prior to construction of a temporary creek crossing or pipeline crossing, and placed back into the creek at completion of construction. If the existing bed material was unable to be salvaged, a comparable sediment size material will cover the bed and be approximately 10 cm thick. If the sediment is fine (mud and/or silt), it is preferred that the bed material be replaced with sand, to prevent future erosion. If the sediment is coarser (gravel,

cobble, pebbles and/or boulder), the new material will be washed prior to placing in the creek.

- Prior to construction, any instream structures (woody debris, large cobbles) will be salvaged bed and placed back in the creek bed after construction. After construction of a temporary creek crossing or pipeline crossing, the aquatic habitat structures will be replaced in the creeks. Felled trees could also be placed into creeks to create woody debris habitat.
- Where practicable, creek crossings will be constructed in accordance with the recommendations in the DPI&F Fish Habitat Guideline FHG 001, Fish Passage in Streams, Fisheries guidelines for design of stream crossings (Cotterell 1998).
- Culverts will be maintained so that there is regular removal of debris or plant growth, which can impede fish passage.
- Pipeline crossings of creeks will be constructed in the dry season when possible. At the completion of construction, banks will be recontoured to the original shape and revegetated. Bank recontouring should include stabilisation methods (crib walls or soil wraps) where appropriate.
- Where pipeline crossings are done in the wet season, turbidity will be monitored and fish salvaged from isolated areas.
- Mosquito and biting midge breeding habitat will be minimised. All drainage lines will be regularly cleared to ensure that water continues to flow and no ponded areas are created. Where practicable, all dams and water storages created to contain stormwater and wastewater will have steep edges, to minimise the amount of shallow water, which can provide breeding habitat.
- Where practicable , building design and full screening of windows will be used to prevent insect entry and ceiling fans or air conditioning installed to increase airflow.
- Where practicable and the water quality is acceptable, native larvivorous fish should be stocked into sediment dams and the raw water storage dam on-site to contribute to mosquito control at densities of around 1 fish per m^2 of potential breeding habitat. Fish species that occur in the study areas that prey on mosquito and midge larvae are recommended for stocking, these species include Agassiz's glassfish (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*) and carp gudgeons (*Hypseleotris* sp.).
- Complaints by Mine employees or surrounding residents should primarily determine the requirement for application of mosquito larvicides in breeding habitats. If complaints are received, breeding habitats should be determined by conducting a survey of breeding habitat, by dipping for larvae along the margins waterways on the site. When a high abundance of mosquito larvae are found in a dip sample (geater than 10 larvae per (cup-sized) dip), the waterway should be treated with a commercial larvicide.

- Monitoring of turbidity levels in the creeks should be completed:
  - on a monthly basis in waterways throughout the MLA areas, and in the creeks crossed by the gas supply pipeline immediately prior to pipeline installation, in order to determine background turbidity levels
  - during periods of rainfall in creeks that are within 500 m of vegetation clearing earth moving activities
  - daily when constructing permanent or temporary creek crossings.
- Turbidity levels should not exceed 10% above background during construction. If turbidity levels exceed 10% of background concentrations, construction will cease and the erosion control measures in place revised prior to re-commencement of construction.
- A long-term aquatic ecology monitoring program will be implemented, with at least two baseline survey events prior to construction.
- The dams on-site (in particular the raw water storage dam) will be monitored for the establishment of exotic species in these waterbodies. If exotic species are discovered, an exotic species management plan should be developed and implemented.

17B.10 REFERENCES

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