Hydrobiology

QGC – Surat North Gas Project

Aquatic Ecology Assessment

May 2012

ABN	26 096 574 659
GST	The company is registered for GST
Head Office	27 / 43 Lang Parade Auchenflower QLD 4066
Registered Office	c/- de Blonk Smith and Young Accountants GPO 119 Brisbane, QLD 4001
Postal Address	PO Box 2151 Toowong QLD 4066
Phone	61 (07) 3368 2133
Fax	61 (07) 3367 3629
Email Contact	info@hydrobiology.biz
Website	http://www.hydrobiology.biz

QGC – Surat North Gas Project

Aquatic Ecology Assessment

May 2012

Document Control Information

Date Printed	1 June 2012		
Project Title	Aquatic Ecology Assessment		
Project Manager	Alan Webb		
Job Number	12-032-ERM01	**Report Number**	1
Document Title	QGC – Surat North Gas Project		

Document File Name	Document Status	Originator(s)	Reviewed By	Authorised By	Date
12-032-ERM01_R1_v0.1_LA	Draft	LA	AW		
12-032-ERM01_R1_v0.2_AW	Draft	AW			26.05.2012
12-032-ERM01_R1_v0.3_AW	Draft	AW			31.05.2012
12-032-ERM01_R1_v0.4_AW	Draft	AW			1.06.2012
12-032-ERM01_R1_v0.5_AW	Draft	AW		AW	1.06.2012
12-032-ERM01_R1_v1.1_SG	Draft	LA/AW/SG	LA	LA	18.06.12
12-032-ERM01_R1_v2.1_LA	Draft	LA		LA	18.06.12

Distribution

Document File Name	Description	Issued To	Issued By
12-032-ERM01_R1_v1.0	Draft	John Brewster (ERM)	Leigh Anderson
12-032-ERM01_R1_v2.0	Draft	John Brewster (ERM)	Leigh Anderson
12-032-ERM01_R1_v3.0	Final	John Brewster (ERM)	Leigh Anderson

EXECUTIVE SUMMARY

This technical report provides the results of the aquatic sampling undertaken between 25 and 31 March 2012, within the North Surat Basin, which incorporates QGC Pty Ltd's Coal Seam Gas (CSG) Surat North Gas Field (Hereafter referred to as "the Project"). Thirteen sampling sites were selected within seven water bodies for habitat assessment, and 12 of these sites were sampled for macroinvertebrates and diatoms. Fish and macrocrustaceans and macrophytes were sampled at five sites only to determine a brief species list.

The landscape within the Project area has largely been modified by farming and agriculture, with the main land use being grazing (beef cattle). The habitat assessments indicated disturbance to the riparian vegetation through clearing, with the vegetation fragmented, and exotic plants present. AUSRIVAS (Australian Rivers Assessment System) is a nationally adopted methodology for determining river health using pollution sensitive macroinvertebrates as indicators. The habitat assessment ratings delivered by the AUSRIVAS methodology during this survey ranged from 43 to 85 across all sites, indicating moderate levels of disturbance. The streams consisted of slow runs or pools, and often the pools were separated by sections of dry bed. The stream substrate was dominated by silt/clay and sand, with only one site with cobbles/pebbles present.

Macroinvertebrates were sampled from two habitats, the edge and the bed habitat. Forty-nine taxa were recorded in edge samples, 69.4% were aquatic insects from six Orders, at least 33 Families and two Sub-families. Fifty-seven taxa were recorded from bed samples, 68.4% were aquatic insects from six Orders, at least 35 Families and 3 Sub-families. Results indicated variable diversity between sites, with Eurombah Creek and a site on Horse Creek having the highest number of the sensitive PET (Plecoptera, Ephemeroptera and Trichoptera) taxa present. The upstream site of Canal Creek had the lowest number of these sensitive taxa. Feeding groups of macroinvertebrates sampled were varied, with all feeding types present at some of the sites. The generalist feeding groups (e.g. predators, gathering collectors) were the most dominant of these feeding types. SIGNAL 2 (Stream Invertebrate Grade Number) is a simple scoring system to provide an indication of water quality and ecosystem health. When used in conjunction with species richness, the SIGNAL 2 index can provide an indication of the types of pollution and other physico-chemical factors that are influencing macroinvertebrate community structure and function. The SIGNAL 2 scores calculated during this survey were similar between sites, and when used in conjunction with taxa richness, indicated the water quality and habitat may be impacted from a range of land uses, such as agriculture and vegetation clearing.

Nineteen native macrophyte species from thirteen Families were recorded during the survey. Macrophytes were present at seven of the sampled sites, with the majority of these emergent and present only on the stream banks. Instream macrophytes were present at two sites (Dawson River U/S (upstream) and Canal Creek D/S (downstream)) with high total reach coverage (45% and 95% respectively). All macrophyte species had coverage of <10% except for water primrose, *Ludwigia peploides*, with 60% at one site (Canal Creek D/S).

Eighty-two diatom species from 11 Orders, 20 Families and 30 Genera were recorded from all sites surveyed. Diatoms have several attributes that render them useful in bioassessment of fresh waters: they are easily and quickly collected and respond to a wide range of environmental conditions including anthropogenic stress. The majority of assemblages were similar in species composition and abundances between sites with assemblages formed in large part by motile forms tolerant of sedimentation. The predominance of species with preferences for elevated salinity (halophilous forms) and alkaline conditions (alkalophilous forms), in part, reflects the underlying sedimentary geology and groundwater of the Project area. Assemblages were also characterised by species tolerating elevated levels of organic and inorganic nutrients indicative of non-point source inputs, for example, from surface runoff and erosion processes, as well as localised point sources, for example, at stock access points with inputs of cattle excrement and detritus from aquatic vegetation. The Diatom Sensitivity Index for Australian Rivers (DSIAR) is a scoring system based on the sensitivity of diatoms to anthropogenic stress. High scores identify the presence of flora highly sensitive to anthropogenic stress, thus indicating that low levels of anthropogenic stress are evident in the habitat. Conversely, low scores indicate a habitat significantly negatively impacted from anthropogenic factors. DSIAR index values were similar across all sites sampled for diatoms in this survey and occurred within a narrow range. The results of the DSIAR evaluation were consistent with the AUSRIVAS habitat assessment and macroinvertebrate SIGNAL 2 scores and were indicative of similar responses of diatom assemblages at each site to moderate levels of anthropogenic disturbance to the surrounding landscape.

Fish were sampled at five sites only. Five native species and no non-native species were recorded. The dominant species in samples was the eastern rainbowfish, *Melanotaenia splendida.* However, all species found are frequently abundant with widespread distributions and can rapidly recolonise intermittent streams. The species are typical of water with low flow and all are able to withstand a range of water quality conditions.

No rare or endangered macroinvertebrates, diatoms or macrophytes were recorded from the sites sampled within and surrounding the Project area. The sites sampled were all in a slightly degraded condition, typical of this region of the Fitzroy Basin.

QGC – Surat North Gas Project

Aquatic Ecology Assessment

May 2012

TABLE OF CONTENTS

TABLES

FIGURES

1 INTRODUCTION

Hydrobiology QLD Pty Ltd was commissioned by Environmental Resources Management (ERM) to undertake the aquatic ecology component of an EIS for QGC's Coal Seam Gas (CSG) field in the North Surat Basin (the Project). The Project takes in 15 graticular blocks of ATP 852 and one graticular block in the north east of Pleiades block of ATP768, herein referred to as the 'Project area'. Gas and associated water will be transported to the existing approved Woleebee Creek Central Processing Plant (CPP) and Water Treatment Plant (WTP) via trunklines which will be located in infrastructure corridors. The CPP and WTP are covered under existing approvals; however the infrastructure corridors are not, and will be assessed as part of the North Surat project.

Waterways in the Project area are part of the Fitzroy Basin, Australia's second biggest coastal-draining catchment (Fitzroy Basin Association 2012), with floodplains lining the basin. The major tributaries of the Fitzroy River in the Project area include Eurombah Creek, Horse Creek and Juandah Creek, which flow into the Dawson River. The Dawson River joins the Mackenzie River downstream to become the Fitzroy River, flowing into the sea south of Rockhampton.

The Project area is located within a subtropical, semi-arid climate, which is typically hot and dry for most of the year. Rainfall is highest during the wet season in the summer months, and during the dry season waterways typically become reduced to minimal or no flow. The streams in the Project area are typically low order intermittent drainages, which have reduced flow at certain times of the year and may be reduced to a few small pools. These small pools act as important refugia for aquatic biota able to survive in the drier climate. The waterways within the Project area are within a modified landscape, with grazing (beef cattle) the major landuse. This land use type can have significant impacts on the stability of the waterways, instream water quality and aquatic biota communities (Schmutzer *et al.* 2008; Silla 2005) and needs to be taken into consideration for this assessment.

Waterbodies in areas affected by agriculture often suffer from elevated nutrient levels (typically nitrogen and phosphorus) due to fertilisers washing into the streams and rivers draining the land. This can lead to extensive plant growth which can have detrimental effects on other aquatic flora and fauna by reducing oxygen concentrations in the water. The clearing of land for agricultural purposes, particularly along the edges of waterways, can cause banksides to become unstable, increasing erosion and sediment loads from the adjacent land, which can increase turbidity levels. These impacts can negatively affect the stream biota through smothering potential habitat and food sources, and decreasing light levels. Farm animals accessing streams can also have an impact as they can further destabilise banks and introduce faecal matter and suspended solids into the aquatic environment.

1.1 Scope and Objectives

The objectives of the survey were to:

- Collect baseline data to characterise the aquatic flora (macrophytes and diatoms) and fauna including macroinvertebrates, fish and macrocrustaceans, with opportunistic collection of amphibians;
- Identify key habitats occurring within areas potentially impacted by the Project;
- Characterise type of waterways present which may be impacted by the development;
- Provide a baseline to assess potential ongoing impacts;
- Determine health status of existing water bodies;
- Identify likely determining factors of stream health; and
- Identify rare, threatened or otherwise noteworthy aquatic flora and fauna species, communities and habitats within areas potentially impacted by the Project.

1.2 Study Assumptions and Limitations

This report has been prepared on the basis of the following assumptions and limitations:

- One round of sampling at the end of the wet season was undertaken. As several reports of a similar nature to this report have been completed in the past, covering the biology and ecology of the survey area and its surrounds, it was considered that sufficient historical data existed to make an informed assessment of the aquatic habitat in the Project area. The single round of sampling conducted by Hydrobiology acted as a supplement to the existing data on the region and helped support the conclusions drawn in this technical report and the associated EIS chapter.
- Due to the sensitivities of the Project, there were a number of site access issues before the field sampling was undertaken. Consequently, many of the proposed sampling sites were relocated. Hydrobiology believes this did not affect the quality of the survey undertaken.

2 METHODS

2.1 Site Selection

Thirteen sites were selected in total for habitat assessment. Due to accessibility and conditions at each site only twelve were sampled for macroinvertebrates and diatoms and 5 were assessed for fish and macrophytes. Sites were selected throughout the tenement that would provide representative examples of stream types, habitats and ecological features within, and surrounding, the Project area. Streams were selected that were assumed likely to be affected by the QGC Project, typically with upstream and downstream sites on each stream to provide an understanding of the existing aquatic environment prior to development by QGC.

Aquatic sampling was undertaken from 25th March to 31st March 2012. The majority of the sites studied were on intermittent streams; however, all sites had some water and were able to be sampled. The sites visited and activities undertaken at each site are summarised in Table 2-1, and a map of the sampled sites is provided in Figure 2-3. Each study site comprised a 100 m reach of stream. Where access to sites was located from bridges, all sites were upstream of the bridge and thereby upstream of any impact the bridge access may have on the stream (i.e. cattle access, anthropogenic effects). Generally impacts caused by bridge crossings affect the area immediately downstream of the crossing with the severity of these effects decreasing with increasing distance downstream.

2.2 Data collection

2.2.1 Aquatic habitat

Aquatic habitat was assessed at each site using field sheets from the Queensland AUSRIVAS (Australian Rivers Assessment System) sampling protocol (Conrick and Cockayne 2001). Photographs were taken at each site, with any significant features shown. A summary of habitat photographs for each site are provided in Appendix 1.

2.2.2 Macroinvertebrates

Macroinvertebrates are widely used as indicators of ecological condition due to their variety of responses to human disturbances (Rosenberg and Resh 1993). AUSRIVAS is a nationally adopted methodology for determining river health using pollution sensitive macroinvertebrates as indicators. Macroinvertebrate samples were taken from each site in accordance with the Queensland AUSRIVAS protocols (Conrick and Cockayne 2001), with slight amendments to the protocol. Macroinvertebrate samples were collected with a standard 250 µm mesh dip net (Figure 2-1). Quantitative sampling was completed by collecting five replicate bed samples from each site where there was suitable habitat. These were predominantly sandy/silty beds. These samples were preserved in 70% ethanol, and returned to the laboratory for sorting, identification and enumeration. One edge sample was collected over a 10 m reach from each site to include all remaining habitats (excluding macrophytes, as these are not sampled for macroinvertebrates in Queensland). The edge samples were live picked in the field following the Queensland AUSRIVAS protocol, then preserved in 70% ethanol. The main alteration to the AUSRIVAS protocol was the collection of five replicate bed samples to replace one quantitative 10 m bed sample recommended by AUSRIVAS. These samples were not live picked, instead they were cleaned of any excess debris caught in the nets during sampling and the entire net contents were preserved in 70% ethanol for transport to the laboratory for picking. Hydrobiology prefers this method as it allows for more statistically robust data analysis and has no effect on the AUSRIVAS protocol.

Samples were delivered to Lisa Le Strange at the University of Queensland (School of Chemistry and Molecular Biosciences) for identification and enumeration. Macroinvertebrates were identified to Family level, with the exception of Oligochaeta (Class), Acarina (Order), Collembola (Order), Turbellaria (Order) and Chironomidae (Sub-family).

a) collecting a macroinvertebrate bed sample in soft sediment

b) transferring the sample to the plastic bag for preservation

Figure 2-1 Macroinvertebrate collection

2.2.3 Macrophytes

The 100 metre sampling reach of each site was surveyed for aquatic macrophytes. Of the thirteen sites surveyed, only seven sites supported macrophyte populations (Table 2-1). The presence and relative abundance of macrophytes were recorded using the AUSRIVAS habitat field sheets (Conrick and Cockayne 2001). Detailed notes and photographs were taken of macrophytes, both *in-situ* and of collected specimens, to assist with identification. Macrophyte specimens for identification were labelled and placed between newspaper and in a plant press. The newspaper was changed several times over a 48 hour period to reduce drying time and, upon returning to Brisbane, specimens were taken to the Brisbane Botanic Gardens Herbarium for identification.

2.2.4 Diatoms

A single composite diatom sample consisting of three sediment surface scrapes from depositional microhabitats, such as backwaters or areas of low flow, was collected from each site. Diatom samples were collected by using a small spoon (1 mL) to scrape the surface area, with the three scrapes added to a 5 mL vial (Figure 2-2). The sample was then preserved with 1% Lugols iodine solution for laboratory analysis. Samples were sent to Dr Jennifer Fluin at the University of Adelaide for processing and identification.

a) Collecting the sediment scrape

b) placing the sediment in the vial

c) preserving the sample with Lugols iodine

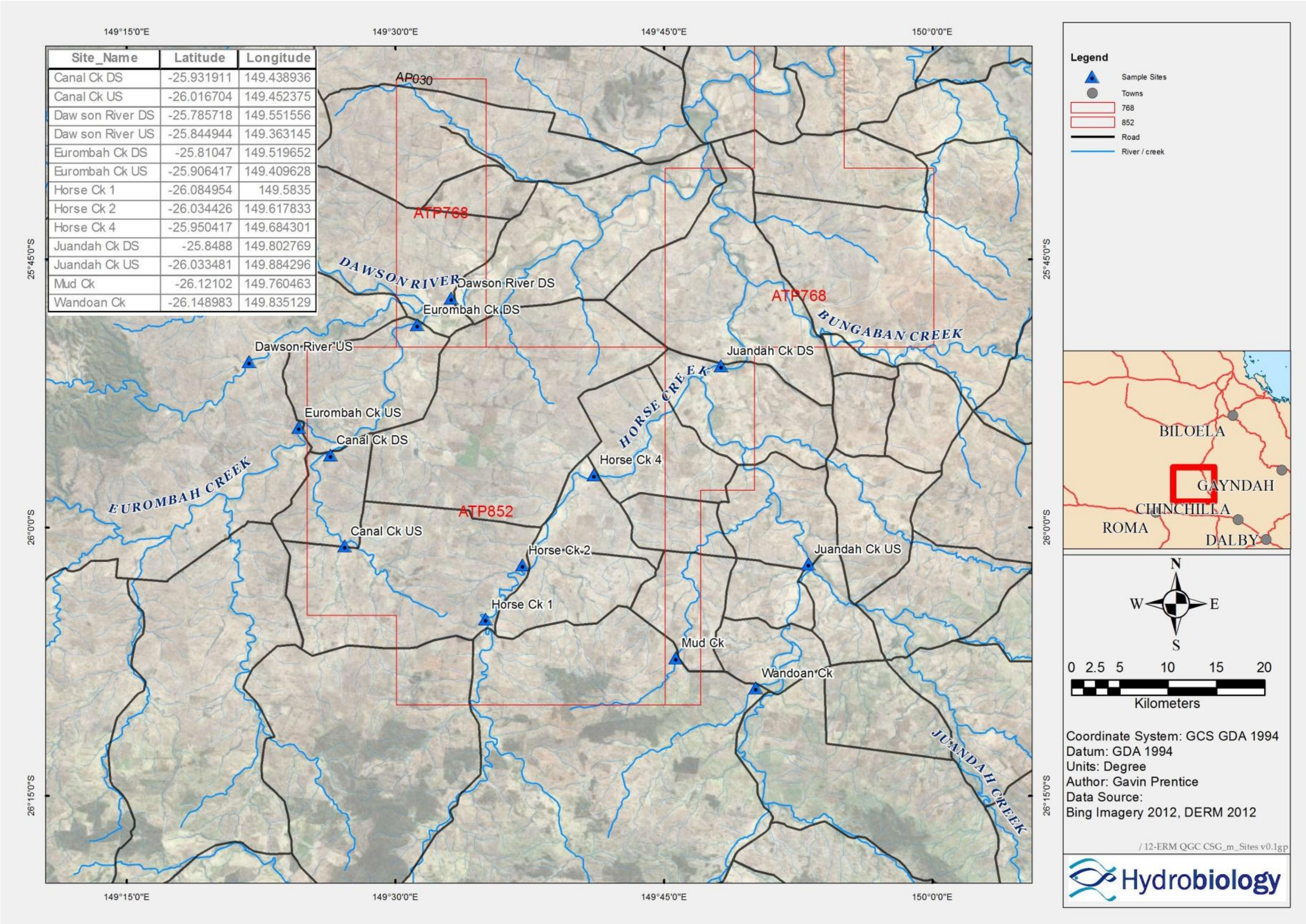
Figure 2-2 Diatom collection

2.2.5 Fish sampling

Although fish sampling was not included in the scope of works, available time and more water than expected allowed the field team to undertake seine netting at five of the 13 sampled sites. Seine netting was conducted using a 6 mm mesh, 5 m width pole seine, with one to two seines completed at each site with available habitat (clear bed with little or no snags). One person stood on the water's edge while the other dragged the seine out into the water, scooping around in a semi-circle before returning to the water's edge, and both team members then carefully pulled in the net as close to the ground as possible to capture all fish in the 5 m area.

Table 2-1 Summary of sites visited and activities undertaken, March 2012

Site	Latitude (S)	Longitude (E)	Habitat Assessment	Macroinvertebrates	Diatoms	Macrophytes	Fish
Canal Ck U/S	26°01'00.8"	149°27'51.3"	✓	✓	✓		
Canal Ck D/S	25°55'47.2"	149°26'27.0"	✓	✓	✓	✓	
Eurombah Ck U/S	25°54'10.4"	149°24'54.1"	✓	✓	✓		✓
Eurombah Ck D/S	25°48'38.1"	149°31'30.3"	✓	✓	✓		
Dawson River U/S trib	27°50'37.1"	149°21'10.4"	✓	✓	✓	✓	
Dawson River D/S	25°47'51.5"	149°33'33.6"	✓	✓	✓		
Horse Ck 1	26°05'35.7"	149°35'03.6"	✓	✓	✓		✓
Horse Ck 2	26°02'23.6"	149°37'25.2"	✓	✓	✓	✓	✓
Horse Ck 4	25°57'09.0"	149°41'20.9"	✓	✓	✓	✓	
Mud Ck	26°07'00.5"	149°45'46.5"	✓			✓	
Wandoan Ck	26°08'47.4"	149°50'21.7"	✓	✓	✓		✓
Juandah Ck U/S	26°02'03.2"	149°53'20.8"	✓	✓	✓	✓	
Juandah Ck D/S	25°50'52.2"	149°48'59.8"	✓	✓	✓	✓	✓



Site_Name	Latitude	Longitude
Canal Ck DS	-25.931911	149.438936
Canal Ck US	-26.016704	149.452375
Daw son River DS	-25.785718	149.551556
Daw son River US	-25.844944	149.363145
Eurombah Ck DS	-25.81047	149.519652
Eurombah Ck US	-25.906417	149.409628
Horse Ck 1	-26.084954	149.5835
Horse Ck 2	-26.034426	149.617833
Horse Ck 4	-25.950417	149.684301
Juandah Ck DS	-25.8488	149.802769
Juandah Ck US	-26.033481	149.884296
Mud Ck	-26.12102	149.760463
Wandoan Ck	-26.148983	149.835129

Figure 2-3 Location of sites, March 2012

2.3 Data analysis

2.3.1 Habitat assessments

Habitat assessments were completed using the field sheets for Queensland AUSRIVAS sampling. Nine site characteristics are scored from excellent (15 or 20) to poor (0), and a total score is given out of 135. This allows the assessment to quantify different aspects of the site.

Water quality measurements were taken as part of the habitat assessment at all sites. Although this was not a requirement, parameters such as conductivity, temperature, pH and dissolved oxygen are important to the in-stream biota. A hand-held Hanna probe was used to collect measurements for conductivity, temperature and pH. No dissolved oxygen data were collected.

2.3.2 Macroinvertebrates

Macroinvertebrate bed samples and edge samples were analysed separately according to the sampling method

PET taxa – edge and bed habitat

The PET (Plecoptera, Ephemeroptera, and Trichoptera) taxa are three Orders of macroinvertebrates which are considered to be the most sensitive to certain types of pollution (Wright *et al.* 2007) and to habitat alterations (Dinakaran and Anbalagan 2007). Plecopterans, for example, are particularly sensitive to organic pollution, industrial effluent and heated water (Department of Natural Resources and Water 2007) and are thus useful in monitoring as indicators of ecosystem health. The PET taxa provides an indication of how sensitive the macroinvertebrate community is to changes, such as habitat and pollution, by calculating the proportion of the number of families in the edge habitat that belong to the PET taxa, and the proportion of the abundances of macroinvertebrates in the bed samples that belong to the PET taxa.

Functional feeding groups – edge and bed habitat

An organism's presence or absence is often related to their ecological niche (Rawer-Jost *et al.* 2000), and for macroinvertebrates, these niches can be represented as functional feeding groups. Macroinvertebrates can be assigned to different functional feeding groups (FFG) based on their morphological and behavioural mechanisms for acquiring food resources (Cummins *et al*. 2005). The relative proportion of the different macroinvertebrate FFGs present at a site can provide an indication of broad scale ecosystem health, and may reflect the in-stream processes of the aquatic habitat (Hawking *et al*. 2009). The presence of specialist feeders, such as shredders and scrapers, is indicative of a healthy habitat (Rawer-Jost *et al.* 2000), while generalists, such as predators, gatherers, filter-feeders and scavengers, are more tolerant to pollution (Dudgeon 1999). Some taxa have more than one feeding group (i.e. the dipteran Family, Culicidae, can be predators or filtering collectors), and some animals will change feeding mode during their development (Dudgeon 1999), and these have been grouped accordingly. Families were divided into their feeding categories, and proportional feeding types were compared between sites. The macroinvertebrate taxa were assigned to FFGs using the categories proposed by Hawking *et al*. (2009) (Table 2-2) and other supplementary sources, and the number of specimens in each guild at each sample location determined.

Table 2-2 Functional feeding group classifications (from Hawking *et al.* 2009)

FFG	FFG code	Food
Shredders	Sh	Living or decomposing vascular plant tissue
Filtering collectors	FCo	Suspended decomposing fine particulate organic matter (POM)
Gathering collectors	GCo	Deposited decomposing fine POM
Scrapers	Sc	Biofilm, i.e. periphyton, bacteria, fungi
Predators	P	Living animals
Scavengers	Scav	Dead animals
Macrophyte piercers	MP	Living vascular plant and algal fluids

SIGNAL 2 scores – edge habitat

The SIGNAL (Stream Invertebrate Grade Number) 2 index uses a simple scoring system to provide an indication of water quality and ecosystem health. The grade number is an indication of the pollution tolerance or intolerance of macroinvertebrates within that taxonomic group (Hawking *et al.* 2009). When used in conjunction with species richness, the SIGNAL 2 index can provide an indication of the types of pollution and other physico-chemical factors that are influencing macroinvertebrate community structure and function. For example, a grade of 10 indicates a taxonomic group which is highly sensitive to pollution, whereas a grade of 1 indicates a taxonomic group with a higher tolerance to pollution. When used in conjunction with taxa richness, a community with high richness and high grade taxa indicates a healthy ecosystem. At the other end of the scale, a community with low diversity and low grade taxa indicates a degraded aquatic habitat. SIGNAL 2 scores were calculated for the edge data, based on Chessman (2003a), without abundance weighting. Results are reported in relation to the quadrat diagram described by Chessman (2003a) (Figure 2-4).

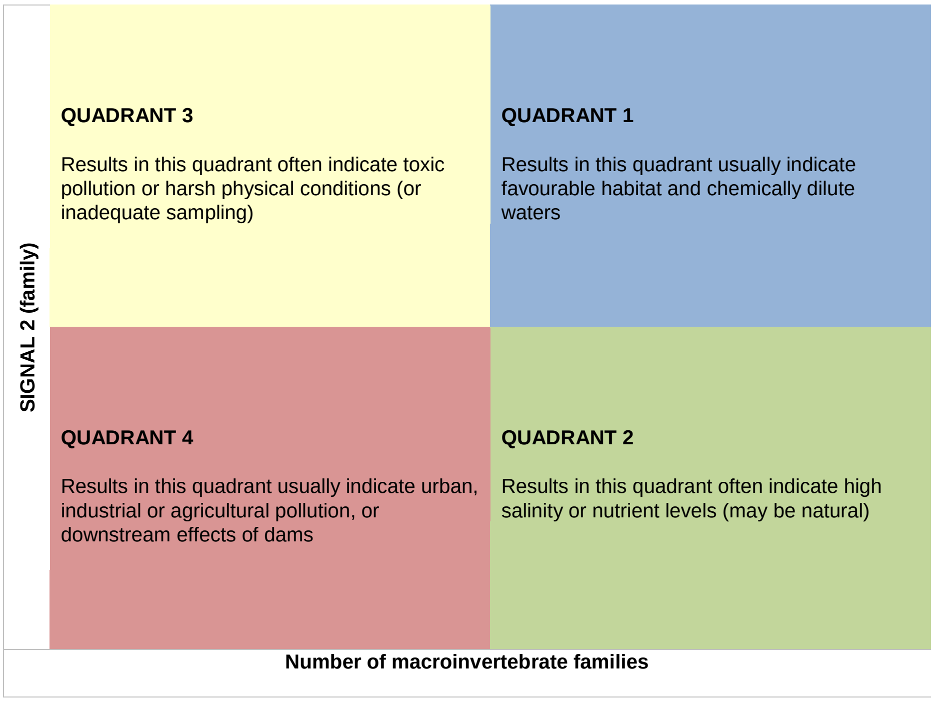


Figure 2-4 Quadrant diagram for the Family version of SIGNAL 2 (reproduced from Chessman 2003a)

Chessman (2003a) states "it is necessary to set the boundaries of the quadrant diagram individually, in order to suit each study region and the local sampling methods". However, insufficient data did not enable specific boundaries to be set for this study. Instead, boundaries used for the quadrant diagram were those suggested by Chessman (2001) for Australian freshwaters (boundary for SIGNAL 2 Families is 4; boundary for number of Families is 15.5).

2.3.3 Macrophytes

Macrophytes were identified to Genus level, where possible, based on field identifications, photographs and preserved specimens. These were assigned a percentage site cover for the 100 m reach at each site.

2.3.4 Diatoms

Diatoms have several attributes that render them useful in bioassessment of Australian fresh waters. They are easily and quickly collected and respond to a wide range of anthropogenic stressors such as thermal and organic pollution (Chessman 1985; Chapman and Simmons 1990), upstream impoundment (Growns and Growns 2001); salinisation (Blinn and Bailey 2001; Blinn *et al*. 2004) and impacts related to mining and agricultural activity (Archibald and Taylor 2007; Smucker and Vis 2009; Urrea-Clos 2010).

Diatom communities at each site were characterised in terms of abundance and species richness. Normalised cell concentration was used as a measure of diatom abundance. The abundance of each sample count was then standardised as a concentration of cells per species per gram. Species richness refers to the number of species recorded in each site sample.

A number of indices which reflect responses of individual diatom species and assemblages to key water quality parameters were also used in the study.

pH preference

Each diatom species was classified according to sensitivity to acidification into one of six categories based on values provided by Van Dam *et al*. (1994) (Table 2-3). Diatom assemblages at each sample location were then characterised as broadly acidophilic, alkalophilic or circumneutral based on the dominant species and overall proportion of species present in each pH class.

Table 2-3 Diatom preference categories in relation to sensitivity to acidification

Class Code	Class	Occurrence
1	Acidobiontic	Optimal occurrence at pH <5.5
2	Acidophilous	Mainly occurring at pH <7
3	Circumneutral	Mainly occurring at pH values around pH 7 (6.5-7.5)
4	Alkalophilous	Mainly occurring at pH >7
5	Alkalobiontic	Exclusively occurring at pH >7
6	Indifferent	No apparent optimum pH

Salinity preference

Each diatom species was classified according to sensitivity to salinity (and chloride concentration) into one of four classes based on values provided by Kelly *et al*. (2005) and Van Dam *et al*. (1994) (Table 2-4). Diatom assemblages at each sample location were then characterised as broadly preferring fresh to fresh-brackish conditions (Class 1+2) or brackish-fresh to brackish conditions (Class 3+4), i.e., based on the dominant species and overall proportion of diatoms in each salinity class. A correlation analysis was performed to examine any relationship between changes in conductivity and occurrence of salt sensitive (Class 1 + 2) taxa.

Table 2-4 Diatom preference categories in relation to chloride concentration and salinity

Class	Class	Cl^- (mg l^{-1})	Salinity (‰)
1	Fresh	<100	<0.2
2	Fresh brackish	<500	<0.9
3	Brackish-fresh	500-1000	0.9-1.8
4	Brackish	1000-5000	1.8-9.0

Motility

Diatoms were classified as motile or non-motile and proportions of each form for each site recorded for both the number of species and total abundance. The proportion of sessile and motile forms at a site may provide an indication of suspended solid concentrations present (Dickman *et al*. 2009) as motile forms will be more abundant in sediment-laden waters as they are able to move around and avoid being smothered by depositing sediments; whereas non-motile forms are unable to do this and their numbers would be greatly reduced.

Nitrogen uptake metabolism

For dominant and sub-dominant forms, diatoms were classified according to their nitrogen metabolism and requirement for sources of organically bound nitrogen following the classification system of Van Dam *et al.* (1994) (Table 2-5). A number of genera (e.g. *Epithemia* and *Rhopalodia*) contain nitrogen fixers as they harbour endosymbiotic bacteria that allow them to convert atmospheric nitrogen into biologically useful forms such as ammonia (Mulholland 1996). These diatoms have a preference for low organic nitrogen conditions. Diatoms classified as nitrogen heterotrophs can use amino acids created by other organisms as sources of carbon and nitrogen (Tuchman 1996) and can tolerate periodic or continuously elevated N levels. Thus, N fixers should decline and nitrogen- heterotrophs predominate with disturbances that increase organic N.

Table 2-5 Diatom nitrogen uptake metabolism indicator categories

Class	Taxon type
1	Nitrogen-autotrophic taxa, tolerating very small concentrations of organically bound nitrogen
2	Nitrogen-autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen
3	Facultative nitrogen-heterotrophic taxa, needing periodically elevated concentrations of organically bound nitrogen
4	Obligate nitrogen-heterotrophic taxa, needing continuously elevated concentrations of organically bound nitrogen

Trophic state

For dominant and sub-dominant forms, diatoms were allocated to one of seven trophic categories following the classification system of Van Dam *et al*. (1994) (Table 2-6). Trophic state refers to the presence of inorganic nutrients such as nitrogen, phosphorus, silica and carbon. Diatoms classified as oligotraphentic are sensitive to elevated levels of these nutrients, while diatoms classified in higher levels, e.g. eutraphentic or hypereutraphentic can tolerate high levels of nutrient enrichment.

Table 2-6 Diatom Trophic state indicator values

Class	Trophic State
1	oligotraphentic
2	oligo-mesotraphentic
3	mesotraphentic
4	meso-eutraphentic
5	eutraphentic
6	hypereutraphentic
7	oligo- to eutraphentic

Saprobity

For dominant and sub-dominant forms, diatoms were allocated to one of five saprobic categories following the classification system of Van Dam *et al*. (1994) (Table 2-7). Saprobity refers to the presence of biodegradable organic matter (e.g. from livestock excrement, wastewater release) and associated oxygen concentrations related to microbial decomposition processes or Biological Oxygen Demand (BOD). Oligosaprobous forms predominate in conditions of low levels of organic matter and require relatively high oxygen levels, while polysaprobous forms predominate in conditions where high levels of organic matter are present with high BOD and therefore tolerate low oxygen concentrations.

Table 2-7 Diatom saprobic indicator categories

Class	Oxygen saturation (%)	BOD (mg l^{-1})
1 oligosaprobous	>85	<2
2 β-mesosaprobous	70-85	2-4
3 α-mesosaprobous	25-70	4-13
4 α-meso-/polysaprobous	10-25	13-22
5 polysaprobous	<10	>22

Sensitivity Index

Diatom Sensitivity Index for Australian Rivers (DSIAR) values for each sample were calculated based on sensitivity values (SV) derived for diatoms in the manner described by Chessman (2003b) and Chessman *et al*. (2007). The index data were obtained from an extensive database for 501 diatom species collected from southern Queensland, New South Wales, Victoria and South Australia (Chessman *et al*. 2007). DSIAR scores have a possible range of 1-100. According to Chessman *et al*. (2007), high DSIAR scores signify a flora sensitive to common anthropogenic stressors, implying that the level of these stressors is likely to be low (i.e., that the river condition is comparatively natural). Conversely, low scores are interpreted as indicating a flora that tolerates anthropogenic stress, or even responds positively to it, and hence the likely presence of such stress, thus providing a measure of habitat disturbance.

3 RESULTS

3.1 Aquatic habitat

Photographs for each site are presented in Appendix 1, and site characteristics and habitat descriptions are presented for each site in Appendix 2. All sites except Juandah Creek D/S were dominated by silt/clay and sand, and the majority of sites were pools connected with runs or dry bed in between.

Stock access was apparent at many sites, with evidence of stock disturbance along the sampling reach (e.g. Plate A1-5 in Appendix 1). Evidence of recent flooding could also be seen at the majority of sites, with large logs, branches, sticks and debris built up causing jams and often blocking flowing water (e.g. Plates A1-1, A1-3 and A1-12 in Appendix 1).

Nearly all sites had less than 50% intact riparian trees, and the streams tended to lack shade and leaf litter input. All sites had high temperature, conductivity and pH (Table 3-1). The pH at all sites was above 7 units, indicating uniformly alkaline conditions. The electrical conductivity was high at nearly all sites, indicating saline conditions.

Table 3-1 Water quality parameters

Site	Electrical conductivity (µS/cm)	Temperature (°C)	pH (units)
Canal Ck U/S	384	19.7	7.7
Canal Ck D/S	261	n/a	8.1
Eurombah Ck U/S	999	21.6	8.4
Eurombah Ck D/S	936	20.1	8.5
Dawson R U/S	1085	23	8.9
Dawson R D/S	733	20.1	8.3
Horse Ck 1	730	23.3	8.1
Horse Ck 2	748	23.4	8.1
Horse Ck 4	628	19.1	7.8
Wandoan Ck	350	21.6	8.2
Juandah Ck U/S	396	24.3	8.3
Juandah Ck D/S	169	24.1	7.9

Canal Creek

Canal Creek upstream consisted of sandy pools, and was 70% dry. There was only a small amount of water present, with pool depth approximately 0.3 m, and the water was turbid. Riparian vegetation was sparse, with up to 10% trees. There was some overhanging vegetation in the form of grasses and shrubs. There was little shade (15%) and approximately 10% of the bed was covered in algae. In contrast, the downstream Canal Creek site had more permanent water present, with no flow, and was just downstream of a wetland. This site had 90% macrophyte cover. Riparian vegetation was slightly more intact at the downstream site, providing more shade (25%), but it was still sparse and patchy (less than 20% trees).

Eurombah Creek

The upstream Eurombah Creek site consisted of a sand/silt/clay bed in a slow flowing run/pool with turbid water. There was good riparian vegetation (50-75% trees, extending over 30 m from the stream), the stream had 40% shade, and some woody debris was present. The downstream site was wider and deeper, and slightly faster flowing. There was evidence of erosion on the banks, with bare ground and tree roots exposed in many sections. Riparian vegetation was good at this site also, extending over 30 m distance from the stream, and consisted of up to 50% trees which provided 60% shade to the stream. Some filamentous algae were present on the substrate (up to 10%).

Dawson River

The Dawson River upstream tributary was an intermittent stream, with occasional pools linked with narrow sections (less than 1 m) of runs, or dry sections. It was a wide silt-dominated stream with patchy riparian vegetation, composed mainly of grasses, with less than 20% trees and no shading. Stock access was evident. There was a high percentage cover of algae on the bed (10-50%) and macrophytes (25%). The main river sampled downstream was much wider and consisted of permanent slow-flowing water over 1.5 m deep. Riparian vegetation was more intact with up to 50% trees and 50% shading, and the riparian vegetation extended up to 80 metres distance from the river. Water temperature, conductivity and pH were all higher at the Dawson River U/S site than the downstream site, and the upstream site had the highest conductivity and pH of all the sites (Table 3-1).

Horse Creek

Three sites were sampled along Horse Creek. Horse Creek 1, the most upstream of the three sites, was wide (7 m wet width), consisting of 95% sandy pools and 5% dry areas, with turbid water. Riparian vegetation only extended 5 m back from the stream, and had less than 20% trees. Horse Creek 2 was narrower (2 m wet width) with less water (20% dry stream bed). Riparian vegetation only extended back 5-10 m from the stream, but was slightly more intact with up to 75% trees which provided approximately 40% shade. The water at this site was typically clear and there was a small amount of algae present. This site had much coarse particulate organic matter (CPOM) present. Horse Creek 4 was 3 m wide composed of a slow run/pool. Riparian vegetation was composed of up to 20% trees; there was some overhanging vegetation, and the stream was approximately 50% shaded. There was some in-stream CPOM present and up to 10% algae present on the substrate.

Mud Creek

Mud Creek was wide (6 m) and deep (over 1.5 m), with riparian vegetation up to 15 m wide, consisting of up to 50% trees. The water was turbid and the Hydrobiology team were unable to safely access the water to assess instream habitat completely. The flow had been blocked by road works on the ford downstream, possibly causing the increased depth and width at this site.

Wandoan Creek

This site consisted of 60% intermittent sandy pools with 20% runs and 20% dry bed connecting these. The riparian vegetation consisted of less than 10% trees and approximately 75% grass and shading was low (10%). Algae were present on approximately 10-15% of the substrate. Channel width was 3 m and average water depth was estimated at 0.5 m. Riparian vegetation on the right bank was approximately 5 m in width and was 20 m in width on the left bank with both banks vegetation reaching heights of *circa* 20 m.

Juandah Creek

Both Juandah Creek sites were mainly dry. The upstream site was dry (60%), with 30% run and 10% pool habitat, and the downstream site was dry with only 20% pool habitat present. At the upstream site, the water depth was only 0.1 m and 1 m wide, and the water was clear. Shading was low (15%), mostly due to the width of the channel (10 m). Riparian vegetation width was high (up to and over 30 m), consisting of up to 50% trees. Algae covered up to 10% of the bed substrate. The downstream site was the only site with substrate other than sand/silt/clay, with predominantly cobbles and pebbles present. Shading covered 30% of the stream, and algae were present on 50-75% of the substrate.

Wetlands

There are no Nationally Important wetlands within the Project area. The closest Nationally Important wetlands are Palm Tree and Robinson Creeks, 35 km north of the Project area and Boggomoss Springs, 56 km north east of the Project area.

Some smaller wetlands, such as blacksoil floodplains, depressions and gilgais that may fill with water during the wet season, are located along Horse, Juandah, Eurombah and Canal Creeks but these are not classified as “important” under Queensland legislation (BAAM, 2012).

3.1.1 Habitat assessments

The results of the habitat assessment sampling are summarised in Table 3-2. Habitat assessment scores ranged from 43 (Canal Creek U/S) to 85 (Juandah Creek D/S), suggesting a range of habitat quality between the sites. These results suggest none of the sampled sites within the area are of pristine quality and have all been affected by agricultural activities.

Table 3-2 Summary of the AUSRIVAS habitat assessments, March 2012

Site	Bottom substrate/ available cover (/20)	Embeddedness (/20)	Velocity/depth category (/20)	Channel alteration (/15)	Bottom scouring and deposition (/15)	Pool/riffle, run/bend ratio (/15)	Bank stability (/10)	Bank vegetative stability (/10)	Streamside cover (/10)	TOTAL (/135)
Canal Ck U/S	3	2	2	7	8	1	6	9	5	43
Canal Ck D/S	16	5	5	14	14	4	10	10	5	83
Eurombah Ck U/S	10	9	8	3	6	4	3	7	9	59
Eurombah Ck D/S	14	6	10	6	8	10	5	4	9	70
Dawson R U/S tributary	7	4	7	1	3	4	4	9	5	44
Dawson R D/S	6	4	5	4	6	7	3	8	5	48
Horse Ck 1	7	10	5	7	7	7	5	8	5	61
Horse Ck 2	9	5	9	6	6	6	7	7	9	64
Horse Ck 4	8	13	9	11	10	9	5	9	5	79
Mud Ck	9	7	5	7	9	5	8	9	5	64
Wandoan Ck	6	6	6	4	4	4	3	8	4	44
Juandah Ck U/S	8	9	10	3	7	3	7	9	5	61
Juandah Ck D/S	15	15	1	11	12	7	7	8	9	85

3.2 Macroinvertebrates

3.2.1 Abundances and PET abundances (bed habitat)

Average abundances (from the five bed samples taken at each of the twelve sites surveyed) ranged from 7 (Dawson River D/S) to 153 (Dawson River U/S tributary) individuals (Figure 3-1).

Although Dawson River U/S site had the highest average abundances, the abundances of sensitive PET taxa were low at this site (Figure 3-2). The high abundances at the Dawson River U/S site were due to a high number of water boatmen (Family Corixidae). This Family of water bugs are common on the edges of lakes and ponds, especially where vegetation is present (Gooderham and Tsyrlin 2002), similar to the habitat present at the Dawson River U/S site.

The average PET abundances ranged from nil (Canal Creek U/S) to 29.6 (Canal Creek D/S) (Figure 3-2). Canal Creek D/S occurs downstream from a wetland (BAMM pers. comm.), and with 90% macrophyte cover had a much higher average abundance of PET taxa than the other sites, consisting of the mayfly Family (Baetidae) which are common in wetlands and feed on algae, wood and aquatic plants (Gooderham and Tsyrlin 2002).

Raw macroinvertebrate data from the bed habitat is presented in Appendix 3.

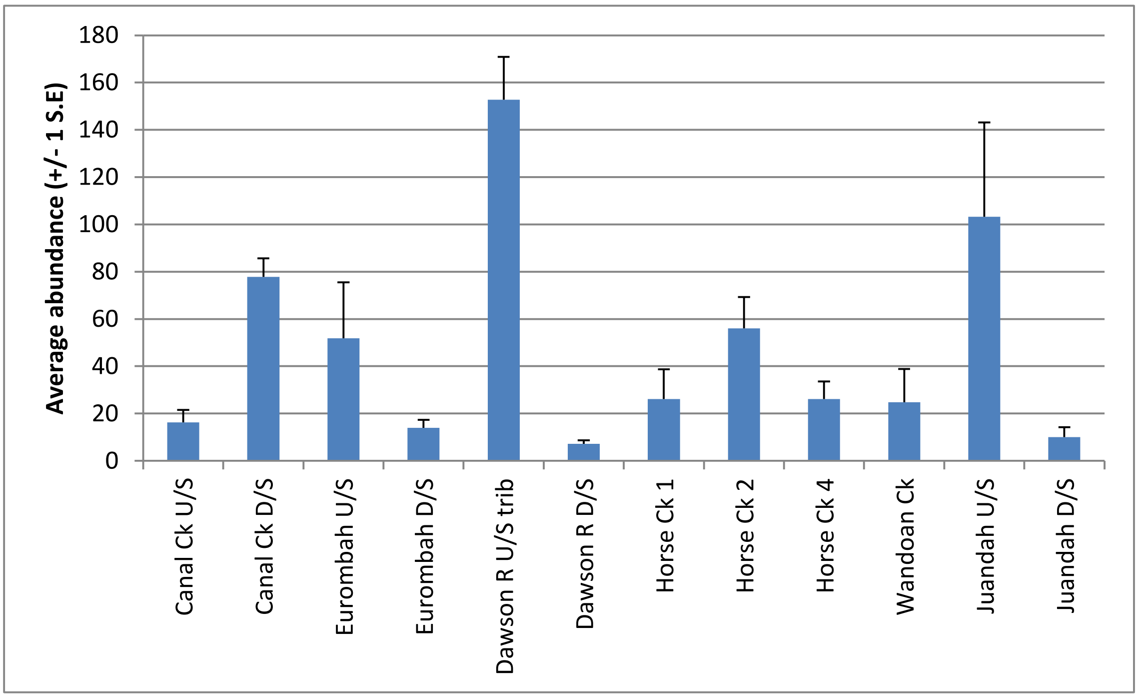


Figure 3-1 Average abundance of macroinvertebrates in the bed habitat

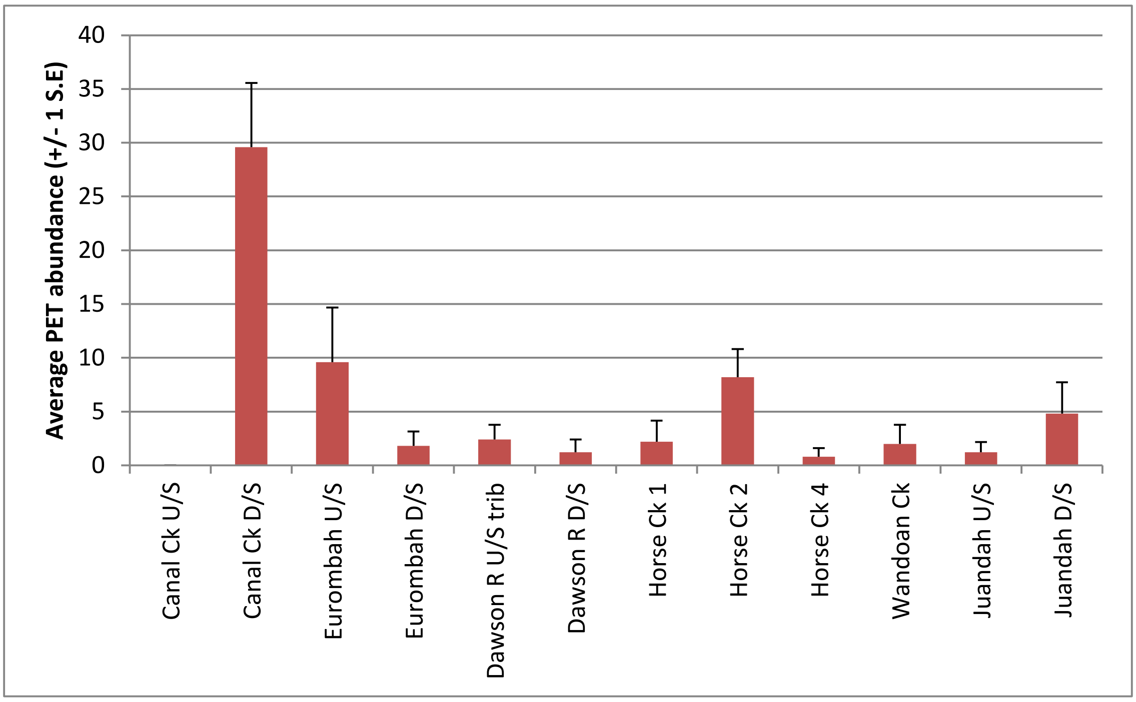


Figure 3-2 Average PET abundance of macroinvertebrates in the bed habitat

3.2.2 Taxa and PET taxa richness (edge habitat)

A total of 49 taxa were collected from the edge samples. The total number of taxa present at a site within the edge samples ranged from 13 (Dawson River D/S) to 29 (Wandoan Creek) (Figure 3-3).

All sites had the sensitive PET taxa present within the edge habitat, and the number of PET taxa at a site ranged from 1 (Canal Creek U/S) to 6 (Eurombah Creek D/S and Horse Creek 2). PET taxa consisted of three Ephemeroptera (mayflies) and two Trichoptera (caddisflies) taxa. No Plecoptera (stoneflies) were found at any of the sites.

Raw macroinvertebrate data from the edge habitats are presented in Appendix 3.

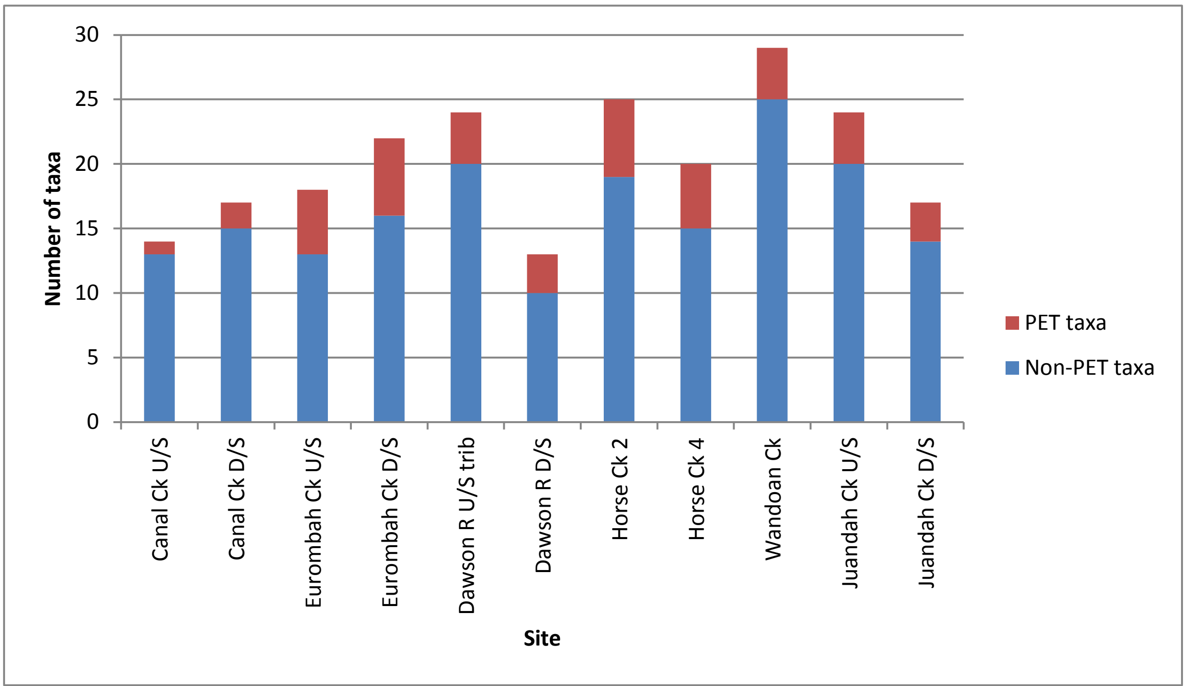


Figure 3-3 Number of macroinvertebrate taxa collected in the edge habitat, March 2012

3.2.3 Functional feeding groups (edge habitat)

The edge habitat contained a variety of macroinvertebrate functional feeding groups, with up to eight different feeding types present (Figure 3-4). Three taxa were unable to be classified into a feeding group (“unclassified”), and some Families of macroinvertebrates had more than one feeding type and these were grouped into multiple types. For example, the Family Veliidae is grouped into “Predator/Scavenger”, and species within this Family may be either predators or scavengers.

The generalist feeding types, predators and gathering-collectors, were the dominant feeding types at all sites. The more specialised feeding groups were less dominant, such as the scrapers and shredders. Of the 49 taxa found in the edge habitat, three taxa belonged to the scraper feeding group, and two belonged to the shredder feeding group. Both these specialist feeding groups were present at four of the sampled sites. The Dawson River sites had both shredders and scrapers present, and Canal Creek D/S and Eurombah Creek D/S had scrapers, while Wandoan Creek and Juandah Creek U/S had shredders present.

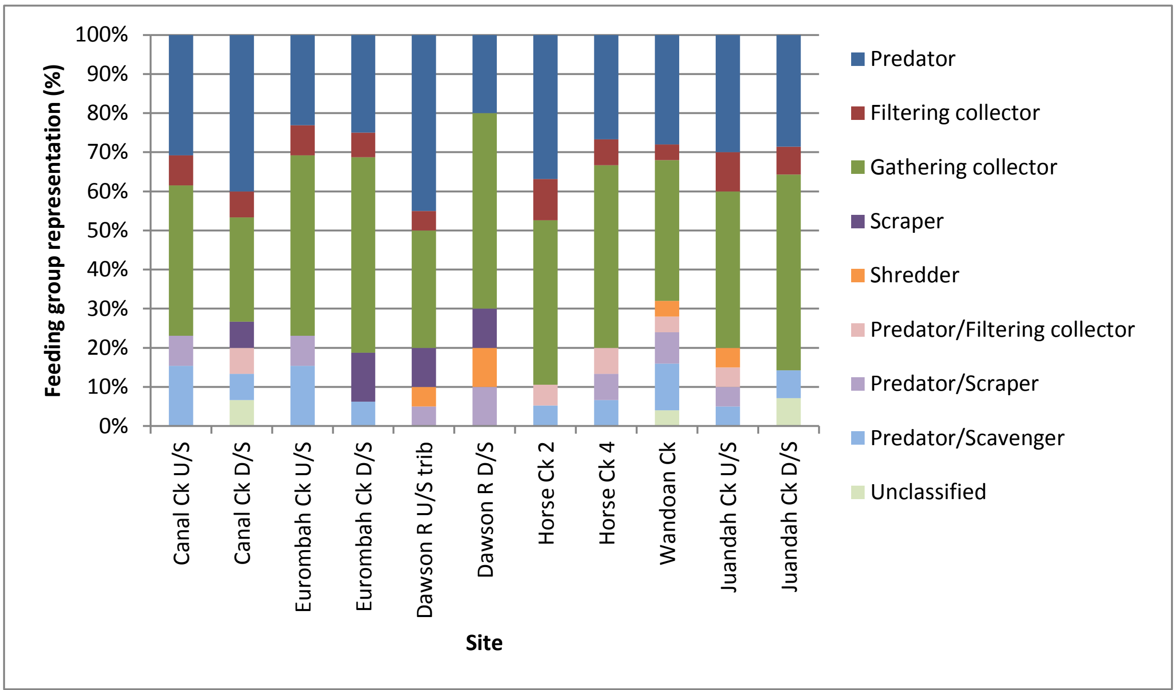


Figure 3-4 Macroinvertebrate functional feeding groups for edge habitat number of Families

3.2.4 Functional feeding groups (bed habitat)

The functional feeding groups were also assessed for the bed habitat samples, using total abundances of separate feeding groups, rather than number of taxa, to determine the relative difference in the populations of each feeding group.

The bed habitat typically had one feeding group that was most dominant at each site. For example, Gathering collectors were the dominant feeding group at 7 sites, Predators at 4 sites and Predator/Scrapers at 1 site (Figure 3-5).

The Dawson River U/S site had the highest proportion of predators, again due to the high number of water bugs (Family Corixidae). Juandah Creek U/S had the highest proportion of filtering collectors due to a high number of the dipteran Family Simuliidae (black flies).

The Majority of sites (Canal Creek U/S, Eurombah Creek U/S, Eurombah Creek D/S, Dawson River D/S, Horse Creek 1, Horse Creek 4 and Juandah Creek D/S) were dominated by gathering collectors, with several of these sites supporting significant proportions of predators (Canal Creek U/S, Eurombah Creek U/S, Horse Creek 1, Horse Creek 4 and Juandah Creek D/S). Both of these feeding groups consisted largely of the dipteran Families Ceratopogonidae (biting midges, predators) and Chironominae (non-biting midges, gathering collectors).

Scrapers were present at four sites (Canal Creek D/S, Eurombah Creek D/S, Dawson River U/S and Dawson River D/S), and comprised approximately one quarter of the total abundance at Eurombah Creek D/S and Dawson River D/S. Scrapers at these two sites consisted of the gastropod snail Family, Thiaridae (marsh snails).

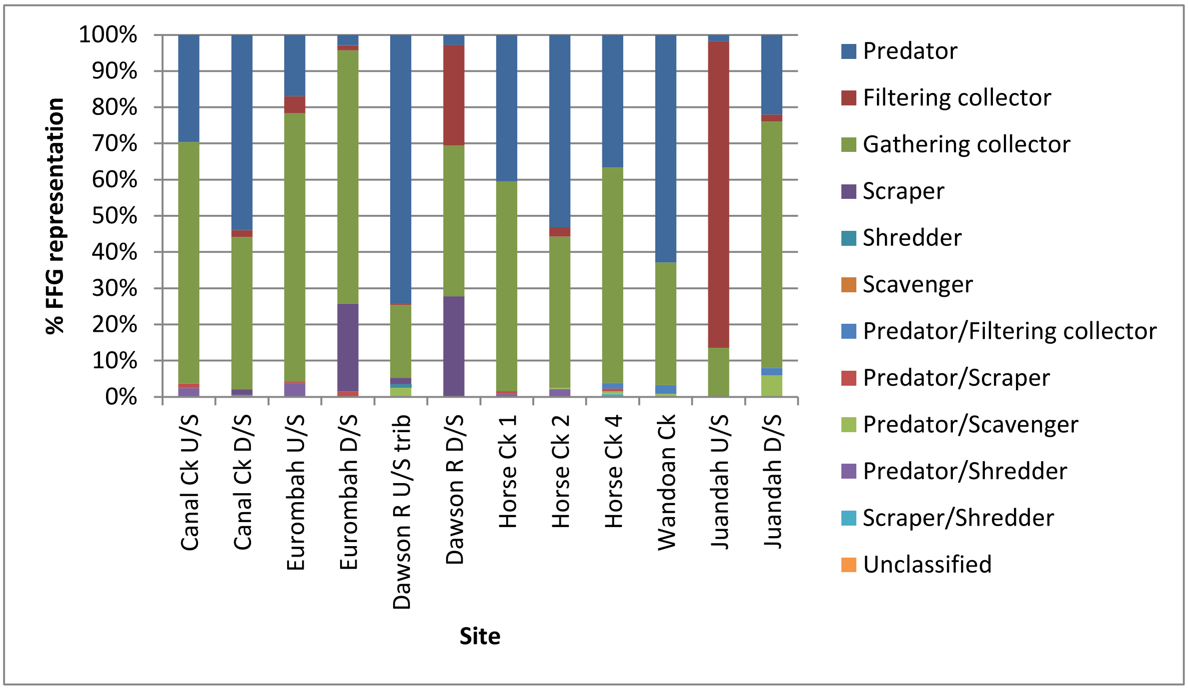


Figure 3-5 Macroinvertebrate functional feeding groups for bed habitat abundances

3.2.5 SIGNAL 2 scores (edge habitat)

Signal 2 scores were calculated for all sites based on the families in the edge sample data. Six Families had no SIGNAL 2 scores available. The SIGNAL 2 scores were low for all sites, ranging from 3.18 (Canal Creek D/S) to 4.36 (Juandah Creek D/S) (with no abundance weighting). Low SIGNAL 2 scores indicate waterways likely to have high levels of salinity, turbidity and nutrients (such as nitrogen and phosphorus) (Chessman 2001).

The most sensitive taxa sampled were the mayfly (Family Leptophlebiidae) (SIGNAL 2 score of 8), and the diving beetle (Family Dytiscidae) (SIGNAL 2 score of 7). All other taxa had a score of six or below, indicating most taxa present are non-sensitive to impacts.

When the macroinvertebrate SIGNAL 2 scores are plotted against macroinvertebrate richness, SIGNAL 2 can provide an indication of the types of pollution and other factors that may be influencing the macroinvertebrate community (Chessman 2001) (Figure 3-6). From this plot, four sites fall into Quadrant 2, and seven sites fall into Quadrant 4 (Figure 3-6).

Quadrant 2 represents low SIGNAL 2 scores and a high number of macroinvertebrate taxa, and potentially indicates high levels of turbidity, salinity and/or nutrients. Three of the sites within Quadrant 2 (Horse Creek 2, Dawson River U/S tributary and Juandah Creek U/S) were the only sites with clear water, so the grouping cannot be indicative of high turbidity.

Water quality results indicated conductivity was high at nearly all the sites, but Dawson River U/S did have the highest recorded electrical conductivity of all the sites. Salinity and nutrients may be high due to natural and/or anthropogenic sources; however it is not possible to distinguish between stressors using SIGNAL 2 boundaries, and many agricultural streams fall into this Quadrant (Chessman 2001).

Quadrant 4 represents low SIGNAL 2 values and low numbers of taxa, and is indicative of anthropogenic impacts, and as the land use in the sampling areas was dominated by agriculture, this may be influencing the low SIGNAL 2 scores and low number of macroinvertebrate taxa. Seven of the 11 sampled sites fall into this Quadrant.

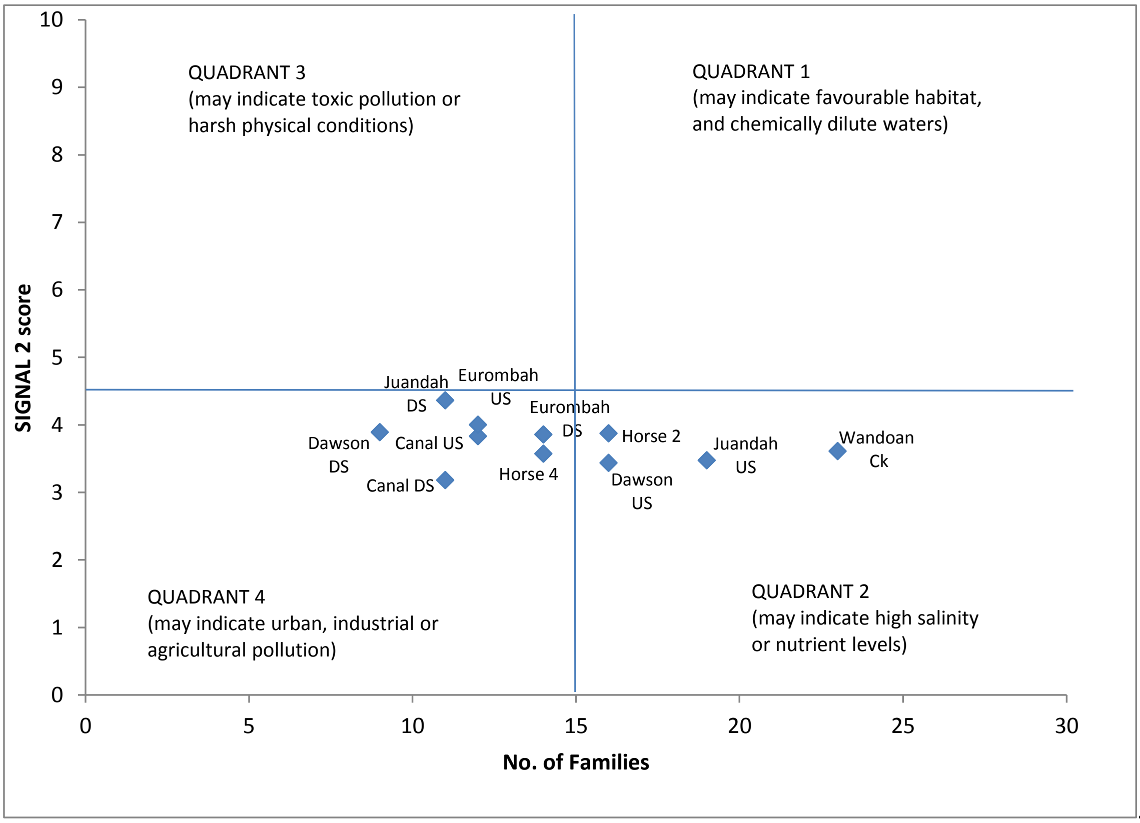


Figure 3-6 Macroinvertebrate SIGNAL 2 (Family level) (edge habitat) bi-plot. Quadrants based on Chessman (2001) for the Dawson River

3.3 Macrophytes

Macrophytes were present at seven of the sites sampled (Table 3-3). Photographs of macrophytes are presented in Appendix 4. Nineteen species were recorded from 13 Families. Twelve species were emergent macrophytes, two of which were only present on the stream banks (common rush, *Juncus usitatus,* and water pepper, *Persiceria hydropiper*). Five of the seven sites with macrophytes had only one species recorded, occurring only on the stream banks.

Only two sites had macrophytes present within the water, Dawson River U/S (45% total macrophyte cover of the stream) and Canal Creek downstream (95% total macrophyte cover of the stream). Canal Creek downstream was 600 m downstream of a wetland (DERM 2012), and this site also had similarities to a wetland as it was nearly 100% covered by macrophytes.

All macrophytes identified were native, and typically have positive effects upon the stream and its banks. For example, many of the macrophytes (e.g. curly pondweed, *Potamogeton crispus*) are an important food source for water birds and provide habitat for instream fauna.

All macrophyte species occurred with abundances of less than 10% of the stream reach, except for the water primrose, *Ludwigia peploides*, at Canal Creek D/S. Some species could have a detrimental impact on streams if they become highly abundant and block the waterway (e.g. slender knotweed, *Persicaria decipiens*). This was noted at Canal Creek D/S, with the water primrose *Ludwigia peploides* covering 60% of the stream reach. Water flow at this site was low, draining from the wetland above (BAMM pers. comm.), although the high proportion of this species does not appear to be having a detrimental effect on the already slow-flowing water at this section of Canal Creek.

Table 3-3 below indicates the proportion of macrophytes present at each site, and includes notes, where information was available, on each macrophyte species.

Table 3-3 Macrophytes collected from sampling sites, March 2012

Family	Species	Common name	Emergent	Submerged	Floating, attached	Dawson R U/S tributary	Canal Ck D/S	Juandah Ck D/S	Juandah Ck U/S	Mud Ck	Horse Ck 2	Horse Ck 4	Notes
Amaranthaceae	*Alternanthera denticulata*	Lesser joyweed	✓				1-5%						
Characeae	*Nitella* sp.	Nitella		✓	✓	1-10%							A charophyte (large green algae); superficially similar to submerged flowering plants. Present in beds/stands. Typically found in clear slow-flowing or still water
Cyperaceae	*Cyperus cf concinnus*	Cyperus	✓				1-5%						
	Cyperus difformus	Rice sedge	✓				1-5%						Can be a weed of rice crops. Useful in stabilisation of banks. Fast growing.
	Cyperus cf trinervis	Sedge	✓									1-5% (edge)	*C. trinervis* is widespread in damp areas near coastal regions of Queensland.
	Eleocharis cf plana	Ribbed spikerush	✓				1-5%						*E. plana* provides good nesting sites for water birds. Useful for bank stabilisation.
	Schoenoplectus validus	River clubrush	✓			1-10%							Prevents erosion, provides cover and nesting for wildlife.
Gramineae	*Phragmites australis*	Common reed	✓							15% (edge)			Tolerant of brackish water, important component of wetlands, provides cover to animals and grazing for stock. Prevents erosion. Can be a weed in constructed waterways

Family	Species	Common name	Emergent	Submerged	Floating, attached	Dawson R U/S tributary	Canal Ck D/S	Juandah Ck D/S	Juandah Ck U/S	Mud Ck	Horse Ck 2	Horse Ck 4	Notes
Haloragaceae	*Myriophyllum verrucosum*	Red water milfoil	✓	✓		1-10%							Common in inland areas in fresh or brackish water. Seeds likely source of extensive growth after flooding; food source for waterbirds; eaten by stock, but may contain high hydrogen cyanide content; can be a pest in dams/irrigation systems.
Hydrocharitaceae	*Vallisneria americana*	Ribbon weed		✓		1-10%							Good indicator of condition of the stream, spreads rapidly and may cause obstruction to flow.
Juncaceae	*Juncus usitatus*	Common rush	✓			1-10%			<1% (edge)		1-5% (edge)	1-5% (edge)	Provides cover and food for animals, useful by providing competition on channel margin for less desirable plants.
Marsileaceae	*Marsilea mutica*	Nardoo			✓		10%						Widespread, but uncommon. Found in coastal and sub coastal Queensland. Present in beds/stands
Najadaceae	*Najas tenuifolia*	Waternymph		✓		1%							Widespread in still or slow moving water. Will grow in brackish water. May obstruct water flow when other plants are present.
Onagraceae	*Ludwigia peploides*	Water primrose			✓	1-10%	60%						Mostly beneficial; seeds are a food source for water birds, but can obstruct waterway. Filling channel at this site
Polygonaceae	*Persicaria decipiens*	Slender knotweed	✓				1-5%						Useful component of wetland flora; may form dense mats impeding water flow
	Persiceria hydropiper	Water pepper	✓					1% (edge)					
	Persicaria sp.	Knotweed	✓			1%							
Pontederiaceae	*Monochoria cyanea*	Monochoria			✓		1-5%						Provides food for water birds

Family	Species	Common name	Emergent	Submerged	Floating, attached	Dawson R U/S tributary	Canal Ck D/S	Juandah Ck D/S	Juandah Ck U/S	Mud Ck	Horse Ck 2	Horse Ck 4	Notes
Potamogetonaceae	*Potamogeton crispus*	Curly pondweed		✓		1-10%							Provides food for water fowl and habitat for fish. Widespread, common
Total instream cover						**45%**	**95%**	**Edge only**	**Edge only**	**Edge only**	**Edge only**	**Edge only**	

NB: Details of growth form and other notes from Sainty and Jacobs (2003) and Stephens and Dowling (2002)

3.4 Diatoms

3.4.1 Abundance and taxa richness

A total of 82 diatom species from 11 Orders and 20 Families and 30 genera were collected during the survey. A species list is provided in Appendix 5.

Of the 82 species, pH index values were available for 73 species (89%), salinity index values available for 70 species (85.4%) and all species were classified as either motile (84.6%) or non-motile (15.4%). In terms of total sample abundance, 89.9% of diatoms were motile and only 10.1% were non-motile.

The community was dominated by two pinnate Orders: Naviculaceae and Bacillariaceae. The Naviculaceae comprised 22 species from four genera (Navicula [20 spp]; Hippodonta [1 sp.]; Caloneis [1 sp.]) while the Bacillariaceae comprised 26 species from four genera (Nitzschia [20 spp]; Tryblionella [4 spp]; Hantzschia [1 sp.]; Bacillaria [1 sp.]). The genera: Navicula and Nitzschia are diverse taxa and constituted a large proportion of species richness and abundance in samples at a majority of sites (Table 3-4).

Table 3-4 Summary of species richness and abundance data for the diatom genera *Navicula* and *Nitzschia* in samples from each survey site

Location	Total no. of taxa	*Navicula*		*Nitzschia*		Genera combined	
		No. spp.	% abundance	No. spp.	% abundance	% spp.	% abundance
Horse Ck 1	19	8	25.8	6	9.5	73.7	35.2
Horse Ck 2	18	5	28.4	3	9.0	44.4	37.4
Horse Ck 4	29	6	35.8	6	13.2	41.4	49.0
Juandah Ck U/S	19	4	15.6	6	14.2	52.6	29.8
Juandah Ck D/S	22	6	30.8	11	18.5	77.3	49.3
Wandoan Ck	17	7	21.0	3	12.9	58.8	33.9
Canal Ck U/S	17	6	63.1	6	15.4	70.6	78.5
Canal Ck D/S	24	7	4.4	5	3.6	50.0	8.0
Eurombah Ck US	18	5	12.4	3	3.6	44.4	16.0
Eurombah Ck DS	17	2	74.9	3	2.5	29.4	94.3
Dawson R U/S	30	8	26.1	5	8.3	43.3	34.4
Dawson R D/S	16	5	66.2	3	7.1	50.0	73.3

Diatom species richness ranged from 17 to 30 with a median value of 18 (Figure 3-7). There was no trend in taxa richness between upstream and downstream sites, nor between different waterbodies, except for Dawson River with a decrease from 30 species in the upstream (U/S) site compared with 16 species in the downstream (D/S) site. The highest number of species was recorded for the Dawson River upstream (U/S) site (30) and the Horse Creek 4 site (29).

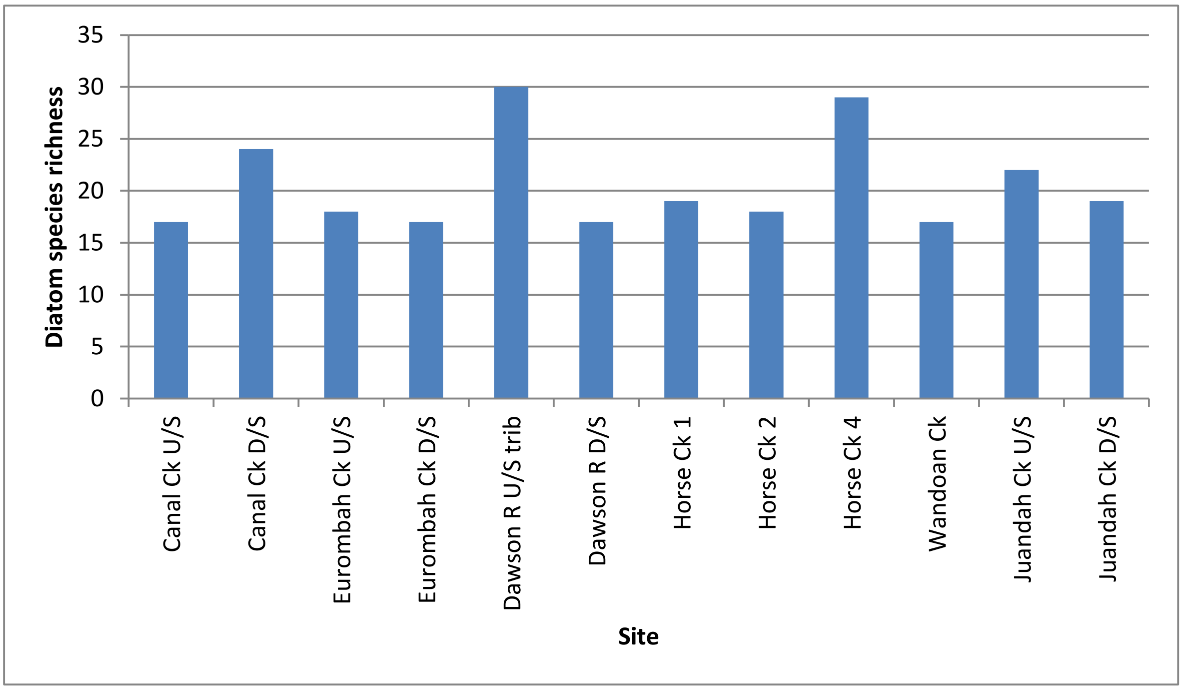


Figure 3-7 Diatom species richness

Diatom abundances were high and ranged from 7,500 to 23,400 cells per mm^3 with a median value of 11,600 cells per mm^3 (Figure 3-8). Abundances were similar across sites except for Dawson River upstream (U/S) site and Horse Creek 4 site with the highest abundances recorded (23,400 and 21,600 cells per mm^3 respectively). These sites also recorded the highest species richness (Figure 3-7).

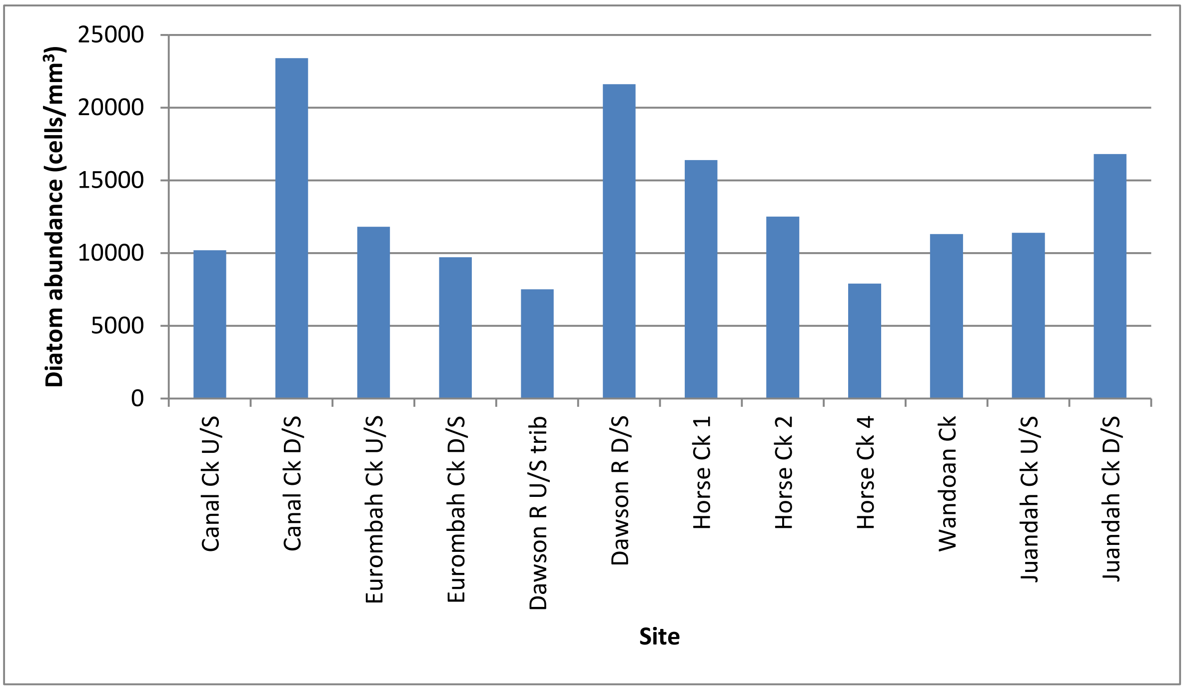


Figure 3-8 Diatom abundance

3.4.2 Motility

The majority of the diatom species collected were motile (68 of the 82 species) (Appendix 5). Motile species were dominant at all sites, contributing to over 75% of the diatom species (Figure 3-9), and 90% of total diatom numbers.

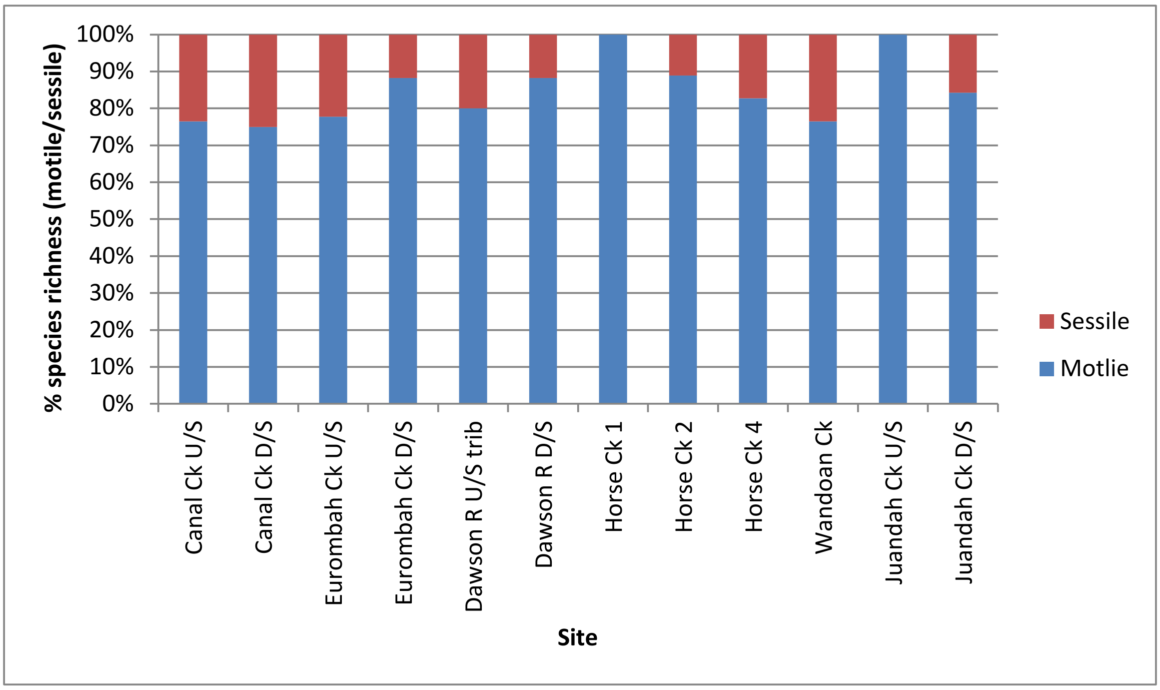


Figure 3-9 Proportion of motile and sessile diatom species richness

3.4.3 pH preference

The percentage of diatom species and species abundance in each pH category are presented in Figure 3-10 and Figure 3-11.

Alkalophilic species (species which prefer pH levels >7 but may still be found in pH levels less than this) dominated across all sites and were the most abundant in samples from a majority of sites. The median species richness and abundance values across all sites for alkalophilic forms were 12.3 and 157.5 respectively. Acidophilic forms (species which prefer pH levels <7) recorded median species richness and abundance as 0.5 species and 0.5 individuals respectively and circumneutral forms (species which prefer pH levels close to 7) recorded median species richness and abundance at 2.5 species and 12.5 individuals respectively.

For the total community, forty-eight species were alkalophilic and six species (*Bacillaria paxillifer, Fallacia pygmaeae, Gyrosigma attenuatum, Rhopalodia gibba, Amphora veneta, Anomoeneis shaerophora*) were alkalobiontic (species found exclusively in alkaline waters - pH >7 only). Of these species, *R. gibba* and *A. sphaerophora* were dominant or sub-dominant in samples from three sites (Juandah Creek U/S, Wandoan Creek, and Dawson River U/S). In contrast, only three species (*Frustulia rhomboides, Navicula heimansoides* and *Navicula* *leptostriata*) were classified as acidophilic and one species (*Nitzschia paleaformis*) was classified as acidobiontic (with optimal occurrence at pH <5.5 only).

Frustulia rhomboides occurred in samples from Juandah Creek U/S and D/S, *N. heimansoides* in samples from Horse Creek 4, Juandah Creek and Dawson River U/S, *Navicula leptostriata* in samples from Horse Creek 4 and Wandoan Creek, while *N. paleaformis* occurred in samples from Horse Creek 1, Wandoan Creek and Eurombah Creek U/S.

All species were present only as a few specimens in samples (<3% of site abundance). For classified species, in terms of total sample abundance, 82.7% were alkalophilic or alkalobiontic, 16.5% were circumneutral and only 0.8% were acidophilic or acidobiontic forms.

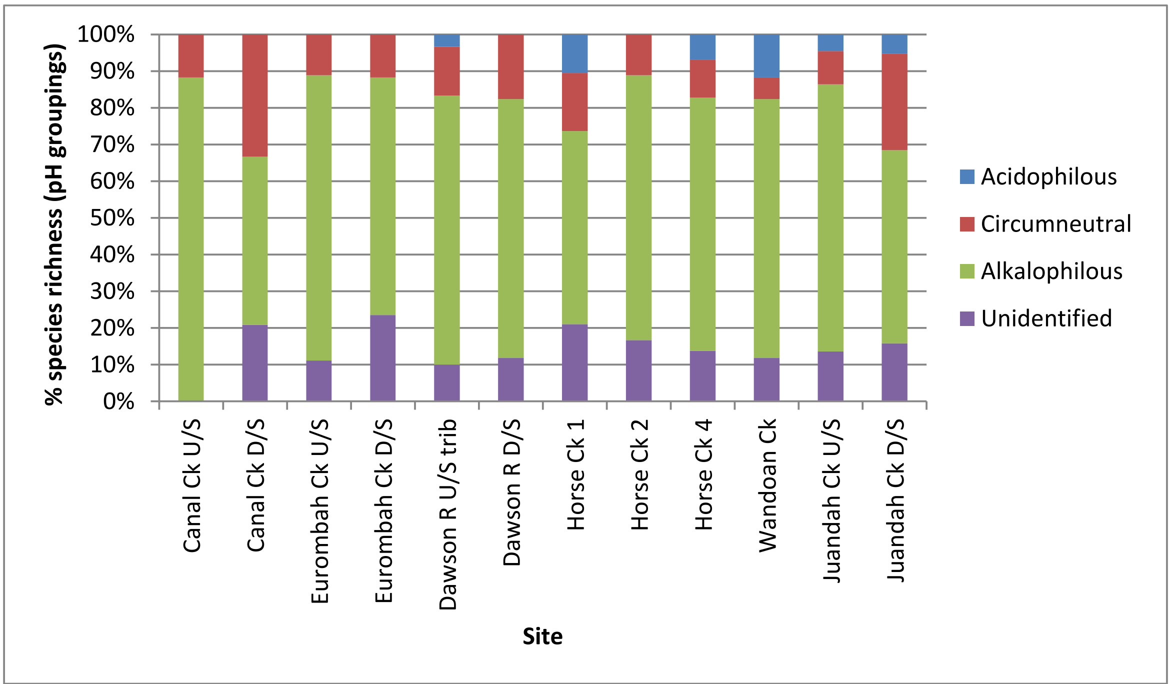


Figure 3-10 Percentage of diatom species in each pH category for all sites surveyed

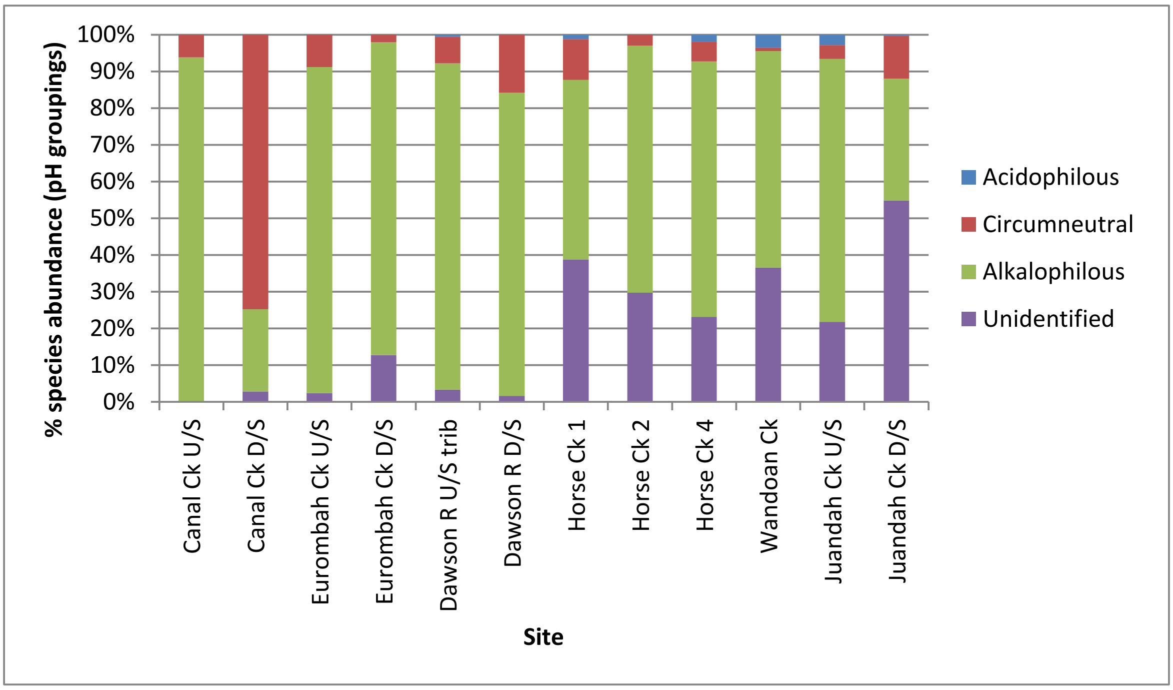


Figure 3-11 Percentage abundance of species in each pH category for all sites surveyed

3.4.4 Salinity preference

The percentage of diatom species in each salinity category for each site is presented in Figure 3-12. While median species richness (11.5) was higher for low salinity tolerance forms (Class 1 and 2) (<0.9 parts per thousand (ppt)) compared with seven species for more salt tolerant forms (Class 3 and 4) (0.9-9.0 ppt), median abundance was much higher for the latter (143.5) compared with diatoms with low salt tolerance (97.5).

For the entire diatom community, only six species were classified as preferentially freshwater forms (optimal occurrence at salinity <0.9ppt), while 40 species were classed as fresh-brackishwater species, having optimal occurrence at salinities <0.9 ppt. Twenty-four species were classified as brackish-freshwater species or brackishwater species with optimal occurrence at 0.9 to 1.8 ppt and 1.8 to 9.0 ppt (class 3 and 4) respectively. Unclassified species were 5.1% of total abundance. In terms of total sample abundance, classified species with optimal occurrence at salinities below 0.9 ppt were 38.6% of total abundance, while diatoms with preferences between 0.9 and 9.0 ppt were 56.3% of total abundance.

There was a significant negative correlation ($r = -0.63662$; $p = 0.047793$) between salt-sensitive species richness and conductivity (Figure 3-14): the number of diatoms with a preference for low salinity conditions (<0.9ppt) at a site decreased with increasing water conductivity (salt concentration).

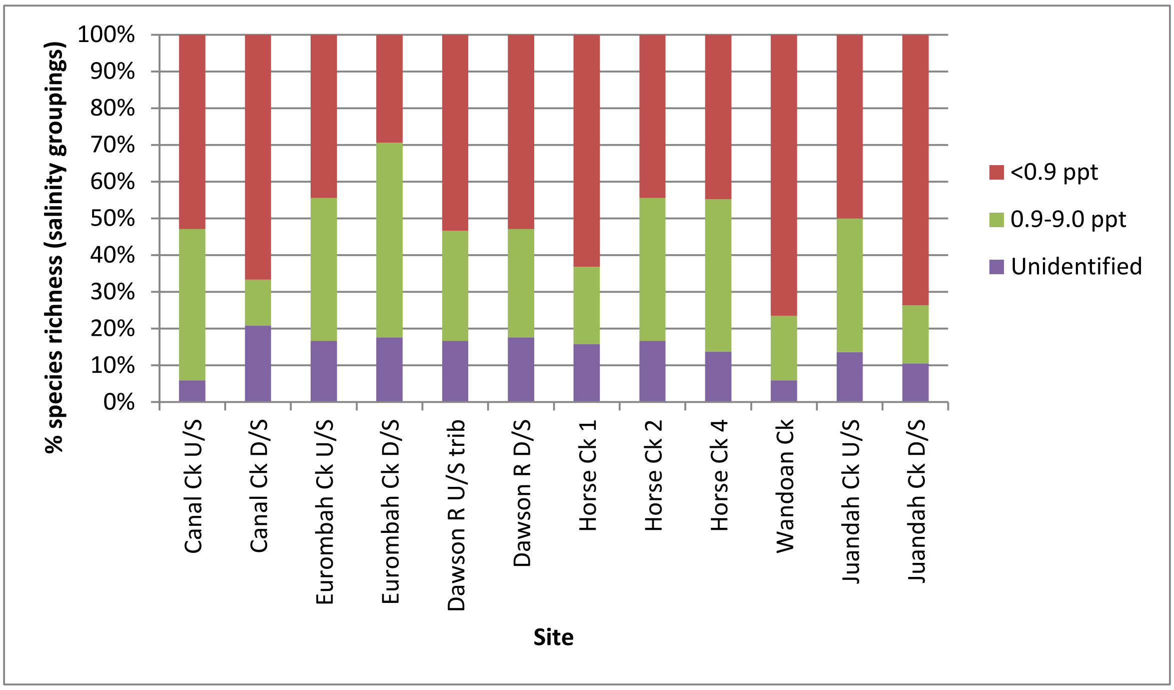


Figure 3-12 Percentage of diatom species in each salinity category for all sites surveyed

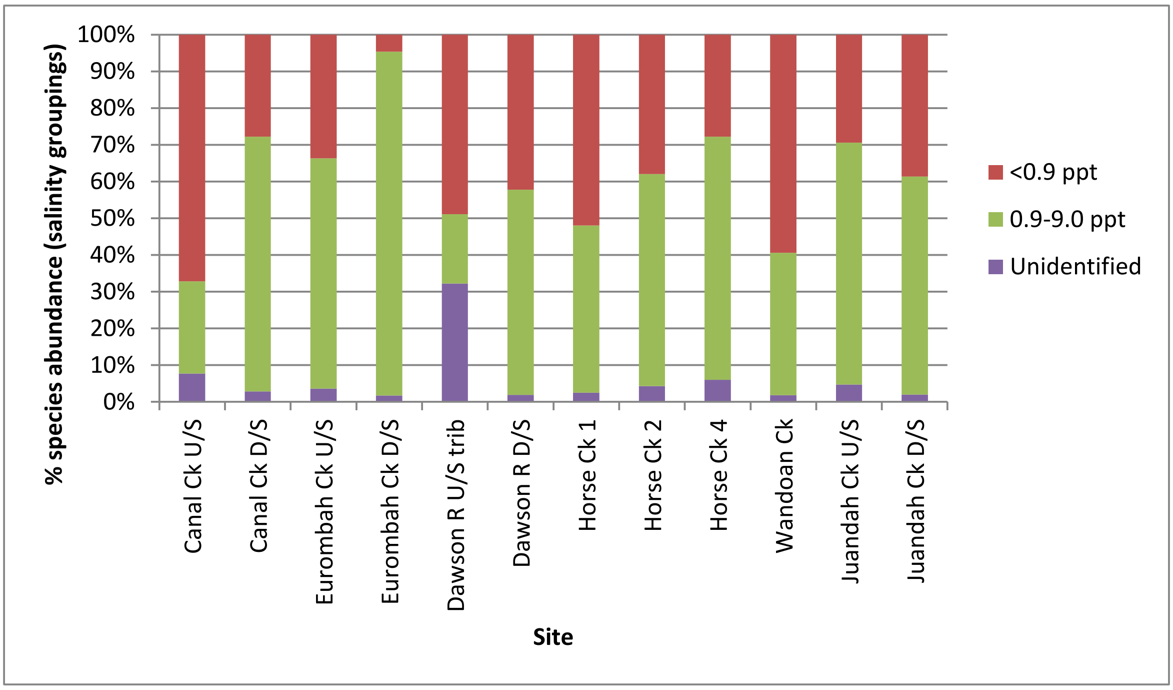


Figure 3-13 Percentage abundance of diatom species in each salinity category for all sites surveyed

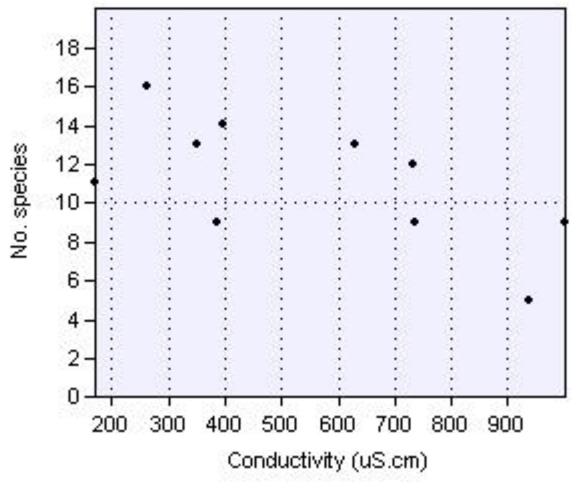


Figure 3-14 Salt sensitive diatom species richness (Class 1 and 2) in relation to water conductivity

3.4.5 Species dominance

There were twelve dominant and sub-dominant diatom species, of which six species were dominant at at least one site (*Rhopalodia musculus*, *Navicula schroeteri*, *Navicula erifugia*, *Navicula viridula, Diadesmis confervacea* and *Anomoeneis sphaerophora*) (Table 3-5).

Of these, 10 species were alkalophilic or alkalobiontic and two species were classified as circumneutral. Six species tolerate low salinities (<0.9ppt) (*P. elginensis, N. viridula, R. gibba, N. tenelloides, S. ulna, G. parvulum*), although none of these species were classed as 'freshwater' forms, i.e., occurring in salinities <0.2 ppt. Six species were classified as tolerating moderate to high salinities between 0.9 ppt and 9.0 ppt (*R. musculus, D. parma, N. schroeterii, N. erefugia, D. confervacea, A. sphaerophora*).

Limited analysis was possible using diatom Saprobity, Trophic State and Nitrogen Uptake Metabolism indicators for the entire diatom community as fewer species could be classified in these index categories. However, values were available for a majority of dominant and sub-dominant species in samples at each site and enabled characterisation of these species.

Across all sites, trophic state values indicated that all of the classified species were eutraphentic and tolerate high concentrations of inorganic nutrients. The Saprobity values indicated that the majority of species (68.4%) were oligosaprobous or β-mesosaprobous (class 1 and 2), i.e. sensitive to elevated levels of elevated organic matter, with 31.6% classified as α-meso-/polysaprobous or polysaprobous (class 3 and 4) which predominate in high concentrations of organic matter.

Table 3-5 Ecological indicator values for dominant and sub-dominant diatom species at each site surveyed

Species	Site												Indices					
	Horse Ck 1	Horse Ck 2	Horse Ck 4	Juandah Ck U/S	Juandah Ck D/S	Wandoan Ck	Canal Ck U/S	Canal Ck D/S	Eurombah Ck U/S	Eurombah Ck D/S	Dawson R U/S trib	Dawson R D/S	pH	Sal	Mot	S	T	N
Anomoeneis sphaerophora											✓*		5	3	x	3	5	2
Diadesmis confervacea								✓*					3	4	✓	-	-	-
Diploneis parma		✓							✓				4	4	✓	-	-	-
Gomphonema parvulum												✓	3	2	✓	4	5	3
Navicula erifugia				✓*						✓			4	3	✓	-	5	2
Navicula schroeteri			✓*						✓*	✓*		✓*	4	3	✓	2	5	2
Navicula tenelloides	✓												4	2	✓	1	5	1
Navicula viridula		✓					✓*		✓			✓	4	2	✓	3	5	2
Placoneis elginensis											✓		4	2	✓	-	-	-
Rhopalodia gibba					✓	✓							5	2	✓	2	5	1
Rhopalodia musculus	✓*	✓*	✓	✓	✓*	✓*							4	4	✓	1	-	1
Synedra ulna								✓					4	2	x	-	5	2

Note: * indicates dominant species at that site; Sal = Salinity; Mot = Motility (✓ indicates motile); S = Saprobity; T = Trophic state; N = Nitrogen uptake metabolism (see Section 2.3.4 for details).

In relation to nitrogen metabolism, approximately 43% of the classified species were autotrophs and tolerate very small concentrations of organically bound nitrogen (class 1), while approximately 52% were autotrophs and tolerate elevated nitrogen levels (class 2), with one facultatively heterotrophic species (*Gomphonema parvulum*) which requires periodically elevated nitrogen conditions (class 3).

3.4.6 Sensitivity index

The DSIAR index values were similar across all sites and occurred within a narrow range between 44.1 and 50.4 with a median value of 47.3 (Figure 3-15). The DSIAR index values occur within a range from 1 to 100, with high scores (>50) indicating relatively pristine conditions, while lower scores (<50) indicate levels of increasing disturbance. The site DSIAR values in this survey indicate a surrounding landscape that has experienced a moderate level of anthropogenic disturbance.

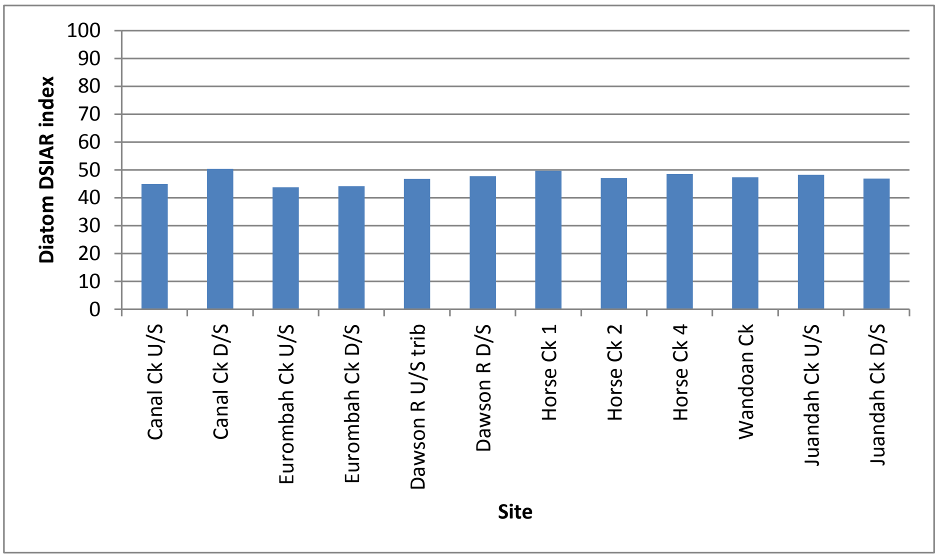


Figure 3-15 Diatom DSIAR index values for each survey site

3.5 Fish and Macrocrustaceans

Seine netting was completed at five of the 12 sampled sites. No introduced species were collected at any sites, and five different species were collected (Table 3-6 and Figure 3-16). Sampling was conducted in addition to requirements to provide a species list only. *Melanotaenia splendida* (Eastern rainbowfish) was the dominant species at three of the sites fished, and the prawn genera, *Macrobrachium* and *Paratya* were the dominant macrocrustaceans, with the crayfish, *Cherax*, sampled at three of the five sites. In addition, macrocrustaceans were also found within the macroinvertebrate samples, and were common at all sites, with the family Palaemonidae the most widespread (Table 3-7).

Table 3-6 Fish and macrocrustaceans collected from seine nets

Family	Taxon	Common name	Horse Ck #1	Eurombah Ck U/S	Horse Ck #2	Wandoan Ck	Juandah Ck D/S
Fish							
Melanotaeniidae	*Melanotaenia splendida*	Eastern rainbowfish	24	21		15	
Terapontidae	*Leiopotherapon unicolor*	Spangled perch	2		1	1	
Clupeidae	*Nematalosa erebi*	Bony bream	1	9			
Eleotridae	*Hypseleotris* sp.	Carp gudgeon	1		1	13	1
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish	3			1	
Macrocrustaceans							
Palaemonidae	*Macrobrachium* sp.	Freshwater shrimp			11	3	5
Atyidae	*Paratya* sp.	Freshwater shrimp	11	1		7	15
Parastacidae	*Cherax* sp.	Crayfish			5	1	4

NB: Two replicate seines were completed at all sites except Eurombah Creek U/S, which had only one seine net.

Table 3-7 Macrocrustaceans collected in macroinvertebrate samples

Family	Common name	Canal Ck U/S	Canal Ck D/S	Eurombah Ck U/S	Eurombah Ck D/S	Dawson R U/S tributary	Dawson R D/S	Horse Ck 1	Horse Ck 2	Horse Ck 4	Wandoan Ck	Juandah Ck U/S	Juandah Ck D/S
Atyidae	Atyid shrimp	X			X	X							
Palaemonidae	Long-armed shrimp	X		X	X	X	X		X	X	X	X	X
Parastacidae	Freshwater yabbie	X	X		X		X			X			X

	
Carp gudgeon, Canal Ck US	Eastern rainbowfish, Eurombah Ck US
	
Agassiz's glassfish, Horse Ck 1	Spangled perch, Horse Ck 1

Figure 3-16 Fish collected from seine nets, March 2012

3.6 Matters of National Environmental Significance (MNES)

During Hydrobiology's survey effort, surveyors were aware of the importance of documenting any MNES species as identified in the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Fitzroy River turtle (*Rheodytes leukops*) is known to occur within the Upper Dawson River Catchment. However, no specimens were observed during the current survey. As the species prefers clear, permanent flowing water, the likelihood of it occurring in the intermittent drainages during the dry season is very low.

4 DISCUSSION

The aquatic ecology survey results from the Project area have reflected local agricultural land-use, (predominantly grazing), with moderate levels of disturbance to the waterbodies. No rare or otherwise noteworthy macroinvertebrates, diatoms or macrophytes were recorded from the surveyed sites. Also no rare or endangered fish or macrocrustacean species were identified. Efforts were made during the survey to document any MNES species which may be present in the area however none were located. The only historically recorded MNES species for this area is the Fitzroy River turtle and this species prefers clear, permanent flowing water in comparison to the intermittent turbid pools found in the survey area.

The habitat assessments indicated local land-use has affected the surrounding riparian vegetation which was often disturbed and fragmented. Riparian vegetation is important to the aquatic ecology in a number of ways. It assists in controlling water quality by effectively keeping temperature low through shading of the stream which, in turn, affects primary productivity (e.g. algae, periphyton and macrophyte growth). It also provides an input of organic matter in the form of large woody debris (LWD) (logs, branches and sticks), and coarse particulate organic matter (CPOM) (leaves, twigs and detritus). These organic products provide food, habitat and shelter for the in-stream biota. While some of these may be provided from upstream sources, much of it depends on the local riparian vegetation. Almost no leaf litter was encountered at the sites, although there was some woody debris at most sites. There were log jams from recent flooding which provided some habitat, but these had the potential to negatively impact the habitat by blocking water flow and restricting fish movement.

At all sampling sites the substrate consisted of a sand/silt, except Juandah Creek D/S, which was dominated by cobble/pebble. The harder substrates are important for macroinvertebrates as they provide shelter from predators, floods and droughts, and ambush locations for predators. It also provides substrate for food sources such as algal and bio-film growth, and a surface for egg attachment (DERM 2012). The sand/silt substrate within the Project area does not provide much habitat for in-stream biota, with fish, macrocrustaceans and macroinvertebrates being dependent on other in-stream substrates to provide habitat. This includes falling leaves and small branches from the riparian vegetation overhead with some provided from upstream sources, and from algae and macrophytes within the stream. Reduced riparian vegetation in the Project area provides reduced amounts of the organic debris required to support a healthy biotic community. In addition to the human impacts already affecting the streams sampled, the lack of hard substrate may also be influencing the low taxa numbers, especially in terms of the sensitive PET taxa.

Shading was typically low at all sites, and water temperatures were high at all sites. The highest shade was recorded at Eurombah Creek D/S (60%), and this site had the highest number of the sensitive PET taxa within the edge habitat, possibly influenced by the shading and the riparian vegetation (10-50% trees) allowing the presence of these taxa. Electrical conductivity and pH levels were also high at all sites. The Australian and New Zealand

Environment Conservation Council (ANZECC) guidelines (ANZECC 1992) consider freshwater to have a conductivity of less than 1000 µS, and only the Dawson River U/S site exceeded this value. Natural factors, such as the geology and climate can often lead to high salinity; however, anthropogenic activities also affect salinity, such as clearing, irrigation, effluent discharges and upstream storages (Department of Environment and Resource Management 2009). High conductivity, affects organisms through physiological changes causing toxicity, or by modifying the species composition of the ecosystem thus affecting food and habitat (ANZECC 2000) and can lead to a potential loss of native biota. The high conductivity results were supported by the presence of salt tolerant diatom species with higher abundances than salt sensitive taxa, with higher species richness but much lower abundances, and the negative correlation between numbers of salt sensitive species and conductivity. The pH levels all indicated sites were alkaline, and this was supported by the presence of greater numbers of alkalophilous species with higher abundances than either circumneutral or acidophilic forms.

Although turbidity was not measured, visual observations indicated nearly all sites had turbid, murky water. Dawson River U/S, Horse Creek 2 and Juandah Creek U/S were the only sites with clear water. Turbidity is caused from suspended matter such as suspended clay, silt, phytoplankton and detritus (ANZECC 2000), and is likely to have arisen from land runoff due to soil erosion rather than direct point sources. Many Australian inland waters are naturally turbid due to soils with high clay content, but the additional impact of clearing land for agriculture can lead to increases in stream turbidity due to destabilisation of stream banks and increased sediment wash off from adjacent land. Turbidity reduces light penetration, which can result in reduced in-stream primary productivity (e.g. algae, periphyton and macrophytes), limiting habitat and food resources for the in-stream fauna. When the sediment settles, it clogs interstitial space between larger particles, reducing available habitat and smothering the bed (Harrison *et al*. 2007). Turbidity can detrimentally impact all in-stream biota. For example, the particulate matter can clog fish gills (ANZECC 2000), smother fish eggs, alter plant production, and reduce the food availability for macroinvertebrate feeding groups such as grazers, shredders and scrapers (Wood and Armitage 1997).

Sampling for this project occurred at the end of the wet season, and in the drier months the streams will be more susceptible to drying up into small pools, providing limited refuge for the in-stream biota. Because of this, the in-stream diversity of intermittent streams is often quite different to streams with continuous flow, and as such diversity may be reduced. For biota to survive *in situ* in intermittent streams they require behavioural, physiological or life history strategies to survive the lack of water (Storey and Quinn 2011). Examples of these strategies include: hard-shelled macroinvertebrates, which are more resistant to desiccation (e.g. Coleoptera beetles); creating burrows or burying themselves below available logs or boulders; sealing moisture within their shells (e.g. bivalve mussels, gastropod snails); desiccation-resistant eggs, hatching only when the water begins to flow again; and biota tend to be r-selected species, having high fecundity and short life cycles (Storey and Quinn 2011). Remnant pools of intermittent streams also tend to become heavily populated, increasing competition, predation, and reducing habitat availability and water quality, further adding to the stress upon the in-stream biota. The intermittent nature of the streams in the area combined with the agricultural land use are probably impacting on the in-stream biota, resulting in observed low species richness, number of sensitive taxa and number of specialised feeding groups within the macroinvertebrate community.

The downstream Dawson River site had the lowest species richness in the edge habitat. The available habitat at this site was minimal, with eroded banks and a downstream ford causing the river to pool. Wandoan Creek surprisingly had a high diversity of macroinvertebrates in the edge habitat, as this site appeared highly affected by anthropogenic activity, with little shading. There were grass edges with slight undercuts, and these were likely to be providing the habitat required for this diverse community. Horse Creek 2 had the highest proportion of sensitive PET taxa, and the habitat at the site was of good quality, with high shade, clear water, small amounts of algae and some coarse particulate organic matter. In contrast, Canal Creek U/S had the lowest proportion of PET taxa, and this site had very little shade, low riparian vegetation and consisted of small murky pools. The SIGNAL 2 scores were similar amongst sites, with no clear differences. The SIGNAL 2 results indicated that the water quality and habitat may be impacted throughout the study area from a range of land uses, such as agriculture and clearing of vegetation. This is supported by the results from the habitat assessments, with clearing and reduction of riparian vegetation to small patches obvious at all the sites.

Of the functional feeding groups, the generalists were dominant at all sites, with the specialist groups, scrapers and shredders, only present at six sites. Both Dawson River sites had shredders and scrapers present. The upstream site had macrophytes, algae and woody debris present, all of which are able to act as a food source and habitat for these feeding groups. The downstream site had less instream habitat, and no algae or macrophytes were noted, but this site did have good riparian vegetation and possibly instream organic debris, although the turbid nature of the water made this difficult to determine. In the absence of degradation of habitat or water quality, there will always be a natural dominance in relation to natural food sources e.g. an abundance of leaf litter will be reflected by an abundance of shredders. However, Hawking *et al.* (2009) suggested that the ideal “healthy” aquatic habitat has representatives of each functional feeding group. Nearly all feeding groups were represented in the sites sampled within the Project area, with only the specialised feeding groups limited among sites. The low taxa richness at sites and a dominance of the generalist feeding groups is indicative of the degraded nature of the sites. This could be a reflection of the agricultural land use in the area, or it could be reflective of the intermittent and stressful nature of the waterways (Rempel *et al.* 2000). There was a mixture of feeding types between upstream and downstream sites, with no trend between the two. The feeding group, shredders, require CPOM as their main food source and therefore are typically associated with streams with good riparian and overhanging vegetation. Shredders were only found at four sites, and this could be due to the low riparian vegetation across the Project area. Scrapers were present at four sites also, and consisted of gastropod Families. Scrapers rely on algae and periphyton for their food source. Sites with scrapers and shredders tended to have either a high presence of algae, macrophytes, and/or riparian vegetation.

A variety of macrophytes were located within the project area at about half of the sites surveyed. The majority of these macrophytes were emergent and present on the stream banks, and only eight of the 19 species were located within the water. This is typical of intermittent streams as many macrophyte species are unable to survive the harsh dry periods. The macrophytes located within the Project area were all native species, and are generally widespread throughout Queensland.

The habitat assessment and macroinvertebrate community analysis are supported by diatom community metrics and indices that are indicative of a modified landscape influencing water chemistry and consequently stream biota in the Project area. Diatom species often have strong preferences for particular chemical conditions, such as pH, salinity and nutrient levels (Stoermer and Smol 1999, Potapova and Charles 2003, 2007; Urrea-Clos and Sabater 2009). Water chemistry varies with catchment geology (Banens 1987; Lay and Ward 1987; McNeil *et al.* 2005) resulting in differing diatom floras. Changes in water chemistry due to human activities such as land clearance for agriculture further interact with geological patterns to influence diatom assemblages (Carpenter and Waite 2000; Leland and Porter 2000). Stratigraphic studies of sediments and fossil diatoms in Australian waterbodies have revealed since the introduction of European agriculture by early settlers increases in the relative proportions of species favouring higher salinity, pH and nutrient concentrations (Tibby *et al*. 2003; Leahy *et al.* 2005; Gell *et al.* 2005).

The overlying geology of the Surat Basin consists of shallow marine mudstones, sandstones and sandy units as oceans retreated in the Early Cretaceous (DNRM 2005). According to Hartmann *et al.* (2000) marine sediments typically have alkaline pore water with increased mineral species with depth. Chessman and Townsend (2010) noted that removal of native vegetation from stream catchments has led to infiltration of rainfall and rises in levels of saline groundwater and discharge into streams. The underlying geology and effects of land clearance in the local catchment are reflected in diatom communities dominated by alkalophilic (alkaline tolerant) and halophilic (salt tolerant) species. The percentage of motile diatoms has been used as an index of siltation (Bahls *et al*. 1992; Hill *et al.* 2001; Dickman *et al.* 2005). Motile diatoms by their ability to move between silt particles and resist burial are able to survive in less stable substrate, such as silt. Because they are able to avoid being buried they are considered more tolerant of sedimentation than other diatoms. The predominance of motile diatoms, particularly *Nitzschia* spp and *Navicula* spp, reflect the substrate characteristics (silt/clay) and high levels of suspended sediments (turbidity) observed at the majority of survey sites. Many of the species within these genera are also indicative of nutrient enrichment. The predominance of species which tolerate high levels of inorganic nutrients and organic matter reflect both non-point source inputs probably from surface runoff and erosional processes, and also localised point sources, for example, increased disturbance in the vicinity of stock access points and from cattle excrement, the impacts of which may be magnified at sites where water levels are low and water flow is reduced. The

DSIAR index based on sensitivity values of individual diatom species correlate with water chemistry and catchment development (Chessman and Townsend 2010). The level of anthropogenic stressors affecting water chemistry will be reflected in diatom composition. In this study, the index values obtained for site assemblages were similar and occurred within a narrow range which indicated a moderate level of landscape disturbance within, and in the vicinity of the Project area.

The fish species located were all native species, and typical of the stream types and habitats surveyed. The eastern rainbowfish, *Melanotaenia splendida,* is usually found in abundance and in a variety of locations. It is thought to be most abundant where there is minimal flow (Allen and Cross 1982; Allen *et al.* 2002). This species survives in a range of water quality conditions, with temperatures from 20 – 29 °C, pH levels from 5.3 – 8.5, and clear to turbid water (Allen and Cross, 1982). The spangled perch, *Leiopotherapon unicolour,* is thought to be the most widespread native freshwater fish (Allen *et al.* 2002). It is tolerant of a wide range of salinity, pH (4.0 – 8.6) and temperature (5 - 44 °C) (Allen *et al.* 2002), and can be found in a variety of habitats, including temporary water after rain. It is suggested the spangled perch is hardy, surviving periods of no water in wet mud or under moist litter (Allen *et al.* 2002). Agassiz's glassfish, *Ambassis agassizii*, is a small species found in a variety of habitats, including drainage ditches and swamps. The carp gudgeon, *Hypseleotris* sp., was not identified down to species level, but carp gudgeons are typically common throughout Queensland. Bony bream, *Nematalosa erebi*, is also widespread, from upland rivers to estuaries, and tends to prefer quiet waters. The species is tolerant of brackish water, a wide water temperature range (9 – 38 °C) and wide pH levels (4.8 – 8.6). Bony bream is not tolerant of low oxygen levels and is less able to survive in smaller waterbodies than the other fish species found.

The sampled sites within the Project area were neither of pristine condition, nor highly degraded. This was indicated by the habitat assessments undertaken, and the results of the macroinvertebrate, diatom and macrophyte sampling. No rare or threatened macroinvertebrates, diatoms, macrophytes or fish were located during this study. The results indicated the Project area is located within a region of slightly degraded waterways, typical for this region of the Fitzroy Basin.

5 REFERENCES

Allen, G.R. and Cross, N.J. (1982). *Rainbowfishes of Australia and New Guinea*. Angus and Robertson, Sydney. In: Froese, R. and Pauly, D. (Editors) (2011). FishBase. www.fishbase.org. Version 04/2012. Accessed on 23 May 2012

Allen, G.R., Midgley, S.H., and Allen, M. (2002). *Field Guide to the Freshwater Fishes of Australia*. Western Australia Museum, Perth, Western Australia.

ANZECC (1992). *Australian and New Zealand Guidelines for Fresh and Marine Waters*. Australian and New Zealand Environment and Conservation Council, Canberra.

ANZECC (2000). *Australian and New Zealand Guidelines for Fresh and Marine Waters*. Australian and New Zealand Environment and Conservation Council, Canberra.

Archibald, C.G. and Taylor, J.C. (2007). The assessment of diffuse pollution from acid mine drainage using an updated and revised diatom assessment procedure as an added-value bio-monitoring tool. Water Science Technology 55(3): 151-160.

Bahls, L.R., Burkantis, R. and Tralles, S. (1992*). Benchmark biology of Montana reference streams.* Department of Health and Environmental Science, Water Quality Bureau, Montana, USA.

Banens, R.J. (1987). The geochemical character of upland waters of northeast New South Wales. *Limnology and Oceanography* 32: 1291-1306.

Blinn, D.W. and Bailey, P.C.E. (2001). Land-use influence on stream water quality and diatom communities in Victoria, Australia: a response to secondary salinization. *Hydrobiologia* 466: 231-244.

Blinn, D.W., Halse, S.A., Pinder, A.M., Shiel, R.J. and McCrae, J.M. (2004). Diatom and micro-invertebrate communities and environmental determinants in the western Australian wheatbelt: a response to salinization. *Hydrobiologia* 528: 229-248.

Carpenter, K.D. and Waite, I.R. (2000). Relations of habitat-specific algal assemblages to land use and water chemistry in the Williamette Basin, Oregon. *Environmental Monitoring and Assessment* 64: 247-257.

Chapman, J.C. and Simmons, B.L. (1990). The effects of sewage on alpine streams in Kosciusko National Park, NSW. *Environmental Monitoring and Assessment* 14: 275-295.

Chessman, B.C. (1985). Artificial-substratum periphyton and water quality in the lower La Trobe River, Victoria. *Australian Journal of Marine and Freshwater Research* 36: 855-871.

Chessman, B. (2001). *SIGNAL 2 – A Scoring System for Macro-invertebrates ('Water Bugs') in Australian Rivers*. User Manual Version 2.

Chessman, B. (2003a). *SIGNAL 2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers*. Monitoring River Health Initiative Technical Report no 31. Commonwealth of Australia. Canberra.

Chessman, B.C. (2003b). New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research* 54: 95-103.

Chessman, B.C., Bate, N., Gell, P.A. and Newall, P. (2007). A diatom species index for bioassessment of Australian rivers. *Marine and Freshwater Research* 58: 542-557.

Chessman, B.C. and Townsend, S.A. (2010). Differing effects of catchment land use on water chemistry explain contrasting behaviour of a diatom index in tropical northern and temperate southern Australia. *Ecological Indicators* 10: 620-626.

Conrick, D. and Cockayne, B. (eds.) (2001). *Queensland Australian River Assessment System (AusRivAS) sampling and processing manual*. Department of Natural Resources and Mines, Queensland.

Cummins, K.W., Merritt, R.W., and Andrade, P.C.N. (2005). The use of invertebrate functional groups to characterize ecosystem attributes in selected streams and rivers in south Brazil. *Studies on Neotropical Fauna and Environment* 40: 69-89.

Department of Environment and Resource Management (2009). *Queensland Water Quality Guidelines 2009*. Version 3, September 2009. 109 pp.

Department of Natural Resources and Water (2007). *Queensland Community Waterway Monitoring Manual*. Waterwatch Queensland, Department of Natural Resources and Water. Queensland, Australia.

DERM (2012). Wetland Info. (http://wetlandinfo.derm.qld.gov.au/wetlands/ScienceAndResearch/ConceptualModels/Riverine/Background/Riparian-Vegetation.html). Accessed on 16th May 2012.

Dickman, M.D., Peart, M.R., Yim, W.W.S. (2005). Benthic diatoms as indicators of stream sediment concentration in Hong Kong. *International Review of Hydrobiology* 90(4): 412-421.

Dinakaran, S., and Anbalagan, S. (2007). Anthropogenic impacts on aquatic insects in six streams of south Western Ghats. *Journal of Insect Science,* **7**(37): 1-9.

DNRM (2005). *Hydrogeographical framework report for the Great Artesian Basin Water Resource Plan area*. http://www.derm.qld.gov.au/wrp/pdf/gab/gab-hydrogeological-framework-report.pdf, accessed 31 May 2012.

Dudgeon, D. (1999). *Tropical Asian Streams. Zoobenthos, Ecology and Conservation*. Hong Kong University Press, Hong Kong.

Fitzroy Basin Association (2011). *Why the Fitzroy floods*. Accessed from http://www.fba.org.au/publication/fitzroyfloods.html, Accessed 17th May 2012.

Gell, P.A., Bulpin, S., Wallbrink, P., Hancock, G., Bickford, S. (2005). Tareena Billabong – a palaeolimnological history of an ever-changing wetland, Chowchilla, floodplain, lower Murray-Darling Basin, Australia. *Marine and Freshwater Research* 56: 441-456.

Gooderham, J., and Tsyrlin, E. (2002). *The Waterbug Book: A Guide to the Freshwater Macroinvertebrates of Temperate Australia*. CSIRO Publishing, Victoria.

Growns, I.O. and Growns, J.E. (2001). Ecological effects of flow regulation on macroinvertebrate and periphytic diatom assemblages in the Hawkesbury-Nepean River, Australia. *Regulated Rivers: Research and Management* 17: 275-293.

Harrison, E.T., Norris, R.H., and Wilkinson, S.N. (2007). The impact of fine sediment accumulation on benthic macroinvertebrates: implications for river management. *Proceedings of the 5th Australian Stream Management Conference. Australian rivers: making a difference.* Charles Sturt University, Thurgoona, New South Wales.

Hartmann, D.J., Beaumont, E.A. and Coalson, E. (2000). *Predicting sandstone reservoir system quality and example of petrophysical evaluation*. http://www.searchanddiscovery.com/documents/beaumont. Accessed 31 May 2012.

Hawking, J.H., Smith, L.M., Le Busque, K. (editors) (2009). *Identification and Ecology of Australian Freshwater Invertebrates.* http://www.mdfrc.org.au/bugguide, Version January 2009, Accessed 2nd April 2012.

Hill, B.H., Stevenson, R.J., Pan, Y., Herlihy, A.T., Kaufman, P.R. and Johnson, C.B. (2001). Comparison of correlations between environmental characteristics and stream diatom assemblages characterized at genus and species level. *Journal of the North American Benthological Society* 20(2): 299-310.

Kelly, M.G., Bennion, H., Cox, E.J., Goldsmith, B., Jamieson, J., Juggins, S., Mann, D.G. and Telford, R.J. (2005). *Common freshwater diatoms of Britain and Ireland: an interactive key*. Environment Agency, Bristol.

Lay, J.A. and Ward, A.K. (1987). Algal community dynamics in two streams associated with different geological regions in the south eastern United States. *Archiv für Hydrobiologie* 108: 305-324.

Leahy, P.J., Tibby, J., Kershaw, A.P., Heijnis, H., Kershaw, J.S. (2005). The impact of European settlement on Bolin Billabong, a Yarra River floodplain lake, Melbourne, Australia. *River Research and Applications* 21: 131-149.

Leland, H.V. and Porter, S.D. (2000). Distribution of benthic algae in the upper Illinois River basin in relation to geology and landuse. *Freshwater Biology* 44: 279-301.

Mulholland, P.J. (1996). Role of nutrient cycling in streams. In: *Algal Ecology: Freshwater Benthic Ecosystems* (Stevenson, R.J., Bothwell, M.L. and Lowe, R.L. eds.). Academic Press, San Diego, CA. Pp. 605-639.

Potapova, M. and Charles, D.F. (2003). Distribution of benthic diatoms in U.S. rivers in relation to conductivity and ionic composition. *Freshwater Biology* 48: 1311-1328.

Potapova, M and Charles, D.F. (2007). Diatom metrics for monitoring eutrophication in rivers of the United States. *Ecological Indicators* 7: 48-70.

Rawer-Jost, C., Bohmer, J., Blank, J. and Rahmann, H. (2000). Macroinvertebrate functional feeding group methods in ecological assessment. *Hydrobiologia* 422: 225-232.

Rempel, L.L., Richardson, J.S., and Healey, M.C. (2000). Macroinvertebrate communitystructure along gradients of hydraulic and sedimentary conditions in a large gravel-bed river. *Freshwater Biology* 45(1) 57-73.

Rosenberg, D.M. and Resh, V.H. (1993). *Freshwater biomonitoring and benthic macroinvertebrates.* Chapman and Hall, New York. 488 pp.

Sainty, G.R. and Jacobs, S.W.L. (2003). *Waterplants in Australia. A field guide. 4th Edition*. Sainty and Associates Pty Ltd, NSW.

Schmutzer, A.C., Gray, M.J., Burton, E.C., and Miller, D.L. (2008). Impacts of cattle on amphibian larvae and the aquatic environment. *Freshwater Biology* 53: 2613 – 2625.

Silla, A.J. (2005). Effects of cattle grazing on macroinvertebrate communities in the Kalgoa River system, north-west Western Australia. Summary report from BSc Honours Thesis, University of Western Australia. Accessed from http://www.water.wa.gov.au/publicationstore/85090.pdf, Accessed on 17th May 2012.

Smucker, N.J. and Vis, M.L. (2009) Use of diatoms to assess agricultural and coal mining impacts on streams and a multiassemblage case study. *Journal of the North American Benthological Society* 28(3): 659-675.

Stephens, K.M. and Dowling, R.M. (2002). *Wetland Plants of Queensland. A field guide.* CSIRO publishing, Australia.

Stoermer, E.F. and Smol, J.P. (1999). *The Diatoms: Applications for the Environmental and Earth Sciences.* Cambridge University Press, Cambridge.

Storey, R.G., and Quinn, J.M. (2011). Life histories and life history strategies of invertebrates inhabiting intermittent streams in Hawke's Bay, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 45(2): 213-230.

Tibby, J., Reid, M.A., Fluin, J., Hart, B.T. and Kershaw, P. (2003). Assessing long-term pH change in an Australian river catchment using palaeolimnological data. *Environmental Science and Technology* 37: 3250-3255.

Tuchman, N.C. (1996). The role of heterotrophy in algae. In: *Algal Ecology: Freshwater Benthic Ecosystems* (Stevenson, R.J., Bothwell, M.L. and Lowe, R.L. eds.). Academic Press, San Diego, CA. Pp. 299-320.

Urrea-Clos, G. (2010). *Distribution of diatom communities in agricultural and mining watersheds of southwest Spain.* PhD Thesis, University of Girona, Spain.

Urrea-Clos, G. and Sabater, S. (2009). Comparative study of algal communities in acid and alkaline waters from Tinto, Odiel and Piedras river basins (SW Spain). *Limnetica* 28(2): 261-272.

Van Dam, H., Mertens, A. and Sinkeldam, J. (1994). A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. *Netherlands Journal of Aquatic Ecology* 28: 117-133.

Wood, P. J., and Armitage, P. D. (1997). Biological effects of fine sediment in the lotic environment. *Environmental Management* 21: 203-217.

Wright, I.A., Davies, P., Wilks, D., Findlay, S. and Taylor, M.P. (2007). Aquatic macroinvertebrates in urban waterways: comparing ecosystem health in natural reference and urban streams. *Proceedings of the 5th Australian Stream Management Conference. Australian rivers: making a difference*. Pp. 467-472.