Wandoan Coal Project Supplementary EIS: MLA Areas and Gas Supply Pipeline,

Aquatic Ecology

Prepared for:

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Glossary

Term	Definition
Aestivate	To be dormant, often buried within the soil or under leaf litter, during months of drought.
Aggradation	The build-up of sediment or some other substance.
Algal mat	A thin layer of algae formed over the surface of the benthos.
Anaerobic	Having or producing no oxygen.
Anthropogenic	Caused by humans or human activity.
Benthos	A term for all of the flora and fauna that live in or on the bottom substrate of waterbodies, including creeks, rivers and wetlands.
Biodiversity	The range of organisms present in a given community or system.
Catchment	The area of land which collects and transfers rainwater into a waterway.
Channelisation	The formation of deeper channels within a waterway.
Crustacean	An arthropod with jointed appendages, a hard protective outer shell, two pairs of antennae and eyes on stalks, e.g. crabs, prawns.
Culvert	A covered channel that carries water, often be covered by a bridge or a road.
Desiccation	Drying out due to the effects of the environment.
DEEDI	Queensland Department of Employment, Economic Development and Innovation.
DERM	Queensland Department of Environment and Resource Management.
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts.
DNRW	The former Queensland Government Department of Natural Resources and Water. Department now forms part of the Department of Environment and Resource Management (DERM).
DPI&F	The former Queensland Government Department of Primary Industries and Fisheries. Department now forms part of the Department of Employment, Economic Development and Innovation (DEEDI).
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.

Term	Definition
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.
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.
Lacustrine	Open, water-dominated systems (for example, lakes) larger than 8 hectares. This definition also applies to modified systems (for example, dams), which possess characteristics similar to lacustrine systems (for example, deep, standing or slow-moving waters).
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.
Palustrine	Vegetated non-channel environments of less than 8 hectares. They include billabongs, swamps, bogs, springs, soaks etc., and have more than 30 percent emergent vegetation.
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.

Term	Definition
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.
Surber sampler	Quantitative aquatic macroinvertebrate sampling device designed to sample a defined area (900 cm^2) of edge habitat with a net size of 250 µm.
Trailing bank vegetation	Riparian vegetation that hangs over the bank of a creek into the water.
Triangular-framed dip net	Aquatic macroinvertebrate sampling device designed to sample bed and edge habitat according to AusRivAS protocols with net size of 250 µm.
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.

Summary

This report has been prepared for PB, on behalf of the Wandoan Joint Venture (WJV). It contributes information on aquatic ecology for the Supplementary Environmental Impact Statement (EIS) for the Wandoan Coal Project (the Project). The purpose of this report is to:

- update the description of aquatic flora and fauna occurring and likely to occur in areas affected by the MLA areas and gas supply pipeline, based on the results of seasonal surveys, including wetlands and matters of National Environmental Significance identified in the *Environment Protection and Biodiversity Conservation Act 1999*
- refine the aquatic ecology impact assessment based on the results of the seasonal survey conducted in January 2009 over the MLA areas and February 2009 over the gas supply pipeline study area
- discuss potential direct and indirect effects of any refinements / modifications to the Project on aquatic flora and fauna, and
- address comments relevant to aquatic ecology that were raised in government department and public submissions on the EIS.

Refinements / modifications to the Project since submission of the EIS which have the potential to impact on the aquatic ecology of the study area include:

- development of Wubagul Pit, deferral of the Woleebee South Pit from the 30 year mine plan, and changes to Austinvale North, Leichhardt and Frank Creek Pits
- refinement of the design of the proposed upgrade of the existing Wandoan Wastewater Treatment Plant and associated infrastructure, and
- changes to road realignments that cross waterways.

Description of the Existing Environment

MLA Study Area

Most of the sites surveyed for aquatic habitat, flora and fauna in the late wet season (March 2008), as described in the EIS and associated technical report, were resurveyed in the early wet season (January 2009). In addition, three artificial dams that are likely to hold permanent water and are mapped as lacustrine wetlands under the EPA's *Wetlands Mapping Programme*, were also surveyed in January 2009.

Aquatic habitat was generally similar between surveys, though higher water levels in the late wet season survey (March 2008) inundated a greater diversity of habitat. One of the constructed dams outside of the MLA areas had poor habitat quality, as there were no trees in the riparian zone and in-stream habitat coverage was low. There was moderate habitat at the other two dams surveyed within the MLA areas, as these dams have some in-stream habitat in the form of submerged and emergent macrophytes, and there are some trees surrounding them.

Aquatic flora (macrophyte) coverage was higher in the off-stream wetlands (farm dams) than in the creeks within the study area. Additional emergent, submerged and floating species were recorded in the dams that were not recorded in the creeks. There were no submerged macrophytes in the creeks, presumably due to the unstable water levels and high turbidity compared with the off-stream sites.

Macroinvertebrate community composition was generally similar between surveys, though richness at most sites was higher in the late wet season than the early wet season, likely due to higher water levels in the late wet season surveys inundating a greater diversity of aquatic habitat. Community composition was indicative of the poor to moderate habitat and water quality observed at the sites during both surveys.

A greater richness and abundance of fish were caught in the early wet season survey than the late wet season survey, most likely due to a number of species dispersing out of isolated pools during the wet season when creek connectivity is much higher. Generally, more fish were caught in off-stream dams, although species richness in the dams was often quite low. Differences in the abundance and species richness between on- and off-stream habitats could be due to suitable habitat availability and stocking efforts by individual farmers.

Krefft's river turtles were found in the dams within the MLA areas in the January 2009 survey, and in Juandah Creek downstream of the MLA areas in both surveys.

Gas Supply Pipeline Study Area

Aquatic habitat, flora and fauna surveys were undertaken in the dry season (August 2008) and the wet season (February 2009) at the three sites that held water that are crossed by the proposed pipeline route. Habitat observations were done at dry sites crossed by the proposed route. Water quality was variable among sites and between surveys, but was generally poor to moderate.

Aquatic habitat quality is typically poor to moderate along the proposed pipeline route, and there were no major changes to habitat between the two surveys. Water quality was poor to moderate, and consistent with water quality in the MLA areas. Macrophytes were uncommon throughout the gas supply pipeline study area both in the dry and wet season surveys.

The richness of macroinvertebrate communities was lower in bed habitats, but greater in edge habitats, in the wet season compared with the dry season. Macroinvertebrate community composition was indicative of the poor to moderate habitat and water quality observed at the sites during both surveys.

Fish communities sampled were similar between the two surveys, and included exotic species such as goldfish. No turtles were caught.

Revised Assessment of Potential Impacts and Mitigation Measures

Refinements / modifications to the Project since submission of the EIS which have the potential to impact on the aquatic ecology of the study area include:

- development of the Wubagul Pit, deferral of the Woleebee South Pit from the 30 year mine plan, and changes to Austinvale North, Leichhardt and Frank Creek Pits
- refinement of the design of the proposed upgrade of the existing Wandoan Wastewater Treatment Plant and associated infrastructure, and
- changes to road realignments that run adjacent to or cross waterways.

Results of the seasonal surveys in the MLA and gas supply pipeline study areas have not altered the assessment of environmental values or potential impacts of this component of the Project. There are no expected impacts to Matters of National Environmental Significance.

The assessment of potential impacts and mitigation measures is consistent with that presented in the EIS. In summary to the comments raised in EIS submissions:

- a discussion of water quality and appropriate Water Quality Objectives (WQOs) is presented in the surface water quality technical report
- waterways in the study area provide important fish habitat, and the creeks to be diverted provide a movement / migration pathway for aquatic fauna. The recommended mitigation measures have taken this into account.
- changes to the flood regime, and the timing and magnitude of flows in watercourses, have the potential to impact on aquatic ecology through increased

water velocities resulting in increased erosion and inhibiting fish passage. These impacts will be eliminated or substantially reduced where erosion control measures are implemented for the diversion channels, and by sizing channels to avoid design velocities in excess of 1 m/s as far as practical (as discussed in Volume 1, Section 11.5.6).

- the co-location of pipeline routes with existing and proposed infrastructure, and the mitigation measures discussed in the EIS and aquatic ecology technical report, are consistent with the objectives of AS2885 and the Australian Pipeline Industry Association Code of Environmental Practice.
- pipeline installation should avoid drought refuge pools, and waterway barrier works approvals are likely to be required for the construction of temporary crossings and pipeline crossings.
- depending on the nature of the works required at each crossing outside of the MLAs, waterway barrier works may be either assessable or self-assessable development under Integrated Planning Act (IPA): this will be determined for each crossing during the detailed design of the Project, and applications will be made for development approvals where required.
- where waterways are diverted, dams removed, and if an isolation method is used for construction of waterway crossings, stranded turtles and fish will be captured and translocated, in accordance with the DPI&F Fish Salvage Guidelines (DPI&F 2004) and relocated to suitable waterholes in the same waterway to prevent the transfer of exotic fish or aquatic disease.
- Underground (trenchless) pipeline installation techniques (such as drilling) will be used for crossing of larger waterways holding water, which may include Juandah and Roche Creeks, if necessary.
- the WJV commits to incorporating biting insect management into its Health and Safety System for the Project, which will be developed prior to commencement of construction of the Project.

1 Introduction

This report has been prepared for PB, on behalf of the Wandoan Joint Venture (WJV). It contributes information on aquatic ecology for the Supplementary Environmental Impact Statement (EIS) for the Wandoan Coal Project (the Project). This report builds upon the information provided in the aquatic ecology technical report for the mining lease application (MLA) areas and gas pipeline, included in the EIS Volume 1, TR 17B-1-V1.5, and its purpose is to:

- update the description of aquatic flora and fauna occurring and likely to occur in areas affected by the MLA areas and gas supply pipeline, based on the results of seasonal surveys, including wetlands and Matters of National Environmental Significance identified in the *Environment Protection and Biodiversity Conservation Act 1999*
- refine the aquatic ecology impact assessment based on the results of the seasonal survey conducted in January 2009 over the MLA areas and February 2009 over the gas supply pipeline study area
- discuss potential direct and indirect effects of any refinements / modifications to the Project on aquatic flora and fauna, and
- address comments relevant to aquatic ecology that were raised in government department and public submissions on the EIS.

1.1 Project Background

A Project Description was provided in the original EIS for the Project, and was summarised in the aquatic ecology technical report TR 17B-1-V1.5.

Refinements / modifications to the Project since submission of the EIS which have the potential to impact on the aquatic ecology of the study area include:

- development of the Wubagul Pit, deferral of the Woleebee South Pit from the 30 year mine plan, and changes to Austinvale North, Leichhardt and Frank Creek Pits
- refinement of the design of the proposed upgrade of the existing Wandoan Wastewater Treatment Plant and associated infrastructure, and
- changes to road realignments that run adjacent to or cross waterways.

1.2 Description of Study Areas

1.2.1 MLA Study Area

The waterways of the MLA areas are a part of the upper Dawson River Catchment (Southern Tributaries or 'Taroom' Subcatchment). 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).

The study area for this assessment included the waterways of the MLA areas; waterways immediately upstream of the MLA areas; and Juandah Creek downstream of the MLA areas (to approximately 60 km downstream of the MLA areas, just upstream of its confluence with the Dawson River). Farm dams within and upstream of the MLA areas were also assessed.

1.2.2 Gas Supply Pipeline Study Area

There are ten waterway crossings along the proposed gas supply pipeline route; the waterways are also part of the upper Dawson River Catchment. The study area for this assessment included the waterways crossed by the proposed pipeline route.

2 Relevant Legislation and Guidelines

The legislation and guidelines relevant to aquatic ecology were described in the EIS and aquatic ecology technical report TR 17B-1-V1.5. In summary:

- The Project is highly unlikely to impact on any listed rare or threatened aquatic species or communities.
- The Project is highly unlikely to impact on any wetlands of National, State or Regional significance.
- An approval through the *Integrated Planning Act 1997* (under the provisions of the *Water Act 2000* and the *Fisheries Act 1994*) will be required for the construction of creek diversions and pipeline crossings of watercourses outside of the MLAs. These approvals will be obtained prior to construction.
- Both palustrine and lacustrine wetlands have been identified in the Environmental Protection Agency's (EPA's) (now Department of Environment and Resource Management (DERM)) recent *Wetland Mapping Programme* as described in the EIS Volume 1, TR 17B-1-V1.5. Lacustrine wetlands within the study areas are likely to be farm dams (pers. obs.). None of the wetlands within the study areas are recognised by the DERM as being of National, State or Regional Significance.

3 Study Methodology

3.1 Survey Timing

3.1.1 MLA Study Area

The aquatic habitats of the MLA areas were initially described during a brief field trip in August 2007, and aquatic floral and faunal surveys and collection of physical water quality data was undertaken during the late wet season, from the 10^{th} – 14^{th} March 2008 as described in the EIS Volume 1, TR 17B-1-V1.5. In order to describe seasonal patterns in flora and fauna abundance, and the likely presence of species throughout the year, a second survey was completed in the early wet season, from the 28^{th} of January to the 1^{st} of February 2009. The weather was fine during the survey. In the months preceding the survey, a total of 183 mm of rain fell in the region between November 2008 and January 2009 (based on rainfall records from the Taroom Post Office, BOM 2009). In the week prior to the survey, 36 mm of rain had fallen (BOM 2009).

3.1.2 Gas Supply Pipeline Study Area

Aquatic floral and faunal surveys and collection of water quality data was undertaken during the dry season, from the 19^{th} to the 28^{th} August 2008 as described in the EIS Volume 1, TR 17B-1-V1.5. In order to describe seasonal patterns in floral and faunal abundance, and the likely presence of species throughout the year, a second survey was completed in the wet season, on the 2^{nd} and 3^{rd} of February 2009.

3.2 Study Sites

3.2.1 MLA Study Area

Nineteen sites were surveyed for aquatic habitat during the initial field trip in August 2007, and ten sites that represented the range of aquatic habitats found in the region were then surveyed for aquatic flora and fauna in the late wet season in March 2008 (EIS Volume 1, TR 17B-1-V1.5). Sites were typically located at road crossings to facilitate access, and because these areas held water.

Most of the sites surveyed for aquatic flora and fauna in March 2008 were resurveyed in the early wet season in January 2009. Table 3.1 and Figure 3.1 indicate the sites surveyed. However, three sites were dry during the January 2009 surveys. The dry site on One-arm Man Creek was replaced with a site downstream on Woleebee Creek (on the Westman property) that holds near-permanent water. In addition, three artificial dams that are likely to hold permanent water and are mapped as lacustrine wetlands under the EPA's *Wetlands Mapping Programme* were also surveyed in January 2009.

Table 3.1 Sites surveyed for aquatic flora and fauna in the late wet season (March 2008) and early wet season (January 2009) in the MLA study area.

Site Description	Site Number	Survey Completed		Location (UTM Zone 55J, GDA 94)	
		Late wet-season (March 2008)	Early wet-season (January 2009)	Easting	Northing
Within the MLA areas					
Frank Creek at Jackson Wandoan Road	1	X	Dry	792 788	7 107 102
One-arm Man Creek at Jackson Wandoan Road	2	X	Dry	785 971	7 104 359
Woleebee Creek on the Westman property	2a	–	X	787 055	7 109 431
Woleebee Creek at Grosmont Road	3	X	X	786 692	7 111 286
Woleebee Creek at Booral Road	4	X	X	787 663	7 115 676
Mud Creek on the 'Ellen Vale' property	5	X	X	779 288	7 120 297
Spring Creek at Kabunga Road	6	X	X	772 324	7 120 294
Juandah Creek at the Leichhardt Highway	7	X	X	792 951	7 113 180
Farm dam on the 'Ellen Vale' property	11	–	X	779 583	7 118 691
Farm dam on the 'Pecos Valley' property	12	–	X	789 359	7 104 987

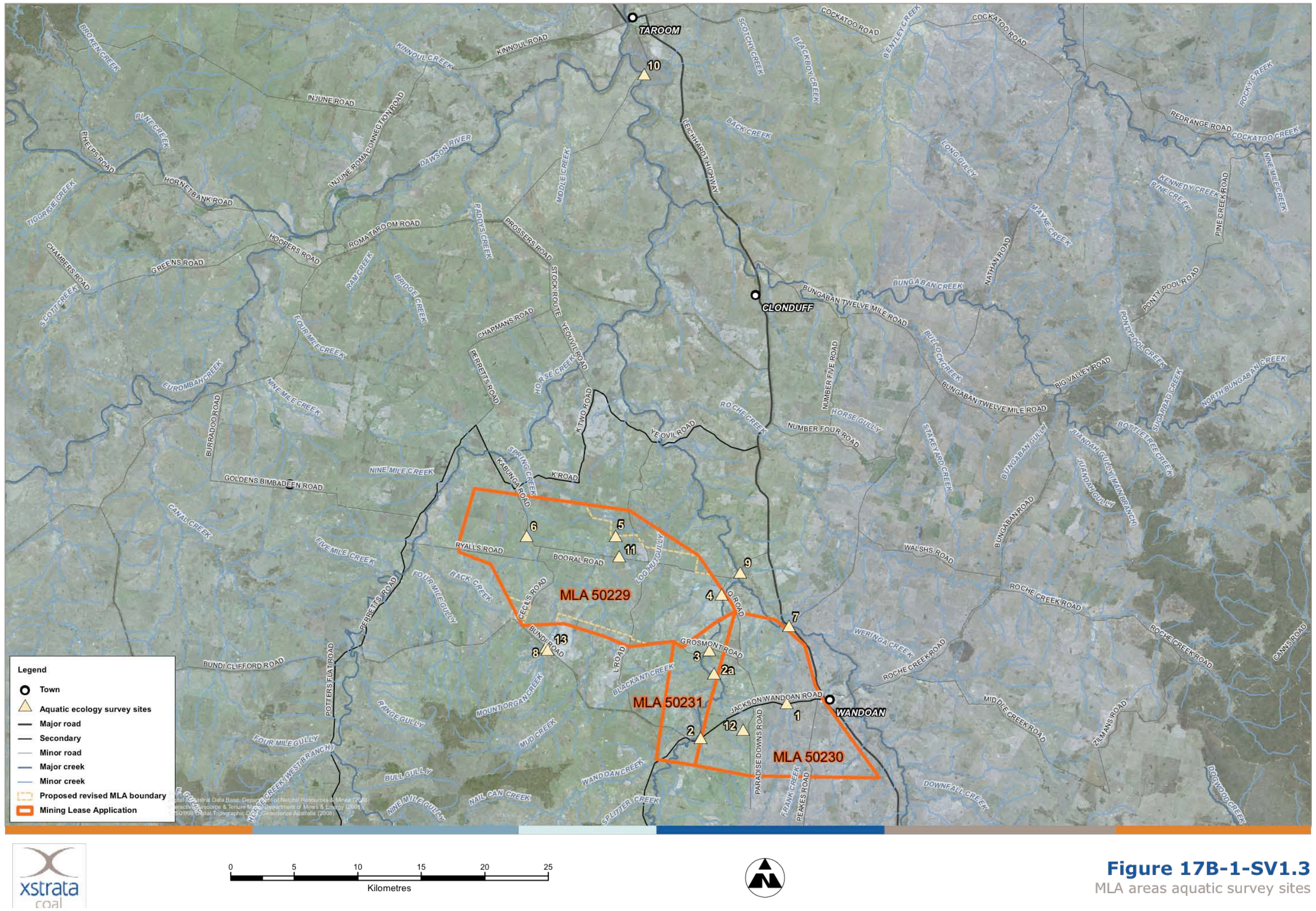
Site Description	Site Number	Survey Completed		Location (UTM Zone 55J, GDA 94)	
		Late wet-season (March 2008)	Early wet-season (January 2009)	Easting	Northing
Upstream of the MLA areas					
Mount Organ Creek at Bundi Road	8	X	X	773 822	7 111 491
Artificial Dam adjacent to Mount Organ Creek	13	–	X	773 963	7 111 328
Downstream of the MLA areas					
Juandah Creek at Booral Road	9	X	Dry	789 131	7 117 431
Juandah Creek at Roma Taroom Road	10	X	X	781 537	7 156 708

X = Habitat assessment, fauna and flora surveys, and *in situ* water quality

– = No survey conducted

Dry = Habitat assessment only (no flora and fauna surveys or in-situ water quality assessment conducted)

A description and photographs of each site surveyed during the aquatic flora and fauna surveys in January 2009 can be found in Attachment A.



	Wandoan Coal Project Supplementary EIS	
	Figure 3.1 Aquatic flora and fauna survey sites for the MLA study area.	
	Source: Provided by PB	August 2009

3.2.2 Gas Supply Pipeline Study Area

Three sites were surveyed for aquatic flora and fauna in both the dry season (August 2008) and the early wet season (February 2009) (only three sites were surveyed as these were the only sites that held water). The aquatic habitat of other waterways crossed by the proposed pipeline route was described in August 2008, as shown in Table 3.2 and Figure 3.2. Dry crossing locations were revisited in February 2009, and it was confirmed that aquatic habitat characteristics had not changed at these sites.

A description and photographs of each site surveyed during the aquatic flora and fauna surveys in February 2009 can be found in Attachment A.

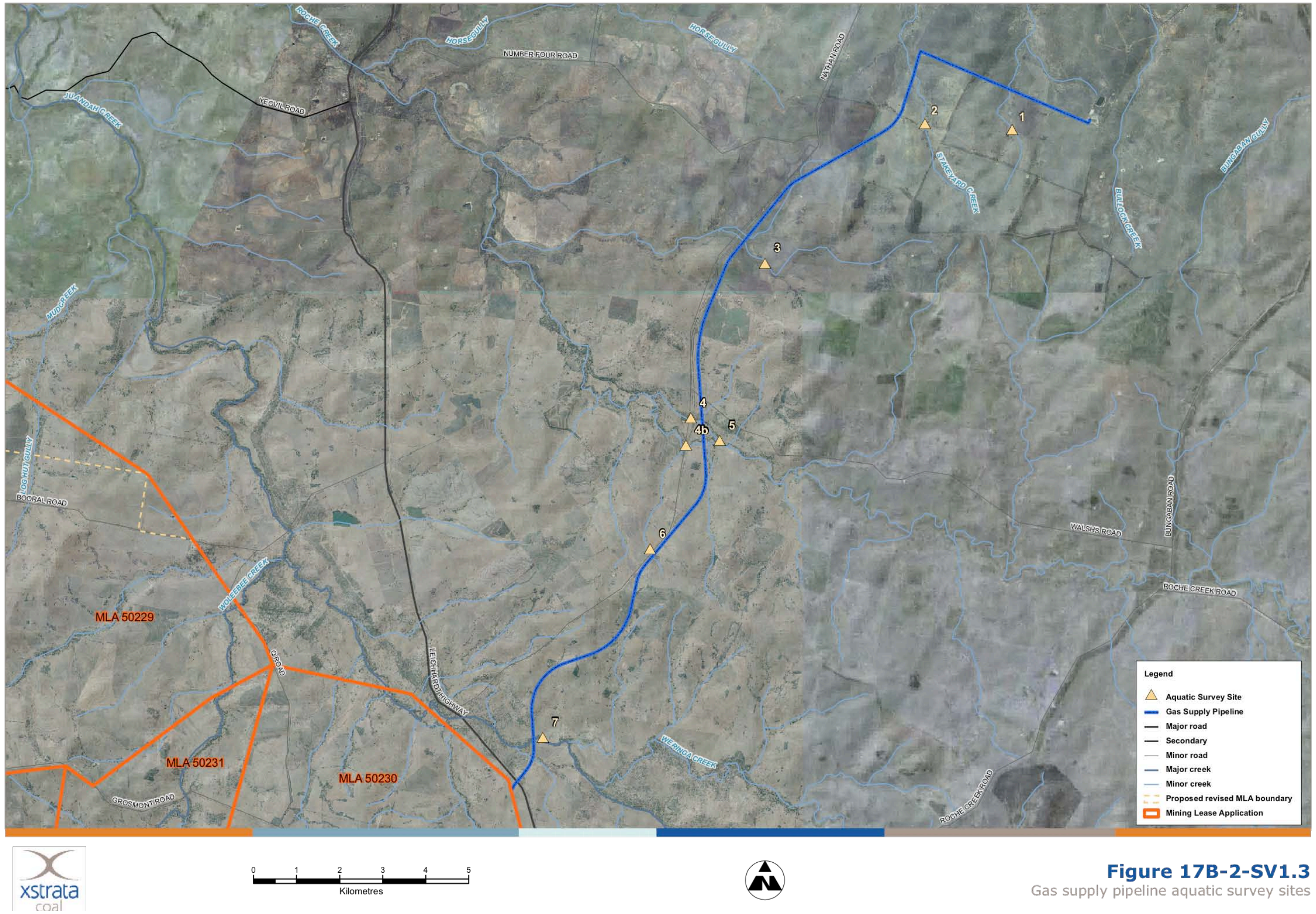
Table 3.2 Sites surveyed for aquatic flora and fauna in the dry season (August 2008) and wet season (February 2009) in the gas supply pipeline study area.

Site	Channel Name	Survey Completed		Location (UTM, MGA 94)		
		Dry season (August 2008)	Early Wet season (February 2009)	Zone	Easting	Northing
1	Unnamed tributary to Bullock Creek	Dry with undefined channel, brief observations only	–	56J	204 962	7 126 958
2	Stakeyard Creek	Dry, habitat observations only	Dry, no changes to habitat	56J	202 926	7 127 010
3	Unnamed tributary to Roche Creek	Dry, habitat observations only	Dry, no changes to habitat	55J	800 129	7 123 616
4	Roche Creek	X	X	55J	798 408	7 120 029
4b	Roche Creek Anabranch	X	–	55J	798 292	7 119 399
5	Roche Creek	–	X	55J	799 080	7 119 512
6	Unnamed tributary to Roche Creek	Dry, habitat observations only	Dry, no changes to habitat	55J	797 468	7 116 955
7	Juandah Creek	X	X	55J	794 977	7 112 625

X = Habitat assessment, fauna and flora surveys, and *in situ* water quality.

– = No survey conducted

Dry = Habitat assessment only (no flora and fauna surveys or in-situ water quality assessment conducted)



Wandoan Coal Project Supplementary EIS	
Figure 3.2 Aquatic flora and fauna survey sites for the gas supply pipeline study area.	
Source: Provided by PB	August 2009

3.3 Aquatic Habitat

At each site, habitat descriptions, River Bioassessment program habitat assessment scores and observations were recorded, in accordance with the methods used in previous surveys as presented in TR 17B-1-V1.5, Attachment B. These current surveys have built upon information collected during previous surveys.

3.4 Water Quality

The objective of water quality sampling was to describe water quality at each of the sites at the time of the aquatic flora and fauna surveys, to aid in the interpretation of biological data. For a full description of water quality, refer to the surface water quality impact assessment technical report, as presented in the EIS Volume 1, TR 11-1-V1.5, and Supplementary EIS Volume 1, STR 11-1-SV1.5.

Physical water quality was measured at each site using a TPS 90 FLMVT water quality meter. The following parameters were measured:

- water temperature (°C)
- electrical conductivity (μS/cm)
- pH
- dissolved oxygen (mg/L and % saturation), and
- turbidity in NTU (Nephelometric Turbidity Units).

As outlined in the EPA's (now DERM's) comments on the EIS, application of the Queensland Water Quality Guidelines (QWQG) is not appropriate for physical water quality and other parameters such as nutrient levels in small isolated pools (EPA 2007a). Rather, water quality should be compared to the QWQG during normal baseflow conditions. Within the study areas, there has been lack of flow during the study period, so such an assessment could not be made.

Water quality data were collected during the conduct of the flora and fauna surveys primarily to aid in the interpretation of the biological data. At the time of the surveys the surface water flow in the study area was low or negligible and the waterways were characterised by a series of isolated pools. As such, the comparison of the field survey water quality data to the QWQG is not strictly applicable; however, for the purposes of a broad assessment, some reference to guideline values has been made.

A water quality monitoring program, which considers the low-flow conditions that characterise the boundary conditions of the MLA area, is being designed and implemented for the Project, as described in the surface water quality technical report EIS Volume 1, TR 11-1-V1.5 and Supplementary EIS Volume 1, STR 11-1-SV1.5. Three of the sites used in the water quality monitoring program (Frank Creek upstream, Mt Organ Creek upstream, and Spring Creek downstream) overlap with sites used for biological monitoring (sites 1, 8 and 6 respectively).

3.5 Aquatic Flora

Aquatic flora (macrophytes) were described at each site in accordance with the methods used during the previous aquatic flora and fauna survey, as given in the EIS Volume 1, TR 17B-1-V1.5.

3.6 Aquatic Macroinvertebrates

3.6.1 Sample Collection

A standard AusRivAS macroinvertebrate sample from each aquatic habitat found was collected at each site, using the same methods as previous surveys (EIS Volume 1, TR 17B-1-V1.5) and as set out in the Queensland AusRivAS sampling manual (DNRM 2001).

3.6.1.1 Replicated Baseline Survey

Quantitative, replicated macroinvertebrate data were collected from the MLA study area during this survey period, to provide a statistically robust assessment of the differences in macroinvertebrate communities between habitats, sites and waterways. Five replicate macroinvertebrate samples were collected from both bed and edge habitat. Each replicate was collected from a 30 cm by 30 cm area of habitat, using a surber sampler in edge habitat or triangular-framed dip net in bed habitat (250 µm mesh). This component of the survey provides baseline data for future aquatic ecology monitoring, which was recommended as a mitigation measure in the EIS.

3.6.2 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).

3.6.3 Data Analysis

Taxonomic richness, PET richness and Signal 2 scores were calculated for each site, and compared with the results of previous surveys, as provided in EIS aquatic ecology technical report TR 17B-1-V1.5.

3.6.3.1 Replicated Baseline Survey

Multivariate data analyses were used to determine the variation in macroinvertebrate community composition, among the sites surveyed in the MLA study area and between habitat types. To determine if there were differences in the structure of macroinvertebrate communities among the different sites, all the rare taxa were removed, then the untransformed abundance data were converted for each sample to a Bray-Curtis similarity matrix, and analysed for differences among the different sites using a one-way ANOSIM (Clarke 1993). Macroinvertebrate communities differed substantially between habitat types (e.g. bed and edge) (ANOSIM $R = 0.59$, $p < 0.001$). Therefore to determine differences in community composition among sites, bed and edge habitats were analysed separately, as habitat type is strongly linked with macro-invertebrate richness, composition and abundance. The results of the analyses were visualised using non-metric multidimensional scaling (nMDS).

SIMPER (similarity percentages – species contributions) was used to determine which taxonomic groups were responsible for biotic differences in community composition among the sites. BIOENV analysis was used to determine correlations between macroinvertebrate community composition and habitat at each site, using the habitat bioassessment score components, which were normalised and converted to a Euclidian similarly matrix. Details are provided in Attachment B.

3.7 Fish

3.7.1 Sample Collection

Fish communities were surveyed using a combination of backpack or boat electrofishing, baited traps and dip nets. Survey methods were consistent with those used for the previous surveys as described in EIS Volume 1, TR 17B-1-V1.5, and as per the sampling effort presented in Attachment C.

Electrofishing was conducted using a Smith-Root LR-24 backpack electrofisher in shallow water, or a Smith-Root boat 2.5 GPP electrofishing system in deep water (the dams and Juandah Creek downstream of the MLA areas), in accordance with the *Australian Code of Electrofishing Practice 1997*.

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

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 D).

3.7.1.1 Data Analysis

Taxonomic richness, total abundance, presence of individual taxa, abundance of rare and threatened species, abundance of exotic species, and the abundance of each life history stage was compared with the results of previous surveys as presented in EIS Volume 1, TR 17B-1-V1.5.

3.8 Turtles

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 as presented in Attachment C. The design of the traps was consistent with traps used by the Environmental Protection Agency's (EPA's) (now DERM) turtle research group and in previous surveys (EIS Volume 1, TR 17B-1-V1.5). Turtles captured or observed were identified to species level and a photographic record 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 D).

3.9 Limitations

The sites chosen for survey within the MLA study area generally represent the range of aquatic habitats present throughout the MLA areas. The waterways surveyed include those that will be diverted during the Project. However, it should be noted that site access and the location of water holes limited the positioning of sites during the survey. Sites were predominantly located at road crossings due to the presence of water, and enhanced access for the survey team with equipment to these sites. It is noted that turbidity can be influenced by proximity to obstructions such as culverts and road crossings, as outlined in the EPA's (now DERM) submission on the EIS. However, in our experience with the study area, which is characterised by high turbidity, the influence of such obstructions on turbidity is negligible (see Section 4.2.2.5).

The habitats surveyed were isolated pools, and there was no flow. This limits the interpretation of water quality data to providing context for the biological results, rather than providing an assessment of water quality against the relevant guidelines. Water quality is discussed in more detail in EIS Volume 1, Chapter 11 and the associated surface water quality technical report.

Within the gas supply pipeline study area, one survey site on Roche Creek was moved upstream in the February 2009 surveys, to where the creek is one channel, rather than a channel and an anabranch (it was not previously surveyed here due to private property access restrictions). This does not have a significant impact on the interpretation of results or the assessment of impacts, as seasonal variation in aquatic flora and fauna communities at this site is expected to be similar to that at the other sites surveyed in both the dry and wet seasons (including Roche Creek at site 4).

The assessment of impacts has been updated where appropriate, based on the results of the early wet season field survey (January / February 2009), and on refinements / modifications to the Project.

4 Existing Environment

4.1 Aquatic Habitat

4.1.1 MLA Study Area

The sites surveyed within the MLA study area during the aquatic flora and fauna survey in the late wet (March 2008) and early wet (January 2009) season surveys typically had a moderate River Bioassessment Program habitat assessment score (Figure 4.3). Generally, these relatively low scores resulted from low habitat variability (only pool habitat was observed), moderate to extensive bank erosion, and substrates dominated by finer sediments such as sand and silt. Slightly lower scores in the early wet season survey compared with the late wet season survey are primarily attributable to higher water levels in the late wet season survey inundating a greater diversity of habitat (e.g. Figure 4.1 & Figure 4.2), rather than major changes in habitat quality between the two surveys.

Bioassessment scores were poor at one of the off-stream dam sites (site 13); which was partially due to the fact that the bioassessment program is primarily designed for use in streams, rather than wetland habitats. However, the dam at site 13 had no trees in the riparian zone, and low in-stream habitat coverage. Bioassessment scores at the other dams were moderate, as these dams had some in-stream habitat in the form of submerged and emergent macrophytes, and there were some trees surrounding them.

Figure 4.1

Boulders were inundated in Woleebee Creek at Booral Rd (site 4) in the late wet season survey (March 2008).

Figure 4.2

There was only one, silty pool inundated in Woleebee Creek at Booral Rd (site 4) early in the wet season survey (January 2009).

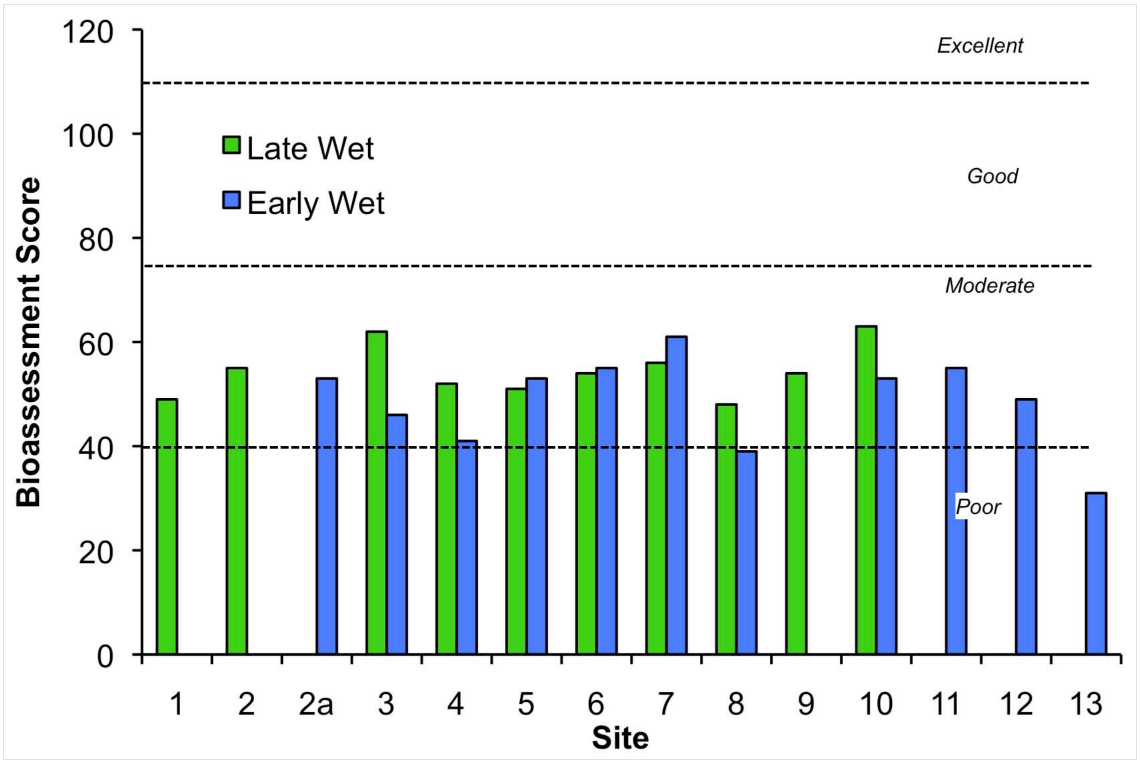


Figure 4.3 River Bioassessment Scores at each of the sites surveyed in the MLA study area, late (March 2008) and early (January 2009) in the wet season.

Figure 4.4

Off-stream dam with poor habitat quality at site 13 (January 2009).

Figure 4.5

Off-stream dam with moderate habitat quality at site 12 (January 2009).

The aquatic habitat found within the MLA study area has been impacted by surrounding land uses, being predominantly grazing on cleared pastures, and passage of aquatic fauna is likely to be restricted at some waterway crossings. Aquatic habitats are in similar condition to those found throughout the wider catchment as discussed in the aquatic ecology technical report TR 17B-1-V1.5.

4.1.2 Gas Supply Pipeline Study Area

Similar to the sites in the MLA study area, the sites surveyed along the gas supply pipeline route typically had poor to moderate River Bioassessment Program habitat assessment scores in the dry season (August 2008) and early wet season (February 2009) surveys (Figure 4.6). The habitat scores remained similar over time, as there were no major changes to in-stream habitats between the two survey events. These relatively low habitat scores were related to low habitat variability (only pool habitat was observed), moderate to extensive bank erosion, and substrates dominated by finer sediments such as sand and silt.

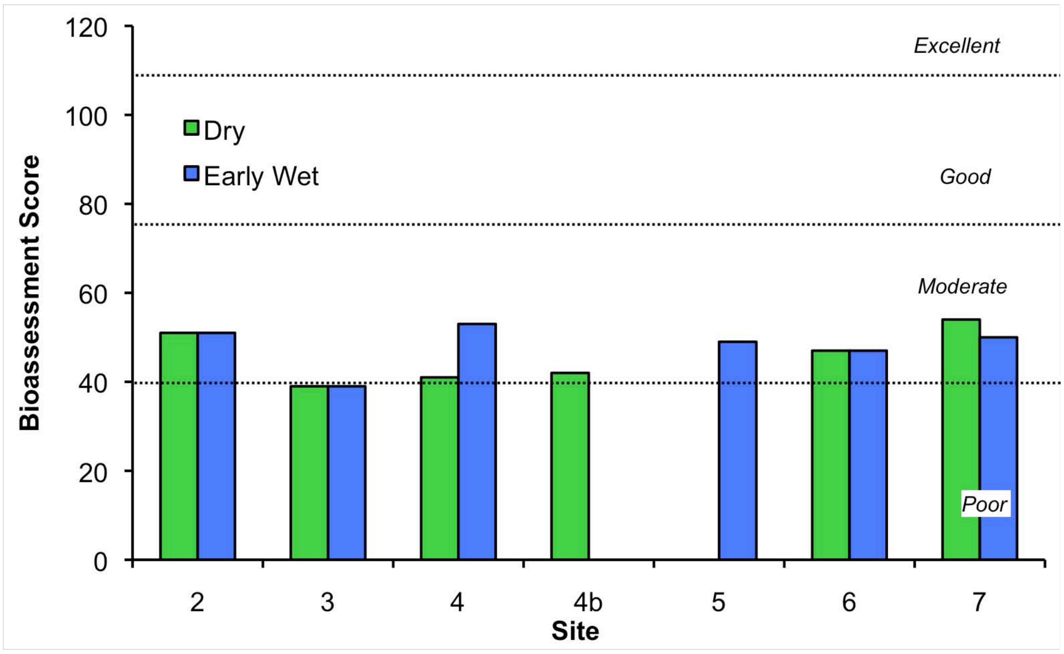


Figure 4.6 River Bioassessment Scores at each of the sites surveyed in the gas supply pipeline study area in the dry (August 2008) and early wet (February 2009) season surveys.

Overall, the aquatic habitats of the creeks surveyed along the gas supply pipeline route were similar to those within the MLA areas. Riparian vegetation clearing, cattle access to the creeks and construction of creek crossings has negatively affected aquatic habitats.

4.1.3 Flow Conditions at the Time of Survey

There was no flow during either baseline survey event, and the sites sampled were characterised by isolated pools. The farm dams surveyed were perennial lacustrine habitat.

4.2 Water Quality

4.2.1 MLA Study Area

4.2.1.1 Water Temperature

Water temperatures in the early wet season survey were within the range of temperatures previously measured in the late wet season survey, ranging between 22.5 and 32.3 °C. Water temperature in dams (sites 11, 12 & 13) was generally lower than in smaller pools found in creeks, probably due to greater water depths (water temperature at all sites is likely to vary on a daily basis and in response to site-specific factors such as canopy coverage and water depth).

4.2.1.2 Dissolved Oxygen

Dissolved oxygen (DO) concentrations were highly variable among sites and between seasons (Figure 4.7).

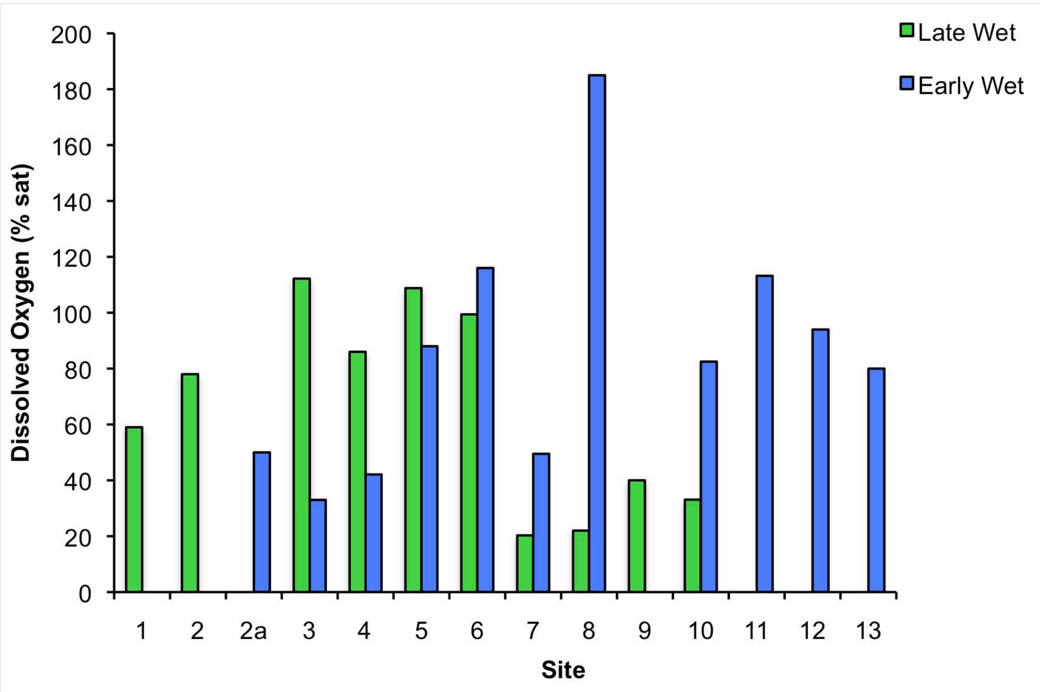


Figure 4.7 Dissolved oxygen at each site in the MLA study area, in the late (March 2008) and early wet (February 2009) season surveys.

As noted in the EPA's (now DERM) submission on the EIS, DO levels in stagnant pools are naturally variable. Low DO concentrations are common, and can be caused by high biological oxygen demand and low mixing of the waters in isolated pools. High DO concentrations (>100%) measured during the day can be caused by 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 critically low DO concentration levels for fauna at night.

The variable DO levels in the study area are likely to be somewhat characteristic of natural conditions, though they are likely to be influenced by factors such as riparian zone clearing, leading to reduced shading and increased sediment and nutrient runoff into the waterways, which can influence water temperatures and primary production in the waterways, therefore influencing DO concentration levels.

4.2.1.3 pH

pH was more variable among sites in the early wet season compared to the late wet season survey, and was particularly alkaline (9.5) at the constructed dam adjacent to Mount Organ Creek (site 13) (Figure 4.8). pH levels were similar at most sites both early and late in the wet season survey, except at sites 6 and 8, where pH was much higher earlier in the wet season.

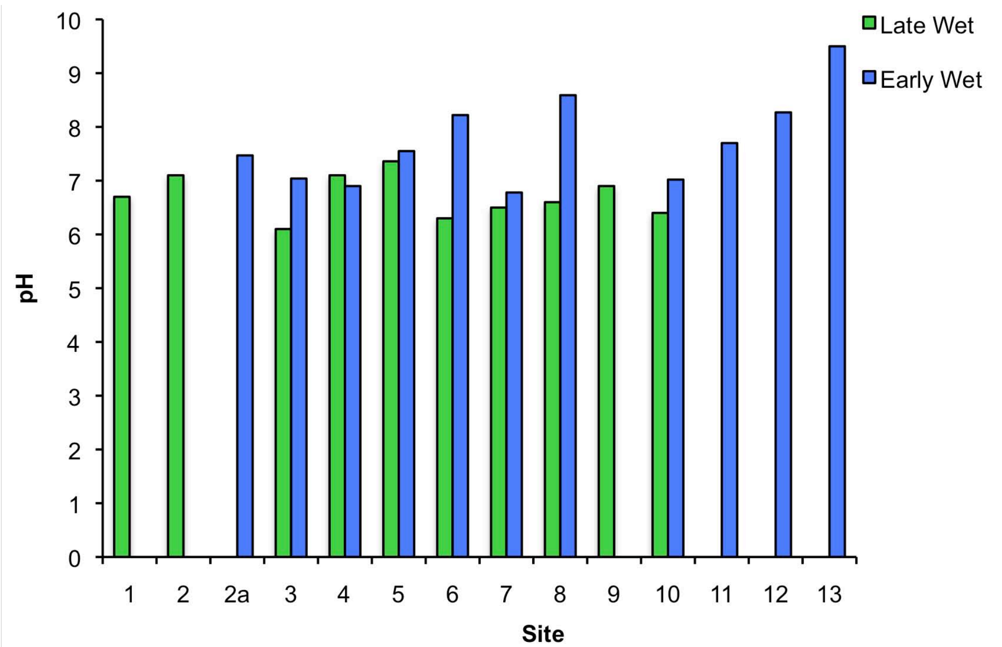


Figure 4.8 pH at each site in the MLA study area, in the late (March 2008) and early wet (February 2009) season surveys.

4.2.1.4 Electrical Conductivity

Electrical conductivity is proportional to the salinity of a water body, i.e. more saline water is more conductive. Conductivity was highly variable among sites within the study area; with comparatively lower conductivity levels measured at most sites during the early wet season survey (Figure 4.9). During the early wet season survey, conductivity generally ranged between 155 and 435 μS/cm, and was highest in the farm dam at site 12.

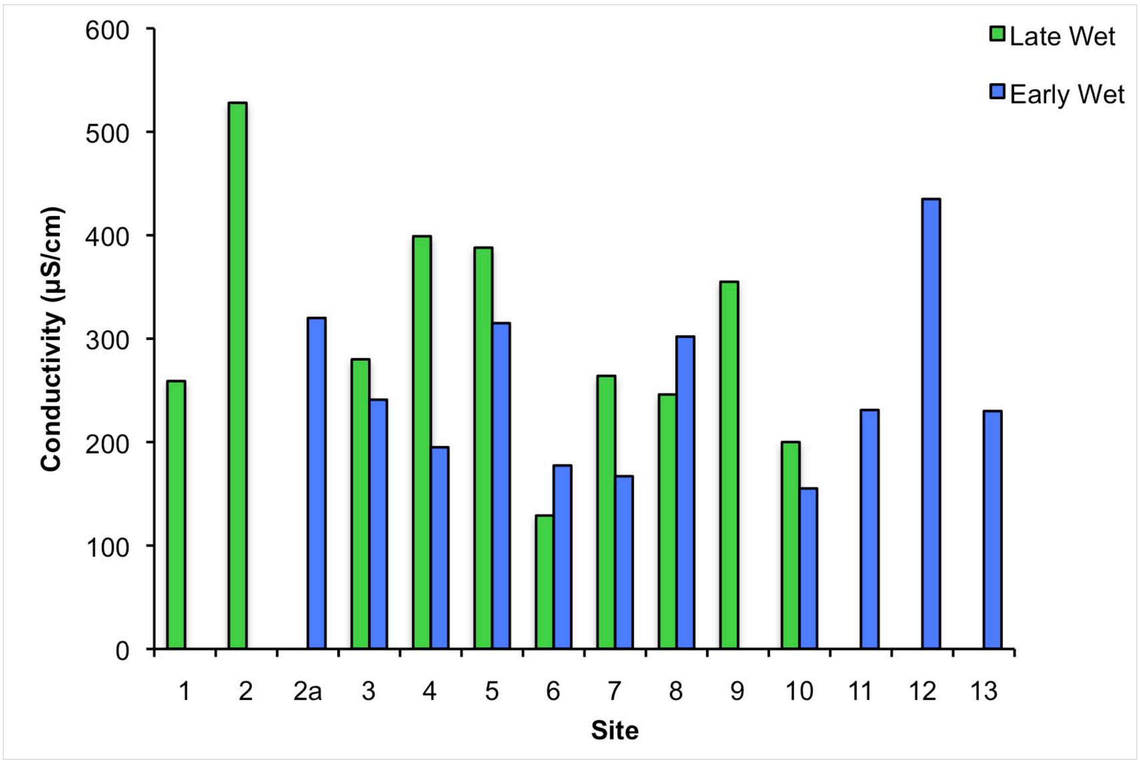


Figure 4.9 Electrical conductivity (μS/cm) at each site in the MLA study area, in the late (March 2008) and early wet (February 2009) season surveys.

4.2.1.5 Turbidity

Turbidity was highly variable across sites both in the early and late wet season surveys. In the early wet season survey, turbidity was much higher at some on-stream sites than previously measured in the late wet season survey (sites 5, 7 & 9), while at other sites it had declined (Figure 4.10). Turbidity in off-stream dams ranged between 19 NTU and 65 NTU, which was much lower than at on-stream sites (Figure 4.10). Several sites (4, 5 & 7) were extremely turbid with the highest turbidity level (2,100 NTU) measured in Woleebee Creek at Booral Road (site 4), which is consistent with previous results from the late wet season survey, and may be related to local geology and erosion, as discussed in the surface water quality technical report EIS Volume 1, TR 11-1-V1.5 (Figure 4.1 & Figure 4.2). Overall, high turbidity throughout the study area was likely related to sediment-laden runoff associated with clearing of riparian vegetation, steepness of bank slopes, bank erosion, differences between on-stream and off-stream sites, and temporal changes reflected in prevailing runoff and water flow conditions.

Obstructions such as road crossings do not appear to have a substantial influence on turbidity. For example, turbidity was similar at site 2a (Woleebee Creek) and site 3 (Woleebee Creek at the Grosmont Road crossing). Turbidity was also higher at site 5 (Mud Creek) (Figure 4.11) than other sites at road crossings.

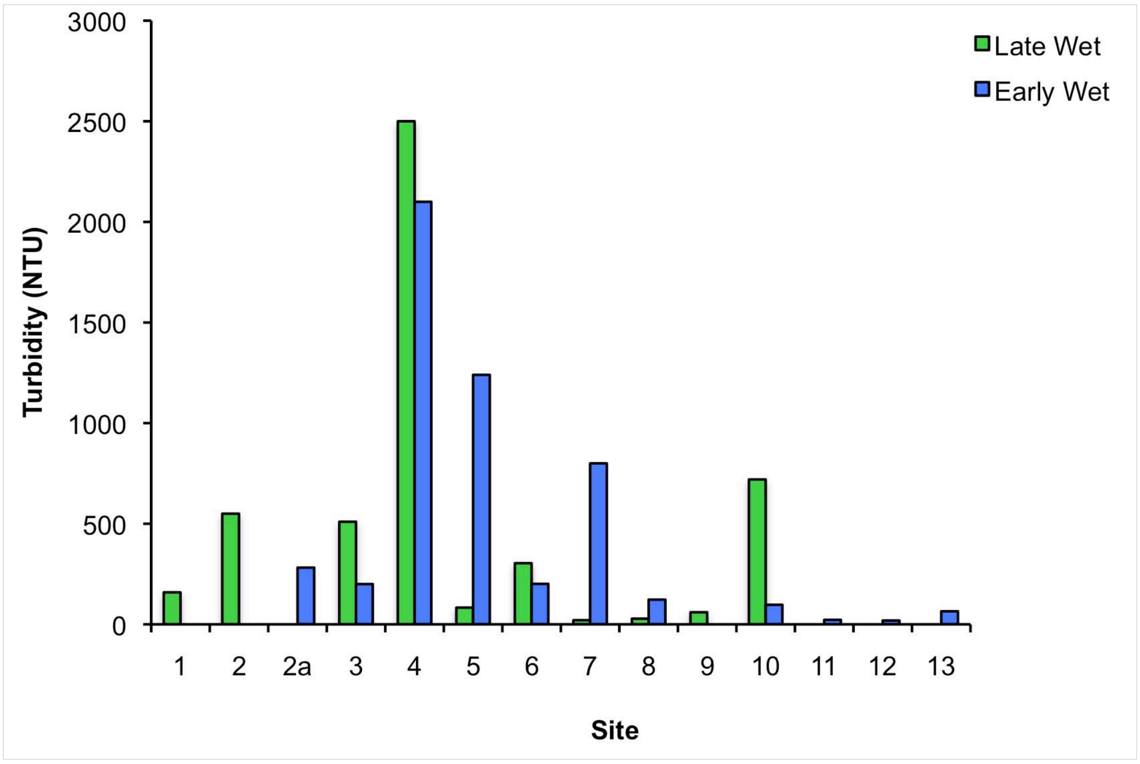


Figure 4.10 Turbidity at each site in the MLA study area, in the late (March 2008) and early wet (February 2009) season surveys.

Figure 4.11

High turbidity in Mud Creek at site 5.

4.2.2 Gas Supply Pipeline Study Area

4.2.2.1 Water Temperature

Water temperature was generally much higher in the wet season (summer – February 2009) than in the dry season (winter – August 2008), due to seasonal factors (though water temperature can also vary on a daily basis and in response to site-specific factors such as canopy coverage and water depth). In the wet season survey, temperatures ranged between 22.7 and 28.2 °C in the sites where water was present along the gas supply pipeline route. Water temperatures during the wet season survey were similar to those sampled within the MLA areas.

4.2.2.2 Dissolved Oxygen

DO levels were generally lower in the wet season survey, than in the dry season survey (Figure 4.12). DO levels were particularly low in Roche Creek at site 5 (Figure 4.12). DO levels fluctuated between seasons and among sites (see discussion of DO levels in isolated pools in Section 4.2.1.2 above).

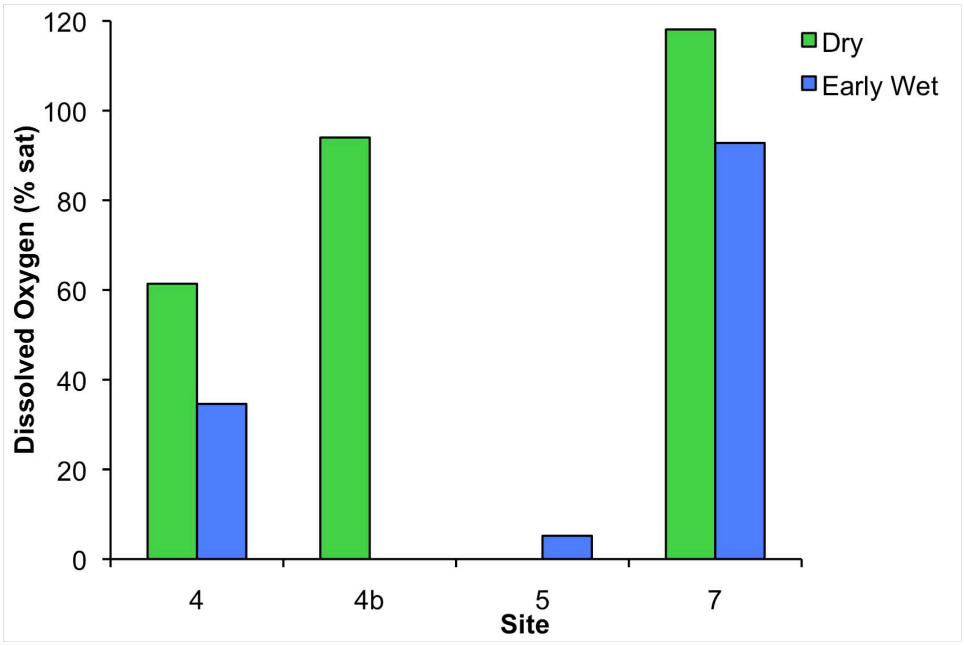


Figure 4.12 Dissolved oxygen at each site that had water along the gas supply pipeline route, in the dry (August 2008) and early wet (February 2009) season surveys.

4.2.2.3 pH

pH values were fairly consistent among sites and between seasons, ranging from 7 to 7.2. These pH levels are typical of those found in a healthy waterway (as they lie within ranges presented in relevant water quality guideline documents).

4.2.2.4 Electrical Conductivity

Conductivity was similar among the sites sampled in the wet season survey (Figure 4.13). These values are within the range sampled during wet season surveys at sites within the MLA areas.

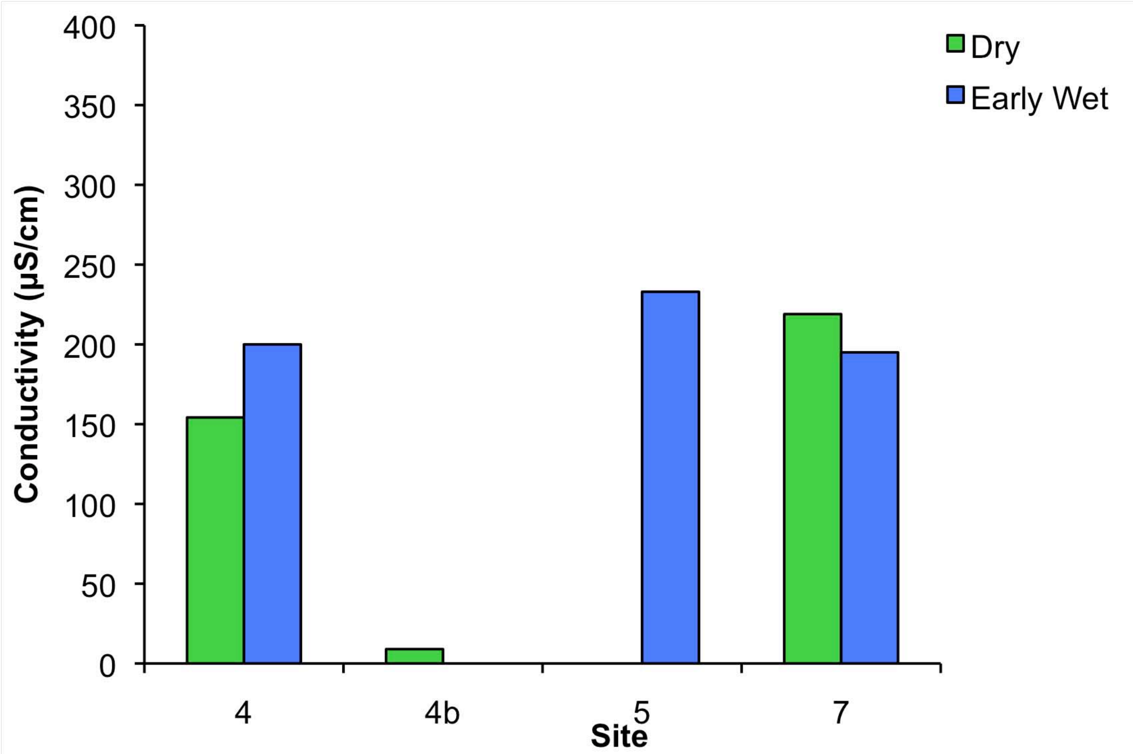


Figure 4.13 Electrical conductivity at each site that held water along the gas supply pipeline route, in the dry (August 2008) and early wet (February 2009) season surveys.

4.2.2.5 Turbidity

Turbidity in Roche Creek ranged from 34 NTU at site 4 to 60 NTU at site 5. In contrast, turbidity was much higher in Juandah Creek at site 7 (206 NTU). No turbidity measurements were recorded at waterways along the gas supply pipeline route during the dry season survey (August 2008). However, during the wet season survey (February 2009), turbidity was generally within the range of turbidity levels recorded in the MLA study area.

4.3 Aquatic Flora

4.3.1 MLA 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 source of food for herbivorous fauna. Across the study area, aquatic vegetation was dominated by native species. Reed sweetgrass (*Glyceria maxima*) was the only introduced species recorded and was only found at two sites. Aquatic macrophytes covered between 3% and 29% at on-stream sites. Coverage was higher (between 27% and 50%) at off-stream sites.

In the late wet season survey (March 2008), fifteen emergent species and one floating species were recorded (EIS Volume 1, TR 17B-1-V1.5). In the early wet season survey (January 2009) eleven emergent species, two floating species and three submerged species were recorded (Table 4.1). The additional submerged and floating species recorded in the early wet season survey were in farm dams, which were previously not sampled in the late wet season survey.

Of the floating species recorded in the early wet season survey (January 2009), ferny azolla (*Azolla pinnata*) increased in coverage from the late wet survey (March 2008) from 3% to 10% at site 7, and water primrose (*Ludwigia peploides* ssp. *monteridensis*) was found for the first time in the off-stream dams, covering between 12 and 20% at sites 11 and 12 respectively (Figure 4.14). Submerged species were found in two of the three off-stream dams surveyed in the early wet season (January 2009) (sites 11 & 12) (Figure 4.14; Table 4.1).

In the late wet season survey (March 2008), lesser joyweed (*Alternanthera denticulate*) was common at most sites, however, in the early wet season survey (January 2009), this species was only found at three of the eleven sites sampled (Table 4.1). The most common emergent macrophyte in the early wet season survey was the common rush (*Juncus usitatus*), which grew at five on-stream sites (Table 4.1) (Figure 4.15). Sedges (*Cyperus* sp.; Figure 4.16), smartweed (*Persicaria decipiens*), *Lomandra* sp. (rush) and water couch (*Paspalum distichum*) were also relatively common.

Figure 4.14

Floating water primrose and submerged ribbonweed in the farm dam (site 12).

Figure 4.15

Common rush and grasses at Woleebee Creek (site 4).

Figure 4.16

Giant sedge on the bank at Mount Organ Creek (site 8), together with grasses.

Table 4.1 Percent cover of all macrophytes at each site within the MLA study area, listed by growth form.

GROWTH FORM / Family / *Latin name*	Common name	Native / Exotic [1]	% Cover at Each Site (Late wet: March 2008; Early wet: January 2009)																									
			1		2a	2	3		4		5		6		7		8		9		10		11		12		13	
			Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet
SUBMERGED																												
Haloragaceae																												
Myriophyllum sasugineum	watermilfoil	N																								10		
Hydrocharitaceae																												
Vallisneria nana	Ribbonweed	N																								10		
Najadaceae																												
Najas tenuifolia	waternymph	N																						5		10		
FLOATING																												
Azollaceae																												
Azolla sp.	azolla	N													3	10												
Onagraceae																												
Ludwigia peploides ssp monteridensis	Water primrose	N																						12		20		
EMERGENT																												
Amaranthaceae																												
Alternanthera denticulata	lesser joyweed	N	5		3		3	2	2		8		1	7	7		2		2		3	5						
Cyperaceae																												
Cyperus aquatilis	water nutgrass	N													4				2									
Cyperus difformis	dirty dora	N			4		2			5		5					7											
Cyperus digitatus	flatsedge	N																			2							
Cyperus exaltus	giant sedge	N									1						5	2										

[1] N = native; E = exotic

GROWTH FORM / **Family** / *Latin name*	Common name	Native / Exotic [1]	% Cover at Each Site (Late wet: March 2008; Early wet: January 2009)																									
			1		2a	2	3		4		5		6		7		8		9		10		11		12		13	
			Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet
Eleocharis cylindrostachys	spikerush	N			2												4											
Unknown sp. 1	sedge	N									5								4									
Unknown sp. 2	sedge	N					5																					
Unknown sp. 3	sedge	N	2																									
Gramineae																												
Glyceria maxima	Reed sweetgrass	E																10										20
Paspalum distichum	water couch	N															10	5						15				5
Phragmites australis	common reed	N				20					4																	
Juncaceae																												
Juncus sp.	rush							1														1						
Juncus usitatus	rush	N	2						2			5	2	1	1			10	2									
Lomandraceae																												
Lomandra sp.	rush	N	5								2	10			10	2					2	1						
Poaceae																												
Eragrostis elongata	clustered lovegrass	N									5																	
Polygonaceae																												
Persicaria attenuata	Smartweed	N						1														1						2
Persicaria decipiens	slender knotweed	N															8	2			2			10				
TOTAL			**14**	**–**	**9**	**20**	**10**	**4**	**4**	**5**	**25**	**15**	**3**	**8**	**25**	**12**	**36**	**29**	**10**	**–**	**9**	**8**	**–**	**42**	**–**	**50**	**–**	**27**

Macrophyte coverage was limited in the streams within the MLA area, especially submerged species. This may be related to the large fluctuations in environmental conditions, including flooding and changes in water level in these waterways, and high turbidity. High turbidity at many sites may not allow sufficient light penetration through the water column for the growth of macrophytes on the substrate and may also prevent observation of submerged macrophytes through the water column. In comparison, submerged species covered a large proportion of off-stream wetland habitat (dams), which typically hold permanent water and have lower turbidity levels than the streams.

4.3.1.1 Algae

Filamentous and mat algae grew at some sites in the early wet season survey, such as Woleebee Creek at Grosmont Road (site 3), although it was less common during the flora and fauna surveys in both the early and late wet season surveys than during the field reconnaissance in the dry season survey in August 2007. The overall reduction in algal growth is most likely associated with flushing of the creeks by flows associated with rainfall, compared with nutrient enrichment of the water (associated with nutrient inputs originating from existing land-uses) in the dry season, as water evaporates from small pools.

4.3.2 Gas Supply Pipeline Study Area

Macrophytes were uncommon throughout the gas supply pipeline study area both in the dry and wet season surveys. *Lomandra* spp. was the most common macrophyte in the study area in the early wet season survey (Table 4.2).

Table 4.2 Percent cover of all macrophytes at each site within the gas supply pipeline study area, listed by growth form.

GROWTH FORM / Family / *Latin name*	**Common name**	**Native / Exotic** [2]	**% Cover at Each Site (Early wet: February 2009, Dry August 2008)**					
			4		**4b**	**5**	**7**	
			Early Wet	**Dry**	**Dry**	**Early Wet**	**Early Wet**	**Dry**
Cyperaceae								
Carex appressa	Tall sedge	N	10					
Cyperus sp.	sedge	N			5			
Gramineae								
Phragmites australis	common reed	N			5			
Lomandraceae								
Lomandra sp.	rush	N	5			5	5	
TOTAL			**15**	**0**	**10**	**5**	**5**	**0**

[2] N = native; E = exotic

4.4 Aquatic Macroinvertebrate Communities

4.4.1 MLA Study Area

Macrocrustaceans (freshwater prawns and crayfish), diving beetles (family Dyticidae) water bugs (families Corixidae, Notonectidae and Veliidae) and non-biting midge larvae (sub-families Chironominae and Tanypodinae) dominated the invertebrate communities of the MLA study area. The richness and distribution of taxa found within the study area varied among sites, largely due to the availability of aquatic habitats found at each site. Macroinvertebrates were not sampled from Frank Creek (site 1), One-arm Man Creek (site 2) or Juandah Creek at Booral Road (site 9), because these sites were dry during the early wet season survey in January 2009.

4.4.1.1 Richness

During the late and early wet season surveys, the taxonomic richness (the number of macroinvertebrate taxonomic groups per sample) in bed habitats generally was low, ranging from two to fifteen at the sites surveyed. Taxonomic richness increased between late and early wet season surveys at five of the eight sites previously sampled in the late wet season survey (March 2008). In the early wet season survey, taxonomic richness was highest in the bed habitats in Woleebee Creek at Grosmont Road (site 3), in Spring Creek (site 6) and also in the farm dam at site 12 (Figure 4.17). High taxonomic richness may be related to higher substrate diversity at these sites, for example, the on-stream sites contained both soft sediment and hard substrates such as cobbles, pebbles and gravel, and the farm dam had submerged macrophytes on the substrate.

Taxonomic richness was generally much higher in edge habitats compared with bed habitats, with up to twenty taxa recorded at some sites. This difference between habitat types is to be expected, as edge and bed habitats support different communities (see Section 4.4.1.4 below). Richness in edge habitats was highest at site 3, on Woleebee Creek, sites 7 and 10 on Juandah Creek, and site 8 on Mount Organ Creek (Figure 4.18), which may be due to the greater availability of microhabitats such as undercut banks, exposed trees roots and high cover of trailing bank vegetation at these sites.

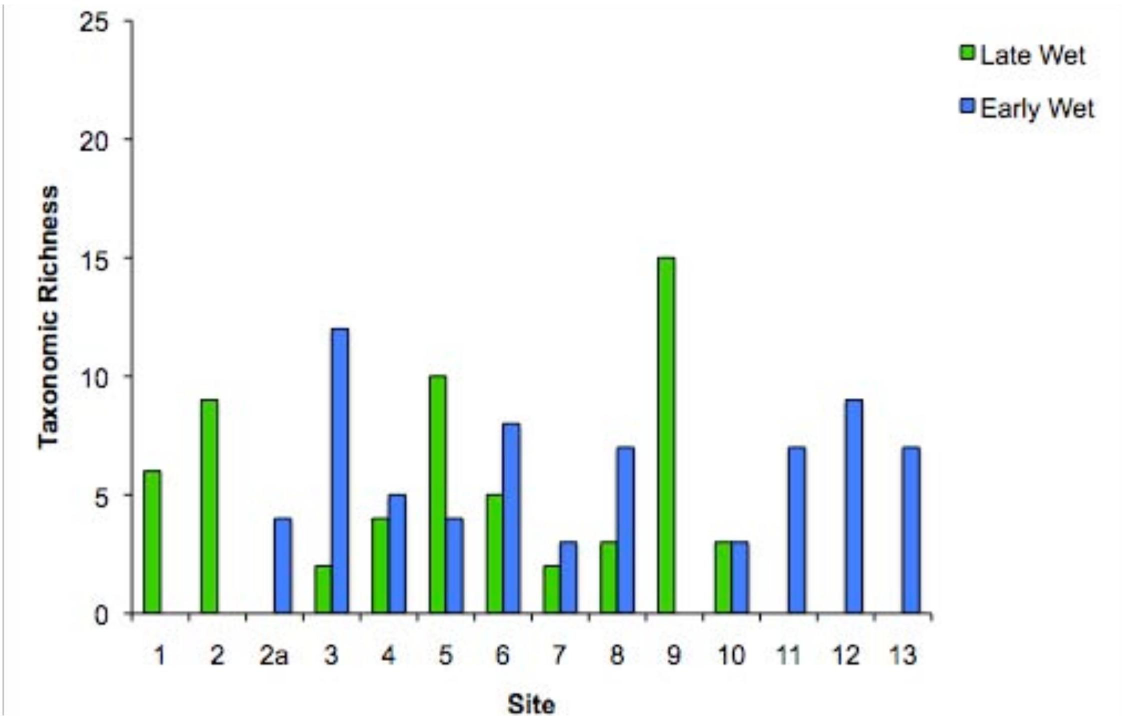


Figure 4.17 Taxonomic richness of macroinvertebrate communities in bed habitats of the MLA study area.

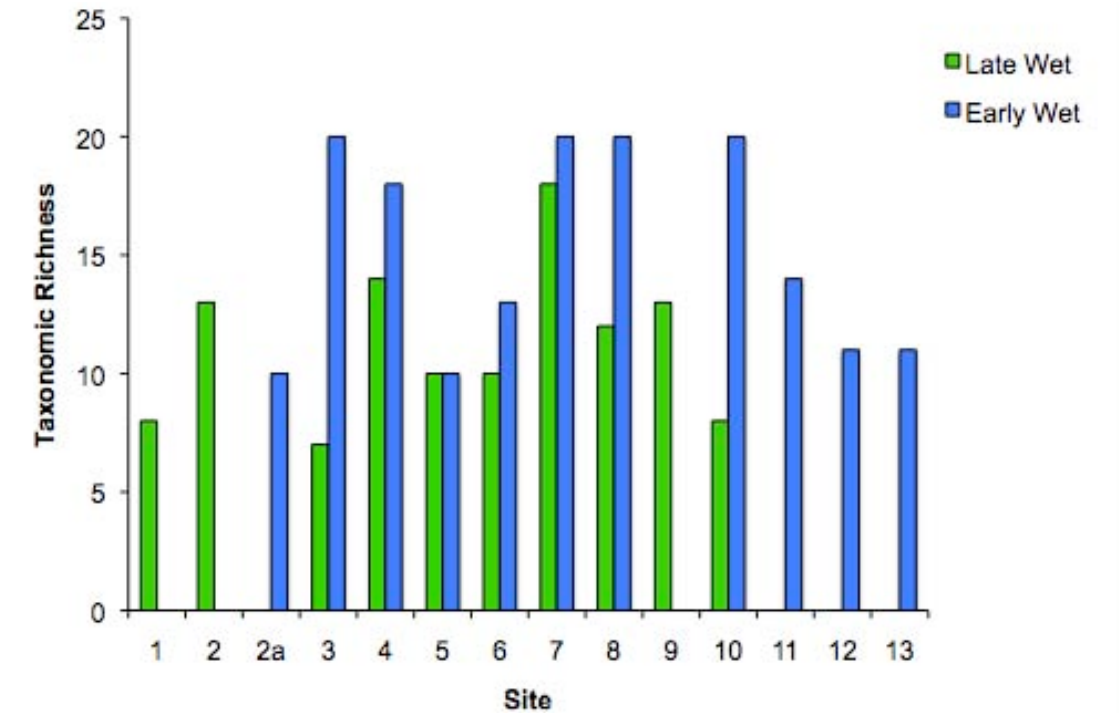


Figure 4.18 Taxonomic richness of macroinvertebrate communities in edge habitats at the MLA study area.

4.4.1.2 PET Richness

In general, PET richness, being 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 indicates good water / habitat quality. PET richness in both bed and edge habitat remained low during the early wet season survey (January 2009), and was indicative of degraded or moderate water and habitat quality at most of the sites surveyed (Figure 4.19 & Figure 4.20).

A greater number of PET taxa were sampled from edge habitats than bed habitats, with the greatest number of PET taxa sampled at sites 7, 8 and 13. Higher numbers of PET taxa at sites 7 and 8 is probably indicative of the diversity of edge habitat recorded, including undercut banks and trailing bank vegetation. However, high numbers of PET taxa at the constructed dam (site 13) is more likely to relate to moderate water quality and a local recruitment event than habitat quality, as habitat diversity in this dam was low.

Many of the on-stream habitats sampled are ephemeral or intermittent systems that are commonly exposed to a range of severe (natural) stresses, such as nutrient enrichment, turbidity and salinity. Consequently, PET families do not commonly occur in these environments (Chessman, B. [Centre for Natural Resources NSW] pers. comm. 2003, 21 October). While the low abundance of PET taxa throughout the study area may be indicative of poor water and/or habitat quality, it is likely that these highly variable ephemeral streams are not an optimal habitat for a diverse range of PET taxa.

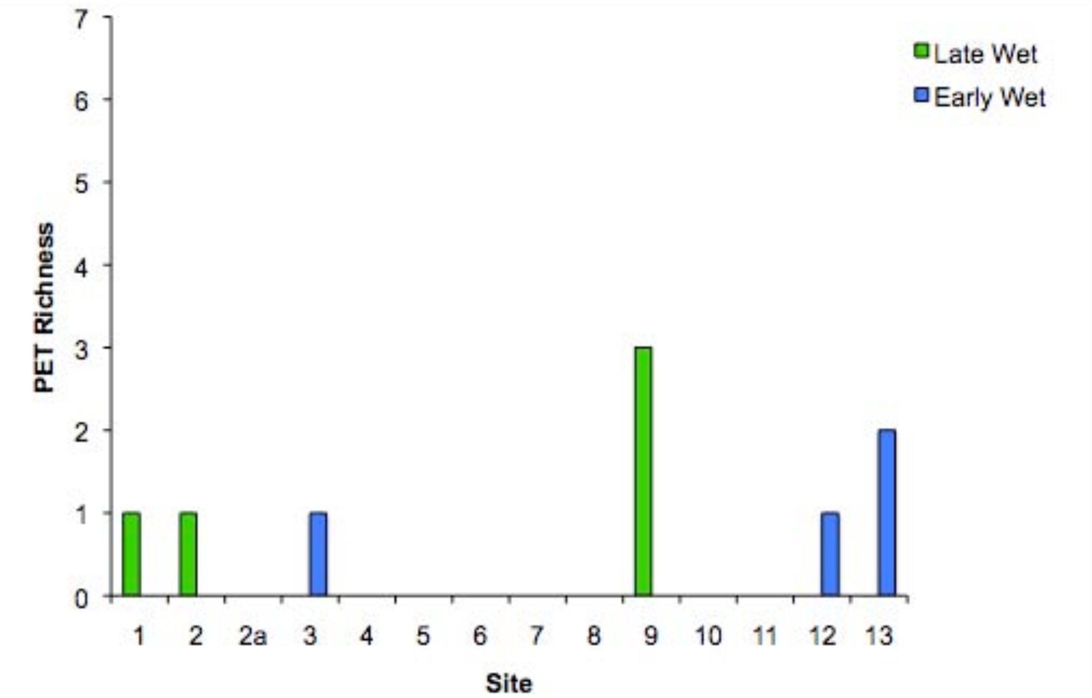


Figure 4.19 PET richness of macroinvertebrate communities in bed habitats of the MLA study area.

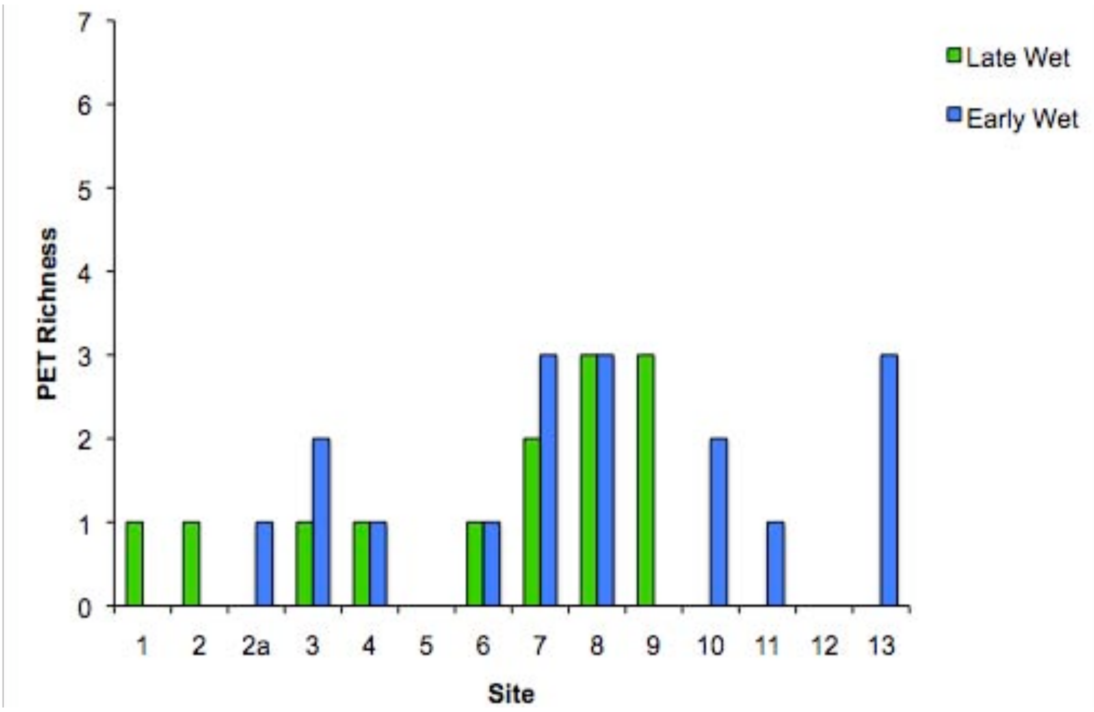


Figure 4.20 PET richness of macroinvertebrate communities in edge habitats of the MLA study area.

4.4.1.3 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 (EIS Volume 1, TR 17B-1-V1.5; Chessman 2003). The communities surveyed in bed habitat during the late wet (March 2008) and early wet (January 2009) season surveys were generally within quadrant 4 of the bi-plot (Figure 4.21), which indicates that the waterways of the study area are subject to agricultural impacts (such as nutrient enrichment) from the surrounding land uses (Attachment B of EIS Volume 1, TR 17B-1-V1.5). Communities from edge habitats were also in quadrant 4, however at a number of sites samples in the early wet season survey, the communities were in quadrant 2 (Figure 4.22). This may also indicate nutrient enrichment, especially given that they are quite close to the quadrant 4 border. However, it is important to note that 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).

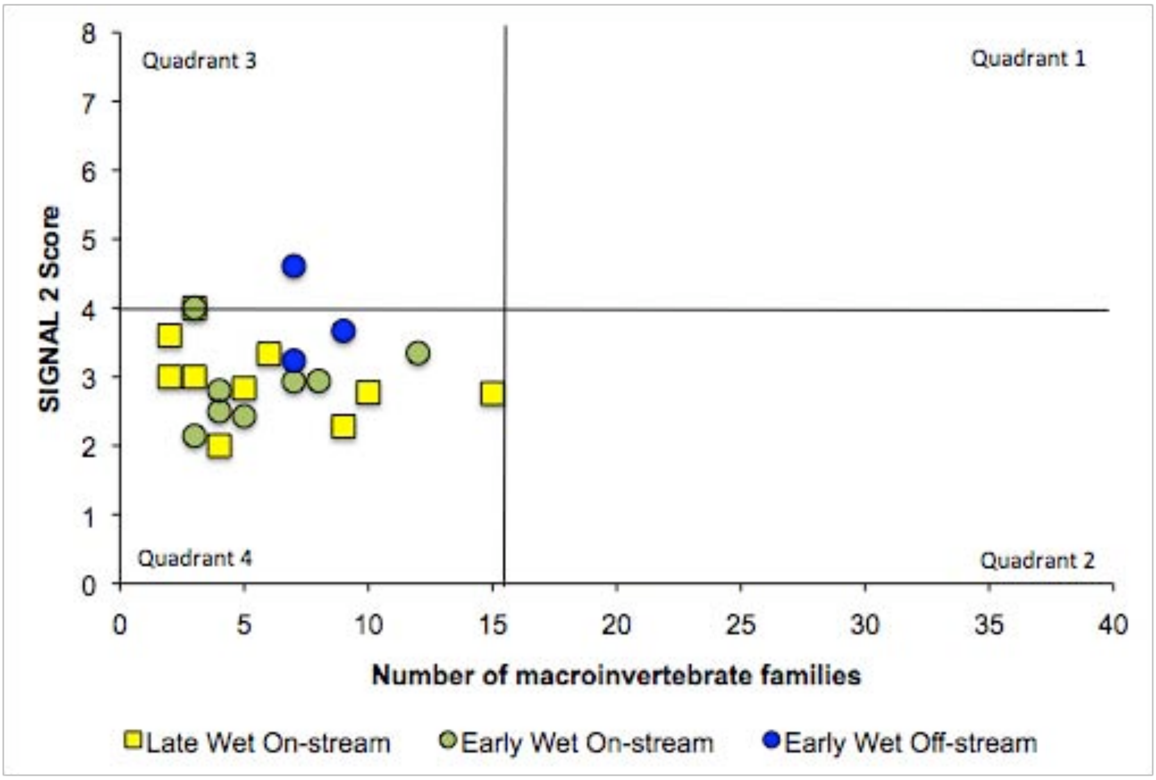


Figure 4.21 SIGNAL 2 / Family Bi-plot for the macroinvertebrate communities sampled from bed habitats in the MLA study area.

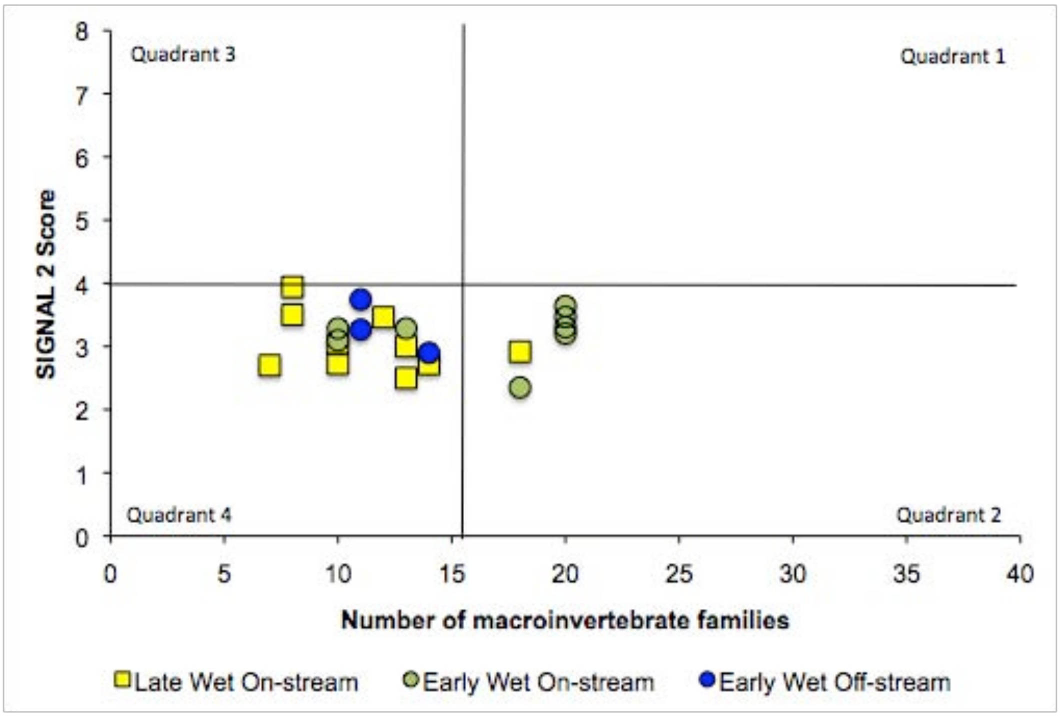


Figure 4.22 SIGNAL 2 / Family Bi-plot for the macroinvertebrate communities sampled from edge habitats in the MLA study area.

4.4.1.4 Replicated Baseline Macroinvertebrate Survey

4.4.1.4.1 Bed Habitat

In bed habitat, community composition differs substantially among sites (Figure 4.23 & Table 4.3: ANOSIM R = 0.74, $p < 0.001$). In particular, the composition of communities in off-stream sites (11, 12 & 13) differs from on-stream sites (Figure 4.23 & Table 4.3). Groups that contributed substantially (individually greater than 35%) to the differences in community composition among sites included non-biting midge larvae (Tanypodinae & Chironominae), diving beetles (Dytiscidae), waterboatmen (Corixidae), phantom midge larvae (Chaoboridae) and freshwater prawns (Palaemonidae) (SIMPER).

For example, non-biting midges were very abundant (> 500 individuals per sample) in Woleebee Creek at Grosmont Road (site 3), yet were surprisingly low in abundance just upstream (site 2a) and further downstream (site 4). Water boatmen and biting midge larvae (Ceratopogonidae) were much more abundant in Mount Organ Creek (site 8) upstream of the MLA areas, and contributed up to 67% of the difference in community composition at this site, compared with sites within, or downstream of the MLA areas. That is, communities were highly spatially variable, even among sites on the same creek.

The spatial variation in macroinvertebrate community composition among sites was strongly correlated with three of the habitat bio-assessment score components (channel alteration, bottom substrate / available cover and bank stability) (BIO-ENV $\rho = 0.47$, $p = 0.003$) (Figure 4.23). The degree of channel alteration was most strongly correlated with macroinvertebrate community composition (BIO-ENV $\rho = 0.55$). For example, Woleebee Creek (site 3) at Grosmont Road had a low (poor) channel alteration score, due to the presence of a raised road with undersized pipe culverts, and excavation in the creek bed. As discussed above, the macroinvertebrate community here differed from other sites, primarily due to high abundances of non-biting midge larvae (Chironominae), which are tolerant to disturbance. Given that community composition is likely to respond strongly to the effects of channel alteration, suggested mitigation measures and design guidelines for creek crossings and stream diversions take this into account (Sections 7.6 & 7.7).

Table 4.3 Pairwise comparisons for the difference in composition of macroinvertebrate communities in bed habitat, among sites. Results are presented as a matrix, which should be read up and down as well as left to right.

Site	3	4	5	6	7	8	10	11	12	13
2a	0.99**	0.97**	0.89**	1.00**	0.36**	1.00**	0.56**	1.00**	0.99**	1.00**
3		0.88**	0.92**	0.83**	0.48*	0.81**	0.40**	0.98**	1.00**	0.43**
4			0.54**	0.85**	0.46*	1.00**	0.60**	1.00**	1.00**	1.00**
5				0.44**	0.42*	1.00**	0.65**	1.00**	1.00**	1.00**
6					0.50**	1.00**	0.60**	1.00**	1.00**	0.98**
7						0.58**	0.29*	0.63**	0.51**	0.62**
8							0.50**	0.99**	1.00**	0.82**
10								0.50**	0.34*	0.34**
11									1.00**	0.94**
12										0.94**

(Significance level: *$p < 0.05$; **$p < 0.01$)

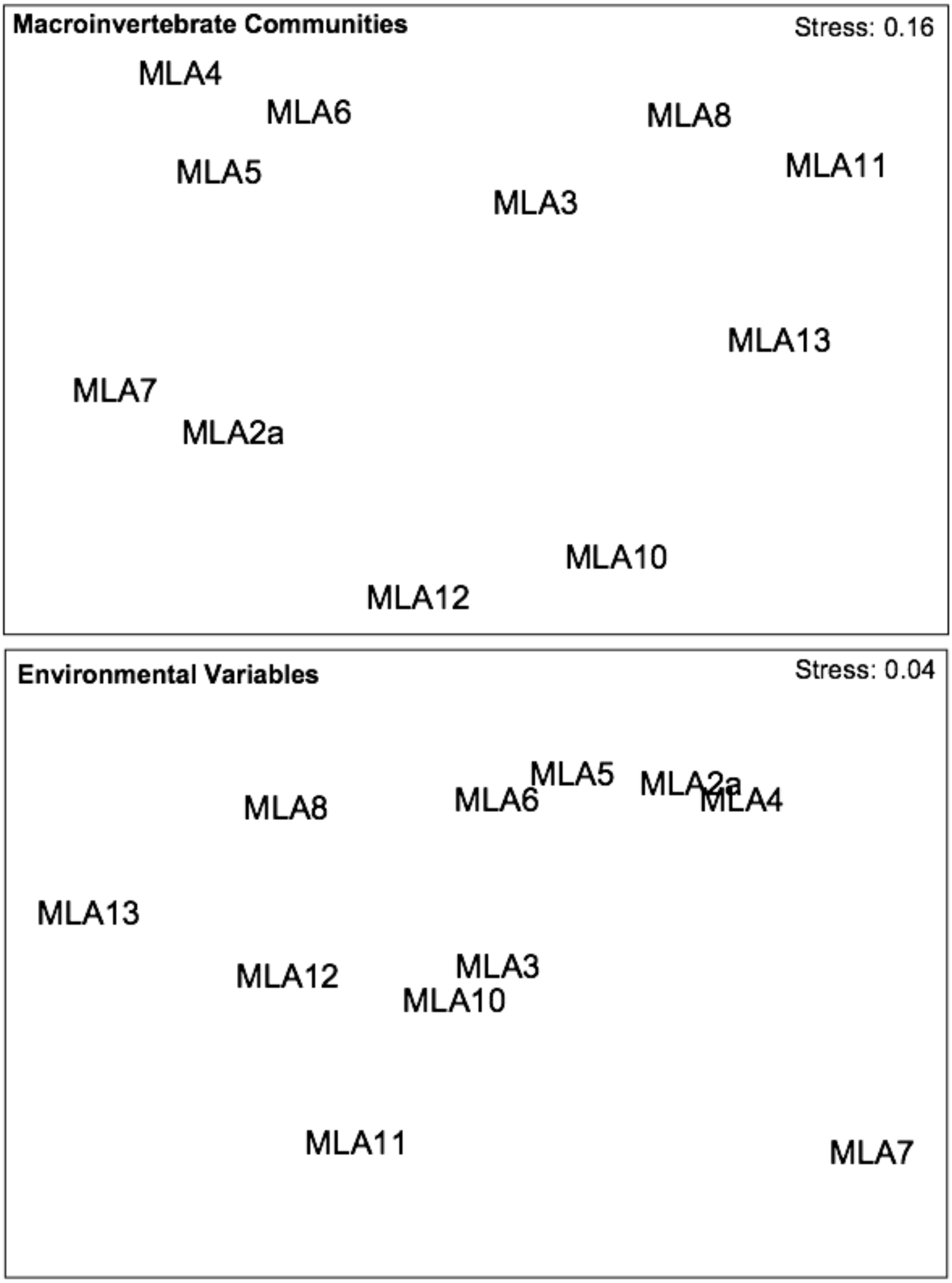


Figure 4.23 nMDS ordination showing differences in macroinvertebrate community composition and environmental habitat variables from bed habitat, among different sites. The plot should be interpreted like a 'map', with sites closer together more similar to each other than those that are far apart.

4.4.1.4.2 Edge Habitat

The composition of macroinvertebrate communities in edge habitat also differs among sites (ANOSIM R = 0.63, $p < 0.001$), although the magnitude of differences among sites was often lower than for bed habitat (Figure 4.24 & Table 4.4). A more diverse selection of taxonomic groups contributed to the differences among sites in edge habitat than bed habitat, and the percentage contribution of individual taxa to differences in community composition among sites was generally much less than in bed habitats (SIMPER). Groups that contributed commonly to differences in community composition among sites included non-biting midge larvae (Tanypodinae & Chironominae), biting midge larvae (Ceratopogonidae), diving beetles (Dytiscidae), baetid mayfly nymphs (Baetidae), waterboatmen (Corixidae), phantom midge larvae (Chaoboridae), freshwater prawns (Palaemonidae), freshwater limpets (Ancylidae), and sculptured snails (Thiaridae) (SIMPER).

Differences in community composition among sites were commonly due to greater abundance of a few key taxa at some sites (particularly sites 3, 11, 13 & 12). Differences in the abundance of some taxonomic groups could be due to a greater diversity of microhabitats, including macrophytes, tree roots and bank overhangs in edge habitat at these sites. The high abundance of non-biting midges and diving beetles at Mount Organ Creek contributed more than 85% of the difference between assemblages at this site and those within or downstream of the MLA areas (SIMPER). The abundance of non-biting midge larvae was particularly high in edge habitat in Mount Organ Creek (site 8), which could be due to localised recruitment events or reduced habitat and/or water quality at this site, given that non-biting midges are tolerant of disturbance and commonly found in degraded habitats.

In comparison to bed habitat, variation in macroinvertebrate communities from edge habitat were only poorly correlated with the habitat bio-assessment scores. Those that were most highly correlated were channel alteration, bottom scouring and deposition, and (as expected for edge habitats) bank stability and streamside cover (BIO-ENV $\rho = 0.27$, $p = 0.029$).

Table 4.4 Pairwise comparisons for the difference in composition of macroinvertebrate communities in edge habitat, among sites. Results are presented as a matrix, which should be read up and down as well as left to right.

Site	**3**	**4**	**5**	**6**	**7**	**8**	**10**	**11**	**12**	**13**
2a	0.72**	0.64**	0.22	0.61*	0.33**	0.82**	0.16	0.74**	0.35*	0.76**
3		0.78**	0.68**	0.33*	0.78*	0.69*	0.73**	1.00**	0.72**	0.14
4			0.49**	0.63**	0.80**	0.92**	0.82**	0.79**	0.87**	0.78**
5				0.54*	0.40**	0.76**	0.44*	0.73**	0.57**	0.65**
6					0.59*	0.86**	0.63*	1.00**	0.62*	0.63**
7						0.93**	0.27*	0.96**	0.68**	0.86**
8							0.74**	1.00**	0.57*	0.95**
10								0.98**	0.16	0.78**
11									0.86**	0.98**
12										0.68**

(Significance level: *p < 0.05; **p < 0.01; no asterix indicates that difference was not signficant)

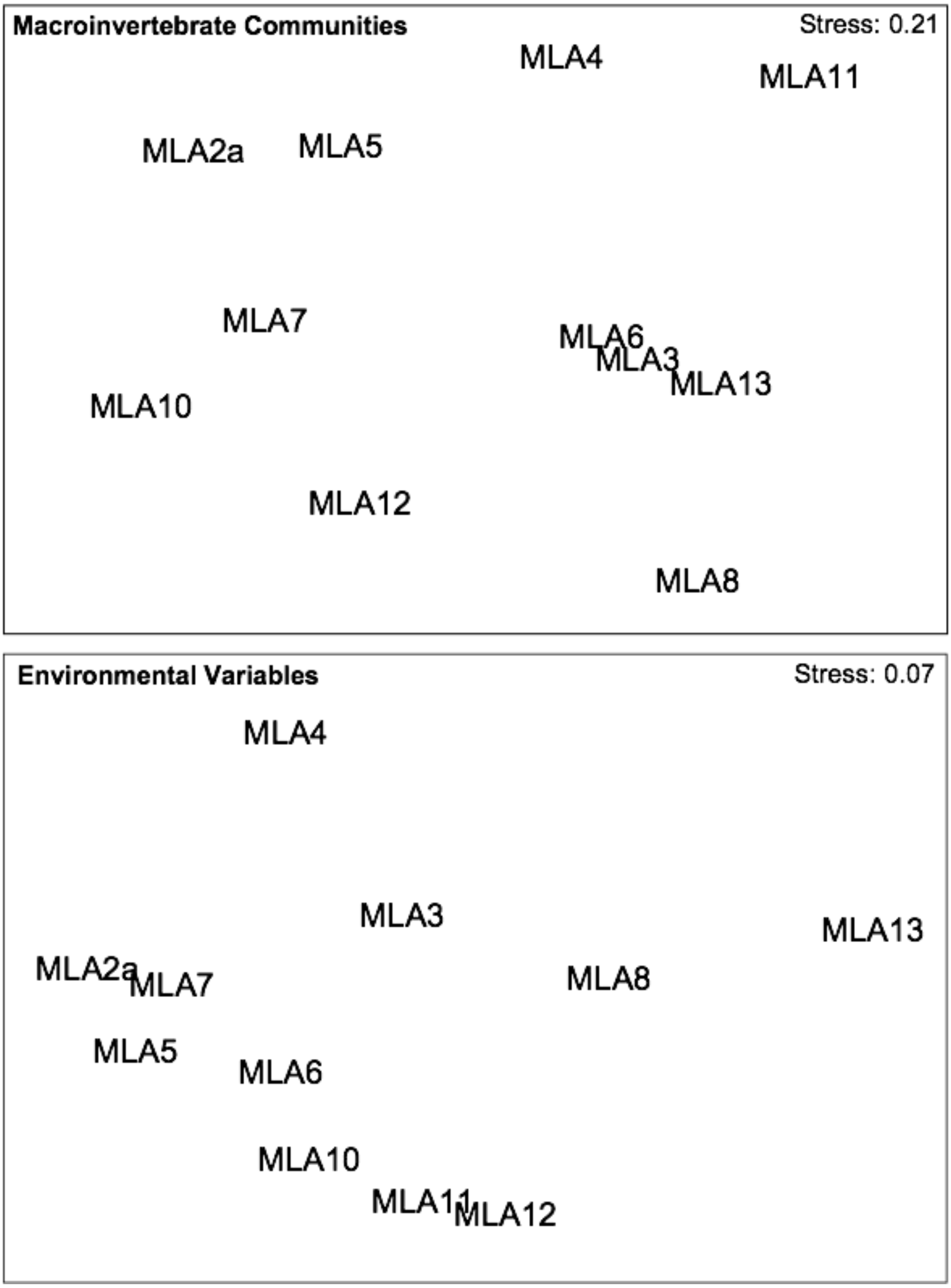


Figure 4.24 nMDS ordination showing differences in macroinvertebrate community composition and environmental habitat variables from edge habitat, among different sites. The plot should be interpreted like a 'map', with sites closer together more similar to each other than those that are far apart.

4.4.1.4.3 Macroinvertebrate Indices

In the early wet season survey (January 2009), the taxonomic richness was generally much higher in edge habitat than bed habitat at most of the sites sampled, except at the off-stream dam adjacent to Mount Organ Creek (site 13) (Figure 4.25). This is consistent with the results of the AusRivAS-style survey, but provides information on the small-scale (within site) variability in macroinvertebrate indices, which is essential to assess changes among sites and between time periods for ongoing impact monitoring.

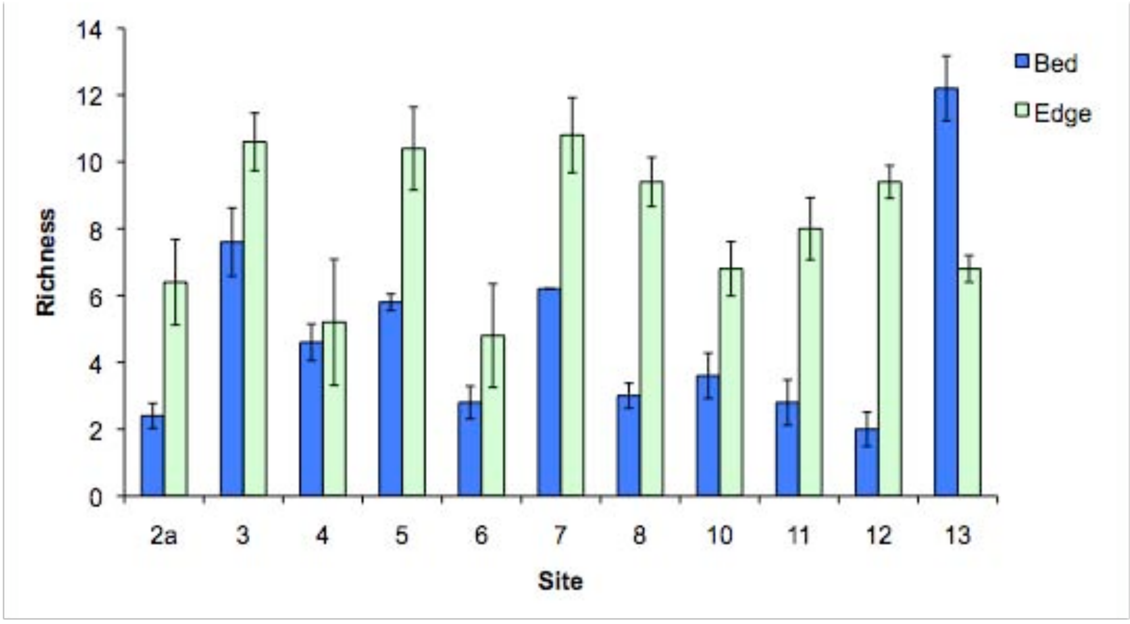


Figure 4.25 Taxonomic richness (mean ± standard error; s.e.) of macroinvertebrate communities in bed and edge habitat among sites in the MLA study area.

PET richness was generally low across all sites and PET taxa were absent from many sites sampled, especially in bed habitat (Figure 4.26). SIGNAL 2 scores were also low (< 4), which is indicative of assemblages that are dominated by tolerant taxa, and reflects the high variability in environmental conditions likely to occur in these ephemeral streams. SIGNAL scores in bed habitat at two of the off-stream dams (sites 12 & 13) were higher than elsewhere, perhaps reflecting the more permanent habitat availability in these dams, while still showing some effect of nutrient enrichment from surrounding agricultural practices.

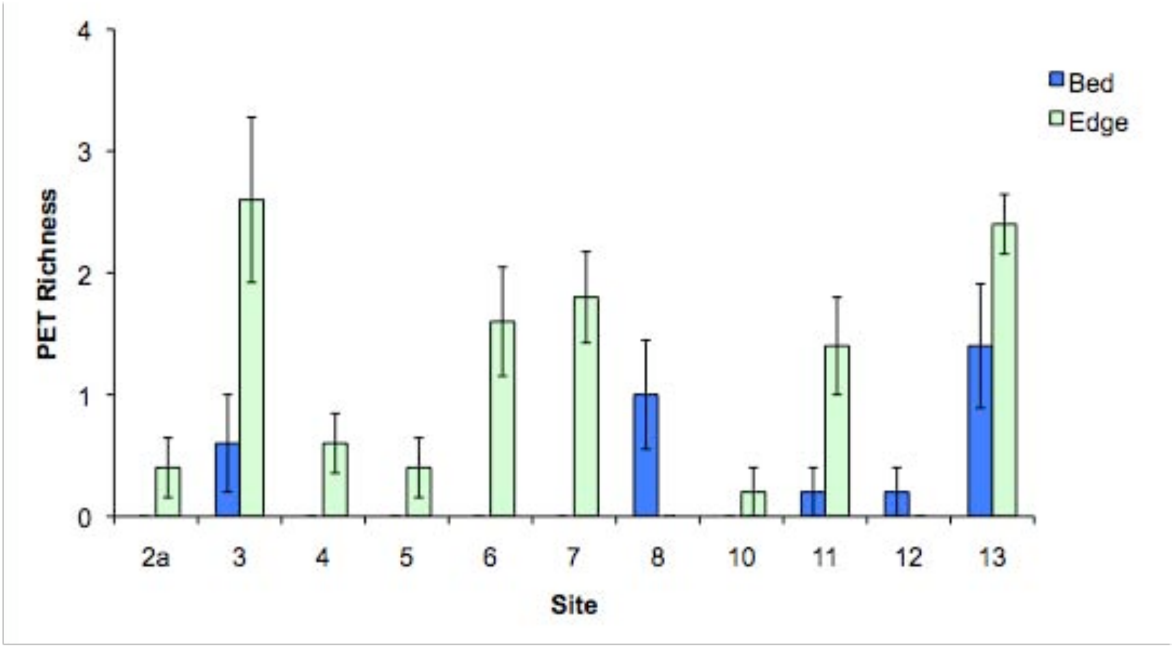


Figure 4.26 PET richness (mean ± s.e.) of macroinvertebrate communities in bed and edge habitat among sites in the MLA study area.

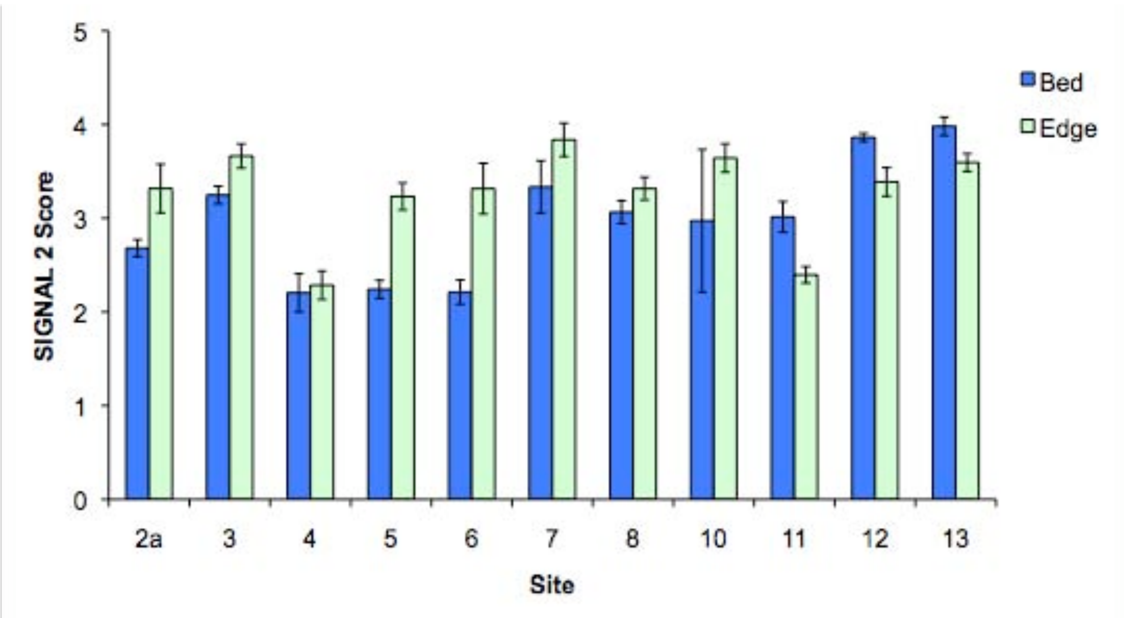


Figure 4.27 SIGNAL 2 score (mean ± s.e.) of macroinvertebrate communities in bed and edge habitat among sites in the MLA study area.

4.4.1.5 Macrocrustaceans

More than three times the number of macrocrustaceans were sampled in the early wet season survey (January 2009) (approximately 1 889), than in the late wet season survey (March 2008) (approximately 515) in the MLA study area. The extremely high abundance of macrocrustaceans caught in the early wet season survey is almost entirely due to high abundance in dams, which were not sampled in the late wet season survey. Macrocrustaceans were caught using a variety of methods, including dip netting for macro-invertebrates, trapping, and observations/captures during electrofishing.

In the early wet season survey, < 20 individuals were sampled per site, however a relatively large number of freshwater shrimp (> 1 000) were captured in the dam at site 12 (Figure 4.28, Table 4.5). Very few macrocrustaceans were captured in Mount Organ Creek (site 8) or in the other dams surveyed (sites 11 & 13). The abundance at each site was similar to that found in the late wet season survey (Figure 4.28).

Four macrocrustaceans species were identified in the MLA study area. *Cherax destructor destructor* (freshwater yabby) was the most common and abundant species, and was recorded at seven sites surveyed. Adult, intermediate and juvenile yabbies were captured at most sites (Table 4.5). *Caridinides* sp. (freshwater shrimp), *Paratya* sp. (freshwater shrimp), and *Macrobrachium australiense* (common Australian river prawn) were also relatively common; adults, intermediates and juveniles of each species were captured at each site. Many more river prawns and freshwater shrimp were observed, but not caught, during electrofishing, and additional species may also be present (Table 4.5).

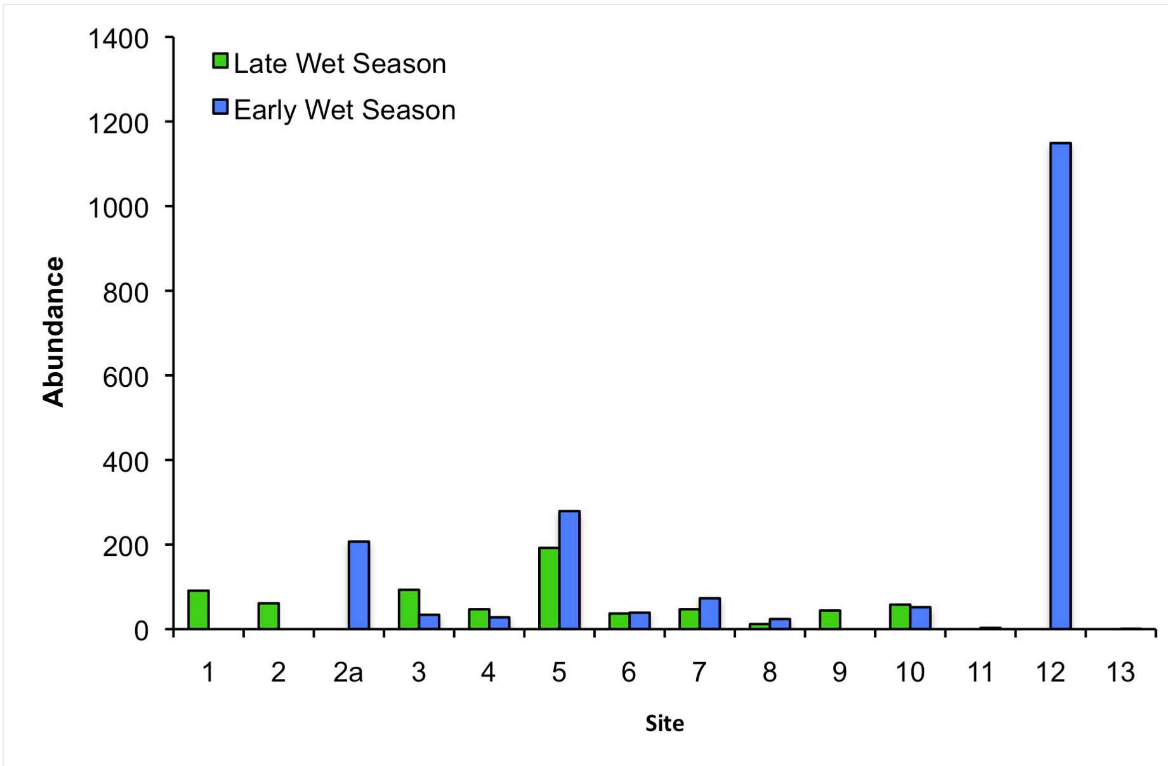


Figure 4.28 Abundance of macrocrustaceans at each site surveyed in the MLA study area in the late (March 2008) and early wet (January 2009) season surveys.

Table 4.5 Relative abundance of macro-crustaceans at each site (all survey methods and age classes combined), in the early wet season survey (January 2009).

Family	Latin Name	Common name	Site										
			2	3	4	5	6	7	8	10	11	12	13
Atyidae	*Caridinides* sp.	freshwater shrimp	****	***	***	****	***	***	**	***	–	*****	–
	Paratya sp.	freshwater shrimp										***	
Palaemonidae	*Macrobrachium australiense*	Australian river prawn	**	**	**	***	**	***	–	**	**	***	*
Parastacidae	*Cherax destructor destructor*	common freshwater yabby	***	**	**	***	***	***	***	–	–	–	–

(log_{10} abundance categories: * 1; ** <10; ***<100; **** < 1,000; ***** >1,000)

4.4.2 Gas Supply Pipeline Study Area

Diving beetles (family Dytiscidae), water bugs (family Corixidae), mayfly nymphs (family Baetidae) and non-biting midge larvae (sub-family Chironominae) dominated the macro-invertebrate communities of the sites within the gas supply pipeline study area during both the early wet (February 2009) and dry season (August 2008) surveys. These families were also common in the macroinvertebrate communities of the MLA study area.

4.4.2.1 Richness

Taxonomic richness ranged from three to nine in bed habitat at the sites surveyed, and was generally much lower in the early wet season survey, than in the dry season survey (Figure 4.29). Richness was much greater in edge habitats early in the dry season survey, especially at site 7, where 22 different taxonomic groups were sampled (Figure 4.30). Increased species richness in bed habitat during the dry season survey could be due to recruitment events of particular taxa in the dry season survey, or a concentration of macroinvertebrates within smaller sized pools as they dried out. In contrast, the number of macroinvertebrate taxa found in edge habitats increased during the early wet season survey, because the availability of suitable edge habitat increases as pools become deeper. Therefore, taxa that have specific edge habitat requirements, such as the presence of tree roots, trailing bank vegetation, undercut banks and / or overhanging vegetation, were able to occupy the available edge habitat.

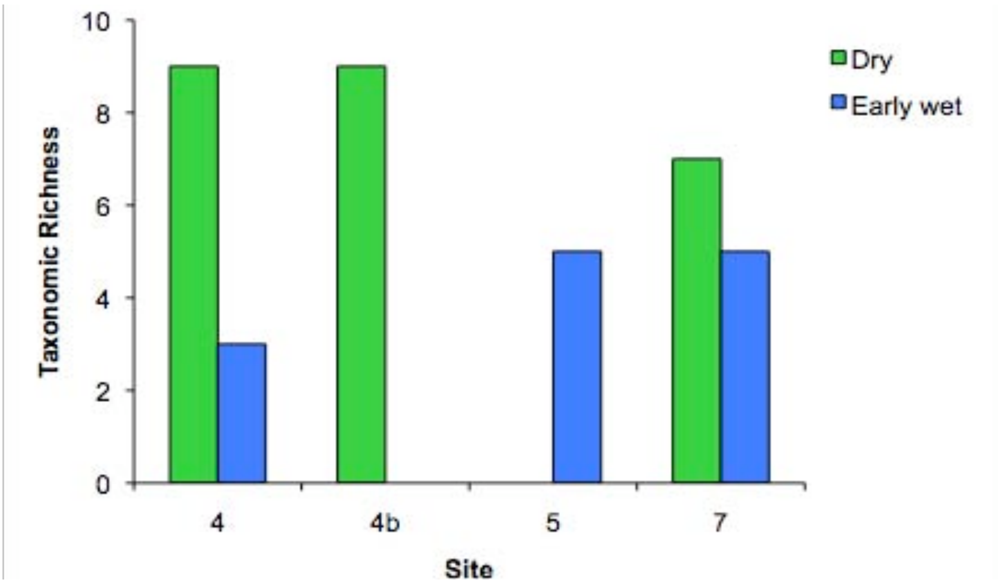


Figure 4.29 Taxonomic richness of macroinvertebrate communities in bed habitat at sites along the gas supply pipeline, sampled in the dry (August 2008) and early wet (February 2009) season surveys.

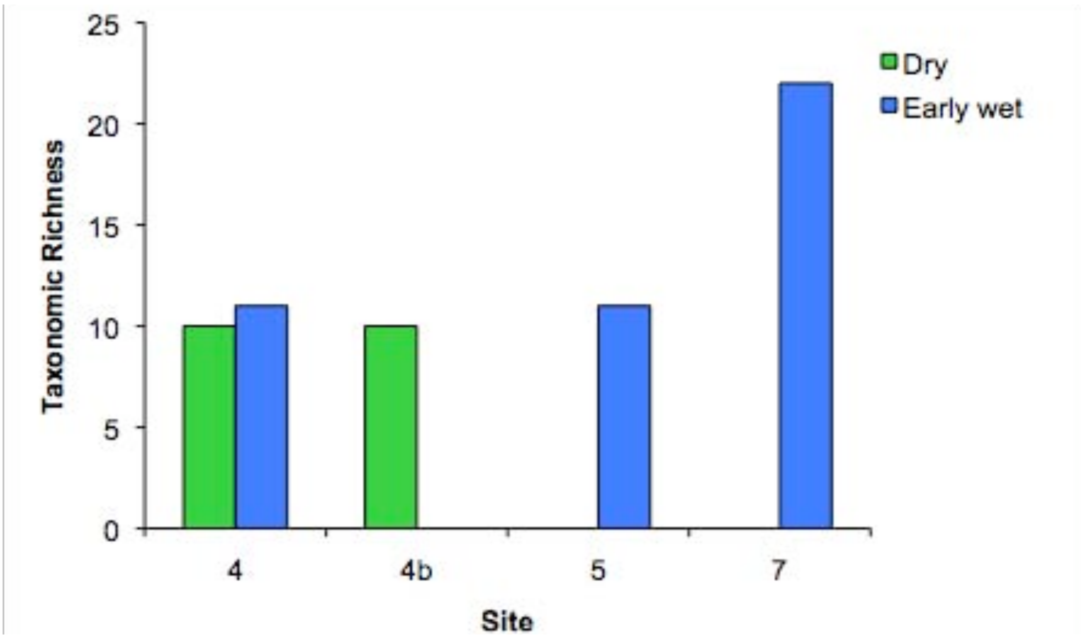


Figure 4.30 Taxonomic richness of macroinvertebrate communities in edge habitat at sites along the gas supply pipeline, sampled in the dry (August 2008) and early wet (February 2009) season surveys.

4.4.2.2 PET Richness

During the early wet season survey, PET taxa were absent from bed habitats at all of the sites (Figure 4.31). In comparison, PET taxa were present in edge habitats and indicative of low to moderate habitat quality (Figure 4.32). Reduced PET richness is likely due to the level of natural environmental stresses associated with the ephemeral or intermittent nature of the waterways throughout the two study areas, which make these creeks unsuitable for many very sensitive PET taxa. The increase in PET taxa during the wet season survey is probably due to increased edge habitat availability and diversity as pools become deeper.

4.4.2.3 SIGNAL 2 / Family Bi-plots

Macro-invertebrate communities surveyed from bed and edge habitats, throughout the gas supply pipeline study area were generally in quadrant 4 of the bi-plot (Figure 4.33 & Figure 4.34), both in the dry and wet season surveys. This indicates communities may be impacted by agricultural pollution and runoff, which is consistent with the surrounding land use and the results in the MLA study area (refer to Attachment B and EIS Volume 1, TR 17B-1-V1.5).

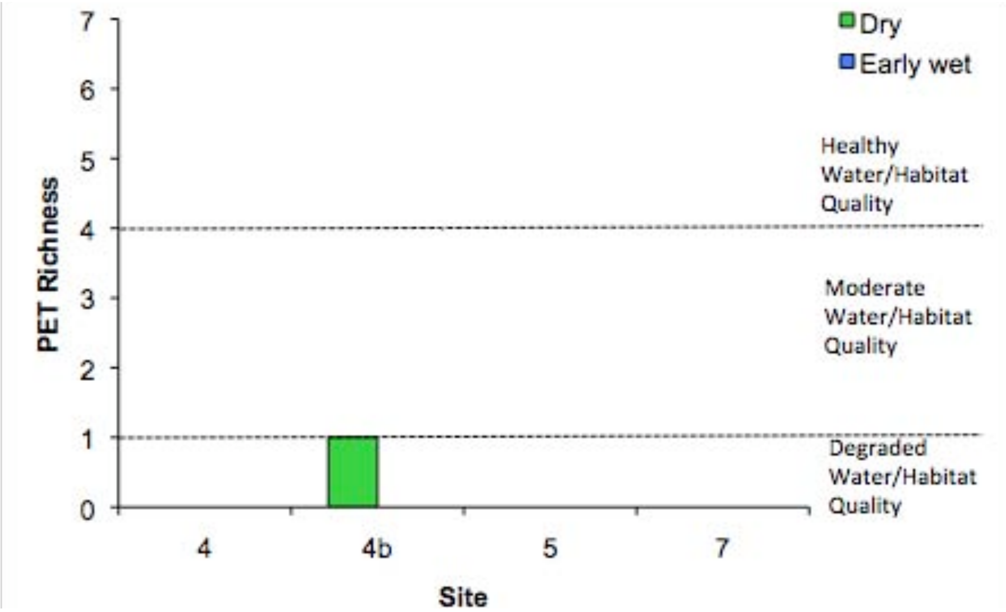


Figure 4.31 PET richness of macro-invertebrate communities in bed habitat at sites along the gas supply pipeline, sampled in the dry (August 2008) and early wet (February 2009) season surveys.

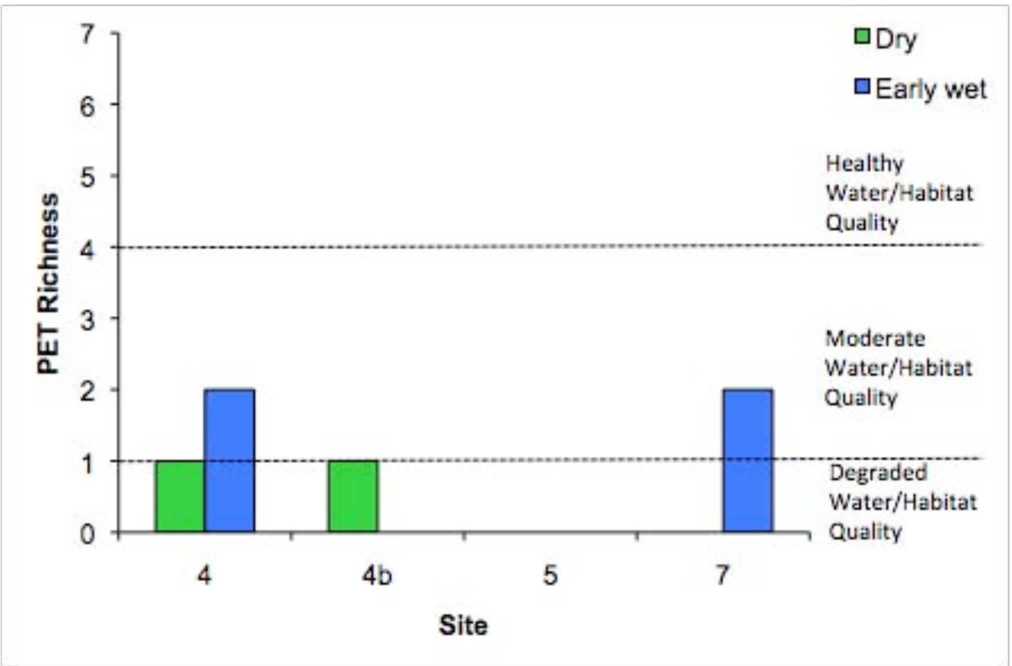


Figure 4.32 PET richness of macroinvertebrate communities in edge habitat at sites along the gas supply pipeline, sampled in the dry (August 2008) and early wet (February 2009) season surveys.

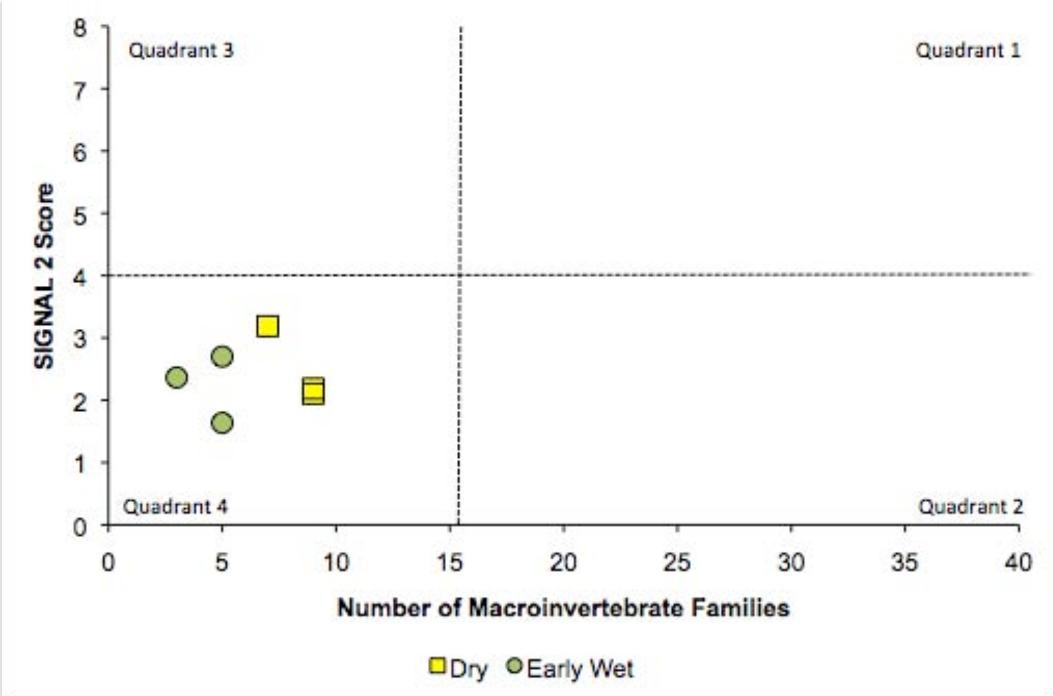


Figure 4.33 SIGNAL 2 / Family Bi-plot for the macro-invertebrate communities sampled from bed habitat in sites along the gas supply pipeline.

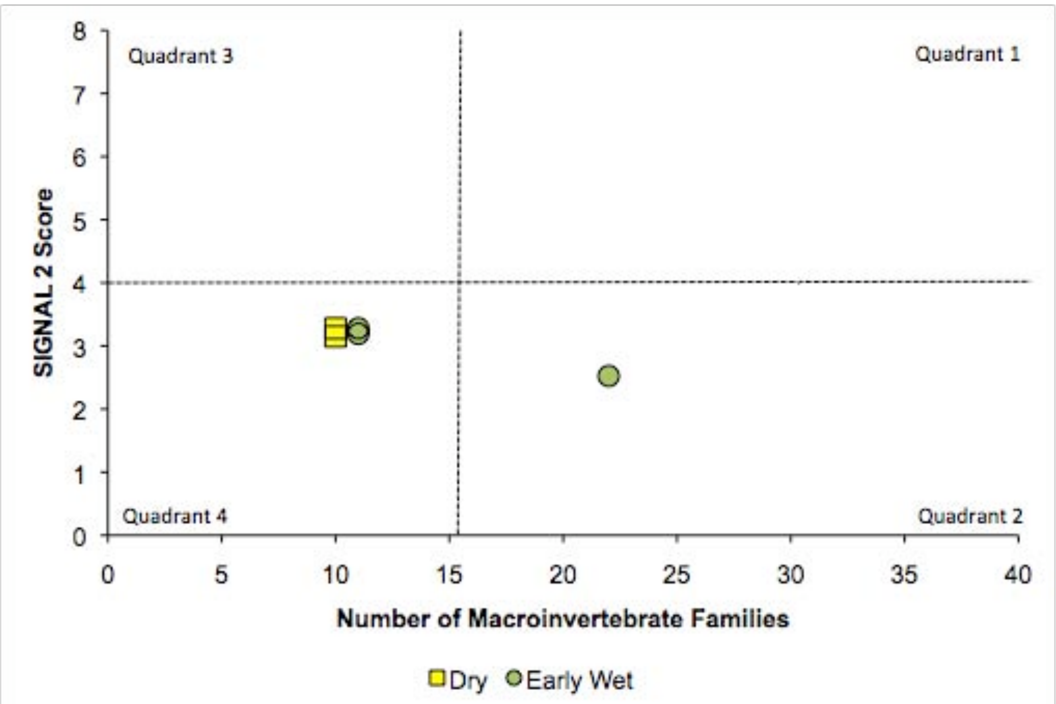


Figure 4.34 SIGNAL 2 / Family Bi-plot for the macro-invertebrate communities sampled from edge habitat at sites along the gas supply pipeline.

4.4.3 Macrocrustaceans

A total of 88 macrocrustaceans were captured across the three sites in the early wet season survey, using a variety of methods. The majority of macrocrustaceans (58) were captured in the early wet season survey (February 2009) from Roche Creek (site 5) (Figure 4.35). A greater number of macrocrustaceans were collected at sites on Roche and Juandah Creeks (sites 4a and 7) in the wet season survey, than in the dry (Figure 4.35). This is likely to be due to higher water levels, and therefore greater habitat availability, in the wet season than the dry season surveys.

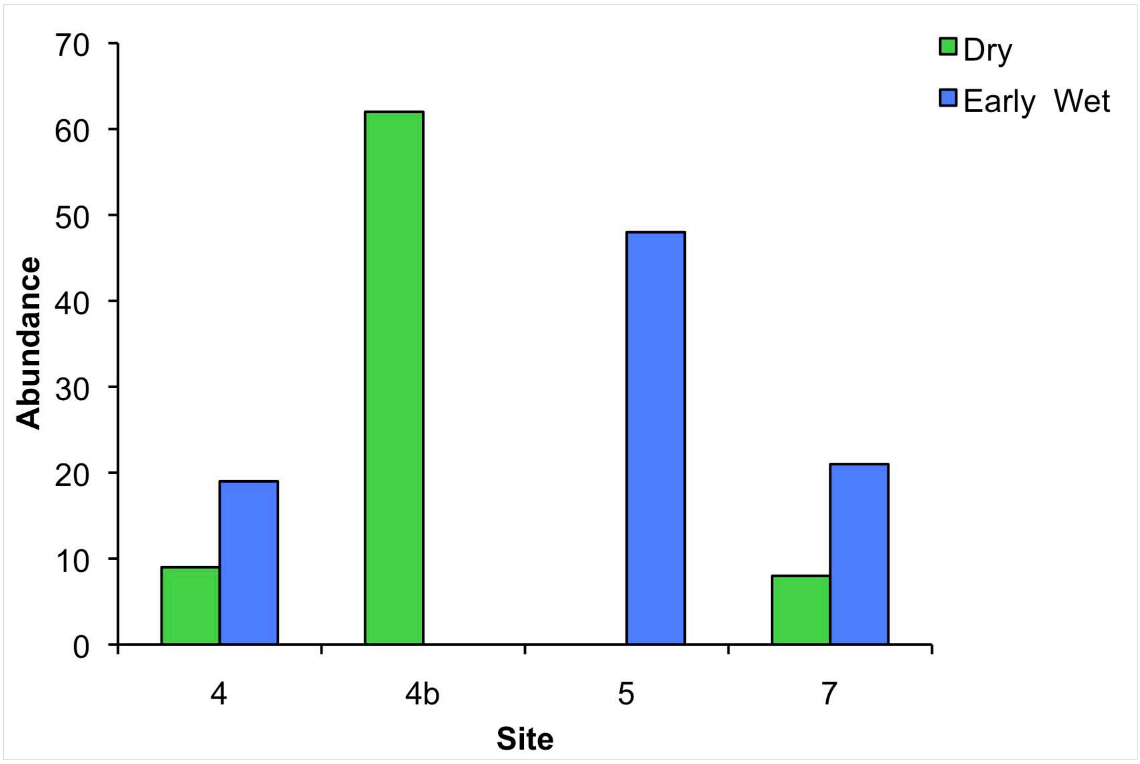


Figure 4.35 Macrocrustacean abundance at each site surveyed in the gas supply pipeline study area, sampled in the dry (August 2008) and early wet (February 2009) season surveys.

The yabby or freshwater crayfish (*Cherax destructor destructor*) was the most common species, being recorded at all three sites surveyed (Table 4.6). Adult, intermediate and juvenile yabbies were captured at all sites sampled in the early wet season survey. *Macrobrachium australiense* were also present at all three sites. *Caridina* sp. were collected from sites 4b and 7, while *Paratya* sp. were collected from sites 4a and 4b.

All four species of macrocrustacean were captured across sites in Roche Creek and two of the species were captured in Juandah Creek (Table 4.6).

Table 4.6 Abundance of macrocrustaceans at each site surveyed in the gas supply pipeline study area.

			Site			
Family	**Latin Name**	**Common Name**	**4**	**4b**	**5**	**7**
Atyidae	*Caradina sp.*	freshwater shrimp	–	–	**	**
Atyidae	*Paratya sp.*	freshwater shrimp	–	–	**	–
Palaemonidae	*Macrobrachium australiense*	Australian river prawn	**	–	–	–
Parastacidae	*Cherax d. destructor*	common freshwater yabby	***	–	***	***

(log 10 abundance categories: * 1; ** <10; ***<100; **** < 1,000; ***** >1,000)

4.5 Fish Communities

4.5.1 MLA Study Area

In total, 1,311 fish from twelve species were captured across sites surveyed in the early wet season survey (January 2009). Fewer fish were caught in the late wet season survey (March 2008), most likely due to a number of species dispersing out of isolated pools during the wet season when connectivity is much higher among pools (see section 4.5.3 in and EIS Volume 1, TR 17B-1-V1.5). In the early wet season survey, abundance in on-stream pools was generally < 50 fish at any one site, however 144 and 101 fish were caught at site 3 in Woleebee Creek and site 10 in Juandah Creek respectively (Figure 4.36 & Table 4.7). Generally, more fish were caught in off-stream dams (sites 11, 12 & 13), with up to 422 fish caught in the dam at site 13; although species richness in dams was often quite low (Figure 4.37). Differences in the abundance and species richness between on and off-stream habitats could be due to suitable habitat availability and stocking efforts by individual farmers.

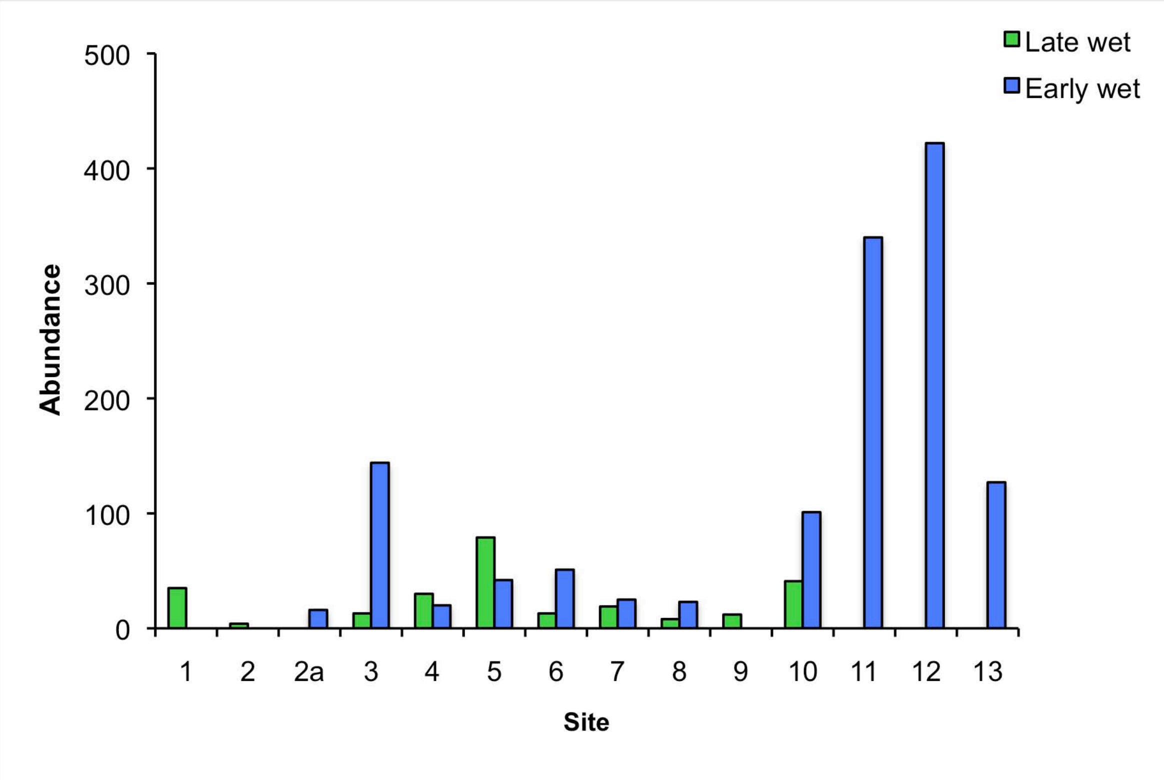


Figure 4.36 Total fish abundance at each site in the MLA study area (all survey methods combined) caught in the early (January 2009) and late wet (March 2008) season surveys. Sites 1, 2 and 9 were dry in the early wet season survey.

Species richness was also generally higher in the early, than late wet season survey, again reflecting differences in the dispersal of fish during higher flow conditions before the late wet season. In the early wet season survey, species richness at on-stream sites ranged from three species at One-Arm Man Creek (site 2) to nine species at Juandah Creek downstream of the MLA areas (site 10) (Figure 4.37). Species richness and abundance at each survey site was likely related to site-specific factors such as the size of the pool surveyed, the presence and abundance of physical habitat such as large woody debris and fish passage within the waterway.

The greatest number of species were caught both in the early and late wet season surveys at Juandah Creek downstream of the MLA areas (site 10), which is close to the perennial waters of the Dawson River (approximately 2 km downstream). A deep water pool behind a constructed ford restricts fish passage downstream during low- to no-flow conditions (Figure 4.38).

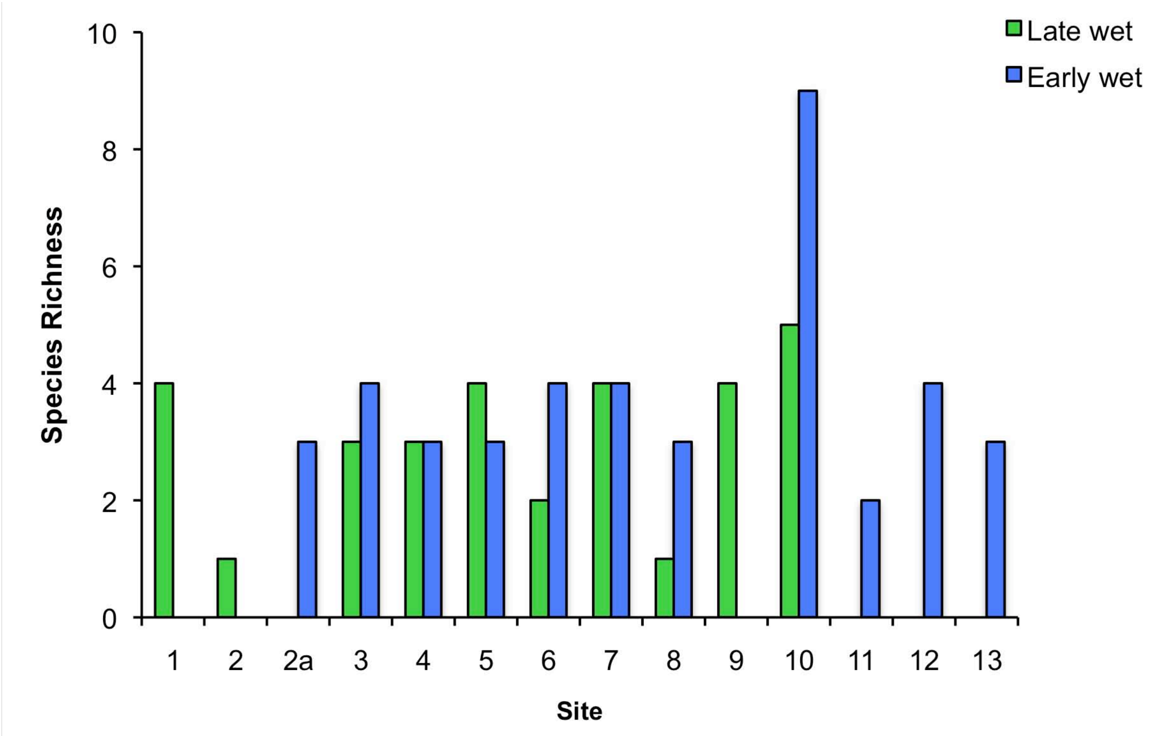


Figure 4.37 Species richness of fish captured at each site in the MLA study area (all survey methods combined) caught in the early (January 2009) and late wet (March 2008) season surveys. Sites 1, 2 and 9 were dry in the early wet season survey.

Figure 4.38

Constructed ford downstream of Roma-Taroom Road on Juandah Creek (site 10).

Table 4.7 Abundance of fish species at each site in the MLA study area (all survey methods combined). Sites 1, 2 and 9 were dry in the early wet season survey (Early wet: February 2009; Late Wet: March 2008).

Family	Species	Common name	1		2	2a	3		4		5		6		7		8		9		10		11		12		13	
			Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet	Late Wet	Early Wet
Ambassis	*Ambassis agassizi*	Agassiz's glassfish	11				2	42		5	50	15		24				7				1						10
Clupeidae	*Nematalosa erebi*	bony bream																			15	59						
Cyprinidae*	*Carassius auratus*	goldfish														2						1						
Eleotridae	*Hypseleotris* spp.^	carp gudgeon	4			12		67	2	1	16	5	7	3	6	10		8				18		336		416		96
Eleotridae	*Oxyeleotris lineolata*	sleepy cod																			1							
Melanotaeniidae	*Melanotaenia splendida*	eastern rainbowfish	1			2	1	19			6			1	3	10			2			13		4				
Osteoglossidae	*Scleropages leichardti*	southern saratoga																				1						
Percichthyidae	*Macquaria ambigua*	golden perch																	3		4	1				1		
Poecliidae*	*Gambusia holbrooki*	Mosquitofish																				6						
Plotosidae	*Neosilurus hyrtlii*	Hyrtl's tandan							2						1				3		20							
	Tandanus tandanus	common catfish																								4		
Terapontidae	*Leiopotherapon unicolor*	spangled perch	19		4	2	10	16	26	14	7	22	6	23	8	1	8	8	4		1	1				1		21
		unidentified juvenile													1													

* Introduced species

^ The gudgeon *Hypseleotris* complex is extremely difficult to identify correctly and can hybridise (interbreed) (Pusey et al. 2004) therefore we have pooled carp gudgeons into a single generic group for analyses.

Spangled perch and carp gudgeons were the most widely distributed and abundant species, and were captured from every site surveyed except the dam at site 11 (Figure 4.39 & Table 4.7). The carp gudgeon (*Hypseleotris*) complex is extremely difficult to identify correctly and can hybridise (interbreed) (Pusey et al. 2004) therefore voucher specimens from the study area were identified by experts at the Queensland Museum (Figure 4.40 & Figure 4.41). At least two *Hypseleotris* species were positively identified: *Hypseleotris* sp. 1 (Midgley's carp gudgeon) and *Hypseleotris* sp. 2 (Lake's carp gudgeon).

Eastern rainbowfish (Figure 4.42) and Agassiz's glassfish (Figure 4.44) were common but not very abundant throughout the study area (Figure 4.42). Less common species included bony bream, golden perch and freshwater catfish (Figure 4.46). Bony bream, southern saratoga, sleepy cod (Figure 4.47) and mosquitofish have only been caught in Juandah Creek downstream of the MLA areas (site 10).

Only one individual southern saratoga (Figure 4.43) was caught in Juandah Creek (site 10), downstream of the MLA areas (Table 4.7). The distribution of southern saratoga is limited to the Fitzroy River Basin (Pusey et al. 2004) and the status of this species is listed as lower risk / near threatened (Pusey et al. 2004; ICUN 2009). No fish caught in this study are listed as threatened species under State or Commonwealth legislation.

Figure 4.39

An adult spangled perch from the dam at site 12.

Figure 4.40

An adult carp gudgeon (*Hypseleotris* sp. 1) from Mud Creek (site 5).

Figure 4.41

An adult carp gudgeon (*Hypseleotris* sp. 2) from Woleebee Creek at Grosmont Road (site 3).

Figure 4.42

An adult eastern rainbowfish from the dam at site 11.

Figure 4.43

An adult southern saratoga in Juandah Creek at site 10.

Figure 4.44

An adult Agassiz's glassfish at Woleebee Creek at Grosmont Road site 3.

Figure 4.45

Golden perch in the farm dam at site 12. The landowner reported that they had been stocked there.

Figure 4.46

An intermediate freshwater catfish caught in the farm dam at site 12.

Figure 4.47

An adult sleepy cod at Juandah Creek, downstream of the MLA areas (site 10).

4.5.1.1 Life History Stages

All life history stages (juvenile, intermediate and adult) were captured for all species except southern saratoga (only one adult was captured at site 10 in the early wet season survey). Across the study area, juveniles and intermediates were the most abundant life history stages for most species including bony bream, eastern rainbowfish, golden perch, Agassiz's glassfish, carp gudgeons and spangled perch. The presence of high numbers of juveniles and intermediates could be related to early breeding events in the wet season (Marsden & Power 2007).

4.5.1.2 Indicators of Stream Health

Mosquitofish and goldfish were the only introduced species captured during the survey. No listed threatened species were captured during the survey. Several spangled perch caught in Mud Creek (site 5) had lesions (Figure 4.48), though the incidence of this was more widespread in the late wet season survey (EIS Volume 1, TR 17B-1-V1.5). This may be due to the fungal disease Epizootic Ulcerative Syndrome (EUS or red spot disease) (EIS Volume 1, TR 17B-1-V1.5), though no testing was done to confirm this, as it was beyond the scope of the current study. The factors that cause this disease are unclear (Humphrey & Pearce 2004). All other fish appeared healthy.

Figure 4.48

At site 5, several spangled perch had lesions.

4.5.2 Gas Supply Pipeline Study Area

The species richness and abundance of fish caught in the early wet season survey (February 2009), was much greater than that caught in the dry season survey (August 2008) (Table 4.8). In total, 181 fish from five species were captured across the three sites surveyed in the early wet season survey. Abundance was quite high for some species, particularly in Roche Creek (site 5) (Table 4.8). The differences in species richness and abundance are likely due to seasonal effects on fish breeding and movement once pools become connected in the wet season.

Carp gudgeons were the most common species caught throughout the gas supply pipeline study area, being captured from two of the three sites surveyed. Goldfish (Figure 4.49) were only captured in Juandah Creek (site 7), however they were less abundant in the early wet season survey than previously found in the dry season.

Table 4.8 Abundance of fish species at each site surveyed along the gas supply pipeline route (all survey methods combined) (Early wet: February 2009; Dry: August 2008).

Family	**Species**	**Common name**	**4**		**4b**	**5**	**7**	
			Dry	**Early Wet**	**Dry**	**Early Wet**	**Dry**	**Early Wet**
Ambassis	*Ambassis agassizii*	Agassiz's glassfish	1	55	1	2		1
Cyprinidae*	*Carassius auratus*	goldfish					10	2
Eleotridae	*Hypseleotris* spp.^	carp gudgeons		1	10	75	3	5
Terapontidae	*Leiopotherapon unicolor*	spangled perch	3			26		4
Melanotaeniidae	*Melanotaenia splendida splendida*	eastern rainbowfish		6				3

* Introduced species.

^ The gudgeon *Hypseleotris* complex is extremely difficult to identify correctly and can hybridise (interbreed) (Pusey et al. 2004) therefore we have pooled carp gudgeons into a single generic group.

Figure 4.49

An intermediate goldfish from Juandah Creek (site 7).

4.5.2.1 Life History Stages

A range of life history stages were found in the fish communities samples at sites in the gas pipeline study area. Intermediate growth forms were the most abundant life stage for carp gudgeons, while adults were the dominant growth form for Agassiz's glassfish and rainbowfish. The largest species (on average) was the goldfish and the smallest species (on average) was the carp gudgeon.

4.5.2.2 Indicators of Stream Health

Goldfish are an introduced species native to eastern Asia, and are listed as non-indigenous under the Fisheries Regulation 2008. They are able to withstand high summer temperatures and low DO levels, and feed on a varied diet that includes detritus, plant matter and aquatic macro-invertebrates (Allen et al. 2002).

No listed threatened species were captured during the surveys.

4.5.3 Fish Habitat Value of the Creeks in the Study Areas

Aquatic habitats within the MLA areas can be classed as ephemeral or intermediate in nature and are exposed to substantial variation in the flow rates and generally low connectivity during the dry season when many of the tributaries dry out (EIS Volume 1, TR 17B-1-V1.5). Despite high environmental variability, these areas provide habitat for many fish species that undergo upstream and downstream migrations to breed during the wet season (see EIS Volume 1, TR 17B-1-V1.5 for a discussion of fish migration), particularly in the larger tributaries such as Woleebee and Juandah Creeks.

Few recreational species were sampled from within the MLA areas, except for those stocked in farm dams (golden perch & catfish). A number of recreational species were caught downstream of the MLA areas in Juandah Creek (site 10) (including golden perch and southern saratoga). These species are likely restricted to the larger more perennial pools found at this site, however golden perch are known to migrate long distances upstream during the wet season when connectivity and water flow along the waterways increases, for example, they were recorded in Woleebee Creek the MLA areas (site 4) in the late wet season survey (Allen et al 2002; see section 5.5.3 in EIS Volume 1, TR 17B-1-V1.5). Southern saratoga are long-lived predatory species, that exhibit high levels of parental care following a prolonged period of courtship and direct pairing (Pusey et al 2004). Little is known of the migration habitats of this species, but it is endemic to the Fitzroy River Basin and it has not been recorded moving through fishways (Pusey et al 2004), so is unlikely to undergo large spawning migrations.

These ephemeral stream habitats are similar to others found in the region and are unlikely to present any unique habitat types in the region.

4.6 Turtle Communities

4.6.1 MLA Study Area

Only one species of turtle was captured or observed throughout the study area during both surveys. Three juvenile *Emydura macquarii krefftii*[3] (Krefft's river turtle) were captured in Juandah Creek downstream of the MLA areas (site 10) in the early wet season (January 2009), where this species had previously been recorded in the late wet season survey (March 2008). In the early wet season (January 2009), four adults were also captured in the farm dam at site 11 (Figure 4.50).

Figure 4.50

An adult Krefft's river turtle at site 11.

4.6.2 Gas Pipeline Study Area

Turtle traps were set at all three sites sampled in the gas pipeline study area in the wet season survey, but no turtles were caught or observed at any of the sites.

[3] 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).

4.6.3 Other Aquatic Vertebrates

The aquatic ecology survey did not target other aquatic vertebrates, however in the MLA areas, various species were noted including a keelback snake (site 3), a cane toad (site 4) and a number of nesting water birds in the farm dams. Platypus were not observed at any sites in the survey area, and anecdotal evidence from landowners suggests that platypus have not been seen within the MLA areas or along the gas supply pipeline route for many years.

Summary of Environmental Values

The results of surveys in the early wet season were consistent with those in the late wet season. While the aquatic flora and fauna communities are spatially and temporally variable, the assessment of aquatic ecological environmental values remains unchanged and consistent with that presented in the previous technical report (EIS Volume 1, TR 17B-1-V1.5). No listed rare or threatened aquatic species were recorded in either survey.

5 Description of Refinements / Modifications to the Proposed Development that affect Aquatic Ecology

Recent refinements / modifications to the Project following submission of the EIS that have the potential to affect the aquatic ecology of the study area are summarised below.

The development of Wubagul Pit, to the south of Frank Creek Pit, will result in the loss of approximately 2.3 km of natural stream from a small, unnamed waterway. It also has the potential to affect Two Mile Creek, which is just south of the proposed pit. Both tributaries flow directly into Juandah Creek just south of Wandoan. Deferral of the Woleebee South Pit will result in the retention of a tributary of Woleebee Creek.

There have been changes to the coarse and fine (tailings) rejects disposal strategy, as outlined in Supplementary EIS Chapter 6. The tailings starter dam has been removed from the strategy, and instead tailings produced in Year 1 of the Project will be stored in the Austinvale North Pit. Throughout mine operation, tailings will be stored in voids created in MLA areas 50230 and 50231. Coarse rejects will be mixed with overburden and stored at overburden storage locations.

The number and location of environmental and sediment dams has also changed due to changes to pit configuration (refer to Supplementary EIS Chapter 11). There are now 12 potential discharge points from the MLA areas, with up to 46 sediment dams and 7 environmental dams (at any time). However despite these changes, the principals of the Water Management System (WMS) remain unchanged, i.e. there is ‘no planned’ pit/process water discharge from the mine site under normal operating conditions. Wastewater from the Coal Handling and Processing Plant (CHPP) will be recycled in a closed-loop system.

The Wandoan Joint Venture (WJV) has also proposed an upgrade of the existing Wastewater Treatment Plant (WWTP) to handle increased supply from the mine. The proposed effluent will meet the requirements of Class B recycled water. Where possible, the effluent will be used for irrigation of the town show grounds and golf course. Excess treated wastewater will be discharged to Juandah Creek during times of high flow of the watercourse, such as during storm events.

Public road realignments such as the Jackson-Wandoan Road, the Booral Road and Grosmont Road intersection, and the Western deviation (connecting Cecils and Ryalls Roads with the Kabundan Road and K Road intersection) cross or run adjacent to minor tributaries of Woleebee, Duck, Spring and Mud Creeks. The realigned Jackson-Wandoan Road will run close to Halfway Creek.

The mine access road has also changed. This access road crosses Frank Creek, and a number of minor tributaries to Juandah Creek. There have also been some minor changes to haul road alignments associated with changes to pit configuration. The revised portions of the haul road alignments cross small waterways such as the upper reaches of Halfway and Frank Creeks.

6 Updated Assessment of Potential Impacts

Given that the assessment of environmental values has not changed since seasonal surveys were undertaken, the assessment of potential impacts associated with construction and operation of the MLA areas and the gas supply pipeline remains consistent with the assessment presented in the EIS.

Changes to the impact assessment due to refinements / modifications of the Project or to respond to the EIS submissions are presented below.

6.1 Operation of Vehicles and Equipment

The assessment of the potential impacts of the operation of vehicles and equipment on aquatic ecology is consistent with the assessment presented in EIS Volume 1, TR 17B-1-V1.5.

6.2 Vegetation Clearing and Earth Moving

The assessment of the potential impacts of vegetation clearing and earth moving on aquatic ecology is consistent with the assessment presented in EIS Volume 1, TR 17B-1-V1.5; the potential impacts of refinements / modifications to the mine plan since the EIS are described below.

6.2.1 Changes to Construction Activities and Timing

The planned development of the Wubagul Pit from Years 3 to 5 is likely to result in the removal of a small un-named tributary of Juandah Creek, and has the potential to indirectly impact on the adjacent Two Mile Creek via runoff of sediment-laden or potentially contaminated water into this creek. The construction of road realignments, particular adjacent to creeks or at creek crossings, also has the potential to impact aquatic ecology via runoff of sediment-laden or potentially contaminated water into waterways.

6.3 Wastewater and Stormwater

6.3.1 Stormwater

Although additional sediment dams are planned, the design and operation of these dams, and the assessment of impacts of these planned discharges on aquatic ecology, is consistent with that described in EIS Volume 1, TR 17B-1-V1.5. Planned release of water from these dams will meet designated water quality criteria (as outlined in the EM Plan in Chapter 27A) and will occur during rainfall (i.e. natural flow) events. The discharge of water from the sediment dams is expected to have a conductivity of no greater than 710 µS/cm (refer to Supplementary EIS Volume 1, STR 11-1-SV1.5), which is not expected to impact on aquatic flora and fauna communities in downstream environments, based on the published tolerances of aquatic flora and fauna to varying levels of salinity (refer to EIS Volume 1, TR 17B-1-V1.5; Hart et al. 1991; Nielsen et al. 2003; Pusey et al. 2004;Kefford et al. 2004; Horrigan et al. 2007). Turbidity levels are also likely to meet discharge limits, which have been based on natural turbidity in the study area, and as such no adverse impacts from high turbidity are expected.

Overflow of the sediment dams, or dam failure, has the potential to allow sediments, nutrients and contaminants (in greater concentrations than for planned discharges) to enter the creeks of the MLA areas and downstream waters. The addition of sediment dams to the Project scope theoretically increases the risk of such a spill. Unplanned discharges from these sediment dams would flow to Juandah Creek, which would have an impact on the aquatic flora and fauna of Juandah Creek (the nature of such impacts is described in EIS Volume 1, TR 17B-1-V1.5), but which would be unlikely to impact on waters further downstream such as the Dawson River. The extent of impacts would be reduced where sediment dams are overtopped during high rainfall events (which is expected to be the likely cause of such a spill), due to dilution and dispersion of sediments, nutrients and contaminants during rainfall events.

6.3.2 Industrial Wastewater

The proposed changes to the tailings disposal strategy are unlikely to directly impact on aquatic ecology. Where groundwater is not impacted, no indirect impacts to aquatic ecology from the tailings storage strategy are likely (refer to Supplementary EIS Chapter 10 for a discussion of potential impacts to Groundwater).

The addition of environmental dams to the Project scope theoretically increases the risk of a spill from these dams. While there is no planned discharge from the environmental dams, and they are not expected to overtop based on historical climate extremes, any spills from the additional environmental dams would impact on the aquatic flora and fauna of Juandah Creek (the nature of such impacts is described in EIS Volume 1, TR 17B-1-V1.5); though impacts on waters further downstream such as the Dawson River would be unlikely. The extent of impacts would be reduced where environmental dams are overtopped during high rainfall events (which is expected to be the likely cause of such a spill), due to dilution and dispersion of sediments, nutrients and contaminants during rainfall events.

6.3.3 Domestic Wastewater

Although the scope for the Wandoan WWTP upgrade and operation has been refined, the assessment of impacts remains consistent with that presented in EIS Volume 1, TR 17B-1-V1.5, Section 6.3.3.

6.4 Water Supply

The assessment of the potential impacts of the proposed water supply options is consistent with the assessment presented in EIS Volume 1, TR 17B-1-V1.5. As outlined in the Department of Primary Industries and Fisheries (DPI&F) (now Department of Employment, Economic Development and Innovation (DEEDI)) submission on the EIS, it is important to note that there is the potential for aquatic disease or exotic species transfer associated with the water supply options. The impacts of these options are further described in the other Volumes of the Supplementary EIS.

6.5 Loss of Catchment Area

Construction of the mine, including the Wubagul Pit, and expansion of the Austinvale North and Leichhardt Pits (but not including the Woleebee South Pit), will result in the loss of up to 100 km of natural streams (which may be lost to pits, replaced by diversion channels or directed into sediment and environmental dams). This increases the total area of catchment directed to the site water management system to up to 10,560 ha by Year 30 of the Project (not including natural buffer areas adjacent to disturbance areas within the MLA areas). However, this loss of catchment area remains unlikely to have a regionally significant impact on aquatic ecology, as there are over 868,000 ha of similar catchment area within the Southern Tributaries Sub-catchment of the Dawson River alone (i.e. only 1.2% of the subcatchment area will be impacted).

6.5.1 Changes to Flow Regimes

As outlined in the EPA's (now DERM) submission, changes to the flood regime, and the timing and magnitude of flows in watercourses, have the potential to impact on aquatic ecology.

An increase in water levels during flooding due to watercourse diversions and flood levees is unlikely to affect aquatic ecology *per se*; rather, the associated increase in water velocities draining the flooded areas is more likely to have an impact. Increased water velocities in waterways have the potential to cause scouring and erosion of the waterways. The potential impacts of increased erosion and sedimentation on aquatic ecology are discussed in the original technical report (EIS Volume 1, TR 17B-1-V1.5). An increase in water velocity in some watercourses may also inhibit fauna migration and movement upstream, and may result in some flora and fauna being swept downstream. However, biota would be expected to re-colonise such watercourses after flow velocities subside.

The rainfall patterns in the region and the design of the sediment dams are such that the release of water that meets the relevant water quality objectives from the water management system to the receiving environment, will only occur during periods of rainfall and natural flow in the creek. It is estimated that flows from sediment dams will only continue for up to 10 days after natural flows in the creeks have ceased. That is, flows from the sediment dams will not be unseasonal, and as such are unlikely to impact on the reproduction and migration cues for aquatic fauna.

The mine and associated water management system is expected to reduce mean annual flows immediately downstream of the MLA areas by approximately 3.4% by Year 30 of the Project (refer to Supplementary EIS Volume 1, STR 11-1-SV1.5). As the timing of flows to the creek systems coincide with natural flows (refer to Supplementary EIS Volume 1, STR 11-1-SV1.5), this decrease in mean annual flow is considered unlikely to significantly impact on aquatic flora and fauna. The impact to smaller waterways such as Duck, Spring and Mud Creeks is greater than for larger waterways such as Woleebee and Juandah Creeks, which may result in these smaller waterways being dry for longer periods of time. However, impacts to flows in these systems are unlikely to result in significant impacts to aquatic flora and fauna in a regional context, given the relatively small contribution of these catchments to the larger catchments of Horse and Juandah Creeks.

6.5.2 Stranding of Fish and Turtles

Surveys completed in farm dams within the MLA areas in early wet season of January 2009 showed that these permanent waterbodies provide habitat for turtles and a number of fish species, including those of recreational fisheries significance. The loss of these farm dams in association with the construction of pits or mine infrastructure will cause turtles and fish to perish unless these fauna are relocated (see Section 7.5.2).

6.6 Creek Diversions

As outlined in the Department of Primary Industries and Fisheries (DPI&F) (DPI&F (now DEEDI) submission on the EIS, it is important to note that the creeks to be diverted provide fish habitat, and a movement / migration pathway for aquatic fauna. Poorly designed diversion channels have the potential to impact on fish habitats and movement / migration, which in turn could affect the fisheries productivity of the catchment upstream. There may be increased water velocities in the diversion channels compared with natural channels, the impacts of which have been discussed above.

6.7 Creek Crossings

The potential impacts of creek crossings of roads, rail and pipelines on aquatic ecology remains consistent with that presented in the EIS and associated technical report (TR17B-1-V1.5), based on results of the seasonal surveys and the known alignment of roads, rail and pipelines.

6.8 Biting Insects

The assessment of the potential impacts of biting insects on human health is consistent with the assessment presented in EIS Volume 1, TR 17B-1-V1.5.

6.9 Matters of National Environmental Significance

There are no predicted impacts to matters of National Environmental Significance after completion of the seasonal surveys. Background to this assessment is presented in the EIS and associated technical report (EIS Volume 1, TR 17B-1-V1.5).

7 Updated Assessment of Avoidance, Minimisation and Mitigation of Impacts

Impacts to aquatic ecology can be avoided, minimised or mitigated by following the recommendations presented in the EIS and associated technical report (EIS Volume 1, TR 17B-1-V1.5), which are considered to be accurate and current based on the results of seasonal surveys and the nature of the refinements / modifications to the Project. Recommendations have been modified or updated below where appropriate.

7.1 Operation and Maintenance of Vehicles and Equipment

The assessment of appropriate measures to avoid, minimise or mitigate the impacts of operation of vehicles and equipment on aquatic ecology is consistent with the assessment presented in EIS Volume 1, TR 17B-1-V1.5.

7.2 Vegetation Clearing and Earth Moving

The assessment of appropriate measures to avoid, minimise or mitigate the impacts of vegetation clearing and earth moving on aquatic ecology is consistent with the assessment presented in EIS Volume 1, TR 17B-1-V1.5.

Impacts from vegetation clearing and earth moving in association with construction of the Wubagul Pit, and expansion of the Austinvale North and Leichhardt Pits, can be minimised and avoided where the recommendations presented in the EIS and associated technical report (EIS Volume 1, TR 17B-1-V1.5) are followed, and water management principles being applied to other pits (such as the construction of sediment and environmental dams in association with these disturbed areas) are used.

Appropriate measures under the erosion and sediment control plan (as described in detail in EIS Volume 1, TR 17B-1-V1.5) should be undertaken to minimise the potential impact of realigning public roads on aquatic ecology. This is particularly important for creek crossings and where the alignment of the Jackson-Wandoan Road runs close to Halfway Creek.

7.3 Wastewater and Stormwater

Where water discharged from the MLA areas and associated infrastructure meet the site-specific Water Quality Objectives (WQOs) for the Project, which are described in Supplementary EIS Chapter 11 Water Supply and Management and the associated Addendum to the Surface Water Quality Technical Report, no significant impacts to the aquatic flora and fauna communities of the region are expected.

7.4 Water Supply

Measures to minimise and mitigate the potential impacts associated with water supply remain consistent with recommendations presented in the EIS and associated technical report (EIS Volume 1, TR 17B-1-V1.5).

To effectively address the risk of aquatic disease or exotic species transfer, as flagged in the DPI&F (now Department of Employment, Economic Development and Innovation DEEDI) submission, water supplied from other catchments should be free of micro and macroalgae, macrophytes and aquatic fauna (including seeds, eggs and larvae). Further information is presented in Supplementary EIS Volume 2, STR 17B-1-V2.5.

7.5 Loss of Catchment Area

Measures to minimise and mitigate the potential impacts associated with the loss of catchment area remain consistent with recommendations presented in the EIS and associated technical report (EIS Volume 1, TR 17B-1-V1.5).

7.5.1 Changes to Flow Regimes

Measures to minimise and mitigate the potential impacts associated with changes to the magnitude and timing of flows to downstream waterways remain consistent with recommendations presented in the EIS and associated technical report (EIS Volume 1, TR 17B-1-V1.5).

7.5.2 Stranding of Fish and Other Aquatic Fauna

As noted in the DPI&F submission, stranded turtles and fish in farm dams to be lost or creeks to be diverted will be captured and translocated, following the DPI&F *Fish Salvage Guidelines* (DPI&F 2004), as outlined in detail in the EIS and associated technical report. Captured turtles and fish will be relocated to suitable waterholes in the same waterway to prevent the transfer of exotic fish or aquatic disease.

7.6 Creek Diversions

Many of the planned diversions described in the EIS and associated technical reports will not be constructed for a number of years. While the creek diversions will be carried out in accordance with the general principles described in Chapter 11 Water Supply and Management, specific design guidelines for the design and management of each of the diversions will be developed for the water licence application process under the *Water Act 2000*. These guidelines will consider the impact that the diversions will have on water flow regimes, provision of fish habitat and habitat connectivity and provide mitigation measures to minimise and manage the impact of each creek diversion. Detailed design of the waterway diversions will require input from a multidisciplinary team of ecologists, hydrologists, geomorphologists etc., and is beyond the scope and timeframe of the Supplementary EIS.

The diversion channels will provide an adequate diversity of habitat types, will not be heavily affected by channel alteration (such as from erosion etc.) and will allow for adequate fish passage if the design considerations with respect to aquatic ecology, as presented in the EIS and associated technical report (EIS Volume 1, TR 17B-1-V1.5), are followed. Where these recommendations are followed, the diversion channels are likely to contain aquatic habitat of a similar value to the natural creeks, and will provide for aquatic fauna passage along the length of the diversions.

The ability of the constructed diversion channels to provide adequate aquatic habitats and fish passage will be monitored as part of the aquatic ecology monitoring program (as described in EIS Volume 1, TR 17B-1-V1.5). Where results indicate that the diversion channels are having a significant impact on aquatic flora and fauna, recommendations will be made to improve the design of the channel.

7.6.1 Changes to Flow Regimes

The impacts of increased flow velocities on erosion, and subsequently aquatic ecology, will be reduced where erosion control measures are implemented for the diversion channels, as recommended in the EIS and associated technical report.

Impacts of stream diversions on fish passage will be mitigated by sizing channels to avoid design velocities in excess of 1 m/s as far as practical (most fish are unlikely to be able to migrate upstream when velocities exceed 1 m/s; Cotterell 1998).

Where possible, the diversion channels will be designed such that natural instream flow velocities are not exceeded (preliminary modelling, as described in Volume 1, Section 11.5.6, has indicated that this will generally be achievable). Preliminary modelling indicates that design velocities of less than 1 m/s can be achieved during instream flow events (such as the 1 year ARI flow) in most locations, the exceptions are where existing instream velocities exceed this limit. During larger flow events (up to 50 year ARI flow) floodplain flow velocities less than 1 m/s are also likely to be achievable at all locations. Consideration of both ecological and hydraulic flow objectives will be incorporated into the detailed design phase for each diversion. Design features that will reduce flows in the diversion channel include the incorporation of:

- instream habitat structures such as large woody debris and boulders, to baffle flows
- bends and meanders
- variations in water depth, including regular deep pools, and
- dense riparian vegetation, to buffer against overland flows into the diversion channel.

7.7 Creek Crossings

This section has been updated in accordance with AS2885 and the Australian Pipeline Industry Association Code of Environmental Practice. In addition to the mitigation measures discussed in the EIS and aquatic ecology technical report, which are consistent with the objectives of the standard and code of practice, additional mitigation measures to minimise the impacts associated with the construction of permanent creek crossings include:

- following existing road corridors, which is being done for the majority of water infrastructure pipelines; the gas supply pipeline follows a proposed railway corridor

- the avoidance of sensitive or problem soil/geotechnical areas (such as contaminated soil) to the extent possible
- recontouring, revegetation and rehabilitation of pipeline corridors and the banks of watercourse crossings, and
- observation of flood and severe weather warnings on a daily and longer term basis during construction.

As noted in the Department of Primary Industries and Fisheries (DPI&F, now DEEDI) submission, pipeline installation should avoid drought refuge pools, and waterway barrier works approvals are likely to be required for the construction of temporary crossings and pipeline crossings where construction requires the use of coffer dams etc, as will potentially be done for small-order streams. Depending on the nature of the works required at each crossing, the works may be either assessable or self-assessable development under IPA (for works outside of the MLAs). This will be determined for each crossing prior to construction of the Project, and applications will be made for development approvals where required.

Underground (trenchless) pipeline installation techniques (such as drilling) will be used for crossing of larger waterways holding water, which may include Juandah and Roche Creeks, if necessary. The use of these techniques will not impact on fish passage or aquatic ecology where the recommended mitigation measures outlined in the EIS (Volume 1, TR 17B-1-V1.5) are followed, in addition to the following (APIA 2009):

- Drilling muds shall consist of approved water based products or synthetic lubricants and shall be contained within the fluid circulation system during drilling.
- Drilling muds shall be recycled where practicable, or disposed of in accordance with regulatory requirements.
- Sediment and erosion control measures should be in place around bellholes and drill exit points.

In addition with the recommendations for the construction and rehabilitation presented in the EIS and associated technical report (TR 17B-1-V1.5), temporary creek crossings should be constructed in accordance with DPI&F (now DEEDI) guidelines for permanent creek crossings (Cotterell 1998, described in detail in the EIS TR 17B-1-V1.5), and may require a waterway barrier works permit.

7.8 Biting Insect Management

Further to section 7.8 of the EIS aquatic ecology technical report TR 17B-1-V1.5, in response to the Submission from Queensland Health, the Wandoan Joint Venture (WJV) commits to incorporating biting insect management into its Health and Safety System for the Project. This will be developed prior to the commencement of construction, however in brief it will include, as required, consideration of the:

- extent of potential mosquito and biting midge breeding habitat within the development footprint and surrounding areas
- mosquito and biting midge species likely to occur in the region
- incidence of arboviruses in the region
- extent to which construction and operation of the proposed mine and associated infrastructure will create mosquito and biting midge breeding habitat
- extent to which mosquitoes and biting midges will pose a threat to the health to construction crews, mine employees, and visitors to and residents of the region
- opportunities available to minimise the incidence of mosquitoes and biting midges on the site
- recommended guidelines for the monitoring and control of mosquitoes and biting midges on the site.

7.9 Threatened Species and Ecological Communities

The Project is unlikely to have a significant impact on any threatened species or ecological communities, as discussed in EIS Volume 1, TR 17B-1-V1.5.

7.10 Monitoring Requirements

As described in EIS Volume 1, TR 17B-1-V1.5, a long-term aquatic ecological monitoring program will be implimented to monitor the impacts of the mine of the waterways within the MLA areas, and downstream, and to inform the mine's environmental management plan and remedial actions. The scope of the required monitoring program remains consistent with that presented in EIS Volume 1, TR 17B-1-V1.5, and will be integrated with the water quality monitoring program as far as practical, as described in Supplementary EIS Chapter 11.

The replicated macroinvertebrate data collected during the January 2009 survey of the MLA areas provides a baseline for future monitoring. However, at least one further survey event should be undertaken prior to commencement of mine construction. The results from this survey should be used to determine whether further baseline surveys are required (due to naturally high temporal variation in the system). This data should also be used to refine the design of the monitoring program if required, to ensure that the monitoring program design has adequate power to detect changes in aquatic flora and fauna communities over time.

8 Updated Assessment of Residual Impacts

Where the mitigation measures presented above are followed, the assessment of residual impacts of the Project, including the refinements / modifications to the Project discussed above, remain consistent with those presented in the EIS and associated technical report (TR 17B-1-V1.5).

9 Conclusions

Results of the seasonal surveys in the MLA and gas supply pipeline study areas have not altered the assessment of environmental values or potential impacts of the Project on aquatic ecology.

The assessment of potential impacts and mitigation measures is consistent with that presented in the EIS. In summary to the comments raised in EIS submissions:

- A discussion of water quality and appropriate Water Quality Objectives (WQOs) is presented in the surface water quality technical report
- It is acknowledged that the waterways in the study areas provide important fish habitat, and the creeks to be diverted provide a movement / migration pathway for aquatic fauna. The recommended mitigation measures have taken this into account.
- Changes to the flood regime, and the timing and magnitude of flows in watercourses, have the potential to impact on aquatic ecology through increased water velocities resulting in increased erosion and inhibiting fish passage. These impacts will be eliminated or substantially reduced where erosion control measures are implemented for the diversion channels, and by sizing channels to avoid design velocities in excess of 1 m/s as far as practical (as discussed in Volume 1, Section 11.5.6).
- The co-location of pipeline routes with existing and proposed infrastructure, and the mitigation measures discussed in the EIS and aquatic ecology technical report, are consistent with the objectives of AS2885 and the Australian Pipeline Industry Association Code of Environmental Practice.
- Pipeline installation should avoid drought refuge pools, and waterway barrier works approvals are likely to be required for the construction of temporary crossings and pipeline crossings.
- Depending on the nature of the works required at each crossing, waterway barrier works outside of the MLAs may be either assessable or self-assessable development under the *Integrated Planning Act 1997* (IPA). This will be determined for each crossing prior to the construction of the Project, and applications will be made for development approvals, where required.
- Where waterways are diverted, dams are removed and if an isolation method is used for construction of waterway crossings, stranded turtles and fish will be captured and translocated, following the DPI&F Fish Salvage Guidelines (DPI&F 2004) and relocated to suitable waterholes in the same waterway to prevent the transfer of exotic fish or aquatic disease.

- Underground (trenchless) pipeline installation techniques (such as drilling) will be used for crossing of larger waterways holding water, which may include Juandah and Roche Creeks, if necessary.
- The WJV commits to incorporating biting insect management into its Health and Safety System for the Project, which will be developed prior to commencement of construction of the Project.

10 References

APIA 2009, *Code of Environmental Practice, Onshore Pipelines*, The Australian Pipeline Industry, pp. 132.

Allen, G. R., Midgley, S. H. & Allen, M. 2002, *Field Guide to the Freshwater Fishes of Australia*, eds J. Knight K & W. Bulgin, Western Australia Museum.

BOM 2009, *Daily Weather Observations, Taroom*, [online] http://www.bom.gov.au/climate/dwo/IDCJDW4116.latest.shtml.

Chessman, B. 2003, Signal 2: *A Scoring System for Macro-Invertebrates ('water-bugs') in Australian Rivers*, User Manual Version 4, September 2003.

Clarke, K.R., 1993, 'Non-parametric multivariate analyses of changes in community structure', *Australian Journal of Ecology* 18: 117-143.

Cotterell, E. 1998, *Fish Passage in Streams, Fisheries Guidelines for Design of Stream Crossings*, Fish Habitat Guideline FHG001, Fisheries Group, Department of Primary Industries, Brisbane.

DNRM 2001, *Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual*, August 2001, Queensland Department of Natural Resources and Mines, Rocklea.

DPI&F 2004, *Fish Salvage Guidelines*, Queensland Department of Primary Industries & Fisheries, Brisbane.

EPA 2007a, *Queensland Water Quality Guidelines 2006*, March 2006, Environmental Protection Agency, Brisbane.

Hart, B. T., Bailey, P., Edwards, R., Hortle, K., James, K., McMahon, A., Meredith, C. & Swadling, K. 1991 'A review of the salt sensitivity of the Australian freshwater biota', *Hydrobiologia*, 210: 105 – 144.

Horrigan, N., Dunlop, J. E., Kefford, B. J. & Zavahir, F. 2007, 'Acute toxicity laregely reflects the salinity sensitivity of stream macroinvertebrates derived using field distribtuions', *Marine and Freshwater Research*, 58, 178–186.

Humphrey, J. D. & Pearce, M. 2004, *Fishnote: Epizootic Ulcerative Syndrome (Red-spot Disease)*, No. 1 October 2004, Northern Territory Government [available online] https://transact.nt.gov.au/ebiz/dbird/TechPublications.nsf/1C8A83D28E2A24B16

9256FB6004C7CE6/$file/FN01.pdf?OpenElement, accessed 11 September 2008.

IUCN 2009, *IUCN Red List of Threatened Species* [online], www.iucnredlist.org, accessed.

Kefford B. J., Dalton, A., Palmer, C. G., & Nugegoda, D., 2004, 'The salinity tolerance of eggs and hatchlings of selected aquatic macro-invertebrates in south-east Australia and South Africa', *Hydrobiologia*, 517:179-192.

Marsden, T. & Power, T. 2007, *Proposal for Raising Eden Bann Weir and construction of Rookwood Weir, An Assessment of the Potential Requirements for Fish Passage*, Queensland Department of Primary Industries & Fisheries.

Nielsen, D. L., Brock, M. A., Rees, G. N., & Baldwin, D. S., 2003, 'Effects of increasing salinity on freshwater ecosystems in Australia', *Australian Journal of Botany*, 51:655-665.

Pusey, B. J., Kennard, M., & Arthington, A., 2004, *Freshwater Fishes of North-Eastern Australia*, CSIRO Publishing, Collingwood pp. 684.

Wilson, S. & Swan, G. 2008, *A Complete Guide to Reptiles of Australia*, Second Edition, New Holland, Chatswood.

Appendix A Description of the Sites Surveyed

View upstream through the site (01-02-09)

View of left bank (01-02-09)

View downstream through the site (01-02-09)

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	5
Wetted Width (m):	5
Water Level:	Low
Bank Shape:	Sloping, Vertical

Water Quality

Temperature (C):	24.9
pH:	7.47
Conductivity (uS/cm):	320
DO (mg/L):	4.3
DO (% Sat):	50
Turbidity (NTU):	282
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m): Left: 2 Right: 4

Dominant Type: Eucalypt, Casuarina

Fauna

Ducks
Goanna

Habitat (%)

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

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	5
Gravel:	40
Sand:	50
Silt/Clay:	5

Cover (%)

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

Dominate Cover Type:
Overhanging Vegetation

Sub Dominate Cover Type:
Trailing Bank Vegetation, Large Woody Debris

Comments: Significant waterhole >200 m in length, some deep areas >1 m deep.

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08.11.16 Wandoan MLA

Survey Date: 01-02-09
Written By: TNM Approved By: LT
Date Issued: May 2009

Woleebee Creek

frc site number 2a

UTM Zone 55J 787055 E 7109431 S GDA94

Cond.

M

				
View upstream through the site (29-01-09)	View of right bank (29-01-09)	View of left bank (29-01-09)	View downstream through the site (29-01-09)	

Channel Habitat

Morphology		Water Quality	
Pattern:	Straight	Temperature (C):	22.5
Flow Regime:	Ephemeral	pH:	7.04
Channel Width (m):	8	Conductivity (uS/cm):	241
Wetted Width (m):	5	DO (mg/L):	3.19
Water Level:	Low	DO (% Sat):	33
Bank Shape:	Sloping, Vertical	Turbidity (NTU):	200
		ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 7	Right: 3
Dominant Type:	Eucalypt, Casuarina	

Fauna

Snake

Habitat (%)		Substrate (%)	
Riffle:	-	Bedrock:	-
Run:	-	Boulder:	-
Pool:	100	Cobble:	10
Rapid:	-	Pebble:	10
Cascade:	-	Gravel:	10
Fall:	-	Sand:	40
Overall Complexity:		Silt/Clay:	30

Cover (%)

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

Dominate Cover Type:

Large Woody Debris

Sub Dominate Cover Type:

Small Woody Debris, Detritus

Comments: Rocky/sandy material piled on upstream side of road due to apparent excavation in the channel - would slow water flow. Pipe culverts undersized and partially blocked with debris.

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08.11.16 Wandoan MLA

Survey Date: 29-01-09
Written By: TNM   Approved By: LT
Date Issued: May 2009

Woleebee Creek

frc site number 3

UTM Zone 55J 786692 E 7111286 S GDA94

Cond. M

View upstream through the site (29-01-09)

View of right bank (29-01-09)

View of left bank (29-01-09)

View downstream through the site (29-01-09)

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Intermittent
Channel Width (m):	15
Wetted Width (m):	5
Water Level:	Low
Bank Shape:	Vertical, Sloping

Water Quality

Temperature (C):	24.1
pH:	6.9
Conductivity (uS/cm):	195
DO (mg/L):	3.9
DO (% Sat):	42.1
Turbidity (NTU):	2100
ORP (mV):	-

Flora and Fauna

Vegetation

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

Fauna

-

Habitat (%)

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

Substrate (%)

Bedrock:	5
Boulder:	10
Cobble:	-
Pebble:	-
Gravel:	-
Sand:	50
Silt/Clay:	35

Cover (%)

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

Dominate Cover Type:

Trailing Bank Vegetation

Sub Dominate Cover Type:

Boulder

Comments: Pool upstream of road similar to size in March 2008, but no water downstream. Water opaque, cattle have access to site.

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08.11.16 Wandoan MLA

Survey Date: 29-01-09
Written By: TNM   Approved By: LT
Date Issued: May 2009

Woleebee Creek

frc site number 4

UTM Zone 55J 787663 E 7115676 S GDA94

Cond.

M

				
View upstream through the site (31-01-09)	View of right bank (31-01-09)	View of left bank (31-01-09)	View downstream through the site (31-01-09)	

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Intermittent
Channel Width (m):	8
Wetted Width (m):	3
Water Level:	Low
Bank Shape:	Vertical, Sloping

Water Quality

Temperature (C):	29
pH:	7.55
Conductivity (uS/cm):	315
DO (mg/L):	6.1
DO (% Sat):	88
Turbidity (NTU):	1240
ORP (mV):	-

Flora and Fauna

Vegetation

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

Fauna

-

Habitat (%)

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

Substrate (%)

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

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	65-90%

Dominate Cover Type:

Large Woody Debris

Sub Dominate Cover Type:

Overhanging Vegetation, Detritus

Comments: Water level lower than in March 08; only upstream pool could be sampled.

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08.11.16 Wandoan MLA

Survey Date:	31-01-09		
Written By:	TNM	Approved By:	LT
Date Issued:	May 2009		

Mud Creek

Cond.

M

frc site number 5

UTM Zone 55J 779288 E 7120297 S GDA94

				
View upstream through the site (30-01-09)	View of right bank (30-01-09)	View of left bank (30-01-09)	View downstream through the site (30-01-09)	

Channel Habitat

Morphology

Pattern:	Meanders
Flow Regime:	Intermittent
Channel Width (m):	10
Wetted Width (m):	4
Water Level:	Low
Bank Shape:	Sloping, Vertical

Water Quality

Temperature (C):	26.1
pH:	8.22
Conductivity (uS/cm):	177.4
DO (mg/L):	9.4
DO (% Sat):	116
Turbidity (NTU):	201.2
ORP (mV):	-

Flora and Fauna

Vegetation

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

Fauna

-

Habitat (%)

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

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	-
Pebble:	5
Gravel:	5
Sand:	20
Silt/Clay:	60

Cover (%)

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

Dominate Cover Type:

Deep Pools

Sub Dominate Cover Type:

Overhanging Vegetation, Detritus

Comments: Water level lower than in March 08 by approximately 0.7m; water slightly green in colour, could be due to an algal bloom in water column.

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08.11.16 Wandoan MLA

Survey Date:	30-01-09		
Written By:	TNM	Approved By:	AM
Date Issued:	May 2009		

Spring Creek

frc site number 6

UTM Zone 55J 772324 E 7120294 S GDA94

Cond.

M

			
View downstream through the channel	View upstream through the channel	View of left bank	View of right bank

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Intermittent
Channel Width (m):	20
Wetted Width (m):	4
Water Level:	Low
Bank Shape:	Sloping

Water Quality

Temperature (C):	29.1
pH:	6.78
Conductivity (uS/cm):	167
DO (mg/L):	2.6
DO (% Sat):	49.5
Turbidity (NTU):	800
ORP (mV):	-

Flora and Fauna

Vegetation

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

Dominant Type: Eucalypt

Fauna

-

Habitat (%)

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

Substrate (%)

Bedrock:	-
Boulder:	-
Cobble:	30
Pebble:	20
Gravel:	15
Sand:	20
Silt/Clay:	15

Cover (%)

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

Dominate Cover Type:

Trailing Bank Vegetation

Sub Dominate Cover Type:

Comments: Water lower than in March 08

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08.11.16 Wandoan MLA

Survey Date: 28-01-09
Written By: TNM Approved By: AM
Date Issued: May 2009

Juandah Creek

Cond.

M

frc site number 7

UTM Zone 55J 792951 E 7113180 S GDA94

				
View upstream through the site (29-01-09)	View of right bank (29-01-09)	View of left bank (29-01-09)	View downstream through the site (29-01-09)	

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Intermittent
Channel Width (m):	8
Wetted Width (m):	6
Water Level:	Low
Bank Shape:	Sloping

Water Quality

Temperature (C):	32.3
pH:	8.59
Conductivity (uS/cm):	302
DO (mg/L):	13.7
DO (% Sat):	185
Turbidity (NTU):	123
ORP (mV):	-

Flora and Fauna

Vegetation

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

Fauna

-

Habitat (%)

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

Substrate (%)

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

Cover (%)

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

Dominate Cover Type:

Large Woody Debris

Sub Dominate Cover Type:

Trailing Bank Vegetation

Comments: Ford prevents flow and pooling upstream

frc environmental deep thinking. science.	08.11.16 Wandoan MLA	Mount Organ Creek	Cond.
	Survey Date: 29-01-09	frc site number 8	P
	Written By: TNM Approved By: AM	UTM Zone 55J 773822 E 7111491 S GDA94	
	Date Issued: May 2009		


View upstream through the site (28-01-09)


View of right bank (28-01-09)


View of left bank (28-01-09)


View downstream through the site (28-01-09)

Channel Habitat

Morphology

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

Water Quality

Temperature (C):	29
pH:	7.02
Conductivity (uS/cm):	155.2
DO (mg/L):	6.3
DO (% Sat):	82.5
Turbidity (NTU):	97.2
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 10	Right: 8
Dominant Type:	Eucalypt	

Fauna

-

Habitat (%)

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

Substrate (%)

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

Cover (%)

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

Dominate Cover Type:

Deep Pools

Sub Dominate Cover Type:
Small Woody Debris, Trailing Bank Vegetation

Comments: Water level higher than in March 08

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08.11.16 Wandoan MLA

Survey Date: 28-01-09
Written By: TNM Approved By: AM
Date Issued: May 2009

Juandah Creek

frc site number 10

UTM Zone 55J 781537 E 7156708 S GDA94

Cond.

M

				
View upstream through the site (31-01-09)	View of right bank (31-01-09)	View of left bank (31-01-09)	View downstream through the site (31-01-09)	

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	25
Wetted Width (m):	25
Water Level:	Moderate
Bank Shape:	Open, Sloping

Water Quality

Temperature (C):	23
pH:	7.7
Conductivity (uS/cm):	231
DO (mg/L):	9.6
DO (% Sat):	113.2
Turbidity (NTU):	22.4
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 4	Right: 2
Dominant Type:	Eucalypt	

Fauna

Pygmy Goose, Ducks, Pelicans
Moorehens, Black Swan
Eastern Brown Snake

Habitat (%)

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

Substrate (%)

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

Cover (%)

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

Dominate Cover Type:
Instream Vegetation
Sub Dominate Cover Type:
Deep pools, Floating Vegetation

Comments: Man made dam on the 'Ellen Vale' property.

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08.11.16 Wandoan MLA

Survey Date:	31-01-09		
Written By:	TNM	Approved By:	AM
Date Issued:	May 2009		

Farm Dam

frc site number 11

UTM Zone 55J 779583 E 7118691 S GDA94

Cond.
M

				
Dense vegetation (02-02-09)	View north (02-02-09)	View west (02-02-09)	View south (02-02-09)	

Channel Habitat

Morphology

Pattern:	Wetland
Flow Regime:	Ephemeral
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Low
Bank Shape:	Vertical, Open

Water Quality

Temperature (C):	25.3
pH:	8.27
Conductivity (uS/cm):	435
DO (mg/L):	8
DO (% Sat):	94
Turbidity (NTU):	19
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m): Left: 0 Right: 0

Dominant Type: -

Fauna

Black Swans + signets
Ducks + ducklings

Habitat (%)

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

Substrate (%)

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

Cover (%)

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

Dominate Cover Type:

Deep pools

Sub Dominate Cover Type:

Instream Vegetation, Floating Vegetation

Comments: Farm dam on the ‘Pecos Valley’ property. Yellowbelly have been stocked to the Dam.

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08.11.16 Wandoan MLA

Survey Date: 02-02-09
Written By: TNM Approved By: AM
Date Issued: May 2009

Farm Dam

frc site number 12

UTM Zone 55J 789359 E 7104987 S GDA94

Cond.

M

				
View southeast (30-01-09)	View northeast (30-01-09)	View towards road (30-01-09)	View towards property (30-01-09)	

Channel Habitat

Morphology

Pattern:	Wetland
Flow Regime:	Ephemeral
Channel Width (m):	-
Wetted Width (m):	-
Water Level:	Moderate
Bank Shape:	Sloping

Water Quality

Temperature (C):	25
pH:	9.5
Conductivity (uS/cm):	230
DO (mg/L):	-
DO (% Sat):	80
Turbidity (NTU):	65
ORP (mV):	

Flora and Fauna

Vegetation

Riparian Width (m): Left: 2 Right: 2

Dominant Type:

Fauna

-

Habitat (%)

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

Substrate (%)

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

Cover (%)

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

Dominate Cover Type:

Deep pools

Sub Dominate Cover Type:

Small Woody Debris

Comments: Artificial dam adjacent to Mount Organ Creek.

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08.11.16 Wandoan MLA

Survey Date:	30-01-09		
Written By:	TNM	Approved By:	AM
Date Issued:	May 2009		

Artificial Dam

Cond.

P

frc site number 13

UTM Zone 55J 773963 E 7111328 S GDA94

				
View upstream through the site (01-02-09)	View of right bank (01-02-09)	View of left bank (01-02-09)	View downstream through the site (01-02-09)	

Channel Habitat

Morphology

Pattern:	Straight
Flow Regime:	Intermittent
Channel Width (m):	20
Wetted Width (m):	10
Water Level:	Low
Bank Shape:	Sloping

Water Quality

Temperature (C):	26.8
pH:	7.01
Conductivity (uS/cm):	200
DO (mg/L):	2.18
DO (% Sat):	34.6
Turbidity (NTU):	34.1
ORP (mV):	-

Flora and Fauna

Vegetation

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

Fauna

Ducks

Habitat (%)

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

Substrate (%)

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

Cover (%)

Periphyton:	None
Moss:	None
Filamentous algae:	None
Macrophytes:	None
Detritus:	65-90%

Dominate Cover Type: Large Woody Debris

Sub Dominate Cover Type: Detritus

Comments: Water level higher in the wet season than the dry season.

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	Survey Date: 01-02-09	frc site number 4
	Written By: TNM Approved By: LT	UTM Zone 55J 798408 E 7120029 S GDA94
	Date Issued: May 2009	Cond. M

				
View upstream through the site (04-02-09)	View of right bank (04-02-09)	View of left bank (04-02-09)	View downstream through the site (04-02-09)	

Channel Habitat

Morphology

Pattern:	Sinuous
Flow Regime:	Intermittent
Channel Width (m):	30
Wetted Width (m):	10
Water Level:	Low
Bank Shape:	Sloping

Water Quality

Temperature (C):	22.7
pH:	6.95
Conductivity (uS/cm):	233
DO (mg/L):	0.42
DO (% Sat):	5.2
Turbidity (NTU):	59.5
ORP (mV):	-

Flora and Fauna

Vegetation

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

Fauna

Cockatoos
Cattle
Wallaby

Habitat (%)

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

Substrate (%)

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

Cover (%)

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

Dominate Cover Type: Large Woody Debris

Sub Dominate Cover Type: Detritus

Comments: Proposed crossing location near a significant waterhole for surrounding reaches of the creek which were dry. Recommend crossing at dry area. Do not damage large gums on banks or their roots. Must rehabilitate bank to original condition and stabilise with matting and vegetation.

frc environmental
deep thinking. science.

08.11.16 Wandoan Gas

Survey Date: 01-02-09
Written By: TNM Approved By: LT
Date Issued: May 2009

Roche Creek

frc site number 5
UTM Zone 55J 799080 E 7119512 S GDA94

Cond.
M

				
View upstream through the site (04-02-09)	View of right bank (04-02-09)	View of left bank (04-02-09)	View downstream through the site (04-02-09)	

Channel Habitat

Morphology

Pattern:	Irregular
Flow Regime:	Ephemeral
Channel Width (m):	10
Wetted Width (m):	3
Water Level:	Low
Bank Shape:	Sloping, Vertical

Water Quality

Temperature (C):	28.2
pH:	7.24
Conductivity (uS/cm):	195
DO (mg/L):	8.15
DO (% Sat):	92.8
Turbidity (NTU):	205.6
ORP (mV):	-

Flora and Fauna

Vegetation

Riparian Width (m):	Left: 8	Right: 10
Dominant Type:	Eucalypt	

Fauna

-

Habitat (%)

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

Substrate (%)

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

Cover (%)

Periphyton:	None	Dominate Cover Type:
Moss:	None	Large Woody Debris
Filamentous algae:	-	
Macrophytes:	-	Sub Dominate Cover Type:
Detritus:	35-65%	Detritus

Comments: Water level higher in the wet season than in the dry season.

frc environmental deep thinking. science.	08.11.16 Wandoan Gas			Juandah Creek	Cond. M
	Survey Date: 01-02-09			frc site number 7	
	Written By: TNM	Approved By:	LT	UTM Zone 55J 794977 E 7112625 S GDA94	
	Date Issued: May 2009				

Appendix B Introduction to the Data Analyses Used

Refer to Attachment B in technical report (frc environmental 2008) for further information on the approaches to data analyses used. Data analysis procedures specific to the supplementary EIS are included below.

Univariate Analyses

ANOVA (analysis of variance) is a statistical hypothesis testing procedure. It compares the mean of different variables, taking into account the variance both within each test group (e.g. site) to variance among each test group (e.g. sites). The null hypothesis is that this mean is the same for all groups. Generally, if the significance level of the test (p value) is below 0.05, the null hypothesis can be rejected. Two-way ANOVA incorporates differences among sites and also time. A significant interaction among sites and time indicates that one group of samples (e.g. impacted sites) has changed at a different rate relative to another group of samples (e.g. control sites).

Where ANOVA indicates that there are significant differences among means, post-hoc tests can be used to separate and group means from the analysis of variance tests, i.e. to determine which groups or sites are different from one another (Zar 1996).

Multivariate Analyses

Multivariate statistical techniques are widely used in ecology to assess the similarities / relationships between communities. Whereas univariate analyses can only compare one variable at a time (e.g. an index of community structure such as a diversity index, or a single indicator species), multivariate analyses can compare samples based on the extent that communities share particular taxa and the relative abundances of each taxa (Clarke & Warwick 2001).

Ordinations are particularly useful tools for analysing, and visually presenting, differences among communities. Ordinations are maps of samples, in which the placement of samples on the map reflects the similarly of the community to the communities in other samples (Clarke & Warwick 2001). Distances between samples on an ordination attempt to match the similarities in community structure: nearby points represent communities with very few differences; points far apart have very few attributes in common (Clarke & Warwick 2001).

The first step of multivariate analysis usually involves the creation of a similarity or dissimilarity matrix, which incorporates the creation of a triangular matrix of similarity coefficients, computed between every pair of samples. The coefficient is usually a measure of how close the abundance levels are for each species (defined so that 100% = total similarity and 0% = complete dissimilarity). While there are a number of metrics used, the Bray-Curtis coefficient is commonly to convert biological data (i.e. abundances of different taxonomic groups) into a similarity or dissimilarity matrix (Clarke & Warwick 2001).

non-Metric Multi-dimensional Scaling (nMDS)

Non-metric multi-dimensional scaling attempts to places samples on a 'map', such that the rank order of the distances among samples matches the rank order of the matching similarities from the similarity matrix (Clarke & Warwick 2001). This provides a visual representation of the similarities among communities within each sample. Note that each of the axes is not related to any particular value; in fact axes can be rotated to provide the best visual representation of the data.

A stress coefficient is calculated to reflect the extent to which the nMDS ordination and the similarity matrix agree (Clarke & Warwick 2001), i.e. how well the nMDS ordination accurately reflects the relationship between samples. Stress values of < 0.15 are generally acceptable for interpretation.

In the example below (Figure A.1), each sample is represented on the nMDS ordination. By looking at the distances between each sample, we can infer that samples (communities) taken from the stream reach (M, STC and US) group together and these samples are quite different form DS samples, which group together on the right hand side. That is, they are more similar to each other than they are to samples taken from other stream reaches.

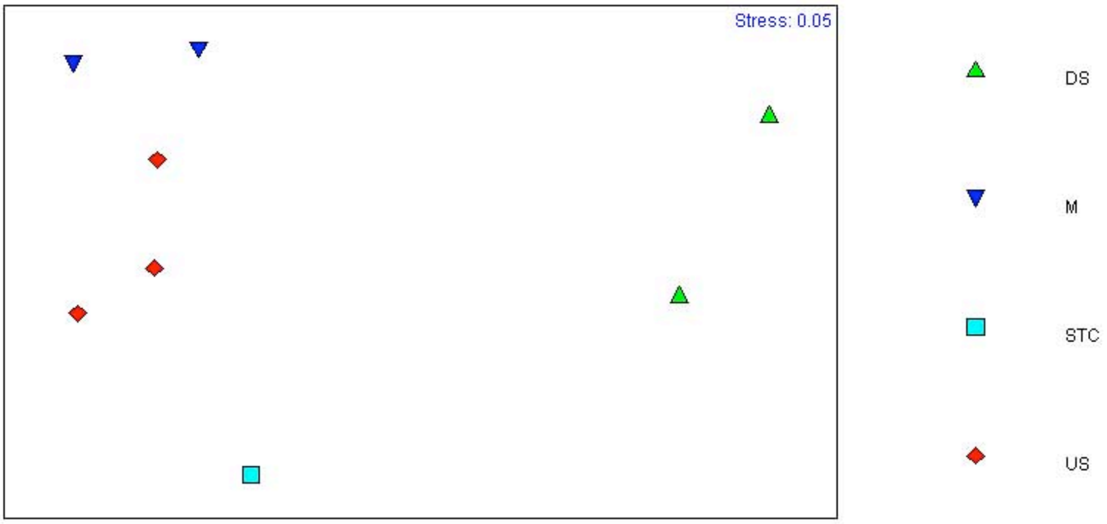


Figure A.1 Example of an nMDS ordination for macroinvertebrate communities sampled in riffle habitats of different stream reaches (from frc environmental 2004).

Analysis of Similarities (ANOSIM)

ANOSIM is analogous to analysis of variance (ANOVA) in univariate statistics (Clarke 1993; Smith 2003). A global R statistic is calculated to determine whether there is a significant difference among all samples. If there are differences, then pairwise comparisons are conducted to test for differences between pairs of samples (analogous to post-hoc tests in ANOVA).

The 'R' value lies between +1 (all similarities within groups are less than any similarity between groups) and -1 (similarities among groups are less than within groups), with a value of zero representing the null hypothesis (no difference among a set of samples) (Clarke & Warwick 2001). Comparison of pair-wise R values can give an indication of how different communities are: R values close to 0 indicate little difference, values around 0.5 indicate some overlap and values close to 1 to indicate many or substantial differences. In many instances however, researches are primarily interested in whether the R value is statistically different from zero (usually at a confidence level of 0.05) (Clarke & Warwick 2001), i.e. whether they can reject the null hypothesis.

ANOSIM can provide information on whether the (visual) differences between assemblages in the MDS ordination are significantly different based on an independent permutation test that is separate from the MDS ordination. It is based on testing the differences between the rank similarities in the similarity matrix, not on the distances between samples in the nMDS ordination (Clarke & Warwick 2001).

Similarity Percentage – Species Contributions (SIMPER)

SIMPER analysis provides information on how dissimilar assemblages of various groups are (e.g. how similar all of the macroinvertebrate samples taken for a particular habitat within a stream reach are), and how similar each group (e.g. reach) is to any other group. SIMPER analysis also identifies the species / taxa that are contributing to the dissimilarity between two assemblages, in rank order (i.e. it identifies which species are contributing the most to the differences among and within sites). SIMPER analysis may help to identify potential 'indicator' species. For example, if a particular species consistently contributes substantially to the differences between impacted and unimpacted assemblages, it may be a useful indicator of environmental harm. The abundance of this indicator species can then be compared among sites using univariate techniques such as ANOVA.

BIOENV

The BIOENV procedure can be used to examine the extent to which observed community patterns in biological data, such as the composition and abundance of macro-invertebrates among different sites, can be related to a combination of observed physical or chemical variables collected from the same sites (Clarke & Warwick 2001). The combinations of physical or chemical variables are compared against biological variables, using increasing levels of complexity. The combination of environmental variable/s that best describe the biological community pattern are ranked and analysed using a rank correlation coefficient test (Spearman's coefficient – Rho (ρ)). Values of ρ lie between -1 and 1, which corresponds to cases that are in complete opposition or in complete agreement, ρ-values around zero occur when there is no match between the two patterns (Clarke & Warwick 2001). The combination of environmental variables that best describes any biological pattern will typically be closer to 1 than 0.

References

Clarke, K.R. & Warwick, R.M., 2001, *Change in Marine Communities: an Approach to Statistical Analysis and Interpretation*, PRIMER-E, Plymouth, pp.

Appendix C Fish and Turtle Survey Effort

Table C1 Fish and turtle survey effort at each site.

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
MLA Study Area								
2a	Small bait traps	pool	1/2/09	1200	02/02/09 0800		100 hrs	
	Backpack Electrofishing	Pool	01/02/09	1050	1150	200V, 30 Hz, 12 %	960 s	
	Cathedral traps	Pool	1/2/09	1030	2/2/09 0800		107.5 hrs	
3	Backpack Electrofishing	Pool	29/01/09	0920	1000	200V, 30 Hz, 12%	582 s	Very small pool, traps not required
4	Backpack Electrofishing	Pool	29/01/09	1115	1200	200V, 30 Hz, 12%	613 s	
5	Backpack Electrofishing	Pool	31/01/09	1410	1450	160 V, 30 Hz, 12%	419 s	
6	Small bait traps	Pool	29/01/09	1645	30/01/09 1215		97.5 hrs	
	Backpack Electrofishing	Pool	30/01/09	1245	1350	220V, 30 Hz, 12%	619 s	
	Cathedral traps	Pool	29/01/09	1645	30/01/09		39 hrs	
7	Small bait traps	Pool	28/01/09	1600	29/01/09 0730		77.5 hrs	
	Backpack electrofishing	Pool	28/01/09	1615	1700	200V, 30 Hz, 12%	527 s	
	Cathedral traps	Pool	28/01/09	1610	29/01/09 0730		77.5 hrs	
8	Backpack Electrofishing	Pool	29/01/09	1410	1515	200V, 30Hz, 12%	465 s	Very small pool, traps not required

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
10	Cathedral traps	Pool	28/01/09	0950	1250		20 hrs	
	Small bait traps	Pool	28/01/09	0950	0950		20 hrs	
	Boat Electrofishing	Pool	28/01/09	1030	1145	50-500V, 60 pulses/ sec	680 s	
11	Boat Electrofishing	Pool	31/01/09	0830	0940	500-1000V, 100% of power, 60 Pulse / s, 3 amps	1022	
	Cathedral traps	Pool	31/01/09	1120	01/02/09 0830		105 hrs	
12	Small bait traps	Pool	02/02/09	1200	03/02/09 0745	-	98.75 hrs	
	Boat Electrofishing	Pool	02/02/02	945	1030	500-1000v 80% of power 60 Pulses/sec 5 amps	929 s	
	Cathedral traps	Pool	02/02/09	1200	03/02/09 0745		98.75 hrs	
13	Small bait traps	Dam	29/01/09	1615	30/01/09 0730		76.25 hrs	
	Boat Electrofishing	Dam	30/01/09	0845	0945	50-500V, 100% of power, 60 pulsese/sec, 5 amps	914 s	
	Cathedral traps	Dam	29/01/09	1615	30/01/09 0730		76.25 hrs	

Table C2 Fish and turtle survey effort at each site in the gas supply pipeline study area.

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort	Comments
Gas Supply Pipeline Study Area								
4	Small bait traps	Pool	01/02/09	1545	02/02/09 1400		108.75 hrs	
	Backpack Electrofishing	Pool	02/02/09	1445	1540	200V, 30 Hz, 12%,	776 s	
	Cathedral traps	Pool	01/02/09	1545	02/02/09 1400		108.75 hrs	
5	Small bait traps	Pool	04/02/09	1000	1645		33.25 hrs	
	Backpack Electrofishing	Pool	04/02/09	0815	0905	180V, 30 Hz, 12%	645 s	
	Cathedral traps	Pool	04/02/09	1000	1630		32.5 hrs	
7	Small bait traps	Pool	04/02/09	1315	1730		21.25 hrs	
	Backpack Electrofishing	Pool	04/02/09	1135	1220	200V, 30 Hz, 12%	592 s	
	Cathedral traps	Pool	04/02/09	1315	1730		21.25 hrs	

Appendix D Copies of Relevant 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 Lomasiak

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.

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

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

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

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

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

1. Applicant details

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

2. Project Details

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

3. Amendment

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

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

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

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

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

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

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

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

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

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

References

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

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

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

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

4. AEC Decision

The amendment has been considered by the AEC and is:

☒ Approved as submitted

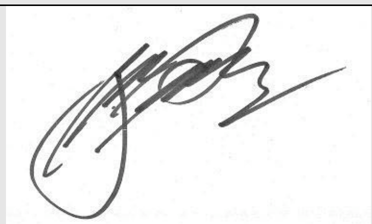
☐ Approved subject to modifications

☐ Pending

☐ Rejected

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

Comments/Reasons:

Name of AEC Chair	Geoff Smith
Signature	
Date	29 October 2007

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.

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

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

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

In plain English, outline your reasons for the request:

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

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

Queensland Government
Department of Primary Industries and Fisheries

DPI&F Animal Ethics

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

3. AEC Decision

The amendment has been considered by the AEC and is:

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

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

* Comments/Reasons:

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