Wandoan Coal Project:

Western Coal Seam

Methane Water Supply Pipeline, Aquatic Ecology Impact Assessment

Prepared for:

Parsons Brinckerhoff Australia Pty Ltd

frc **environmental**

PO Box 2363
Wellington Point Qld 4160

Telephone: + 61 7 3820 4900
Facsimile: + 61 7 3207 5640

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Project Team:	C. Jones, A. Morton, L. Thorburn, J. Thorogood
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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 western coal seam gas 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 Eurombah Creek and associated tributaries, and tributaries of Juandah Creek. Each of these waterways is located in the Dawson River subcatchment in the Fitzroy River catchment. 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 15th August 2008 (although three additional sites surveyed in the MLAs in March 2008 are also described in this report). 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 and WP88 turbidity meter. Aquatic macrophyte, macro-invertebrate, fish and turtle communities were surveyed at six sites using standard techniques.

Surrounding land uses and their associated impacts, including vegetation clearing, cattle grazing and cropping, have negatively affected the aquatic habitat of the study area and the wider catchment. Water quality is relatively poor, and reflects the predominantly agricultural nature of the region and the ephemeral nature of the creeks. Biodiversity in the study area is slightly lower than that found in the more permanent waters of the region (such as the Dawson River). Only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabit the study area. 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 movement/migration. Freshwater turtles were not noted in the study area, and are unlikely to be abundant in the ephemeral creeks of the study area at any given time. 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 pipeline will generally be located underground, constructed using a section trench and backfill method with vegetation clearing required along the pipeline corridor. The western coal seam methane water supply pipeline will be 91 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. Of the potential impacts of the western 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 western coal seam methane (CSM) water supply pipeline alignment for the Wandoan Coal Project (the Project).

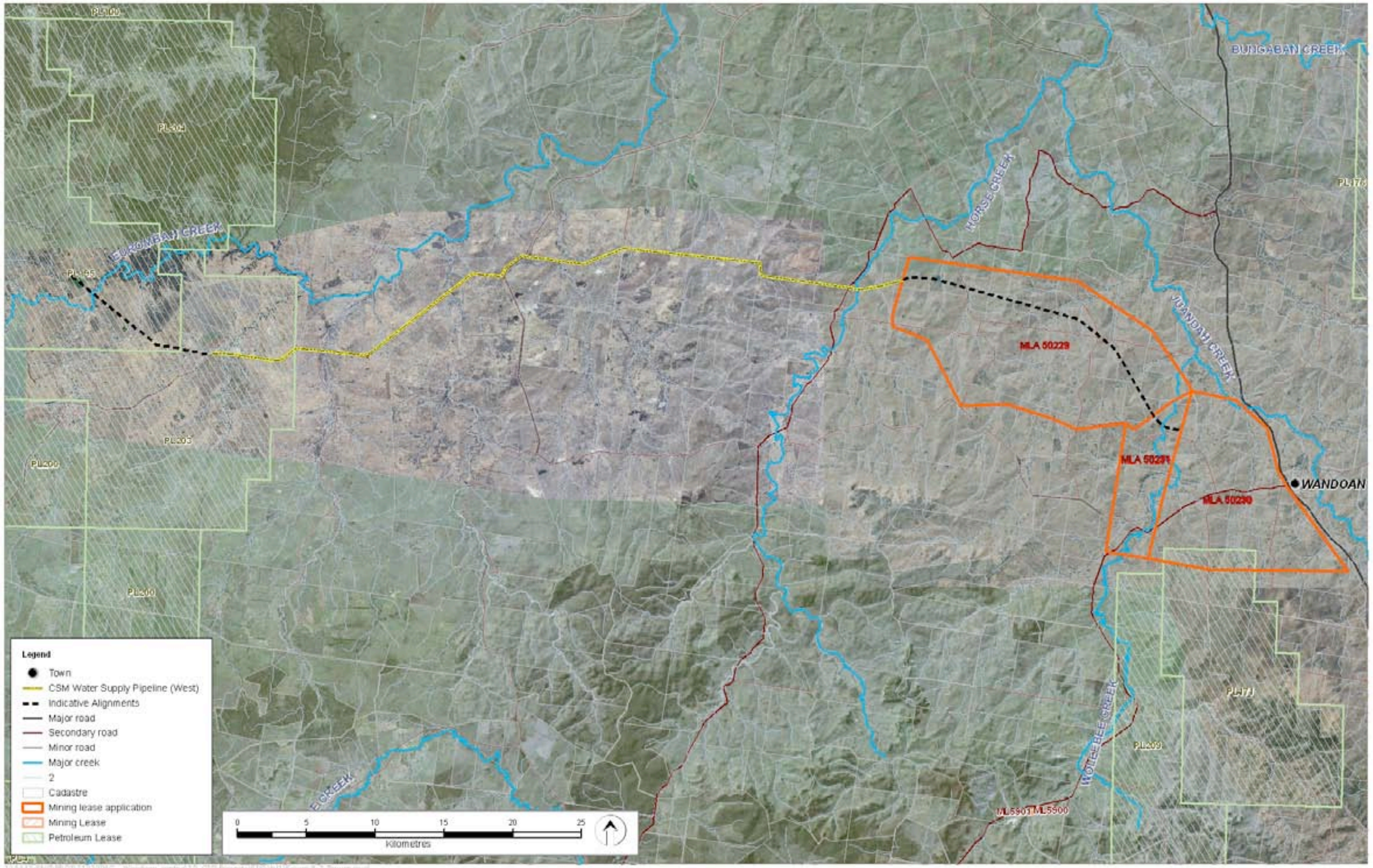
1.1 Project Background

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 reserves 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 the Spring Gully and Fairview gas fields west 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 Origin's Spring Gully Reverse Osmosis Plant and associated facilities, to the raw water supply storage dam adjacent to the Mine Infrastructure Area (MIA) of the Project via the western boundary of MLA 50229. Figure 1–2 shows an indicative alignment of the pipeline.

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: Western Coal Seam Methane Water Supply Pipeline	
	Figure 1.1 Wandoan Coal Project location.	
		September 2008



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Wandoan Coal Project: Western Coal Seam Methane Water Supply Pipeline

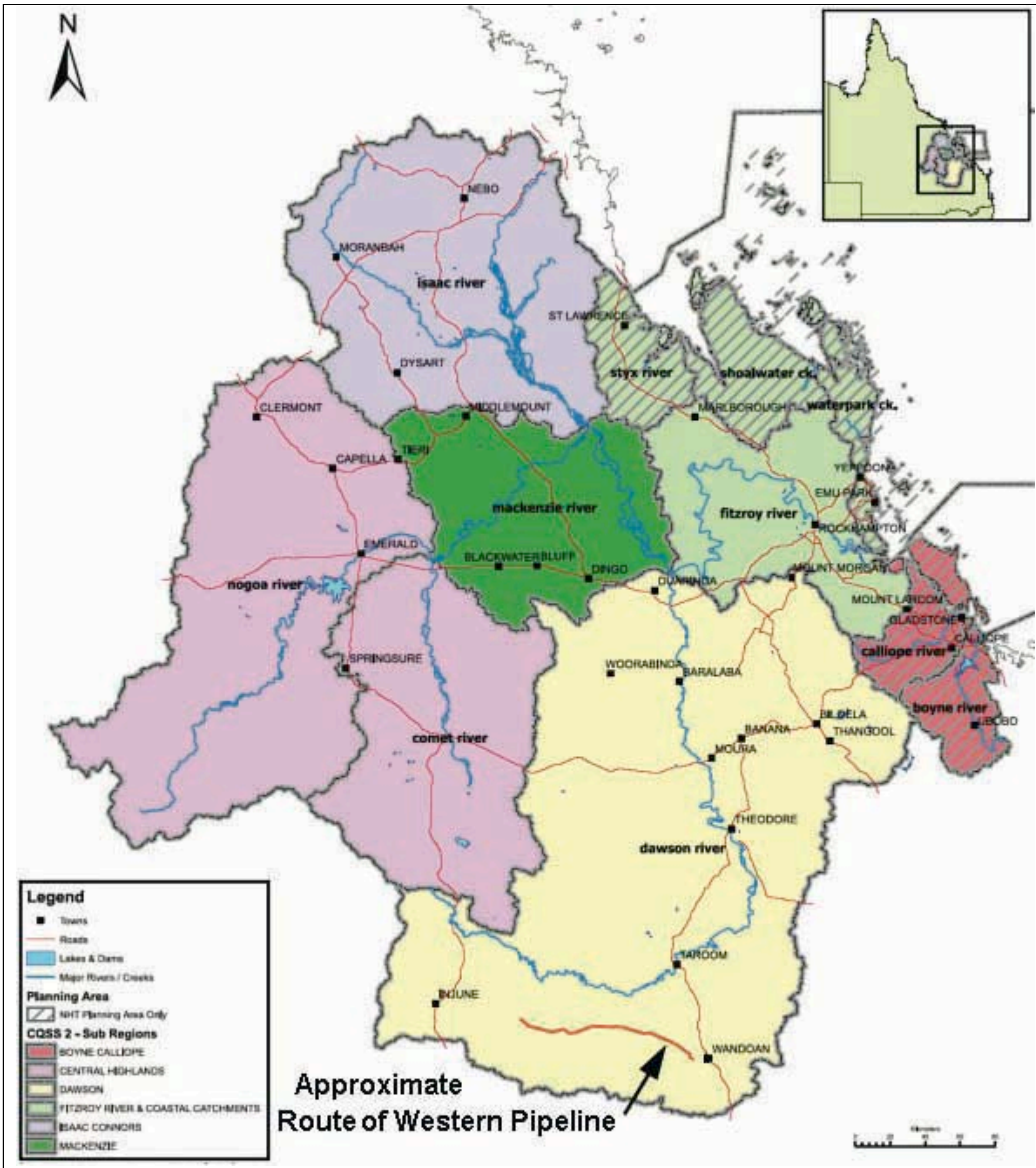
Figure 1.2 The western water supply pipeline route alignment, shown in red.

September 2008

1.2 Description of the Study Area

The western CSM water supply pipeline crosses eight creeks, along with several smaller tributaries and gullies, which are all part of the Dawson River Catchment (Southern Tributaries or 'Taroom' Subcatchment) (Figure 1.3). The pipeline crosses Eurombah Creek and its major tributaries Kurrajong Gully, Slatehill Creek, Barton Creek, Kangaroo Creek and Canal Creek. The pipeline route also crosses a tributary of Nine-Mile Creek, which may connect to Eurombah Creek during periods of rainfall. The pipeline also crosses Horse Creek, Spring Creek, Mud Creek and Woleebee Creek, which are each tributaries of Juandah Creek.

Eurombah Creek and Juandah Creek both flow into the Dawson River approximately 100 km downstream from the pipeline alignment. The Dawson River eventually 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).



frc environmental deep thinking. science.	Wandoan Coal Project: Western Coal Seam Methane Water Supply Pipeline	
	Figure 1.3 The Fitzroy River Basin, showing the approximate route of the western CSM water supply pipeline.	
	Adapted from FBA 2005	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.

2.1.1 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 western CSM water supply pipeline is not expected to result in a significant impact to the values of the Great Barrier Reef World Heritage Area.

2.1.2 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 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 values of the Great Barrier Reef World Heritage Area.

2.1.3 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.

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.

2.2 Queensland *Water Act 2000*

The purpose of the *Water Act 2000* 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.

2.3 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.

2.4 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

For the Eurombah Creek catchment, aquatic floral and faunal surveys and collection of water quality data was undertaken during the dry season, from the 11th to the 15th August 2008. The weather was fine and cool during the survey. Rainfall was relatively low during the months prior to the survey (between 0 mm in April, to 74 mm in July at the Taroom Post Office) (BOM 2008). No rain had fell in the three weeks preceding the survey; however there was relatively heavy rainfall on the 24th of July 2008 (recorded at the Taroom Post Office, BOM 2008).

Sites on Spring Creek, Mud Creek and Woleebee Creek (tributaries of Juandah Creek) were surveyed from the 10th – 14th March 2008 during a survey of the MLAs; the data from these sites is included in this report. The weather was fine during the survey. In the months preceding the survey, there had been between 129 and 185 mm of rainfall per month in December 2007, January 2008 and February 2008 (based on rainfall records from the Taroom Post Office, BOM 2008). No rain had fallen in the week prior to the survey (BOM 2008).

3.1 Study Sites

Thirteen waterways crossed by the proposed pipeline route were surveyed (Figure 3.1). Whenever possible, surveys were conducted at the proposed crossing location, however, due to land access issues, some creeks were assessed at nearby road crossings. Sites surveyed during the March 2008 survey event (sites 3, 5, and 6) were close to, but not at, the proposed pipeline crossing locations. 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 sites B and Gi, 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 below). Site B was a small farm dam that was dry, and site Gi was a gully with no defined channel bed or banks; only brief observations and photographs were taken at these sites. Water was present at eight of the sites surveyed, and water quality measurements were done at each of these sites. Flora and fauna surveys were completed at six of the thirteen sites (Refer to Sections 3.4 to 3.6 below).

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

Crossing Number	Channel Name	Date Survey Completed			
		Aquatic Habitat	Water Quality	Macrophytes	Fauna
A	Eurombah Creek	14/08/08	14/08/08	14/08/08	14/08/08
B	–	14/08/08	–	–	–
C	Kurrajong Gully	13/08/08	13/08/08	13/08/08	13/08/08
D	Slatehill Creek	11/08/08	11/08/08	–	–
E	Barton Creek	11/08/08	11/08/08	12/08/08	12/08/08
F	Kangaroo Creek	11/08/08	Dry	Dry	Dry
G	Tributary to Canal Creek	13/08/08	Dry	Dry	Dry
Gi	–	12/08/08	–	–	–
H	Tributary to Nine-Mile Creek	12/08/08	Dry	Dry	Dry
I	Horse Creek	13/08/08	Dry	Dry	Dry
3	Woleebee Creek	12/03/08	12/03/08	12/03/08	12/03/08
5	Mud Creek	13/03/08	13/03/08	13/03/08	13/03/08
6	Spring Creek	13/03/08	13/03/08	13/03/08	13/03/08

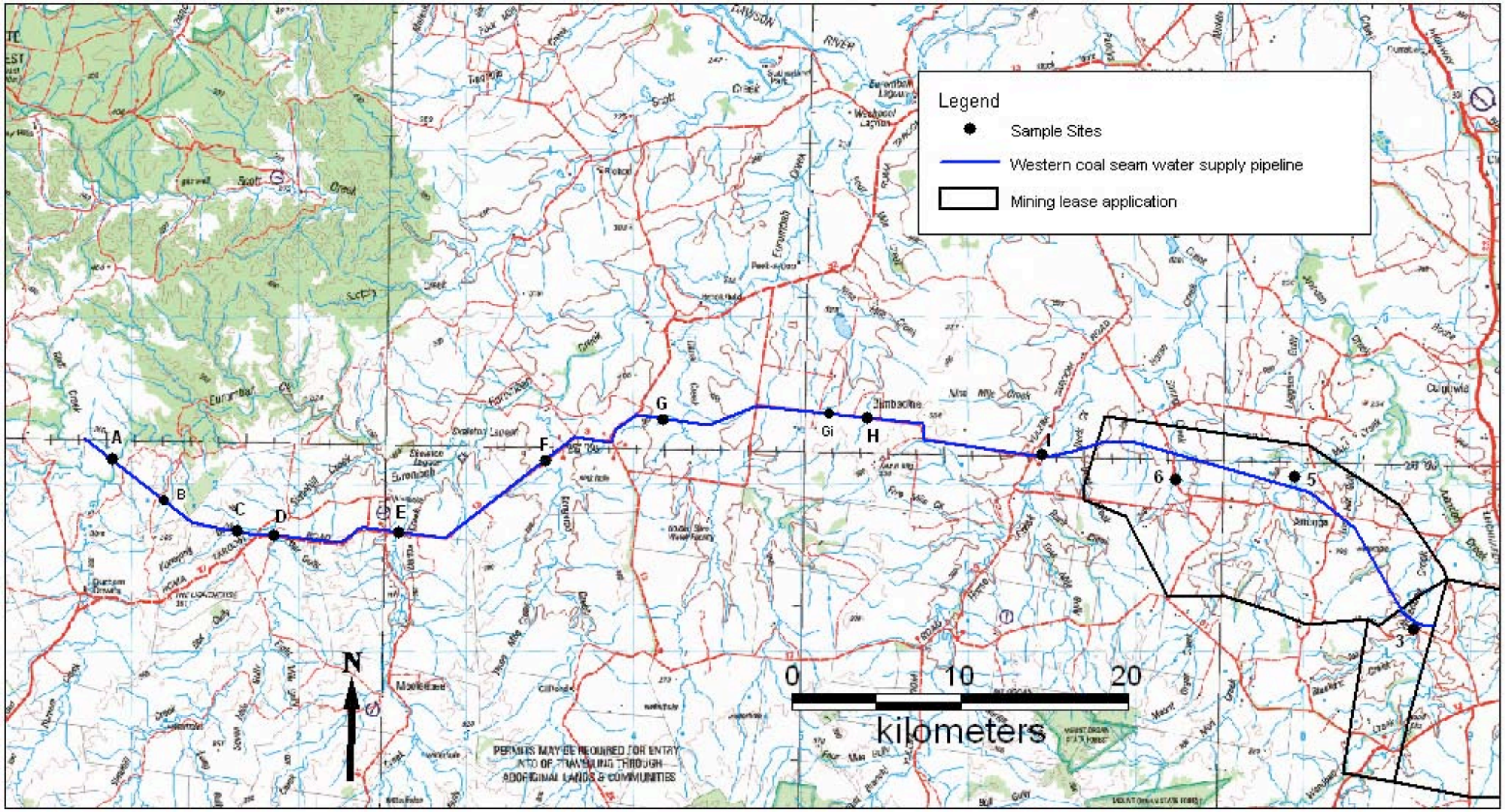


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Figure 3.1 Location of the sampling sites.	
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3.2 Aquatic Habitat

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 were described through literature review, to provide a regional context for the condition of the creeks along the pipeline route.

3.3 Water Quality

3.3.1 Of the Study Area

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).

Where practical, turbidity in NTU (Nephelometric Turbidity Units) was estimated at the sites, based on the experience of the field team, who had each previously surveyed water quality in the region.

While specific Water Quality Objectives (WQOs) have been developed for many waterways within south east Queensland, no WQOs have been prescribed for the waterways within the study area. Water quality parameters at each of the sites have therefore been compared to Queensland Water Quality Guidelines (QWQG) values for upland (altitude >150 m) streams in the central coast region (EPA 2007a). These QWQG are used in preference to the national ANZECC & ARMCANZ guidelines where possible (EPA 2007a; ANZECC & ARMCANZ 2000).

3.3.2 A Regional and Ecological Perspective

The typical water quality of the streams and creeks in the Dawson River catchment and Fitzroy Basin were 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 River Catchment 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 western 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 of the waterways near the some of the creeks crossed by the pipeline route. These surveys included sites on the Dawson River at Taroom (Site 130302A) and Juandah Creek at Sandy Bridge (Site 1303086) (refer Figure 3.2).

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.

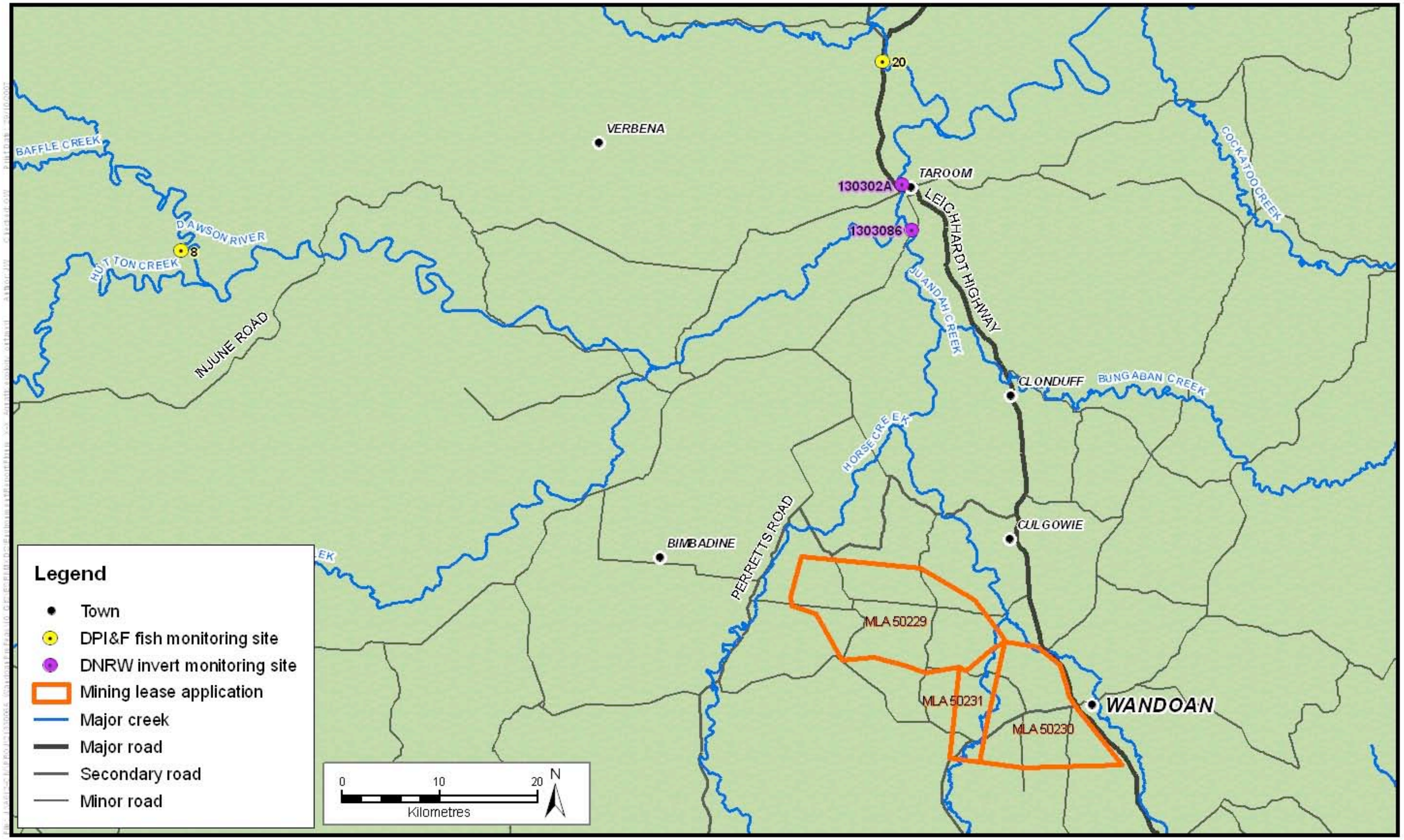

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Figure 3.2 Location of the sites previously surveyed in the region by others.

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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*.

As a minimum at each site (where water depth allowed), five replicate samples were also collected using small (2 mm mesh) baited traps and large cathedral traps, which designed to capture turtles, but which may also capture fish (mesh size approximately 20 mm). At sites where electrofishing returned few fish, or was not appropriate to the conditions, sampling was also conducted using set nets (multi-panel gill nets of between 2 mm and 150 mm mesh size). Sampling effort is presented in Table 3.2.

Table 3.2 Fish and turtle survey effort at each site.

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
A	Backpack Electrofishing	large pool	14/08/08	11:00	12:30	350 V, 30 Hz, 12%	799 s	electrofishing effective
C	Backpack Electrofishing	small pools	13/08/08	15:25	15:45	250 V, 30 Hz, 12%	256 s	shallow, electrofishing effective
E	Backpack Electrofishing	small pool	13/03/08	11:37	12:11	250 V, 30 Hz, 12%	443 s	shallow, electrofishing effective
3	Small bait traps	pools		12:30 12/03/08	09:00 13/03/08		102.5 hrs	
	Backpack Electrofishing	pools	13/03/08	12:37	13:11	200 V, 30 Hz, 12%	502 s	shallow, electrofishing effective

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
	Cathedral traps	pools		12:30 12/03/08	09:00 13/03/08		102.5 hrs	
5	Backpack Electrofishing	pools	13/03/08	11:00	11:40	200 V, 30 Hz, 12%	427 s	shallow, electrofishing effective
6	Small bait traps	pool		16:30 11/03/08	10:00 12/03/08		87.5 hrs	
	Backpack Electrofishing	pool	11/03/08	15:30	15:55	300 V, 30 Hz, 12%	292 s	deep, could only fish edges
	Cathedral traps	pool		16:30 11/03/08	10:00 12/03/08		52.5 hrs	

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. 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 (Sites 8 & 20) (refer Figure 3.2). 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). No data were available specifically for Eurombah or Juandah Creeks.

3.7 Turtle Communities

3.7.1 Of the Study Area

At sites where water depths were suitable, five large baited cathedral traps were set along the bank and adjacent to cover (vegetation, snags etc.) for a minimum of two hours (Table 3.2). The design of the traps was consistent with traps used by the Environmental Protection Agency's (EPA's) turtle research group, and consisted of a series of collapsible chambers (totalling approximately 3.5 m in height, 0.7 m in diameter) with two one-way entrances in the lower baited chamber. Traps were deployed so that the top of the chamber was positioned to allow turtles access to the surface to breathe.

Traps were closely monitored, to ensure that no turtles or other air-breathing species became entangled or trapped below the surface. Turtles were occasionally captured by other techniques or observed and recorded outside traps.

Turtles captured or observed were identified to species level and a photographic record was kept. The sampling of turtles was conducted under Scientific Purposes Permit WISP05080608 and Animal Ethics Approval No. CA 2006/03/106 issued to frc environmental (Attachment C).

3.7.2 A Regional and Ecological Perspective

The turtle communities of the streams and creeks in the Dawson River Catchment were described through literature review, where possible, to provide a regional context for the condition of the creeks along the supply pipeline route.

3.8 Other Aquatic Vertebrates

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

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, Spring Creek could not be surveyed at the proposed pipeline crossing location, due to access restrictions. This waterway was surveyed during March 2008 where it is crossed by Kabunga Road, approximately 1.5 km downstream of the proposed 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 a moderate River Bioassessment Program habitat assessment score (Figure 4.1). Generally, these relatively low scores were related to low habitat variability (with no riffles observed), moderate to extensive bank erosion, and substrates dominated by finer sediments such as sand and silt. However, Eurombah Creek (site A) was in good condition, as it has good riparian vegetation cover, and it contained a variety of habitat types (deep pools and shallow pools), physical habitat for fauna (such as woody debris and overhanging banks) and substrate types (including sand, bedrock, and boulders).

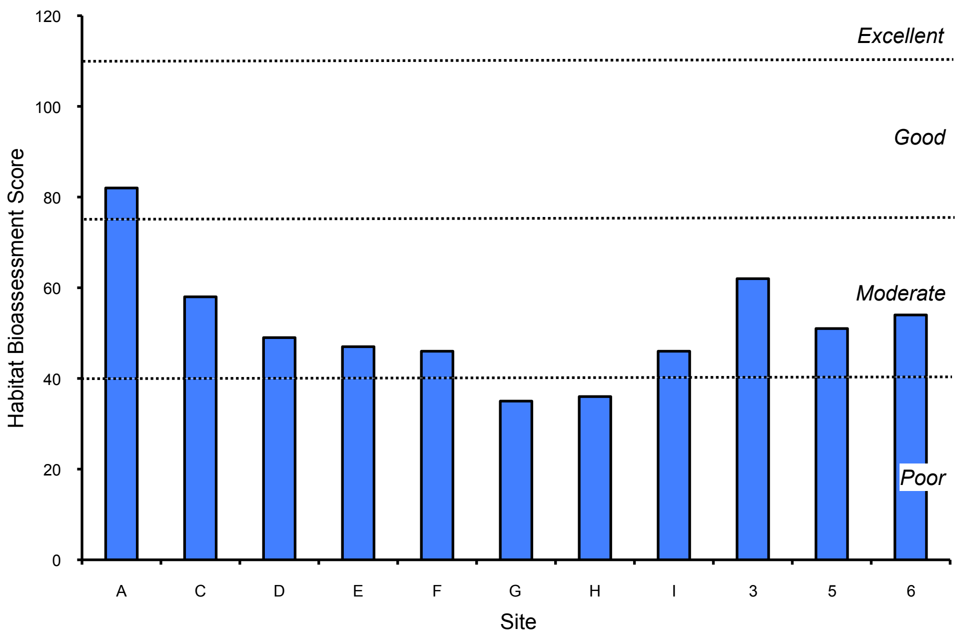


Figure 4.1 River Bioassessment Scores at each of the sites surveyed.

Reach Environs

The reach environs of the creeks surveyed have been moderately impacted by human activities and overall condition at each of the sites ranged between poor and good. Landuse throughout the study area was dominated by cattle grazing on pastures and crops. 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). Cattle access to the creeks has also caused some disturbance to bed and bank habitats, particularly in Kurrajong Gully (site C), Canal Creek (site G), tributary to Nine-mile Creek (site H), Horse Creek (site I), and Mud Creek (site 5).

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 C, H, I, & 6), or concrete fords (site F). A box culvert was used at the road crossing at Barton Creek (site E). A pipe culvert was used to cross Woleebee Creek (site 3). Slatehill Creek (site D) was the only stream with a bridge crossing. No road crossings were present along the alignment at Eurombah Creek (site A) or Canal Creek (site G).

Road crossings are likely to cause alterations of flow and may prevent or restrict fish and turtle passage in some instances. All of the ford crossings are likely to restrict aquatic fauna passage during low flow events, as the road forms a physical barrier (Figure 4.2), but during periods of medium to high flow, the creek would flow over the road. The crossings at Barton Creek (site E) and Woleebee Creek (site 3) are likely to restrict aquatic fauna passage during periods of low to moderate flow, as the water must flow through undersized culverts (Figure 4.3 & Figure 4.4).

The bridge crossing at Slatehill Creek (site D) would not generally inhibit aquatic fauna movement, although during flood events, pylons can alter flow patterns and trap debris that can potentially restrict aquatic fauna passage (Figure 4.5). Paddock fences also cross some sites and are likely to restrict water flows, and potentially aquatic fauna passage, if they become blocked with debris (Figure 4.6).

Figure 4.2

The dirt crossing at Spring Creek (site 6) forms a physical barrier to water flows and aquatic fauna passage during periods of low flow.

Figure 4.3

The narrow culvert crossing at Barton Creek (site E) may restrict aquatic fauna passage during periods of low flow.

Figure 4.4

The undersized culverts on Grosmont Road at Woleebee Creek are likely to restrict aquatic fauna passage during periods of low to moderate flow.

Figure 4.5

The bridge pylons at the crossing of Slatehill Creek (site D) are unlikely to restrict aquatic fauna movements.

Figure 4.6

At most road crossings, property fences across creeks have the potential to trap debris, which may restrict aquatic fauna passage.

Riparian Vegetation

Across the study area, riparian zones were generally 5 – 10 m wide, but ranged from being more than 20 m wide at Eurombah Creek (Figure 4.7) to almost entirely cleared in some places, such as Barton Creek and Horse Creek (Figure 4.8 & Figure 4.9). Grasses typically dominated the riparian zone of the creeks, although shrubs and trees also grew at most sites.

Figure 4.7

Wide riparian zone at Eurombah Creek (site A).

Figure 4.8

Mostly cleared riparian vegetation dominated by grasses at Barton Creek (site E).

Figure 4.9

Riparian vegetation cleared on the right bank but relatively intact along the left bank at Horse Creek (site I).

Riparian vegetation throughout the study area was dominated by native species, although exotic grasses were found. Prickly pear, a declared Class 2 pest in Queensland under the *Land Protection (Pest and Stock Route Management) Act 2002*, was noted at several sites including sites C & F. Giant sensitive tree (*Mimosa pigra*), a declared Class 1 pest, was noted throughout the study area and particularly along the roadside. The class 2 declared pest parthenium (*Parthenium hysterophorus*) is likely to grow adjacent to Mud Creek and its tributaries, and adjacent to Juandah Creek and its tributaries towards the north of the MLAs.

Bank Stability

Banks were eroded at all sites surveyed, apart from site H. Steep banks were common, and appeared to be the result of water scouring during periods of high flow. Bank stability was maintained despite steep banks is some places by a relatively high cover of bank vegetation (Figure 4.10). At several sites, disturbance caused by cattle access (Figure

4.11) or riparian vegetation clearing had negatively affected bank stability. This was particularly evident at Kurrajong Gully (site C), Canal Creek (site G), Horse Creek (site I), and Mud Creek (site 5).

Figure 4.10

Kangaroo Creek (site F) had steep banks that were stabilised by vegetation in plces.

Figure 4.11

Erosion and cattle damage at Kurrajong Gully (site C).

Figure 4.12

Erosion along the left bank of Canal Creek (site G).

Bed and Bar Stability

Overall, stream beds throughout the study area were relatively stable, but there was evidence of scouring on the outside of bends or downstream of obstructions. High embeddedness of sediment was common at sites where eroding banks had deposited fine material into the stream bed. Again, this was most evident at Kurrajong Gully (site C), Canal Creek (site G) and Horse Creek (site I).

Channel Diversity

Channel diversity was extremely low across the study area; isolated pools were the dominant habitat category. Bends and changes in water depth are likely to provide some channel diversity during periods of flow. The only run and riffle habitat was observed was approximately 1 km downstream from site A on Eurombah Creek, where water from the Spring Gully RO plant was being discharged.

Aquatic Habitat

The condition of aquatic habitats was variable, but some physical aquatic habitat was found at most of the sites. Habitat was generally in the form of small stick piles, fallen logs, tree roots, boulders and undercut banks (Figure 4.13). Instream vegetation, trailing bank vegetation and floating vegetation were seldom observed. 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 logs as habitat (Figure 4.14).

Figure 4.13

Trailing bank vegetation and undercut banks at Barton Creek (site E).

Figure 4.14

Boulders, instream vegetation, log jams and overhanging vegetation downstream of site A on Eurombah Creek.

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 4.15). The proposed pipeline alignment crosses many of the waterways of the Southern Tributaries Subcatchment (Telfer 1995).

Reach Environs

The Southern Tributaries subcatchment covers 8,689 km^2, and includes the minor catchments of Juandah Creek in the east (Figure 4.15). 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 adjacent to the pipeline alignment, 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 current study areas are in a similar condition, and are affected by similar factors, to sites typical of the subcatchment.

Bank Stability

In the present study, most sites in the study area were deemed moderately stable, whereas most stream banks in the subcatchment were rated as stable (Telfer 1995). 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 current study area.

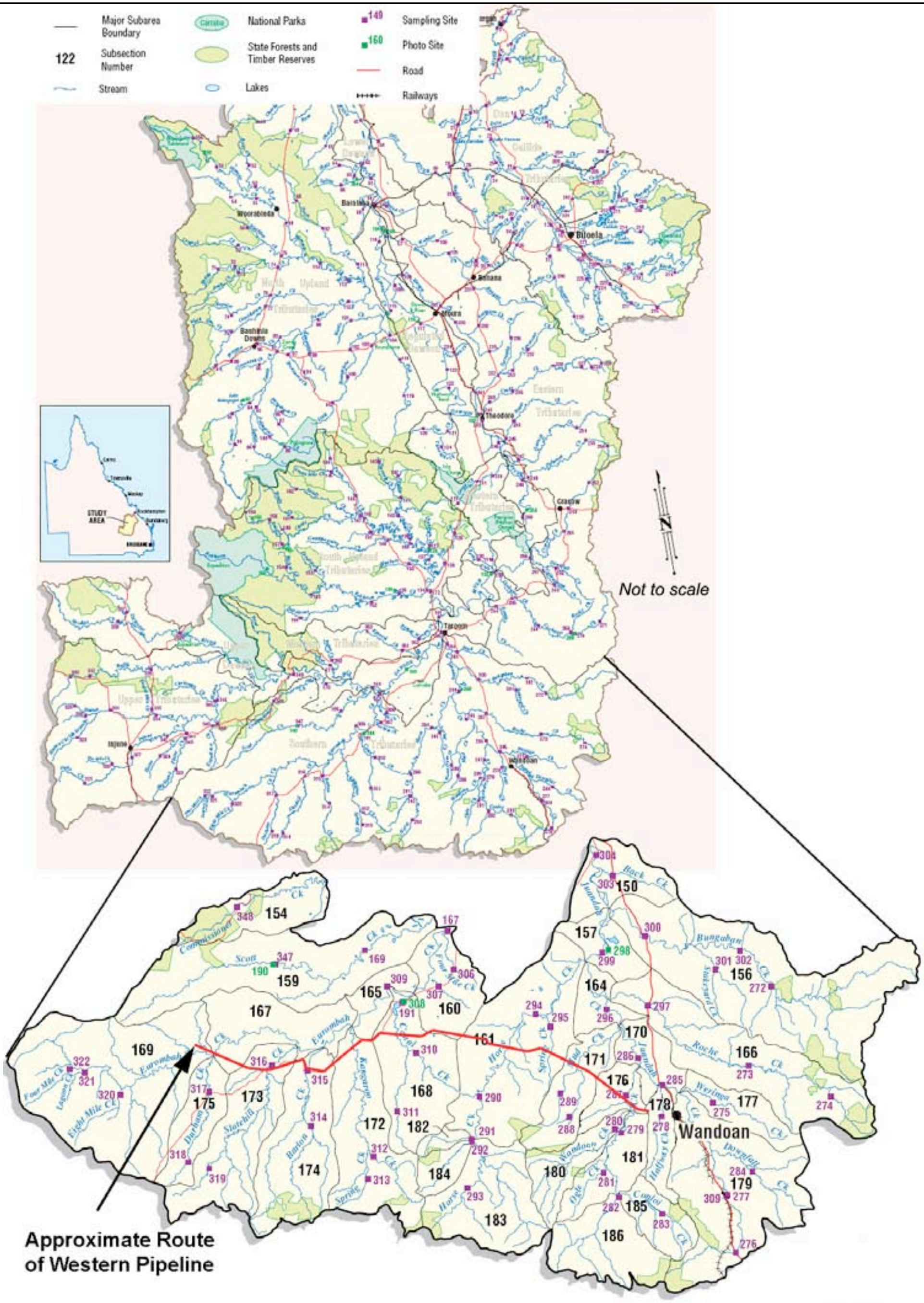
Bed and Bar Stability

Bed aggradations and erosion throughout much of the subcatchment are 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%). 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. This is similar to the pattern of sediment deposition and stability observed at waterways crossed by the western water supply pipeline alignment.

Channel Diversity and Habitat Types

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. Across the subcatchment pools, averaged 1 m deep and 8.4 m wide, which was significantly larger than the pools surveyed at sites C and E, but smaller than the pools surveyed at site A.

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 present study area (refer to Attachment A for the sediment composition at each survey site).



frc environmental deep thinking. science.	Wandoan Coal Project: Western Coal Seam Methane Water Supply Pipeline	
	Figure 4.15 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

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 at creeks crossed by the western water supply pipeline alignment were also dominated by grasses 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%). It was suggested that poor riparian vegetation reduced the supply of vegetative debris, resulting in poor aquatic habitat. In the present study, aquatic habitat was poor at sites C, F, G, H & I, moderate at sites D, E, 3, 5 & 6 and good at site A on Eurombah Creek.

Conservation Values

Subjective evaluations during the *State of the Rivers* assessment reported high conservation value in terms of aquatic habitat, riparian habitat and wildlife corridors 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, 63% was in poor condition, 23% was in moderate condition, 7% was in good condition and no sites were regarded as being in very good condition. Generally, the aquatic habitats of the sites surveyed during this study were in moderate condition.

4.1.3 Summary

The study areas are in the Southern Tributaries (Taroom) Subcatchment. This catchment comprises approximately 17% of the Dawson River catchment, and 6.1% of the Fitzroy Catchment.

Six of the nine sites surveyed had moderate River Bioassessment Program habitat scores, and sites G and H had poor habitat scores. Poor to moderate habitat assessment scores reflect low habitat variability, moderate to extensive bank erosion, clearing of riparian vegetation and substrates dominated by finer sediments such as sand and silt. Aquatic habitat condition at Eurombah Creek (site A) was good.

Overall, the reach environs of the creeks surveyed have been moderately affected by human activities. Cattle-grazing is the dominant surrounding land-use and cattle access to the creeks has caused some disturbance. There has been some clearing of riparian vegetation across the western water supply 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 subcatchment.

Riparian zone condition throughout the study area was poor and characteristic of the region. Riparian zones were generally 5 – 10 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 is generally low to moderate in the region, and was extremely low across western water supply 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 Eurombah Creek (A).

Some physical aquatic habitat for fauna was found at most of the sites. In-stream physical habitat was typically in the form of undercut banks 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

Across the sites surveyed, water temperature ranged between 11.6 °C at site C to 29.1 °C at site 6 on Spring Creek (Figure 4.16). Water temperatures were much higher at sites 3, 5, & 6, which were sampled in March 2008. There are no guidelines available for water temperature (ANZECC & ARMCANZ 2000; EPA 2007a).

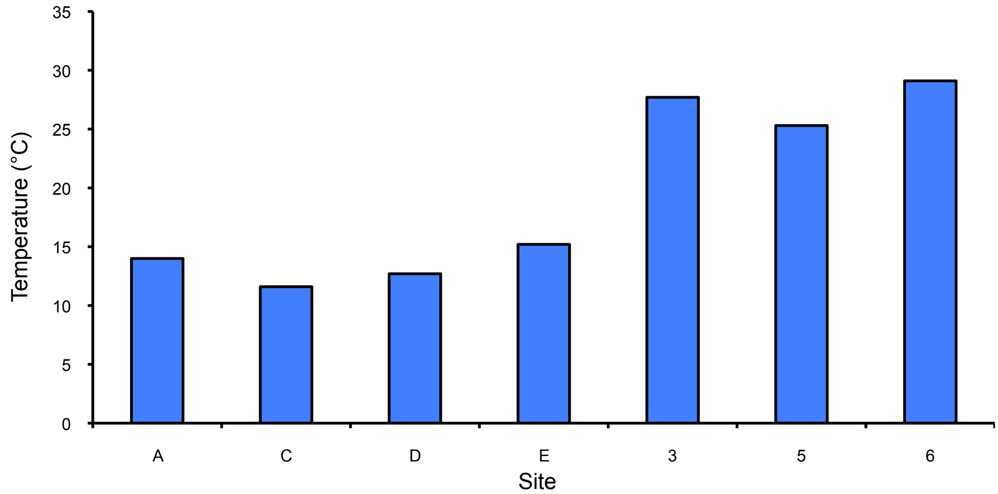


Figure 4.16 Water temperature at each site.

Dissolved Oxygen

Dissolved oxygen (DO) concentrations were highly variable among sites, ranging from 54% saturation (sat.) at Slatehill Creek (site D) to 123% sat. at Kurrajong Gully (site C) (Figure 4.17). Eurombah Creek (site A), Mud Creek (site 5) and Spring Creek (site 6) were the only sites with DO concentrations that fell within the Queensland Water Quality Guidelines (QWQG) range (EPA 2007a), although the DO concentrations at Barton Creek (site E) and Woleebee Creek (site 3) were close to the guideline range.

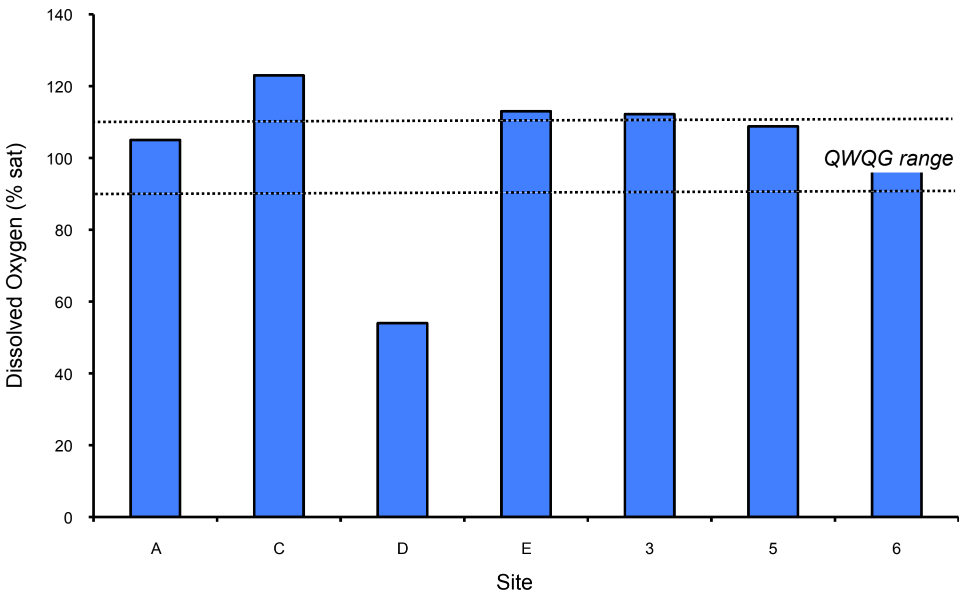


Figure 4.17 Dissolved oxygen at each site, compared with the QWQG range for central coast upland streams (EPA 2007a).

Low DO concentrations at Slatehill was probably due to high biological oxygen demand, low mixing, and shading. This creek had steep sides and consisted of evaporating remnant pools that were shaded by the bank for much of the day. Low light penetration and relatively high amounts of organic matter and microbial activity within the stagnant waters likely produced these low readings.

High diurnal DO concentrations generally indicate that DO drops to critically low levels for fauna at night. This is because high DO levels during the day usually indicate large quantities of algae and aquatic plants photosynthesising and producing oxygen, which at night respire and consume the DO within the water column (together with all other organisms within the system), thereby creating low DO levels. The complete absence of fish at Kurrajong Gully (C) may be the result of overnight hypoxia.

pH

pH tended to be basic (> 7) across most sites, but it ranged from 6.1 at Woleebee Creek (site 3) to 9.38 at Kurrajong Gully (site C) (Figure 4.18). Mud Creek (site 5) was the only creek with a pH value within the QWQG range, Woleebee (site 3) and Spring (site 6) creeks were well below the QWQG range, and the remainder were well above the QWQG upper limit (EPA 2007a). Differences in pH between sites may be related to local geomorphology.

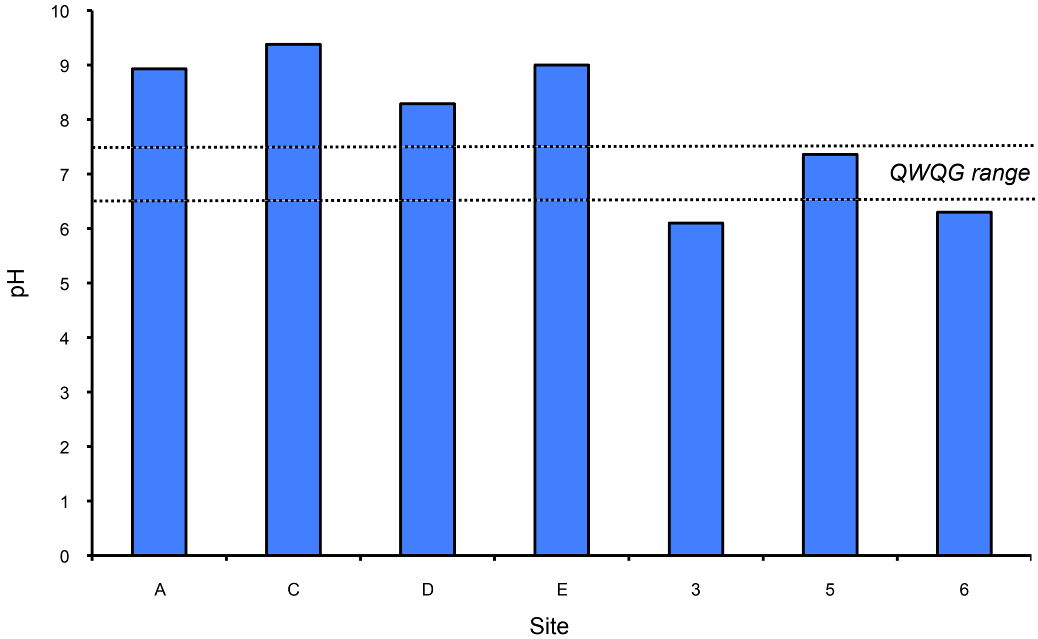


Figure 4.18 pH at each site, compared with the QWQG range for central coast upland streams (EPA 2007a).

Electrical Conductivity

Conductivity ranged from 110 µS/cm at Slatehill Creek (site D) to 388 µS/cm at Mud Creek (site 5) (Figure 4.19). Conductivity was below the QWQG upper limit (EPA 2007a) for all sites except Mud Creek. It should be noted that the QWQG value for conductivity is a preliminary guideline only (EPA 2007a).

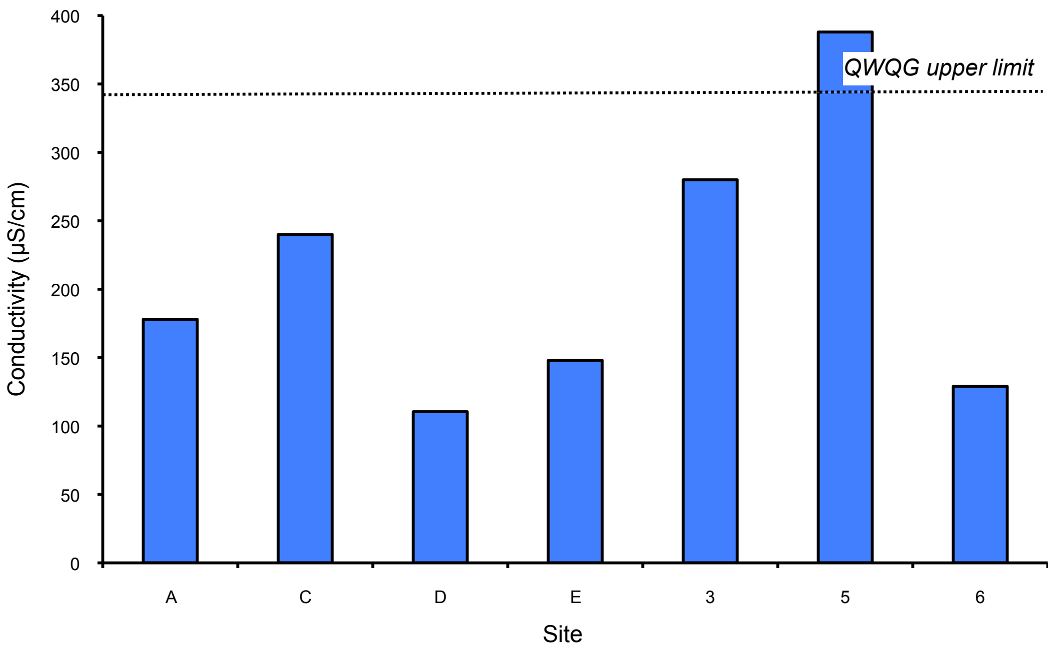


Figure 4.19 Electrical conductivity at each site, compared with the QWQG upper limit for Fitzroy central region (preliminary guideline based on the 75th percentile of data from the Fitzroy central salinity zone; EPA 2007a).

Turbidity

Water at Eurombah and Slatehill Creeks was relatively clear, and turbidity was estimated to be below the guideline value (Figure 4.20). High turbidity at Kurrajong Gully, Barton, Woleebee, Mud and Spring Creeks (sites C, E, 3, 5, & 6) was typical of the study area, probably related to local sediment composition, clearing of riparian vegetation, and bank erosion and cattle access to the creek bed.

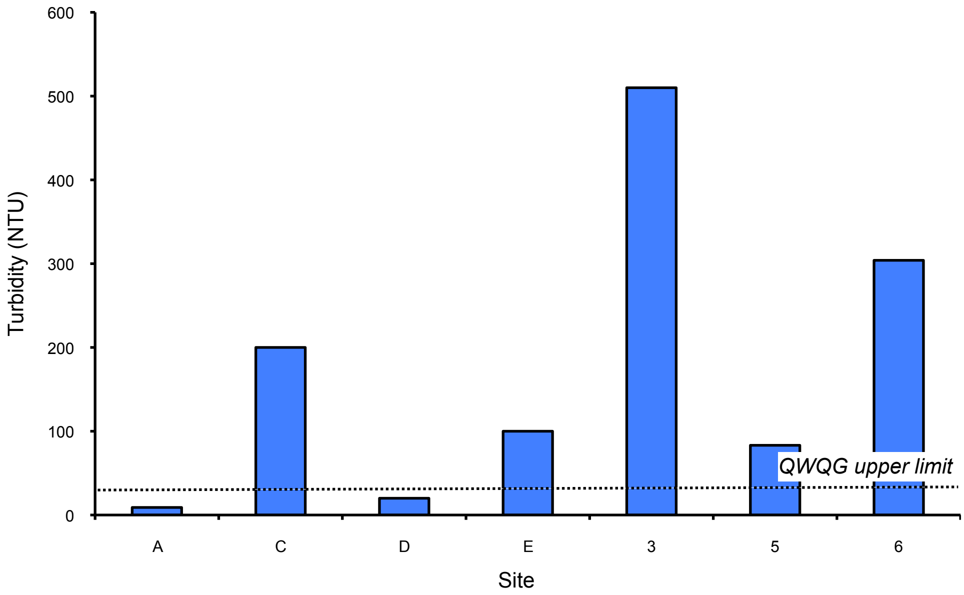


Figure 4.20 Estimated turbidity at each site, compared with the QWQG range for central coast upland streams (EPA 2007a).

4.2.2 A Regional and Ecological Perspective

The waterways of the study area are a part of the upper Dawson River Catchment (Southern Tributaries or 'Taroom' Subcatchment) (Figure 4.15). The Dawson River is the largest tributary in the Fitzroy River basin, which eventually feeds into the Great Barrier Reef (GBR) Lagoon.

Dawson River Catchment

Agricultural land 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). Based on a subcatchment area of 868,900 ha (out of a total Dawson River catchment area of 5,080,000 ha), the Taroom subcatchment contributes only 1.6% and 1.4% of the total nitrogen and total phosphorus exported out of the Dawson River catchment annually.

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 was summarised by Meecham (2003):

- pesticide and herbicide contamination, particularly in irrigation areas;
- erosion and runoff increasing sedimentation and nutrients levels in waterways and reaching the GBR;
- high risk of blue-green algal bloom in still waters;
- rising salinity, particularly in streams between Theodore and Rockhampton;
- acid mine drainage in localised areas including Blackwater Creek, Crinum Creek, Don River and Dee River;
- heavy metal contamination, mostly from cadmium and copper in parts in of the Mackenzie, Nogoa and lower Dawson catchments; 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 in the study area during the present 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). Water temperatures were variable during the present survey, likely related to survey timing.

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 by Noble et al. (1996) concluded that life within the river system was fairly healthy, but that the significant flow events moved millions of tonnes of soil into the GBR lagoon, which in turn would carry any nutrients and pesticides present in the soil into the GBR lagoon.

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 levels did not comply with the QWQG except at Eurombah, Mud and Spring Creeks (sites A, 5, & 6). Low DO concentrations were probably the result of high biological oxygen, low mixing and shading of the waters. High DO was possibly due to nutrient input and riparian clearing (that would result in less shading of the channel) in association with cattle grazing. Turbidity was variable, and was estimated to have exceeded QWQG levels at all sites except for Eurombah (site A) and Slatehill (site D) creeks. Sites that were highly turbid were also cleared of riparian vegetation and were affected by cattle access. 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).

Similarly, water quality across the wider catchment is also characterised by high turbidity and fluctuating DO concentrations. Due to surrounding land uses, waterways within the region are impacted by relatively high inputs of nutrients, pesticides and other contaminants. The Taroom Subcatchment, which contains the study areas for the present study, only contributes 1.6% of the total phosphorus and 1.37% of the total nitrogen exported out of the Dawson River catchment each year.

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 < 25%).

Up to fourteen species were recorded across the eight sites that held water (Table 4.1). Ten species had an emergent growth form and the remaining two were submerged (Figure 4.21). No floating species were recorded.

At all sites, cover by any one species was less than or equal to 10%. No macrophytes were recorded from Kurrajong Gully (site C), which contained several pools of water.

Several macrophytes could only be identified to genus level, due to the absence of seeds or flowers. The most abundant and common macrophyte was *Lomandra longifolia,* which covered 10% of the substrate at Slatehill Creek (site D). It was present at five of the eight sites where macrophytes were observed.

Figure 4.21

Chara sp. from Eurombah Creek (site A).

Figure 4.22

Lomandra longifolia at Barton Creek (site E) surrounded by pasture grasses.

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

GROWTH FORM / Family / *Latin name*	Common name	Native/ exotic	% Cover at Each Site								
			A	**C**	**D**	**E**	**F**	**I**	**3**	**5**	**6**
SUBMERGED											
Characeae											
Chara sp.	stonewort	N	1								
Najadaceae											
Najas sp.	water nymph	N				4					
EMERGENT											
Amaranthaceae											
Alternanthera denticulata	lesser joy-weed	N				2	1		3	8	1
Cyperaceae											
Cyperus sp.	unknown sedge					1	1			5	
Cyperus difformis	dirty dora	N							2		
Cyperus exaltus	giant sedge	N								1	
Eleocharis acuta	common spiekrush	N						1			
Fimbristylis sp.	fringe-rush	N	2								
Schoenoplectus validus	river club-rush	N			2						
Graminae											
Phragmites australis	common reed									4	
Juncaceae											
Juncus usitatus	rush	N	2								2
Juncus sp.	rush		2								
Lomandraceae											
Lomandra longifolia	rush	N			10	5	3	1		2	
Poaceae											
Eragrostris elongata	clustered lovegrass	N								5	
TOTAL			**7**	**0**	**12**	**12**	**5**	**2**	**5**	**25**	**3**

Submerged macrophytes are limited in distribution throughout the region by high turbidity, as it reduces light penetration through the water column, essential for the growth of macrophytes. Submerged macrophytes were only found at Eurombah Creek, where the water as relatively clear. All of the emergent forms in this study were found growing above the current water level.

Algae

Filamentous algae were also observed at Eurombah Creek (site A) 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.

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 recent study in the upper Dawson River catchment (frc environmental 2007) reported a similar result to our survey. 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).

4.4 Aquatic Macro-invertebrate Communities

4.4.1 Of the Study Area

Cladocerans (water fleas) were by far the most abundant taxonomic group across the sites surveyed, although non-biting midge larvae (sub-families Chironominae and Tanypodinae) were also very abundant. Macro-crustaceans (freshwater prawns and crayfish) were also common throughout the sites surveyed.

Richness

Taxonomic richness (the number of macro-invertebrate taxa, generally families, per sample) in stream bed habitat varied from 2 – 15; Kurrajong Gully (site C), and Woleebee Creek (site 3) has the least number of taxa, and Eurombah Creek (site A) had the most taxa (Figure 4.23). There was a similar pattern in edge habitats, where 7 – 20 families were recorded. These patterns in macro-invertebrate richness are largely consistent with the presence of habitat availability at these sites. Site A on Eurombah Creek had the most water and the most diverse edge and bed habitats.

Spring, Mud and Woleebee Creeks were sampled in the vicinity of the pipeline crossing location in March 2008. Richness ranged from two to ten taxa per site in bed habitats, and from seven to eighteen taxa per site in edge habitats. This is similar to the sites surveyed in August 2008, although the results are not directly comparable due to the differences in survey timing.

Across all sites sampled, richness was higher in edge habitats than bed habitats. This is to be expected, as edge habitats provided more diverse habitat.

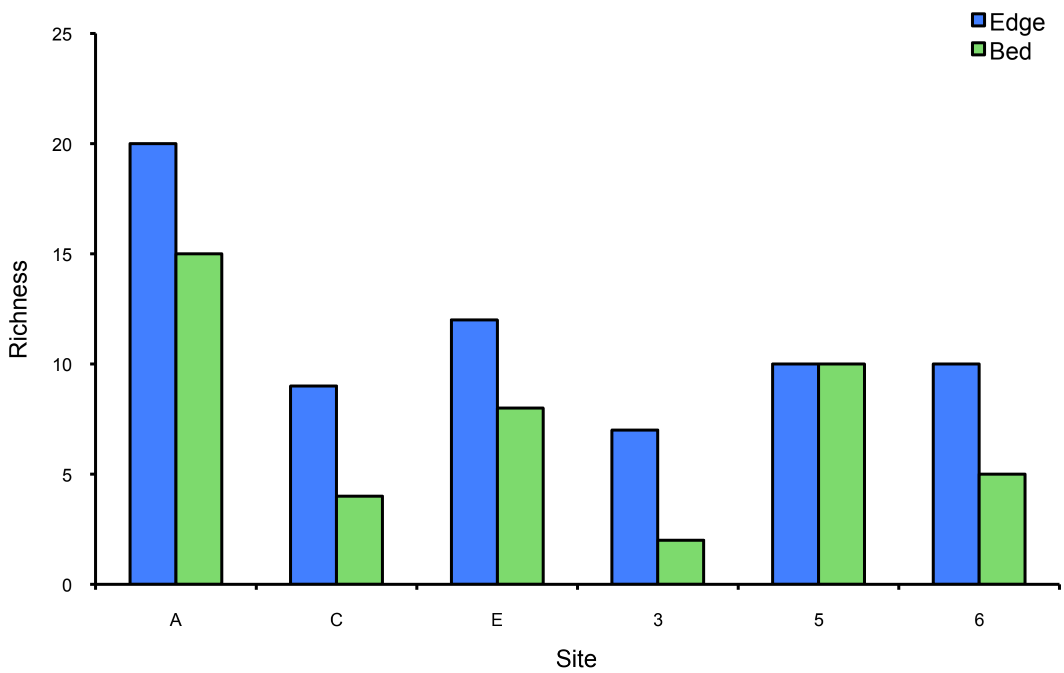


Figure 4.23 Taxonomic richness of macro-invertebrate communities in bed and edge habitats at each site.

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 indicated degraded or moderate quality water and habitat quality at most of the sites, and no PET taxa were sampled from Kurrajong Gully (site C) during the present survey, or from bed habitats in Spring, Mud and Woleebee Creeks in March 2008. However, edge habitat at Eurombah Creek (site A) appeared to be in good condition (Figure 4.24). This is probably related to the perennial nature of this site, which provides stable habitat for macro-invertebrates that are sensitive to pollution.

While the low abundance of PET taxa throughout the study area may be indicative of poor water and / or habitat quality, the waterways sampled are ephemeral or intermittent systems. 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.

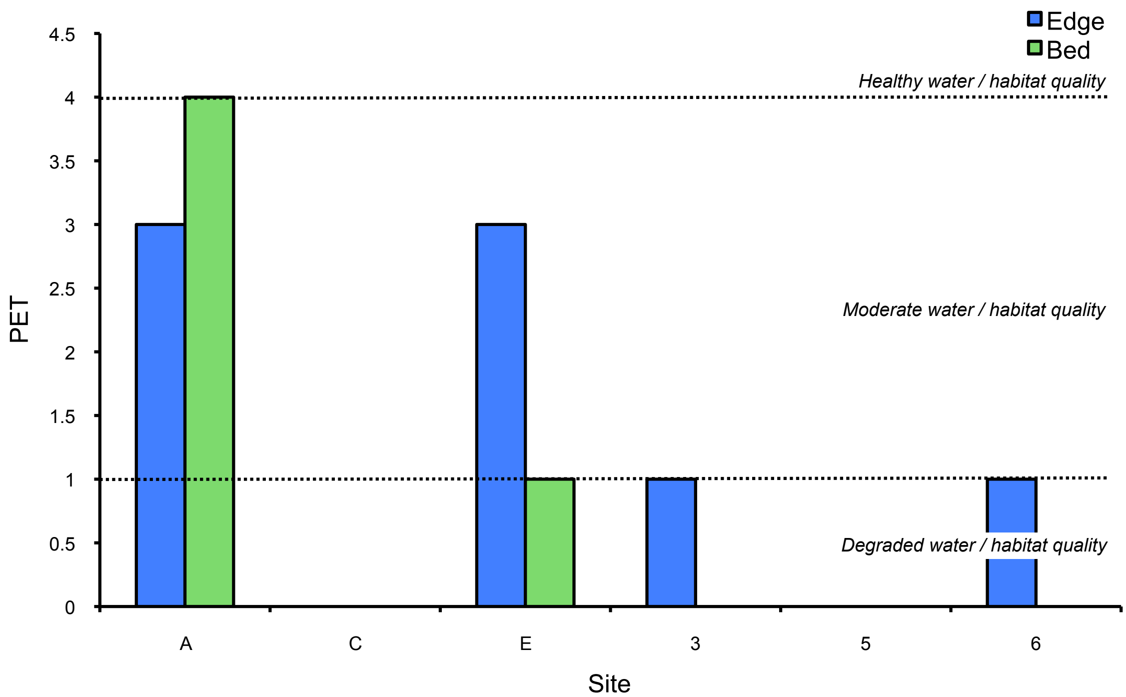


Figure 4.24 PET richness of macro-invertebrate communities in bed and edge habitats at each site.

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.

Most macro-invertebrate communities surveyed from bed and edge habitats fell into quadrant 4 of the bi-plot (Figure 4.25), indicating that these communities may be impacted by urban, industrial or agricultural pollution. The community from the edge habitat at Eurombah Creek (A) were within quadrant 2, suggesting that the community here may be 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 in the form of eutrophication and turbidity, considering the level of disturbance from grazing observed at most sites. However, for ephemeral 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.

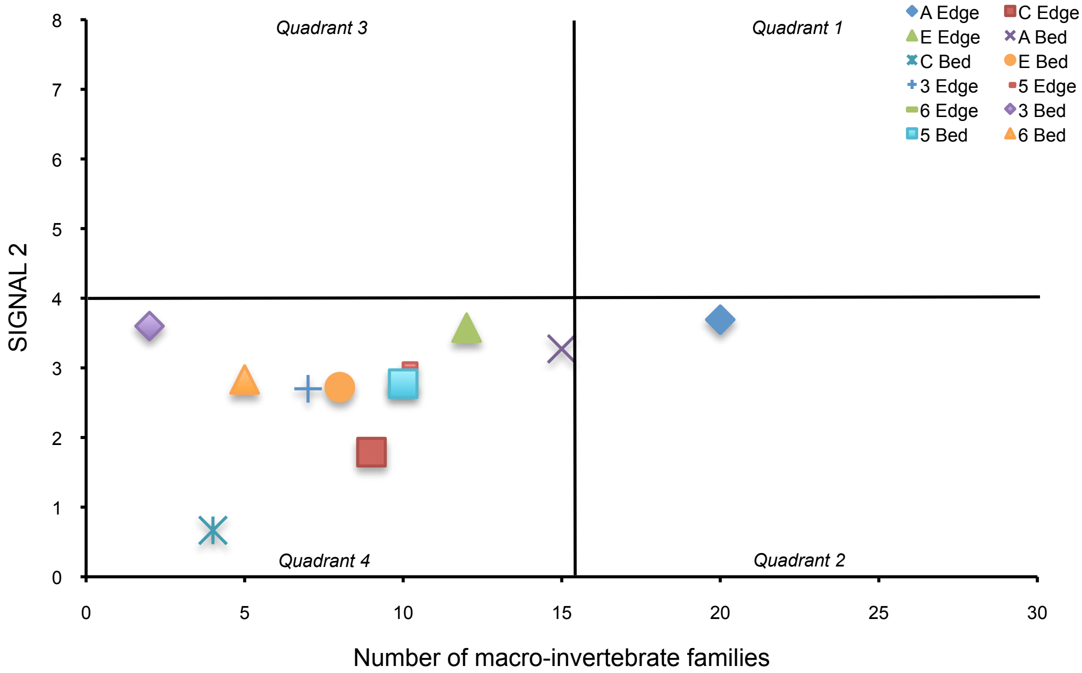


Figure 4.25 SIGNAL 2 / Family Bi-plot for the macro-invertebrate communities sampled from bed habitats in the study area.

4.4.2 Macro-Crustaceans

Macro-crustaceans (367) were captured across the six sites surveyed for fish using back-pack electrofishing, dip netting and trapping. The majority of this catch was from Mud Creek (site 5), where 192 macro-crustaceans were collected (Figure 4.26). Although Kurrajong Gully (site C) did not support any fish, eight orange-fingered yabbies (*Cherax depressus*) were captured here. The relatively large catch at sites 3, 5, and 6 is probably related to temporal differences in sampling, as these sites were sampled in March, rather than August, 2008.

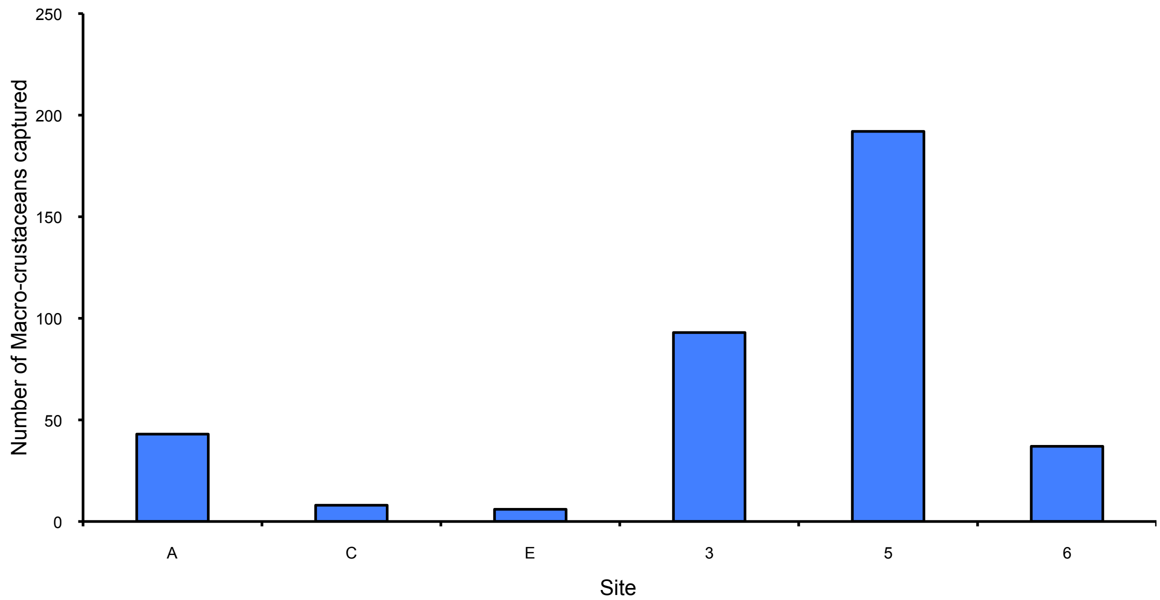


Figure 4.26 Macro-crustacean abundance at each site.

Cherax depressus (orange-fingered yabby) was the most abundant species captured; it was recorded at all sites surveyed (Figure 4.28). Adult, intermediate and juvenile orange-fingered yabbies were captured at each site, except for Eurombah Creek (A) where only juveniles were captured. *Macrobrachium* sp. (river prawn) were also present at sites A and E. *Caridina* sp. and *Paratya* sp. (freshwater shrimp) were also collected from Eurombah Creek (A), which had the highest species richness (Figure 4.27, Table 4.2).

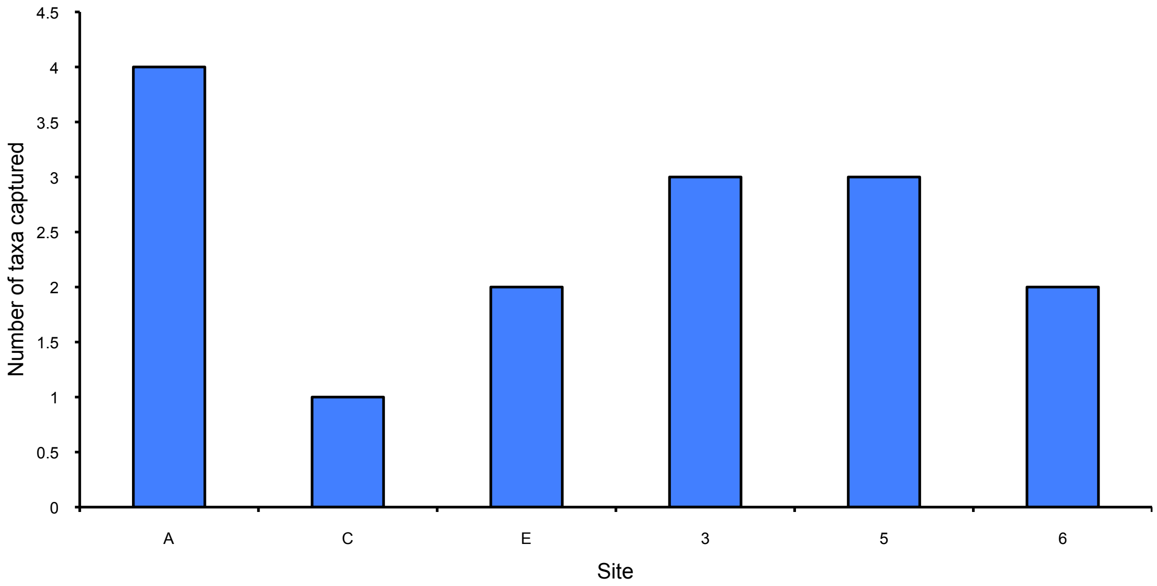


Figure 4.27 Richness of macro-crustaceans at each site.

Table 4.2 Abundance of macro-crustaceans at each site.

Family	Latin Name	Common name	Site A	C	E	3	5	6
Atyidae	*Caradina* sp.	freshwater shrimp	9			28	33	20
	Paratya sp.	freshwater shrimp	3					
Palaemonidae	*Macrobrachium* sp.	river prawn	28		2	23	83	
Parastacidae	*Cherax depressus*	orange-fingered yabby	3	8	4	42	76	17
Total			**43**	**8**	**6**	**93**	**192**	**37**

Figure 4.28

An orange-fingered yabby from Barton Creek (site E).

4.4.3 A Regional and Ecological Perspective

Richness

Sandy pool habitats sampled by DNRW (2007) in the Dawson River supported between 7 – 18 families per sample, and rocky pool habitats supported between 10 – 25 families per sample (refer Figure 4.29 and Figure 4.30). That is, macro-invertebrate richness was similar to the Dawson River site surveyed by DNRW at Eurombah Creek (site A), but lower at Kurrajong Gully (site C) and Barton Creek (site E). Some of this variation may be attributable to temporal variation, as DNRW surveys were done between 4 – 13 years ago. Similarities between Eurombah Creek and the Dawson River site are probably related to the perennial nature of the streams, which offer more stable habitat for macro-invertebrates.

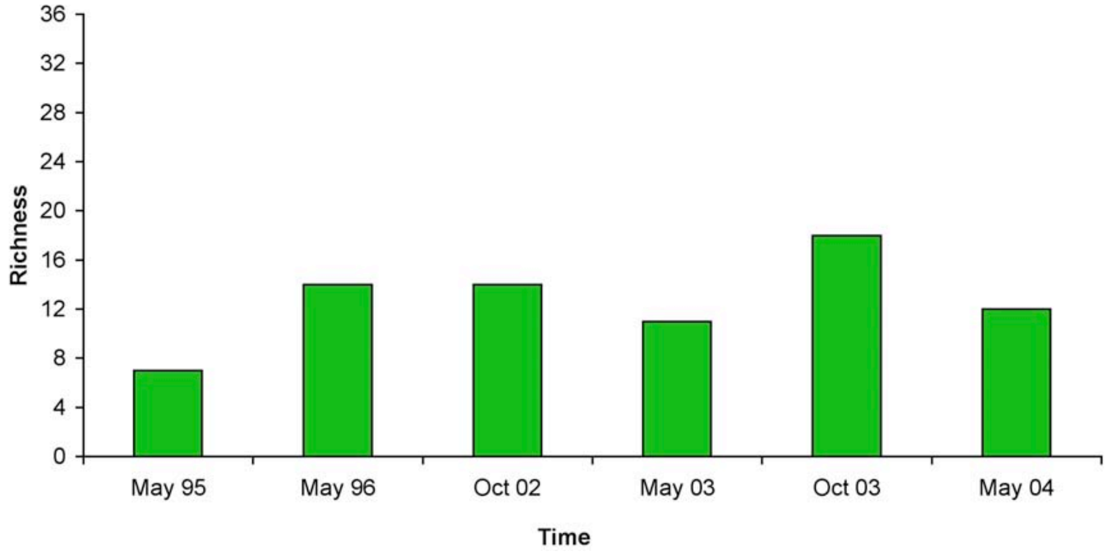


Figure 4.29 Taxonomic richness in sandy pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

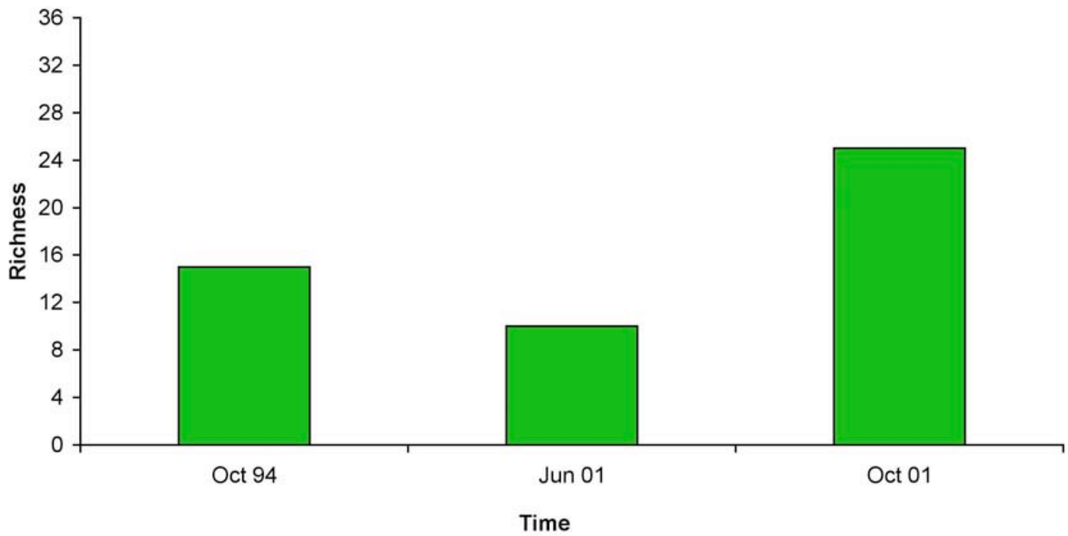


Figure 4.30 Taxonomic richness in rocky pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

Similar to the pattern observed in the present study area, 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 4.31). This is a relatively high richness, and is likely to be indicative of relatively good quality edge habitat and water quality at this site.

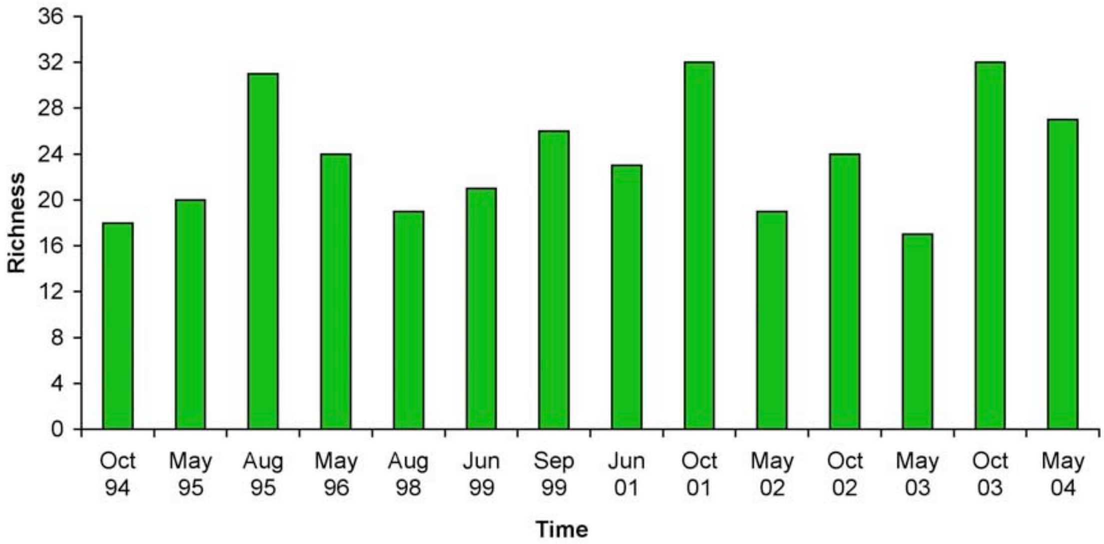


Figure 4.31 Taxonomic richness in edge habitat of the Dawson River at Taroom (DNR&W site 130302A).

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 4.32 – Figure 4.34). PET Richness varied over time, but was generally higher than the PET richness recorded in the study area during the present surveys.

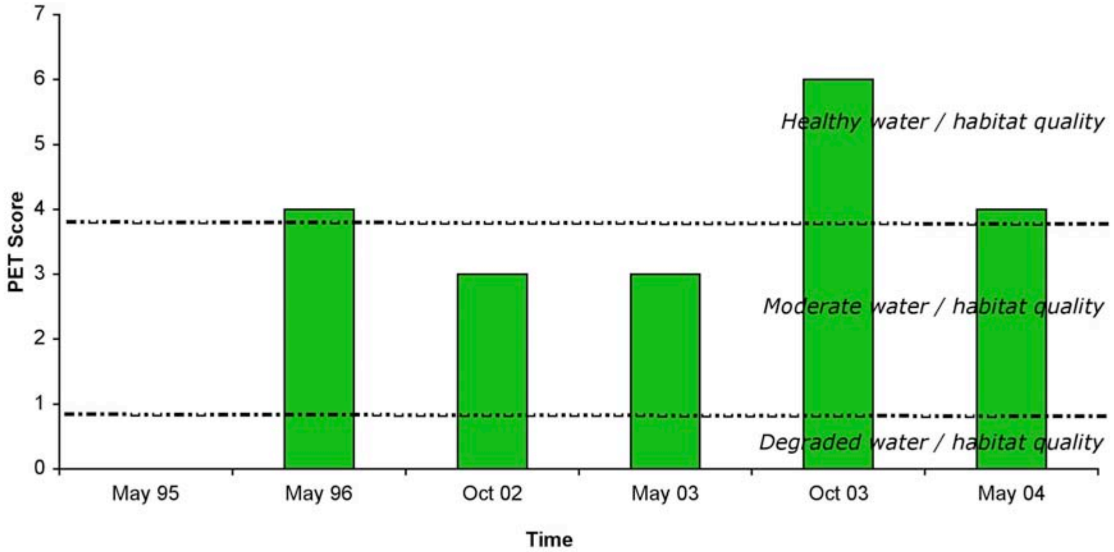


Figure 4.32 PET richness in sandy pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

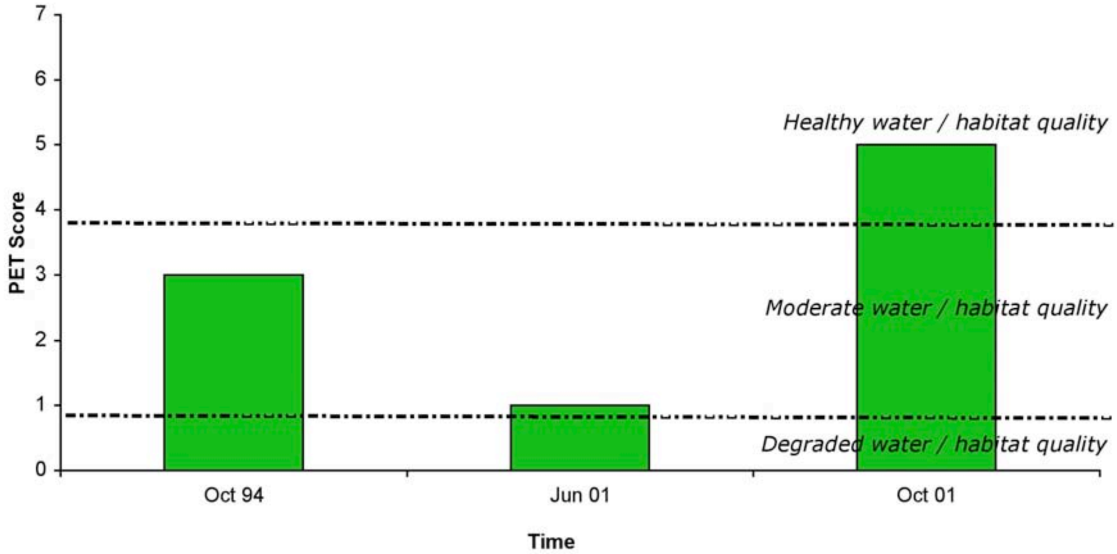


Figure 4.33 PET richness in rocky pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

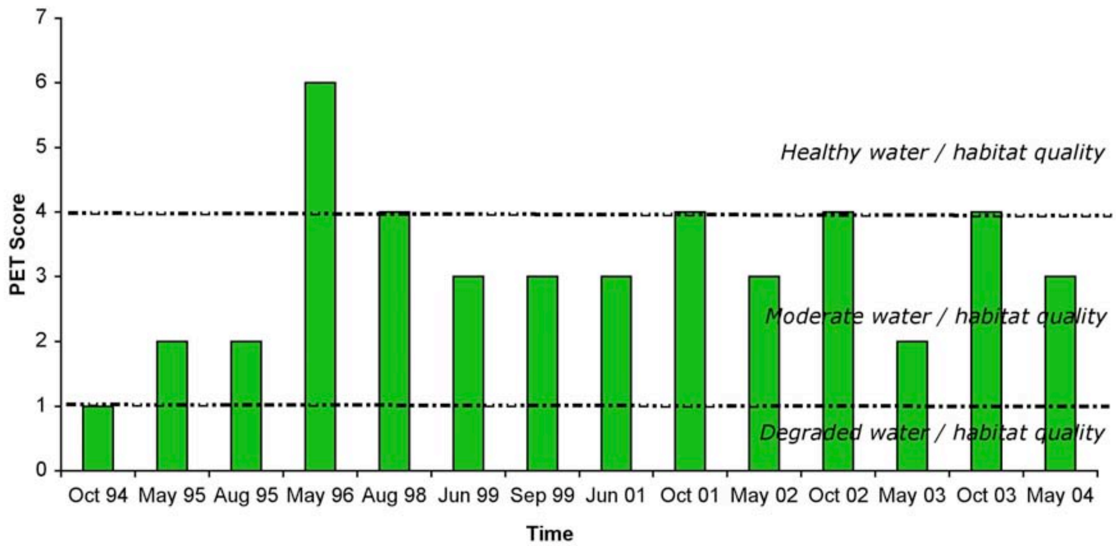


Figure 4.34 PET richness in edge habitat of the Dawson River at Taroom (DNR&W site 130302A).

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 4.35 – Figure 4.37; Attachment B).

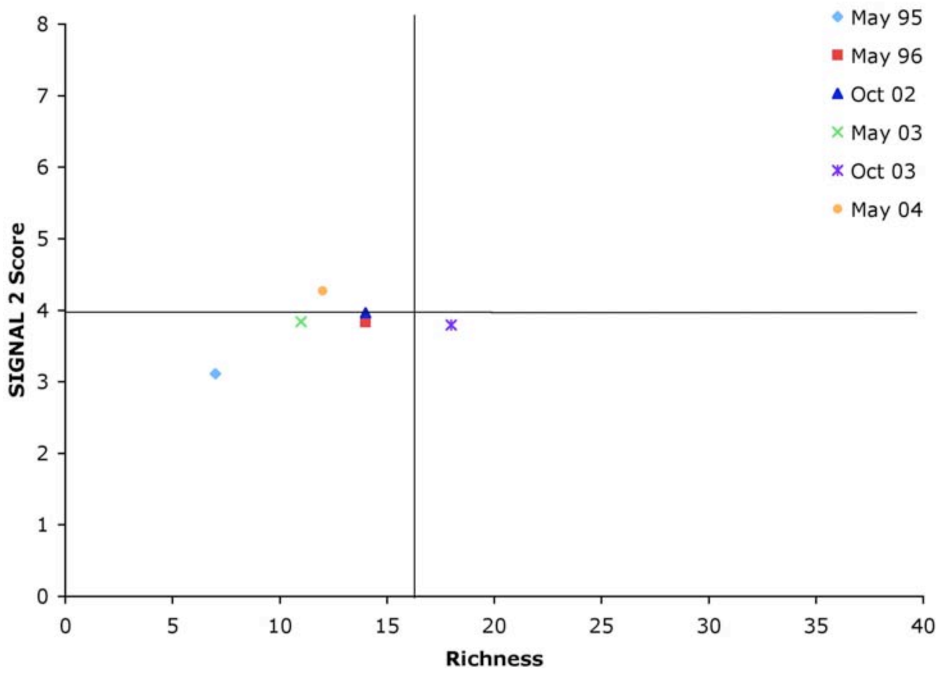


Figure 4.35 SIGNAL 2 / family bi-plot for sandy pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

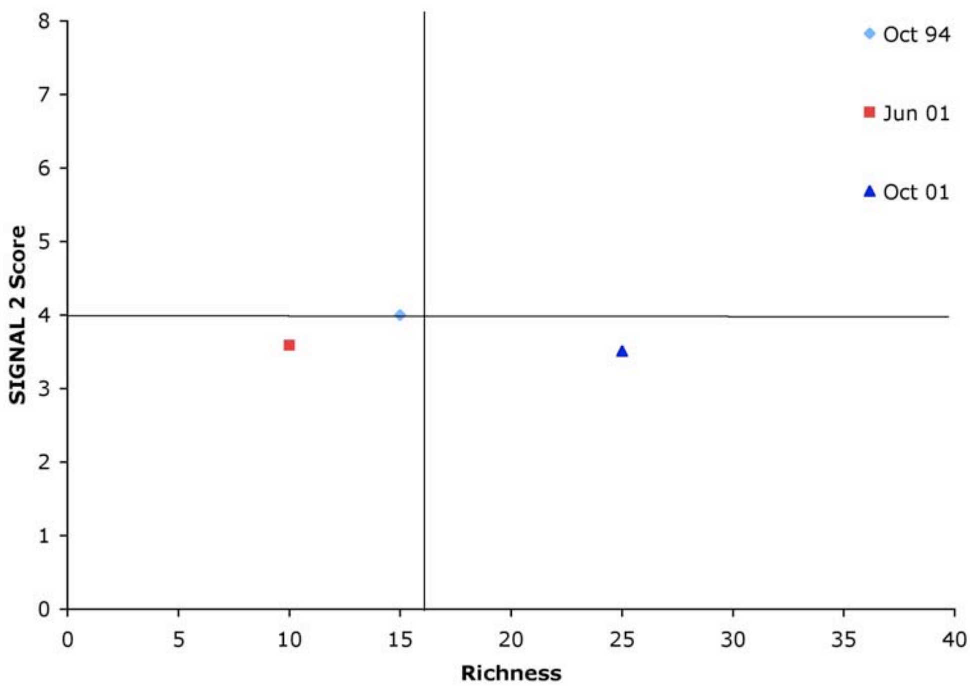


Figure 4.36 SIGNAL 2 / family bi-plot for rocky pool habitat of the Dawson River at Taroom (DNR&W site 130302A).

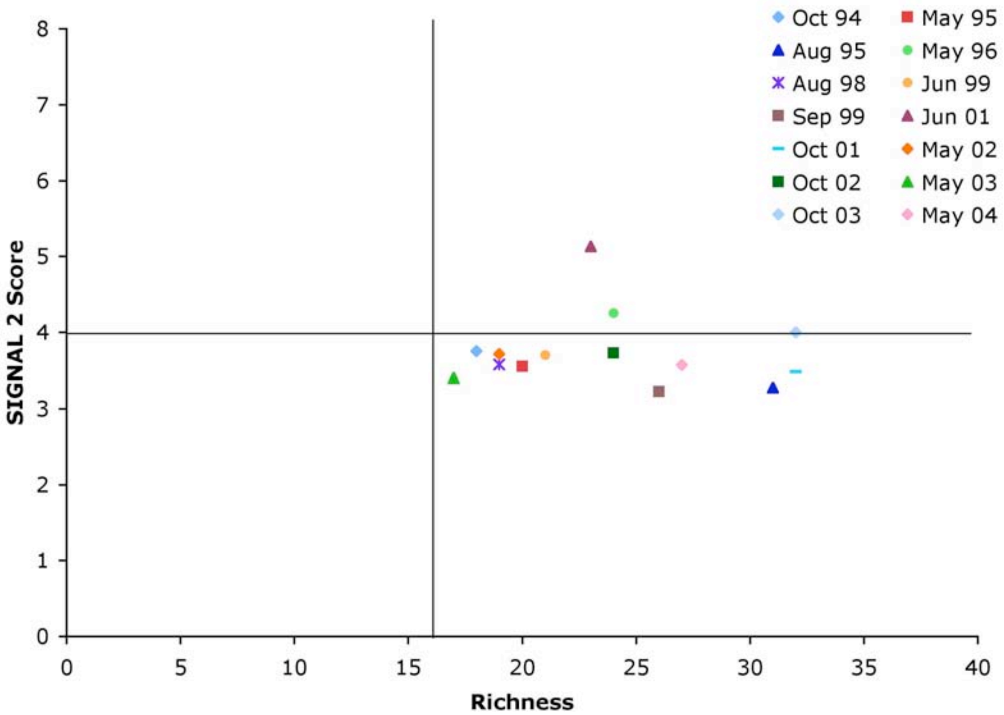


Figure 4.37 SIGNAL 2 / family bi-plot for edge habitat of the Dawson River at Taroom (DNR&W site 130302A).

Macro-crustaceans

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. Freshwater prawns and shrimps were not present at Kurrajong Gully, possibly due to the frequency of drying of this pool.

The freshwater crab (*Austrothelphusa* sp., formerly *Holthuisana* sp.) is widespread throughout Australia and is well adapted to living in ephemeral streams (Jones & Morgan 1994). No freshwater crabs were captured during the survey of the study area, which was viewed as surprising.

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). The differences in macro-invertebrate diversity appeared to be related to site-specific differences in water quality, habitat availability and diversity. However, the composition of macro-invertebrate communities indicates that Eurombah Creek is in relatively good condition, and in particular provides diverse and stable edge habitat. Freshwater crayfish and prawns/shrimp were common in the study area.

In general, the macro-invertebrate communities of the downstream Dawson River were more diverse and contained more taxa sensitive to pollution and disturbance than those of communities within the study area. The Dawson River at Taroom and Eurombah Creek have permanent water, therefore, offer more stable habitat for macro-invertebrates. In contrast, other communities of creeks along the western water supply pipeline alignment 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, 136 fish from five species were captured across the six sites surveyed. The abundance of fish varied from no fish at Kurrajong Gully (site C) to 79 fish at Mud Creek (site 5) (Figure 4.38 &Figure 4.39).

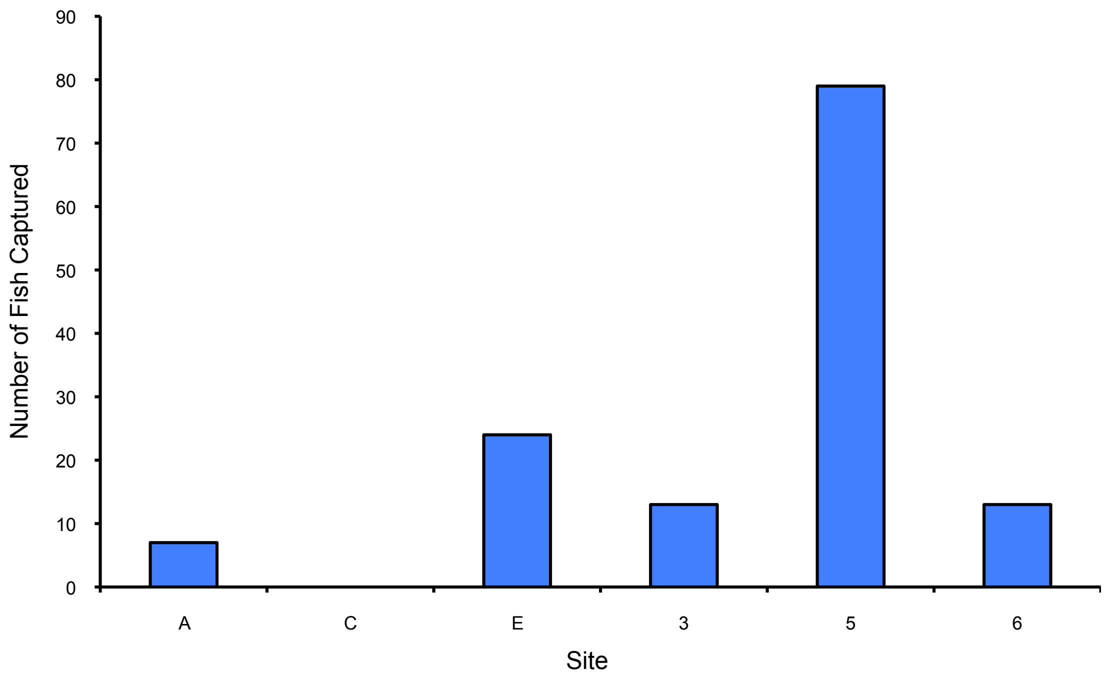


Figure 4.38 Fish abundance at each site (all survey methods combined).

Species richness was highest at Mud Creek (site 5) with four species captured, followed by Woleebee Creek (site 3) and Eurombah Creek (site A), where three species were captured (Figure 4.39). The pool sampled at Barton Creek was relatively small compared to Eurombah Creek and Mud Creek, but deep (approximately 1.5 m), and it contained carp gudgeons (*Hypseleotris* sp.) and spangled perch (*Leiopotherapon unicolor*). Eurombah and Mud Creeks were larger bodies of water with relatively diverse aquatic habitat (Figure 4.40). Crevices and overhangs in bedrock and boulders, as well as fallen logs, provided shelter for carp gudgeons and spangled perch, as well as larger golden perch (*Macquaria ambigua*) at Eurombah Creek. The pool at Kurrajong Gully (site C) was a similar size to the one at Barton Creek, yet no fish were captured.

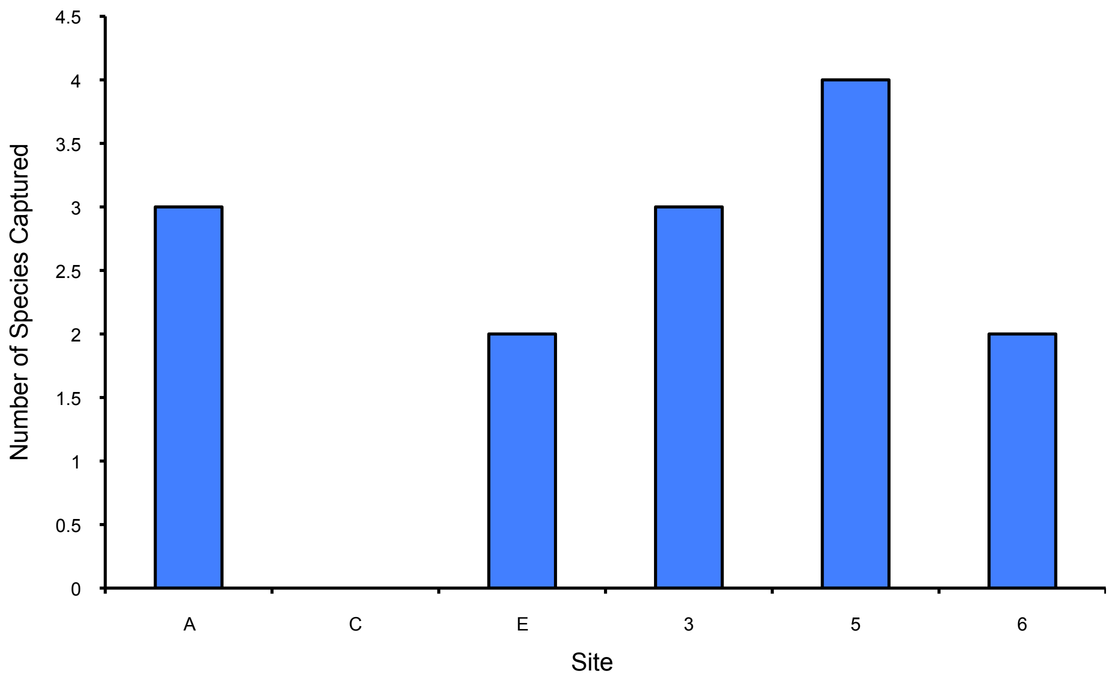


Figure 4.39 Species richness of fish captured at each site (all survey methods combined).

Figure 4.40

Rock crevices and boulders provided aquatic habitat for fish at Eurombah Creek.

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

			Site					
Family	**Latin Name**	**Common name**	**A**	**C**	**E**	**3**	**5**	**6**
Ambassidae	Ambassis agassizii	Agassiz's glassfish				2	50	
Eleotridae	*Hypseleotris* sp.	Carp gudgeon	3		21		16	7
Melanotaeniidae	*Melanotaenia splendida*	eastern rainbowfish				1	6	
Percichthyidae	*Macquaria ambigua*	golden perch	3					
Terapontidae	*Leiopotherapon unicolor*	spangled perch	1		3	10	7	6
Total			**7**	**0**	**24**	**13**	**79**	**13**

Spangled perch (Figure 4.41) was the most widely distributed species in the study area, and it was found at all sites where fish were present. Carp gudgeons (Figure 4.42) were also widely distributed, and were found at four of six sites. Agassiz's glassfish were the most abundant species, although they only found at two sites (50 individuals were collected from Mud Creek (site 5)). Three intermediate golden perch (*Macquaria ambigua*) (Figure 4.43) were collected from under a large boulder at Eurombah Creek (site A).

Overall, fish were more abundant at sites surveyed during March 2008 than August 2008, this is likely to reflect the seasonal variation in fish communities throughout the study area.

Figure 4.41

A juvenile spangled perch from Barton Creek (site E).

Figure 4.42

An intermediate carp gudgeon from Barton Creek (site E).

Figure 4.43

An intermediate golden perch from Eurombah Creek (site A).

Indicators of Stream Health

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

4.5.2 A Regional and Ecological Perspective

The fish communities of Juandah Creek or other creeks adjacent to the pipeline alignment 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. 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, carp gudgeons and glassfish were the most abundant species captured within the study are during the present survey. Bony bream were only caught at the most downstream site in Juandah Creek, as part of the MLA study, presented in Volume 1.

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 (present study, Ecowise 2008), and *Gambusia holbrooki* (mosquitofish) have been captured in the Dawson River in November 2007 (frc environmental 2007). Mosquitofish are declared noxious species in Queensland under the *Fisheries Regulation 2008*.

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

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

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

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, **Error! Reference source not found.**). Adult golden and spangled perch move upstream to spawn, and juveniles move downstream for dispersal. This movement is typically triggered by large flow events (Cotterell 1998). Glassfish, rainbowfish and gudgeons move within freshwaters to disperse to new habitats. This movement also typically occurs following flow events; and in the case of the study area could only occur when the creeks are flowing (i.e. when the isolated pools currently holding these species are connected).

Table 4.5 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 2003). 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 relatively common across 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).

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 2003). 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 and widespread during the surveys of the western CSM water supply pipeline study area.

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 (Volume 1) captured eastern rainbowfish at the majority of sites; 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 recorded at waterways crossed by the western CSM water supply pipeline route that were surveyed in March 2008, but they were not recorded in the August 2008 survey. This is likely due to seasonal factors, and eastern rainbowfish are expected to occur in the major waterways crossed by the pipeline during the wet season.

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 (Midgely 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 only recorded in Eurombah Creek, in a perennial pool. It was also Junadah Creek, downstream of the MLAs (site 10) during the post-wet season survey of the MLA study area (Volume 1). Golden perch are unlikely to be common in the smaller, isolated pools that characterise the majority of waterways crossed by the western CSM water supply pipeline route.

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 (Ivanstoff & Crowley 1996, Allen et al 2002). Spangled perch are likely to persist in the creeks within the study areas throughout the year; they were sampled in both March and August 2008.

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 have been captured in Juandah Creek, downstream of the MLAs (refer Volume 1), and it is possible that they would migrate upstream to the waterways crossed by the western CSM water supply pipeline route during the wet season.

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 have been captured in Juandah Creek, downstream of the MLAs (refer Volume 1), and it is possible that they would migrate upstream to the larger waterways crossed by the western CSM water supply pipeline route during the wet season (particualry Eurombah Creek).

Sleepy Cod

Sleepy cod are common and widespread in northern Australia between 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 have been recorded downstream from the western CSM water supply pipeline route (in Juandah Creek, refer to Volume 1). It is possible that they migrate into the waterways crossed by the pipeline at certain times of the year, particularly the larger waterways such as Eurombah Creek.

Most of the species that were captured from the study area can tolerate a large range of water quality conditions (Table 4.6). Spangled perch, glassfish and carp gudgeons are tolerant species that can live in water characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity (Table 4.6). Golden perch have narrower water quality tolerances than the other species collected, however the pH at Eurombah Creek exceeded the upper limit observed for this subspecies.

Table 4.6 Reported water quality tolerances of fish species that have been captured 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
Eleotridae	*Hypseleotris* spp.[A]	carp gudgeons	8.4 - 31.2	0.3-19.5	4.4-8.9	51-4123	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)
Percichthyidae	*Macquaria ambigua oriens*[B]	golden perch	24 – 31	3.6 – 10.0	7.2 – 8.8	NA	4 – 40 cm secchi depth
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

Along the pipeline route, turtle traps were set at two of the twelve sites (sites 3 and 6). Turtle traps could not be set at the other sites along the pipeline route, due to insufficient water depths. No turtles were captured or observed.

4.6.2 A Regional and Ecological Perspective

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 western 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.

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[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).

Gordos, Conservation Manager, NSW DPI, pers. comm. July 2007). Snorkel surveys 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).

4.7 Other Vertebrates

Our survey did not target other aquatic vertebrates, but several echidnas were observed within the study area including at Eurombah Creek (site A) and Slatehill Creek (site D) (Figure 4.44). Wallaby and kangaroo prints and droppings were also observed at most crossings.

Figure 4.44

An echidna under a log jam at Slatehill Creek (site D).

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

4.8 Summary of Aquatic Environmental Values

The Environmental Values of aquatic ecosystems within the study areas are relatively low and consistent with those of the wider catchment. Environmental values are dictated primarily by the ephemeral nature of the region's waterways; although agricultural development within the region has significantly influenced water quality and the physical characteristics of aquatic habitat (Telfer 1995). Degraded creeks in the catchment are characterised by riparian vegetation loss, erosion, invasion of weed species, poor water quality and sedimentation (Telfer 1995); all features of the creeks along the western CSM water supply pipeline route (refer Attachment A).

Water quality was generally poor throughout the study area, but was typical of the region. Biodiversity was relatively low, with only fish and macro-invertebrate species that are tolerant of varying and often harsh conditions inhabiting the study areas at the time of survey. Nevertheless, the creeks along the western CSM water supply pipeline route do provide 'upstream' dispersal habitat for the fish species that were recorded in the study area (and possibly breeding habitat for some species).

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

5 Description of Proposed Development

5.1 General Description

The western CSM water supply pipeline will be 91 km in length, and the preferred alignment has been selected to 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).

The pipeline will require a single lift pump station at the point of supply nominated by the water supplier, likely adjacent to the existing Spring Gully RO plant. 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:

- Eurombah Creek, and two minor tributaries (first order streams) of this creek
- Slatehill Creek, and tributary Kurrajong Gully and two minor tributaries (first order streams)
- Barton Creek, and three minor tributaries (first order streams) of this creek
- Kangaroo Creek, and two minor tributaries (first order streams) of this creek
- Canal Creek, and two minor tributaries (first order streams) of this creek
- two minor tributaries (first order streams) of Nine-Mile Creek
- Horse Creek, and tributaries Duck and Spring Creeks
- Mud Creek, and three minor tributaries (first order streams) of this creek, and
- Woleebee Creek and three minor tributaries (first order streams) 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 4,000 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 creek (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

6.2.1 Increases in Turbidity

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.

6.2.2 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).

6.2.3 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 Dawson catchment, as fertilisers are unlikely to be used on adjacent lands (where the land use is dominated by grazing on native pastures), and the Taroom subcatchment contributes a relatively low amount of the nutrients exported form the Dawson catchment as a whole each year (refer to Section 4.2.2). 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).

6.2.4 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 Eurombah Creek, Slatehill Creek, Kurrajong Gully, Barton Creek, Kangaroo Creek, Canal Creek, Horse Creek, Mud Creek and Woleebee Creek, sediment deposition would lead to a decline in habitat diversity and a reduction in the number of pools available as 'refuge' habitat in the dry season. These impacts would lead to a decline in the abundance 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 6.2.1).

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 western CSM pipeline enters the creeks crossed by the pipelines or within the MLAs, it may impact on aquatic ecology.

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 western CSM water supply pipeline route (DEWHA 2008a).

The Great Barrier Reef World Heritage Area and the Shoalwater and Corio Bays Ramsar site are unlikely to be impacted by the pipeline, as they are over 300 km to the north-east of the pipeline, 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 western 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 western CSM water supply pipeline.

7 Mitigation Measures

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 and temporary road crossings of creeks, particularly of major waterways (Kurrajong Gully and Eurombah, Slatehill, Barton, Canal, Kangaroo, Horse, Spring, Mud and Woleebee 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 (for example 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 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 western coal seam methane 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				
A	Open cut	Trenchless (drill)	Ford	Access from either side of watercourse or ford over dry area	Yes in wet conditions	Yes in wet conditions and during trenchless crossing	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	20 m
B	Open cut	Isolate	Ford	Use existing road	If water present	No	Recontour bed and bank shape	5 m
C	Open cut	Isolate (steel plates) or trenchless (drill) (depends on exact crossing location)	Ford	Ford if crossing at existing ford; or temporary single span bridge or box culvert	Yes in wet conditions	Yes in wet conditions and during trenchless crossing	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape (crib wall)	10 m
D	Open cut	Isolate (steel plate)	Use existing road	Use existing road	Yes in wet conditions when isolating	Yes in wet conditions when isolating	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	5 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				
E	Open cut	Isolate	Use existing road	Use existing road	Yes in wet conditions when isolating	Yes in wet conditions when isolating	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	5 m
F	Open cut	Isolate (flume or steel plates)	Use existing road	Use existing road	Yes in wet conditions when isolating	Yes in wet conditions when isolating	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	5 m
G	Open cut	Isolate (steel plates)	Ford	Temporary Culvert	Yes in wet conditions when isolating	Yes in wet conditions when isolating	Replace bed and bank structure including boulders, trees and vegetation (seeded soil wraps, crib wall), recontour bed and bank shape	5 m
Gi	Open cut	Isolate if flowing	Ford	Ford	If wet	If flowing	Recontour bed and bank shape.	5 m
H	Open cut	Isolate (steel plates)	Use existing road and shoulder	Build up existing road	Yes in wet conditions when isolating	Yes in wet conditions when isolating	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	5 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				
I (Proposed location)	Open cut	Isolate (steel plates)	Ford	Temporary single-span bridge or box culvert.	Yes in wet conditions when isolating	Yes in wet conditions when isolating	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	5 m
3	Open cut	Isolate (steel plates) or trenchless (drill)	Use existing road	Use existing road, or Temporary single-span bridge or box culvert if necessary due to flows over existing road.	Yes in wet conditions when isolating	Yes in wet conditions when isolating	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	10 m
5	Open cut	Isolate (steel plates)	Ford	Temporary single-span bridge or box culvert.	Yes in wet conditions when isolating	Yes in wet conditions when isolating	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	5 m
6	Open cut	Isolate	Use existing road	Use existing road	Yes in wet conditions when isolating	Yes if flowing	Replace bed and bank structure including boulders, trees and vegetation, recontour bed and bank shape	5 m

7.3.3 Water Quality Monitoring

Table 7.1 outlines recommended water quality monitoring during the installation of the pipeline and temporary vehicle creek 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 4.6).

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 the region.

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

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.

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.

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 western CSM water supply pipeline route are considered to be in poor to moderate condition overall; and aquatic habitats at Eurombah Creek were in good condition. 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. However, while typically less diverse than the faunal communities in the Dawson River 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.

Of the potential impacts of the western 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 pipeline and temporary road crossings of creeks, particularly of major waterways (Kurrajong Gully and Eurombah, Slatehill, Barton, Canal, Kangaroo, Horse, Spring, Mud and Woleebee 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 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).
    - Revegating 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 western 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.

- 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 (14-08-08)


Typical view downstream through the site (14-08-08)


Typical view of left bank (14-08-08)


Typical view of right bank (14-08-08)


Golden perch captured (14-08-08)

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Intermittent
Channel Width (m):	20
Wetted Width (m):	15
Water Level:	Moderate
Bank Shape:	Sloping

Water Quality

Temperature (C):	14
pH:	8.93
Conductivity (uS/cm):	178
DO (mg/L):	11.4
DO (% Sat):	105
Turbidity (NTU):	9
ORP (mV):	231

Flora and Fauna

Vegetation

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

Fauna

-

Habitat (%)

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

Substrate (%)

Bedrock:	30
Boulder:	10
Cobble:	10
Pebble:	10
Gravel:	10
Sand:	10
Silt/Clay:	20

Cover (%)

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

Dominate Cover Type:

Deep pools

Sub Dominate Cover Type:

Boulder, cobble

Comments: Two deep pools separated by bedrock shallow section. Water from Spring Gully RO plant being discharged ~1km downstream; discharged water is blue in colour indicating very pure water. Landowner reported saratoga lived in pools downstream prior to discharge. Started discharging ~1 year ago.

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08.06.11 Wandoan West

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

Eurombah Creek

Cond.

G

frc site number A

UTM Zone 55K 708854 E 7121516 N WGS84


Typical view upstream through the site (13-08-08)


Typical view of right bank (13-08-08)


Typical view of left bank (13-08-08)


Typical view downstream through the site (13-08-08)


Crayfish captured (13-08-08)

Channel Habitat

Morphology

Pattern:	Meanders
Flow Regime:	Intermittent
Channel Width (m):	5
Wetted Width (m):	1
Water Level:	Low
Bank Shape:	Sloping, Vertical

Water Quality

Temperature (C):	11.6
pH:	9.38
Conductivity (uS/cm):	240
DO (mg/L):	13.4
DO (% Sat):	123
Turbidity (NTU):	200
ORP (mV):	255

Flora and Fauna

Vegetation

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

Fauna

-

Habitat (%)

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

Substrate (%)

Bedrock:	-
Boulder:	5
Cobble:	10
Pebble:	10
Gravel:	5
Sand:	40
Silt/Clay:	30

Cover (%)

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

Dominate Cover Type:
Large woody debris

Sub Dominate Cover Type:
Small woody debris, boulder, cobble, instream vegetation, detritus

Comments: Riparian vegetation cleared to edge of creek. At crossing point right bank is very steep with lots of erosion. Preferred alignment where the riparian vegetation is cleared with fords. There is evidence of high flow, a series of isolated pools, with lots of cattle pugging.

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Survey Date:	13-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Kurrajong Gully

Cond.
M

frc site number C

UTM Zone 55K 716330 E 7117197 N WGS84

				
Typical view upstream through the site (11-08-08)	Typical view of right bank (11-08-08)	Typical view of left bank (11-08-08)	Typical view downstream through the site (11-08-08)	Echidna observed at the site (11-08-08)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Intermittent
Channel Width (m):	4
Wetted Width (m):	2
Water Level:	Low
Bank Shape:	Sloping, Vertical

Water Quality

Temperature (C):	12.7
pH:	8.29
Conductivity (uS/cm):	110.5
DO (mg/L):	5.8
DO (% Sat):	54
Turbidity (NTU):	20
ORP (mV):	285

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 5	Right: 10
Dominant Type:	Eucalypt, Casuarina	

Fauna

Dead duck and cane toads. Live echidna.

Habitat (%)

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

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	80
Silt/Clay:	20

Cover (%)

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

Dominate Cover Type:

Detritus

Sub Dominate Cover Type:

Small and large woody debris

Comments: Evidence of high flow downstream. Narrow intermittent channel with one pool. No pools in road reserve. Dry within road reserve, lots of detritus. If possible avoid large casuarinas to maintain bank stability.

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08.06.11 Wandoan West

Survey Date:	11-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Slatehill Creek

Cond. M

frc site number D

UTM Zone 55K 718504 E 7116921 N WGS84

Typical view upstream through the site (11-08-08)

Typical view of right bank (11-08-08)

Typical view of left bank (11-08-08)

Typical view downstream through the site (11-08-08)

Carp gudgeon captured (11-08-08)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Intermittent
Channel Width (m):	5
Wetted Width (m):	4
Water Level:	Low
Bank Shape:	Vertical, sloping

Water Quality

Temperature (C):	15.2
pH:	9
Conductivity (uS/cm):	148
DO (mg/L):	11.6
DO (% Sat):	113
Turbidity (NTU):	100
ORP (mV):	260

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 1	Right: 1
Dominant Type:	Eucalypt	

Fauna

-

Habitat (%)

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

Substrate (%)

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

Cover (%)

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

Dominate Cover Type:

Small woody debris

Sub Dominate Cover Type:

Instream vegetation, detritus

Comments: Riparian vegetation cleared downstream. Cement box culvert under road. Riparian vegetation mostly grasses, ground moist, likely to hold water upstream.

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Survey Date: 11-08-08
Written By: TS Approved By: LT
Date Issued: Sept 2008

Barton Creek

Cond. M

frc site number E

UTM Zone 55K 726028 E 7117100 N WGS84

				
Typical view upstream through the site (11-08-08)	Typical view of right bank (11-08-08)	Typical view of right bank (11-08-08)	Typical view of left bank (11-08-08)	Typical view downstream through the site (11-08-08)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Ephemeral
Channel Width (m):	3
Wetted Width (m):	0
Water Level:	Dry
Bank Shape:	Sloping, 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: 10	Right: 15
Dominant Type:	Eucalypt	

Fauna

-

Habitat (%)

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

Substrate (%)

Bedrock:	-
Boulder:	5
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	60
Silt/Clay:	35

Cover (%)

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

Dominate Cover Type:

Instream vegetation

Sub Dominate Cover Type:

Large woody debris, detritus

Comments: Road is a ford crossing, would be a barrier to fish movement during low flow. Farm dam upstream.

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Survey Date: 11-08-08
Written By: TS Approved By: LT
Date Issued: Sept 2008

Kangaroo Creek

frc site number F

UTM Zone 55K 734799 E 7121419 N WGS84

Cond.

M

				
View upstream through the site (13-08-08)	View of right bank (13-08-08)	View of left bank (13-08-08)	View downstream through the site (13-08-08)	

Channel Habitat

Morphology

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

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: 8	Right: 3
Dominant Type:	Eucalypt, Melaleuca	

Fauna

-

Habitat (%)

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

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	5
Sand:	75
Silt/Clay:	20

Cover (%)

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

Dominate Cover Type:
Large woody debris

Sub Dominate Cover Type:
Small woody debris, instream vegetation, banks

Comments: High erosion on outside meanders. Cattle pugging upstream from fence. Banks very unstable.

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08.06.11 Wandoan West

Survey Date:	13-08-08		
Written By:	TS	Approved By:	LT
Date Issued:	Sept 2008		

Tributary to Canal Creek

Cond.

P

frc site number G

UTM Zone 55K 741806 E 7123892 N WGS84

				
View upstream through the site (12-08-08)	View of right bank (12-08-08)	View of left bank (12-08-08)	View downstream through the site (12-08-08)	

Channel Habitat

Morphology

Pattern:	Meanders
Flow Regime:	Ephemeral
Channel Width (m):	2.5
Wetted Width (m):	1.5
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: Eucalypt

Fauna

-

Habitat (%)

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

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	20
Silt/Clay:	80

Cover (%)

Periphyton:	0
Moss:	0
Filamentous algae:	0
Macrophytes:	0
Detritus:	0

Dominate Cover Type:

Instream vegetation

Sub Dominate Cover Type:

Deep pools, man made

Comments: Ford crossing of road is a disturbance to the creek bed. Sediment has accumulated upstream of the ford, and it is difficult to discern the channel as it is filled with grasses. Downstream of ford where vegetation has been cleared there are lots of weeds.

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08.06.11 Wandoan West

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

Tributary to Nine-Mile Creek

frc site number H

UTM Zone 55K 753967 E 7123934 N WGS84

Cond.

P

				
Typical view upstream through the site (13-08-08)	Typical view of right bank (13-08-08)	Typical view of left bank (13-08-08)	Typical view downstream through the site (13-08-08)	Typical view upstream through the site (13-08-08)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Ephemeral
Channel Width (m):	3
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:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	5
Pebble:	5
Gravel:	-
Sand:	45
Silt/Clay:	45

Cover (%)

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

Dominate Cover Type:
Small woody debris

Sub Dominate Cover Type:
Large woody debris, overhanging vegetation, instream vegetation, detritus

Comments: Cattle have access to channel, pugging throughout. Lots of large woody debris with some deposits. Left bank / valley was ~ 4 m high, unstable at top because of sloughing, right bank stable with grasses, vegetation (trees) with roots provide good habitat.

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Survey Date: 13-08-08
Written By: TS Approved By: LT
Date Issued: Sept 2008

Horse Creek

frc site number I

UTM Zone 55K 764419 E 7121710 N WGS84

Cond.

M

				
View downstream through the channel	View upstream through the channel	View of left bank (downstream of road)	View of right bank	Culverts were 90% blocked with flood debris

Channel Habitat

Morphology		Water Quality	
Channel Width (m):	6	Temperature (°C):	27.7
Mean Depth (m):	0.5	pH:	6.1
Water Level:	No flow	Conductivity (uS/cm):	280
Bank Erosion:	Moderate	DO (% Sat):	112
Sediment Deposits:	None	Turbidity (NTU):	510
Catchment Position:	Midland	Water Odour:	Nil
Adjacent landuse:	Grazing	Water Oils:	Nil
Stream Order:	4		

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	5
Pool:	50	Cobble:	10
Edge:	20	Pebble:	10
Dry:	30	Gravel:	10
Overall Complexity:	Low	Sand:	55
		Silt/Clay:	10

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	10
Dominant Type:	Native
Canopy Cover (%):	30

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	7	2	-	NA
PET Richness	2.7	3.6	-	NA
Signal 2 Index	1	0	-	NA

Substrate Cover (%)		Bank Cover	
Periphyton:	10–35	Streambank Cover (%):	>80
Moss:	None	Overhanging Vegetation:	Moderate
Filamentous algae:	None	Trailing Bank Vegetation:	Slight
Macrophytes:	10–35	Dominant type:	Grasses and sedges
Detritus:	10–35	Bank stability:	Moderately unstable

Comments: Within MLA50231 (northern); large pool upstream of road crossing and series of isolated pools downstream of road crossing; the three small culverts in the road crossing substantially impeded flow during recent flood event and continue to do so; log piles, bent-over casuarinas, flipped slabs of bedrock and erosion indicate high velocity flood event; riparian vegetation included several native trees.

frc environmental deep thinking. science.	Wandoan Coal Project				Woolebee Creek	Habitat Score
	Survey Date: 12-03-08	Date Issued: April 2008			frc site number 3 (reconnaissance site S11)	M
	Written By: K.M.	Approved By: L.T.			UTM Zone 55K 786,688 E 7,111,284 N WGS84	

View downstream through the channel

View upstream (from the left bank)

View of left bank

View of right bank

Prickly pear in the riparian zone

Channel Habitat

Morphology

Channel Width (m):	4
Mean Depth (m):	0.3
Water Level:	No flow
Bank Erosion:	Extensive
Sediment Deposits:	Sand
Catchment Position:	Upland
Adjacent landuse:	Grazing
Stream Order:	3

Water Quality

Temperature (°C):	25.3
pH:	7.36
Conductivity (uS/cm):	388
DO (% Sat):	108.8
Turbidity (NTU):	83.2
Water Odour:	Nil
Water Oils:	Slick

Habitat (%)

Riffle:	-
Run:	-
Pool:	70
Edge:	10
Dry:	30
Overall Complexity:	Low

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	70
Silt/Clay:	30

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	5
Dominant Type:	Mixed
Canopy Cover (%):	50

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	10	10	-	NA
PET Richness	3.0	2.8	-	NA
Signal 2 Index	0	0	-	NA

Substrate Cover (%)

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

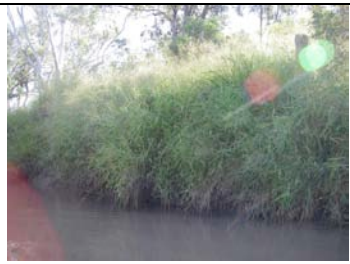
Bank Cover

Streambank Cover (%):	50 – 75
Overhanging Vegetation:	Slight
Trailing Bank Vegetation:	Slight
Dominant type:	Grasses and sedges
Bank stability:	Moderately unstable

Comments: Within MLA 50229 (northern). Moved downstream of reconnaissance site due to access issues and location of waterhole. Cattle have access to creek, and paddock fence crossing may trap debris and restrict water flow and faunal passage at times. Large woody debris and detritus provide habitat and food.


View downstream through the channel


View upstream through the channel


View of left bank


View of right bank


The road crossing did not have culverts

Channel Habitat

Morphology

Channel Width (m):	3.5
Mean Depth (m):	1.0
Water Level:	No flow
Bank Erosion:	Limited
Sediment Deposits:	None
Catchment Position:	Midland
Adjacent landuse:	Light Grazing

Water Quality

Temperature (°C):	29.1
pH:	6.3
Conductivity (uS/cm):	129
DO (% Sat):	99.4
Turbidity (NTU):	304
Water Odour:	Nil
Water Oils:	Nil
Stream Order:	2

Habitat (%)

Riffle:	
Run:	
Pool:	100
Edge:	30
Dry:	
Overall Complexity:	Low

Substrate (%)

Bedrock:	
Boulder:	
Cobble:	2
Pebble:	3
Gravel:	5
Sand:	80
Silt/Clay:	10

Flora and Fauna

Riparian Vegetation

Riparian Width (m):	7 - 10
Dominant Type:	Exotic
Canopy Cover (%):	15

Macro-invertebrates

	Edge	Bed	Riffle	Guidelines
Taxonomic Richness	10	5	-	NA
PET Richness	2.7	2.8	-	NA
Signal 2 Index	1	0	-	NA

Substrate Cover (%)

Periphyton:	<10
Moss:	<10
Filamentous algae:	<10
Macrophytes:	10–35
Detritus:	10–35

Bank Cover

Streambank Cover (%):	>80
Overhanging Vegetation:	Slight
Trailing Bank Vegetation:	Slight
Dominant type:	Grasses
Bank stability:	Moderately stable

Comments: Within MLA 50229 (western). Grasses heavily dominate the riparian zone. Little large woody debris in-stream to provide habitat. No culvert at the road crossing so water pooled upstream of the road.

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Wandoan Coal Project

Survey Date:	13-03-08	Date Issued:	April 2008
Written By:	T.S.	Approved By:	LT

Spring Creek

frc site number 6 (reconnaissance site S17)

UTM Zone 55K 772,324 E 7,120,292 N WGS84

Habitat Score

M

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.

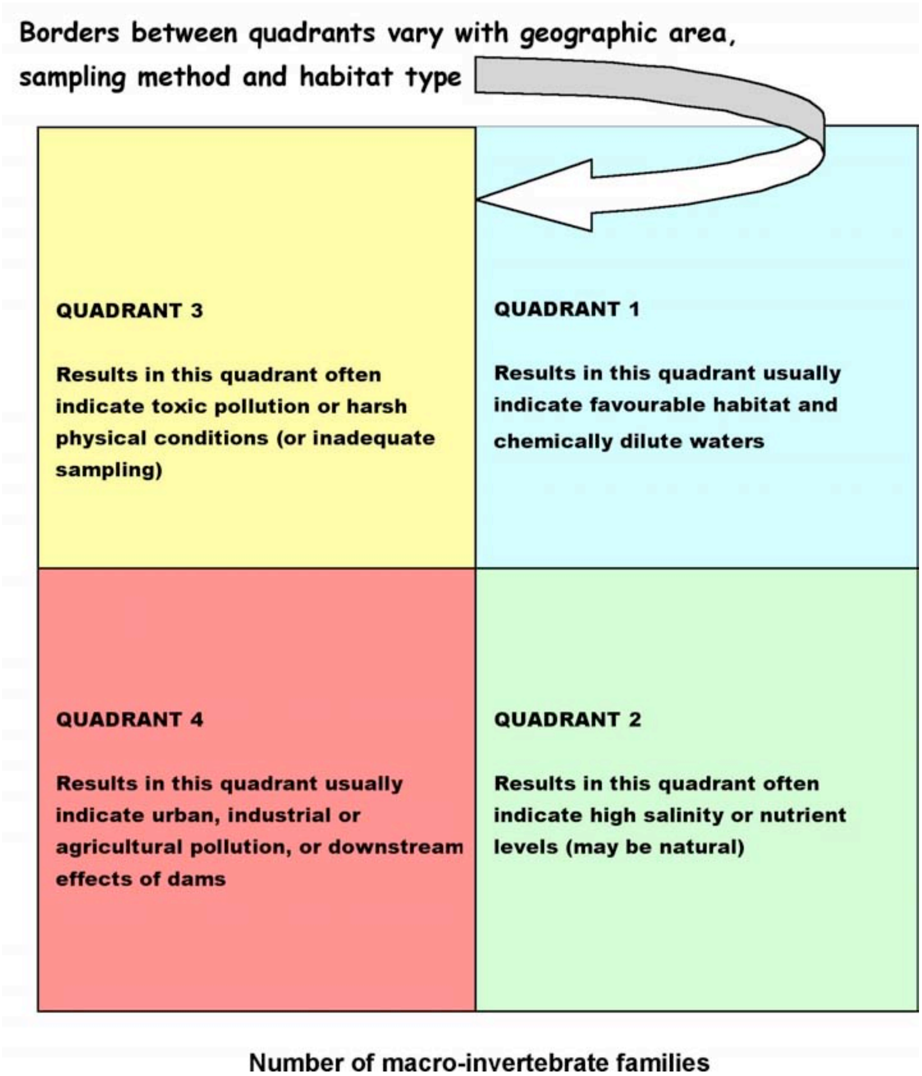


Figure B.1 The quadrant diagram for the family version of SIGNAL 2 (Chessman 2003).

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

R Lomasich

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

- 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.

Amendment request for an approved activity

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

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	WJ 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 <u>without</u> 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

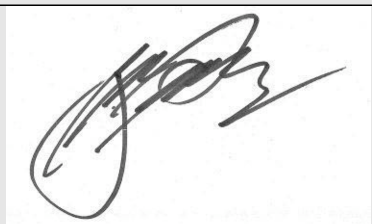
☐ Approved subject to modifications

☐ 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.

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