Wandoan Coal Project:

Southern Coal Seam Methane Water Supply Pipeline, Aquatic Ecology Impact Assessment

Prepared for:

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Glossary

Term	Definition
Aestivate	To be dormant, often buried within the soil or under leaf litter, during months of drought.
Aggradation	The build-up of sediment or some other substance.
Algal mat	A thin layer of algae formed over the surface of the benthos.
Anaerobic	Having or producing no oxygen.
Anthropogenic	Caused by humans or human activity.
Benthos	A term for all of the flora and fauna that live in or on the bottom substrate of waterbodies, including creeks, rivers and wetlands.
Biodiversity	The range of organisms present in a given community or system.
Catchment	The area of land which collects and transfers rainwater into a waterway.
Channelisation	The formation of deeper channels within a waterway.
Crustacean	An arthropod with jointed appendages, a hard protective outer shell, two pairs of antennae and eyes on stalks, e.g. crabs, prawns.
Culvert	A covered channel that carries water, often be covered by a bridge or a road.
Desiccation	Drying out due to the effects of the environment.
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts
DNRW	Queensland Department of Natural Resources and Water
DPI&F	Queensland Department of Primary Industries and Fisheries
Dissolved Oxygen (DO)	The amount of oxygen dissolved in water.
Diversity	The variety of a particular factor.
Ecological	Relating to the relationships between organisms and their environment.
Edge (habitat)	The habitats on the edge of a stream, which may contain undercut banks, trailing bank vegetation, aquatic macrophytes, tree roots etc.
Environmental flow	Freshwater flow that is maintained solely for environmental reasons, e.g. flows to act as an environmental cue, to deliver nutrients and sediment downstream etc.
EPA	Queensland Environmental Protection Agency
Ephemeral	Lasting for a short amount of time, e.g. ephemeral waterways are often dry.

Term	Definition
Erosion	The wearing away of rock or soil caused by physical or chemical processes.
Euryhaline	Tolerant of a wide range of water salinities.
Eutrophic	A body of water impacted by high concentrations of nutrients.
Eutrophication	The process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth. This enhanced plant growth, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die.
Habitat	The natural conditions and environment in which a plant or animal lives.
Invertebrate	Animals that don't have a backbone, e.g. insects, crustaceans.
Macro-invertebrate	An invertebrate large enough to be seen without magnification.
Macrophyte	A plant large enough to be seen with the naked eye.
Noxious	Harmful to the environment or ecosystem.
Perennial	Lasting for an indefinite amount of time.
PET richness	The richness of pollution-sensitive invertebrate taxa (**P**lecoptera (stoneflies), **E**phemoptera (mayflies), and **T**richoptera (caddisflies) within an area.
pH	Measure of the acidity or alkalinity of a substance, with 1 being the most acidic, 7 being neutral and 14 being the most alkaline.
Pool	An area in a stream that has no water flow and that is often deeper than other parts of the stream.
Quantitative	An assessment based on the amount or number of something.
Riffle zone	An area within a stream that is characterised by shallow water, rocky sediment and fast water flows.
Riparian	Situated along or near the bank of a waterway.
Run	An area in a stream that is characterised by moderately straight channels and medium water flow.
Senescing	Ageing and deteriorating, e.g. pools that drying out over time.
SIGNAL 2	An index of macro-invertebrate communities that gives an indication of the types of pollution and other physical and chemical factors affecting a site.
Species richness	The number of different species/taxonomic groups present in a given area.
Substrate	The underlying base to something, e.g. the streambed.

Term	Definition
Trailing bank vegetation	Riparian vegetation that hangs over the bank of a creek into the water.
Trophic	Describes the diet of groups of plants or animals within the various levels of a food web.
Turbidity	The clarity of a waterbody; depends on the concentration of particles that are suspended in the water column.
Velocity	The rate of water movement with respect to time.

Executive Summary

This report has been prepared for PB, on behalf of the Wandoan Joint Venture (WJV). It contributes information on aquatic ecology of creeks crossed by the southern coal seam methane water supply pipeline alignment for the Wandoan Coal Project (the Project). The study area for this assessment included the waterways along the pipeline route, including Juandah Creek and associated tributaries (part of the Dawson River Catchment in the Fitzroy Basin); and Dogwood Creek and associated tributaries (part of the Condamine Catchment in the Murray-Darling Basin). Likely impacts further downstream were also assessed based on literature review and local knowledge.

Aquatic floral and faunal surveys and collection of water quality data was undertaken during the dry season, from the 11th to the 28th August 2008. At most sites, habitat descriptions and observations were recorded, and photographs taken. Based on these descriptions, each site was given a habitat assessment score and condition rating following the River Bioassessment Program scoring system. When water was present, water quality was measured at each site using a TPS 90 FLMV water quality meter. Aquatic flora, macro-invertebrate and fish communities were surveyed at seven sites using standard techniques.

Surrounding land uses, including vegetation clearing, cattle grazing and cropping, have negatively impacted the physical 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. Biodiversity in the study area is slightly lower than that found in the more permanent waters of the region. Only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabit the study area. However, macro-invertebrate and fish communities found within the creeks crossed by the pipeline are likely to contribute to the success of downstream populations through migration. Freshwater turtles were not found in the study area, and are unlikely to be abundant in the ephemeral creeks crossed by the pipeline (though they are likely to occur in Dogwood Creek). No rare or threatened aquatic floral or faunal species were found in the survey area.

The pipeline will generally be located underground, constructed using a section trench and backfill method with vegetation clearing required along the pipeline corridor. The southern coal seam methane water supply pipeline will be 101 km in length. Installation of the pipeline, including: the operation of vehicles and other equipment; vegetation clearing and earth moving; management of stormwater runoff; and construction of creek crossings, each have the potential to impact on aquatic ecology.

The potential impacts of fuel handling and stormwater runoff on the creeks along the pipeline route (and downstream waterways) can be minimised to an acceptable level if current best-practice environmental management programs are followed. Where no equipment that is used in surface waters in the Condamine catchment has contact with the CSM water (unless it has been thoroughly cleaned with bleach) and where the Proponent ensures that the supplied and stored CSM water is free from noxious carp on a regular basis, the likelihood of transferring carp from the Condamine catchment to the Fitzroy Basin via the southern CSM water supply pipeline is considered to be negligible.

Of the potential impacts of the southern CSM water supply pipeline, the construction of creek crossings (which can affect riparian and aquatic habitats, and fish movement), poses the greatest threat to aquatic ecology. However, the significance of this impact can be reduced if appropriate mitigation measures are followed. In particular, after creek crossings are completed, the bed and bands should be constructed so that they replicate the natural channel in terms of channel morphology, sediment types and riparian vegetation.

1 Introduction

This report has been prepared for PB, on behalf of the Wandoan Joint Venture (WJV). It contributes information on aquatic ecology of creeks crossed by the southern coal seam methane (CSM) water supply pipeline alignment for the Wandoan Coal Project (the Project).

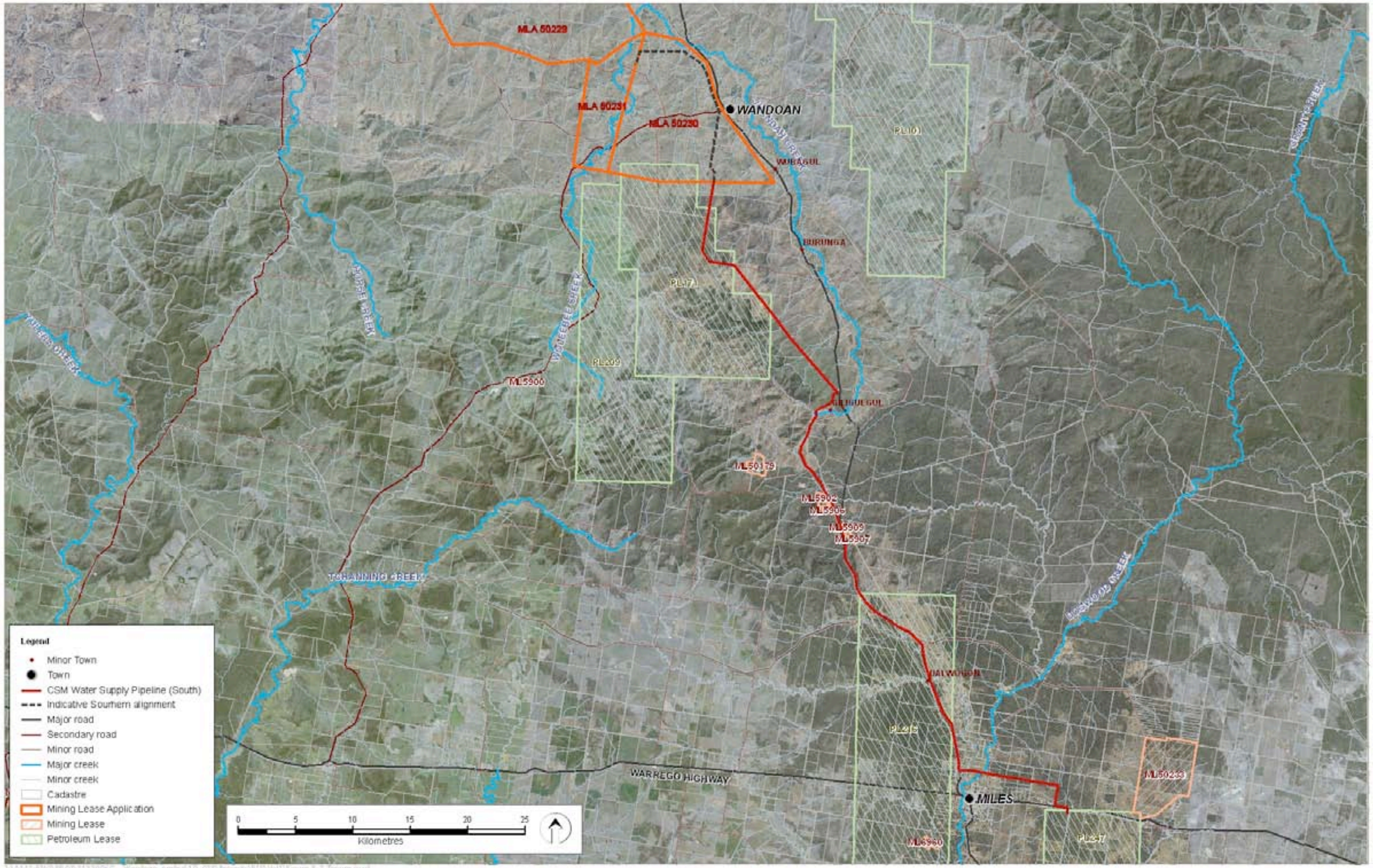
1.1 Project Background

The Wandoan Coal Project (the Project) comprises the development of thermal coal resources situated immediately west of the Wandoan township, located in Dalby Regional Council. The Project is located approximately 350 km northwest of Brisbane and 60 km south of Taroom as shown in Figure 1.1. The coal resources for this Project exist within three mining lease applications, MLA 50229, 50230 and 50231. The coal resources will be developed as an open cut mine with related local infrastructure. The Project covers an area of approximately 32,000 ha.

The Wandoan Coal Project will include on-site coal handling and processing which will require a constant and reliable water supply. One of three potential water supply options is from coal seam methane (CSM) by-product water from gas fields south of the Wandoan Coal Project mining lease application areas. The pipeline proposed to bring CSM by-product water from these gas fields will be from the Condamine Power Station, which is currently under construction, to the water supply storage dam adjacent to the Mine Infrastructure Area (MIA) of the Project via the southern boundary of MLA 50230, as shown in Figure 1.2. The CSM by-product water will be totally or partially treated prior to intake into the pipeline, so as to meet the water specifications for the Project.

The Project will be developed by the Wandoan Joint Venture. The joint venture partners are Xstrata Coal Queensland Pty Ltd (XCQ), ICRA Pty Ltd and Sumisho Coal Australia Pty Ltd.

frc environmental deep thinking. science.	Wandoan Coal Project: Southern Coal Seam Methane Water Supply Pipeline	
	Figure 1.1 Wandoan Coal Project location.	
		September 2008

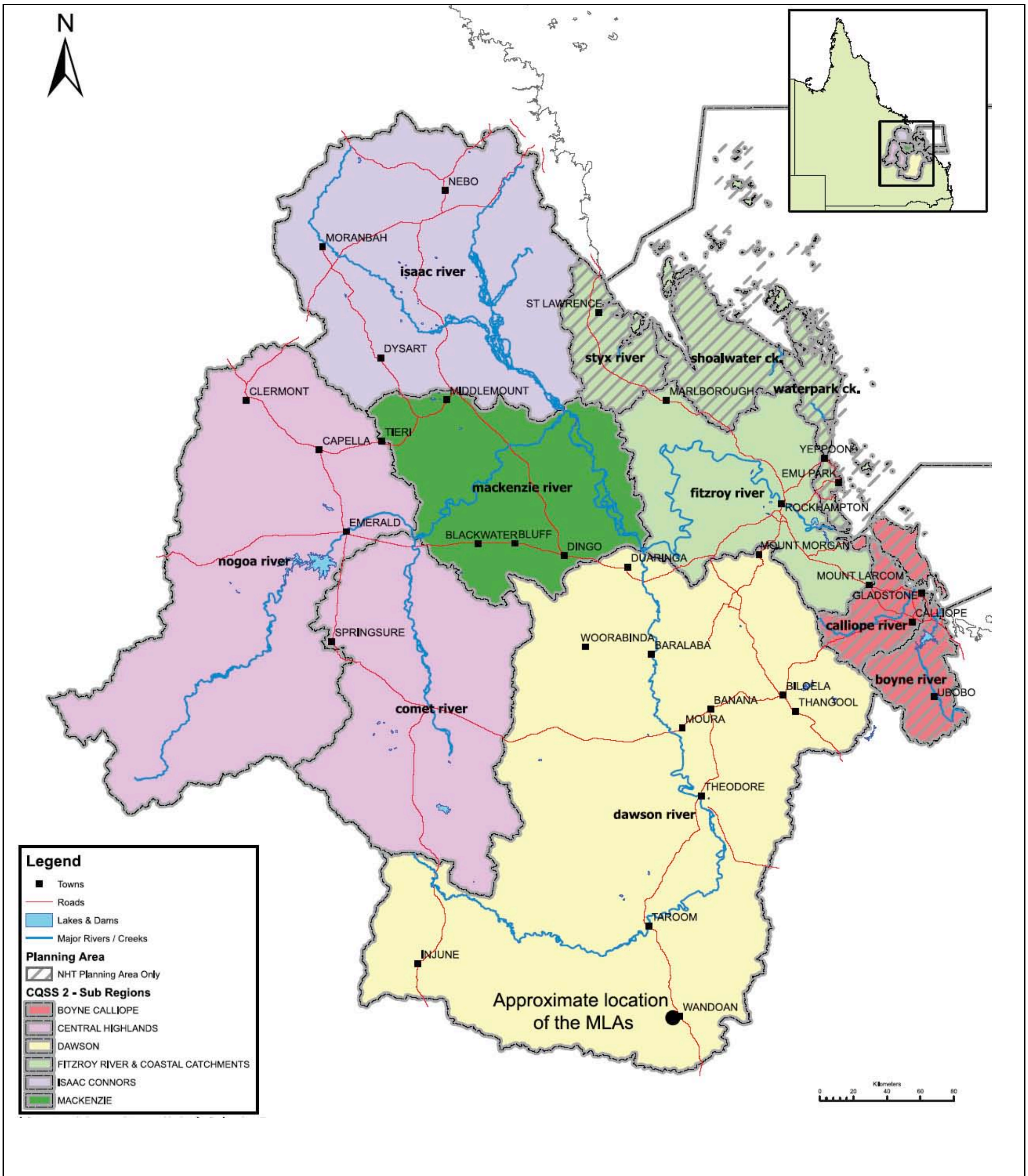


frc environmental deep thinking. science.	Wandoan Coal Project: Southern Coal Seam Methane Water Supply Pipeline
	Figure 1.2 Southern CSM water supply pipeline route.
	September 2008

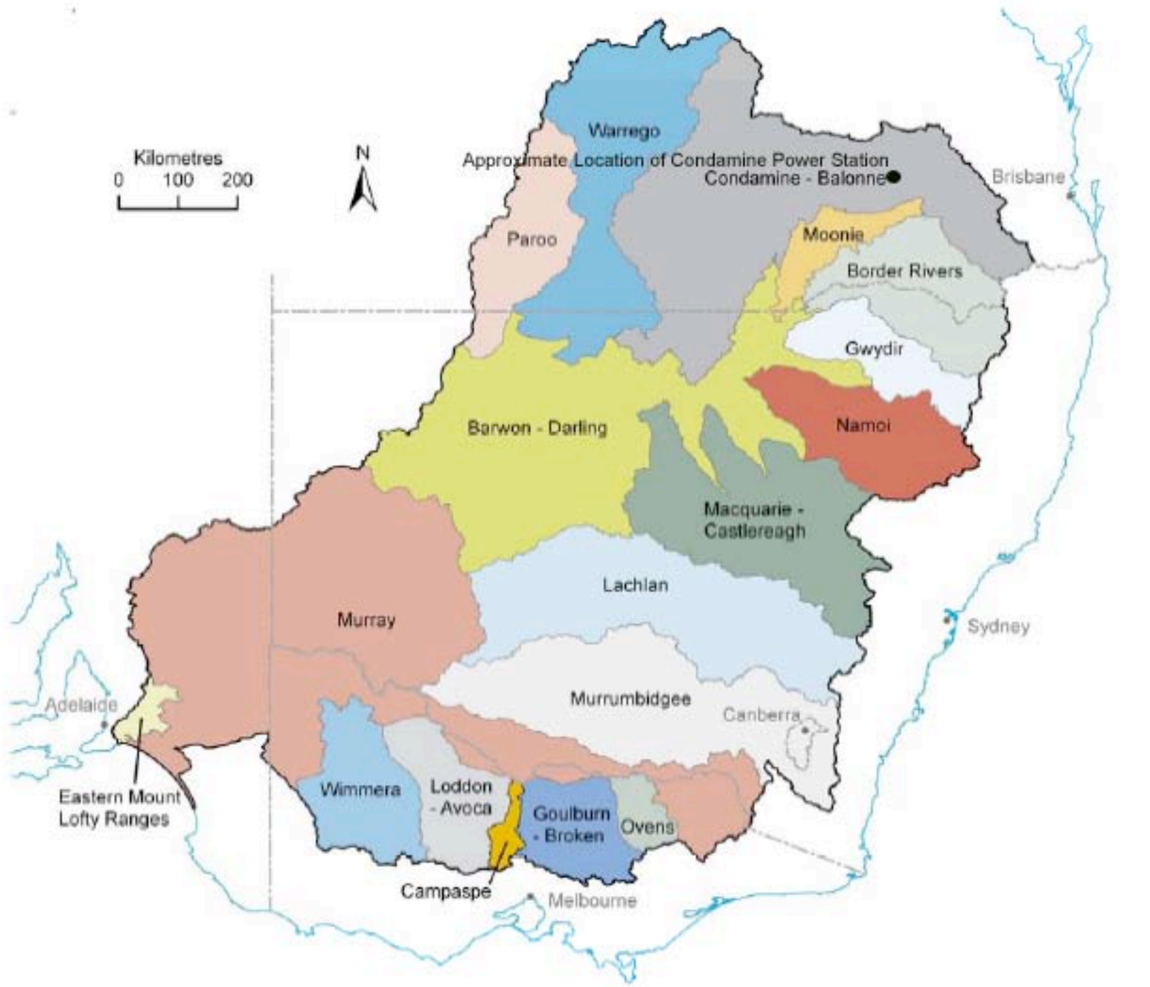
The southern CSM water supply pipeline crosses six major creeks, along with several smaller tributaries and gullies, which are part of the Dawson River Catchment (Southern Tributaries or 'Taroom' Subcatchment) and the Condamine Catchment (Figure 1.3 and Figure 1.4). The pipeline crosses Juandah Creek and tributaries of this creek: Six Mile Creek, Sandy Flat Creek, and Frank Creek. The pipeline crosses Dogwood Creek and its tributaries L Tree Creek, Nine Mile Creek, Eleven Mile Creek, and Wallan Creek.

Juandah Creek flows into the Dawson River approximately 100 km downstream from the pipeline alignment. The Dawson River flows into the Fitzroy River, approximately 85 km south west of Rockhampton. The Dawson River is the largest tributary of the Fitzroy River, and the Dawson Catchment covers 35% of the Fitzroy Basin (Joo et al. 2000).

Dogwood Creek flows into the Condamine River approximately 100 km downstream from the pipeline alignment. The Condamine River originates in the Great Dividing Range and flows into the lower Balonne floodplain wetland complex, approximately 250 km downstream from the pipeline alignment. The Balonne River flows into the Murray River, approximately 500 km downstream from the pipeline alignment. The Condamine Catchment covers 13% of the Murray-Darling Basin (CSIRO 2008).



frc environmental deep thinking. science.	Wandoan Coal Project: Southern Coal Seam Methane Water Supply Pipeline	
	Figure 1.3 The Fitzroy River Basin, showing the approximate location of the MLAs.	
	Adapted from FBA 2005	September 2008



frc environmental deep thinking. science.	Wandoan Coal Project: Southern Coal Seam Methane Water Supply Pipeline	
	Figure 1.4 The Murray-Darling Basin, showing the approximate location of the Condamine Power Station.	
	Adapted from CSIRO 2008	September 2008

2 Relevant Legislation and Guidelines

2.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Any actions that are likely to have a significant impact on a Matter of National Environmental Significance are subject to assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval process. Matters of National Environmental Significance include:

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

2.2 World Heritage Properties (Great Barrier Reef)

The EPBC Act regulates actions that will, 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 pipeline alignment. The southern CSM water supply pipeline is not expected to result in a significant impact to the values of the Great Barrier Reef World Heritage Area.

2.3 Wetlands of International Importance (Ramsar Wetlands)

The EPBC Act regulates actions that will, 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 (DEWHA 2008a). The Shoalwater and Corio Bays Ramsar wetland is approximately 620 km downstream from the pipeline alignment, and the pipeline is not expected to result in a significant impact to the ecological character of this Ramsar Wetland.

The Narran Lake Nature Reserve Ramsar wetland is part of a large terminal wetland system at the end of the Condamine River system (DEWHA 2008c). The Narran Lake Nature Reserve Ramsar wetland is approximately 540 km downstream from the pipeline alignment, and the pipeline is not expected to result in a significant impact to the ecological character of this Ramsar Wetland.

2.3.1 Threatened Species and Ecological Communities

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).

Biological data on the movement patterns of *R. leukops* is largely limited to tracking studies conducted in the Fitzroy River at Glenroy Crossing (above the Eden Bann Weir) (Tucker et al. 2001). Home ranges typically vary widely among individuals, however, on average, turtles were observed to have a local mean range span of 417 m (Tucker et al. 2001).

Tucker et al. (2001) found that individual turtles exhibit relatively long sedentary periods, ranging from 3 to 24 hours. When active, mean movement was 20 m per day on average, with a range of 0 to 350 m per day (Tucker et al. 2001). Overall, the distribution of movements and positions of turtles was not far from riffle zones, generally regardless of flow conditions (Tucker et al. 2001). However, when the data was conditioned by flow rates, descriptive patterns suggested that turtles: moved slightly upstream of riffle zones under moderate flows; moved downstream of riffle zones under base flows; and showed no obvious directional movement patterns under flood conditions (Tucker et al. 2001). Under low flow events, or as riffle zones became seasonally ephemeral, or dried completely, female *R. leukops* were observed to retreat to deeper sections of pool habitats adjacent to riffle zones (Tucker et al. 2001).

Gordos & Franklin (2002) observed a weakly bimodal pattern of increased surfacing activity during dawn and dusk in *R. leukops*, however this pattern was not consistently observed among individual turtles. At the time of writing no information on diurnal habitat preferences of *R. leukops* was available. No seasonal movement patterns have been observed for *R. leukops*.

Impacts of the pipeline on this species are addressed in Section 6.7.

Murray Cod

The Murray cod (*Maccullochella peeli peeli*) is listed as vulnerable under the EPBC Act. It is found in a range of warm-water habitats in the waterways of the Murray Darling Basin (DEWHA 2008d). This species can be found in a variety of habitats, including slow-flowing turbid waters as well as fast-moving, clear waters in upstream reaches (Allen et al. 2002). However, it prefers deeper-water habitats around in-stream habitat structures such as boulders, logs, undercut banks and overhanging vegetation (Allen et al. 2002). In-stream woody debris is particularly important to this species, with adults establishing home 'territories' around a particular snag (DEWHA 2008d). This species migrates upstream (up to 120 km upstream) during spring and early summer to spawn, with adults then returning to their home territory (DEWHA 2008d).

Murray cod have not been recorded within 15 km of the proposed pipeline crossing of Dogwood Creek (EPA 2008). Impacts of the pipeline on this species are addressed in Section 6.7.

Boggomoss Communities

On the Dawson River, approximately 100 km downstream from the pipeline alignment, mound springs from the Great Artesian Basin (Boggomoss Areas 1 & 2) are listed on the Register of the National Estate. The boggomoss communities form part of the native species dependent on natural discharge of groundwater from the Great Artesian Basin, which 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, approximately 100 km downstream of the creeks along the pipeline alignment (DEWHA 2008b).

Impacts of the pipeline on these species are addressed in Section 6.7.

2.4 Queensland *Water Act 2000*

The purpose of the *Water Act 2000* (Water Act) is to provide for the sustainable management of water and other resources. Under Section 266 of the Water Act, a riverine protection permit is required from the Department of Natural Resources and Water (DNRW) to:

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

The proposed pipeline alignment traverses a number of watercourses and therefore, it is likely that approvals will be required under the Water Act for pipeline crossings of watercourses. Additionally, where waters are to be taken from a watercourse, lake, spring or underground water, for example for use in dust suppression during construction works, a permit may be required pursuant to S. 237 of the Water Act.

2.5 Queensland *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). If litter, soil, a noxious substance, refuse or other polluting matter is on land (including the foreshore and non-tidal land), in waters, or in a fish habitat, and it appears to the Chief Executive that the polluting matter is likely to adversely affect fisheries resources or a fish habitat, the Chief Executive of the Department of Primary Industries & Fisheries (DPI&F) may issue a notice requiring the person suspected of causing the pollution to take action to redress the situation.

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 pipeline. If approval is given the Chief Executive, DPI&F may direct the building of a specified fishway for the barrier if required.

To get an approval, an application must be made to DPI&F and lodged with the required fees. An assessment is done by DPI&F staff to see whether or not an approval should be issued, and whether a fishway is required to be built with the structure. To assess the requirements for a fishway on a proposed structure, the following sorts of questions are assessed:

- are there fish in the waterway that need to move across the site of the waterway barrier works?
- are there habitats upstream and/or downstream of the proposed works that the fish need to move into?
- what are the effects of existing barriers (natural or man-made) up or downstream of the site of the waterway barrier works?
- will the drown-out characteristics of the proposed waterway barrier works allow adequate fish passage? and
- can a fishway be incorporated into the proposed works?

When a fishway is required, DPI&F have developed a standard design process. This ensures that both biologists and engineers are involved in developing the fishway design. Once the fishway is built, monitoring is required to confirm that the fishway is effective, or to identify any adjustments needed. Fishways are not expected to be a requirement for this Project, and have not been considered further.

Impacts of the pipeline on fish passage are addressed in Section 6.3.1.

2.6 Queensland *Nature Conservation Act 1992*

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

Impacts of the pipeline on this species are addressed in Section 6.7.

3 Study Methodology

Aquatic floral and faunal surveys and collection of water quality data was undertaken during the dry season, from the 11th to the 28th 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; and 12mm in April and 46 mm in July at Miles at Constance Street) (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 Taroom and Miles, BOM 2008).

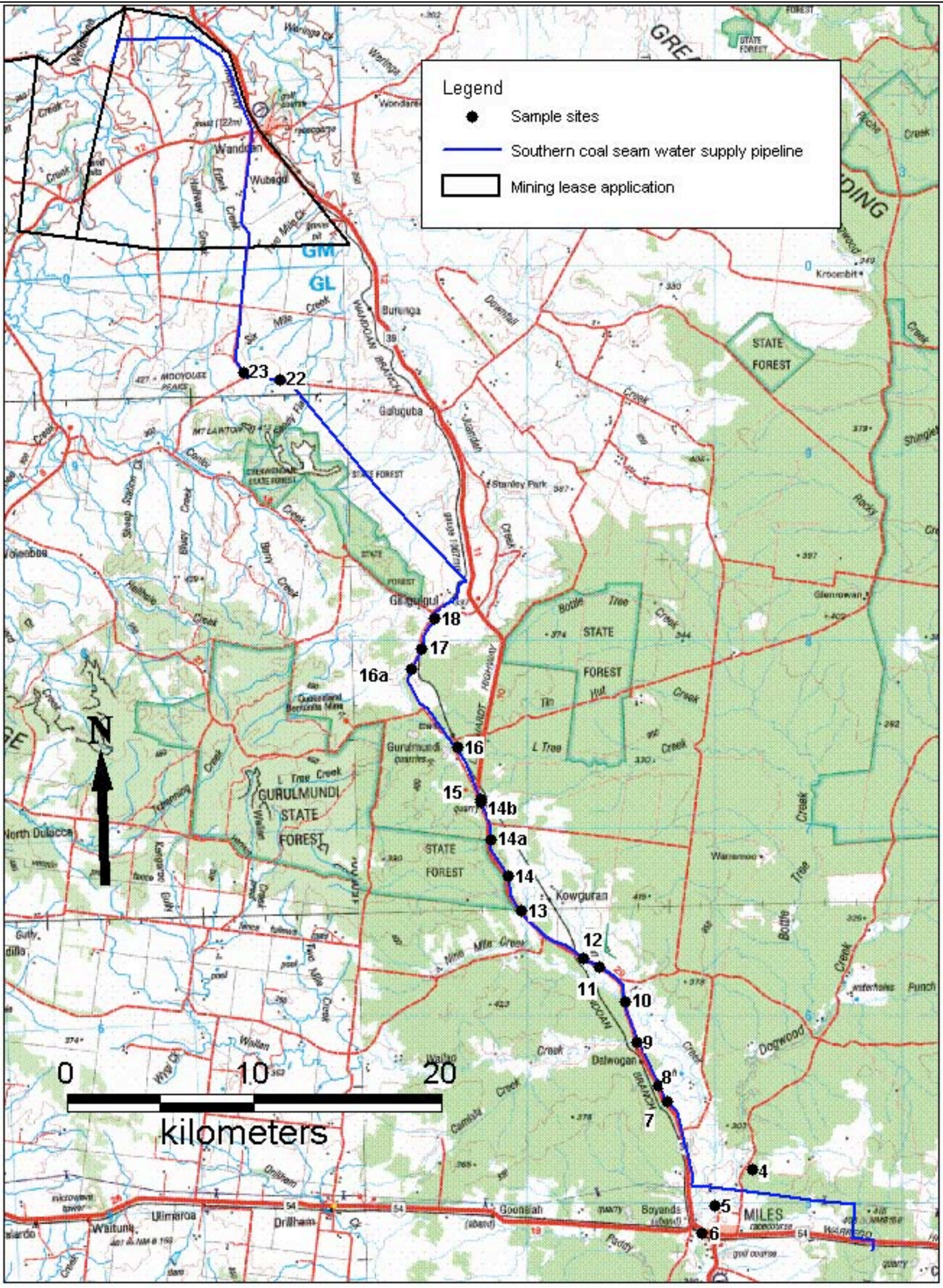
3.1 Study Sites

Twenty waterways crossed by the proposed pipeline route were surveyed (Table 3.1). Whenever possible, surveys were completed at the proposed crossing location, however, due to land access issues, some creeks were assessed at nearby road crossings; and some creeks crossed by the pipeline could not be surveyed. Stream orders were determined for each creek at the survey site, following the Strahler method, as used in AusRivAS models (e.g. two first order streams combine to form a second order stream, two second order streams combine to form a third order stream etc.).

At all sites (with the exception of site 14 on a minor tributary to Nine Mile Creek, sites 14a and 14b on minor tributaries to L Tree Creek, site 16a on a minor tributary to Juandah Creek, and site 23 at the headwaters of Six Mile Creek), the broad habitat type, channel pattern, water level and flow, substrate character and cover, bed and bank stability, and riparian cover were described using AusRivAS protocols (Refer to Section 3.2.1 below). Only brief observations and photographs were taken at sites 14, 14a, 14b, 16a and 23, as these sites were on minor watercourses within no defined channel or banks. Water was present at seven of the sites surveyed; water quality measurements and flora and fauna surveys were done at each of these sites. Water was only present at sites surveyed in the Condamine Subcatchment.

Table 3.1 Date and type of survey completed at watercourses on the southern coal seam methane water supply pipeline route.

Site	Channel Name	Date Survey Completed			
		Aquatic Habitat	Water Quality	Macrophytes	Fauna
4	Tributary to Dogwood Creek	15/08/08	Dry	Dry	Dry
5	Dogwood Creek	27/08/08	27/08/08	27/08/08	28/08/08
6	Dogwood Creek	28/08/08	28/08/08	28/08/08	28/08/08
7	Tributary to Eleven Mile Creek	15/08/08	Dry	Dry	Dry
8	Tributary to Eleven Mile Creek	15/08/08	Dry	Dry	Dry
9	Wallan Creek	15/08/08	15/08/08	15/08/08	26/08/08
10	Eleven Mile Creek	15/08/08	15/08/08	15/08/08	22/08/08
11	Tributary to Eleven Mile Creek	15/08/08	Dry	Dry	Dry
12	Eleven Mile Creek	15/08/08	Dry	Dry	Dry
13	Tributary to Nine Mile Creek	12/08/08	12/08/08	26/08/08	26/08/08
14	Tributary to Nine Mile Creek	-	-	-	-
14a	Tributary to L Tree Creek	-	-	-	-
14b	Tributary to L Tree Creek	-	-	-	-
15	Tributary to L Tree Creek	12/08/08	12/08/08	21/08/08	21/08/08
16	LTree Creek	14/08/08	14/08/08	21/08/08	21/08/08
16a	Tributary to Juandah Creek	-	-	-	-
17	Tributary to Juandah Creek	14/08/08	Dry	Dry	Dry
18	Juandah Creek	14/08/08	Dry	Dry	Dry
22	Tributary to Sandy Flat Creek	14/08/08	Dry	Dry	Dry
23	Six Mile Creek	-	-	-	-



frc environmental deep thinking. science.	Wandoan Coal Project: Southern Coal Seam Methane Water Supply Pipeline	
	Figure 3.1 Aquatic ecology survey sites.	
		September 2008

3.2 Aquatic Habitat

3.2.1 Of the Study Area

At each site, habitat descriptions and observations were recorded, and photographs taken. The broad habitat type, channel pattern, water level and flow, substrate composition and cover, bed and bank stability, and riparian cover were described using AusRivAS protocols (DNRM 2001).

Based on these descriptions, each site was given a habitat assessment score following the River Bioassessment Program scoring system (DNRM 2001). These scores were used to give each site a habitat condition rating (Attachment B). Habitat descriptions, River Bioassessment Scores and condition ratings at the aquatic flora and fauna sites built upon information collected during the reconnaissance surveys.

3.2.2 A Regional and Ecological Perspective

The typical aquatic habitat of the streams and creeks in the Southern Tributaries Subcatchment of the Dawson River and the Condamine River Subcatchment of the Maranoa, Balonne and Lower Condamine System were described through literature review, to provide a regional context for the condition of the creeks along the pipeline route.

3.3 Water Quality

Water quality was measured at each site using a TPS 90 FLMV water quality meter. The TPS 90 FLT water quality meter was used to measure:

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

Turbidity was not measured in this study.

Each site that held water was within the Dogwood Creek catchment, which is a part of the Condamine River catchment and the Murray Darling Basin. There are no Queensland

Water Quality Guidelines (QWQG) values for the Murray Darling Basin (EPA 2007a). Water quality parameters at each of the sites have therefore been compared to the national ANZECC & ARMCANZ guidelines (ANZECC & ARMCANZ 2000). The QWQG note that the national guidelines are unlikely to be appropriate for the flood-plain reaches of the Queensland rivers within the basin, and recommend that local Water Quality Objectives (WQOs) be derived. However, while specific WQOs have been developed for many waterways within south east Queensland, no WQOs have been prescribed for the waterways within the study area.

3.3.1 Water Quality of the Region

The typical water quality of the streams and creeks in the Dawson and Condamine Catchments was described through literature review, to provide a regional context for the condition of the creeks along the pipeline route.

3.4 Aquatic Flora

3.4.1 Of the Study Area

The description of aquatic flora (macrophytes) included:

- submerged, floating (free-floating or rooted) and emergent aquatic macrophytes
- macroscopic algae, and
- the presence of any introduced or pest plants.

Macrophytes with a submerged growth form predominantly grow beneath the surface of the water, although flowers may protrude through the water surface, and some leaves may float on the water surface (Sainty & Jacobs 2003).

Macrophytes with a floating growth can be either free-floating or rooted (Sainty & Jacobs 2003). Free-floating species are usually not attached to the substrate, whereas rooted species are attached to the substrate and normally have at least the mature leaves floating on the water surface (Sainty & Jacobs 2003).

Macrophytes with an emergent growth form are rooted in the substrate with stems, flowers and most of the mature leaves projecting above the water surface (Sainty & Jacobs 2003).

Aquatic flora was assessed along a 100 m reach at each site. The following was recorded for each site:

- the presence of all native and exotic macrophytes, and their form, and
- the percent cover of each species at each site.

Percent cover refers to the area of substrate (bed or bank) covered by vegetation. Due to the physical overlap of emergent, floating and submerged growth forms, total percent cover could exceed 100%.

Photographs of macrophytes were taken at each site and species were identified in the field, where practical. Representative samples of indefinite identifications were collected and pressed for later identification in the laboratory. The *Census of Queensland Flora 2007* (Queensland Herbarium 2007) was used to classify macrophytes as native or exotic.

3.4.2 A Regional and Ecological Perspective

The macrophytes of the streams and creeks in the Dawson and Condamine Catchments were described through literature review, where possible, to provide a regional context for the condition of the creeks along the pipeline route.

3.5 Aquatic Macro-invertebrate Communities

3.5.1 Of the Study Area

Sample Collection

A standard AusRivAS macro-invertebrate sample from each aquatic habitat found was collected at each site. Each site had edge and bed (pool / run) habitats; riffle habitats were not present. Sampling methodology followed the procedures set out in the Queensland AusRivAS sampling manual (DNRM 2001). A standard triangular-framed, cone-shaped net with 250 µm mesh was used to collect all samples.

Sample Processing

Samples were frozen and returned to frc environmental's Brisbane benthic laboratory where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AusRivAS standards and those described in Chessman (2003).

Data Analysis

A number of indices have been developed for freshwater macro-invertebrate communities to provide an indication of ecosystem health, as described in Attachment B. At each site, taxonomic richness, PET richness and Signal 2 scores were calculated. These indices have been used to provide an indication of the current ecological health of creeks associated with the southern CSM water supply pipeline, and to compare the health of these creeks to other waterways in the catchment.

3.5.2 A Regional and Ecological Perspective

The macro-invertebrate communities of the region were described through literature review. The Department of Natural Resources & Water (DNRW) has previously undertaken macro-invertebrate surveys in the same catchments as the waterways crossed by the pipeline route. These surveys included sites on the Dawson River at Taroom (Site 130302A), Juandah Creek at Sandy Bridge (Site 1303086) and Dogwood Creek at Paradise Crossing (Site 4222059).

In order to use the macro-invertebrate communities as an indicator of the likely health / condition of the DNRW sites, a number of macro-invertebrate indices were calculated, including taxonomic richness, PET richness and Signal 2 scores.

3.6 Fish Communities

3.6.1 Of the Study Area

Sample Collection

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

Electrofishing was conducted using a Smith-Root LR-24 backpack electrofisher. Field sampling followed the methods used in the south-east Queensland Ecological Health

Monitoring program (EHMP) (EHMP 2007), adapted where appropriate to suit local conditions. All available habitat units were fished at each site. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*. Sampling effort is presented in Table 3.2.

Table 3.2 Fish survey effort at each site.

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
5	Boat Electrofishing	Pool	28/08/08	9:00	10:15	50-1000 V, 40%	536 s	electrofishing effective
6	Boat Electrofishing	Pool	28/08/08	13:30	14:10	50-1000 V, 60%	1045 s	electrofishing effective
9	Backpack Electrofishing	Pool	26/08/08	8:00	8:30	250 V, 30 Hz, 12%	487 s	electrofishing effective
10	Backpack Electrofishing	Pool 1	22/08/08	8:40	9:10	425 V, 30 Hz, 12%	223 s	electrofishing effective
10	Backpack Electrofishing	Pool 2	22/08/08	9:45	10:15	300 V, 30 Hz, 12%	407 s	electrofishing effective
13	Boat Electrofishing	Pool	26/08/08	10:40	11:20	50-1000 V, 60-90%	390 s	electrofishing effective
15	Backpack Electrofishing	Pool	21/08/08	13:30	14:00	300 V, 30 Hz, 12%	463 s	electrofishing effective
16	Backpack Electrofishing	Pool	21/08/08	15:15	15:40	300 V, 30 Hz, 12%	345 s	electrofishing effective

At each site, the species present, the abundance of each species by life history stage (juvenile, intermediate, adult) and the apparent health of individuals was recorded. Specimens that were unable to be identified in the field were euthanised and returned to the laboratory for identification.

The sampling of fishes was conducted under General Fisheries Permit No. 54790 and Animal Ethics Approval No. CA 2006/03/106 issued to frc environmental (Attachment C).

Data Analysis

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

3.6.2 A Regional and Ecological Perspective

The fish communities of the region have been described through literature review. Within the upper Dawson River catchment, the most recent available fish surveys within the region were done by the Department of Primary Industries & Fisheries (DPI&F) (Berghuis & Long 1999), who sampled two sites on the Dawson River. Waterways further downstream on the Dawson River (in the vicinity of Glebe Weir) were also surveyed in November 2007 (frc environmental 2007) and June 2008 (Ecowise 2008). DPI (2002) sampled seven sites along the Condamine River between 2000 and 2001. No data were available specifically for Juandah or Dogwood creeks.

3.7 Turtle Communities

The likely presence of turtles 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, 2008).

3.8 Other Aquatic Vertebrates

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, 2008).

3.9 Limitations

The waterways in the study area are ephemeral, and are dry for much of the year. Our field data is based on a single, dry-season survey. To account for the expected high temporal variability in community structure (Smith et al. 2004), a further survey event is required to adequately assess and describe seasonal variations in the aquatic communities of the study area. A second survey event is recommended following the first significant rainfall event of the 2008 – 2009 wet season (in conjunction with planned surveys of the waterways within and downstream of MLAs). A supplementary report should be provided documenting the results of this survey.
Along the pipeline route, Dogwood Creek, and a major tributary of Dogwood Creek, could not be surveyed at the proposed pipeline crossing location, due to property access restrictions. Dogwood Creek was surveyed at the nearest road crossing, and also downstream from the confluence with the major tributary. Tributaries of Six Mile and Juandah Creeks could not be surveyed due to property access restrictions. Due to changes in the alignment since field surveys were completed, site 4 is no longer on the pipeline route. In addition, a turbidity meter could not be sourced for the August 2008 field survey.

The assessment of impacts is based on conceptual and preliminary information developed for the Project.

4 Existing Environment

4.1 Aquatic Habitat

4.1.1 Of the Study Area

The sites surveyed within the proposed pipeline alignment typically had poor to moderate Habitat Bioassessment Program assessment scores (Figure 4.1). Generally, these low scores were related to moderate to extensive bank erosion, low habitat variability (with no runs or riffles observed), and substrates dominated by finer sediments such as sand and silt.

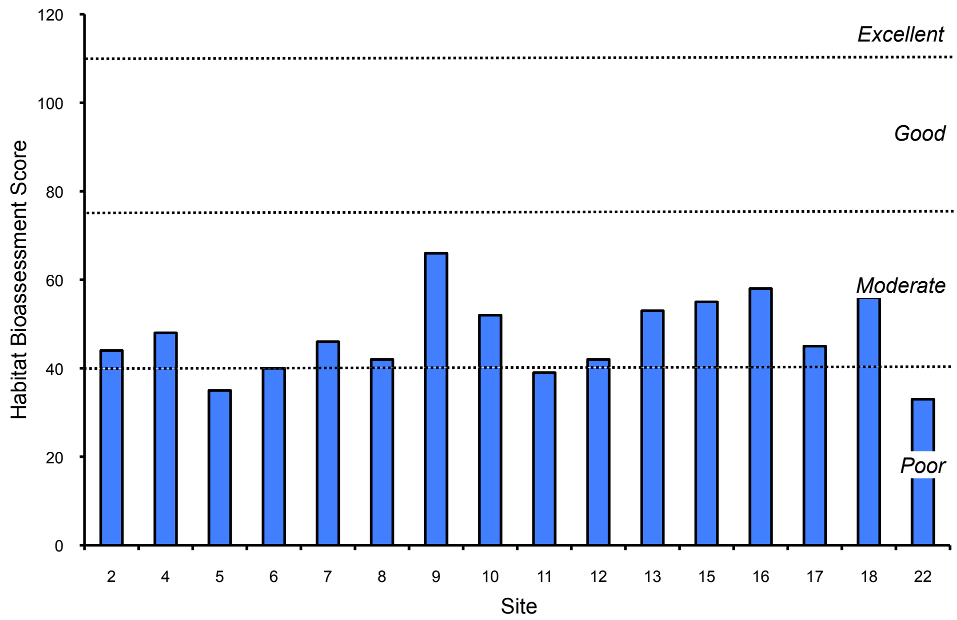


Figure 4.1 Habitat Bioassessment Scores at each of the sites sampled.

Reach Environs

Overall disturbance of the reach environs of the creeks surveyed ranged from poor at sites adjacent to grazing land, to good at sites adjacent to forested areas. Pasture, grazed and un-grazed forests are the dominant land uses surrounding the creeks of the southern pipeline alignment and in the broader area. There has been some riparian vegetation clearing across the study area, although large trees still grew on the creek banks at many sites (and in particular at sites on higher order streams). Erosion at road crossings was a major form of disturbance, particularly at Eleven Mile Creek and its tributary (sites 8 and 10) and Juandah Creek (site 17).

Road crossings were a mix of dirt crossings without culverts, concrete crossings with culverts, and bridges. Lower order streams tended to have dirt crossings without culverts (sites 4, 17, 18, and 22), while most waterway crossings on the Leichhardt Highway are box culverts or bridges.

Road crossings potentially cause alterations of flow and may prevent or restrict fish and turtle passage in some instances. Most of the dirt ford crossings were not built up and would only restrict aquatic fauna passage during very low flows (Figure 4.2).

The bridge crossings at Dogwood (site 6), Wallan (site 9) and Eleven Mile (site 10) creeks, are unlikely to restrict aquatic fauna movement, even though debris was noted around the pylons (Figure 4.3). Box culverts are likely to allow reasonable aquatic fauna passage in most cases, but severe scouring downstream of culverts, and accretion and snagging upstream of culverts, is likely to restrict passage on L Tree Creek, and tributaries of Nine Mile and L Tree creeks (sites 13, 15 & 16) (Figure 4.4 and Figure 4.5).

Figure 4.2

The dirt crossing at tributary to Dogwood Creek (site 4) forms a physical barrier to water flows and aquatic fauna passage during periods of very low flow.

Figure 4.3

The bridge pylons at the crossing of Wallan Creek are unlikely to restrict aquatic fauna movement.

Figure 4.4

A large scour downstream of the box culvert at a tributary to Nine Mile Creek (site 13).

Figure 4.5

Upstream obstructions at the box culvert at L Tree Creek (site 16).

Riparian Vegetation

Throughout the study area, riparian zones were generally 10 – 20 m wide, but the riparian zone was more than 30 m wide at Wallan Creek (site 9), Eleven Mile Creek (site 10), Dogwood Creek (site 6) and a tributary to L Tree Creek (site 15) (Figure 4.6). Conversely, riparian zones were almost entirely cleared at tributaries to Eleven Mile and Sandy Flat creeks (sites 8 and 22) (Figure 4.7 and Figure 4.8). Grasses typically dominated the riparian zone of the creeks, although shrubs and trees also grew at most sites.

Figure 4.6

Wide and tall riparian vegetation at Dogwood Creek (site 6).

Figure 4.7

Mostly cleared riparian vegetation consisting only of grasses at a tributary to Sandy Flat Creek (site 22).

Figure 4.8

Riparian vegetation cleared from the right bank but relatively intact along the left bank at a tributary to Eleven Mile Creek (site 8).

Riparian vegetation throughout the study area was dominated by native species, although exotic grasses were found. Forested areas were dominated by eucalypts, cypress pines, acacias and casuarinas. Prickly pear, a declared Class 2 pest in Queensland under the *Land Protection (Pest and Stock Route Management) Act 2002*, was noted at sites 13 & 18.

Bank Stability

There was considerable bank erosion at most sites in the study area. Vertical banks were common and appeared to be the result of water scouring during periods of high flow. Despite the steep banks, bank stability was often maintained by a relatively high cover of bank vegetation and by the root systems of larger trees (Figure 4.9). On Eleven Mile Creek and its tributaries (sites 10, 11 and 12) and on a tributary to Sandy Flat Creek (site 22) disturbance caused by cattle access was observed (Figure 4.10).

Figure 4.9

Extensive tree root stabilising the bank on Eleven Mile Creek (site 10).

Figure 4.10

Cattle trails collapsing stream banks east of the highway crossing at Eleven Mile Creek (site 12).

Bed and Bar Stability

Overall, stream beds throughout the study area were moderately stable, with evidence of scouring on outside meanders, downstream of obstructions and along roadside drainage channels. Larger particles were embedded in fine sediments where eroding banks had deposited silt and sand into the stream bed. Streambeds were sandy at a number of sites (refer to Attachment A for the sediment composition at each site).

Channel Diversity

Channel diversity was extremely low across the study area, and isolated pools were the dominant habitat category. Bends and changes in water depth are likely to provide some channel diversity during periods of flow. No run or riffle habitat was observed during the survey.

Aquatic Habitat

The condition of habitats within streams was variable but some physical aquatic habitat was found at most of the sites. Habitat was generally in the form of small woody debris, fallen logs and tree roots (Figure 4.11 and Figure 4.12). Cobbles, boulders, overhanging vegetation and instream vegetation were also observed, but seldom inundated, at the time of survey. These features would provide in-stream habitat during times of flow or when water levels are higher. At sites surveyed in higher order creeks, there was generally greater habitat availability, as there was more water present and large trees on the banks provided tree roots and fallen branches / logs as habitat (Figure 4.13).

Figure 4.11

Overhanging vegetation, stick piles, and undercut banks at a tributary to L Tree Creek (site 15).

Figure 4.12

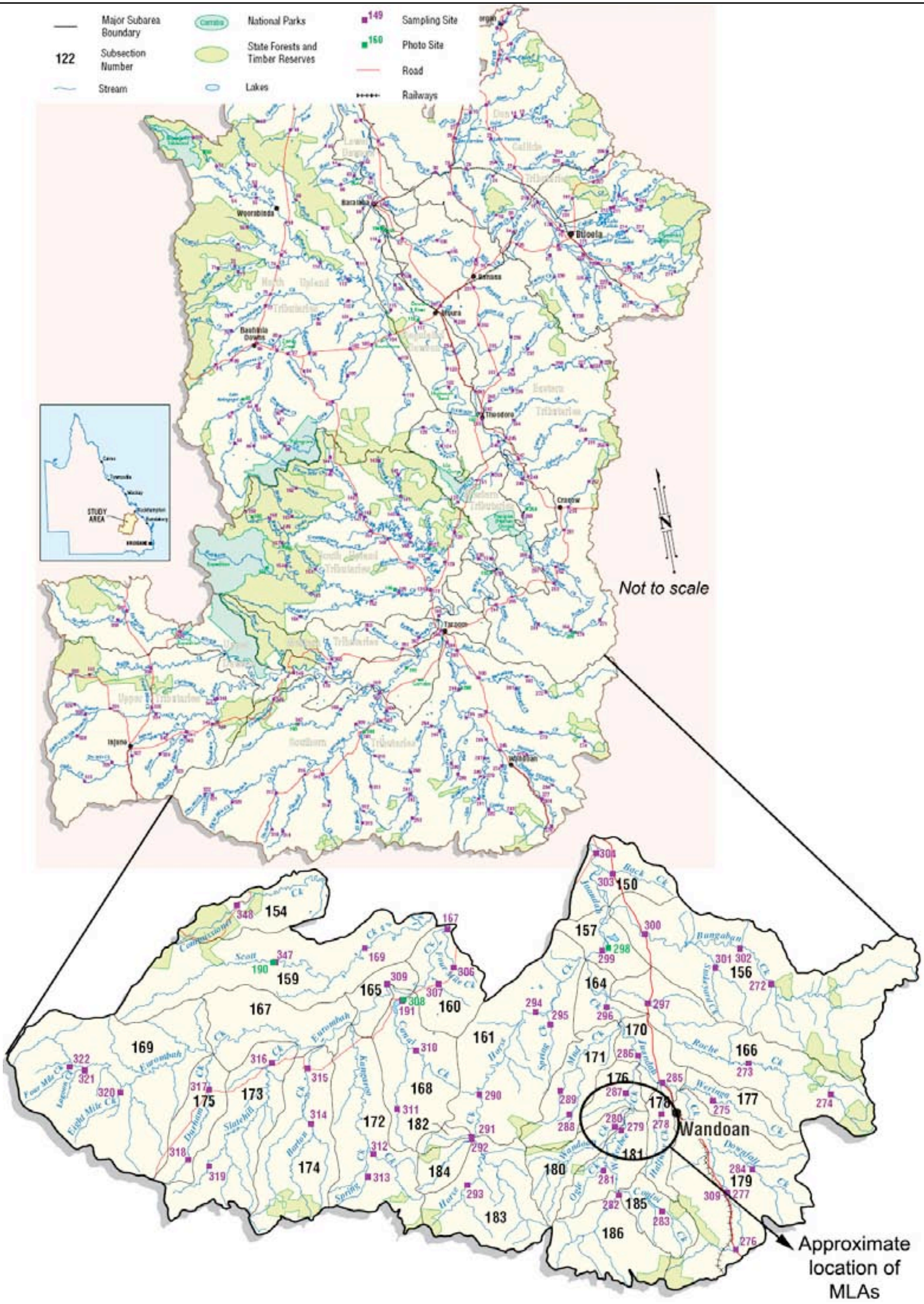
Fallen logs at Dogwood Creek (site 5).

Figure 4.13

Tree roots and branch piles at Wallan Creek (site 9).

4.1.2 A Regional and Ecological Perspective

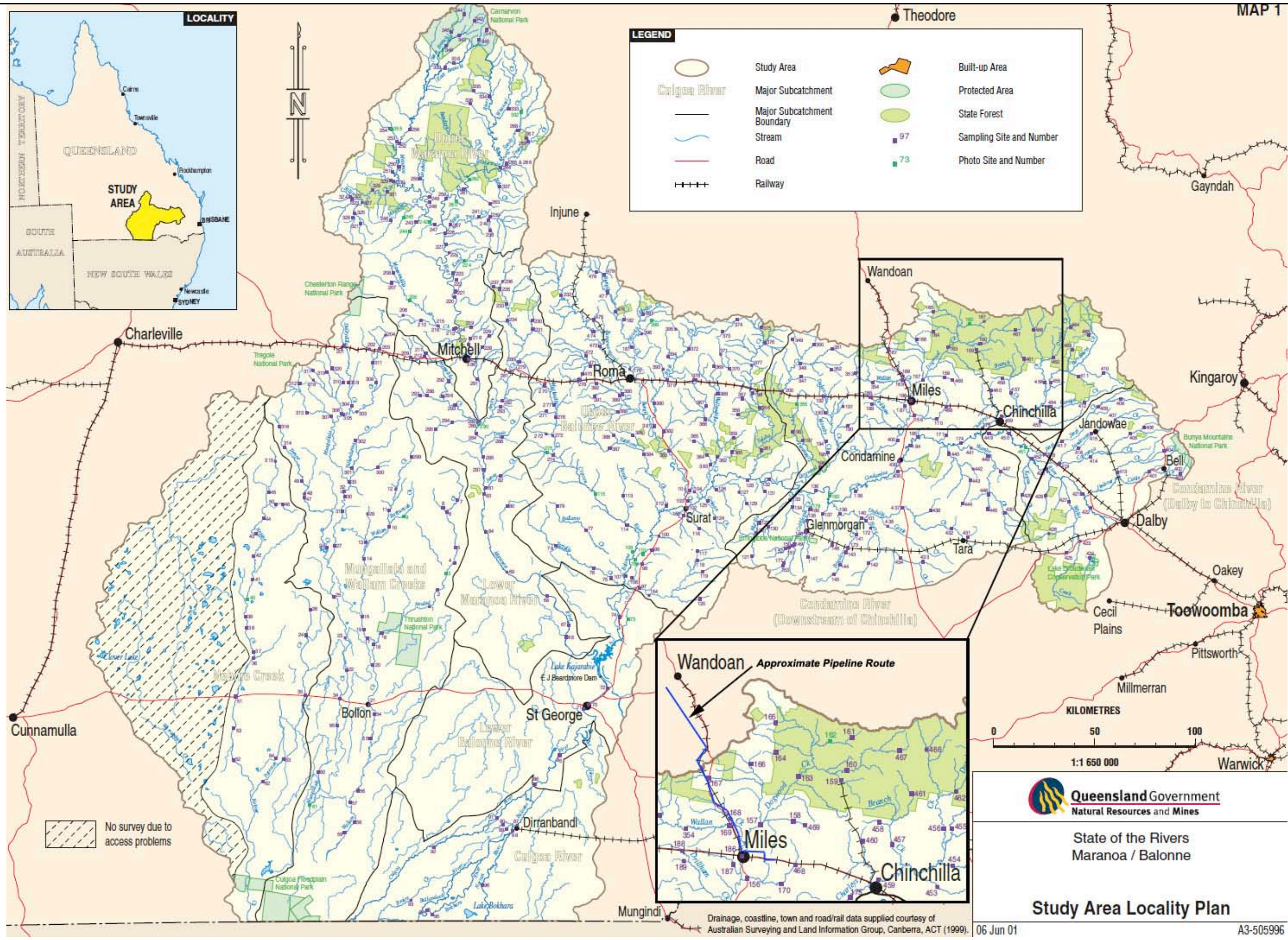
The following description of the aquatic habitat of the region is a summary of the *State of the Rivers* report for the Southern Tributaries Subcatchment of the Dawson River (Telfer 1995) (Figure 4.14) and the Condamine Subcatchment of the Maranoa, Balonne and Lower Condamine System (Van Manen 2001) (Figure 4.15).



Wandoan Coal Project EIS

Figure 4.14 The Dawson River Catchment, showing sites surveyed in the Southern Tributaries Subcatchment during the *State of the Rivers* assessment.

Adapted from Telfer 1995 | September 2008



frc environmental deep thinking. science.	Wandoan Coal Project: Southern Coal Seam Methane Water Supply Pipeline	
	Figure 4.15 The Maranoa, Balonne and Condamine River Catchments, showing sites surveyed near the southern CSM water supply pipeline route during the *State of the Rivers* assessment.	
	Adapted from Van Manen 2001	September 2008

The Dawson River Catchment

Reach Environs

The Southern Tributaries subcatchment covers 8,689 km^2, and includes the minor catchments of Juandah Creek in the east (Figure 4.14). There are approximately 2,258 km of streams in the subcatchment, and approximately 89% are in poor to moderate condition. Of the fifty-four sites surveyed within the subcatchment, 43% were highly disturbed (vegetation on one side of the stream was completed cleared, and vegetation on the other side was highly disturbed or had a significant weed presence) and 15% were extremely disturbed (the land of both sides of the stream was cleared or had a significant weed presence). Similar to the land use along the pipeline route in the Dawson River catchment, most of the land adjacent to the sites surveyed in the *State of the Rivers* assessment had been cleared, and were covered in native pasture for cattle grazing. Other disturbances included bridges, culverts, fords and forestry activities. Overall, it appears that many of the sites within the present study area are in a similar condition, and are affected by similar factors, to sites typical of the subcatchment.

Bank Stability

Similar to the banks of the creeks along the pipeline route in the Dawson River catchment, most stream banks in the Southern Tributaries Subcatchment were rated as stable. Bank aggradations were observed at 57% of sites and eroding banks were observed at 96% of sites. The presence of grazing stock, land clearing, man-made structures, flood scouring and eroded walking tracks negatively affected bank stability throughout the subcatchment. Similar impacts were seen throughout the present study area.

Bed and Bar Stability

Bed aggradations and erosion throughout much of the subcatchment is indicative of a dynamic stream. Bars were present at 46% of sites and many of these had formed around obstructions (26%) or channel points (26%). This is similar to the pattern of sediment deposition along the pipeline route in the Dawson River catchment.

Factors reducing stream bed stability throughout the subcatchment included the presence of stock, bank erosion and bed deepening, while fallen trees, rock outcrops and man-made structures provided stream bed stabilisation. Bed stability along the pipeline route in the Dawson River catchment had been affected by similar factors.

Channel Diversity and Habitat Types

Similar to the low channel diversity recorded in the creeks in the current study areas, channels across the subcatchment lacked diversity (diversity ratings ranged from low to moderate). The average depths of pools, runs and riffles throughout the subcatchment (measured from the watermark) were 1.0, 0.5 and 0.1 m, respectively. Average widths of pools, runs and riffles were 8.4, 8.5 and 7.4 m, respectively. Pools within the present study area were slightly shallower and narrower than the average size of pools across the subcatchment. Riffles were not recorded in the current study areas.

Sediments in the upper banks and stream beds varied from boulders to fine silt, and lower banks were composed of sand and fine silt. Organic matter made up between 5 – 20% of the sediment in pools, runs and riffle habitats. This is generally similar to the sediment composition recorded in the creeks along the pipeline route and throughout the study area (refer to Attachment A for the sediment composition at each survey site).

Riparian Vegetation

Across the subcatchment, riparian vegetation included trees, shrubs, vines, rushes, grasses, and mosses. The most dominant structural types were grasses (97%), trees 10 – 30 m (85%), trees <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.. Riparian vegetation along the pipeline route and across the study area, was also dominated by grasses but included fewer trees, rushes and herbs and forbs than other sites in the subcatchment.

Most of the riparian zones in the subcatchment were in very poor condition (70%), due to agricultural clearing and grazing. Weed species were recorded from 92% of sites; and within sites, weeds comprised an average of 23% of the vegetation. These were mostly burrs, milk weeds, Mexican poppies, thistles, rag weeds, rhodes grass, buffel grass, green panic and prickly acacia. Riparian zones within the present study area were generally also in poor to very poor condition and supported several of the same weed species.

Aquatic Habitat

Across the subcatchment, most aquatic habitats were rated as poor or very poor (69%). Stream cover was provided by forest canopy (16.4% of bank length), vegetation overhang (22.5%), root overhang (6.1%) and bank overhang (3.0%). Telfer (1995) suggested that poor riparian vegetation reduced the supply of vegetative debris, resulting in poor aquatic habitat. Aquatic habitat was also poor at most of the survey sites for this study, although there was a moderate amount of aquatic habitat at some of the higher stream order sites such as Juandah Creek.

Conservation Values

Aquatic, riparian and wildlife corridor habitat was assessed as being of high conservation value at 15%, 7% and 13% of sites, respectively. 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 (ratings for most categories were very low, and the bed and bank habitats were very unstable); 63% was in poor condition (ratings for most categories were low, and the bed and bank habitats were unstable); 23% was in moderate condition (ratings for most categories were moderate, and the bed and bank habitats were moderately stable); 7% was in good condition (ratings for most categories were high, and the bed and bank habitats were stable) and no sites were regarded as being in very good condition. Generally, the aquatic habitats of the sites surveyed during the present study were in moderate condition.

Condamine River Catchment

Reach Environs

The Condamine Catchment (downstream of Chinchilla) is 18,131 km^2 in area. The Dogwood Creek Subcatchment is 99.5 km^2 in area, and comprises <1% of the Condamine Catchment (Condamine Alliance 2005). There are approximately 3,636 km of streams in the subcatchment, and approximately 61% of the reach environs are in good or very good condition. Of the 109 sites surveyed within the subcatchment, 29% had low disturbance (intact vegetation on both sides of the stream, with minor disturbance from introduced species), 26% were moderately disturbed (cleared on one side of the stream, but native vegetation on the other side undisturbed), 26% were highly disturbed (vegetation on one side of the stream was completed cleared, and vegetation on the other side was highly disturbed or had a significant weed presence), 17% were very highly disturbed (the land of both sides of the stream was cleared or had a significant weed presence, but there was some native shoreline vegetation), and 2% were extremely disturbed (the land of both sides of the stream was cleared or had a significant weed presence, and there was little shoreline vegetation). Similar to the land use along the pipeline route in the Dogwood Creek catchment, most of the land adjacent to the sites surveyed in the *State of the*

Rivers assessment was cattle grazing, predominantly on thinned or cleared native vegetation. Other disturbances included bridges, culverts, fords, cultivation and forestry activities. Many of the sites surveyed within the present study areas were in a similar condition, with disturbance higher at sites adjacent to grazing lands than sites adjacent to state forest.

Bank Stability

Stream banks at 85% of sites surveyed in the Condamine Subcatchment were rated as stable or very stable. However, erosion was noted along the banks at the majority of sites, with some aggradation at bends and obstacles. Stock access, scouring from water flows and clearing of vegetation negatively affected bank stability throughout the subcatchment. Similar impacts were seen throughout the present study area.

Bed and Bar Stability

Stream beds were rated as stable or very stable at 87% of the sites surveyed. Bars had formed as mid-channel islands, and around obstructions and along the edge of the stream bed. This is similar to the pattern of sediment deposition along the pipeline route in the Condamine River catchment.

Factors reducing stream bed stability throughout the subcatchment included agricultural and grazing practices, bank erosion and bed deepening, while vegetation, fallen trees, rock outcrops and man-made structures provided stream bed stabilisation. Bed stability along the pipeline route in the current study area had been affected by similar factors.

Channel Diversity and Habitat Types

Similar to the low channel diversity recorded in the creeks in the current study areas, channels across the subcatchment lacked diversity (diversity ratings ranged from low to moderate). The average depths of pools, runs and riffles throughout the subcatchment (measured from the watermark) were 0.8, 0.5 and 0.3 m, respectively. Average widths of pools, runs and riffles were 10.1, 10.9 and 7.0 m, respectively. Pools within the present study area were slightly shallower and narrower than the average size of pools across the subcatchment (apart from at Dogwood Creek). Riffles were not recorded in the present study area.

Sediments in the upper banks and stream beds varied from boulders to fine silt, and lower banks were composed of sand and fine silt. Organic matter made up between 5 – 20% of the sediment in pools, runs and riffle habitats. This is generally similar to the sediment composition recorded in the creeks along the pipeline route and throughout the study area (refer to Attachment A for the sediment composition at each survey site).

Riparian Vegetation

Across the subcatchment, riparian vegetation included trees, shrubs, vines, rushes, grasses, and mosses. The most dominant structural types were grasses (65% cover), trees 10 – 30 m (37% cover) and trees <10 m (27% cover). Eucalypt woodlands and cypress pine forests were the dominant vegetation communities. Native species recorded included *Eucalyptus* spp., cypress pines (*Callitris* spp.), *Lomandra* spp., *Acacia* spp., and *Casuarina* spp.. Riparian vegetation along the pipeline route and across the study area, was also dominated by grasses, but almost always included eucalypt and acacia trees.

Most of the riparian zones in the subcatchment were in poor or very poor condition (68%), due to agricultural clearing and grazing. Weed species were recorded from 88% of sites; these were mostly exotic grasses and herbs, Mayne's pest (*Verbena tenuisecta*) and prickly pear. Riparian zones within the present study area were generally also in poor to very poor condition and supported several of the same weed species.

Aquatic Habitat

Across the subcatchment, most aquatic habitats were rated as poor or very poor (69%). Stream cover was provided by forest canopy (37.4% of bank length), vegetation overhang (38.2%), root overhang (5.2%) and bank overhang (5.5%). Logs, branches, leave and twigs and tree roots, provided in-stream habitat. Aquatic habitat was also poor at most of our survey sites, although there was a moderate amount of aquatic habitat at some of the higher stream order sites such as sites Wallen Creek and Dogwood Creek.

Conservation Values

Conservation values in terms of aquatic, riparian and wildlife corridor habitats was assessed as being poor or very poor at 16% of sites, moderate at 23% of sites and good to very good at 61% of sites.

Overall, 1% of the subcatchment was in very poor condition (ratings for most categories were very low, and the bed and bank habitats were very unstable); 22% was in poor condition (ratings for most categories were low, and the bed and bank habitats were unstable); 55% was in moderate condition (ratings for most categories were moderate, and the bed and bank habitats were moderately stable); 21% was in good condition (ratings for most categories were high, and the bed and bank habitats were stable) and 1% was in very good condition (ratings for most categories were very high, and the bed and bank habitats were very stable). Generally, the aquatic habitats of the sites surveyed during the present study were in moderate condition.

4.1.3 Summary

The study areas are in the Southern Tributaries (Taroom) Subcatchment and the Condamine River Subcatchment. The Southern Tributaries (Taroom) Subcatchment comprises approximately 17% of the Dawson River catchment, and 6.1% of the Fitzroy Basin. The Condamine River Subcatchment (as defined in the *State of the Rivers* report) comprises approximately 16% of the Maranoa, Balonne and lower Condamine system, and 1.7% of the Murray-Darling Basin.

The sites surveyed within the proposed pipeline alignment typically had a moderate Habitat Bioassessment Program assessment score. These relatively low scores were related to moderate to extensive bank erosion, low habitat variability (with no runs or riffles observed), and substrates dominated by finer sediments such as sand and silt.

Overall, the reach environs of the creeks surveyed have been moderately affected by human activities. Pasture, grazed and un-grazed forests are the dominant land uses surrounding the creeks of the southern pipeline alignment and in the broader area. Erosion at road crossings was a major form of disturbance. There has been some clearing of riparian vegetation across the pipeline alignment, although large trees still grow on the creek banks at many sites. Several road and fence crossings of creeks in the study area are likely to cause alterations of flow and restrict aquatic fauna passage under particular flow regimes. Similar impacts were observed throughout the Southern Tributaries and Condamine River subcatchments, although the extent of disturbance was lower throughout the Condamine subcatchment.

Riparian zone condition throughout the study area was poor and characteristic of the region. Riparian zones were generally 10 – 20 m wide and dominated by grasses. Riparian vegetation was dominated by native species, although similar to sites surveyed during the *State of the Rivers* assessments, exotic species were found at all sites. Erosion was prominent in waterways throughout the region, and there was some bank erosion at most sites in the study area.

Stream beds were relatively stable; however, there was scouring along outside meanders or downstream of obstructions, and deposition of sediments in pools or upstream of obstructions in places. Bars forming around obstructions or channel points are also a common feature of the streambeds in the region. Channel diversity was generally low to moderate in the region, and was extremely low across the pipeline alignment; isolated pools were the only habitat category observed. Pools within the study area were shallower and narrower than the average size of pools across the subcatchment, with the exception of Dogwood Creek.

Some physical aquatic habitat for fauna was found at most of the sites. In-stream physical habitat was typically in the form of tree roots and woody debris. In-stream habitat diversity was highest at sites with a higher cover of trees in the riparian zone and a higher cover of bank overhang vegetation. Throughout the region, disturbances to the riparian zone have led to a reduction in the cover and diversity of in-stream habitat such as large woody debris.

4.2 Water Quality

4.2.1 Of the Study Area

Water Temperature

Water temperature was between 10.6 and 20.4 °C in the sites that held water along the southern water supply pipeline route (Figure 4.16). Water temperatures were higher in Dogwood Creek, which may be related to the larger amount of water at this site. There are no guidelines available for water temperature (ANZECC & ARMCANZ 2000; EPA 2007a).

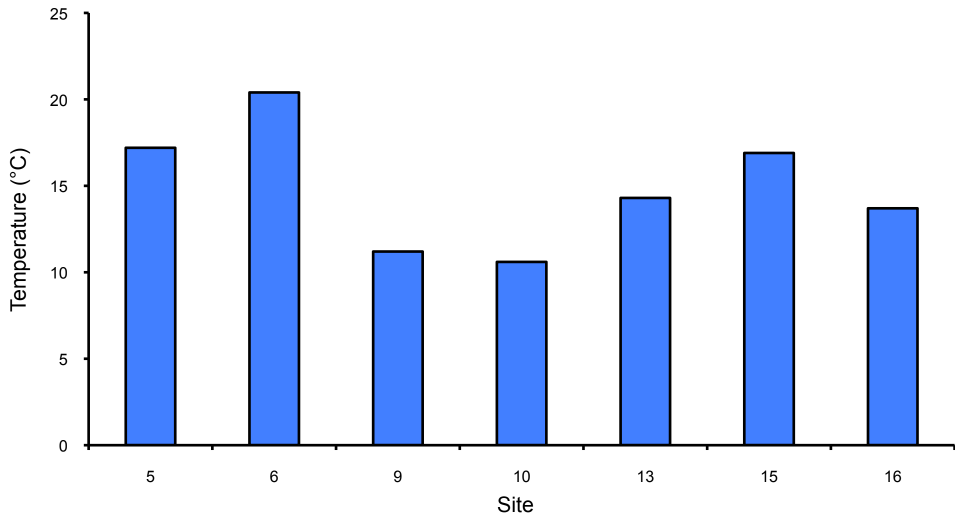


Figure 4.16 Water temperature at each site that held water along the southern water supply pipeline route.

Dissolved Oxygen

Dissolved oxygen (DO) levels were within the QWQG range in Wallan Creek (site 9), Eleven Mile Creek (site 10) and tributaries to Nine Mile and L Tree creeks (sites 13 and 15), but were below the QWQG range in Dogwood (sites 5 and 6) and L Tree creeks (site 16) (Figure 4.17). Low DO concentrations at Dogwood and L Tree creeks was probably due to high biological oxygen demand, low mixing, and shading.

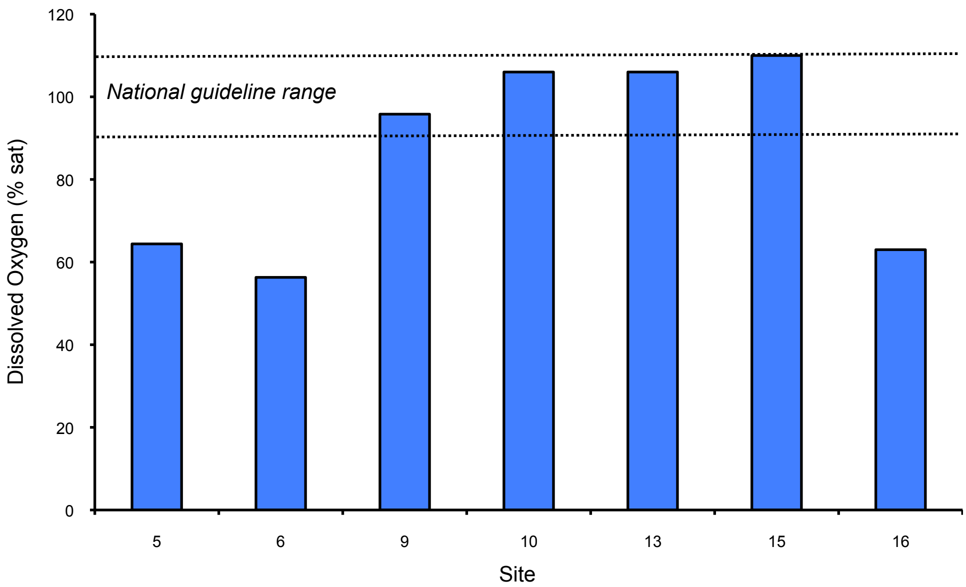


Figure 4.17 Dissolved oxygen at each site that held water along the southern water supply pipeline route, compared with the National water quality guideline for upland rivers (ANZECC & ARMCANZ 2000).

pH

pH tended to be acidic (< 7) across most sites, but it ranged from 5.6 at Dogwood Creek (site 5) to 7.8 at L Tree Creek (site 16) (Figure 4.18). Eleven Mile Creek (site 10) and a tributary to L Tree Creek (site 15) were the only creeks with a pH value within the National water quality guideline range. The pH at Dogwood (sites 5 and 6) and Wallan (site 6) creeks was below the guideline range, and the pH at L Tree Creek (site 16) and a tributary to Nine Mile Creek (site 13) above the guideline upper limit (Figure 4.18). Differences in pH between sites may be related to local geomorphology.

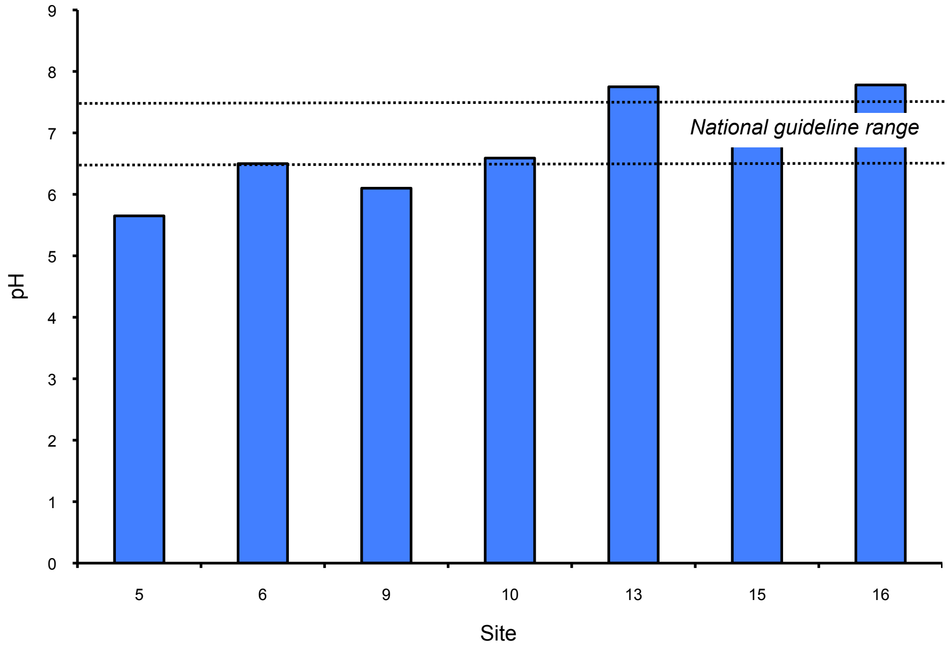


Figure 4.18 pH at each site that held water along the southern water supply pipeline route, compared with the National water quality guideline for upland rivers (ANZECC & ARMCANZ 2000).

Electrical Conductivity

Conductivity ranged from 37 μS/cm at Dogwood Creek (site 5) to 523 μS/cm at L Tree Creek (site 16) (Figure 4.19). Conductivity was below the QWQG upper limit (EPA 2007a) for all sites except Wallan and L Tree creeks. It should be noted that the QWQG value for conductivity is a preliminary guideline only (EPA 2007a).

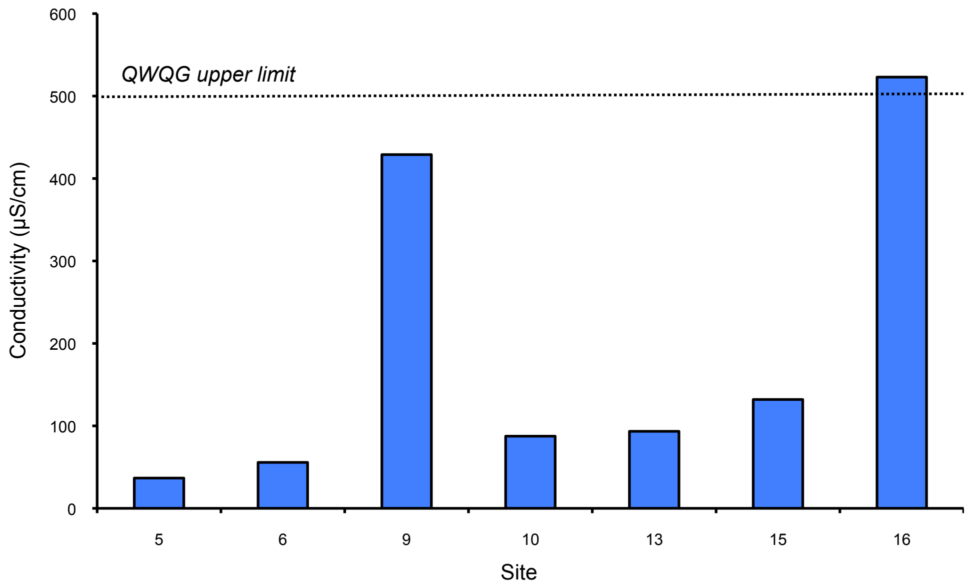


Figure 4.19 Electrical conductivity at each site that held water along the southern water supply pipeline route, compared with the QWQG upper limit for the Murray Darling region (preliminary guideline based on the 75th percentile of data from the Fitzroy central salinity zone; EPA 2007a).

Turbidity

No turbidity measurements were recorded at waterways along the southern water supply pipeline route. Turbidity was observed to be variable, but generally high, and was likely within the range of turbidity levels recorded in the MLA study area (refer to EIS Volume 1). Turbidity appeared to be particularly high in L Tree Creek, where there was a layer of very fine silt on the stream bed.

4.2.2 A Regional and Ecological Perspective

Dawson River Catchment

Agricultural land use dominates the Dawson River catchment; 77% of the area is grazed, 12% is State forest, 7% is cropped, and 3% is national park (EPA 2001). Within the Dawson River catchment there are eight subcatchments, which vary in their aggregate emission rates of nitrogen and phosphorus. In comparison with other Dawson River subcatchments, the upper Dawson River catchment is a moderate emitter of nitrogen and a light emitter of phosphorus (EPA 2001). Total nitrogen emitted from the Taroom

Subcatchment is approximately 0.95 kg/ha/year, and total phosphorus is 0.33 kg/ha/year (EPA 2001).

Grazing lands are the primary source of both nitrogen and phosphorus in the Dawson Basin (43 and 80%, respectively) (Joo et al. 2000). For nitrogen, the next biggest source is from State forests (39%), then cropping (9%) (Joo et al. 2000). For phosphorus, cropping is the source of second largest source, contributing 12% of the total, and State forests are the source of 4% of total phosphorus (Joo et al. 2000).

Fitzroy River Catchment

Water quality in the Fitzroy River catchment received a report card score of 'C' (fair) for freshwaters above the Fitzroy Barrage (near Rockhampton), 'F' (fail) for the barrage itself and 'D' (poor) for estuarine waters (when compared to other central Queensland catchments) (Meecham 2003).

Water quality in this catchment is compromised by (Meecham 2003):

- pesticide and herbicide contamination, particularly in irrigation areas;
- erosion and runoff increasing sedimentation and nutrients levels in waterways and reaching the Great Barrier Reef (GBR);
- high risk of blue-green algal bloom in still waters;
- rising salinity, particularly in stream 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; and
- substantial areas of poor riparian vegetation cover, particularly in the Dawson catchment and Central Highlands.

In the Fitzroy basin, between 1994 and 1996, surface DO concentrations ranged from 51 – 129% sat (Berghuis & Long 1999). The lower concentrations were below the QWQG whereas the upper concentrations were above the QWQG (range of 90 – 110 % sat for upland streams Central Coast region) (EPA 2007a). DO concentrations recorded during our survey were lower than those recorded by Berghuis & Long (1999).

In the Fitzroy basin, between 1994 and 1996, water temperatures ranged from 14.1 – 29 °C (Berghuis & Long 1999).

Land use in the Fitzroy River catchment is primarily agricultural; 90% of land is grazed and 6% is cropped (Noble et al 1996). Accordingly, levels of total nitrogen and phosphorus are elevated in the waterways (Noble et al 1996). Nutrient levels exceed the QWQG (EPA 2007a) values at times, especially during periods of moderate and high flows (based on data presented by Noble et al 1996).

Noble (et al 1996) reported the presence of the herbicide atrazine in 43% of streams in the Fitzroy River system. Concentrations were low and within the guidelines at that time. Residual cotton sprays such as endosulfan, prometryne and profenofos were also detected downstream from cotton irrigation areas. However, the results of aquatic invertebrate sampling suggested that the streams within the catchment possessed relatively diverse invertebrate communities. Overall the study concluded that life within the river system was fairly healthy, but that the significant flow events moved millions of tonnes of soil into the GBR lagoon, which in turn would carry any nutrients and pesticides present in the soil in to the GBR lagoon.

Condamine River Catchment

Generally, the Condamine-Balonne system is characterised by high turbidity that exceeds guideline values (DEWHA 2007). The highest turbidities actually occur in the less intensively cultivated lower reaches of the catchment, which indicates that the natural soil type of the region may be the cause of high turbidity recordings (DEWHA 2007). However, vegetation clearing and cattle grazing are known to cause erosion, and are likely to contribute to high turbidity (DEWHA 2007). No significant increases in turbidity have been reported in the Condamine catchment over the last decade; however, turbidity levels generally increase with distance downstream (DEWHA 2007). Nutrient levels can be high in the catchment, with total nitrogen concentrations of 2.14 mg/L and total phosphorus concentrations of 0.25 mg/L recorded in Dogwood Creek during a storm-flow event in 2005 (Waters 2006).

Agriculture in the Condamine catchment has a strong reliance on the use of pesticides and fertilisers. The herbicide atrazine can persist in both soil and water for long periods of time. Low levels of atrazine residues have been consistently detected in the aquatic environment, especially close to cropping lands (CA 2004). High surface water concentrations of atrazine and endosulfan have been recorded in up to 91% of samples from some weirs in the Uplands and the Upper Floodplain of the catchment (CA 2004).

Central Queensland

Overall, Central Queensland's water quality is of moderate condition but there are a number of issues that will be problematic unless they are remedied. Key issues 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; and
- changes to river flows.

4.2.3 Summary

DO concentrations complied with the QWQG, except at Dogwood and L Tree creeks (sites 5, 6, and 16). Low DO concentrations in L Tree and Dogwood Creeks were probably due to high biological oxygen demand and low mixing of the waters. High turbidity was probably related to sediment-laden runoff associated with clearing of riparian vegetation and erosion of steep banks. High turbidity is characteristic of region, in both the Dawson and Condamine catchments. Due to surrounding land uses, waterways within the region are impacted by relatively high inputs of nutrients, pesticides and other contaminants. 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).

4.3 Aquatic Flora

4.3.1 Of the Study Area

Aquatic vegetation provides physical structure for use by aquatic fauna (e.g. as a refuge habitat, or a substrate for fish to lay eggs upon), as well as a food source for herbivorous fauna and detritivores. Across the study area, aquatic vegetation was entirely native, although diversity was low and cover was sparse (at each site, total macrophyte cover was < 20%).

Up to nine species were recorded across the seven sites that held water (Table 4.1). All species had an emergent growth form; no floating or submerged species were recorded.

At all sites, cover by any one species was less than or equal to 10%, except for at Wallan Creek (site 9), where common reed (*Phragmites australis*) covered 20% of the lower bank and bed area.

Several macrophytes could only be identified to genus level, due to the absence of seeds or flowers. The most abundant and common macrophyte was the common rush (*Juncus usitatus*), which was present at six of the seven sites where macrophytes were observed (Figure 4.20).

Figure 4.20

Common rush was the most abundant and common macrophyte.

Figure 4.21

Lomandra sp. grew on the bank at Dogwood Creek (site 6).

Table 4.1 Percent cover of all aquatic macrophytes at each site, listed by growth form.

GROWTH FORM / Family / *Latin name*	Common name	Native / exotic	% Cover at Each Site 5	6	9	10	13	15	16
EMERGENT									
Amaranthaceae									
Alternanthera denticulata	lesser joy-weed	N					1		
Cyperaceae									
Cyperus sp.	unknown sedge	N				2			
Cyperus polystachos	bunchy sedge	N				2		10	
Cyperus exaltus	giant sedge	N					5		
Eleocharis acuta	common spikerush	N					1	5	
Graminae									
Phragmites australis	common reed	N	5	1	20	5			
Juncaceae									
Juncus usitatus	rush	N	5	3		2	2	2	5
Lomandraceae									
Lomandra sp.	rush	N	1	5			2		
Poaceae									
Eragrostris elongata	clustered lovegrass	N					5		
TOTAL			**11**	**9**	**20**	**11**	**16**	**17**	**5**

The limited cover of macrophytes, and in particular the lack of submerged species, is likely to be related to the largely ephemeral nature of the waterways and turbid water. Ephemeral waterways do not offer appropriate habitat for submerged macrophytes. Turbidity may not allow sufficient light penetration through the water column for the growth of macrophytes on the substrate. High turbidity could also prevent observation of submerged macrophytes through the water column.

Algae

Filamentous algae was also observed at Dogwood Creek (site 5 and 6) and had an estimated cover of 2%.

4.3.2 A Regional and Ecological Perspective

Very little information is available regarding aquatic macrophytes of the region.

Dawson River Catchment

State of the Rivers (Telfer 1995) sites in the subcatchment were dry at the time of sampling (91%), and sites with water did not support aquatic macrophytes. A similar result was obtained during a reconnaissance of the upper Dawson River catchment (frc environmental 2007).

frc environmental (2007) reported ten different species of macrophyte from seven sites, with richness ranging from 0 to 8 species at any one site. All aquatic macrophytes had an emergent growth form (there were no floating or submerged species).

Condamine River Catchment

The depth of visibility was 0.1 m at many sites surveyed during the *State of the Rivers* assessment (Van Manen 2001), which meant that an assessment of aquatic vegetation could not be completed at 55% of the sites surveyed in the subcatchment. However, at sites where aquatic vegetation was surveyed, submerged macrophytes were recorded at 38% of sites, including species such as water snowflake (*Nymphoides indica*), native watermilfoil (*Myriophyllum* spp.), and hornwort (*Ceratophyllum demersum*) (Van Manen 2001). Floating vegetation was only recorded at 4% of the sites surveyed, and included swamp lilies (*Ottelia ovalifolia*), nardoo (*Marsilea mutica*) and *Azolla* spp. (Van Manen 2001).

Emergent vegetation was the most common form of macrophyte in the subcatchment, with common species including common reed (*Phragmites australis*), cumbungi (*Typha* spp.), water ribbons (*Triglochin procerum*) and the introduced weed species para grass (*Urochloa mutica*) (Van Manen 2001).

4.4 Aquatic Macro-invertebrate Communities

4.4.1 Of the Study Area

Each of the sites surveyed in the area were within the Dogwood Creek Subcatchment, as no sites within the Juandah Creek Subcatchment held water. Non-biting and phantom midge larvae (sub-family Chironominae and Chaoboridae), diving beetles (family Dyticidae), water bugs (family Corixidae) and water fleas (family Cladocera) dominated the invertebrate communities of the study area.

Richness

Taxonomic richness (the number of macro-invertebrate taxa, generally families, per sample) ranged from 3 to 9 in bed habitats and 6 to 24 in edge habitats at the sites surveyed. Richness was highest in the edge habitats at Dogwood Creek (sites 5 and 6). Richness was also high at the tributary to Nine Mile Creek (site 13) (Figure 4.22). This may be related to high edge habitat diversity at these sites.

Generally, richness was higher in edge habitats than bed habitats at most sites. This is to be expected, as edge habitats provided more diverse habitat. The exception was at a tributary to L Tree Creek (site 15), where richness was higher in bed habitats, probably due to the habitat provided by cobles at this site.

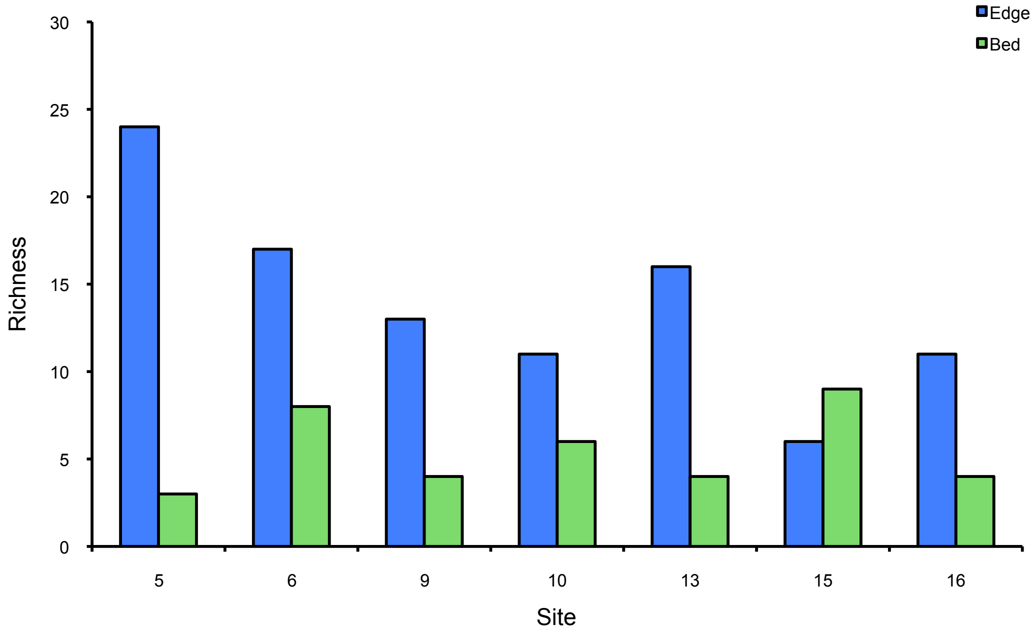


Figure 4.22 Taxonomic richness of macro-invertebrate communities in edge and bed habitats of the study area.

PET Richness

In general, PET richness (a measure of pollution-sensitive invertebrate taxa richness) of <1 is indicative of degraded water or habitat quality, PET richness of 1 – 4 is considered to indicate moderate water / habitat quality, and PET richness of >4 indicated good water / habitat quality. PET richness in edge habitats at Dogwood Creek (site 5), Eleven Mile Creek (site 10) and a tributary to Nine Mile Creek (site 13) was indicative of moderate water and habitat quality (Figure 4.23).

There were no PET taxa recorded from bed habitats at Dogwood Creek (site 5 and 6), Wallan Creek (site 9), Eleven Mile Creek (site 10), tributary to Nine Mile Creek (site 13), or at L Tree Creek (site 16). A tributary to L Tree Creek (site 15) was the only site with PET taxa recorded from bed habitats; this may be due to cobbles in the substrate at this site providing habitat diversity.

The low abundance of PET taxa at most sites may be due to the ephemeral or intermittent nature of these waterways. By their nature, ephemeral streams are commonly subject to a range of severe (natural) stresses, such as nutrient enrichment, turbidity and salinity (Chessman, B. [Centre for Natural Resources NSW] pers. comm. 2003, 21 October), and as a consequence, PET families are not commonly abundant in these environments.

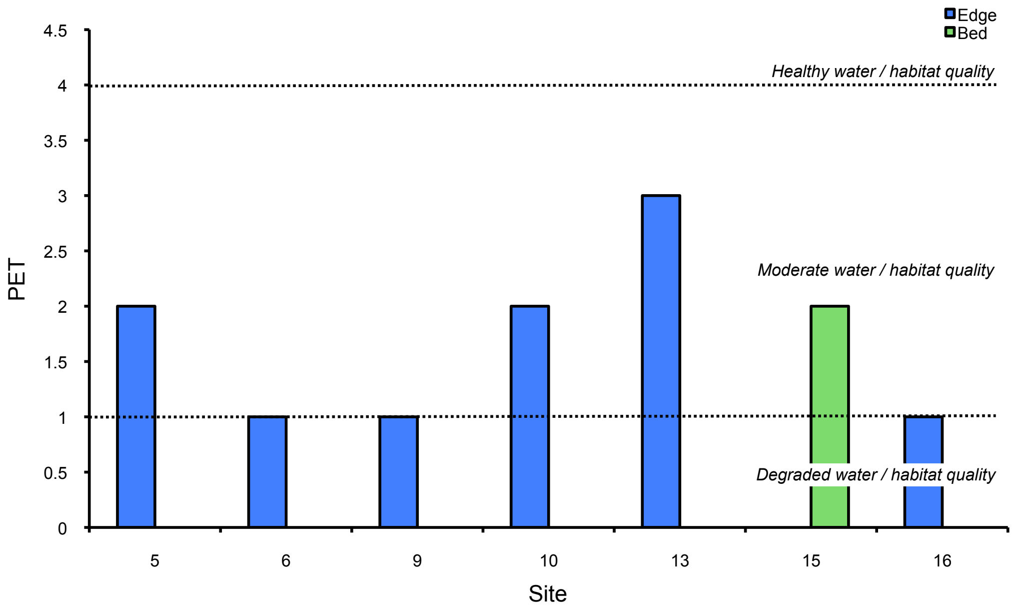


Figure 4.23 PET richness of macro-invertebrate communities in edge and bed habitats of the study area.

SIGNAL 2 / Family Bi-plots

The interpretation of SIGNAL 2 indices in conjunction with the number of macro-invertebrate families recorded, enables the simple characterisation of aquatic macro-invertebrate communities. Quadrant boundaries for the SIGNAL 2 / Family Bi-plot used for this study are interim suggested boundaries (Chessman 2001) for Australian freshwaters (excluding the Murray – Darling Basin and rivers east of the Great Dividing Range in Queensland). Recently, an alternative approach has been recommended, which includes boundary setting for each study (Chessman 2003). This technique would require considerable sampling (in effect calibration) within the region, which is beyond the scope of this study. Interpretation of the bi-plot with regard to quadrant boundaries should therefore be approached with caution.

Macro-invertebrate communities surveyed from bed and edge habitats throughout the study area were generally within quadrant 4 of the bi-plot (Figure 4.24), which indicates that these communities may be impacted by urban, industrial or agricultural pollution. The communities sampled from edge habitats at Dogwood Creek (site 5 and 6) and a tributary to Nine Mile Creek (site 13) were within quadrant 2, which may indicate that communities here are affected by high salinity or nutrient levels (which may be natural).

It is likely that the waterways of the study area are subject to agricultural pollution (e.g. nutrient enrichment) from the surrounding land uses. However, for ephemeral and intermittent waterways such as those in the study area, the interim boundaries for the SIGNAL 2 / Family Bi-plots may not adequately distinguish sites that are impacted by anthropogenic disturbance from those that are naturally impacted (B. Chessman [NSW Centre for Natural Resources], pers. comm. 2003, 21 October). It is recommended that only limited interpretation should be made of the absolute position of scores within the matrix.

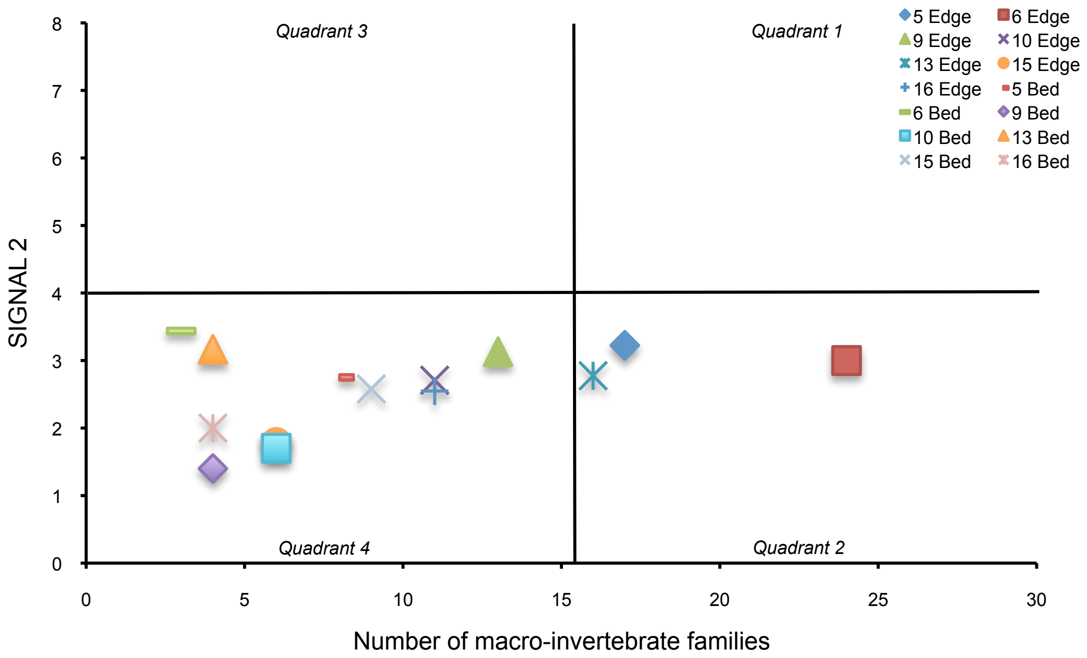


Figure 4.24 SIGNAL 2 / Family Bi-plot for the macro-invertebrate communities sampled from edge and bed habitats in the study area.

4.4.2 Macro-Crustacean Communities

An estimated 201 macro-crustaceans were captured across the seven sites surveyed for aquatic fauna. Abundance was highest at Dogwood Creek (site 5), Wallan Creek (site 9) and Eleven Mile Creek (site 10) where between 42 and 71 individuals were captured per site (Figure 4.25). Very few macro-crustaceans were captured at Dogwood Creek (site 6) and a tributary to Nine Mile Creek (site 13).

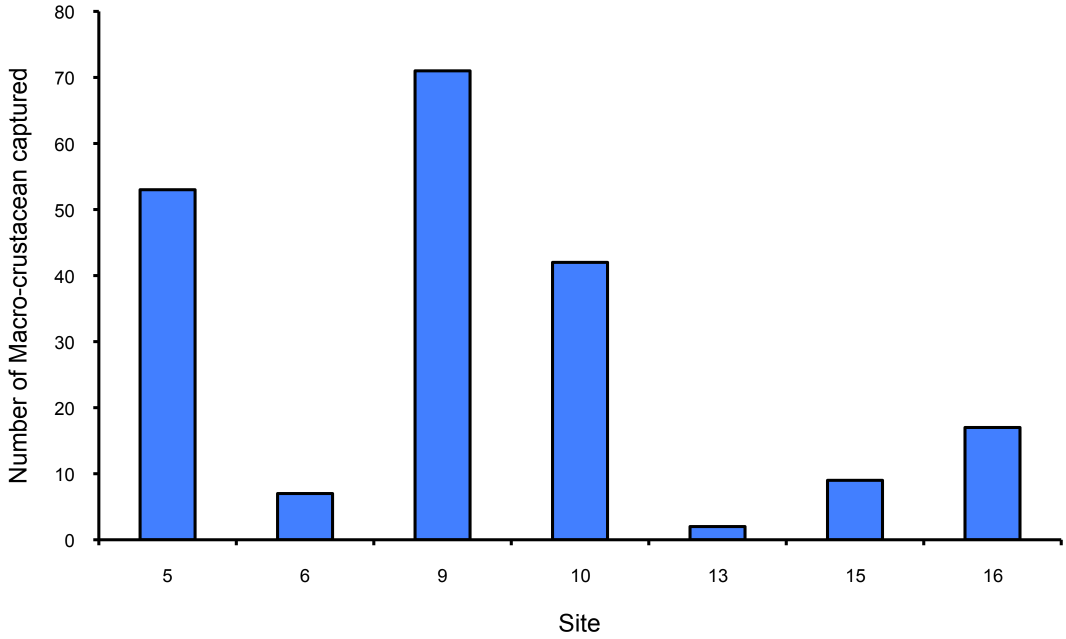


Figure 4.25 Macro-crustacean abundance at each site.

Across the seven sites surveyed, four macro-crustaceans species were positively identified (Table 4.2). Freshwater shrimp (*Paratya* sp) was the most common and abundant species and was recorded at five of the seven sites surveyed. *Cherax depressus* (orange-fingered yabby) was the second most abundant species. This species was found at Wallan Creek (site 9), Eleven Mile Creek (site 10), tributary to L Tree Creek (site 15) and L Tree Creek (site 16) but was most abundant at Eleven Mile Creek (site 10) and L Tree Creek (site 16).

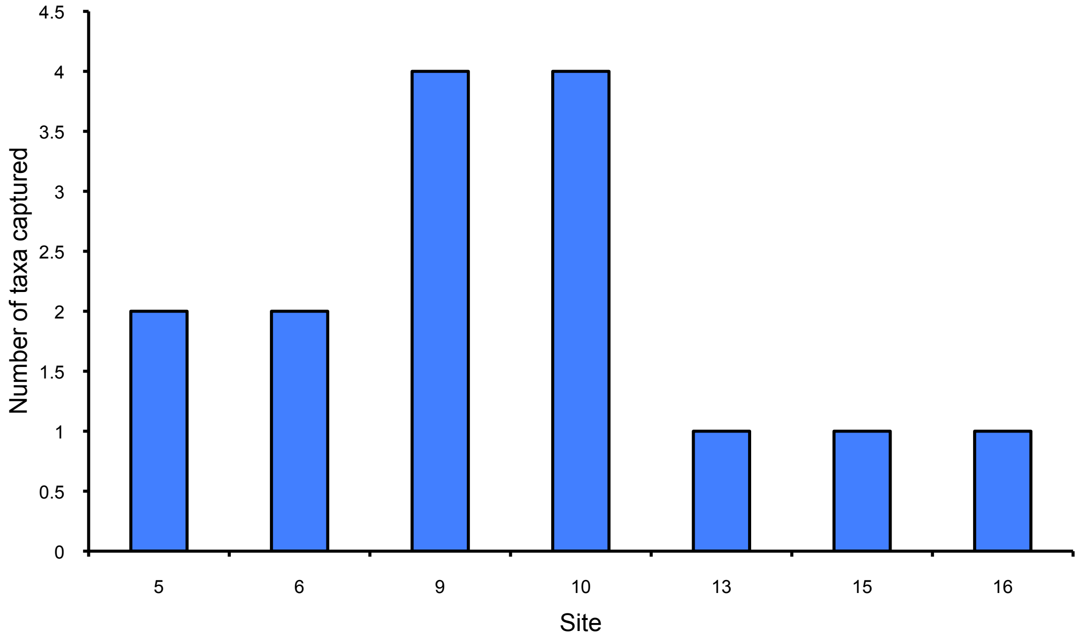


Figure 4.26 Richness of macro-crustaceans at each site.

All four species of macro-crustacean were captured at Wallan and Eleven Mile Creeks (sites 9 and 10) (Table 4.2). Richness was two species at each site in Dogwood Creek (sites 5 and 6) and 1 at each of the other sites surveyed.

Table 4.2 Abundance of macro-crustaceans at each site (all survey methods combined).

Family	Latin Name	Common Name	5	6	9	10	13	15	16
Atyidae	*Caradina sp.*	freshwater shrimp	5	-	1	1	-	-	-
Atyidae	*Paratya sp.*	freshwater shrimp	48	6	64	21	2	-	-
Palaemonidae	*Macrobrachium sp.*	river prawn	-	1	3	3	-	-	-
Parastacidae	*Cherax depressus*	orange fingered yabby	-	-	3	17	-	9	17

4.4.3 A Regional and Ecological Perspective

Macro-Invertebrate Communities of the Dawson River Catchment

Richness

Sandy pool habitats sampled by DNRW in the Dawson River supported between 7 – 18 families per sample, and rocky pool habitats supported between 10 – 25 families per sample (Figure 4.27 and Figure 4.28). Sites within the Juandah Creek Subcatchment are likely to contain fewer macro-invertebrate taxa than this site, as these creeks do not hold permanent water, which would provide a more stable habitat for macro-invertebrates. For example, bed habitats in Frank and Juandah Creeks near the northern extent of the southern CSM water supply pipeline alignment supported less than four taxa (refer to Aquatic Ecology Technical Report of Chapter 17B in Volume 1).

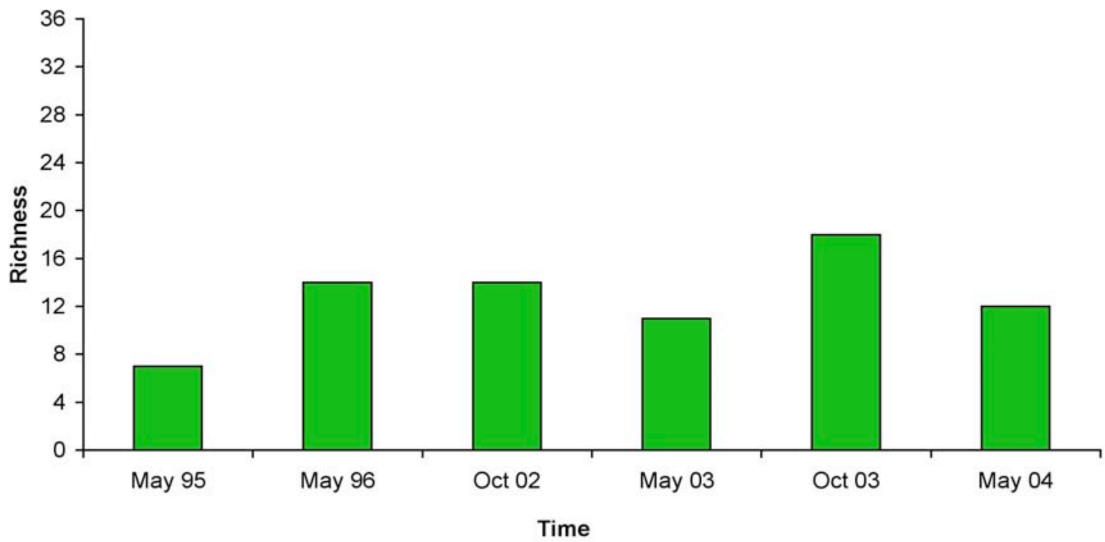


Figure 4.27 Taxonomic richness in sandy pool habitat of the Dawson River at Taroom (DNRW site 130302A).

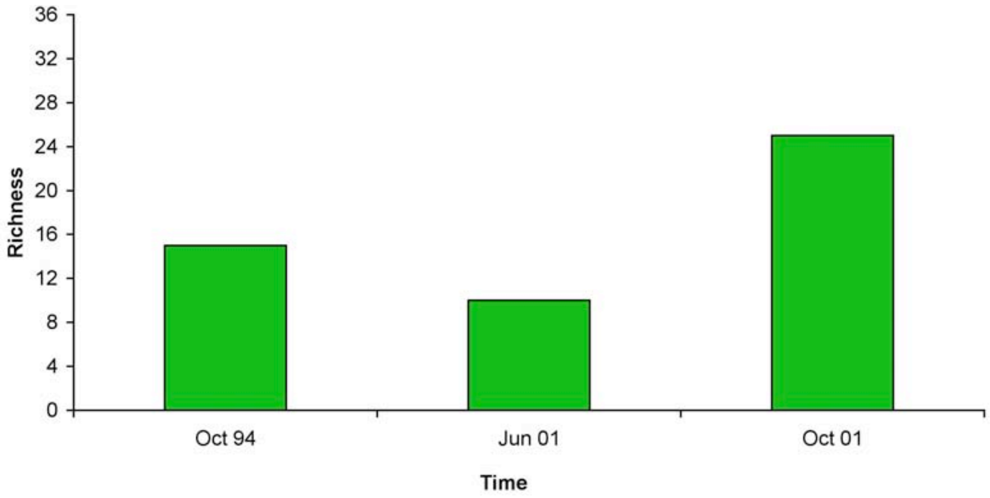


Figure 4.28 Taxonomic richness in rocky pool habitat of the Dawson River at Taroom (DNRW site 130302A).

Macro-invertebrate community richness for edge habitats in the Dawson River was higher than the richness found in bed communities. Taxonomic richness ranged between 17 and 32 at the DNRW sampling site on the Dawson River at Taroom (Site 130302A) from 1994 – 2004 (refer Figure 4.29). This is a relatively high richness, and is likely to be indicative of relatively good quality edge habitat and water quality at this site. Similar to bed habitats, ephemeral waterways of the Juandah Creek catchment, surveyed near the northern extent of the southern CSM water supply pipeline alignment, supported fewer taxa than the permanent waters of the Dawson River (< 18 taxa per site, refer to Aquatic Ecology Technical Report of Chapter 17B in Volume 1).

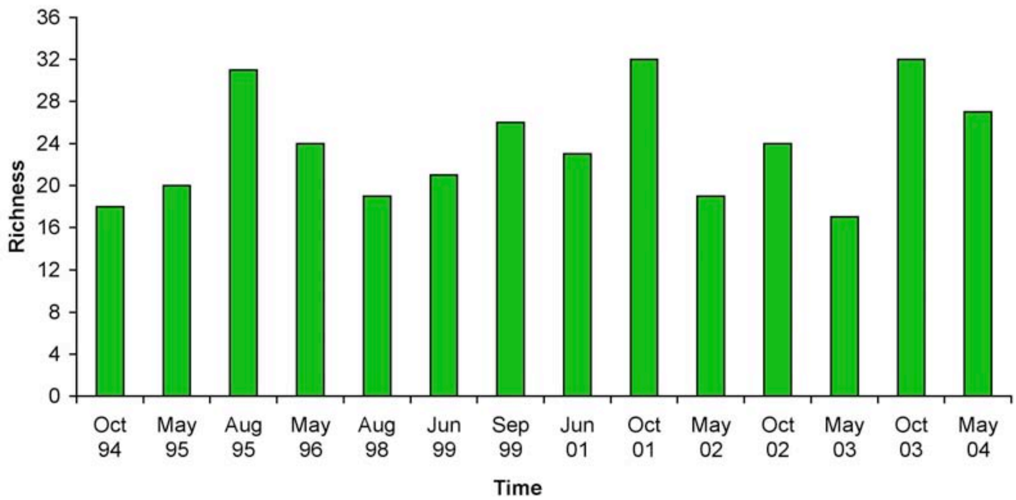


Figure 4.29 Taxonomic richness in edge habitat of the Dawson River at Taroom (DNRW site 130302A).

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 (Figure 4.30 – Figure 4.32). PET Richness varied over time, but was generally higher than the PET richness that has been recorded in the Juandah Creek Subcatchment (see Aquatic Ecology Technical Report of Chapter 17B in Volume 1).

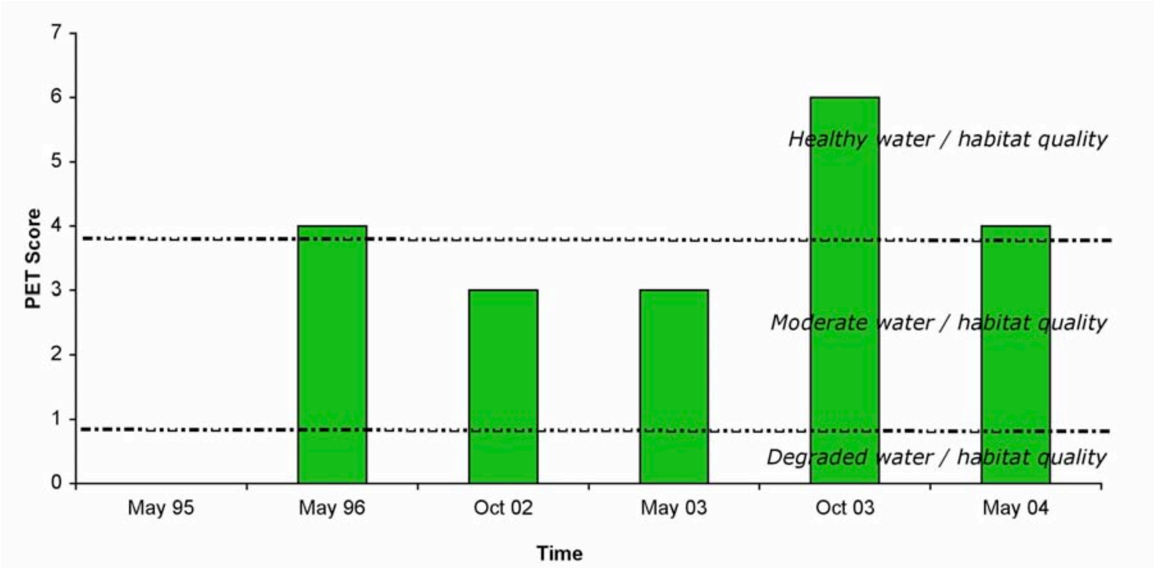


Figure 4.30 PET richness in sandy pool habitat of the Dawson River at Taroom (DNRW site 130302A).

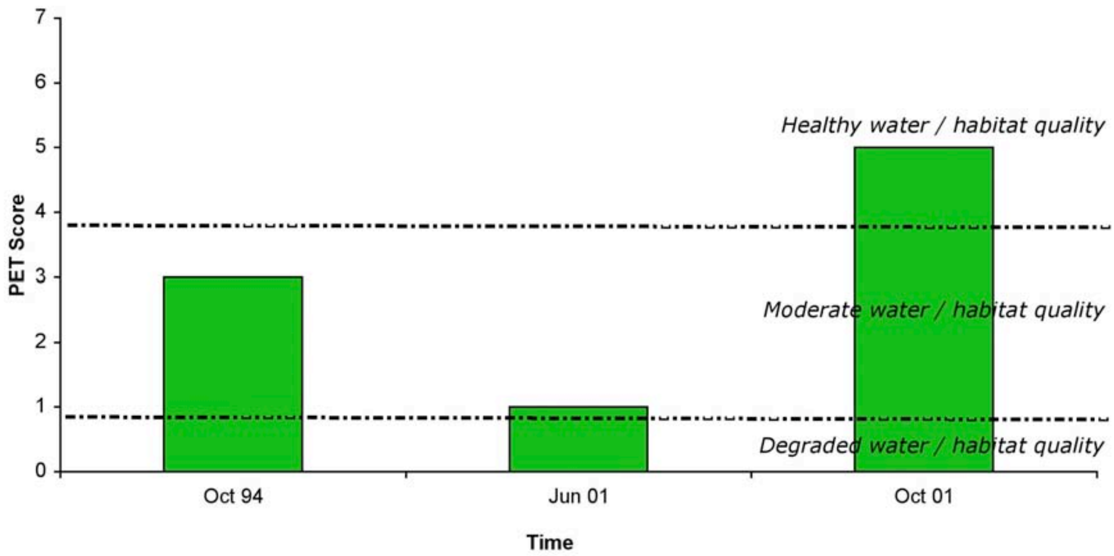


Figure 4.31 PET richness in rocky pool habitat of the Dawson River at Taroom (DNRW site 130302A).

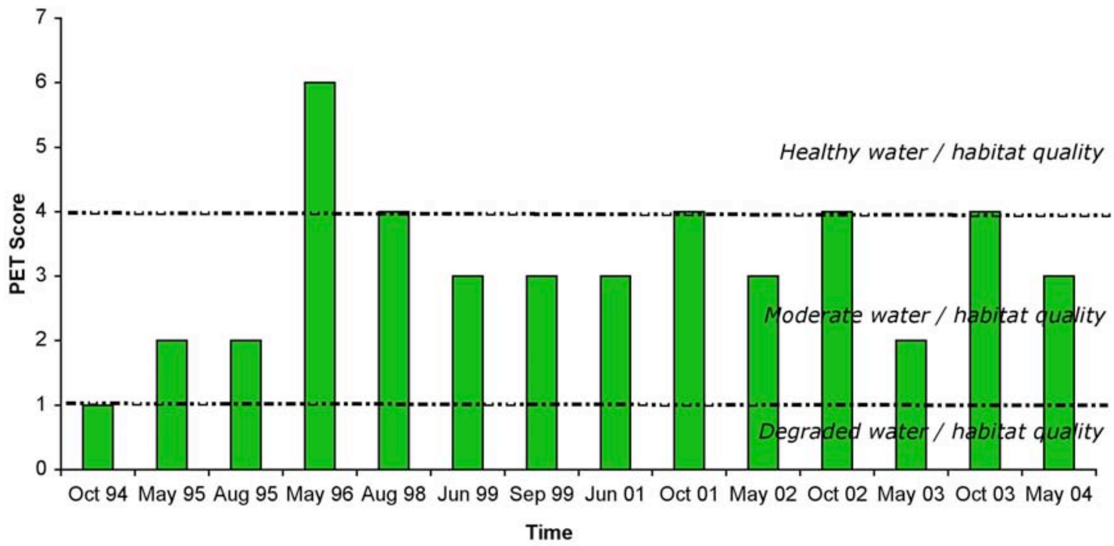


Figure 4.32 PET richness in edge habitat of the Dawson River at Taroom (DNRW site 130302A).

SIGNAL 2 / Family Bi-plots

The SIGNAL 2 / family bi-plots 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 (Figure 4.33 – Figure 4.35; Attachment B). Similar results would be expected for the waterways within the Juandah Creek Subcatchment that are crossed by the southern CSM water supply pipeline route.

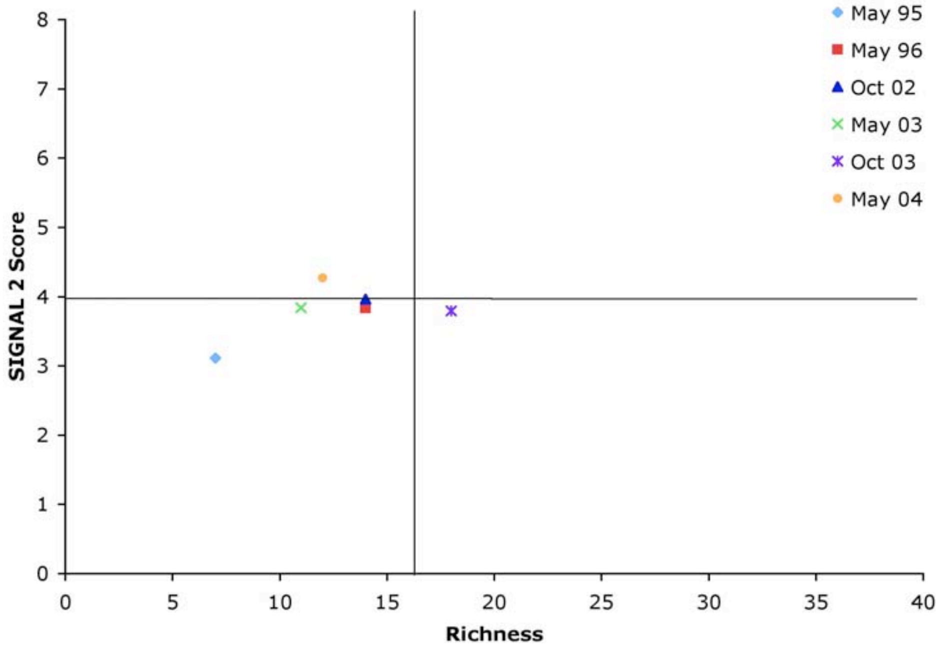


Figure 4.33 SIGNAL 2 / family bi-plot for sandy pool habitat of the Dawson River at Taroom (DNRW site 130302A).

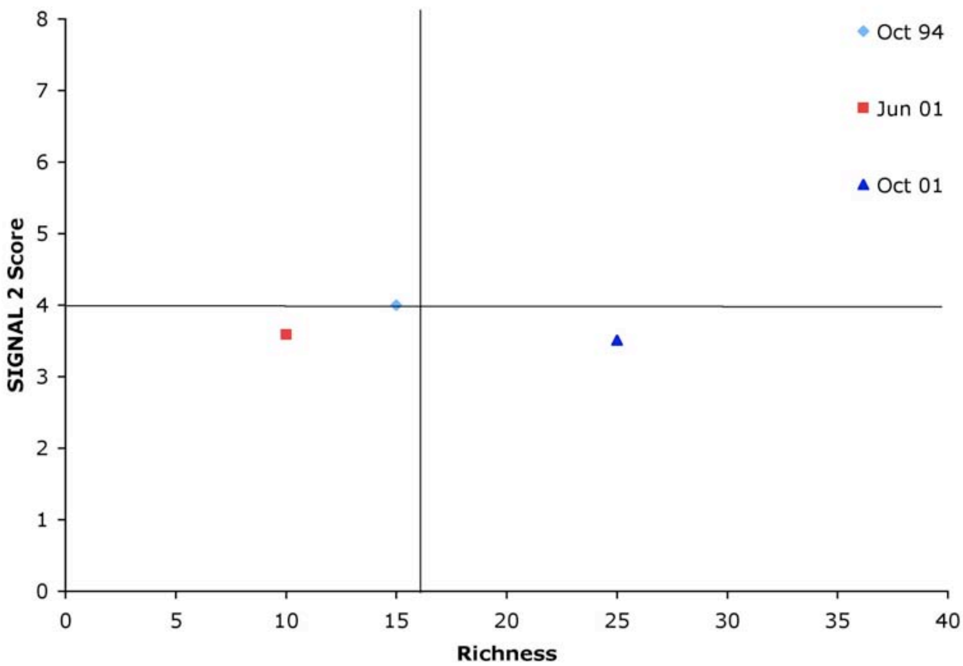


Figure 4.34 SIGNAL 2 / family bi-plot for rocky pool habitat of the Dawson River at Taroom (DNRW site 130302A).

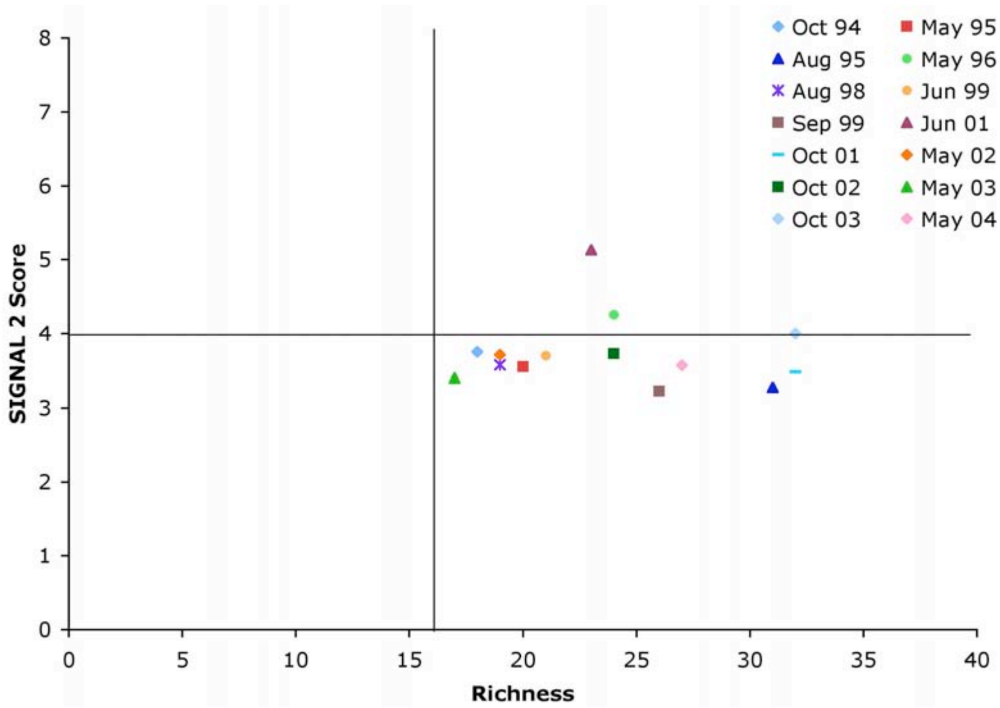


Figure 4.35 SIGNAL 2 / family bi-plot for edge habitat of the Dawson River at Taroom (DNRW site 130302A).

Macro-Invertebrate Communities of the Condamine River Catchment

Richness

DNRW sampled Dogwood Creek at Paradise Crossing (site 4222059) from edge, sandy and rocky pool habitats between 1998 and 2004 (Figure 4.36). Macro-invertebrate richness varied over time, ranging from 14 to 25 in edge habitats, 5 to 21 in rocky pool habitats and was 5 in sandy pool habitat when it was sampled on October 2003 (Figure 4.36). Richness at Dogwood Creek (sites 5 and 6) in the present survey was within the range found at the DNRW site, with 17 to 24 macro-invertebrate taxa found in edge habitats, and 3 to 8 taxa found in bed (sandy pool) habitats (Figure 4.29). Macro-invertebrate Richness in Dogwood Creek during the DNRW and present survey tended to be higher than the richness recorded in other creeks within the Dogwood Creek Subcatchment that are crossed by the southern CSM water supply pipeline route.

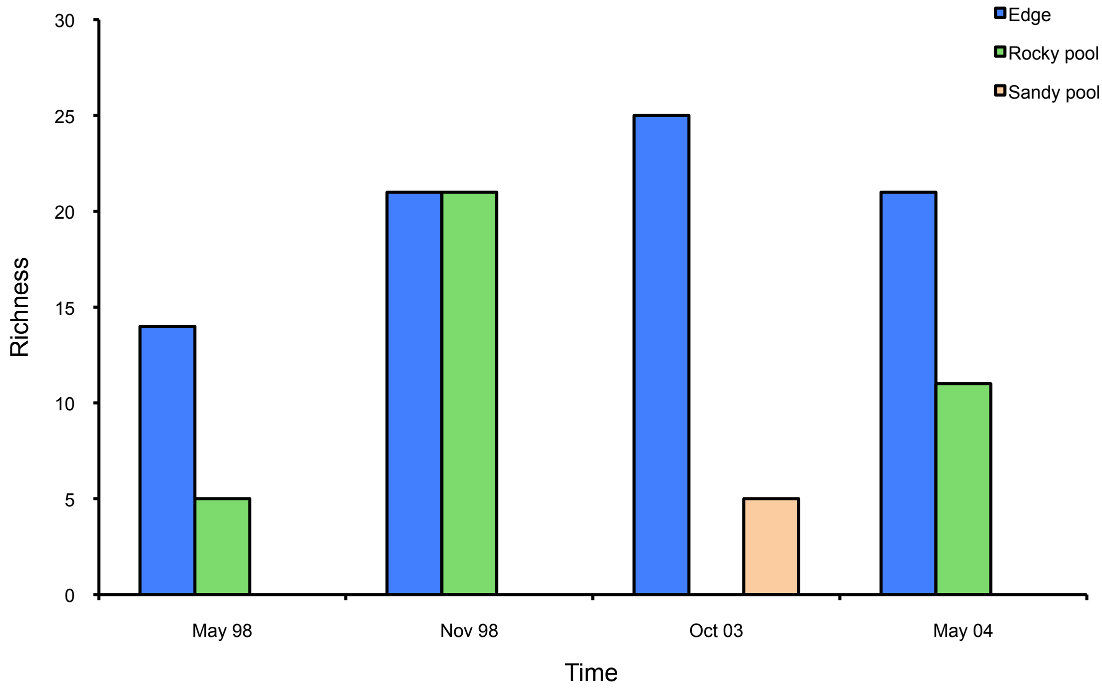


Figure 4.36 Taxonomic richness in edge, rocky and sandy pool habitats of Dogwood Creek at Paradise Crossing (DNRW site 4222059).

PET Richness

The PET Richness of edge, rocky and sandy pool habitats in Dogwood Creek at Paradise Crossing was indicative of moderate to healthy habitat and / or water quality (Figure 4.37). PET Richness varied over time, but was generally higher than the PET richness recorded in the study area and Dogwood Creek during the present surveys.

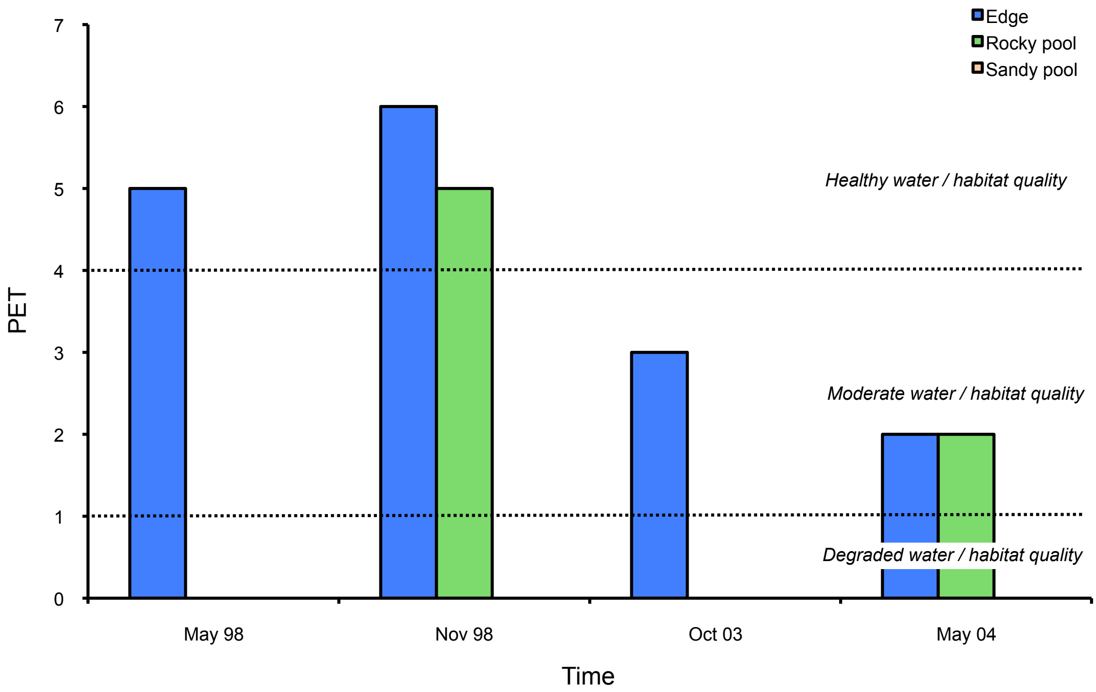


Figure 4.37 PET richness in edge, rocky and sandy pool habitats of Dogwood Creek at Paradise Crossing (DNR&W site 4222059).

SIGNAL 2 / Family Bi-plots

The SIGNAL 2 / family bi-plots for communities sampled from Dogwood Creek are indicative of poor to fair habitat and water quality in the Condamine River. The macro-invertebrate communities may be affected by high nutrient or salinity levels, urban or agricultural pollution, and / or harsh physical conditions (Figure 4.38; Attachment B).

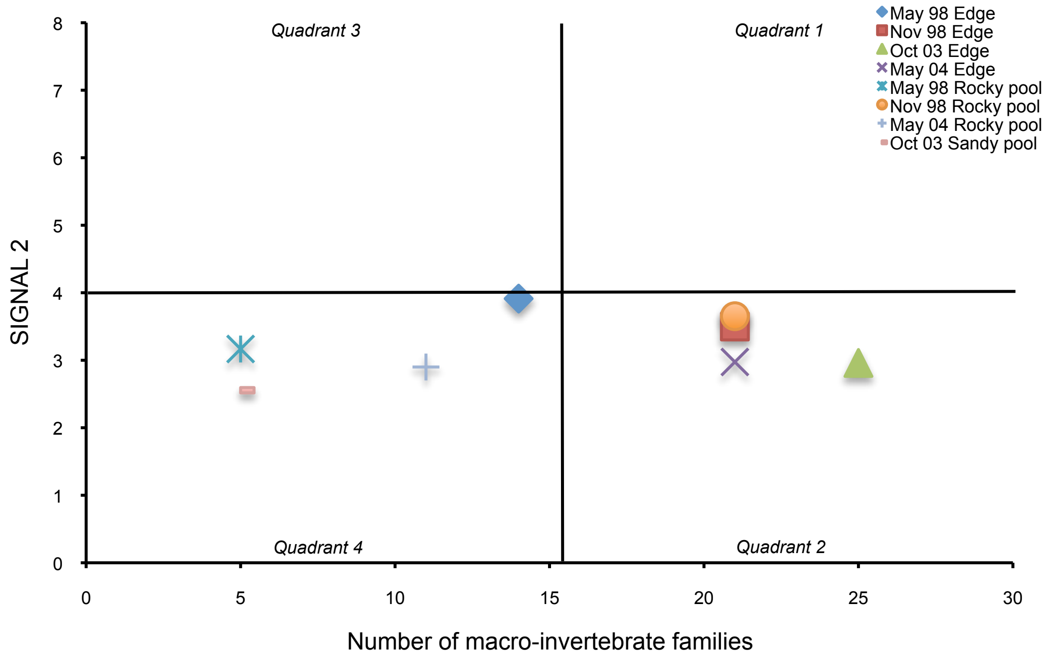


Figure 4.38 SIGNAL 2 / family bi-plot for edge, rocky and sandy pool habitats of Dogwood Creek at Paradise Crossing (DNR&W site 4222059).

Macro-Crustacean Communities of the Dawson River Catchment

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

Parastacids (freshwater crayfish), the largest freshwater invertebrate family, are common in a variety of habitats such as lakes, streams, ponds and swamps. *Cherax* is a common genus of this family, and is also known as the yabby. Yabbies are omnivorous, and feed on decaying plant matter, aquatic invertebrates and fish. They are able to aestivate in their burrows (which may be up to 2 m deep) to survive droughts (Gooderham & Tsyrlin 2002). *Cherax* are moderately tolerant to poor water quality (Chessman 2003), including low dissolved oxygen levels, therefore allowing them to survive in ephemeral streams that are impacted by surrounding land-uses.

Freshwater prawns (*Macrobrachium* sp.), unlike yabbies, are not resistant to desiccation and therefore mostly inhabit permanent waterbodies (Williams 1980). Freshwater prawns tend to be more common in more permanent waterways, and feed on decaying organic matter (Gooderham & Tsyrlin 2002). Atyid shrimps are more tolerant of seasonal drying of creeks and rivers, breeding when creeks become a series of poorly connected pools

(Gooderham & Tsyrlin 2002). However for the first months of their lives the shrimp have a planktonic stage (Gooderham & Tsyrlin 2002) and are therefore unable to survive complete drying of the pools at such time.

The freshwater crab (*Austrothelphusa* sp., formerly *Holthuisana* sp.) is widespread throughout Australia and is well adapted to living in ephemeral streams (Jones & Morgan 1994).

Macro-Crustacean Communities of the Condamine River Catchment

No specific information regarding the macro-crustacean communities of the Condamine Catchment could be found. Crayfish, shrimp and prawns (identified to family level) were all collected in the DNRW macro-invertebrate samples collected from Dogwood Creek, and based on the results of the present survey, the species within this catchment have similar environmental tolerances as those found in the Dawson Catchment, as described above.

4.4.4 Summary

Aquatic macro-invertebrate community structure within the study area was generally indicative of poor – moderate habitat and / or water quality, reflecting the results of water quality and aquatic habitat assessments at the sites (see Sections 4.1 & 4.2). Differences in macro-invertebrate community structure appeared to be related to site-specific differences in habitat availability and diversity. Freshwater crabs, crayfish and prawns / shrimp were common in the study area.

In general, the macro-invertebrate communities of the downstream Dawson River are likely to be more diverse and contained more taxa sensitive to pollution and disturbance than communities within the Juandah Creek catchment that are crossed by the southern CSM water supply pipeline. Macro-invertebrate communities of Dogwood Creek were generally indicative of better conditions than those sampled in smaller tributaries within the subcatchment. The larger waterways in the study area are likely to have more permanent water, and therefore offer more stable habitat for macro-invertebrates. In contrast, the communities living within the smaller creeks of the study area are influenced by harsh physical conditions, such as the drying of pools.

4.5 Fish Communities

4.5.1 Of the Study Area

In total, 503 fish from eleven species were captured across the seven sites surveyed. Abundance varied across the sites, with no fish caught on L Tree Creek (site 16) to 147 fish caught at the tributary to Nine Mile Creek (site 13) (Figure 4.39 & Table 4.6).

Species richness ranged from no species at L Tree Creek (site 16) to 7 species at Dogwood Creek (site 6) (Figure 4.40). Species richness and abundance at each survey site was likely related to site-specific factors such as the size of the pool surveyed, the presence and abundance of physical habitat such as large woody debris and fish passage within the waterway. For example, there was a high richness and abundance of fish in Dogwood Creek, which was characterised by good riparian cover, good in-stream habitat cover such as large woody debris and relatively good water quality. In contrast, species richness and abundance was low at sites 15 & 16, which were characterised by smaller water bodies, low riparian cover, and a lack of in-stream habitat.

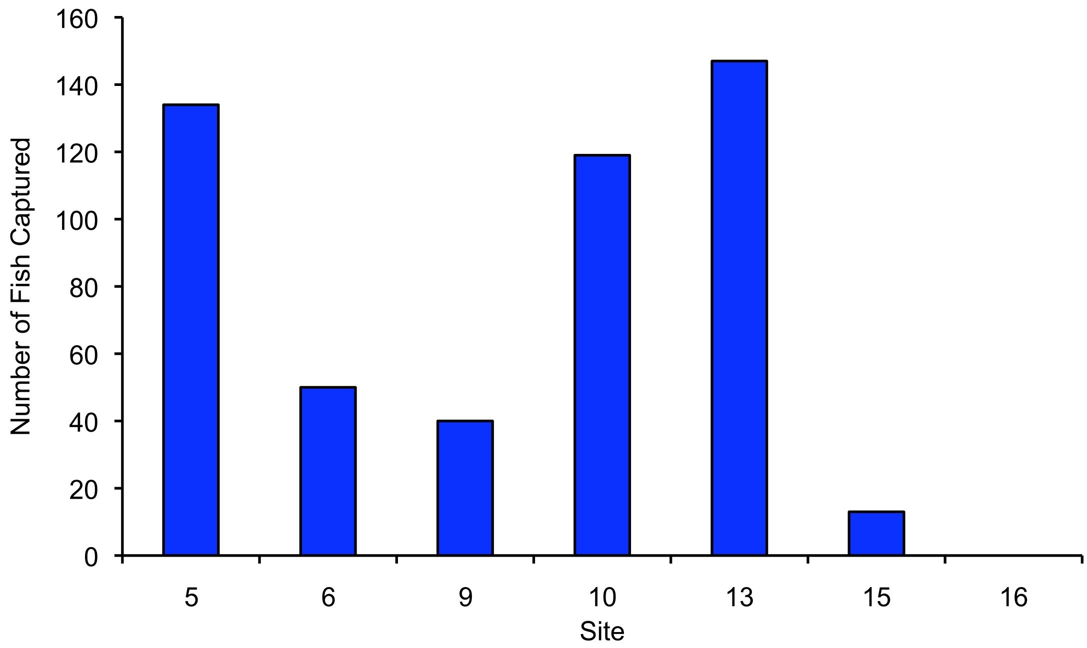


Figure 4.39 Fish abundance at each site (all survey methods combined).

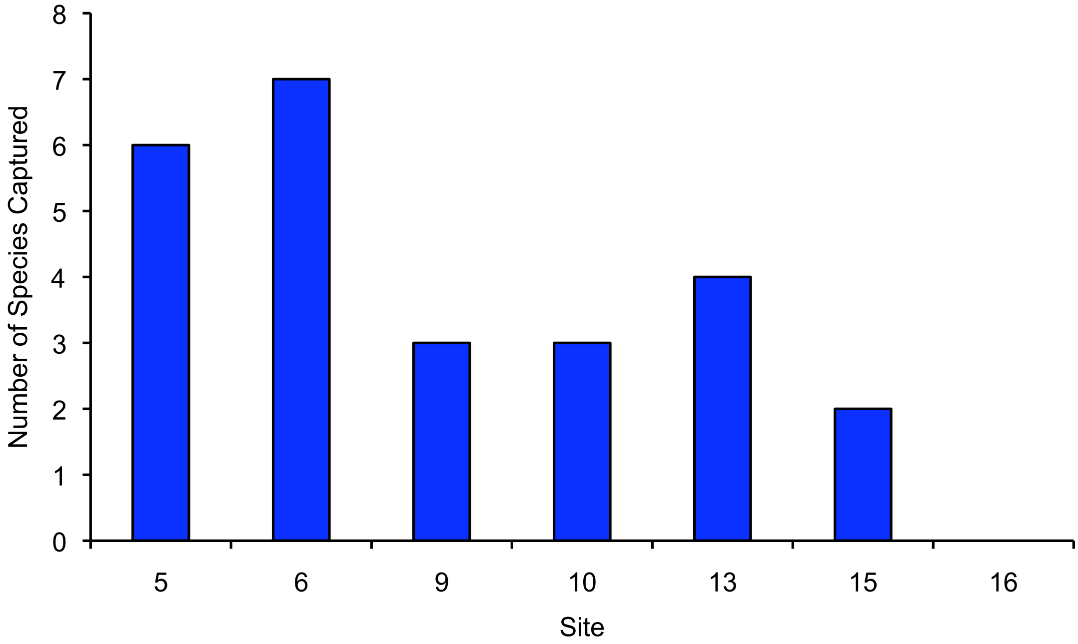


Figure 4.40 Species richness of fish captured at each site (all survey methods combined).

Table 4.3 Abundance of fish species at each site (all survey methods combined).

Family	Latin Name	Common Name	5	6	9	10	13	15	16
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish					8	1	
Ariidae	*Tandanus tandanus*	eel-tailed catfish		1					
Clupeidae	*Nematalosa erebi*	bony bream	1	7					
Clupeidae		unidentified		1					
Cyprinids	*Cyprinus carpio*	common carp	1	1					
Cyprinids	*Carassius auratus*	goldfish	7	14		8	30		
Eleotridae	*Hypseleotris* sp.	carp gudgeon	117	23	36	76	107	12	
Melanotaeniidae	*Melanotaenia fluviatilis*	Murray River rainbowfish		1					
Percichthyidae	*Macquaria ambigua*	golden perch			1				
Poeciliidae	*Gambusia holbrooki*	mosquitofish	5		3	35			
Retropinnidae	*Retropinna semoni*	Australian smelt	3						
Terapontidae	*Leiopotherapon unicolor*	spangled perch		2			2		

Hypseleotris sp. (carp gudgeon) was the most widely distributed and abundant species and was captured from every site surveyed. *Carassius auratus* (goldfish) was also relatively widely distributed and abundant (Figure 4.41). *Gambusia holbrooki* (mosquitofish) were common but not very abundant throughout the study area. Less common species included *Ambassis agassizii* (Agassiz's glassfish), *Nematalosa erebi* (bony bream), *Leiopotherapon unicolor* (spangled perch), *Cyprinus carpio* (common carp), *Melanotaenia fluviatilis* (Murray River rainbowfish, area (Figure 4.42)), *Macquaria ambigua* (golden perch), *Retropinna semoni* (Australian smelt) (Figure 4.43) and *Tandanus tandanus* (freshwater catfish). Common carp, Murray River rainbowfish, bony bream, freshwater catfish, Australian smelt and golden perch were only caught in Dogwood Creek. One unidentified fish was captured in Dogwood Creek (site 6). This was likely to be a bony bream, however the identification could not be confirmed.

Figure 4.41

A goldfish at Dogwood Creek (site 5).

Figure 4.42

An intermediate Murray River rainbowfish at Dogwood Creek (site 6).

Figure 4.43

An adult Australian smelt at Dogwood Creek (site 5).

Life History Stages

All life history stages (juvenile, intermediate and adult) were captured for five of species caught (Agassiz's glassfish, bony bream, carp gudgeon, goldfish, and mosquitofish). Across the study area, juveniles were most abundant life stages for most species (bony bream, goldfish, and mosquitofish) and adults were the most abundant Agassiz's glassfish and carp gudgeon life stage. The largest species (on average) was bony bream and the smallest species (on average) was carp gudgeon.

Indicators of Stream Health

Three introduced species were captured during the survey: goldfish, common carp and mosquitofish. In total, 104 introduced fish were captured at the 5 of the 7 sites surveyed. No introduced species were captured at L Tree Creek and its tributary (sites 15 and 16). When captured, abundance of introduced species accounted for 10% of the total catch at Dogwood Creek (site 5) to 36% of the total catch at Eleven Mile Creek (site 10) (Figure 4.44).

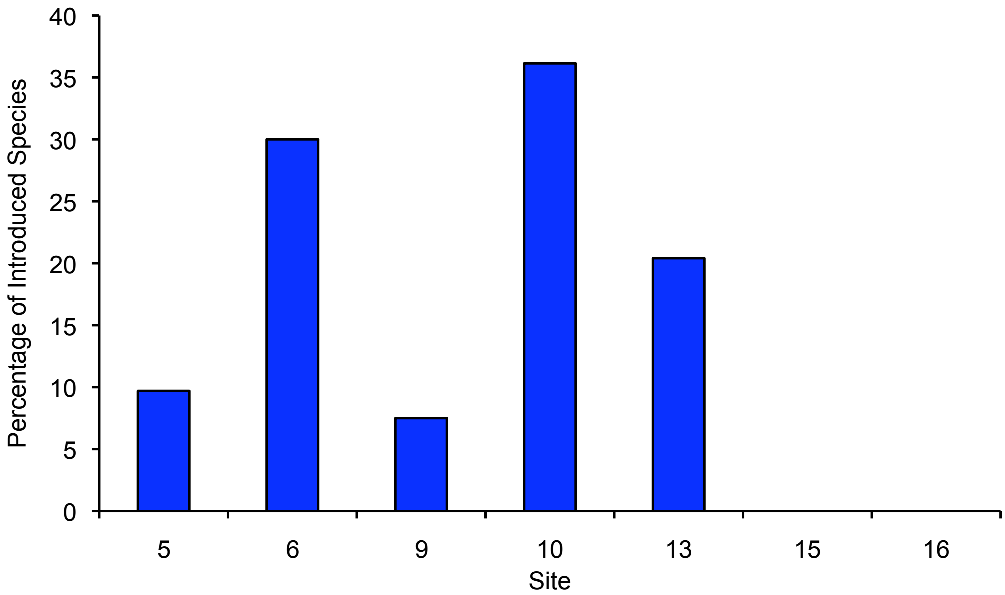


Figure 4.44 Percentage of introduced fish captured at each site (all survey methods combined).

No listed threatened species were captured during the survey. All fishes appeared healthy.

4.5.2 A Regional and Ecological Perspective

Dawson River Catchment

The fish communities of creeks along the pipeline route within the Dawson River catchment have not been previously sampled. Berghuis & Long (1999) sampled two sites along the upper Dawson River during surveys of the Fitzroy Basin undertaken between 1994 and 1996, and caught 775 fish comprising ten species. More recently, a dry season survey of four sites in the upper Dawson River catchment captured 267 fishes, comprising eight species (frc environmental 2007), and a wet season survey of eight sites captured a total of 481 fish across 20 species. Dry season surveys associated with areas discussed in Volumes 1 and 3 of the EIS in the upper Dawson River catchment captured 316 fishes, comprising nine species (see Chapters 17B Aquatic Ecology and technical reports of Volumes 1 and 3). The number and species of fish caught during these studies are listed in Table 4.4.

The most abundant fish species captured in the upper Dawson River catchment during these studies were bony bream and eastern rainbowfish (Berghuis & Long 1999). Conversely, spangled perch and glassfish were the most abundant species captured within the Project study area.

Berghuis & Long (1999) did not report any exotic species in the Dawson Catchment, although they were recorded in the Fitzroy Basin. *Poecilia reticulata* (guppy) was caught from an urban creek near Rockhampton. *Carassius auratus* (goldfish) was also seen (but not caught) near Rockhampton (Berghuis & Long 1999). Since then, goldfish have been caught in Juandah Creek and the Dawson River (Chapters 17B Aquatic Ecology and technical reports of Volumes 1 & 3; Ecowise 2008), and *Gambusia holbrooki* (mosquitofish) have been captured in the Dawson River in November 2007 and June 2008 (frc environmental 2007, Ecowise 2008). Mosquitofish are declared noxious species in Queensland under the *Fisheries Regulation 2008*. Goldfish and guppies are listed as a non-indigenous fish under the *Fisheries Regulation 2008*.

Table 4.4 Number and species of fish caught in the upper Dawson River catchment during previous studies.

Family *Species*	Common Name	Study frc environmental (Volumes 1 & 3)	Berguis & Long (1999)	frc environmental (2007)	Ecowise 2008
Ambassidae					
Ambassis agassizii	Agassiz's glassfish	65	52	0	3
Antherinidae					
Craterocephalus stercusmuscarum	fly-specked hardyhead	0	88	0	2
Clupeidae					
Nematolosa erebi	bony bream	15	214	196	211
Cyprinidae					
Carassius auratus	goldfish	10	0	0	5
Eleotridae					
Hypseleotris sp.	carp gudgeon	72	–	–	–
Hypseleotris sp. A	Midgley's gudgeon	–	89	8	2
Hypseleotris klunzingeri	western carp gudgeon	–	23	0	20
Mogurnda adsepersa	purple spotted gudgeon	0	0	0	8
Oxyeleotris lineolata	sleepy cod	1	0	4	8
Philypnodon grandiceps	flathead gudgeon	0	0	0	3
Melanotaeniidae					
Melanotaenia s. splendida	eastern rainbowfish	17	224	3	26

Family *Species*	Common Name	Study			
		frc environmental (Volumes 1 & 3)	Berguis & Long (1999)	frc environmental (2007)	Ecowise 2008
Osteoglossidae					
Scheropages leichardti	Southern saratoga	0	0	0	4
Percichthyidae					
Macquria ambigua oriens	golden perch	10	16	0	20
Plotosidae					
Neosilurus hyrtlii	Hyrtl's tandan	26	0	8	22
Porochilus rendahli	Rendahl's catfish	0	0	0	1
Tandanus tandanus	eel-tailed catfish	0	6	1	9
Poecillidae					
Gambusia holbrooki	mosquitofish	0	0	16	32
Pseudomugilidae					
Pseudomugil signifer	pacific blue eye	0	56	0	0
Terapontidae					
Leiopotherapon unicolor	spangled perch	100	7	31	76
Scortum hillii	leathery grunter	0	0	0	13

Condamine River Catchment

The fish communities of creeks along the pipeline route within the Condamine River catchment have not been previously sampled. DPI (2002) sampled seven sites along the Condamine River between 2000 and 2001, and caught twelve species. The EPA reports that the Condamine River catchment contains 25 species of fish from 13 families (EPA 2007). Four introduced species have been recorded: goldfish, carp, mosquitofish and guppy. Mosquitofish and carp are declared noxious species in Queensland under the *Fisheries Regulation 2008*. Goldfish and guppies are listed as a non-indigenous fish under the *Fisheries Regulation 2008*.

Table 4.5 Presence of fish species caught in the Condamine River catchment during previous studies and the present survey.

Family *Species*	**Common Name**	**Study**		
		EPA (2007)	**DPI (2002)**	**Present Surveys**
Ambassidae				
Ambassis agassizii	Agassiz's glassfish	✓		✓
Antherinidae				
Craterocephalus stercusmuscarum	fly-specked hardyhead	✓	✓	
Clupeidae				
Nematolosa erebi	bony bream	✓	✓	✓
Cyprinidae				
Cyprinus carpio	common carp	✓	✓	✓
Carassius auratus	goldfish	✓	✓	✓
Eleotridae				
Hypseleotris sp.	carp gudgeon		✓	✓
Hypseleotris sp. A	Midgley's gudgeon	✓		
Hypseleotris klunzingeri	western carp gudgeon	✓		
Mogurnda adsepersa	purple spotted gudgeon	✓		
Hypseleotris galii	firetail gudgeon	✓		
Hypseleotris species 2	Lake's carp gudgeon	✓		
Philypnodon grandiceps	flathead gudgeon	✓		
Melanotaeniidae				
Melanotaenia fluviatilis	Murray River rainbowfish	✓	✓	✓
Melanotaenia duboulayi	Crimson spotted rainbowfish	✓	✓	

Family *Species*	Common Name	Study		
		EPA (2007)	DPI (2002)	Present Surveys
Galaxiidae				
Galaxias olidus	mountain galaxias	✓		
Gadopsidae				
Gadopsis marmoratus	river blackfish	✓		
Percichthyidae				
Maccullochella peelii peelii	Murray River cod	✓	✓	
Macquria ambigua oriens	golden perch	✓	✓	✓
Plotosidae				
Neosilurus hyrtlii	Hyrtl's tandan	✓		
Tandanus tandanus	eel-tailed catfish	✓	✓	✓
Poecillidae				
Poecilia reticulata	guppy	✓		
Gambusia holbrooki	mosquitofish	✓	✓	✓
Retropinnidae				
Retropinna semoni	Australian smelt	✓	✓	✓
Terapontidae				
Leiopotherapon unicolor	spangled perch	✓	✓	✓
Bidyanus bidyanus	silver perch	✓		

Comparison of Catchments

Within the upper Dawson River Catchment, 20 species have been recorded near the study area. Within the Condamine River Catchment, 25 species have been recorded near the study area.

Six species (sleepy cod, eastern rainbowfish, Southern saratoga, Rendahl's catfish, pacific blue eye and leathery grunter) have been recorded in the upper Dawson River catchment but have not been recorded in the Condamine River catchment. Conversely, eleven species (Australian smelt, common carp, crimson spotted rainbowfish, firetail gudgeon, guppy, Lake's carp gudgeon, mountain galaxias, Murray cod, Murray River rainbowfish, river blackfish, and silver perch) have been recorded in the Condamine River catchment but have not been recorded in the upper Dawson River catchment.

Murray River Cod

Murray River cod (*Maccullochella peeli peeli*) are listed as vulnerable under the EPBC Act, and occur throughout the Murray Basin. Murray cod were not found in this study, and have not been recorded within 15 km of the proposed pipeline crossing of Dogwood Creek (EPA 2008). As this species prefers deeper-water habitats around in-stream habitat structures such as boulders, logs, undercut banks and overhanging vegetation (Allen et al. 2002), it is unlikely to occur in the majority of creeks along the southern CSM pipeline route, although it is possible that this species is present in Dogwood Creek from time to time.

Fish Movement

The relative composition and abundance of fish communities within the study area is largely controlled by the life history requirements of the species involved. Many of the fish native to ephemeral systems of central and western Queensland migrate up and downstream and between different habitats at particular stages of their lifecycle. Stimuli for movement include small and large discharge events and changes in temperature. Australian rivers are notoriously unstable, and fish may need to move up and downstream to avoid undesirable water quality and the drying out of pools (Kennard 1997, Freshwater Fisheries Advisory Committee 1996).

Of the fish likely to be found in the study areas, most undertake freshwater migrations (Cotterell 1998, Marsden & Power 2007, Table 4.6). Adult golden and spangled perch move upstream to spawn, and juveniles move downstream for dispersal. This movement typically occurs in spring and summer, and is 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 (i.e. when the isolated pools currently holding these species are connected).

Table 4.6 Timing of critical movements of fish known to inhabit the region (shaded cells indicate large numbers of fish are known to migrate) (Marsden and Power 2007, Cotterell 1998).

Family *Species*	Common Name	Season[1]			
		Summer	Autumn	Winter	Spring
Ambassidae					
Ambassis agassizii	Agassiz's glassfish	s	L	L	L
Antherinidae					
Craterocephalus stercusmuscarum	fly-specked hardyhead	s	-	s	L
Clupeidae					
Nematolosa erebi	bony bream	L	L	L	L
Cyprinidae					
Cyprinus carpio	common carp	?	?	?	?
Carassius auratus	goldfish	?	?	?	?
Eleotridae					
Hypseleotris sp.	carp gudgeon	?	?	?	?
Hypseleotris sp. A	Midgley's gudgeon	?	?	?	?
Hypseleotris klunzingeri	western carp gudgeon	?	?	?	?
Mogurnda adsepersa	purple spotted gudgeon	?	?	?	?
Oxyeleotris lineolata	sleepy cod	?	?	?	?
Hypseleotris galii	firetail gudgeon	L	?	?	?
Hypseleotris species 2	Lake's carp gudgeon	?	?	?	?
Philypnodon grandiceps	flathead gudgeon	?	?	?	?
Melanotaeniidae					
Melanotaenia s. splendida	eastern rainbowfish	s	s	s	L
Melanotaenia fluviatilis	Murray River rainbowfish	?	?	?	?

Family *Species*	Common Name	Season[1]			
		Summer	Autumn	Winter	Spring
Melanotaenia duboulayi	crimsonspotted rainbowfish	?	?	?	?
Osteoglossidae					
Scheropages leichardti	Southern saratoga	s	?	?	s
Galaxiidae					
Galaxias olidus	mountain galaxias	?	?	?	?
Gadopsidae					
Gadopsis marmoratus	river blackfish	?	?	?	?
Percichthyidae					
Maccullochella peelii peelii	Murray River cod	L	s	s	L
Macquria ambigua oriens	golden perch	L	s	s	L
Plotosidae					
Neosilurus hyrtlii	Hyrtl's tandan	L	?	?	L
Porochilus rendahli	Rendahl's catfish	L	?	?	L
Tandanus tandanus	eel-tailed catfish	?	?	?	?
Poecillidae					
Poecilia reticulata	guppy	?	?	?	?
Gambusia holbrooki	mosquitofish	?	?	?	?
Retropinnidae					
Retropinna semoni	Australian smelt	?	?	?	?
Pseudomugilidae					
Pseudomugil signifer	pacific blue eye	?	?	?	?
Terapontidae					

Family *Species*	Common Name	Season[1]			
		Summer	Autumn	Winter	Spring
Leiopotherapon unicolor	spangled perch	L	s	s	L
Bidyanus bidyanus	silver perch	L	s	s	L
Scortum hillii	leathery grunter	s	s	s	s

[1]L= large number of fish migrate, s = small numbers of fish migrate, ? = limited information.

The habitat preferences, diet and migrations of each of the fish species captured in the study area (including the timing of critical movements of these fishes) are described below. Each of the native fish species found in study area require some physical in-stream habitat to provide shelter or for reproduction. 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.

Agassiz's Glassfish

Agassiz's glassfish is commonly found in rivers, creeks, ponds, reservoirs, drainage ditches and swamps from Cairns in Queensland to Lake Hiawatha in New South Wales, and in the Murray-Darling system (McDowall 1996, Allen et al 2002). This species has a temperature range of 18 – 27 °C (Merrick & Schmida 1984), although they are not tolerant of low dissolved oxygen levels (Tait & Perna 2002). The diet of this species consists largely of small crustaceans and insect adults and larvae, including mosquitos (McDowall 1996). This species deposits and fertilises demersal eggs on aquatic vegetation (Merrick & Schmida 1984). The Agassiz's glassfish was caught within the study area. However, these creeks are unlikely to provide a regionally important breeding habitat due to the lack of aquatic vegetation (although terrestrial grasses on the edge of the creeks may provide some suitable substrate for the deposition of eggs).

Bony Bream

Bony bream are abundant detritivores / algivores that form the basis of the food chain for a number of higher order consumers including larger fishes and birds such as cormorants and pelicans (Pusey et al. 2004).

Bony bream commonly occur in the shallows of still or slow-flowing streams, particularly in turbid conditions such as those of the region (Allen et al. 2002). Within the Fitzroy River system, bony bream have been recorded from water temperatures between 24 – 29 °C (Pusey et al. 2004). They have a wide pH (4.8 – 8.6) tolerance and have been recorded from waters with salinity levels approaching those of the seawater (Ruello 1976). High salinity tolerance is undoubtedly one of the factors influencing the widespread distribution of bony bream throughout Australia's freshwater habitats. However, they cannot tolerate low dissolved oxygen levels (Allen et al. 2002) and are the first species to perish when ephemeral habitats start to dry up (Allen et al. 2002). Bony bream were only caught at the largest waterway surveyed during the present studies (at Juandah Creek, downstream of the MLAs, and Dogwood Creek, in the vicinity of the pipeline crossing location); they were not found in smaller waterways that are crossed by the southern water supply pipeline route. The unidentified Clupeidae at site 6 was most likely a bony bream; however this identification could not be confirmed.

Common Carp

Common Carp are an exotic species, and are listed as noxious in Queensland under the *Fisheries Regulation 2008*. Their diet involves molluscs, crustaceans, insect larvae and seeds but when food is scarce, aquatic plants and detritus is sucked from the substrate causing high turbidity (Allen et al. 2002). They prefer still or slow flowing water with abundant aquatic vegetation, but can also be found in brackish lower reaches of rivers and coastal lakes (Allen et al. 2002). Eggs are deposited on any fibrous plant matter and hatch after only a few days, with juveniles growing rapidly in warm water (McDowall 1996).

Goldfish

Goldfish are an exotic species, introduced into Australia in the 1960's as an ornamental fish (Allen et al. 2002). They have are now established in the Murray-Darling and Fitzroy basins (Allen et al. 2002). Inhabiting slow or still water, they are able to tolerate high temperatures and low oxygen concentrations (Allen et al. 2002). Goldfish feed on plant materials, organic detritus and a variety of small insects (McDowall 1996). Eggs are laid among aquatic plants and hatch after a few days, at which point the young attach themselves to aquatic plants for a few days while they absorb the remainder of their egg yolk (McDowall 1996).

Carp Gudgeons

Carp gudgeons (*Hypseleotris* spp.) are common in coastal drainage basins of eastern Australia, from the northern section of the Murray-Darling Basin to Tully in north Queensland. This species is commonly confused with *Hypseleotris galii* (firetail gudgeon), especially as a juvenile; ecologically, the two species are probably very similar (Pusey et al 2004). Firetail gudgeons are usually found in open water, around aquatic plants in streams, ponds, swamps and drains (Allen et al 2002). Adult carp and firetail gudgeons are known to feed on invertebrates, such as mosquito larvae (Diptera: Culicidae), and small crustacea such as cladocerans and ostracods (Merrick & Schmida 1984, Allen et al 2002). These species are quite tolerant to changes in water quality, and under ideal conditions can rapidly increase in numbers (Merrick & Schmida 1984). This species was relatively abundant during the surveys of the MLAs and southern water supply pipeline route.

Eastern Rainbowfish

The eastern rainbowfish is the common rainbowfish of many parts of north-eastern and central Australia, and is usually abundant wherever it occurs (Allen et al 2002). This species spawns all year round, although spawning peaks immediately before and during flood periods (Merrick & Schmida 1984). Surveys of the MLA study area captured eastern rainbowfish at the majority of sites (Volume 1); however, the creeks of the MLAs are unlikely to provide suitable breeding habitat because spawning tends to occur in slow-flowing, weedy areas (Merrick & Schmida 1984). Eastern rainbowfish were not found in the creeks along the southern water supply pipeline route, however they are likely to be present in the creeks crossed by the pipeline route that are within the Juandah Creek catchment, at least in the wet season.

Murray River Rainbowfish

Murray River Rainbowfish are the most southward ranging rainbowfish, adapted to low winter temperatures (Allen et al. 2002). They extend within the Murray-Darling Basin system from Roma in Queensland to the Murray River and its Tributaries in New South Wales, Victoria and South Australia (Allen et al. 2002). They often congregate along grassy banks or around submerged logs and branches (Allen et al. 2002).

Golden Perch

Golden perch are large piscivorous predatory fish that are sought after by anglers. Golden perch inhabit numerous water bodies east of the Great Dividing Range, due to transplanting and stocking, however the Fitzroy River Basin is the only drainage (east of the Great Dividing Range) where they naturally occur as the subspecies *Macquaria ambigua oriens.* Golden perch can tolerate extremes in temperature (4 – 35 °C) (Allen et al 2002) although in the Fitzroy River they have been recorded in waters ranging from 24 – 31 °C (Midgeley 1942, cited in Pusey et al 2004). Golden perch are very tolerant of high turbidity (Gehrke et al 1993), and may move long distances upstream during floods (Allen et al 2002). This species was recorded in Juandah Creek, downstream of the MLAs during the post-wet season survey (Volume 1), and in Dogwood Creek during the present surveys. However, they are unlikely to be common in the smaller, isolated pools that characterise the waterways crossed by the southern water supply pipeline route.

Mosquitofish

The mosquitofish is an introduced species in Australia. The mosquitofish is declared noxious under the *Fisheries Regulation 2008*. They were initially brought into the country for aquariums and subsequently introduced into waterways to help control the mosquito populations (McDowall 1980, Allen et al. 2002). They are widespread and abundant throughout Victoria, New South Wales, South Australia, coastal drainages of Queensland and parts of Western Australia. They prefer warm gently flowing or still waters and are typically associated with aquatic vegetation. They are livebearers and spawning occurs in spring. They feed on terrestrial and aquatic insects, including mosquitoes, and have the capacity to displace native fish populations.

Australian Smelt

Australian smelt are common from the Fitzroy River in Queensland to the Murray River mouth in South Australia, and are also found in Cooper Creek (Allen et al. 2002). Australian Smelt are usually found in slow flowing streams and still water, and they shoal near the surface or around aquatic plants and woody debris (Allen et al. 2002). Their diet included insects, microcrustaceans and algae (Allen et al. 2002). Spawning tends to occur at temperatures over 15 ^{o}C, usually in late winter and spring (Pusey et al. 2004). Eggs are laid among aquatic vegetation and hatch in about 10 days (Allen et al. 2002).

Spangled Perch

Spangled perch are Australia's most widespread native fish, being abundant within most habitats (Allen et al. 2002). They can tolerate wide ranges of temperature (5 – 44 °C), salinity (0 –34 ppt) and pH (4 – 10.2). Of particular relevance to their abundance in western and central Queensland creeks is their ability to aestivate in wet mud or under moist leaf litter in ephemeral water holes during droughts (Allen et al. 2002). As an adaptation to living in quick-drying waterholes, spangled perch eggs hatch in 2 days and the larvae develop in 24 days (Allen et al. 2002). Spangled perch are likely to persist in the creeks within the study area throughout the year.

Eel-tailed catfish

Eel-tailed catfish have been stocked throughout eastern Australia for recreational angling. They are found in a range of habitats, from small-order streams to rivers, and they are generally more abundant when the riparian zone is intact and there is abundant terrestrial debris in the channel to provide habitat (Pusey et al. 2004). In general, they are tolerant of low oxygen concentrations and a range of temperatures (8.4 – 33.6 °C), although they can be sensitive to sudden decreases in temperature (Pusey et al. 2004). They mainly feed on aquatic insects as juveniles and switch to a more varied diet as adults. Adults exhibit some parental care by building circular nests in gravel beds.

Hyrtl's Tandan

This species is very common and widespread in coastal drainages of northern Australia, as far south as Mary River on the east coast and the Pilbara on the west coast (Allen et al 2002). It also occurs widely throughout central Australia (Allen et al 2002) and is known to occur in the Fitzroy River (Merrick & Schmida 1984). Hyrtl's tandan is a shoaling species that occupies a diverse range of habitats including still or flowing waters, pools and billabongs (Allen et al 2002). This species feeds on insects, molluscs, small crustaceans and worms (Allen et al 2002). The spawning behaviours of interior populations are unknown; however, northern populations breed at the beginning of the wet season in shallow, sandy areas in the upper reaches of streams (Allen et al 2002). Further research is required as this species may actually represent more than one species (Allen et al 2002). Hyrtl's tandan are not likely to be common in the Condamine Catchment, and have only been recorded in Juandah Creek downstream of the MLAs, as discussed in Chapter 17B Aquatic Ecology and the technical report of Volume 1. Based on these survey results, they are unlikely to occur in the creeks crossed by the pipeline route.

Sleepy Cod

Sleepy cod are common and widespread in northern Australia between the Ord River on the west coast and Noosa on the east coast (Allen et al 2002). They are a hardy species inhabit rivers, creeks and billabongs, usually in quiet or slow-flowing water among vegetation, around woody debris or beneath undercut banks (Merrick & Schmida 1984, Allen et al 2002). This species is a sluggish bottom dwelling carnivore that feeds on insects, small fishes and crustaceans (Merrick & Schmida 1984, Allen et al 2002). Sleepy cod appear to have a lower thermal limit of 15 °C and Northern Territory populations can withstand temperatures to 32 °C (Merrick & Schmida 1984). Spawning usually occurs between October and February (Allen et al 2002), when water temperatures reach 24 °C. The nest is located on a solid surface (usually rock, tree roots or submerged log) and the male guards the nest for the incubation period of 5 – 7 days (Merrick & Schmida 1984, Allen et al 2002). Sleepy cod are not found in the Condamine Catchment, and have only been recorded in Juandah Creek downstream of the MLAs, as discussed in Chapter 17B Aquatic Ecology and the technical report of Volume 1. Based on these survey results, they are unlikely to occur in the creeks crossed by the pipeline route.

Summary

Most of the species that were captured from the study area can tolerate a large range of water quality conditions (Table 4.7). Spangled perch, glassfish, carp gudgeons, eastern rainbowfish, eel-tailed catfish and Australian smelt are tolerant species that can live in water characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity (Table 4.7). Although exact water quality tolerances could not be sourced for the exotic carp, goldfish and mosquitofish, these species are also reported to have wide environmental tolerances. Golden perch and bony bream have narrower water quality tolerances than the other species collected.

Table 4.7 Reported water quality tolerances of fish species captured in, or that are considered likely to occur in, the study area (data sourced from Pusey at al. 2004).

Family	Latin Name	Common name	Water Temperature (º C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Turbidity
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish	11 – 33	0.3 – 19.5	6.3 – 9.9	19.5 – 15 102	0.2 – 144
Clupeidae	*Nematolosa erebi*	bony bream	24 – 29	4.8 – 11	6.9 – 8.8	70 – 770	4 – 160
Cyprinidae	*Cyprinus carpio*	common carp	NA	NA	NA	NA	NA
	Carassius auratus	goldfish	NA	NA	NA	NA	NA
Eleotridae	*Hypseleotris* spp.[A]	carp gudgeons	8.4 – 31.2	0.3 – 19.5	4.4 – 8.9	51 – 4 123	0.1 – 331.4
Melanotaeniidae	*Melanotaenia splendida*[C]	eastern rainbowfish	15 – 32.5	1.1 – 10.8	6.8 – 8.5	49 – 790	0.6-16, but up to 600 (frc pers obs)
	Melanotaenia fluviatilis	Murray River rainbowfish	NA	NA	NA	NA	NA
Percichthyidae	*Macquaria ambigua oriens*[B]	golden perch	24 – 31	3.6 – 10.0	7.2 – 8.8	NA	4 – 40 cm secchi depth
Plotosidae	*Tandanus tandanus*[A]	eel-tailed catfish	8.4 – 33.6	0.3 – 17.1	4.8 – 9.1	19.5 – 3 580	0.2 – 250
Poecillidae	*Gambusia holbrooki*	mosquitofish	NA	NA	NA	NA	NA
Retropinnidae	*Retropinna semoni*[A]	Australian smelt	8.4 – 31.7	0.6 – 16.2	6 – 9.1	51 – 1 624.2	0.4 – 144
Terapontidae	*Leiopotherapon unicolor*	spangled perch	5 – 41	≥ 0.4	4 – 8.6	0.2 – 35.5 ppt salinity	1.5 – 260

A environmental data from captures during surveys in south-east Queensland
B environmental data from captures during surveys in the Fitzroy River system
C environmental data from captures during surveys in the Burdekin River system
NA not available

4.6 Turtle Communities

4.6.1 Of the Study Area

No turtles were captured or observed in the study area.

4.6.2 A Regional and Ecological Perspective

Dawson River Catchment

Emydura macquarii krefftii[1] (Krefft's river turtle) were captured from Juandah Creek, downstream of the MLAs, in March 2008 (refer to Volume 1). Similarly, only Krefft's river turtles were caught from two sites during a recent survey of the upper Dawson River catchment (frc environmental 2007). Krefft's river turtle inhabits rivers, creeks and lagoons through eastern Queensland from just north of Brisbane to Princess Charlotte Bay (Wilson & Swan 2008). Turtles from the *Emydura* genus are omnivorous, feeding on macrophytes, invertebrates, small vertebrates and carrion (Wilson & Swan 2008). They are often observed basking on protruding rocks or logs (Wilson & Swan 2008).

Other freshwater turtle species may occur in the Dawson Catchment, such as the eastern snake-necked turtle (*Chelodina longicollis*), and the saw-shelled turtle (*Elseya latisternum*) (Cogger 1996); with the eastern snake-necked turtle having been recorded from within 20 km of the pipeline alignment (EPA 2007b). However, these turtles are only likely to inhabit larger waterways (Cogger 1996) and are unlikely to be abundant in the ephemeral creeks along the southern CSM water supply pipeline.

Fitzroy River turtles (*Rheodytes leukops*) were first described in 1980 (Legler & Cann 1980). This species is only found in the Fitzroy River and its tributaries, in central Queensland. This species is listed as 'vulnerable' under the Queensland *Nature Conservation Act 1992* (NCA); the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); and the International *IUCN Red List of Threatened Species 2007* (IUCN 2007).

Fitzroy River turtles were not captured during either field survey. The species is particularly difficult to catch in nets, and rarely enters traps (M. Gordos, Conservation Manager, NSW DPI, pers. comm. July 2007). The most successful, and therefore most commonly used, method to survey Fitzroy River turtles is hand capture on snorkel (M. Gordos, Conservation Manager, NSW DPI, pers. comm. July 2007). Snorkel surveys

[1] Formerly known as *Emydura krefftii*. This species has recently been re-classified and included in the *Emydura macquarii* complex, a group of closely related sub-species (Wilson & Swan 2008).

were not possible during the present surveys, as most sites were very shallow, and had very high turbidity (and hence extremely low visibility).

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 along the CSM water 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 of the Project location, in the upper Dawson River, as it has previously been recorded in the river (EPA 2007b).

Condamine River Catchment

Turtle species occurring in the Murray-Darling Basin, including the Condamine catchment, include: the broad-shelled river turtle (*Chelodina expansa*), the eastern snake-necked turtle (*Chelodina longicollis*), and the Macquarie turtle (*Emydura macquarii*) (Wilson & Swan 2008); though no turtles have been recorded from within 15 km of the pipeline crossing of Dogwood Creek (EPA 2008). Freshwater turtles are only likely to inhabit larger waterways (Cogger 1996) and are unlikely to be abundant in the ephemeral creeks along the southern CSM water supply pipeline (though they may be present in Dogwood Creek).

4.7 Other Aquatic Vertebrates

Our survey did not target other aquatic vertebrates. No aquatic amphibians or reptiles were recorded in this study. No conservationally significant aquatic amphibians or reptiles have been recorded from, or are likely to occur in, the study area (DEWHA 2008a; EPA 2007b, 2008).

4.8 Summary of Aquatic Environmental Values

The Environmental Values of aquatic ecosystems within the study area are relatively low and consistent with those of the wider catchment. Environmental values are dictated primarily by the ephemeral nature of the region's waterways; although agricultural development (particularly grazing) within the region has significantly influenced water quality and the physical characteristics of aquatic habitat (Van Manen 2001, Telfer 1995). Degraded creeks in the catchment are characterised by riparian vegetation loss, erosion, invasion of weed species, poor water quality and sedimentation (Van Manen 2001, Telfer 1995); all features of the creeks along the pipeline route and the area surveyed during this study. The riparian and aquatic habitats of the creeks crossed by the southern water supply pipeline that are within forested areas are in better in condition than those adjacent to grazing land.

Water quality is generally poor and is characterised by high turbidity and variable dissolved oxygen levels. Biodiversity is relatively low, with only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabiting the study area. Introduced species, including the declared noxious mosquitofish and carp, were found in the waterways crossed by the pipeline alignment. Nevertheless, the creeks along the southern CSM water supply pipeline route do provide 'upstream' dispersal habitat for the native fish species that were recorded in the study area (and possibly breeding habitat for some species).

No rare or threatened species of aquatic fauna have been recorded from the waterways of the study area.

5 Description of Proposed Development

5.1 General Description

The southern CSM water supply pipeline will be 101 km in length, and the preferred alignment will mainly be located on the eastern side of the Leichhardt Highway and other roads, as this alignment will minimise vegetation clearing along the alignment. Details of the pipeline material and dimensions will be determined during detailed design, however the indicative pipe diameter is 600 mm, and the pipe will be made of either ductile iron with cement mortar lining (DICL), or mild steel with cement mortar lining (MSCL).

It is proposed to establish the southern water supply pipeline from the Condamine Power Station to the Wandoan Coal Project MLA raw water storage dam. The pipeline will typically supply a water demand of less than 8,400 ML/a, with demand peaking at 9,100 ML/a; but will be able to carry a maximum capacity of 11,400 ML/a.

Installation and operation of the pipeline has the potential to impact on aquatic ecology through:

- operation of vehicles and equipment
- vegetation clearing and earth moving adjacent to the creek, and within the bed and banks
- stormwater entering watercourses
- creation of pipeline creek crossings
- construction of temporary vehicle creek crossings
- obstruction of flow and aquatic fauna passage, and
- supply and storage of water from outside of the Project area.

5.2 Operation and Maintenance of Vehicles and Other Equipment

5.2.1 Fuel and Oil Spills

Various vehicles and equipment will be used in the construction of the pipeline. All vehicles and equipment will be diesel operated, and may also use other substances such as hydraulic fluid and lubricating fluids, which each pose a potential threat to aquatic ecology if spilt.

No vehicle maintenance facilities, including fuel storage facilities, will be located along the pipeline route. They will all be located within the mine infrastructure area (MIA) for the Project.

5.3 Vegetation Clearing and Earth Moving

The pipeline will generally be located 0.6 – 1 m underground, constructed using a section trench and backfill method with vegetation clearing required along the pipeline corridor. The pipeline will be laid on a non-cohesive, granular material. It is expected that the actual pipeline and access track will likely only have a construction footprint of 10 m width, however, a vegetation clearing width of 20 m has been adopted for this impact assessment.

5.4 Creek Crossings

The proposed pipeline route crosses:

- Frank Creek within the MLAs, in the vicinity of proposed road crossings (refer to Volume 1 for a discussion of this creek)
- Juandah Creek, and five 1st or 2nd order tributaries of this creek
- Six Mile Creek (at the headwaters of this creek)
- Sandy Flat Creek (at the headwaters of this creek)
- L Tree Creek and four first order tributaries of this creek
- Nine Mile Creek and one first order tributary of this creek
- Eleven Mile Creek (2 crossings) and a first order tributary of this creek
- Wallan Creek, and
- Dogwood Creek, plus one major and four minor first order tributaries of this creek.

5.5 Supply and Storage of CSM Water

Water quality specification of the CSM by-product water is to contain a maximum concentration for total dissolved solids of 4000 mg/L, preferably less. A detailed water quality specification will be prepared as part of detailed design. Water supplied by the pipeline will be stored in the raw water dam within the MLA areas of the Project.

Scour outlets will be placed in the pipeline sags, approximately one every 1 km to 2 km, to minimise the area that needs to be emptied during maintenance and to reduce volume of water to be carted. Scour outlets will be equipped with a cam-loc coupling to allow the pipe to be dewatered to a water truck. Water released from scour outlets will be captured in mobile water tankers, and trucked to the mine site for release into the collection pond, or water storage dam (if the water quality meets water quality requirements), or otherwise disposed to the tailings dam.

6 Potential Impacts

6.1 Operation of Vehicles and Equipment

Fuels and oils required for the operation of construction equipment, present a risk to aquatic ecology if spilt. Both diesel and petrol are toxic to aquatic flora and fauna at relatively low concentrations.

Spilt diesel oil and petrol are both likely to form a layer on the surface of the water. The volatility of both diesel and petrol contributes to substantial evaporative loss, while neither product is likely to form water-in-oil emulsions due to their low viscosity. Lubricating oils, of the kind used in diesel engines and gearing, are of a relatively similar density to diesel oils. As such, lubricants would be expected to behave in a similar fashion to diesel oil, and form a surface layer. Lubricants are much less volatile, however, and thus would not evaporate as rapidly.

Spilt fuel is most likely to enter the creeks via an accidental spill on the access route near creek crossings; or when there are construction activities adjacent to creeks. The pipeline route crosses the major creeks in the area and a significant fuel spill to any of these creeks (in the order of tens or hundreds of litres) is likely to have a significant impact on both flora and fauna, with the quantity spilt being the most influential factor on the length of stream impacted.

The risk of an impact to aquatic flora and fauna along the pipeline route from a fuel or oil spill is reduced as the creeks are dry or isolated pools for much of the year, and therefore many spills could be effectively cleaned up before they can disperse throughout the waterways.

6.2 Vegetation Clearing and Earth Moving

Vegetation clearing and/or sediment disturbance can increase sediment run off to creeks and elevate turbidity. The pipeline route proposed is generally straight and traverses several hills, and as a result clearing along the route has the potential to direct stormwater runoff directly along the pipeline route and into creeks. This has the potential to drastically increase turbidity within the local drainages, and result in sediment deposition in the waterways.

6.2.1 Increased Turbidity

Increased turbidity may impact on fishes and macro-invertebrates because highly turbid water reduces respiratory and feeding efficiency (Karr & Schlosser 1978: cited in Russell & Hales 1993). Increased turbidity may also adversely affect submerged macrophytes as light availability (required for photosynthesis) is reduced. Reduced light penetration, caused by increased turbidity, can also lead to a reduction in temperature throughout the water column (DNR 1998).

At the time of survey, waterways along the pipeline route were generally highly turbid, and substrates were generally dominated by silt. Faunal communities of the study area are adapted to living in turbid water. Given these background conditions, the introduction of small amounts additional sediment is unlikely to have ecologically significant impacts on faunal communities; however, substantial increases may have a significant impact on the aquatic flora and fauna communities. Therefore, best practice erosion and sediment controls and stormwater runoff management plans should be implemented to minimise the likelihood of Project-related turbidity and sedimentation (refer to Section 7.2).

6.2.2 Input of Nutrients or Contaminants

Aquatic biota could also be impacted by nutrients or contaminants washed into the waterways with the sediment, e.g. nutrients from fertilisers. Nutrient inputs can lead to algal or macrophytes blooms, which produce high levels of dissolved oxygen (DO) in the water when photosynthesising during the day. However, at night when the algae can't photosynthesise, they consume oxygen due to respiration. This can cause DO to be reduced to very low levels, which are harmful to fish and biota, during the night.

Nutrient levels in the sediments are likely relatively low in the study area compared with other areas in the catchment, as fertilisers are unlikely to be used on adjacent lands (where the land use is dominated by grazing and forest). 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. Nevertheless, best practice erosion and sediment controls and stormwater runoff management plans should be implemented to minimise the likelihood of Project-related nutrient-laden runoff (refer to Section 7.2).

6.2.3 Decreases in Available Aquatic Fauna Habitat

Vegetation clearing and earth moving near and within the creeks will decrease the amount of available habitat for aquatic fauna. Aquatic fauna use a variety of instream and offstream structures for habitat including, large and small woody debris, bed and banks, detritus, tree roots, boulders, undercut banks, and instream, overhanging and trailing bank vegetation, which were all found in creeks along the pipeline route and will all be cleared along the pipeline route footprint.

Instream habitat is an important habitat component and territory marker for many fish and macroinvertebrates. Many species live on or around instream habitat as they provide shelter from temperature, current and predators; contribute organic matter to the system; and are important for successful reproduction. Australian fish species typically spawn either on instream vegetation or on hard surfaces like cobbles, boulders, and woody debris. The impacts of decreased habitat structures will be localised but on a linear scale the impacts may be unacceptable in both a local and regional context, given the length of the pipeline.

The deposition of fine sediments and subsequent decrease in stream bed roughness and also has the potential to completely fill in the existing pools. Within the minor (first order) tributaries throughout the study area, this would be unlikely to have a significant impact, as these streams appear to only carry flood flows, and they do not generally hold water. However, in larger watercourses (second order and higher) such as Dogwood, Wallen, Eleven Mile, L Tree, Juandah and Frank creeks, 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 diversity of both invertebrate and fish communities in the creeks.

After construction, the newly formed bed and banks may continually erode given the high flows that occur in the region in the wet season. The potential impact will be that the creeks increase in width and lose channel definition and as a result downstream flow may be decreased. The impacts of decreased bed and bank stability will be localised but on a linear scale the impacts may be unacceptable in both a local and regional context, given the length of the pipeline.

Therefore, a rehabilitation management plan should be implemented to minimise the impact on available fauna aquatic habitat (refer to Section 7.3.4 for appropriate rehabilitation techniques).

6.3 Construction of Creek Crossings

Construction of temporary vehicle and permanent pipeline creek crossings will disturb bed and bank stability, leading to increases in localised erosion, potentially leading to increases in turbidity and sediment deposition (see section 6.2 above).

6.3.1 Obstruction of Fish Passage

Many of the fish native to ephemeral systems of central and western Queensland migrate up and downstream and between different habitats at particular stages of their lifecycle. Fish passage is already restricted in creeks along the pipeline route. During the installation of the pipeline, instream obstructions will be temporary, however, poorly-designed crossings have the potential to further impact on fish movement within the study area.

6.4 Supply and Storage of CSM By-Product Water

Overall, the CSM by-product water is expected to be high in total dissolved solids (TDS) compared with the TDS concentration in the natural waterways. If water supplied from the southern CSM pipeline enters the creeks crossed by the pipelines or within the MLAs, it may impact on aquatic ecology.

The declared noxious fish carp (*Cyprinus carpio*) is known from the Condamine catchment. Therefore, transfer of water from the Condamine catchment theoretically poses a significant threat for carp to be transferred to the waterways of the MLAs, and thus the Fitzroy Basin, where they do not currently occur. However, CSM by-product will be directly used for this project, and surface water from watercourses in the Condamine catchment should not at any time be entering the CSM water process; and CSM water should not be discharging into a watercourse without first being treated. Therefore, the likelihood of carp entering the CSM water process is negligible, unless they are transferred into the CSM water by human activities.

6.5 Biting Insects

Mosquito eggs are laid in mud or on vegetation associated with shallow pooled water, and hatch when water levels rise (e.g. with the incidence of rainfall). The larvae and pupae of most species take at least 6 days to develop. 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 midge.

Construction 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 midge has the potential to impact on human health. Opportunities exist to minimise the breeding of mosquitoes and biting midge during construction (refer to Section 7.5).

6.6 Conservationally Significant Habitats

There is no conservationally significant habitat located within, or immediately downstream of the pipeline route.

The pipeline is not likely to impact on boggomoss springs, as there are no springs within, or in the immediate vicinity of, the southern CSM water supply pipeline route (DEWHA 2008a).

The Great Barrier Reef World Heritage Area, and the Shoalwater and Corio Bays and Narran Lake Nature Reserve Ramsar sites are unlikely to be impacted by the pipeline, as they are over 300 km downstream of the proposed pipeline route, and water quality that far downstream of the study area will not be impacted by the installation of the pipeline.

6.7 Threatened Species and Ecological Communities

The Fitzroy River turtle (*Rheodytes leukops*) has a relatively small home range (mean 417 m) and is generally found in association with riffle zones or deeper sections of pool habitats adjacent to riffle zones as riffles become seasonally ephemeral (Tucker et al. 2001). No riffles or deeper sections were observed during the survey and it is unlikely that the Fitzroy River turtle inhabits the ephemeral creeks along the pipeline alignment. Fitzroy River turtles were not captured during this survey. The southern CSM water supply pipeline 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 pipeline route on the Dawson

River. Boggomoss communities are unlikely to be impacted by the southern CSM water supply pipeline.

Murray Cod (*Maccullochella peeli peeli*) may be impacted by the installation of the southern CSM water supply pipeline, if it is present in Dogwood Creek, and if in-stream habitat structures such as boulders, logs, undercut banks and overhanging vegetation are affected. However, the likelihood of an impact is low (due to the low likelihood of Murray Cod being present, and the narrow construction footprint in the creek), and the consequence of any impact would also be low and reversible if aquatic habitat is replaced after construction (that is, there would be no significant impact to the Murray Cod population).

7 Avoidance, Minimisation and Mitigation of Impacts

7.1 Operation of Vehicles and Equipment

Risks associated with the spillage of fuels and other contaminants can be substantially reduced, if not eliminated, where:

- Vehicle maintenance areas and storage of fuels, lube and oil and batteries is undertaken within bunded areas designed and constructed in accordance with AS1940.
- Portable refuelling stations, for refuelling of machinery in the field, are also bunded to meet AS1940, and placed above the Q100 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, or other relevant personnel.
- 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 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).

7.2 Vegetation Clearing and Earth Moving

Risks associated with the clearing of vegetation and subsequent erosion may be substantially reduced where an erosion and sediment control management plan is developed (as a part of the Environmental Management Plan (EMP)) to minimise the quantity of sediment run off into waterways during pipeline installation. This plan should incorporate the following elements where possible:

- construction of the pipeline in the dry season
- use of erosion control matting
- monitoring turbidity during construction
- rehabilitation with native vegetation after clearing, including the establishment of ground cover, and
- rehabilitation of instream aquatic habitat after clearing, including bed and bank rehabilitation.

7.2.1 Timing

The risk of sediment runoff impacting nearby waterways will be further reduced where:

- Construction of pipeline crossings of creeks, particularly of major waterways (Dogwood, Wallen, Eleven Mile, L Tree, Juandah and Frank creeks) is done in the dry season.

7.2.2 Erosion Control Matting

During and after construction, water quality and ecosystem health of nearby waterways may be protected by:

- Erosion control matting, placed in ditches and drainage lines running from all cleared areas, especially on slopes and levee banks.
- Contour banks or ditches formed across cleared slopes to direct runoff towards surrounding vegetation and away from creeks.
- Monitoring creek water quality upstream and downstream of the pipeline crossing point during periods of water flow (refer to Section 7.3.3 for a description of monitoring).

7.2.3 Rehabilitation of Vegetation

After construction, water quality and ecosystem health of nearby waterways may be protected by rehabilitation of the landscape, focusing on the:

- Salvaging clumps of native grass, shrubs and trees prior to clearing.
- Use of native vegetation of local provenance for replanting where possible, and
- Replanting along creek margins 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.

7.3 Creek Crossings

7.3.1 Construction of Permanent Pipeline Creek Crossings

Impacts associated with the construction of permanent pipeline crossings will be minimised if:

Dry Season

- Crossings are located to result in minimal disturbance to wooded areas.
- Construction is undertaken during the dry season (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. Table 7.1 outlines appropriate crossing methods for both temporary vehicle and permanent pipeline creek crossing methods.

Wet Season

- Where practical, a trenchless crossing method is used (e.g. horizontal directional drill), in accordance with the following recommendations (AE 2001):
  - The drilling be done in a manner that does not cause a disturbance in the water, to the exposed bed or shore of the water body, or to an area of undisturbed vegetation that measures 10 m from each bank of the active channel.
  - Where pressurized drilling fluids[2] or water are used, the waterbody is monitored in case drilling fluids are released into the waterbody. At a minimum, this monitoring should be conducted at a distance of 400 m downstream of the crossing site. Contingency and monitoring measures are put in place, including:
    - instructions to monitor for potential seepage into the water body of drilling fluids or water used, including monitoring and recording drilling fluid volumes on a continuous basis during and after the drilling operation, and

[2] Drilling fluids can contain drilling muds can consist largely of a bentonite clay-water mixture, and they are not classified as toxic or hazardous substances. However, if it is released into water bodies, bentonite has the potential to adversely impact fish and macro-invertebrates.

- instructions on how to mitigate for the effect of any seepage into the water body of drilling fluids or water used.

If a trenchless crossing method is not possible, isolation and open-cut methods are also appropriate under wet conditions at numerous crossings (Table 7.1). The workspace should be isolated, irrespective of if there is an isolated pool or flowing water. The isolation should be designed such that (AE 2001):

- It is completed within one work-day, to minimise the impact on aquatic fauna.
- Measures are taken to prevent erosion of the area at, and surrounding, the outlet of a bypass/dewatering pump or flume. This can be done by dissipating the energy of the released water using devices that include, but are not limited to, tarps, flip buckets, plates, and appropriately sized granular materials.
- 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 pumps with a capacity that exceeds expected flows. Backup pumps and generators should be on site and operational if required.
- Pump intakes have a screen, with openings no larger that 2.54 mm, to ensure that no fish are entrapped.
- Fish are salvaged from the isolated workspace and translocated (see section 7.3.5).
- The upstream dam is slowly removed, to allow water to flush the sediment from the workspace area.
- Sediment-laden water is be pumped into sumps or onto vegetation.
- Operation of the clean-water pump to sustain partial flow below the downstream dams is continued until the downstream dam is removed.

7.3.2 Construction of Temporary Vehicle Creek Crossings

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

- Are constructed during the dry season.

- Follow the guidelines presented in Section 7.3.1 above.
- The bed and bank habitat is rehabilitated after removal of the temporary crossing (see section 7.3.4).

Due to the limited water flow within the creeks of the region, opportunities for fish to migrate should be maximised (Cotterell 1998). The construction of temporary creek crossings can minimise disruption of fish passage if:

- The crossing structures at each site follow the recommendations presented in Table 7.1.
- If culverts are used for temporary crossings, they should be designed such that they are (Cotterell 1998):
  - as short and wide as possible; whist being designed to allow the passage of anticipated flood volumes and associated debris, and to allow enough water depth within the culvert to facilitate fish movement (estimated at >0.5 m depth for the fish species likely to be present),
  - installed without a 'drop off' at the culvert outlet or inlet, as this impedes fish migration upstream and downstream
  - constructed with minimum disturbance to the outer banks on stream bends, as these are usually the most unstable and prone to erosion, and
  - removed when pipeline construction is complete, and the riparian vegetation is rehabilitated (by re-planting after construction if necessary) to stabilise banks, provide food and habitat for fauna and prevent predation of aquatic fauna by birds.

Table 7.1 Summary of creek crossing recommendations for the southern CSM water supply pipeline.

Site	**Recommended Pipeline Crossing**		**Recommended Road Crossing**		**Fish Salvage Required?**	**Water Quality Monitoring required?**	**Description of Required Rehabilitation**	**Minimum width of planted Riparian Vegetation**
	Dry Conditions	**Wet Conditions**	**Dry Conditions**	**Wet Conditions**				
2	Open cut	Isolate with steel plates.	Use existing road and culvert.	Use existing road and culvert.	Required only at pipeline crossing in wet conditions.	Required only at pipeline crossing in wet conditions.	Replace sand, boulders and cobbles (clean) in bed when finished.	20 m
4	Open cut	Isolate with steel plates and sand bags.	Use existing ford.	Isolate with steel plates and install culvert if required.	Required at both pipeline and road crossings in wet conditions.	Required at both pipeline and road crossings in wet conditions if flowing.	To rehabilitate wash gravel, plant riparian vegetation and instream vegetation. Erosion control required. Install culvert at road crossing if required.	Left bank 20 m, right bank 5 m.
5	Open cut or drill	Drill or isolate with steel plates and pump.	Temporary bridge or large box culvert required due to high banks and wide channel.	Isolate and install temporary bridge or large box culvert.	Required at both pipeline and road crossings in wet conditions.	Required at both pipeline and road crossings in wet conditions.	Re-vegetate banks and rehabilitate bed and in-stream habitat.	15 m

Site	Recommended Pipeline Crossing		Recommended Road Crossing		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum width of planted Riparian Vegetation
	Dry Conditions	**Wet Conditions**	**Dry Conditions**	**Wet Conditions**				
6	Open cut or drill	Drill or isolate with steel plates and pump.	Temporary bridge or large box culvert required due to high banks and wide channel.	Isolate and install temporary bridge or large box culvert.	Required at both pipeline and road crossings in wet conditions.	Required at both pipeline and road crossings in wet conditions.	Re-vegetate banks and rehabilitate bed and in-stream habitat.	Left bank 30 m, right bank 20 m.
7	Open cut	Isolate with steel plates.	Use existing and create temporary ford if required.	Use existing and create temporary single span bridge or box culvert only if necessary.	Required at both pipeline and road crossings in wet conditions.	Required at both pipeline and road crossings in wet conditions.	Rehabilitate bed and bank habitat including re-vegetation. Place any fallen trees into stream to provide habitat. Vegetation in channel indicates that site will not flow for long.	20 m

Site	Recommended Pipeline Crossing		Recommended Road Crossing		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum width of planted Riparian Vegetation
	Dry Conditions	**Wet Conditions**	**Dry Conditions**	**Wet Conditions**				
8	Open cut	Isolate with steel plates.	Use existing and create temporary ford if required.	Use existing and create single span bridge or box culvert if required. Unlikely to flow for long periods or hold water.	Required at both pipeline and road crossings in wet conditions.	Required at both pipeline and road crossings in wet conditions.	Rehabilitate bed with boulders, cobbles, gravel, etc. Erosion control required. Rehabilitate banks as compensation. Unlikely to flow for long periods or hold water.	15 m
9	Open cut, preferably west of highway.	Water likely to be deep and difficult to isolate. Drill so at to not disturb riparian vegetation. Or isolate with flume or coffer dam.	Use existing bridge and ford downstream (east) of bridge	Use existing bridge.	Required at pipeline crossing in wet conditions if isolated.	Required at pipeline crossing in wet conditions in both cases.	Replace boulders, cobbles and logs in bed when finished. Stabilise banks using seeded sediment mats, planting and placing cobbles and boulders. Preferred crossing at west of highway, as banks are not as steep.	50 m

Site	Recommended Pipeline Crossing		Recommended Road Crossing		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum width of planted Riparian Vegetation
	Dry Conditions	**Wet Conditions**	**Dry Conditions**	**Wet Conditions**				
10	Open cut. Banks are steep, slightly less steep east of the bridge.	Isolate with steel plates or flume.	Use existing. Create temporary ford east of bridge if required.	Use existing bridge. Create temporary single span bridge or culvert only if required.	Required at pipeline crossing in wet conditions. Only required at road crossing in wet conditions if a culvert is required.	Required at pipeline crossing in wet conditions. Only required at road crossing in wet conditions if crosses creek.	Stabilise banks with seeded soil wrap, re-vegetation and or boulders (not concrete). Preferred pipeline crossing east of bridge as banks are not as steep.	Left bank 30 m, right bank 20 m.
11	Open cut	Isolate with steel plates.	Use existing or temporary ford.	Use existing highway culvert. Temporary single span bridge or culvert if necessary.	Required at pipeline crossing in wet conditions. Only required at road crossing in wet conditions if a culvert is required.	Required at pipeline crossing in wet conditions. Only required at road crossing in wet conditions if crosses creek.	Rehabilitate bed and banks with vegetation. Erosion control required. Place any fallen trees in channel to provide habitat.	20 m

Site	Recommended Pipeline Crossing		Recommended Road Crossing		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum width of planted Riparian Vegetation
	Dry Conditions	Wet Conditions	Dry Conditions	Wet Conditions				
12	Open cut	Isolate with steel plates.	Use existing or temporary ford.	Use existing and create temporary single span bridge or box culvert only if required.	Required at pipeline crossing in wet conditions. Only required at road crossing in wet conditions if a culvert is required.	Required at pipeline crossing in wet conditions. Only required at road crossing in wet conditions if culvert crosses creek.	Rehabilitate banks with boulders, vegetation and sediment mats if required. Place any fallen trees in channel to provide habitat.	25 m
13	Open cut immediately adjacent to culvert.	Immediately adjacent to culvert. Don't cross when flowing. Once flow subsides, pipeline area will drain quickly. Difficult to isolate, could divert flow with pumps, but this would also be difficult.	Use existing culvert and ford downstream from culvert.	Use existing culvert.	Required at pipeline crossing only if isolate.	Required at pipeline crossing only if isolate or pump water.	Rehabilitate banks vegetation and bed habitat. Replace boulders and cobbles with excavated or washed ones. Place any fallen trees in pool to provide habitat.	30 m

Site	Recommended Pipeline Crossing		Recommended Road Crossing		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum width of planted Riparian Vegetation
	Dry Conditions	**Wet Conditions**	**Dry Conditions**	**Wet Conditions**				
15	Open cut	Sandbag pool to isolate construction area.	Use existing or ford next to culvert.	Use existing	Required at pipeline crossing if isolated.	Required at pipeline crossing if isolated.	Remediation including revegetation.	Left bank 30 m, right bank 40 m.
16	Open cut	Isolate with steel plates.	Use existing ford.	Temporary single span bridge or box culvert.	Required at both pipeline and road crossings in wet conditions.	Required at both pipeline and road crossings in wet conditions.	Rehabilitate including re-vegetation of bed, banks and bend habitats. Stay as close to road as possible.	20 m
17	Open cut	Isolate with steel plates.	Use existing ford.	Temporary single span bridge or box culvert.	Required at both pipeline and road crossings in wet conditions.	Required at both pipeline and road crossings in wet conditions.	Erosion control measures to be used. Stabilise banks when complete. Rehabilitate bed and re-vegetate banks.	10 m
18	Open cut	Isolate with steel plates.	Use existing ford.	Temporary culvert.	Required at both pipeline and road crossings in wet conditions.	Required at both pipeline and road crossings in wet conditions.	Rehabilitate bed and banks with re-vegetation and filling bed with sandy material.	10 m

Site	Recommended Pipeline Crossing		Recommended Road Crossing		Fish Salvage Required?	Water Quality Monitoring required?	Description of Required Rehabilitation	Minimum width of planted Riparian Vegetation
	Dry Conditions	**Wet Conditions**	**Dry Conditions**	**Wet Conditions**				
22	Open cut	Isolate and open cut.	Use existing	Use existing, temporary culvert if required.	Required at pipeline crossing in wet conditions if isolate.	Required at pipeline crossing in wet conditions if isolate. Required at road crossing in wet conditions if culvert.	Rehabilitate riparian vegetation and stream bed.	5 m
Frank Creek	Open cut	Isolate and open cut.	Temporary ford	Temporary culvert if required.	Required at pipeline crossing in wet conditions if isolate.	Required at pipeline crossing in wet conditions if isolate. Required at road crossing in wet conditions if culvert.	Rehabilitate riparian vegetation and stream bed.	10 m

1 Small ephemeral stream, not expected to flow for very long after rain

7.3.3 Water Quality Monitoring

Table 7.2 outlines recommended water quality monitoring during the installation of the pipeline creek and temporary vehicle crossings. The aim of this monitoring is to determine whether sediment runoff during construction is likely to impact upon aquatic fauna. As a guide, Table 7.2 presents preliminary water quality objectives for the waterways to be crossed by the pipeline. These guidelines aim to maintain the natural fish communities of the region, based on the water quality recorded during the current studies, and published environmental tolerances (as outlined in Table 4.7).

Table 7.2 Preliminary water quality objectives for the water quality required in the creeks crossed by the pipeline, to maintain the natural fish communities of these creeks.

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	6.5 – 8.5
Conductivity (µS/cm)	19.5 – 770
Turbidity (NTU)	< 200*, or 10% above background values, whichever is higher

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

It is recommended that water quality be measured with a hand-held probe:

- immediately upstream of the crossing site immediately prior to construction, to determine background conditions
- daily during construction, at locations both upstream and downstream of the crossing
- daily after construction until water quality returns to background conditions, as established by the initial background monitoring prior to crossing construction.

Where water quality objectives in the creek are exceeded, it is recommended that construction cease and that stormwater and erosion and sediment control measures be revised prior to re-commencement of construction.

7.3.4 Rehabilitation of Instream Aquatic Habitat

After installation of the pipeline and removal of a temporary crossing, impacts should be mitigated by:

- Rehabilitation of the bed and bank structure such that original dimensions and shape of the creek are achieved. Bank recontouring should include stabilisation methods (crib walls or soil wraps) where appropriate (Table 7.1).
- Revegetation of the banks as outlined in section 7.2.3.
- 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).
- Replacing aquatic habitat structures within the channel. Prior to construction, any instream structures (woody debris, large cobbles) may be salvaged. Felled trees may also be placed into creeks to create woody debris habitat.

7.3.5 Stranding of Fish and Other Aquatic Fauna

If an isolation method is used, fish and other aquatic fauna will become stranded once the work area is isolated. Stranded fish must be captured and translocated, following the DPI&F *Fish Salvage Guidelines* (DPI&F 2004), which recommend that:

- fish should be captured from the creek using gear appropriate to the waterways and species present (at the site, this is likely to include electrofishing, cast nets, seine nets and set traps)
- translocation should be done in the cooler months if possible, to minimise stress to the fish (fish are less active in the cooler months)
- fish should be removed from the existing channel before water flow is isolated from the channel, and
- fish should be handled, transported and released so as to minimise damage to the fish (e.g. handle with wet hands, hold fish correctly etc.)

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 should 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.

7.4 Supply and Storage of CSM By-Product Water

Water supplied by the southern CSM pipeline will be stored in a raw water storage dam in the MLA area of the Project. The dam should be designed so that this water, which has a high TDS concentration, is not released into natural waterways.

The pipeline should be regularly inspected and maintained so that water does not leak from the pipeline into surrounding natural waterways.

No equipment that is used in surface waters in the Condamine catchment (such as water quality meters or sampling equipment) should have contact with the CSM water, unless it has been thoroughly cleaned with bleach. The Proponent should also ensure that the supplied water, and the raw water storage dam in the MLA area, is free from noxious carp on a regular basis (refer to Volume 1 for details regarding monitoring of fish in the raw water dam).

7.5 Biting Insects

Mosquito breeding habitat may 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.

7.6 Threatened Species and Ecological Communities

The Project is unlikely to have a significant impact on any threatened species or ecological communities where each of the mitigation measures described above is adopted (and in particular, where riparian and aquatic habitat is rehabilitated after construction).

8 Residual Impacts

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) during installation of the pipeline, the risk to the aquatic ecology is considered to be very low.

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

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

When construction is carried out in the wet season, 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.

Where no equipment that is used in surface waters in the Condamine catchment has contact with the CSM water (unless it has been thoroughly cleaned with bleach) and where the Proponent ensures that the supplied and stored CSM water is free from noxious carp on a regular basis, the likelihood of transferring carp from the Condamine catchment to the Fitzroy Basin via the southern CSM water supply pipeline is considered to be negligible.

Where in-stream habitat is replaced after construction, no impacts to conservationally significant aquatic habitats or species are expected.

9 Conclusions

Surrounding land uses, including vegetation clearing, cattle grazing and cropping, have negatively impacted the physical 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. The aquatic habitat of the creeks within along the southern CSM water supply pipeline route are considered to be in poor to moderate condition overall; and aquatic habitats in creeks adjacent to forested areas were in better condition than those adjacent to grazing land. Despite the surrounding impacts, many of the creeks surveyed contained large trees in the riparian zone and a variety of aquatic habitats available to fauna.

Biodiversity in the study area is slightly lower than in the more permanent waters of the region. Only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabit the study area; and introduced species, including the declared noxious mosquitofish and carp, were found in the waterways crossed by the pipeline alignment. However, while typically less diverse than the faunal communities in the Dawson or Condamine Rivers downstream, macro-invertebrate and fish communities found within the creeks along the pipeline route are likely to contribute to the success of downstream populations through migration. Freshwater turtles were not found in the study area. No rare or threatened aquatic floral or faunal species were found in the study area or are considered likely to occur, based on the habitats present.

The potential impacts of fuel handling and stormwater runoff on the creeks along the pipeline route (and downstream waterways) can be minimised to an acceptable level if current best-practice environmental management programs are followed. Where no equipment that is used in surface waters in the Condamine catchment has contact with the CSM water (unless it has been thoroughly cleaned with bleach) and where the Proponent ensures that the supplied and stored CSM water is free from noxious carp on a regular basis, the likelihood of transferring carp from the Condamine catchment to the Fitzroy Basin via the southern CSM water supply pipeline is considered to be negligible.

Of the potential impacts of the southern CSM water supply pipeline, the construction of creek crossings (which can affect riparian and aquatic habitats, and fish movement), poses the greatest threat to aquatic ecology. However, the significance of this impact can be reduced if appropriate mitigation measures are followed. In particular, after creek crossings are completed, the bed and bands should be constructed so that they replicate the natural channel in terms of channel morphology, sediment types and riparian vegetation.

10 Summary of Impact Avoidance, Minimisation and Mitigation Strategies

Recommended strategies to avoid, minimise and mitigate potential impacts of the Project to aquatic flora and fauna, as previously detailed in this aquatic ecology assessment, are summarised below:

- Vehicle maintenance areas and storage of fuels, lube and oil and batteries should be undertaken within bunded areas designed and constructed in accordance with AS1940.
- Portable refuelling stations, for refuelling of machinery in the field, should also bunded to meet AS1940, and placed above the Q100 flood level of nearby waterways and dams.
- All spills of contaminants (such as diesel, oil, hydraulic fluid etc.) should be immediately reported to the Project's Environmental Officer or other relevant personnel.
- Appropriate spill containment kits should be 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 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).
- An erosion and sediment control management plan should be developed (as a part of the EMP) to prevent excess sediment from running off into the creeks during earth moving and vegetation clearing related to installation of the pipeline.
- Construction of road and pipeline crossings of creeks, particularly of major waterways (Dogwood, Wallan, Eleven Mile, Nine Mile, Juandah and Frank creeks) should be done in the dry season if possible.
- Erosion control matting should be placed in ditches and drainage lines running from all cleared areas, especially on slopes and levee banks.
- Contour banks or ditched should be formed across cleared slopes to direct runoff towards surrounding vegetation and away from creeks.
- After construction, water quality and ecosystem health of nearby waterways should be protected by rehabilitation of the landscape, focusing on the:
  - Salvaging clumps of native grass, shrubs and trees prior to clearing.
  - Use of native vegetation of local provenance for replanting where possible, and

  - Replanting along creek margins following construction of creek crossings. The width of the replanted riparian vegetation should match the existing riparian vegetation; however, 5 m would 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.

- Impacts associated with the construction of pipeline crossings in the dry season will be minimised if:
  - Crossings are located to result in minimal disturbance to wooded areas.
  - Stormwater and erosion and sediment control measures are implemented.
  - Crossing construction methods minimise disturbance to aquatic habitat and fish passage. Table 7.1 outlines appropriate crossing methods for both the pipeline and temporary roads.

- Impacts associated with the construction of pipeline crossings in the wet season will be minimised if:
  - Where practical, a trenchless crossing method is used (e.g. horizontal directional drill), in accordance with the following recommendations (AE 2001):
    - The drilling be done in a manner that does not cause a disturbance in the water, to the exposed bed or banks of the water body, or to an area of undisturbed vegetation that measures 10 m from each bank of the active channel.
    - Where pressurized drilling fluids[3] or water are used, the waterbody is monitored in case drilling fluids are released into the waterbody. At a minimum, this monitoring should be conducted at a distance of 400 m downstream of the crossing site. Contingency and monitoring measures are put in place, including:
      - instructions to monitor for potential seepage into the water body of drilling fluids or water used, including monitoring and recording drilling fluid volumes on a continuous basis during and after the drilling operation, and
      - instructions on how to mitigate for the effect of any seepage into the water body of drilling fluids or water used.

[3] Drilling fluids can contain drilling muds can consist largely of a bentonite clay-water mixture, and they are not classified as toxic or hazardous substances. However, if it is released into water bodies, bentonite has the potential to adversely impact fish and invertebrates.

- If a trenchless crossing method is not possible, the workspace should be isolated, irrespective of if there is an isolated pool or flowing water. The isolation should be designed such that (AE 2001):
    - It is completed within one work-day, to minimise the impact on aquatic fauna.
    - Measures are taken to prevent erosion of the area at, and surrounding, the outlet of a bypass/dewatering pump or flume. This can be done by dissipating the energy of the released water using devices that include, but are not limited to, tarps, flip buckets, plates, and appropriately sized granular materials.
    - 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 pumps with a capacity that exceeds expected flows. Backup pumps and generators should be on site and operational if required.
    - Pump intakes have a screen, with openings no larger that 2.54 mm, to ensure that no fish are entrapped.
    - Fish are salvaged from the isolated workspace and translocated (see section 7.3.5).
    - The upstream dam is slowly removed, to allow water to flush the sediment from the workspace area.
    - Sediment-laden water is be pumped into sumps or onto vegetation.
    - Operation of the clean-water pump to sustain partial flow below the downstream dams is continued until the downstream dam is removed.
- The crossing structures at each site follow the recommendations presented in Table 7.1.
- If culverts are used for temporary road crossings as part of the pipeline construction, they should be designed such that they are (Cotterell 1998):
    - as short and wide as possible; whist being designed to allow the passage of anticipated flood volumes and associated debris, and to allow enough water depth within the culvert to facilitate fish movement (estimated at >0.5 m depth for the fish species likely to be present),

  - installed without a 'drop off' at the culvert outlet or inlet, as this impedes fish migration upstream and downstream
  - constructed with minimum disturbance to the outer banks on stream bends, as these are usually the most unstable and prone to erosion, and
  - removed when pipeline construction is complete, and the riparian vegetation is rehabilitated (by re-planting after construction if necessary) to stabilise banks, provide food and habitat for fauna and prevent predation of aquatic fauna by birds.
- Water quality should be monitored during construction of creek crossings, to determine whether sediment runoff during construction is likely to impact upon aquatic fauna. As a guide, Table 7.2 presents preliminary water quality objectives for the waterways to be crossed by the pipeline.
- After installation of the pipeline and removal of temporary crossings, impacts should be mitigated by:
  - Rehabilitation of the bed and bank structure such that original dimensions and shape of the creek are achieved. Bank recontouring should include stabilisation methods (crib walls or soil wraps) where appropriate (Table 7.1).
  - Revegetating banks as outlined in section 7.2.3.
  - 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).
  - Replacing aquatic habitat structures within the channel. Prior to construction, any instream structures (woody debris, large cobbles) may be salvaged. Felled trees may also be placed into creeks to create woody debris habitat.
- If an isolation method is used, fish and other aquatic fauna will become stranded once the work area is isolated. Stranded fish must be captured and translocated, following the DPI&F *Fish Salvage Guidelines* (DPI&F 2004)

- Water supplied from the southern CSM pipeline will be stored in the raw water storage dam. The dam should be designed so that this water, which has a high TDS concentration, is not released into natural waterways.
- No equipment that is used in surface waters in the Condamine catchment (such as water quality meters or sampling equipment) should have contact with the CSM water, unless it has been thoroughly cleaned with bleach.
- The Proponent should also ensure that the supplied water, and the raw water storage dam in the MLA area, is free from noxious carp on a regular basis (refer to Volume 1 for details regarding monitoring of fish in the raw water dam).
- The Proponent should also ensure that the supply dam and the dams on the site are free from noxious species on a regular basis.
- The pipeline should be regularly inspected and maintained so that water does not leak from the pipeline into surrounding natural waterways.
- Mosquito breeding habitat may 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.

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Attachment A Description of the Sites Surveyed

				
Typical view upstream through the site (15-08-08)	Typical view of right bank (15-08-08)	Typical view of left bank (15-08-08)	Typical view downstream through the site (15-08-08)	

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	10
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Sloping

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (mg/L):	-
DO (% Sat):	-
Turbidity (NTU):	-
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 20	Right: 5
Dominant Type:	Eucalypt	

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	5
Pebble:	5
Gravel:	15
Sand:	70
Silt/Clay:	5

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	-
Macrophytes:	-
Detritus:	-

Dominate Cover Type:

-

Sub Dominate Cover Type:

-

Comments: Small first order stream. Wide flat bed and vegetation in channel indicates that it carries flow during rain but does not hold water.

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08.06.11 Wandoan South

Survey Date:	15-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Tributary to Dogwood Creek

frc site number 4

UTM Zone 56K 221873 E 7051744 N WGS84

Cond.

M

				
Typical view upstream through the site (15-08-08)	Typical view of right bank (15-08-08)	Typical view of left bank (15-08-08)	Typical view downstream through the site (15-08-08)	

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Ephemeral
Channel Width (m):	15
Wetted Width (m):	8
Water Level:	Low
Bank Shape:	Vertical, Sloping

Water Quality

Temperature (C):	17.2
pH:	5.65
Conductivity (uS/cm):	36.7
DO (mg/L):	64.4
DO (% Sat):	5.88
Turbidity (NTU):	-
ORP (mV):	256

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 15	Right: 15
Dominant Type:	Eucalypt, Callistemon	

Fauna

Cane toad

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	40
Silt/Clay:	60

Cover (%)

Periphyton:	None
Moss:	<10%
Filamentous algae:	<10%
Macrophytes:	None
Detritus:	10-35%

Dominate Cover Type:

Large woody debris

Sub Dominate Cover Type:

Detritus

Comments: Lots of dead trees in and around water. Potential turtle nesting bank upstream.

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Survey Date:	27-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Dogwood Creek

Cond.

P

frc site number 5

UTM Zone 56K 219857 E 7049837 N WGS84

Typical view upstream through the site (15-08-08)

Typical view of right bank (15-08-08)

Typical view of left bank (15-08-08)

Typical view downstream through the site (15-08-08)

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	40
Wetted Width (m):	15
Water Level:	Moderate
Bank Shape:	Sloping

Water Quality

Temperature (C):	20.4
pH:	6.5
Conductivity (uS/cm):	55.7
DO (mg/L):	5.2
DO (% Sat):	56.3
Turbidity (NTU):	-
ORP (mV):	253

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 30	Right: 20
Dominant Type:	Eucalypt, Callistemon	

Fauna

Fish

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Moderate

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	50
Silt/Clay:	50

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	<10%
Macrophytes:	None
Detritus:	<10%

Dominate Cover Type:

Large woody debris

Sub Dominate Cover Type:

Instream vegetation including roots

Comments: Evidence of fishing and dog tracks. Lots of dead trees in water at downstream end.

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Survey Date:	28-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Dogwood Creek

Cond. M

frc site number 6

UTM Zone 56K 219216 E 7048342 N WGS84

				
Typical view upstream through the site (15-08-08)	Typical view of right bank (15-08-08)	Typical view of left bank (15-08-08)	Typical view downstream through the site (15-08-08)	Typical view downstream through the site (15-08-08)

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Ephemeral
Channel Width (m):	6
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Sloping

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (mg/L):	-
DO (% Sat):	-
Turbidity (NTU):	-
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 20	Right: 20
Dominant Type:	Eucalypt, Cyperus	

Fauna

Kangaroo prints, animal burrows

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	20
Sand:	30
Silt/Clay:	50

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	<10

Dominate Cover Type:

-

Sub Dominate Cover Type:

Overhanging vegetation, man made

Comments: Small ephemeral creek. Box culverts unlikely to restrict fish passage. Kangaroo prints and animal burrows observed at the site.

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Survey Date:	15-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Tributary to Eleven Mile Creek

frc site number 7

UTM Zone 56K 217315 E 7055369 N WGS84

Cond.

M

Typical view upstream through the site (15-08-08)

Typical view of right bank (15-08-08)

Typical view of left bank (15-08-08)

Typical view downstream through the site (15-08-08)

Typical view downstream through the site (15-08-08)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Ephemeral
Channel Width (m):	-
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Undercut, Vertical, Sloping

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (mg/L):	-
DO (% Sat):	-
Turbidity (NTU):	-
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m): Left: 15 Right: 15

Dominant Type: Eucalypt, Casuarina, Cyperus

Fauna

Cat prints, kangaroo prints

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	10
Sand:	80
Silt/Clay:	10

Cover (%)

Periphyton:	-
Moss:	-
Filamentous algae:	-
Macrophytes:	-
Detritus:	-

Dominate Cover Type:

-

Sub Dominate Cover Type:

Man made

Comments: Braided erosion channels running into a box culvert. No defined channel upstream from culvert. Downstream channel is defined. Undercut banks and heavy erosion. Some riparian vegetation conserved in pasture land.

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08.06.11 Wandoan South

Survey Date: 15-08-08
Written By: TS Approved By: LT
Date Issued: Sept 2008

Tributary to Eleven Mile Creek

frc site number 8

UTM Zone 56K 216871 E 7056204 N WGS84

Cond.

M

				
Typical view upstream through the site (15-08-08)	Typical view of right bank (15-08-08)	Typical view of left bank (15-08-08)	Typical view of left bank (15-08-08)	Typical view downstream through the site (15-08-08)

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Intermittent
Channel Width (m):	18
Wetted Width (m):	7
Water Level:	Low
Bank Shape:	Vertical

Water Quality

Temperature (C):	11.2
pH:	6.1
Conductivity (uS/cm):	429
DO (mg/L):	10.51
DO (% Sat):	95.8
Turbidity (NTU):	40
ORP (mV):	234

Flora and Fauna

Vegetation

Riparian Width (m): Left: 50 Right: 50

Dominant Type: Eucalypt

Fauna

Kangaroo and stock prints

Habitat (%)

Riffle:	-
Run:	-
Pool:	50
Rapid:	-
Cascade:	-
Dry:	50
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	25
Pebble:	5
Gravel:	5
Sand:	5
Silt/Clay:	60

Cover (%)

Periphyton:	<10
Moss:	None
Filamentous algae:	None
Macrophytes:	10-35
Detritus:	10-35

Dominate Cover Type:
Large woody debris, instream vegetation

Sub Dominate Cover Type:
Small woody debris, boulder, cobble, deep pools, overhanging vegetation

Comments: Large deep channel filled with perennial pools. Riparian vegetation dominated by very large Eucalyptus that provide bank stabilisation. Banks covered by dense *Phragmites australis*. Downstream of highway there is a ford which is causing the backup of sediment and debris upstream.

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08.06.11 Wandoan South

Survey Date: 15-08-08
Written By: TS Approved By: LT
Date Issued: Sept 2008

Wallan Creek

frc site number 9

UTM Zone 56K 215747 E 7058513 N WGS84

Cond.

M

View upstream through the site (15-08-08)

View downstream through the site (15-08-08)

Macrophytes at the site (15-08-08)

Bat trap under a bridge at the site (15-08-08)

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Intermittent
Channel Width (m):	18
Wetted Width (m):	5
Water Level:	Low
Bank Shape:	Vertical, Sloping

Water Quality

Temperature (C):	10.6
pH:	6.59
Conductivity (uS/cm):	87.5
DO (mg/L):	11.7
DO (% Sat):	106
Turbidity (NTU):	-
ORP (mV):	263

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 30	Right: 20
Dominant Type:	Eucalypt	

Fauna

Wallaby tracks, bat trap under bridge

Habitat (%)

Riffle:	-
Run:	-
Pool:	25
Rapid:	-
Cascade:	-
Dry:	75
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	5
Gravel:	5
Sand:	85
Silt/Clay:	5

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	35-65
Detritus:	<10

Dominate Cover Type:

-

Sub Dominate Cover Type:
Small and large woody debris, deep pools, overhanging vegetation, trailing bank vegetation, instream vegetation

Comments: Deep channel with some eroding banks, downstream and upstream of bridge. Ford creating erosion around eastern end of bridge. Large treefalls upstream of bridge creating a scour but currently dry. Very sandy substrate. Banks are lined with *Phragmites.*

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Survey Date:	15-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Eleven Mile Creek

Cond.

M

frc site number 10

UTM Zone 56K 215116 E 7060734 N WGS84

				
Typical view upstream through the site (15-08-08)	Typical view of right bank (15-08-08)	Typical view of left bank (15-08-08)	Typical view of left bank (15-08-08)	Typical view downstream through the site (15-08-08)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Ephemeral
Channel Width (m):	10
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Sloping

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (mg/L):	-
DO (% Sat):	-
Turbidity (NTU):	-
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 20	Right: 20
Dominant Type:	Eucalypt	

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	-
Silt/Clay:	100

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	65-90
Detritus:	10-35

Dominate Cover Type:

Instream vegetation

Sub Dominate Cover Type:

Overhanging vegetation

Comments: Box culvert crossing with lots of Juncus instream vegetation. East side of highway has more riparian vegetation intact. Some prickly pear present.

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08.06.11 Wandoan South

Survey Date:	15-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Tributary to Eleven Mile Creek

Cond. M

frc site number 11

UTM Zone 56K 213744 E 7062528 N WGS84

				
Typical view upstream through the site (15-08-08)	Typical view of right bank (15-08-08)	Typical view of right bank (15-08-08)	Typical view of left bank (15-08-08)	Typical view downstream through the site (15-08-08)

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Ephemeral
Channel Width (m):	10
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Vertical

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (mg/L):	-
DO (% Sat):	-
Turbidity (NTU):	-
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 25	Right: 25
Dominant Type:	Eucalypt, Cyperus	

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	95
Silt/Clay:	5

Cover (%)

Periphyton:	-
Moss:	-
Filamentous algae:	-
Macrophytes:	-
Detritus:	-

Dominate Cover Type:

-

Sub Dominate Cover Type:

Large woody debris

Comments: Sandy bed creek with large scour upstream of highway crossing. Erosion prominent on both sides. Downstream riparian vegetation has been preserved but erosion undermining trees is evident.

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08.06.11 Wandoan South

Survey Date:	15-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Eleven Mile Creek

Cond. M

frc site number 12

UTM Zone 56K 212860 E 7063034 N WGS84


Typical view upstream through the site (12-08-08)


Typical view upstream through the site (12-08-08)


Typical view of right bank (12-08-08)


Typical view of left bank (12-08-08)


Typical view downstream through the site (12-08-08)

Channel Habitat

Morphology

Pattern:	Meanders
Flow Regime:	Ephemeral
Channel Width (m):	18
Wetted Width (m):	1
Water Level:	Low
Bank Shape:	Vertical, Sloping

Water Quality

Temperature (C):	14.3
pH:	7.75
Conductivity (uS/cm):	93.4
DO (mg/L):	11.56
DO (% Sat):	106
Turbidity (NTU):	-
ORP (mV):	267

Flora and Fauna

Vegetation

Riparian Width (m): Left: 30 Right: 30

Dominant Type: Eucalypt

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	0
Boulder:	10
Cobble:	25
Pebble:	10
Gravel:	20
Sand:	20
Silt/Clay:	5

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	35-65

Dominate Cover Type:

Large woody debris

Sub Dominate Cover Type:

Small woody debris, boulder

Comments: Meandering braided channel with ephemeral pools. Eroding on outer meanders. Pool upstream of road is very small and contains cobbles. Pool downstream of road is deep and sandy. There is a box culvert crossing.

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08.06.11 Wandoan South

Survey Date: 12-08-08
Written By: TS Approved By: LT
Date Issued: Sept 2008

Tributary to Nine Mile Creek

frc site number 13

UTM Zone 56K 209553 E 7065547 N WGS84

Cond.

M

Typical view upstream through the site (12-08-08)

Typical view of right bank (12-08-08)

Typical view of left bank (12-08-08)

Typical view downstream through the site (12-08-08)

Typical view downstream through the site (12-08-08)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Ephemeral
Channel Width (m):	3
Wetted Width (m):	2
Water Level:	Low
Bank Shape:	Undercut, Vertical, Sloping

Water Quality

Temperature (C):	16.9
pH:	6.8
Conductivity (uS/cm):	132
DO (mg/L):	10.98
DO (% Sat):	110
Turbidity (NTU):	-
ORP (mV):	318

Flora and Fauna

Vegetation

Riparian Width (m): Left: 30 Right: 40

Dominant Type: Eucalypt

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	20
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	40
Silt/Clay:	40

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	<10
Detritus:	10-35

Dominate Cover Type:
Overhanging vegetation

Sub Dominate Cover Type:
Large woody debris, cobble, undercut banks, deep pools, instream vegetation

Comments: Upstream is covered by rushes along entire stream bed length. There are cobbles immediately upstream of box culvert. Downstream sediment is finer and there are no rushes. There is a long pool downstream of the road that is approximately 80 m in length.

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08.06.11 Wandoan South

Survey Date: 12-08-08
Written By: TS Approved By: LT
Date Issued: Sept 2008

Tributary to L Tree Creek

frc site number 15

UTM Zone 56K 207395 E 7071543 N WGS84

Cond.
M

				
Typical view upstream through the site (14-08-08)	Typical view of right bank (14-08-08)	Typical view of left bank (14-08-08)	Typical view downstream through the site (14-08-08)	Typical view downstream through the site (14-08-08)

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Intermittent
Channel Width (m):	4
Wetted Width (m):	0.8
Water Level:	Low
Bank Shape:	Sloping

Water Quality

Temperature (C):	13.7
pH:	7.78
Conductivity (uS/cm):	523
DO (mg/L):	6.4
DO (% Sat):	63
Turbidity (NTU):	-
ORP (mV):	213

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 20	Right: 20
Dominant Type:	Eucalypt, Casuarina	

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	100
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	40
Silt/Clay:	60

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	<10
Detritus:	<10

Dominate Cover Type:

Instream vegetation

Sub Dominate Cover Type:

Large woody debris

Comments: Small isolated pools with a ford crossing. Earth moving on downstream side of road.

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08.06.11 Wandoan South

Survey Date:	14-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

L Tree Creek

Cond. M

frc site number 16

UTM Zone 56K 206115 E 7074312 N WGS84


View upstream through the site (14-08-08)


View of right bank (14-08-08)


View of left bank (14-08-08)


View downstream through the site (14-08-08)

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Ephemeral
Channel Width (m):	1
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Sloping

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (mg/L):	-
DO (% Sat):	-
Turbidity (NTU):	-
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m): Left: 10 Right: 10

Dominant Type: Eucalypt

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	-

Substrate (%)

Bedrock:	-
Boulder:	10
Cobble:	10
Pebble:	10
Gravel:	10
Sand:	60
Silt/Clay:	-

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	<10

Dominate Cover Type:

Large woody debris

Sub Dominate Cover Type:

Small woody debris, boulder, cobble

Comments: Box culvert under train ~ 2 m above channel, too high for fish.

frc environmental
deep thinking. science.

08.06.11 Wandoan South

Survey Date: 14-08-08
Written By: TS Approved By:
Date Issued: Sept 2008

Tributary to Juandah Creek

frc site number 17

UTM Zone 56K 204251 E 7079579 N WGS84

Cond.

M

				
View upstream through the site (14-08-08)	View of right bank (14-08-08)	View of left bank (14-08-08)	View downstream through the site (14-08-08)	

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Ephemeral
Channel Width (m):	5
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Sloping

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (mg/L):	-
DO (% Sat):	-
Turbidity (NTU):	-
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 10	Right: 10
Dominant Type:	Eucalypt, Casuarina	

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	-

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	10
Sand:	90
Silt/Clay:	-

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	None

Dominate Cover Type:

Instream vegetation

Sub Dominate Cover Type:

-

Comments: Channel is sandy, dry, and straight.

frc environmental deep thinking. science.	08.06.11 Wandoan South	Juandah Creek	Cond. M

Survey Date:	14-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

frc site number 18

UTM Zone 56K 204909 E 7081153 N WGS84

				
View upstream through the site (14-08-08)	Typical view upstream (14-08-08)	Typical view upstream from road (14-08-08)	View of right bank (14-08-08)	View downstream through the site (14-08-08)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Ephemeral
Channel Width (m):	1
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Sloping

Water Quality

Temperature (C):	-
pH:	-
Conductivity (uS/cm):	-
DO (mg/L):	-
DO (% Sat):	-
Turbidity (NTU):	-
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 0	Right: 0
Dominant Type:	Grass	

Fauna

-

Habitat (%)

Riffle:	-
Run:	-
Pool:	-
Rapid:	-
Cascade:	-
Fall:	-
Overall Complexity:	-

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	-
Silt/Clay:	100

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	None

Dominate Cover Type:

Overhanging vegetation

Sub Dominate Cover Type:

Instream vegetation

Comments: No riparian vegetation downstream from road.

frc environmental
deep thinking. science.

08.06.11 Wandoan South

Survey Date:	14-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Tributary to Sandy Flat Creek

Cond. P

frc site number 22

UTM Zone 55K 796033 E 7094053 N WGS84

Attachment B Introduction to the Data Analyses Used

Habitat Bioassessment Scores

The standard Habitat Bioassessment Score datasheets (DNRM 2001) were used to numerically assess 9 criteria in four categories: excellent, good, moderate and poor. The sum of the numerical rating from each category produced an overall habitat assessment score. Each site was given an indicative overall condition category, based on the following total habitat assessment score categories: Excellent >110; Good 75 – 110; Moderate 39 – 74; and poor ≤38. Condition categories were based on minimum possible score required for each criteria to be scored within that condition category (Table B.1).

Table B.1 Habitat assessment scores used to derive overall condition categories (adapted from DNRM 2001).

Habitat Variable	**Minimum Possible Score Within Each Condition Category**			
	Excellent	**Good**	**Moderate**	**Poor**
Bottom substrate / available cover	16	11	6	0
Embeddedness	16	11	6	0
Velocity / depth category	16	11	6	0
Channel alteration	12	8	4	0
Bottom scouring & deposition	12	8	4	0
Pool / riffle, run / bend ratio	12	8	4	0
Bank stability	9	6	3	0
Bank vegetative stability	9	6	3	0
Streamside cover	9	6	3	0
Total	**111**	**75**	**39**	**0**

Macro-invertebrate Indices

Aquatic macro-invertebrates play a major role in the ecology of rivers. They form a key link in the aquatic food chain, forming a pathway between primary producers and predators (Chessman 1986). Aquatic invertebrates are sensitive to flow conditions, water quality and habitat conditions (Choy & Marshall 1997). They are characteristically not very mobile, and are therefore good indicators of local impacts (Walsh 2006; Choy &

Marshall 1997). Aquatic invertebrate diversity is crucial to the maintenance of a healthy ecosystem (Choy & Marshall 1997).

Physical and chemical monitoring of water quality can only provide a snapshot of the conditions in an aquatic ecosystem. Biological monitoring provides a more time-integrated picture of ecosystem health, and may for example, indicate the pollution history of an environment. Macro-invertebrates are often used in biological monitoring as they are widespread; occupy many different niches and are an integral part of the food web; are sensitive to the effects of surrounding landuses such as turbidity, eutrophication, increased salinity and high toxicant levels; and have relatively long life-cycles. The effects of changes in water quality on populations can be long lasting; and impacts can thus be detected for some time after they occur.

A number of indices are effective indicators of ecosystem health (EHMP 2004). Use of multiple indices contributes to the robustness and reliability of any assessment. These indices have all been found to be effective indicators of ecological health (EHMP 2004).

Taxonomic Richness

Taxonomic richness is the number of taxa (typically families) in a sample. Taxonomic richness is the most basic and unambiguous diversity measure, and is considered to be among the most effective diversity measures. It is however, affected by arbitrary choice of sample size. Where all samples are considered to be of equal size, species richness index is considered to be a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxa, so rare taxa have as much 'weight' as common ones.

PET Richness

While some groups of macro-invertebrates are tolerant of pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). The **P**lecoptera (stoneflies), **E**phemoptera (mayflies), and **T**richoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families in sites with good habitat and water quality than in degraded sites, and PET Taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2004). The lower the PET score, the greater the inferred degradation.

SIGNAL 2 Scores

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

SIGNAL 2 scores are weighted for abundance, such that the relative abundance of tolerant or sensitive taxa can be taken into account (instead of only the presence / absence of these taxa). The overall SIGNAL 2 score for a site is based on the total of the SIGNAL grade (multiplied by the weight factor) for each taxa present at the site, divided by the total of the weight factors for each taxa at the site. It is important to note that the DNRW data used in this study only presents abundances of up to 10 specimens per family per site, yet the SIGNAL 2 scores are weighted for abundances of up to 20 specimens per family per site. This may have artificially lowered the SIGNAL 2 scores calculated from the DNRW data. Therefore, these SIGNAL ranges may be used to provide an *indication* of water quality, and should not be deemed conclusive. SIGNAL scores above 6 generally indicate 'good water quality', values between 5 and 6 indicate 'possible mild pollution', whilst indices of less than 4 indicate 'probable pollution' (Chessman 1995, cited in Gooderham & Tsyrlin 2002). Habitat quality can affect macro-invertebrate community structure, and may also affect SIGNAL 2 scores.

SIGNAL 2 scores should be interpreted in conjunction with the number of families found in the sample. This can be achieved using a SIGNAL 2 / Family bi-plot (Chessman 2003). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure B.1). Quadrant boundaries for the SIGNAL 2 / Family Bi-plot used for this study are interim suggested boundaries (Chessman 2001) for Australian freshwaters (excluding the Murray – Darling Basin and rivers east of the Great Dividing Range in Queensland). Recently, an alternative approach has been recommended, which includes boundary setting for each study (Chessman 2003). This technique would require considerable sampling (in effect calibration) within the region. Interpretation of the bi-plot with regard to quadrant boundaries should therefore be approached with caution.

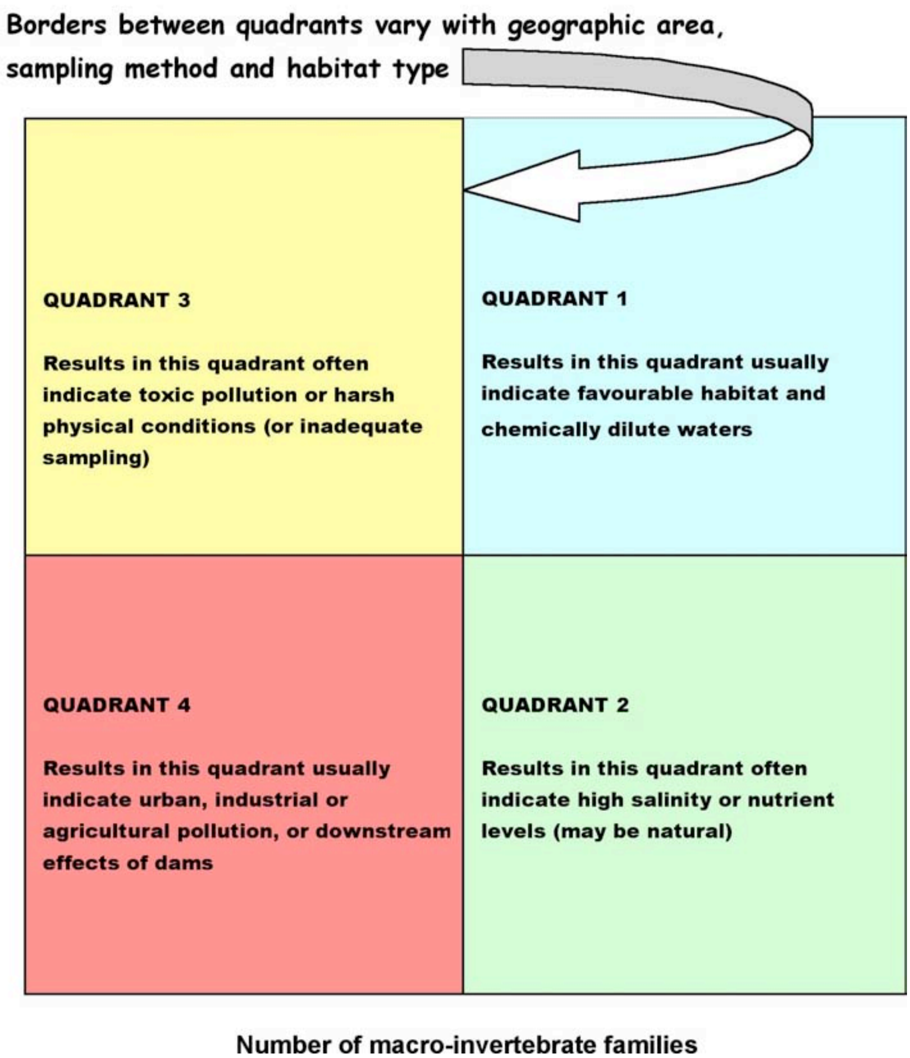


Figure B.1 The quadrant diagram for the family version of SIGNAL 2 (Chessman 2003).

Attachment C Copies of Survey Permits

Queensland Government
Department of Primary Industries and Fisheries

Fisheries Act 1994

General fisheries permit

COPY

LT

10 Sep 2007

JOHN THOROGOOD
FRC ENVIRONMENTAL
185 MAIN ROAD
WELLINGTON POINT QLD 4160

Delegate of the Chief Executive
Department of Primary Industries
and Fisheries

Permit Number	Issue Date	Expiry Date
54790	01/07/2006	15/05/2010

AUTHORISED ACTIVITIES

(1) The permit holder is authorised to collect fish from all Queensland waters other than those waters closed to such apparatus described. The permit holder is permitted to keep and be in possession of a maximum of ten specimens of each species other than those species listed in condition 4 to this permit, taken per year for identifications and other biological research studies. This does not include species that are subject to no-take regulations.

(2) The permit holder is authorised to use:
- * gill nets
  - 1 x 10m in length, 25mm mesh
  - 1 x 20m in length, 50mm mesh
  - 1 x 20m in length, 75mm mesh
- * seine nets
  - 1 x 70m in length, 2.5m drop, 25mm mesh
  - 1 x 50m in length, 1m drop, 10mm mesh
  - 1 x 10m in length, 3m drop, 2mm mesh
- * multi-panel nets
  - 1 x 3x15m panels, 1", 2", 3" mesh
  - 1 x 3x15m panels, 4", 5", 6" mesh
- * dip nets
  - 0.1 20mm mesh, up to 600mm mouth diameter
- * recreational bait nets
- * beam trawl
  - 1 x 0.5m mouth, 12mm mesh
- * traps
  - 20 x 0.2m x 0.2m x 0.2m volume, 5mm mesh
  - 40 x 0.2m x 0.2m x 0.2m volume, 1mm mesh
- * vessels
  - 4.3m punt, 2.2m wide, 430kg tonnage
  - 3m punt, 1.5m wide, 250kg tonnage
  - 4m hovercraft

Fisheries

Telephone Enquiries: 13 25 23
Facsimile: (07) 3229 8182

It is your responsibility to advise of any change of address.

- various chartered vessels away from brisbane
* backpack electrofisher
* fyke nets
  - wings up to 10m in length, 2mm, 10mm and 25mm mesh

CONDITIONS

(1) The permit extends to the permit holder, John Thorogood, Carol Conacher, Arthur Hawthorn, Andrew Olds, Lauren Thorburn, Brad Moore, Ashley Morton and Kylie McPherson and any person under their direct supervision on the water involved in the authorised activities.

(2) The following fish species are not to be taken:
- Maori wrasse
- Barramundi cod
- Potato cod
- Red bass
- Chinaman
- Paddletail
- Great white shark, and Grey nurse shark
- Clam
- Helmet Shell
- Trumpet Shell

This permit does not apply to threatened fish as listed under the Environmental Protection and Biodiversity Conservation Act 1999 or that are protected under the Nature Conservation Act 1992 or the Fisheries Act 1994.

(3) The permit holder shall ensure that all apparatus used during permitted activities is marked clearly with the holders name, address and Department of Primary Industries and Fisheries permit number and be in attendance of such apparatus at all times. In attendance means within 100m.

(4) A sign, minimum dimensions of 30cm x 50cm, with the message "Scientific Research in progress under DPI&F permit" is to be located within 15m of collecting activities when nets are in use.

(5) The holder shall ensure that all fish specimens taken are for research purposes only and are not to be sold.

(6) The holder shall ensure that all fish taken unintentionally during permitted activities are returned to the water as soon as practicable with as little harm or injury as possible.

(7) The holder shall ensure that all noxious fish captured during permitted activities are to be destroyed and disposed of appropriately by burying or placing in a bin.

(8) The holder shall notify the local office of the Queensland Boating & Fisheries Patrol not less than 48 hours prior to any activities commencing under this permit.

(9) The holder shall submit a written report one year after the issue of the permit and each subsequent year of the permit outlining the

Fisheries

number of fish taken, apparatus used and days fished to the Chief Executive, Department of Primary Industries and Fisheries, GPO Box 2764, BRISBANE QLD 4001.

(10) The holder must carry this permit (or a copy) during authorised activities and produce it at any time on request for inspection by an officer authorised under the Fisheries Act 1994.

(11) The holder must ensure that the use of electrofishing apparatus is in accordance with the Australian Code of Electrofishing Practice.

Queensland Government
Department of Primary Industries and Fisheries

The Animal Care and Protection Act 2001, *Section 57*

Scientific Use Registration Certificate

The following person, having satisfied the registration requirements of Section 52 of the *Animal Care and Protection Act 2001*, has this day been registered as a person who can use animals for scientific purposes.

FRC Environmental
185 Main Road, Wellington Point Qld 4160

Registration Number:

47

This approval is valid until: ***14 February 2009***

This registration may be cancelled or suspended pursuant to section 73 of the *Animal Care and Protection Act 2001*.

Dated 13 January 2006

Dr Rick Symons
delegate of
Director-General
Department of Primary Industries
and Fisheries

Queensland Government
Department of Primary Industries and Fisheries

DPI&F Animal Ethics

Form: AE 08

Amendment request for an approved activity

Please Note:
Any proposed change to an activity must be submitted to an Animal Ethics Committee (AEC) for approval.

If an activity leader carries out an activity other than in accordance with the AEC approval, that person is acting without approval.

Agenda Item 8.4

1. Activity Leader details

Name: John Thorogood		
Organisation: FRC Environmental		Centre:
Postal Address: 185 Main Rd, Wellington Point, QLD, 4160		
Phone: 3207 5135	Fax: 3207 5640	E-Mail: jthorogood@frcenv.com.au

2. Activity Details

Title of the Activity	AEC Approved Application Number
Fisheries Ecological Surveys	**CA 2006/03/106**

3. Amendment

In plain English, describe the proposed amendment:

We propose to include electrofishing in our suite of sampling techniques to conduct freshwater fisheries surveys. To ensure safe operation of the electrofisher, electrofishing will be conducted following the procedures outlined in the *Australian Code of Electrofishing Practice* (1997). We will be using an approved, commercially produced backpack unit from Smith-Root. By following established procedures and the instructions that accompany the equipment, we anticipate that the fish will be stunned by the electrofisher for a very short period (<5 secs), and that they will recover quickly. The senior operator of the electrofisher will be certified by DPI&F to conduct electrofishing. All frc staff are trained in animal welfare and are familiar with our animal ethics permit and responsibilities.

Approximately 100 m of a stream reach will be sampled, incorporating as many habitats as possible (e.g. riffles, runs etc.). Nets will be set (in accordance with our current animal ethics approval) at each end of the reach, to prevent fish movement in and out of the reach during sampling. The operator will sample a variety of habitats as he/she moves upstream along the reach. At each habitat sampled, pulses of current will be passed through the water from the anode ring for a period of 5 – 10 seconds. Stunned fish will be collected from the water by the operator using a net connected to the anode ring, and by a second person using an insulated dip net. The pass of the reach will be repeated heading downstream. It is anticipated that 3 – 4 passes of the reach will be required in order to effectively characterised the fish community.

Only the minimum power necessary to attract and stun the fish effectively will be used. We will not touch the fish with live anodes, and we will not continue electrofishing when within 15 m of a non-target animal standing in or drinking from the water, or if an animal is in contact with a wire fence line that enters the water. Electrofishing will be stopped if there are / we suspect there are native birds, turtles or mammals (e.g. platypus) in the water.

After capture in the nets, all animals will be placed into a 50L nallie bin or 10L buckets half filled with 'fresh' ambient water for identification and counting. All animals not required for further research will be returned to the waters of capture, as soon as possible (once electrofishing of the reach has ceased, although larger fish and eels may be released downstream of the set net straight away, to avoid fouling of the water in the container (e.g. with slime)). Set nets will be removed once the reach has been effectively sampled; any animals caught in these nets will be removed in accordance with the protocols outlined in our current ethics approval.

Some animals may need to be kept for positive identification in the laboratory (e.g. by counting fin rays etc.) or for further analysis, e.g. gut content analysis or otolith ageing. Animals to be kept will be euthanased in a bath of clove oil/water (by adding clove oil at 10 ppt). Deceased animals will be bagged, tagged and frozen for transport to the laboratory for further analysis. Introduced pest species will also be euthanased using the above methods.

In plain English, outline your reasons for the request:

Electrofishing has become an essential sampling tool in the study of freshwater fish ecology. It is successful in catching a range of different species and individuals, such that it is effective in characterising the resident fish communities. Fish surveys are often required by Local and State Governments (through formal terms of reference) in order for these agencies to assess the significance of fisheries habitat against, for example, the likely impacts of urban / commercial / agricultural development of an aquatic environment. In some instances, the use of electrofishing to survey the fish communities is specifically required by these agencies.

Electrofishing is currently used by various government agencies (such as the Department of Primary Industries & Fisheries, and the Department of Natural Resources, Mines & Water) to sample freshwater fish communities. In particular, electrofishing is used in the Ecological Health Monitoring

Queensland Government
Department of Primary Industries and Fisheries

DPI&F Animal Ethics

Form: AE 08

Amendment request for an approved activity

Program (EHMP) in south east Queensland (using the same model of electrofisher that we intend to purchase). The use of electrofishing will enable us to directly compare our data to data collected by the government agencies. In some instances, this may reduce the amount of sampling that is required, as we will be able to obtain government data for some sites (e.g. data from the EHMP in south east Queensland).
Signature of Activity Leader:
Date:

3. AEC Decision

The amendment has been considered by the AEC and is:

- [x] Approved as submitted
- [ ] Approved subject to modification/conditions*
- [ ] Pending*
- [ ] Rejected*

Any inquiry regarding this response should be directed to the AEC Coordinator, in the first instance. The Coordinator may be contacted via the DPI&F Call Centre on 13 25 23.

* Comments/Reasons:

Name of AEC Chair	Wal Scattini
Signature	W J Scattini
Date	31 July 2006

Queensland Government Department of Primary Industries and Fisheries	*DPI&F Animal Ethics*	Form: AE 08
	Amendment request for an approved project	

Please Note:
Any proposed change to a project must be submitted to an Animal Ethics Committee (AEC) for approval.

If a person uses or allows an animal to be used for a scientific purpose other than in accordance with the AEC approval, that person is acting without approval and, therefore, unlawfully.

Text boxes will expand automatically to accommodate entry. Please do not delete headers or footers.

1. Applicant details

Name: John Thorogood		
Organisation: FRC Environmental		Centre:
Postal Address: 185 Main Rd, Wellington Point, QLD, 4160		
Phone: 3207 5135	Fax: 3207 5640	E-Mail: jthorogood@frcenv.com.au

2. Project Details

Title of the Project	AEC Proposal Reference Number
Aquatic Ecological Surveys **(proposed change from Fisheries Ecological Surveys)**	CA 2006/03/106

3. Amendment

In plain English, cite each section of your proposal that you wish to amend and then describe the proposed amendment to that section and outline your reasons for the request.

We propose to expand our ethics permit to cover surveys of freshwater turtles as well as fish (which we are currently permitted for). We will conduct turtle surveys on an 'as required' basis, throughout the freshwaters of Queensland. Where required, turtle surveys will be conducted under a Scientific Research Purposes Permit, issued by the EPA.

Freshwater turtles species in Queensland include: the broad-shelled river turtle, *Chelodina expansa*; the eastern snake-necked turtle, *C. longicollis*; the northern snake-necked turtle, *C. rugosa*; *C. novaeguineae*; the northern snapping turtle, *Elseya dentata*; the Burnett River turtle, *E. albagula*; the saw-shelled turtle, *E. latisternum*; the Krefft's river turtle, *Emydura krefftii*; the Murray turtle, *E. macquarii*; *E. signata*; *E. subglobosa*; *E. victoriae*; and the Fitzroy River turtle, *Rheodytes leukops*. Each of these species may be caught depending on the particular area surveyed. Surveys of freshwater turtles (including population numbers, and the size / age distribution and sex ratios of the population) will provide valuable information on the populations of these turtles in various waterways throughout Queensland, and will add to our current understanding of the population dynamics of freshwater turtles. Knowledge of these populations is likely to become increasingly important in the face of increasing water resource development throughout Queensland, which can impact on turtle populations, including threatened species. Knowledge of current freshwater turtle populations will provide essential information for impact assessments of proposed dams, weirs, water extraction and other development on freshwater creeks and rivers.

Turtles will be captured so that they can be accurately counted, as well as measured, weighed and sexed. This will provide important information regarding the population dynamics of the turtle populations. Knowledge of the population dynamics of each species (e.g. size distributions, sex ratios) is an important information requirement for developing management plans that "address population numbers, population dynamics, habitats and sustainability… as a whole" (Hamman et al. 2007). For example, a bias towards adult animals in the wild is indicative of poor survival of clutches laid in the wild, and would lead to a focus on managing habitats to improve hatchling survival (Hamman et al. 2007).

Turtles will be caught following the methods used by the EPA in similar turtle surveys (e.g. Hamann et al. 2004). Specifically, we will use capture turtles a combination of seine nets, dip nets, traps and by hand using snorkel. Discrete sites along the waterway will be sampled in a single sample event. Each of the sampling apparatus will be thoroughly cleaned between sites, to minimise the risk of translocation of aquatic plant or algae species, and any potential diseases.

With the exception of the traps, all sampling apparatus will have an operator in immediate attendance to prevent the accidental drowning of turtles. Traps will be fitted with an ‘air chamber’ to ensure that no turtles drown during our surveys. Our trap design follows the ‘Cathedral Trap’ design used by the Queensland EPA for freshwater turtles surveys (Hamann et al. 2004). As per the EPA methods, traps will be checked every 24 hours at a minimum (Hamann et al. 2004). During sampling, every effort will be made not to disturb the aquatic habitat of the creek or river, which may provide habitat for turtles and fish (e.g. logs, macrophytes etc.). Any fish caught during our surveys will be handled and released unharmed, as per our existing ethics approval.

Once caught, the turtles will be carefully removed from the sampling apparatus. The turtle will be held firmly by its shell in a quite and controlled manner by one team member to minimise stress, while another team member measures the animal with a clean measuring tape, and sexes the animal (if possible) via a brief visual inspection of their tail. Animals will also be weighed by placing them in a bag suspended from a scale. The dark environment of the bag will calm most animals (NSW DPI 2007). It is anticipated that each individual will be handled for a period of less than 5 minutes. The turtles will then be released back to the environment at the point of capture. However, turtles will only be released once the waterway is clear of all nets and traps. If necessary, prior to release, turtles will be held in 50 L Nallie Bins half-filled with ambient river water until the waterway is cleared of sampling apparatus. As each site will only be sampled once, the chance of recapture of individuals is considered to be extremely low. No native turtles will be kept.

The red-eared slider turtle (*Trachemys scripta elegans*) is a listed Class 1 pest in Queensland, and cannot be returned to the environment or kept. This turtle can be readily identified by the distinctive red stripe behind its eyes (which may fade with age, however pale stripes will remain) and the fact that it can retract its head straight back into its shell (native turtles withdraw their heads to the side). If the red-eared slider turtle is caught, a Department of Natural Resources and Water Lands Protection Officer will be contacted for advice. We will either surrender the animals to DNRW, or If advised to do so, we will euthanase turtles of this species.

Euthanasia will be done in accordance with the publication *Euthanasia of Animals Used for Scientific Purposes* (ANZCCART 2001). Specifically, we will cool the animal (by 3–4 ºC) to facilitate handling and injection of a euthanasia solution. Sodium pentobarbitone (at a dose of 60 mg/kg of body weight) will be injected intravenously. The needles and syringes used will be sterile and only used once. We do not anticipate having to euthanase any native turtles. However, if a turtle has unforseen serious injuries, it will be allowed to recover in a 50L nallie bin filled with ambient water that also contains a ‘dry’ rest areas (e.g. exposed rock). If the turtle remains stressed and its condition does not improve (to the point where it can be released) it would be humanely euthanased using the methods described above.

All frc staff are trained in animal welfare and anatomy, and are familiar with our animal ethics permit and responsibilities. Each of the senior frc staff responsible for the turtle surveys have had previous experience in handling freshwater turtles during previous studies, including during their university studies under the supervision of experienced academics and researchers.

References

ANZCCART 2001, *Euthanasia of Animals Used for Scientific Purposes,* ed. J.S. Reilly, Australian and New Zealand Council for the Care of Animals in Research and Teaching, Adelaide.

Hamman, M., Schäuble, C. S., Limpus, D. J., Emerick, S. P. & Limpus, C. J. 2007, *Management Plan for the Conservation of Elseya sp. [Burnett River] in the Burnett River Catchment*, Environmental Protection Agency, Brisbane.

NSW DPI 2007, *Model Standard Operating procedures for the Humane Research of Pest Animals*, New South Wales Department of Primary Industries [online] http://www.dpi.nsw.gov.au/aboutus/resources/majorpubs/guides/model-sops-research-pest-animals.

	Lauren Thorburn (Senior Environmental Scientist, FRC Environmental)	15/10/07
Signature of the Applicant (or its duly authorised agent).	**Please print name if signing as a duly authorised agent.**	**Date**

4. AEC Decision

The amendment has been considered by the AEC and is:

☒ Approved as submitted

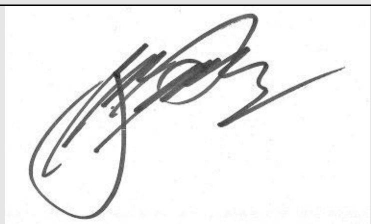
☐ Approved subject to modifications

☐ Pending

☐ Rejected

Any inquiry regarding this response should be directed to the AEC Coordinator, in the first instance. The Coordinator may be contacted via the DPI&F Call Centre on 13 25 23.

Comments/Reasons:

Name of AEC Chair	Geoff Smith
Signature	
Date	29 October 2007

ecoaccess
environmental licences & permits

Permit[1]

This permit is issued under the following legislation:

S12(E) Nature Conservation (Administration) Regulation 2006

Scientific Purposes Permit

Permit number: **WISP05080608**

Valid from: **12-MAR-2008** **to** **12-MAR-2013**

Parties to the Permit

Role	Name	Address
Principal Holder	JA Thorogood Pty Ltd (t/a FRC Environmental) 72 002 896 007	185 Main Road WELLINGTON POINT QLD 4160
Joint Holder	Mr Andrew Olds	185 Main Road WELLINGTON POINT QLD 4160
Joint Holder	Ms Lauren Thorburn	185 Main Road WELLINGTON POINT QLD 4160

Permitted Location Activity Details

Location (s)	Activity (s)
Non Protected Areas - Queensland	Research on non-protected areas for scientific purposes

1 Permit includes licences, approvals, permits, authorisations, certificates, sanctions or equivalent/similar as required by legislation administered by the Environmental Protection Agency and the Queensland Parks and Wildlife Service.

Environmental Protection Agency
www.epa.qld.gov.au ABN 87 221 158 786

Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service

Permit Details

Species Details

Location	Activity
Non Protected Areas - Queensland	Research on non-protected areas for scientific purposes

Schedule	***Category***	***Quantity***
Turtles and tortoises (family Chelidae) Nature conservation (Wildlife) Regulation 2006	Live	Unlimited Animal/s

Conditions of Approval

Agency Interest: Biodiversity

PB1 The Principal Holder must obtain permission from the landholder prior to commencing activities.

Environmental impact is to be kept to a minimum.

This permit (or a copy plus proof of identity of Principal Holder) must be carried while engaged in any activity authorised by the permit.

This permit is issued subject to the Principal Holder holding the current approval of a registered animal ethics committee.

All collecting activities are to be effected away from public view.

The Principal Holder may trap animals by methods as outlined in the application. Animals are to be released unharmed at the point of capture within 24 hours of capture. Any mortality during capture or subsequent handling is to be reported immediately to the Assessment and Approvals Unit, Queensland Parks and Wildlife, Toowoomba. The Queensland Museum has first refusal of any material resulting from mortality.

To prevent the risk of spreading disease, all traps, items of clothing (including footwear), vehicles and handling equipment must be cleaned before and after each separate collection activity.

Two (2) specimens of possible new or undescribed species may be kept as voucher specimens and must be deposited with the Queensland Museum.

Upon completion of field work, a detailed list is to be supplied to the Assessment and Approvals Unit, Queensland Parks and Wildlife, Toowoomba, showing numbers of specimens of each species, the type of habitat and locality or localities where they were collected. Separate data returns and reports must be provided for each survey.

A copy of any resulting report/publication must be forwarded to the Assessment and Approvals Unit, Queensland Parks and Wildlife, Toowoomba.

All practices and procedures undertaken pursuant to this permit are to be in accordance with those details contained in and attached to the Application for a Scientific Purposes Permit signed by the Principal Holder on 22 January 2008.

Signed

Ian Bryant
Delegate
Environmental Protection Agency