Australia Pacific LNG Project

Volume 5: Attachments

Attachment 18: Aquatic Ecology, Water Quality and Geomorphology Impact Assessment –

Gas Transmission Pipeline

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Australia Pacific LNG Project

Aquatic Ecology, Water Quality and Geomorphology Impact Assessment – Gas Transmission Pipeline

March 2010

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Australia Pacific LNG Project

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EXECUTIVE SUMMARY

Introduction

Australia Pacific LNG Pty Limited proposes to develop its coal seam gas (CSG) reserves located within the Walloons Gas Fields Development Area in Queensland.

The Australia Pacific LNG project (the Project) involves further development of the Australia Pacific gas fields, construction of gas processing plants, water storage and treatment facilities, water and gas delivery pipelines, the main gas delivery pipeline and a LNG plant and associated facilities near Gladstone. The Project is divided into two components – upstream and downstream. The upstream component addresses the gas fields and the associated infrastructure (roads, high pressure gas network, etc) that extend beyond the tenement area, and main gas delivery pipeline up to the LNG Plant. The downstream component addresses the LNG plant and associated infrastructure.

Hydrobiology was commissioned by WorleyParsons on behalf of Australia Pacific LNG Pty Ltd to describe the existing environmental values and assess the potential impacts of the upstream components of the Project on aquatic ecology, water quality and fluvial geomorphology. This report presents the preliminary outcomes of the gas transmission pipeline assessment. The impact assessment for the gas fields is provided in Volume 5, Attachment 27 to the Environmental Impact Statement (EIS).

Objectives

The objectives of the Study were to:

- Characterise the aquatic flora and fauna (fish, macroinvertebrates and macrophytes), including any native, feral or exotic species occurring within the areas potentially impacted by the Project;
- Characterise the key aquatic habitats occurring within the areas potentially impacted by the Project;
- Describe the existing water quality occurring within the areas potentially affected by the Project in terms of the values identified in *Environmental Protection (Water) Policy (2009)* and the Queensland Water Quality Guidelines (DERM 2009a);
- Identify rare, threatened or otherwise noteworthy aquatic flora and fauna species, communities and habitats occurring within the areas potentially impacted by the Project, including any Matters of National Environmental Significance (MNES) identified under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- Describe the existing fluvial geomorphic condition (including physical integrity, fluvial processes and morphology) of watercourses occurring within the areas potentially impacted by the Project;
- Assess the potential impacts on aquatic ecology, water quality and fluvial geomorphology during the construction, operation and decommissioning of the Project;
- Identify measures to mitigate adverse impacts to aquatic ecology, water quality and geomorphology, where possible;
- Identify strategies to manage any residual impacts following mitigation; and

- Identify appropriate monitoring programs to assess the effectiveness of proposed management strategies during construction, operation and decommissioning of the Project.

Existing Environment

Two dry season water quality surveys and one dry season aquatic ecology and geomorphology survey were undertaken at sites throughout the Dawson, Don and Calliope catchments. Additional data were reported for the Condamine-Balonne catchment in the technical report for the gas fields impact assessment (Volume 5, Attachment 27). Information collected during the dry season surveys was used to supplement reported literature in order to describe the existing aquatic environment and assess the potential impacts associated with the gas transmission pipeline component of the Project.

No rare, endangered or otherwise noteworthy fish, macroinvertebrates or aquatic macrophytes were recorded from the sites sampled. However, three endemic fish species (Saratoga / Dawson River salmon, Leathery grunter and Fitzroy yellow belly) have been recorded in the Fitzroy River system and two species of aquatic macrophytes (the EPBC listed Salt pipewort and Artesian milfoil) are known to occur in Cockatoo Creek.

Potential Impacts

The risks to the aquatic environment associated with construction and operation activities (following mitigation) were considered to be low.

The residual risk of impact to artesian spring communities (Salt pipewort and Artesian milfoil) associated with construction activities was assessed to be low, provided that actively flowing discharge springs are identified and avoided by construction across Cockatoo Creek.

The impact assessment undertaken for this study was based on data that were collected during one dry season. As the majority of streams in the Project Area are intermittent, water quality and aquatic ecology would exhibit large seasonal variations. Further monitoring during the wet season was proposed to establish seasonal variations in water quality and aquatic ecology.

Australia Pacific LNG Project

Aquatic Ecology, Water Quality and Geomorphology Impact Assessment – Gas Delivery Pipeline

March 2010

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ABBREVIATIONS

Abbreviation	Meaning
ANZECC	Australian New Zealand Environment and Conservation Council
Australia Pacific LNG	Australia Pacific Liquefied Natural Gas
APHA	American Public Health Association
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASL	Above Sea Level
AUSRIVAS	Australian River Assessment System
AWQC	Australian Water Quality Centre
BACI	Before-After-Control-Impact
BGA	Blue Green Algae
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
Ca	Calcium
Cl	Chlorine
cm	Centimetre
CPOM	Coarse Particulate Organic Matter
CRCFE	Cooperative Research Centre for Freshwater Ecology
CSG	Coal Seam Gas
DERM	Queensland Department of the Environment and Resource Management
DEWHA	Australian Government Department of Environment, Water, Heritage and the Arts
DNR	Former Queensland Department of Natural Resources
DNRW	Former Queensland Department of Natural Resources and Water
DPIF	Former Queensland Department of Primary Industries and Fisheries
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EP Act	Environmental Protection Act, 1994 (Qld)
EPA	Former Queensland Environmental Protection Agency
EPP (Water)	Environmental Protection (Water) Policy, 1997
ERA	Environmentally relevant activity
EVR	Endangered, vulnerable and rare
FBA	Fitzroy Basin Association
Fisheries Act	Fisheries Act, 1994 (Qld)
FPZs	Functional Process Zones
FRP	Filterable reactive phosphorus
GAB	Great Artesian Basin
GLNG	Gladstone Liquefied Natural Gas
HCO3	Bicarbonate

Abbreviation	Meaning
IAS	Initial Advice Statement
ILUA	Indigenous land use agreement
IPA	Integrated Planning Act, 1997 (Qld)
IUCN	International Union for Conservation of Nature
K	Potassium
km2	Square Kilometre
LB	Left Bank
LWD	Large Woody Debris
µS/cm	Micro siemens per centimetre
Mg	Magnesium
mg/L	milligram per Litre
mg/m3	milligram per cubic metre
Na	Sodium
NCR	Nature Conservation Regulation
NLWRA	National Land and Water Resources Audit
NOx	Nitrate + Nitrite
NSW	New South Wales
NTU	Nephelometric Turbidity Units
oC	Degrees Centigrade
OCPs	Organochlorine Pesticides
OPPs	Organophosphate Pesticides
ORWB	Off River Water Bodies
PAH	Polycyclic Aromatic Hydrocarbons
PET	Plecoptera-Ephemeroptera-Trichoptera
QC	Quality Control
QWQG	Queensland Water Quality Guidelines
RB	Right Bank
ROP	Resource Operations Plan
RoW	Right of Way
SEAP	Stream and Estuarine Assessment Program
SO4	Sulphate
SRA	Sustainable Rivers Audit
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TPH	Total Petroleum Hydrocarbons
TSS	Total suspended solids

Abbreviation	Meaning
US EPA	United States Environmental Protection Agency
VPZ	Valley Process Zone

GLOSSARY

Descriptor	Preferred wording/meaning
Abstraction	The removal of water from a resource e.g. the pumping of groundwater from an aquifer. Interchangeable with extraction.
Alluvium	Sediments deposited by flowing water.
APLNG joint venture description	Origin and ConocoPhillips are joint owners of Australia Pacific LNG (APLNG). This is a 50:50 joint venture to deliver a coal seam gas (CSG) to liquefied natural gas (LNG) Project located in Queensland.
Aquatic ecosystems	The abiotic and biotic component, habitats and ecological processes contained within rivers and their riparian zones and reservoirs, lakes, wetlands and their fringing vegetation.
Aquatic macrophytes	Plants which grow in or near water. In lakes macrophytes provide cover for fish and substrate for aquatic invertebrates, produce oxygen, and act as food for some fish and wildlife. A decline in a macrophyte population may indicate water quality problems.
Aquifer	A saturated permeable geological unit that is permeable enough to yield economic quantities of water to boreholes.
Baseflow	The amount of groundwater flowing into a river.
Biodiversity	The number and variety of organisms found within a specified geographic region or within a given ecosystem.
Bioregion	A landscape pattern that reflect changes in geology and climate, as well as major changes in floral and faunal assemblages at a broad scale.
Brackish	A mixture of seawater and freshwater
Catchment	The term used to describe the area which is drained by a river. It is sometimes called the river basin or watershed. The size of the catchment is the most significant factor determining the amount or likelihood of flooding.
Coal seam gas	A form of natural gas extracted from coal beds; primarily methane.
Coarse Particulate Organic Matter (CPOM)	Any organic material greater than about 1 mm in diameter; examples include twigs, leaves, fruits and flowers of terrestrial or aquatic vegetation.
Collectors/Gatherers	An ecological functional feeding group of macroinvertebrates. Collectors /Gatherers depend upon fine particulate organic matter (FPOM) for their primary food resource.
Conductivity	Is a measure of waters ability to conduct electricity.
Controlled action	A term used under the Environment Protection and Biodiversity Conservation Act, 1999 to describe an action that is likely to have an impact on a matter of national environmental significance. If a project is declared a 'controlled action', approval is required from the Minister for Environment, Heritage and the Arts.
Diadromous	Life cycle which involves migration between fresh and sea waters.
Downstream component	The main gas delivery pipeline downstream of the Narrows and the LNG plant and associated infrastructure.
Ecosystem	A natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the non-living physical (abiotic) factors of the environment.
Electrofishing	The use of electricity to stun fish. Electrofishing is a common scientific survey method used to sample fish populations to determine abundance, density and species

Descriptor	Preferred wording/meaning
	composition. When performed correctly, electrofishing results in no permanent harm to fish, which return to their natural state in as little as 2 minutes after being stunned.
Endemic	Endemic species are those plants and animals that are found exclusively in a particular area and are naturally not found anywhere else.
Environmental impact statement (EIS)	The information document prepared by a proponent when undertaking an environmental impact assessment. It is prepared in accordance with a terms of reference (TOR) prepared or approved by Government.
Ephemeral waterbodies	Are temporary waters that contain water only after irregular rainfall or flow events.
Fauna	Animal life.
Field Blank	A water sample containing ultra-pure water, collected in the field, used for laboratory analysis QC checking.
Fine Particulate Organic Matter (FPOM)	Any organic material smaller than about 1 mm in diameter. In the process of feeding, shredders often create FPOM when they consume Coarse Particulate Organic Matter (CPOM).
Flora	Plant life.
Fluvial geomorphology	The study of rivers and streams and the processes that shape them, including the transport of sediment, erosion of or deposition on the river bed.
Functional Feeding Groups	An ecological approach to the classification of macroinvertebrates that identifies the manner in which an organism acquires food (i.e. by shredding or filtering) as opposed to classification be the material it eats (i.e. carnivores and herbivores).
Hydrobiology	Hydrobiology Pty Ltd.
Hydrocarbons	An organic molecule containing hydrogen and carbon; the major component of petroleum.
Impact Mechanisms	The pathway for potential impacts associated with an activity
in situ	A Latin phrase meaning in the place.
Intermittent waterbodies	Are temporary waters that are predictably inundated each year, although the duration for which they retain water is highly variable.
Liquefied natural gas	Natural gas that has been converted to liquid form for ease of storage or transport. Liquefied natural gas takes up about 1/600th the volume of natural gas at a stove burner tip. It is odourless, colourless, non-corrosive, and non-toxic. When vaporized, it burns only in concentrations of 5 per cent to 15 per cent when mixed with air. The density of LNG is roughly 0.41 to 0.5 kg/L at -164 °C.
Macrocrustaceans	The taxonomic group of crustaceans that are visible without magnification.
Macroinvertebrates	The taxonomic group of freshwater invertebrates that are visible without magnification.
Origin	Origin Energy Limited
Perennial waterbodies	Are waterbodies that flow year round, except during periods of extreme drought.
pH	pH is a measure of the acidity or basicity of a solution. It approximates but is not equal to p[H], the negative logarithm (base 10) of the molar concentration of dissolved hydrogen ions (H+).
Pipeline	Gas transmission pipeline.

Descriptor	Preferred wording/meaning
Predators	An ecological functional feeding group of macroinvertebrates. Predators require live prey organisms; some ingest whole animals, while others tear off and swallow large pieces or piercing their prey in order to suck up the body fluids.
Proponent	Australia Pacific LNG Pty Limited
Quaternary	Geologic time unit covering the past 2.5 million years.
Receptors	Sensitive component of the ecosystem that reacts to, or is influenced by, environmental stressors.
Rehabilitation	To restore to a former condition or status.
Riparian	Any land which adjoins, directly influences or is influenced by a body of water.
Risk	The potential impact of an event, determined by combining the likelihood of an event occurring, and the consequence if it were to occur.
Sampling sites	Specific locations within the study area where data is collected.
Scrapers	An ecological functional feeding group of macroinvertebrates. Scrapers depend upon attached algae and associated flora and fauna that develop on submerged substrates for their primary food resource.
Sensitivity	The relative susceptibility to adverse impacts to environments.
Shredders	An Ecological Functional Feeding Group of Macroinvertebrates. Shredders depend upon Coarse Particulate Organic Matter (CPOM) for their primary food resource. They have specialised mouthparts that cut particulate matter for various uses. In the process of feeding, shredders create fine particulate organic material (FPOM).
SILO	The Australian Bureau of Meteorology's online rainfall data archive.
Stakeholder	Usually a representative from Government departments, agencies, members of parliament/council, who represents the interests of the establishment for which they are employed or appointed.
Taxonomic assessment	The classification of organisms into identified groups based on evolutionary relationships.
Tertiary	A geological time unit covering 65 million before present until approximately 2.5 million years ago.
the Project	Australia Pacific LNG
Topography	A description of the surface features of a place or region.
Trip Blank	A sample of analyte-free media taken from the laboratory to the sampling site and returned to the laboratory unopened.
Turbidity	The cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.
Upstream component	The gas fields and main gas delivery pipeline up to and including where it crosses the Narrows.
Weeds	Plant species that invade native ecosystems and can adversely affect the survival of indigenous flora and fauna.
Wetland	The land area alongside fresh and salt waters, that is flooded all or part of the time.
WorleyParsons	WorleyParsons Services Pty Ltd.

1. Introduction

Australia Pacific LNG Pty Limited proposes to develop a world scale project sustaining a long-term industry that utilises Australia Pacific LNG's substantial coal seam gas resources in Queensland. The coal seam gas reserves occur in the Surat and Bowen Basins with the main development planned for the Walloons gas fields area.

A 450 km underground high pressured gas transmission pipeline will connect the Walloons gas fields with the LNG plant on Curtis Island in Gladstone. The 42 inch (107 cm) diameter pipeline will be co-located with other high pressure gas transmission pipelines, where practicable, including the Callide and Gladstone State Development Area Common-user Infrastructure Corridors being developed by the Queensland Government.

Hydrobiology was commissioned by WorleyParsons on behalf of Australia Pacific LNG Pty Ltd to describe the existing environmental values and assess the potential impacts of the upstream components of the Project on aquatic ecology, water quality and geomorphology. This report presents the preliminary outcomes of the gas transmission pipeline impact assessment. The impact assessment for the gas fields is provided in Volume 5, Attachment 27 to the Environmental Impact Statement (EIS).

1.1 Project Overview

1.1.1 General components

The upstream components of the Project include:

- Progressive development of the Walloons Gas Fields (up to 10 000 gas wells over 30 years);
- A network of underground water and gas collection and delivery pipelines to link the wells to the respective water treatment facilities and gas processing plants and to transfer gas from the gas processing plants to the main gas transmission pipeline;
- A network of underground pipelines to deliver gas to the Project Area from the existing Fairview and Spring Gully gas fields;
- Gas processing plants;
- Water storage and treatment facilities;
- The main high pressure gas transmission pipeline (approximately 450 km long) extending from the northern Walloons area and the proposed LNG facility at Curtis Island in Gladstone; and
- Associated infrastructure, such as access roads, accommodation camps, equipment stores, power and communications systems.

1.2 Scope and Objectives

This report describes the existing environment and provides an assessment of potential impacts associated with the main gas transmission pipeline components of the Project on aquatic ecology, water quality and fluvial geomorphology[1]. The report does not address the potential impacts associated with the gas fields or the LNG facility. These are addressed in separate documents as part of the Environmental Impact Statement (EIS) (Volume 5, Attachments 27 and 35).

Riparian vegetation was assessed in the context of aquatic habitat availability only. Detailed assessments of riparian vegetation composition, reptiles, birds, mammals and amphibians have been assessed as part of the Terrestrial Flora and Fauna impact assessment report (Volume 5, Attachment 24).

The objectives of the Study were to:

- Characterise the aquatic flora and fauna (fish, macroinvertebrates and macrophytes), including any native, feral or exotic species occurring within the areas potentially impacted by the Project;
- Characterise the key aquatic habitats occurring within the areas potentially impacted by the Project;
- Describe the existing water quality occurring within the areas potentially affected by the Project in terms of the values identified in Environmental Protection (Water) Policy (2009) and the Queensland Water Quality Guidelines (DERM 2009a);
- Identify rare, threatened or otherwise noteworthy aquatic flora and fauna species, communities and habitats occurring within the areas potentially impacted by the Project, including any Matters of National Environmental Significance (MNES) identified under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act);
- Describe the existing geomorphic condition (including physical integrity, fluvial processes and morphology) of watercourses occurring within the areas potentially impacted by the Project;
- Assess the potential impacts on aquatic ecology, water quality and geomorphology during the construction, operation and decommissioning of the Project;
- Identify measures to mitigate adverse impacts to aquatic ecology, water quality and geomorphology, where possible;
- Identify strategies to manage any residual impacts following mitigation; and
- Identify appropriate monitoring programs to assess the effectiveness of proposed management strategies during construction, operation and decommissioning of the Project.

1.3 Study Assumptions and Limitations

This report has been prepared on the basis that only one round of (dry season) ecological and geomorphic and two rounds of (dry season) water quality monitoring have been undertaken. No wet season was available to be surveyed during the period of this impact assessment process.

[1] Note: Fluvial geomorphology and geomorphology are used interchangeably throughout this document

1.4 Relevant Policy and Legislation

The Commonwealth and Queensland policy and legislation relevant to aquatic ecology, water quality and geomorphology for the main gas delivery pipeline component of the Project are summarised in Table 1-1.

Table 1-1 Relevant Policy and Legislation

Policy or legislative instrument	Description	Relevant
Commonwealth		
Environment Protection and Biodiversity Conservation Act (1999)	Provides for the protection of Matters of National Environmental Significance (MNES) A project will require approval from the Commonwealth Environment Minister if the project is a controlled action which will have, or is likely to have, a significant impact on a matter of national environmental significance. Approval by the Commonwealth Environment Minister is in addition to any approvals under Queensland legislation.	On 3 August 2009, the Project was declared a Controlled Action. The controlling provisions in relation to aquatic environments were the potential impacts on Wetlands of International Importance (Sections 16 and 17B) and Listed threatened species and ecological communities (Sections 18 and 18A).
Queensland		
Environment Protection Act 1994	Provides for sustainable resource development while protecting ecological processes. The Act, amongst other things, regulates Environmentally Relevant Activities (ERAs). An environmental authority is required to carry out an ERA which is a petroleum activity. The environmental authority will also authorise other activities that are ERA's to be carried out in the area of a petroleum authority granted under the Petroleum and Gas (Production and Saftey) Act 2004.	Environmental Protection (Water) Policy 2009 aims to achieve the object of the Environmental Protection Act 1994 in relation to Queensland waters through establishing Environmental Values (EVs) and Water Quality Objectives (WQOs). No specific EVs or WQOs have been established for any of the catchments within the development area, therefore the Queensland Water Quality Guidelines (2009) apply. Environmental Protection Regulation 2008 lists all of the Environmentally Relevant Activities (ERAs) for which an environmental authority is required. Schedule 9 lists the prescribed water contaminants for the offence in the Act.
Water Act 2000	Provides for the sustainable management of water and other resources by establishing a system for the planning, allocation and use of water.	Approval is required under Section 266 of the Act unless the activity is carried out under a licence, petroleum lease or ATP under the Petroleum and Gas (Production and Safety) Act 2004. Approval may also be required to destroy vegetation, excavate or place fill within a watercourse, lake or spring. The water resource planning process, under the Water Act 2000 provides the framework for the sustainable allocation of water

Policy or legislative instrument	Description	Relevant
		for human consumptive needs and environmental values. The Water Resources (Condamine – Balonne) Plan 2004 sets out the statutory environmental flow objectives (EFOs) for the Condamine River, which require consideration in relation to any proposed discharges to the Condamine River. It requires water abstractors to obtain licences in accordance with the Resource Operations Plan in order to protect surface water flows and to provide compensation flows to the Narran Lakes Nature Reserve Ramsar Site. The Water Resource (Great Artesian Basin) Plan 2006 provides the framework for the sustainable management of groundwater in the Great Artesian Basin. It requires water abstractors to obtain a licence for taking water, which must ensure consistency with the criteria for the protection of flow of water to springs and baseflow to water courses stated in the Resource Operations Plan.
Fisheries Act 1994	Provides for the use, conservation and enhancement of fisheries resources and fish habitats	Construction of waterway barrier works, such as road crossings, pipeline crossings and culverts that limit fish stock access and movement would require a development approval under the Sustainable Planning Act 2009 assessed against the relevant provisions of the Fisheries Act 1994.
Nature Conservation Act 1992	Provides for the conservation of Queensland's flora and fauna	The Nature Conservation (Wildlife) Regulation 2006 lists and describes the management intent for wildlife considered extinct, endangered, vulnerable, rare, near threatened or least concern.

1.5 Matters of National Environmental Significance (MNES)

An EPBC Referral for the main gas delivery pipeline component of the Project was lodged with DEWHA on 6 July 2009 (referral number: 2009/4976).

The Project was declared a Controlled Action on August 3, 2009. In relation to aquatic ecosystems, the Project was declared a Controlled Action due to the potential impacts on Listed threatened species and ecological communities (Sections 18 and 18A), specifically Great Artesian Basin (GAB) Spring Communities. GAB Spring Communities known to occur in the vicinity of the pipeline (namely on Cockatoo Creek) are *Eriocaulon carsonii* (Salt pipewort or button grass) and *Myriophyllum artesium* (Artesian milfoil) stands.

Descriptions of the above MNES, including their relationship to state legislation and the International Union for Conservation of Nature (IUCN) Red List of threatened species™ are provided in Section 4.5.3.

2. Location and study sites

2.1 Main Gas Delivery Pipeline

A 450 km long underground high pressured gas transmission pipeline will connect the Walloons gas fields with the LNG plant on Curtis Island in Gladstone (see Figure 2.1). The 107 cm diameter pipeline will be co-located with other high pressure gas transmission pipelines, where practicable, including the Callide and Gladstone State Development Area Common-user Infrastructure Corridors being developed by the Queensland Government.

2.2 General Catchment Descriptions

The majority of the gas transmission pipeline corridor is located within the Fitzroy (Dawson and Don rivers) and Calliope catchments. A small portion of the pipeline corridor is located in the north-eastern part of the Condamine-Balonne catchment. Dogwood Creek is the only watercourse that is intersected by the pipeline corridor in the Condamine-Balonne catchment.Two sites (GF1 and R1) were sampled to assess impacts associated with the gas transmission pipeline in the Condamine catchment. readers are also referred to Volume 5, Attachment 27 for further details on the existing environment throughout the Condamine-Balonne catchment in relation to potential impacts associated with the gas fields.

2.2.1 Fitzroy Catchment (Dawson and Don rivers)

The Dawson River catchment is a sub-catchment of the Fitzroy Basin. It has a total area of about 50 800 km2 and is bordered by the Auburn, Calliope, Ulam and Dee Ranges to the east, the Great Dividing Range to the west and south and the Lynd and Canarvon, Expedition and Bigge ranges to the northwest (Telfer 1995). The south-western headwaters of the Dawson River flow easterly through relatively narrow valleys until about the Nathan Gorge constriction, where the channel alters direction, flowing north, with a gradual downstream broadening of the valley to wide alluvial plains.

No major water resource infrastructure occurs within the Dawson River catchment. However, water extractions occur as part of the Dawson Valley Water Supply Area water management area 1.

The Don River is a tributary of the Dawson River and has a catchment area of 3 695 km2. The Dee River and Callide Creek converge to form the Don River (Telfer 1995). No major water resource infrastructure occurs in the Don River, although the Callide River Dam is on Callide Creek. Mining occurs in the Callide and Dee catchments (Callide Mine – Callide River and Mount Morgan Mine – Dee River).

2.2.2 Calliope River Catchment

The Calliope River catchment is a small central Queensland coastal catchment, covering an area of 1 890 km2. The main river flows eastward for about 95 km from the headwaters in the Calliope Range to approximately two kilometres north-west of Gladstone. It is largely unregulated, with only minor artificial barriers occurring along its length.

The Calliope catchment differs from the Fitzroy catchment in that its waterways are largely unregulated with sustained base flows and is directly connected to the marine environment via a large estuary.

2.2.3 Condamine River Catchment

The Condamine River extends for approximately 500 km and is a major tributary of the Darling River, located in the upper Murray-Darling catchment. Its boundaries to the east and north are formed by the Great Dividing Range (~1 400 m above sea level (ASL)) near Toowoomba and Warwick, while its southern boundary comprises the much lower Herries Range (~800 m ASL). The western boundary comprises the Dogwood Creek sub-catchment which flows into the Condamine River where it becomes the Balonne River (Clayton et al. 2008).

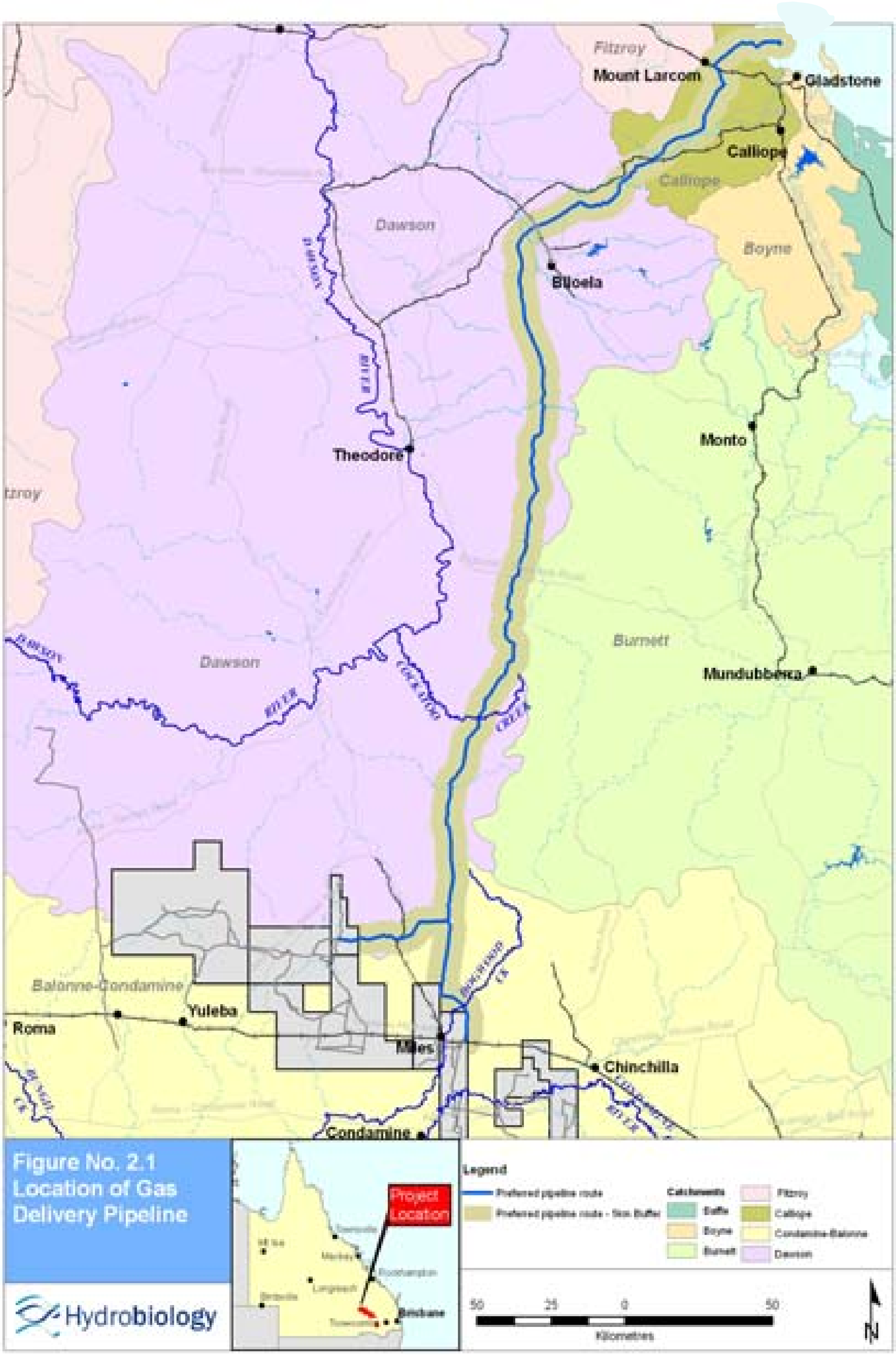


Figure 2-1 Main Gas Delivery Pipeline Footprint

2.3 Site Locations and Descriptions

Sampling sites were selected based on a desktop review of information followed by a helicopter-assisted reconnaissance survey. The reconnaissance survey enabled rapid assessment of appropriate waterbodies to be sampled according to habitat features, accessibility and availability of water.

Sampling sites were selected to provide representative examples of stream types, habitats and ecological features and to adequately assess the range of potential impacts along the gas transmission pipeline corridor. Reference sites were selected, where possible.

Sampling site locations are provided in Figure 2-2.

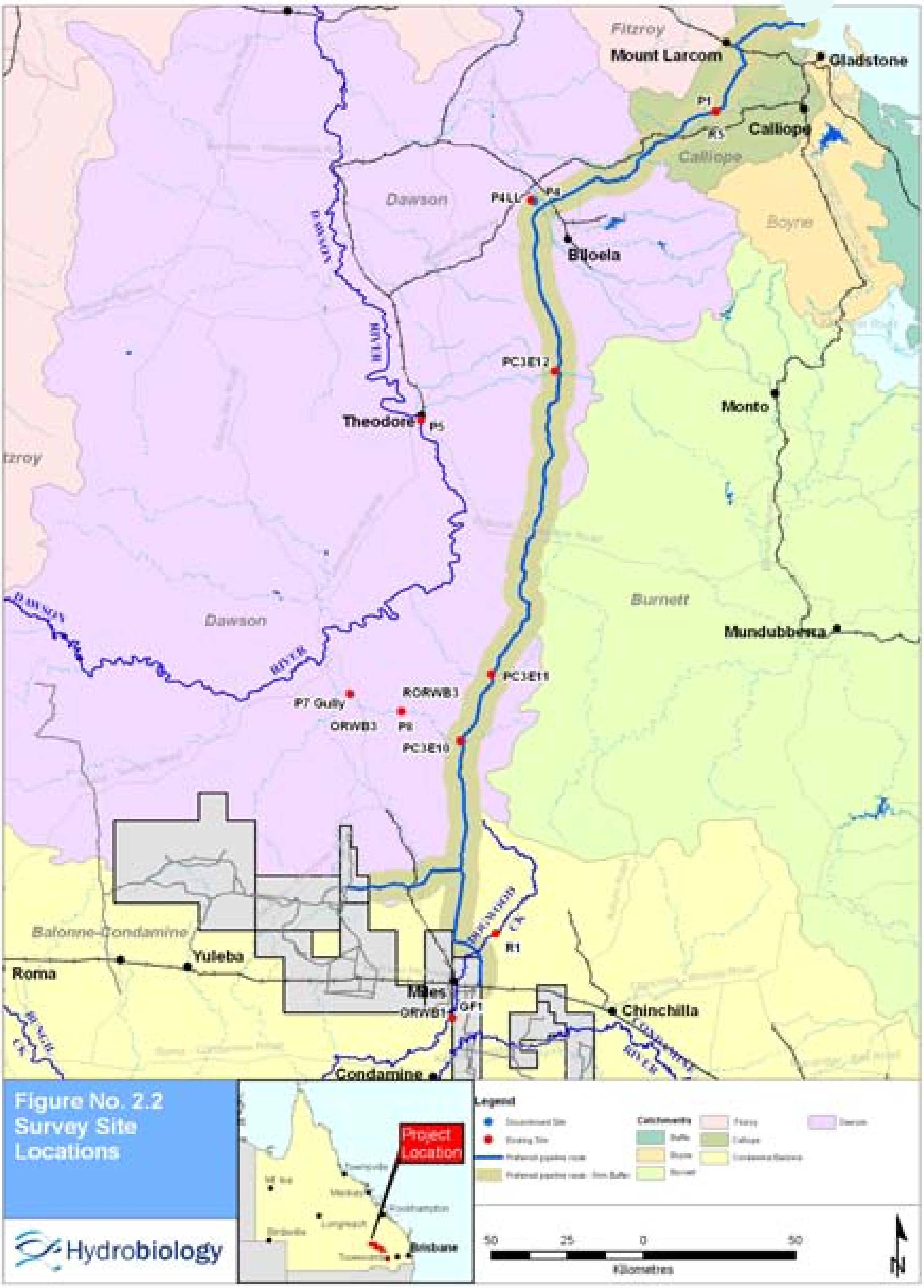


Figure 2-2 Survey Site Locations

3. Methods

The following sections outline the monitoring frequencies, sampling, quality assurance / quality control (QA / QC), data analysis and impact assessment methods for the aquatic monitoring program incorporating:

- Water quality;
- Fish and macrocrustacea;
- Macroinvertebrates;
- Geomorphology; and
- Aquatic habitat.

3.1 Field Surveys

Dry season field surveys were undertaken on the following dates:

- 28-30 April (initial reconnaissance and site selection survey);
- 22 June–5 July;
- 27 July–3 August;
- 31 August–10 September; and
- 28 September-6 October.

It was originally planned to undertake two rounds of sampling – one for aquatic ecology, geomorphology and aquatic habitat and two for water quality. However, due to difficulties encountered with site access, the sampling trips had to be broken up over four separate events. During the above dates, each site (where site access was granted) was surveyed once for aquatic ecology and once for geomorphology. Sites P5 (Dawson River), P7 (Juandah Creek) P8 (Bungaban Creek), RORWB3 and ORWB3 (both adjacent to Bungaban Creek) were located at river crossings associated with the original (western) pipeline corridor. The corridor changed substantially (to the east) in late August and additional sites (P3CE10, P3CE11 and P3CE12) were added to the sampling program in September, while sites P5, P7 and P8 were dropped. Therefore only one round of water quality sampling was undertaken at these sites (note: Sites RORWB3 and P3CE12 were dry at the time of sampling and no land access was available to site ORWB3). The pipeline route did not change substantially in the Don and Calliope catchments. Therefore, two rounds of water quality sampling were undertaken at sites P1 (Calliope River) and P4LL (Don River). No land access was available to Site R5 on the Calliope River. A summary of survey dates and types is provided in Table 3-1.

In the Dawson and Don catchments, most waterways along the main gas delivery pipeline route were intermittent and a number of sites were dry during sampling. Where water was present, sampling was generally confined to small (non-flowing) pools. A notable exception was site P3CE11, located on Cockatoo Creek, which is a spring fed stream.

The Calliope catchment has a sustained base flow due to its connection to shallow underlying aquifers. Site access was only available to one of the two sites (P1) scheduled for sampling during the dry season surveys (Table 3-1).

A key issue in designing monitoring programs for intermittent waterbodies, particularly those encountered in the Fitzroy catchment, is the inherent seasonal variability in physico-chemical and ecological properties. As the dry season approaches, water recedes to a series of unconnected pools which provide a refuge for aquatic fauna. As pools dry out further, it results in loss of habitat (surface area / volume) and physical and chemical extremes (e.g. high temperatures, low dissolved oxygen, concentrated salinity and nutrients etc (Arthington *et al.* 2005, Magoulick and Kobza 2003, Smith *et al.* 2004)). Subsequent flooding and inundation of floodplains provides important nursery habitat for juvenile fishes and enables biota to disperse (Arthington *et al.* 2005). Therefore, it is important for monitoring programs to cover the range of seasonal variation (Smith *et al.* 2004). Although data presented in this report are based on a single dry season survey (ecology and geomorphology) and two sampling events (water quality), a further round of wet season sampling is proposed (rainfall dependent). Additional results will be reported when these data become available.

3.2 Water Quality

3.2.1 Sample collection, storage and preservation

Field water quality measurements (temperature, electrical conductivity, turbidity, dissolved oxygen and pH were recorded using a YSI 6600 multiparameter water quality meter.

Surface grab samples were collected using powder free latex gloves for the following parameters:

- Total suspended solids (TSS);
- Total dissolved solids (TDS);
- Major ions (K+, Ca2+, Mg2+, Na+, Cl-, SO42-, HCO3-);
- Total and dissolved nutrients (TN, TP, FRP, NO2 + NO3, NH4);
- Pesticides (OCPs, OPPs); and
- Hydrocarbons (BTEX, TPH, PAH).

Bottles that were not pre-dosed with preservatives were rinsed twice with site water. Samples collected for dissolved nutrients were field filtered using sterile syringes with disposable 0.45 μm syringe-filters.

Samples were stored on ice in the field and delivered to the ALS laboratory in Brisbane as soon as possible following collection. Filtered (dissolved) nutrient samples were frozen, where possible. Samples were analysed according to the American Public Health Association (APHA) and US EPA standard methods and to the limits of detection identified in Table 3-2.

Table 3-1 Overview of sample collection dates and survey type

Site	Catchment	River	Date	Fish	Macros	Water Quality	Geomorphology	Habitat	Comments
P1	Calliope	Calliope River	04/07/2009; 03/08/09 (Geomorph)	✓	✓	✓	✓	✓	
R5	Calliope	Calliope River	Not sampled	-	-	-	-	-	No land access
P4LL	Don (Fitzroy)	Kroombit Creek	08/08/2009; 02/09/2009	✓	✓	✓	-	-	No land access for geomorph
P5	Dawson (Fitzroy)	Dawson River	03/07/2009; 02/08/09 (Geomorph)	-	-	✓	✓	✓	Required boat based EF. Too deep to sample edge
P7	Dawson (Fitzroy)	Juandah Creek	2/07/2009; 02/08/09 (Geomorph)	✓	✓	✓	✓	✓	
P8	Dawson (Fitzroy)	Bungaban Creek	03/10/09; 01/08/09 (Geomorph)	-	✓	✓	✓	-	
RORWB3	Dawson (Fitzroy)	Adjacent to Bungaban Creek	01/08/09 (Geomorph)	-	-	-	✓	-	Dry
P3CE10	Dawson (Fitzroy)	Bungaban Creek	3/10/2009	✓	✓	✓	✓	✓	
P3CE11	Dawson (Fitzroy)	Cockatoo Creek	4/10/2009	✓	✓	✓	✓	✓	
P3CE12	Dawson (Fitzroy)	Pump Creek	5/10/2009 (Geomorph)	-	-	-	✓	-	Dry
ORWB3	Dawson (Fitzroy)	Adjacent to Bungaban Creek	Not sampled	-	-	-	-	-	No land access
GF1	Condamine	Dogwood Creek	26/06/2009; 25/06/09	✓	✓	✓	✓	✓	

Site	Catchment	River	Date	Fish	Macros	Water Quality	Geomorphology	Habitat	Comments
			(Geomorph)						
R1	Condamine	Dogwood Creel	27/06/2009; 26/06/09 (Geomorph)	✓	✓	✓	✓	✓	

Table 3-2 Analytical methods and detection limits

Analyte	Method	Detection Limits
Suspended Solids	APHA 2540 D	1 mg/L
Alkalinity	APHA 2320 B	1 mg/L
Dissolved Major Cations – Na, K, Mg, Ca	APHA 3120 (Ca, Mg, Na, K) - B	1 mg/L
Sulphate	APHA 3120	1 mg/L
Chloride	APHA 4500-Cl^{-}B	1 mg/L
Total Nitrogen	APHA 4500-N_{org}/NO_3	0.1 mg/L
Nitrite plus Nitrate (NOx)	APHA 4500-NO_3^- I	0.01 mg/L
Ammonia as N	APHA 4500-N_{org}/NO_3	0.01 mg/L
Total Kjeldahl Nitrogen	APHA 4500-N_{org}-D	0.1 mg/L
Total Phosphorus	APHA 4500 P-H	0.01 mg/L
Total Reactive Phosphorus	APHA 4500 P-G	0.01 mg/L
Chlorophyll-a	APHA 10200 H	1 mg/m3
Organochlorine Pesticides	USEPA 3510/8270 GC/ECD/ECD/MS	alpha-BHC (0.5 µg/L); Hexachlorobenzene (HCB) (0.5 µg/L); beta-BHC (0.5 µg/L); gamma-BHC (0.5 µg/L); delta-BHC (0.5 µg/L); Heptachlor (0.5 µg/L); Aldrin 0.5 µg/L); Heptachlor epoxide (0.5 µg/L); trans-Chlordane (0.5 µg/L); alpha-Endosulfan (0.5 µg/L); cis-Chlordane (0.5 µg/L); Dieldrin (0.5 µg/L); 4.4`-DDE (0.5 µg/L); Endrin (0.5µg/L); beta-Endosulfan (0.5 µg/L); 4.4`-DDD (0.5 µg/L); Endrin aldehyde (0.5 µg/L);Endosulfan sulphate (0.5 µg/L); 4.4`-DDT (2 µg/L); Endrin ketone (0.5 µg/L); Methoxychlor (2 µg/L).
Organophosphorus Pesticides	USEPA 3510/8270 GC/FPD/MS	Dichlorvos (0.5 µg/L); Demeton-S-methyl (0.5 µg/L); Monocrotophos (2 µg/L); Dimethoate (0.5 µg/L); Diazinon (0.5µg/L); Chlorpyrifos-methyl (0.5 µg/L); Parathion-methyl (2 µg/L); Malathion (0.5 µg/L); Fenthion (0.5 µg/L); Chlorpyrifos (0.5 µg/L); Parathion (2 µg/L); Pirimphos-ethyl (0.5 µg/L); Chlorfenvinphos (0.5 µg/L); Bromophos-ethyl (0.5 µg/L); Fenamiphos (0.5 µg/L); Prothiofos (0.5 µg/L); Ethion (0.5 µg/L); Carbophenothion (0.5 µg/L); Azinphos Methyl (0.5 µg/L).
Polynuclear Aromatic Hydrocarbons (PAH)	USEPA 8270 GC/MS SIM	Naphthalene (1.0 µg/L); Acenaphthylene (1.0 µg/L); Acenaphthene (1.0 µg/L); Fluorene (1.0 µg/L); Phenanthrene (1.0 µg/L); Anthracene (1.0 µg/L); Fluoranthene (1.0 µg/L); Pyrene (1.0µg/L); Benz(a)anthracene (1.0 µg/L); Chrysene (1.0 µg/L); Benzo(b)fluoranthene (1.0 µg/L); Benzo(k)fluoranthene (1.0 µg/L); Benzo(a)pyrene (0.5 µg/L); Indeno(1.2.3.cd)pyrene (1.0 µg/L); Dibenz(a.h)anthracene (1.0 µg/L); Benzo(g.h.i)perylene (1.0 µg/L).
benzene, toluene, ethylbenzene, and	US EPA 5030/8260	Benzene (1 µg/L); Toluene (2 µg/L); Ethylbenzene (2 µg/L); meta- & para-Xylene (2 µg/L); ortho-Xylene (2 µg/L).

Analyte	Method	Detection Limits
xylenes (BTEX)	GC/MS	
Total Petroleum Hydrocarbons (TPH) (Silica Gel Cleanup)	USEPA 5030/8260 USEPA 3510/8015 P&T GC/MS/FID	C6 - C9 Fraction (20 µg/L); C10 - C14 Fraction (50 µg/L); C15 - C28 Fraction (100 µg/L); C29 - C36 Fraction (50 µg/L).

3.2.2 QA/QC

Inter and intra-lab duplicates were collected at 10% of sites. Field blanks and trip blanks were also collected. Normal laboratory duplicates, method blanks, single control spikes and duplicate control spikes were run for each analysis batch. All laboratory quality control measures were checked against the certificate of analysis to ensure data were within certified limits.

If a problem was detected, the laboratory was asked to rerun the samples, and generally the problem was resolved.

- The following QA / QC issues were encountered:
- Ammonia contamination was found in trip and field blanks during the August and September field trips. It is unlikely that samples were contaminated in the field by ammonia, and the source is most likely to be the rinsate water provided by the laboratory;
- Filters used in the August sampling trip failed, and samples were filtered on return to the laboratory. However, the Queensland Water Quality Sampling Manual (EPA 1999) states that samples should be filtered within 48 hours of collection. Therefore, dissolved nutrient results from this trip were not used. These filters were also used in June/July for P1, P5, and P7 and so dissolved nutrient results are not reported for those samples; and
- The temperature probe malfunctioned during the August field trip and therefore these data are not available.

TDS comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and some small amounts of organic matter that are dissolved in water. The relationship between TDS and conductivity is a function of the type and nature of the dissolved cations and anions in the water and possibly the nature of any electrically charged suspended materials.

There was no significant relationship between TDS and conductivity (Figure 3-1). The reasons for this were not clear. Further analysis will be undertaken on data collected during the wet season sampling.

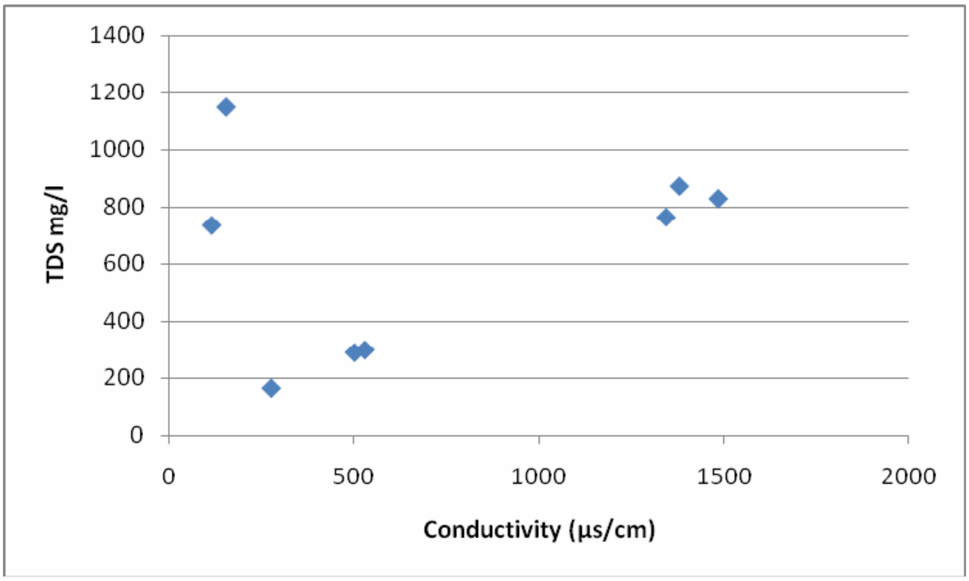


Figure 3-1 Relationship between TDS and conductivity

3.2.3 Data analysis

As no specific local water quality guidelines existed, data were described in terms of the existing Environmental Values (EVs) and Water Quality Objectives (WQOs) established under the Environment Protection (Water) Policy (2009), the national guidelines for the protection of aquatic ecosystems (ANZECC / ARMCANZ, 2000) and the Queensland Water Quality Guidelines (DERM 2009a). Comparisons were also made to historical data collected by the then DNRW (now DERM) and relevant published and unpublished literature.

3.3 Fish

3.3.1 Sample collection, storage and preservation

Electrofishing is one of the most effective methods of sampling fish and crustaceans from shallow streams. The Sustainable Rivers Audit (SRA) fish theme pilot study reported that electrofishing was found to be a cost effective method of estimating overall community composition relative to using all gear types (MDBC 2004a).

Electrofishing and trapping were used to sample fish wherever practical. Electrofishing was carried out by trained operators, in accordance with the Australian Code of Electrofishing Practice (NSW Fisheries Management 1997). The operator worked in an upstream direction (when water was flowing) and sampled all available aquatic habitats (e.g. pools, riffles, runs). An assistant followed behind with a dip-net to collect animals missed by the operator. Electrofisher 'on-time' was recorded at each site as a measure of sampling 'effort'.

Five baited traps (45 x 25 x 25 cm dimensions) were set at each site for a period of two hours. Traps were set at variable times, according to the scheduling of each site. Dry cat food was used as bait for every site. Traps were set according to scientific permitting conditions.

Fish and macrocrustaceans were identified to species level in the field. All native specimens were returned to the stream alive following identification and enumeration. Exotic species were euthanased on site using clove oil and buried, in accordance with the requirements of Hydrobiology's animal ethics committee.

3.3.2 Laboratory QA / QC

Detailed notes and photographs were recorded in the field to accompany species records. For species unable to be identified in the field, representative specimens were preserved and sent to the Queensland Museum for further taxonomic assessment.

3.3.3 Data analysis

The fish community was described in terms of abundance, diversity (species richness), abundance of exotic species and abundance of rare and threatened species.

3.4 Macroinvertebrates

3.4.1 Sample collection, storage and preservation

Macroinvertebrates were collected from edge habitats according to standard Australian Rivers Assessment System (AUSRIVAS) protocols (Environment Australia 2001). Traditionally, Queensland state-wide methods established for the Monitoring River Health Initiative were based on AUSRIVAS assessment protocols. However, the Department of Environment and Resource Management (DERM) Stream and Estuarine Assessment Program (SEAP) now undertakes a combination of AUSRIVAS style (qualitative) sampling and composite (quantitative) sampling of all bed habitat types in order to report broad scale ecosystem health on the bioregion scale.

AUSRIVAS sampling protocols also require that the relevant habitat should be sampled if it accounts for more than 10% of the study reach. Therefore, macroinvertebrates were collected from both the edge /backwater and bed habitats (where available) at all sites.

Each study site comprised a 100 m reach of stream (50 m upstream and 50 m downstream from the point of entry). Macroinvertebrates were collected over 10 m for each habitat using a standard 200 µm mesh dip net. Edge samples were live picked in the field. Bed samples were preserved whole and delivered to the laboratory for picking. Samples were preserved in 70% ethanol and delivered the Australian Water Quality Centre (AWQC) for identification and enumeration. Organisms were generally identified to family level with the exception of lower Phyla (Porifera, Nematoda, Nemerta etc.), Oligochaetes (freshwater worms), Acarina (mites) and microscrustacea (Ostracoda, Copepoda and Cladocera). Chironomids were identified to sub-family level, in accordance with standard AusRivas protocols (Environment Australia 2001).

3.4.2 Laboratory QA / QC

QA /QC checks were undertaken by AWQC on field residues retained for 10% of samples.

Within the laboratory, 10 % of samples were selected at random, and then examined by a member of the identification team other than the original operator. In only one of 29[2] identifications was a taxon recorded by the second operator that had not been reported by the original operator; this was for a single turbellarian worm (a cryptic taxon likely to be overlooked by live-picking) of very small size. Approximately 60 % of sample records differed in abundance between the operators; in most cases, the second operator recorded more individuals. Almost all discrepancies in abundance were for 1-4 individuals, with an outlier of 23 more Cladocera for the second operator.

In addition to the intra-laboratory checks, 10 % of field collected residues were retained and examined within the laboratory. A list of taxa that were exclusive to residues in one or more samples is provided in Table 3-3. Nematoda, together with Cladocera, Ostracoda, Collembola, bryozoan statoblasts, Hydrobiidae, Ceratopogonidae, Chironomidae and many of the other dipteran taxa listed are (often) extremely small and are characteristically not well collected by live-picking. Other taxa were at very low abundances (e.g. Physidae, Hydraenidae, Corbiculidae, Isostictidae) and thus there was a low chance of them being observed by the field operators.

Table 3-3 List of macroinvertebrate taxa recorded exclusively in residue samples.

Family	
Nematoda	Hydrophilidae
Physidae	Hydraenidae
Hydrobiidae	Scirtidae
Ancylidae	s-f Tanypodinae
Corbiculidae	s-f Orthocladiinae
Cladocera	Ceratopogonidae
Ostracoda	Culicidae
Collembola	Tipulidae
Gomphidae	Ephydridae
Isostictidae	Calamoceratidae
Dytiscidae	Bryozoa

3.4.3 Data analysis

Stream Invertebrate Grade Number – Average Level – 2 (SIGNAL 2) scores were calculated according to Chessman (2003). In order to provide a comprehensive assessment of macroinvertebrate community structure and function and potential flow/sediment related responses, macroinvertebrate communities were also described in terms of the following:

- Flow and substrate sediment preference groups (using indices developed for the SEAP);
- Total species richness,

[2] Note: This includes all samples collected (edge and bed habitats) for both the gas transmission pipeline and gas fields studies.

- Plecoptera-Ephemeroptera-Trichoptera (PET) richness; and
- Functional feeding group proportions.

3.5 Geomorphology

Physical habitat was defined in MDBC (2003) as that related to hard surfaces (including channel shape, rocks, logs and plants). This includes *in situ* geomorphic processes and characteristics, large woody debris (LWD) and riparian vegetation. *In situ* type, condition and extent of physical habitat and their interaction with hydrological and chemical processes and characteristics ultimately define the presence and success of particular organisms. As such, assessing physical habitat is an important component of any aquatic biological monitoring study, particularly when involved in impact assessment.

Numerous rapid assessment methodologies exist that rate reach-based habitat / geomorphic condition. A review of the methods previously used in the Dawson and Calliope catchments indicated that the State of the Rivers and AUSRIVAS methods were the most widely used. Further, an assessment technique combining both of these methods was used by MDBC (2003) within the Condamine River catchment in their SRA. As such, an adapted version of the MDBC (2003) technique was used for this study as it provided the most detailed habitat assessment and enabled comparisons with other State of the Rivers and AUSRIVAS assessed sites within the three impacted catchments. The field proforma is provided in APPENDIx 1 . This technique included assessments of:

- Physical channel condition (e.g. channel size, shape and stability; type, occurrence and degree of erosion; channel pattern; channel slope; stream order; bank and bed material);
- Riparian condition (e.g. width, shading, longitudinal continuity, structure, exotics, aquatic vegetation); and
- Influential factors (e.g. artificial features, factors affecting bank stability, land use).

3.6 Aquatic Habitat

3.6.1 Field survey

Aquatic habitat was assessed using information provided on the AUSRIVAS habitat sampling field sheet and the geomorphic assessment proforma. Aquatic macrophytes were visually identified in the field along a 100 m reach at each site, using the field guide of Sainty and Jacobs (2003). The presence and relative abundance of macrophytes were recorded using the AUSRIVAS macroinvertebrate sampling field sheet. Detailed notes and photographs were also recorded for each site to support field identifications.

3.6.2 Data analysis

Aquatic habitat was described in terms of channel diversity and in-stream features, surrounding land uses, presence and composition of aquatic macrophytes, riparian zone condition and connectivity, shading and presence of in-stream debris.

Macrophytes were described in terms of relative diversity, aquatic habitat condition, presence of exotic species and presence of any endangered, rare or otherwise noteworthy species.

3.7 Impact Assessment Criteria

The approach to the assessment of impacts involved identification of the key impact mechanisms and possible impacts associated with each mechanism, followed by a qualitative risk assessment. Potential impact mechanisms were identified for all aspects of construction, operation and decommissioning phases of the Project. The potential impacts associated with each mechanism were described and the information was used to inform the risk assessment. Risks to the aquatic environment were determined in consideration of the combination of consequences (including vulnerability) and likelihood of occurrence. The risk assessment used the Project Risk Matrix and criteria as defined in Volume 4, Chapter 21 of the EIS. In order to maintain consistency with other technical areas, Hydrobiology used the Project Risk Matrix and tailored the consequence descriptors in relation to aquatic ecology, water quality, geomorphology and aquatic habitat. The revised consequence descriptors are provided in Table 3-4.

Table 3-4 Criteria for determining consequence

Classification	Consequence
Catastrophic	Fundamental change to ecological structure and function through deterioration in water quality, geomorphic changes or habitat destruction/fragmentation, resulting in a reduction of over 40 % in the regional occurrence of any habitat or resulting in a species no longer occurring in the relevant region as a result of direct or indirect impacts from the Project. Significant impact on a critically endangered species, habitat or ecological community as defined by EPBC Act 1999 Policy Statement 1.1 Significant Impacts Guidelines.
Critical	Major change to ecological structure and function through deterioration in water quality, geomorphic changes or habitat destruction/fragmentation, resulting in a reduction of between 25 % and 40 % in the regional occurrence of any habitat or resulting in a species having an overall reduction of over 60 % as a result of direct or indirect impacts from the Project. Significant impact on an endangered or vulnerable species, habitat or ecological community as defined by EPBC Act 1999 Policy Statement 1.1 Significant Impacts Guidelines.
Major	Moderate to major change to ecological structure and function through deterioration in water quality, geomorphic changes or habitat destruction/fragmentation, resulting in a reduction of between 15 % and 25 % in the regional occurrence of any habitat or resulting in a species having an overall reduction of between 40% and 60% as a result of direct or indirect impacts from the Project. Significant long term impact on species, habitat or ecological communities listed under other state and international legislation, such as the Nature Conservation (Wildlife) Regulation 2006 or IUCN red list.
Serious	Moderate disturbance to ecological structure and function through deterioration in water quality, geomorphic changes or habitat destruction/fragmentation, resulting in a reduction of between 10 % and 15 % in the regional occurrence of any habitat or resulting in a species having an overall reduction of between 25 % and 40 % as a result of direct or indirect impacts from the Project. Significant short term (but not lasting) impacts on species, habitat or ecological communities listed under other state and international legislation, such as the Nature Conservation (Wildlife) Regulation 2006 or IUCN red list..
Moderate	Minor to moderate disturbance to ecological structure and function through deterioration in water quality, geomorphic changes or habitat destruction/fragmentation, resulting in a reduction of between 5 % and 10 % in the regional occurrence of any habitat or resulting in a

Classification	Consequence
	species having an overall reduction of between 10 % and 25 % as a result of direct or indirect impacts from the Project. Potential long term changes to species, communities or habitats of low environmental value.
Minor	Minor, none or positive impacts to ecological structure and function through changes in water quality, geomorphology or habitat availability, resulting in a reduction of less than 5 % in the regional occurrence of any habitat or resulting in a species having an overall reduction of less than 10 % as a result of direct or indirect impacts from the Project. Potential short term changes to species, communities or habitats of low environmental value.

4. Existing Environment

This section provides the results obtained during the field surveys for water quality, fish and macrocrustaceans, macroinvertebrates, geomorphology and aquatic habitat. Where sufficient site numbers existed (i.e. for geomorphology), results were presented on the sub-catchment and catchment scale. A large number of sites were dry or did not contain suitable habitat at the time of sampling. Therefore, results for water quality, fish and macroinvertebrates were only able to be presented for a sub-set of sites and it was considered appropriate to present these as combined catchment results (as opposed to presenting individual results for each catchment).

A regional perspective is given within each section, which provides a comparison between the results from this study and other relevant published and unpublished literature and data.

4.1 Water Quality

4.1.1 National and state guidelines

Raw water quality data are provided in APPENDIx 2 . As mentioned previously (Section 3.1), only one round of dry season water quality sampling was undertaken for sites P5 (Dawson River), P7 (Juandah Creek), P3CE10 (Bungaban Creek) and P8 (Bungaban Creek). Two rounds of dry season sampling were undertaken for sites P4LL (Don River), P1 (Calliope River), P3CE11 (Cockatoo Creek), GF1 and R1 (Dogwood Creek). All other sites were either dry, did not have sufficient water to sample or for which access was not granted (refer to Table 3-1 for survey dates and types).

In the Dawson, Don and Condamine catchments, most waterways along the main gas transmission pipeline route were intermittent and a number of sites were dry during sampling. Where water was present, sampling was generally confined to small (non-flowing) pools. A notable exception was site P3CE11, located on Cockatoo Creek, which is a spring fed stream. Standing water bodies experience changes in physical and chemical status over time as evaporation reduces the water volume thereby concentrating contaminants, or rain delivers sediments and nutrients and provides chemical dilution as the water body starts to refill. In addition, higher temperatures increase microbial decomposition and increase oxygen demand, resulting in remobilisation of dissolved nutrients and metals (Smith, *et al*. 2004).

Given that ephemeral and intermittent water bodies experience natural seasonal changes in chemical and physical status, an accurate comparison of sampling data with the relevant national and state water quality guidelines was not possible. These guidelines were established mainly for steady-state conditions in perennial waters. Notwithstanding this, a comparison was made to gain an understanding of the physical and chemical condition of the water bodies at the time of sampling and how this changed throughout the dry season. Further wet season sampling is proposed during January-February (weather dependent).

The Queensland Water Quality Guidelines (DERM, 2009a) (QWQG) generally adopt the ANZECC/ARMCANZ (2000) target guidelines for each parameter, except where a sub-regional guideline has been compiled, as well as identifying other parameters that the national guidelines do not address.

Table 4-1 provides the ANZECC /ARMCANZ (2000) and QWQG (DERM, 2009a) guidelines relevant to the study area. In accordance with the QWQG, the Dawson, Don and Calliope rivers were classified as Upland rivers within the Central Coast region. The Condamine-Balonne river was classified as an Upland River in the Murray Darling region. For the purposes of this assessment, the QWQG was used as the default guidelines for comparison.

Table 4-1 ANZECC / ARMCANZ and QWQG relevant to the main gas delivery pipeline

Parameter	ANZECC/ARMCANZ 2000	QWQG 2009	
	Upland river	Central Coast (Upland river)	Murray-Darling (Upland River)
Ammonia mg/L	0.01	0.01	ANZECC
Oxidised N mg/L	0.015	0.015	ANZECC
Organic N mg/L	-	0.225	-
Total N mg/L	0.25	0.25	ANZECC
FRP mg/L	0.015	0.015	ANZECC
Total P mg/L	0.02	0.03	ANZECC
DO %	90-110	90-110	
Turbidity NTU	2-25	25	ANZECC
pH	6.5-7.5	6.5-7.5	ANZECC
Conductivity µS/cm	30-350	340	ANZECC
			500 (Condamine)

4.1.2 Temperature and dissolved oxygen

Surface water temperature increased by several degrees between the dry season surveys. Temperature ranged between 15 °C and 15.62 ºC at sites sampled in July, between 20.8 ºC and 23 ºC at sites sampled in September and 24.11 ºC at PC3E11 in October (Figure 4-1 and Figure 4-2).

Dissolved oxygen was supersaturated at P4LL (Kroombit Creek) and P3CE11 (Cockatoo Creek). Large amounts of filamentous and macro algae were observed at both of these sites, which may indicate that increased algal metabolism was contributing to increased dissolved oxygen concentrations at the time of sampling. This is also supported by the elevated pH levels at both sites (on both sampling occasions).

Only two sites were within the QWQG (P4LL and R1 in Dry season 2), all remaining sites were outside the QWQG range of 90-110 %. This is expected as most of the sites (with the exception of P3CE11 and P1) were not flowing at the time of sampling and standing or stagnant waterbodies regularly record levels lower than 50 % (ANZECC/ARCANZ, 2000; QWQG, 2009), but can be much higher (Smith *et al.* 2004).

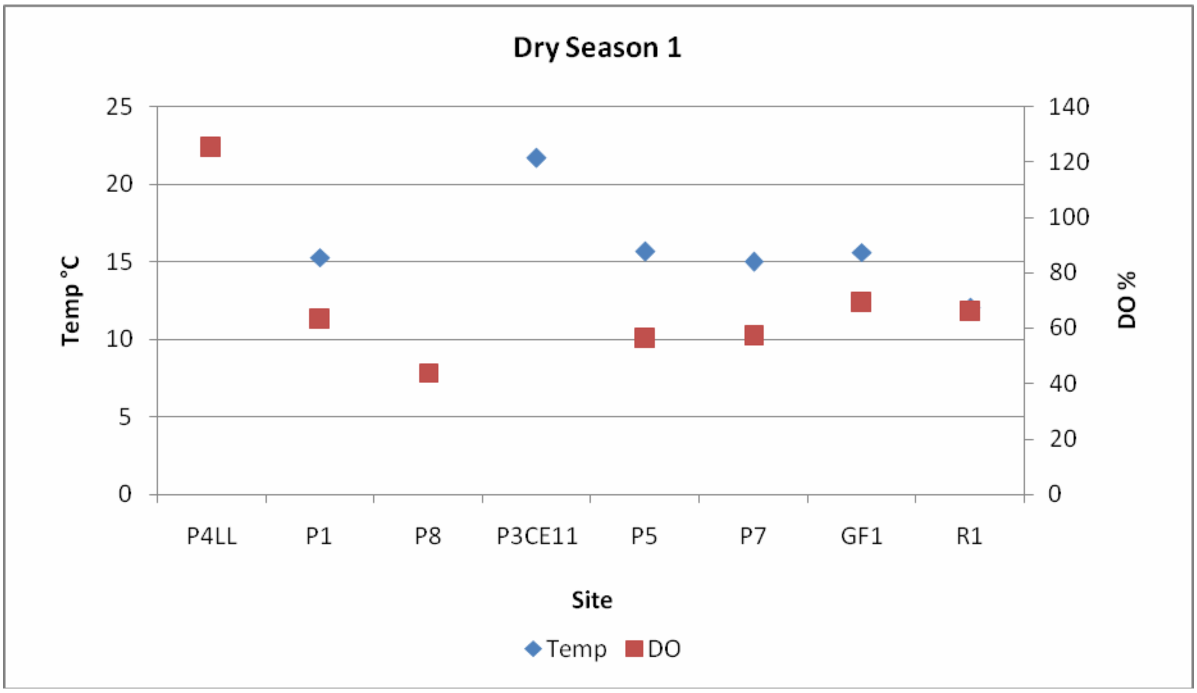


Figure 4-1 Temperature and dissolved oxygen Dry Season 1

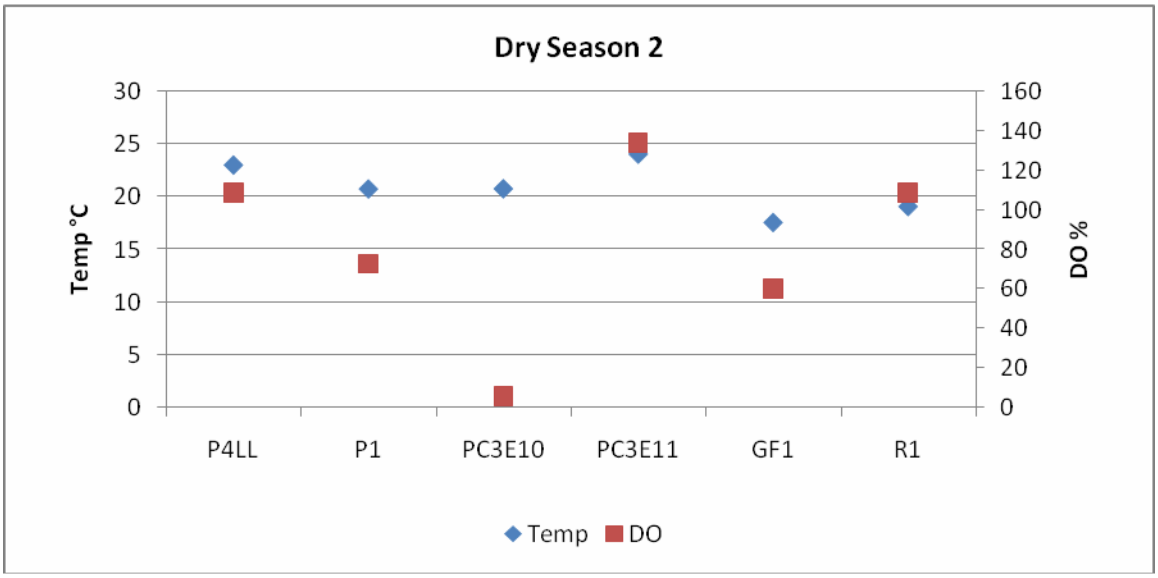


Figure 4-2 Temperature and dissolved oxygen Dry Season 2

4.1.3 Salinity

Conductivity exceeded the QWQG of 340 us/cm for all sites in the Dawson and Calliope catchments except P8 (June) and P3CE10 (October) on Bungaban Creek and P7 on Juandah Creek. Conductivity was within QWQG sites GF1 and R1 (on Dogwood Creek) within the Condamine catchment (Figure 4-3 and Figure 4-4).

P3CE11 recorded the highest conductivity levels (1 484 and 1 611 µS/cm in September and October, respectively). P3CE11 is a spring fed site located on Cockatoo Creek. The high conductivity and ionic composition suggests that deeper aquifers were contributing to base flows at this site.

P1 on the Calliope River also recorded elevated conductivity levels (1 343 and 1 379 µS/cm in July and September, respectively). High conductivity is expected at this site due to the connectivity with shallow aquifers contributing to perennial base flow. C & R consulting commented that the base flow may be supplemented by more consistent (but lower) flow rates and slightly more saline waters originating from deeper aquifers.

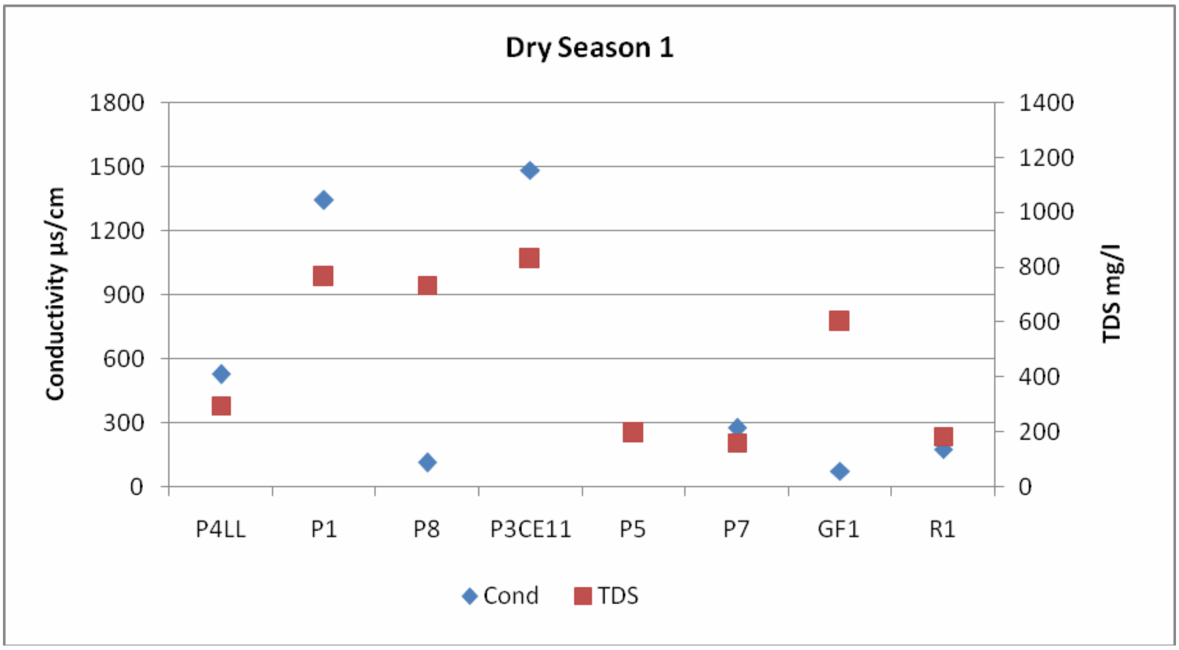


Figure 4-3 Conductivity and TDS – Dry season 1

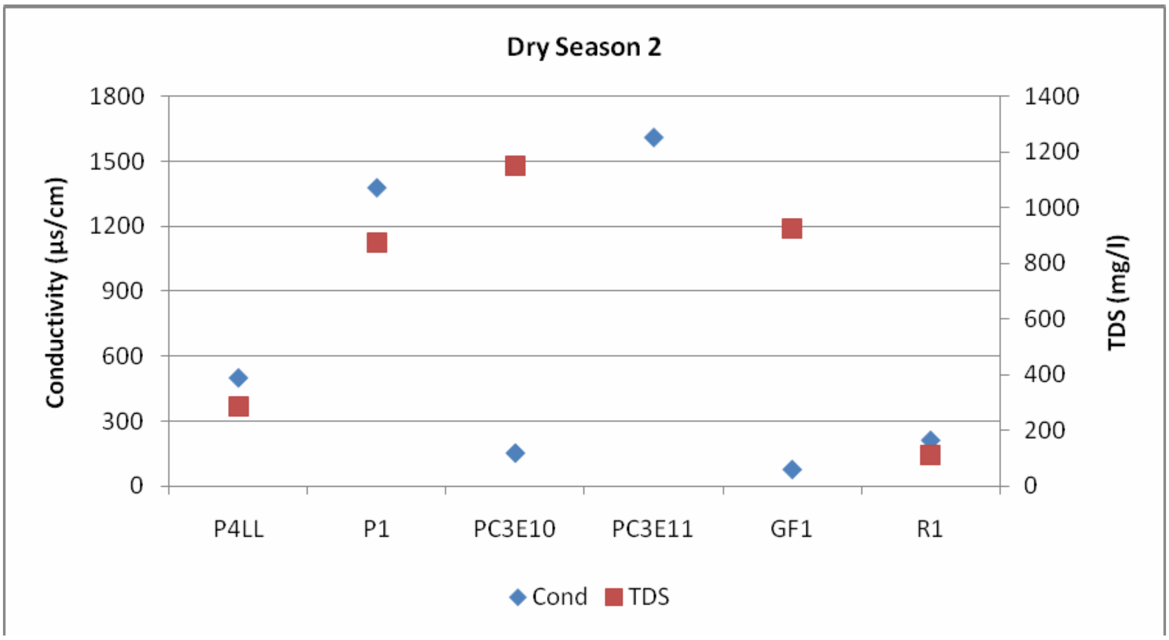


Figure 4-4 Conductivity and TDS - Dry Season 2

The Dawson, Don and Condamine-Balonne catchments had a reasonably well balanced mix of magnesium, sodium and calcium with bicarbonate predominating over chloride in the Dawson catchment (Figure 4-5). This is expected in actively weathering catchments that receive water from multiple surface runoff and groundwater sources. Chloride and sulphate predominated at site P1 on the Calliope River, although it had a reasonably well balanced mix of sodium, calcium and magnesium. The chloride / sulphate dominance is expected due to the groundwater connectivity at this site.

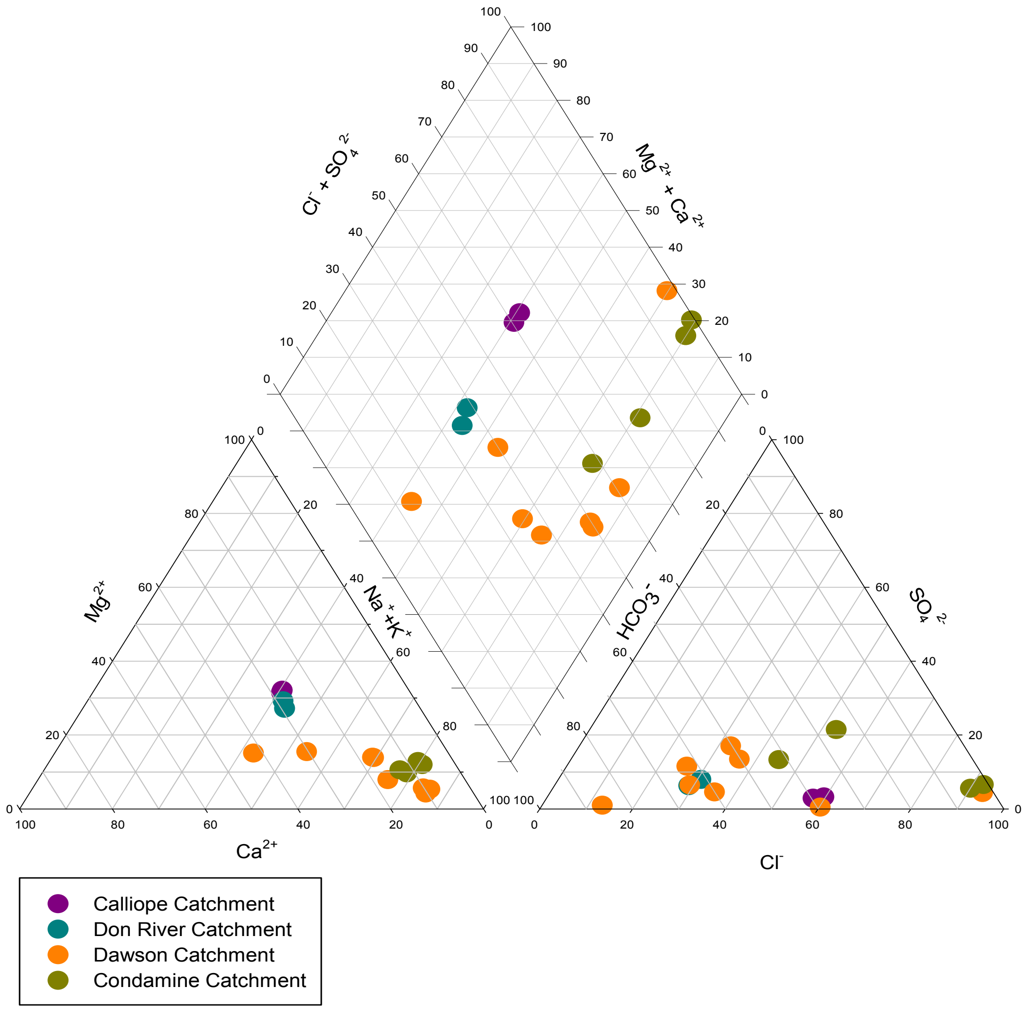


Figure 4-5 Proportion of major cations and anions in the Calliope, Dawson, Don and Condamine catchments.

4.1.4 pH

pH exceeded the QWQG of 6.5 – 7.5 at sites P4LL and P3CE11 on both sampling occasions and GF1 during the second dry season survey (Figure 4-6 and Figure 4-7). As discussed in Section 4.1.2, this

may have been a result of increased algal metabolism at these sites and the time of day of sampling. pH also marginally exceeded QWQG at site P1 (Calliope River) in June.

Sites P8 on Bungaban Creek, R1 on Dogwood Creek and P5 on the Dawson River recorded the lowest pH levels (5.76, 5.4 and 6.1, respectively). The reasons for the reduced pH levels at these sites are not known. Further monitoring would be required to establish baseline pH and long term trends within the catchments.

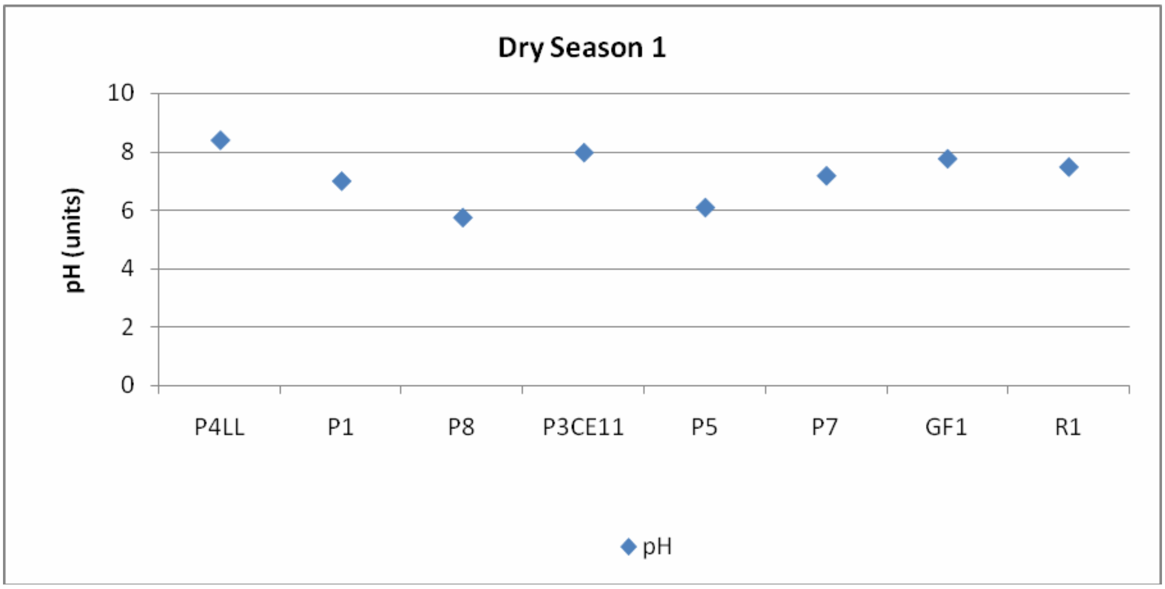


Figure 4-6 pH - Dry Season 1

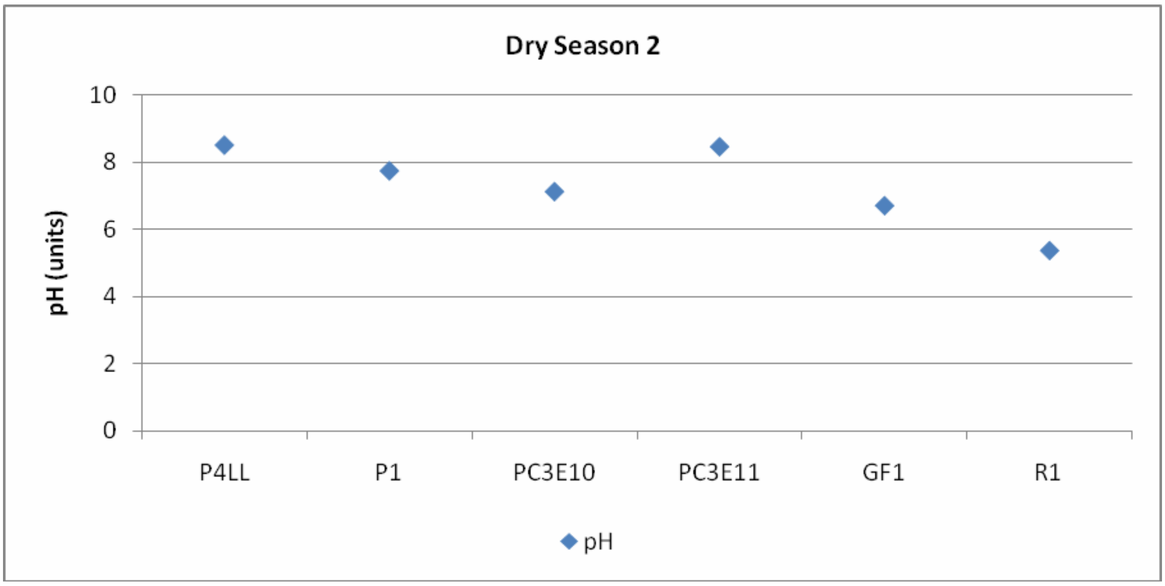


Figure 4-7 pH - Dry Season 2

4.1.5 Turbidity and Suspended Solids

Turbidity and TSS varied throughout the catchments, with the lowest levels recorded at site P1 on the Calliope River and highest level recorded at site P8 on Bungaban Creek (618 NTU), which exceeded the QWQG. Turbidity also exceeded the QWQG of 25 NTU at sites P5 on the Dawson River (July), P4LL on Kroombit Creek (September) and P3CE11 on Cockatoo Creek (October) and GF1 and R1 both on Dogwood Creek (both sampling occasions) (Figure 4-8 and Figure 4-9).

The elevated turbidity and TSS levels were not considered unusual for these catchments and are likely to be a result of a combination of natural (e.g. unstable and dispersive soils and highly variable rainfall) and anthropogenic (e.g. livestock grazing and land clearing) sources.

The marginal exceedance of the QWQG at site P3CE11 in October was considered unusual, given the connectivity with groundwater at this site. However, the previous sampling occasion recorded a turbidity of 22, which may indicate that localised catchment runoff contributed to the elevated levels in October. Further monitoring would be required to establish baseline turbidity and seasonal trends within these catchments.

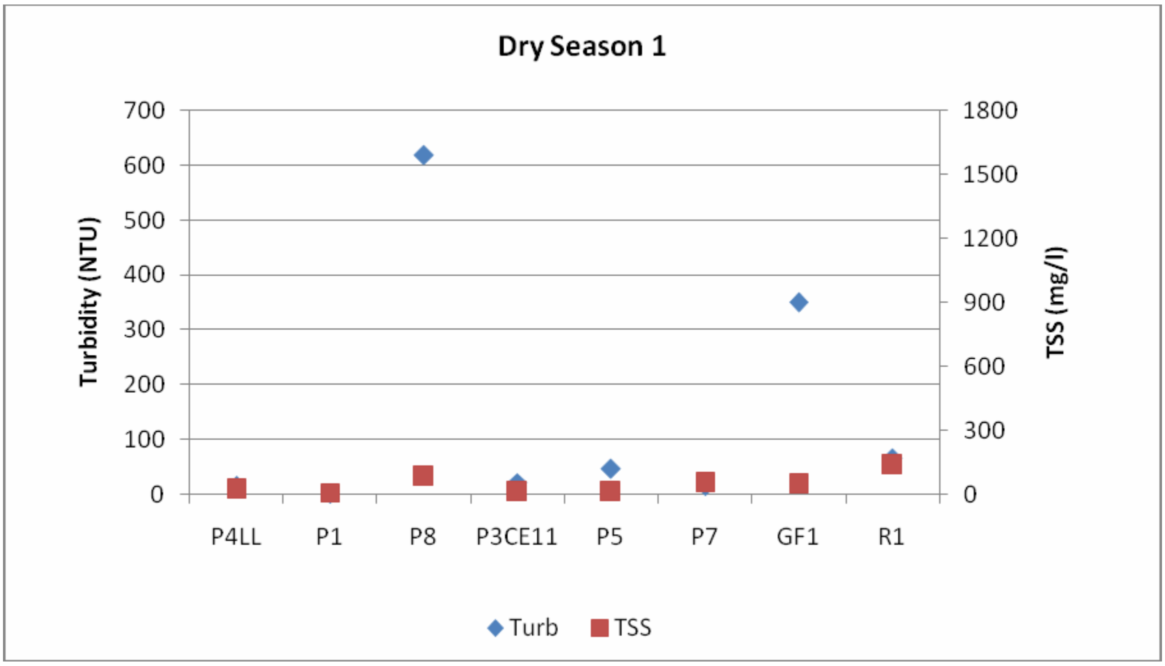


Figure 4-8 Turbidity and TSS - Dry Season 1

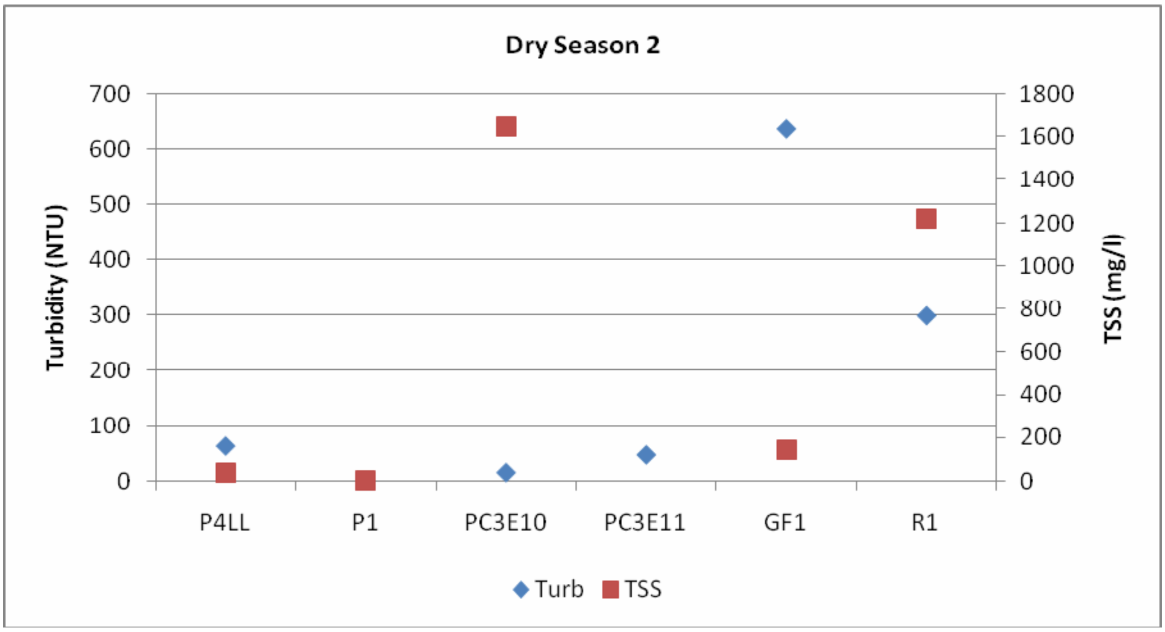


Figure 4-9 Turbidity and TSS - Dry Season 2

4.1.6 Nitrogen

Total nitrogen exceeded the QWQG of 0.25 mg/L at all sites in September, with the exception of P1 on the Calliope River. The highest concentrations of total nitrogen were recorded at sites P4LL on Kroombit Creek (August and September), P7 on Juandah Creek (July) and P8 on Bungaban Creek (August). Most of the total nitrogen was Kjeldahl nitrogen, indicating that it was mostly present in organic form (Figure 4-10 and Figure 4-11).

Ammonia exceeded the QWQG of 0.01 mg/L at all sites, with the exception of GF1 during the first sampling occasion. NOx exceeded the QWQG at sites P8 and P3CE10 (Bungaban Creek), P3CE11 (Cockatoo Creek) and P5 (Dawson River) (Figure 4-12 and Figure 4-13).

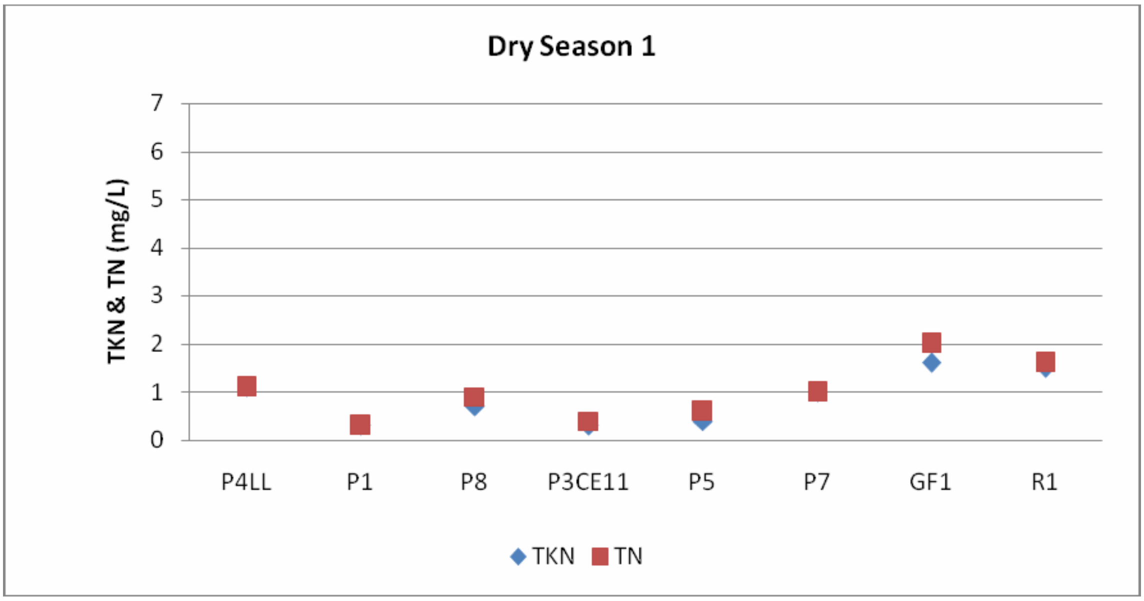


Figure 4-10 TN and TKN - Dry Season 1

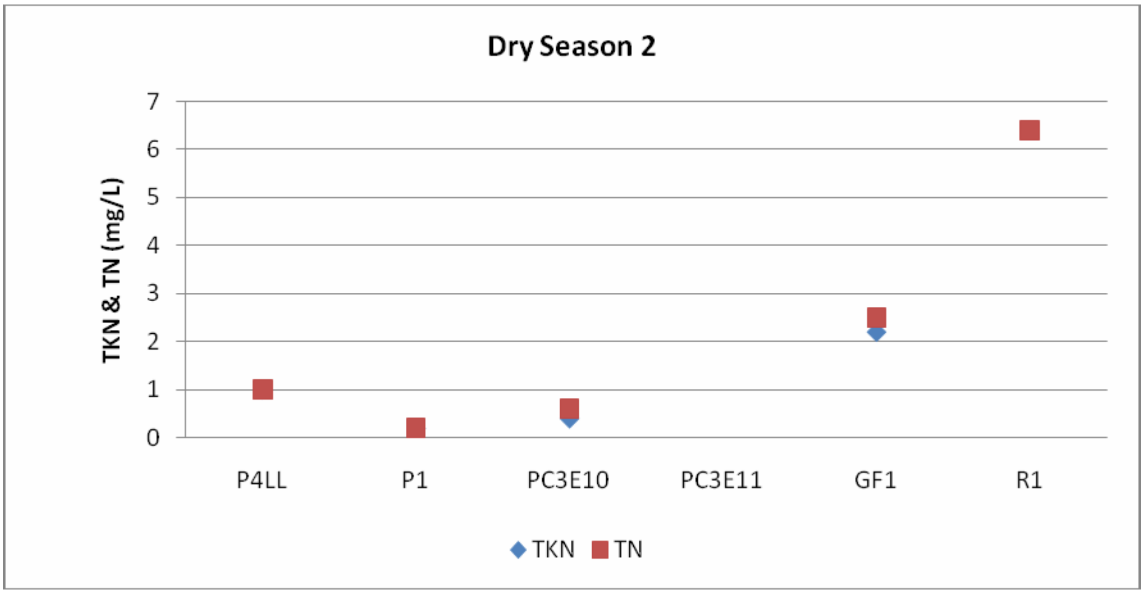


Figure 4-11 TN and TKN – Dry Season 2

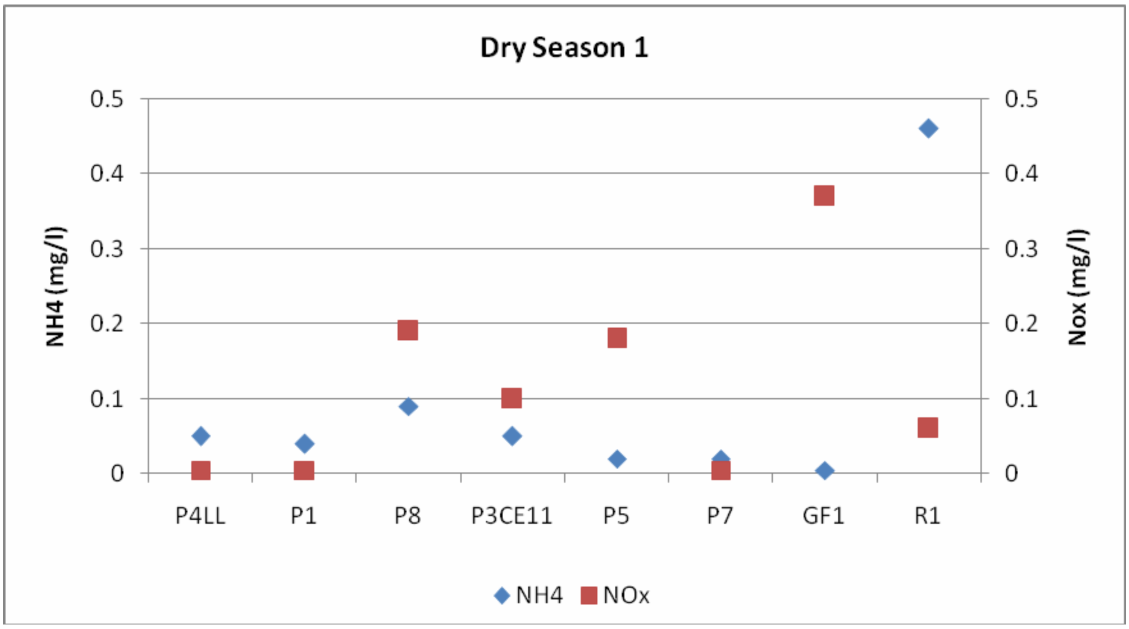


Figure 4-12 NH_4 and NOx – Dry Season 1

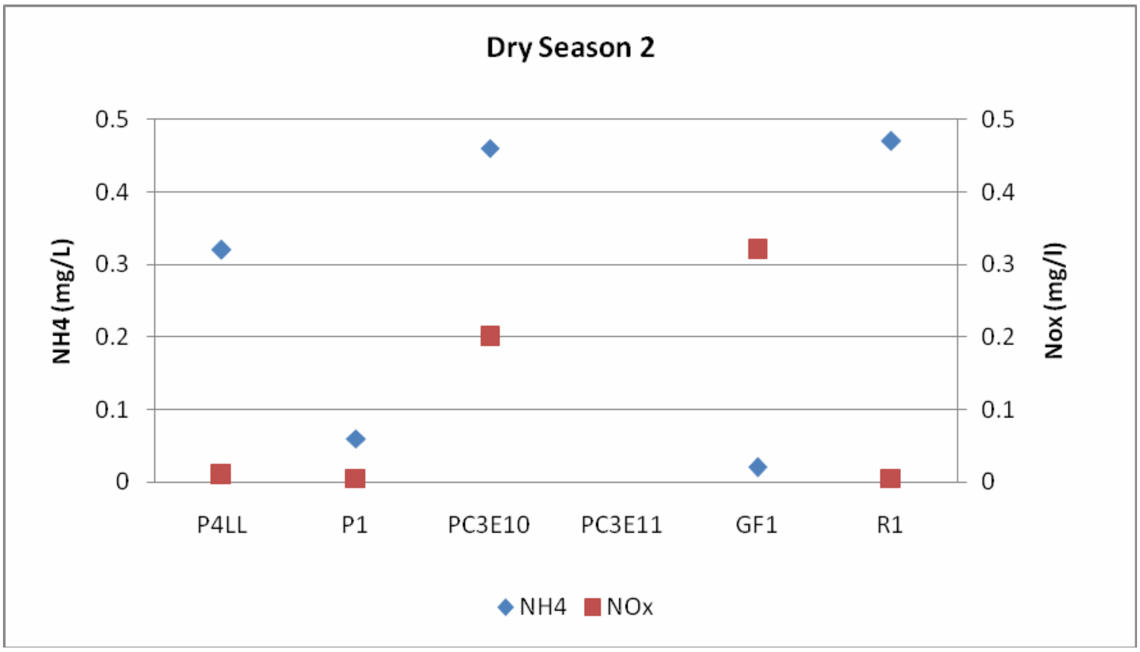


Figure 4-13 NH_4 and NOx – Dry Season 2

4.1.7 Phosphorus

Total phosphorus concentrations exceeded the QWQG at all sites with the exception of P4LL in August and R1 in June (Figure 4-14 and Figure 4-15). FRP concentrations also exceeded guidelines at a number of sites, although due to faulty filters used during the August and September field trips, only the datum for P5 is deemed reliable. Further sampling would be required to determine baseline phosphorus conditions with any level of confidence.

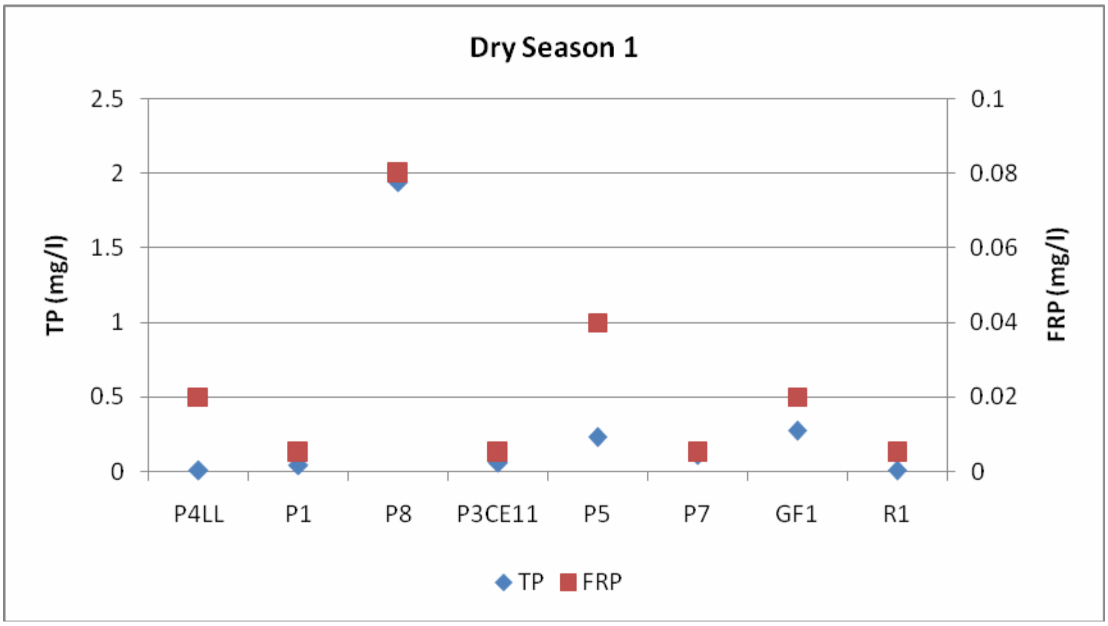


Figure 4-14 TP and FRP – Dry Season 1

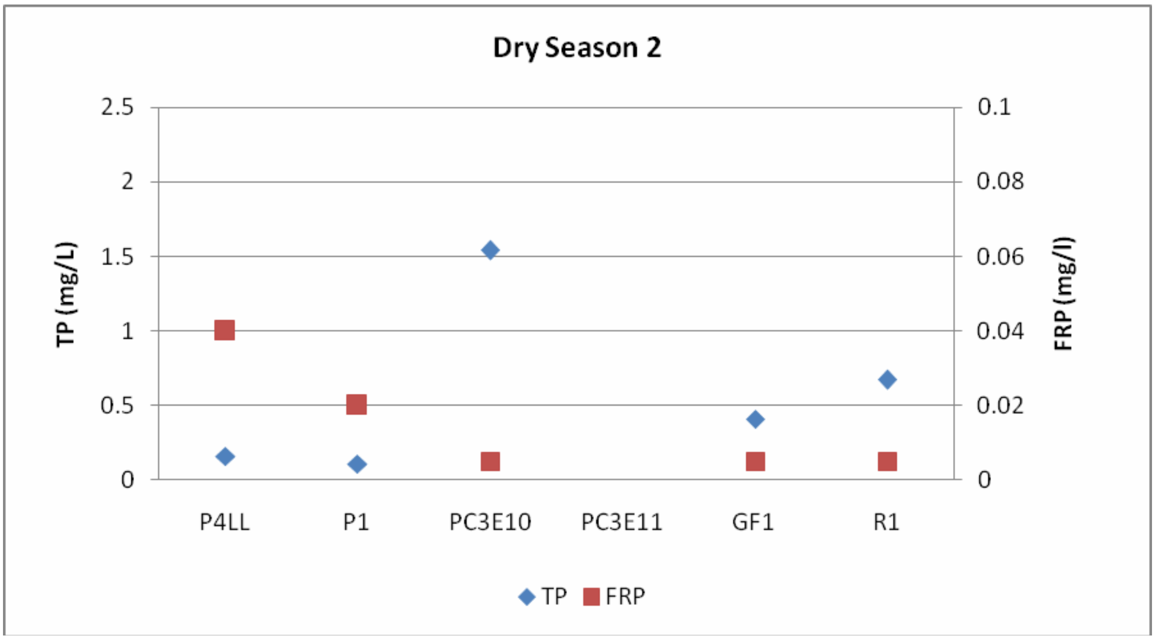


Figure 4-15 TP and FRP – Dry Season 2

4.1.8 Hydrocarbons

Site P3CE10 recorded elevated TPH concentrations in October. Subsequently, a silica gel cleanup was conducted on the samples within the laboratory. All TPH results from the additional testing were less than detection, indicating that any TPH present was likely to have resulted from natural, biogenic sources (e.g. some algae and the decay of organic material) (APPENDIx 2).

4.1.9 Pesticides

Pesticides were not found in detectable concentrations at any site for all sampling occasions (APPENDIx 2).

4.1.10 Regional Perspective

Fitzroy (Dawson and Don Rivers)

Water quality in the Fitzroy catchment is characterised by low to moderate conductivity levels, high turbidity and suspended solids and high nutrients (FBA 2008, www.4t.com.au, www.fba.org.au). The Fitzroy Basin Association reported dissolved metal concentrations (aluminium, copper, lead, zinc and nickel) exceeded the ANZECC / ARMCANZ guidelines 95 % protection level for biota (www.fba.org.au). Monitoring by DERM has also found elevated metals at various sites within the Fitzroy Basin.

The Fitzroy catchment has extensive mineral deposits and highly fertile soils and therefore supports a large number of mines (particularly coal) and high level of agricultural production. Water quality deterioration has been linked to changes in land use and outdated land management practices (FBA 2008). The catchment has been heavily impacted by stock, loss of riparian vegetation and diffuse pollution and numerous weirs and dams have modified flow regimes and contributed to reduced water quality (DNR 1998).

Mining also occurs in the Don catchment on the Dee and Callide Rivers. The Callide open cut coal mine and Callide Power Station are located in the Callide catchment adjacent to Biloela. Mount Morgan Mine, located on the Dee River, is one of the largest gold mines in Australia. Inadequate historical mine practices has left the Dee River in a poor state, with pH as low as 2.8 (Tarakemeh *et al.* 2007). There is no recent evidence of acidic flows extending beyond the Dee catchment into the Don and Dawson Rivers, although there was anecdotal evidence of this occurring when the mine was still operational. Department of Natural Resources and Water (DNRW) data presented in SunWater (2005) showed that the Don River was characterised by low conductivity, neutral to slightly alkaline pH and high nitrates. Mean turbidity and TSS values were low, although maximum values exceeded QWQG (1 600 and 800, respectively).

Calliope

Water quality in the Calliope River catchment is highly seasonal, although, it is generally characterised by moderate to high conductivity levels, low to moderate turbidity and low to moderate levels of nutrients (DNR 1999). Generally these parameters fall within ANZECC / ARMCANZ (2000) guideline values, although nutrient levels have been recorded in exceedence of those values (C&R 2005). C & R (2005) reported that although very limited data are available, pH and conductivity suggested that the river is a reasonably healthy, flowing system. They further noted that water quality impacts, usually associated with poor catchment condition and increased sediment and nutrient loading in the basin, were not readily indicated by the available data.

C & R Consulting (2005) reported that the Calliope River has naturally elevated surface water conductivity levels. This is largely because in many locations, shallow aquifers overlie aquifers with moderate to high salinities, which may infiltrate the shallower alluvial systems, particularly if overexploited (C & R 2005). Although only one site was sampled during the present study, this

appears consistent with our findings. Poor historical land practices and extensive vegetation clearing has led to the development of salinity scalding in some areas, particularly along drainage lines near Calliope and Mt Larcom. Further deterioration in land quality may contribute to increased salinity of the shallow ground waters and their containing aquifers will impact on surface water salinity within the Calliope River.

The Calliope River system is unusual among other east coast rivers of Queensland as it is a largely unregulated river, with direct marine connections and which maintains a perennial baseflow over most years. It is moderately to highly impacted by agricultural, industrial and urban land use, although major anthropogenic influences which are present in neighbouring catchments, such as those derived from mining, are currently absent.

Condamine-Balonne

Water quality in the Condamine-Balonne catchment is characterised by elevated turbidity and nutrients and low salinity, although conductivity levels have been shown to be increasing in the upper Condamine catchment (CBWC 2002, EECO 2009, http://www.anra.gov.au/topics/water/quality/qld/basin-condamineculgoa-rivers.html). This is consistent with the findings of this study. CBWC (1999) showed that the main Condamine River downstream of Chinchilla rarely had turbidity levels below 100 NTU and regularly had levels above 500 NTU, particularly following intense rainfall. CBWC (1999) also showed that total phosphorus concentrations and turbidity generally increased with increasing distance downstream and proximity to urban areas.

CBWC (1999) regularly recorded pesticides (particularly Atrazine, Endosulfan, Prometryn, Fluometuron and Methomyl) at sites in the Condamine-Balonne catchment. Levels were generally lower during drought conditions and highest during summer (peak cropping times) and following rainfall. Pesticides have also been linked to fish mortality events in the catchment (CBWC 1999).

The dominant land uses in the Condamine-Balonne catchment are cattle and sheep grazing and to a lesser extent irrigated cropping, rural residential and urban development. Extensive land clearing in combination with inappropriate land management practices, highly variable and intense rainfall and dispersive soils has contributed to the elevated sediment and nutrient levels within the waterways (CBWC 2002). Clayton *et al.* (2008) stated that due to historical clearing of streamside vegetation and introduction of weed species such as willow, riparian condition, wetland condition and water quality were identified as major issues in the catchment. Point sources such as feedlots, piggeries, sewage outflows and landfills have also delivered concentrated loads of nutrients, sediments, and other contaminants to waterways, resulting in localised differences in water quality, habitat quality and aquatic flora and fauna diversity. It was also recognised that the elevated turbidity, hardness, pH, conductivity and total dissolved ions could be improved through better land management, although some parameters were likely to be naturally high (CBWC 2002).

4.2 Fish and Macrocrustaceans

4.2.1 Results

A total of 650 fish belonging to 17 species (13 native and two introduced) was recorded at seven sites surveyed during the dry season in the Calliope, Don, Dawson and Condamine (Dogwood Creek) catchments. Within the Calliope catchment, one site located on the Calliope River (R5) was not sampled due to land access constraints. Within the Don (Fitzroy) catchment, one site on Kroombit Creek (P4) could not be sampled for the same reason. Within the Dawson catchment five sites (P5, P8, RORWB3, PCE12 and ORWB3) could not be sampled as they were either dry, too deep to sample with the electrofisher, or land access was not granted (refer to Table 3-1). Fish and macrocrustacean abundance and species richness are summarised in Table 4-2. The proportion of native and exotic fish species is shown in Table 4-2. Fish distribution and abundance raw data are provided in APPENDIx 3 .

Table 4-2 Abundance and species richness of fish and macrocrustaceans in the Dawson, Don and Calliope catchments (dry season surveys)

Catchment	Site	Total no. of fish	No. of fish species	Total no. of crustaceans	No. of crustacean species
Calliope	P1	130	12	0	0
Dawson	P3CE10	14	3	72	2
	P3CE11	242	6	2	0
	P7	113	7	0	0
Don	P4LL	105	7	0	0
Condamine	GF1	1	1	0	0
	R1	55	6	0	0

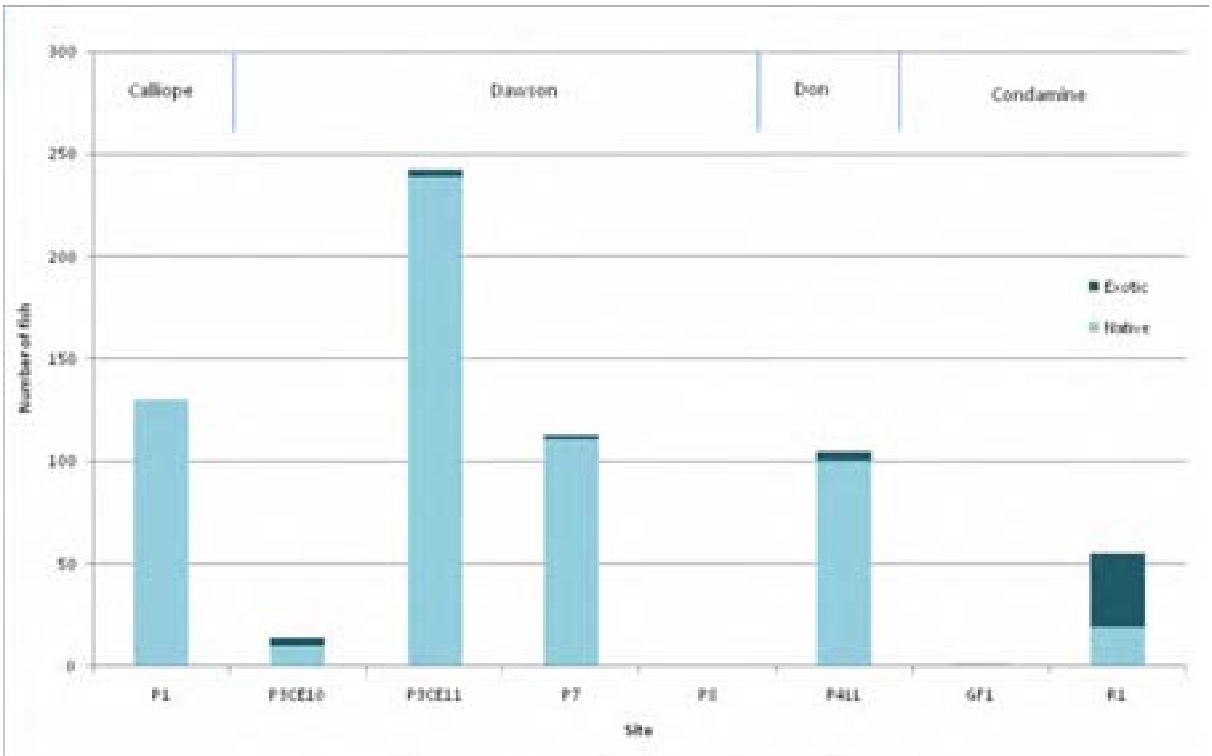


Figure 4-16 Fish abundance at each site, showing proportion of native vs exotic species

The fish assemblage at all sites was dominated by native species, with the exception of site R1 on Dogwood Creek. *Gambusia holbrooki* (Eastern gambusia) was the only exotic species recorded in the Don and Dawson catchments and was present in low numbers. Gambusia and *Carassius auratus* (Goldfish) accounted for more than half of the catch at site R1 on Dogwood Creek.

No exotic species were recorded from site P1 on the Calliope River.

The Calliope River displayed the highest species diversity (12) and second highest abundance (130) of all the sites. The Calliope River site differed from the other sites sampled as the Calliope River maintains much of its natural habitat and ecological processes. Most notably these include relatively good riparian vegetation, good abundance and diversity of aquatic vegetation, a natural flow regime and an absence of significant fish passage barriers. The fish assemblage at this site was dominated by *Ambassis agassizii* (Olive perchlet) (34 individuals) and *Hypseleotris compressa* (Empire gudgeon) (25 individuals).

Anguilla reinhardtii (Speckled eel or Longfinned eel), *Glossamia aprion* (Mouth almighty), *Pseudomugil signifier* (Pacific blue-eye) and *Amniataba percoides* (Barred grunter) were only caught at this site during the study. Speckled eels and Pacific blue-eyes are both affiliated with marine and brackish environments, for breeding for the former, and their presence at this site is likely due to its close proximity to the coast and perennial, unimpeded connectivity along the length of the river. Barred grunter typically have an aversion to high gradient tributary streams, such as those sampled in the Dawson River and Don River catchments, and are more commonly associated with larger channel habitats and permanent floodplain habitats (Pusey *et al.*, 2004). Mouth almighty are ambush predators

and favour slow flow areas and are most common in coastal streams with good macrophyte cover, such as that found in the Calliope River system.

A total of 369 fish, belonging to nine species was caught across the three sites within the Dawson River catchment. *Nematalosa erebi* (Bony bream) was only recorded from this catchment at site P7 (Juanda Creek) during the dry season surveys. Site P7 had a relatively large, long lasting, pool habitat at the time of sampling, which was possibly providing dry season refugia for aquatic communities at this time. Bony bream commonly proliferate in this type of habitat as they have high physiochemical tolerances and have generalist habitat, reproductive and feeding requirements (Pusey *et al.* 2004). Carp gudgeons were the most abundant species with a total of 159 specimens being recorded at the three sites.

Site P3CE11 on Cockatoo Creek recorded the equal second highest species richness (7) and highest abundance (242) of all sites sampled. This site was a shallow, clear water, spring fed stream, which possibly provided permanent dry season refugia. Furthermore, the extensive presence of Cumbungi and Juncus at this site could explain the higher number of *Ambassis agassizii* (Oliver perchlet – 12 individuals), *Craterocephalus stercusmuscarum* (Fly-speckled hardyhead – 53 individuals), *Melanotaenia splendida* (Eastern rainbowfish – 93 individuals) and Carp gudgeon (*Hypseleotris* spp. - 78 individuals), which deposit their eggs amongst aquatic macrophytes during spawning (*Pusey* et al. 2004). Eastern rainbowfish and Carp gudgeons were the two most abundant taxa with 93 and 78 specimens being recorded respectively. The greater abundance of Eastern rainbowfish may also be due to the fact that they rely heavily upon visual cues during courtship and this site represented the only clear water habitat sampled within the catchment.

Only one Bony bream specimen was caught at site R1, which is considered unusual because this site had a high aquatic habitat rating. Site P3CE10 on Bungaban Creek recorded the second lowest species richness (3) and abundance (14) of all the sites. This site was characterised by shallow, drying pools that would likely dry out completely in the next few months unless they received additional watering. As a result, most fish species were being excluded by degrading habitat and water quality.

Within the Don River catchment, one site at Cockatoo Creek (P3CE11) was sampled during the dry season surveys. This site represented permanent, deep pool habitat and supported an extensive macrophyte fringe along the shallow edges. The presence of this habitat is reflected by the fish community, which predominantly comprised species that deposit their eggs amongst aquatic vegetation during spawning, such as Olive perchlet, Eastern rainbowfish and Carp gudgeons (Pusey *et al.* 2004). Carp gudgeons were the most abundant species at this site with 94 specimens being recorded. Anecdotal reports from the local landholder indicated that the pool dried out for the first time since European settlement in early 2009. This indicates that the site usually acts as permanent dry season refugia and may explain why catch numbers were relatively low at the time of sampling.

Two species of macrocrustaceans, *Macrobrachium* spp. (prawns) and *Cherax quadricarinatus* (Red claw), were recorded from two sites within the Dawson catchment (P3CE10 and P3CE11). P3CE10 recorded the highest abundance of prawns and red claw (35 and 37 individuals, respectively). This is in contrast to the low fish diversity and abundance recorded at this site. Red claw are able to survive periods of complete drying by retreating into burrows, and therefore are common in these types of habitat, Two prawns were caught at P3CE11 and no other crustaceans were recorded from sites P1, P4LL and P7. The habitat at each site appeared to be suitable for macrocrustaceans and there recorded absence or low abundance may be due to time constraints on sampling or lack of predation.

Table 4-3 summarises the distribution, habitat and dietary requirements and sensitivity of the native fish and macrocrustacean species caught during the dry season surveys.

Table 4-3 Distribution, biology and sensitivity of native fish and macrocrustaceans caught in the dry season survey

Species	Common Name	Distribution and abundance	Habitat, Food and Reproduction	Sensitivity
Ambassis agassizii	Agassiz's glassfish (Olive perchlet)	Coastal drainages from the Mowbray River south of Cairns (QLD) to the Murray River in South Australia.	Found in rivers, creeks, ponds, reservoirs, drainage ditches and swamps. Usually associated with aquatic vegetation and woody structure in areas of low to no flow. They are carnivorous, feeding on microcrustaceans, insects and occasionally small fish. Spawn from Oct-Dec when temperatures reach 22-23°C. Adhesive eggs attached to aquatic plants and rocks.	Reasonably hardy fish but declining numbers in recent years in the Murray-Darling are linked to competition and predation from introduced species, altered flow regimes, cold water pollution, and degradation of breeding habitat such as macrophyte beds.
Anguilla reinhardtii	Speckled eel/ Longfinned eel	Widespread and common along the entire east coast of Australia occurring mainly in lowland coastal drainages but also being found in some upland streams.	Found in streams, lakes and swamps, preferring flowing water. They are nocturnal predators feeding on fish, crustaceans, molluscs, insects, and occasionally juvenile water birds. Migrates annually to the coral sea to spawn.	A very hardy species and can tolerate a variety of conditions, and has a propensity to recolonise streams due to its migratory habits. However, large passage barriers may be of concern to migrating juveniles.
Amniataba percoides	Barred grunter	Widespread in coastal drainages from the Ashburton River (WA), around northern Australia and down to south of the Burnett River (QLD).	Found in still pools to fast-flowing streams in clear and turbid water. They are omnivorous, feeding on insects, crustaceans and plant material. Breeds from Aug-Mar laying demersal eggs in the sediment.	Very hardy fish, tolerates temperatures up to 40°C, pH (4.5-8.6) and fresh to saline waters.
Craterocephalus stercusmuscarum	Fly-speckled hardyhead	Relatively common In coastal streams in NT, western Cape York Peninsular, and Eastern Australia from the Jardine River to the Brisbane River.	Found in still waters, slow sections of larger rivers, small, slow to fast streams, lakes, ponds and reservoirs. Generally found close to aquatic vegetation over substrates of sand, gravel or mud. Breeds from Oct-Feb. They can breed during wet and dry	Reasonably hardy species, tolerates temperatures in excess of 30°C, hypoxic conditions and moderately acidic waters. Salinity tolerance before stress has been recorded to be 30ppt.

Species	Common Name	Distribution and abundance	Habitat, Food and Reproduction	Sensitivity
			seasons and spawning generally corresponds with increasing temperature.	
Glossamia aprion	Mouth almighty	Common across northern and eastern Australia from about the Fitzroy River (WA) to coastal northern NSW.	Juveniles are commonly associated with the floodplain, although adults may also be found in small sandy streams and mainstream waterbodies. They often use submerged vegetation and woody structure as cover. They are veracious predators feeding on small fish, crustaceans and insects. Breed during the wet season and brood the eggs in their bucal cavity.	Very hardy fish, tolerates temperatures to at least 38°C, pH between 4.5-8.1, a large turbidity range, and hypoxic conditions.
Hypseleotris spp.	Carp gudgeons	Widespread and common in mid and lower altitudes of coastal drainage basins from central NSW to north Qld.	Prefers slow flowing and still waters and generally associated with macrophytes or fringing vegetation (although in these catchments high turbidity appears to provide suitable cover). Diet consists of small microcrustaceans, insects, worms and snails. Spawn in shallow water at temperatures above 22.5°C. Eggs are deposited on submerged macrophytes or twigs.	Very hardy fish, tolerates high turbidity and a wide range of physiochemical conditions.
Hypseleotris compressa	Empire Gudgeon	Relatively common in coastal drainages from the Pilbara (WA), the Kimberley (WA) and around northern and eastern Australia down to around the Towamba River (NSW).	They are found in flowing or still waters and are generally associated with aquatic vegetation and woody debris. Juveniles may occur in fast flowing streams or in estuaries. They are omnivorous, predominantly consuming aquatic insects, aquatic vegetation and microcrustaceans. Breeding season may extend between	A very hardy fish tolerating temperatures up to 33°C, pH between 4.6-9.1, hypoxic conditions and high salinity levels. They may be sensitive to fish passage barriers as there migratory requirements are unclear.

Species	Common Name	Distribution and abundance	Habitat, Food and Reproduction	Sensitivity
			summer and autumn and is likely in response to increased temperature and flows. Eggs are attached to submerged vegetation.	
Leiopotherapon unicolor	Spangled perch	One of Australia's most widespread native fish behind the Bony bream. Occurs in most coastal drainage basins from Greenough River (WA) across Northern Australia and down the East Coast to the Hunter River (NSW), and the Murray Darling System north of Condobolin. It is thought to be common throughout the Fitzroy River Basin.	Occurs in wide range of habitats including flowing streams, billabongs, lakes, dams, bore drains and pools in intermittent streams. Feeds on small crustaceans and juvenile fishes. Spawns in summer on soft substrates between 20-25°. Flooding maximises recruitment enabling dispersion via sheet flow during the wet season.	Very hardy fish. Prefer temperatures between 7.3-37.5°C and are able to tolerate DO 0.8mg/L, pH 4.0-8.6, turbidity up to 260NTU.
Nematalosa erebi	Bony bream	Arguably the most widespread of Australia's freshwater fishes. Occurs in drainages of the Indian Ocean (Pilbara), Timor Sea, Gulf of Carpentaria, Northeast Coast, Murray-Darling and Lake Eyre divisions. Is thought to be common and abundant throughout the Fitzroy River catchment.	Lowland rivers. Diet consists of microalgae, detritus and microcrustaceans.	Very hardy fish. Tolerates high temperatures, salinity and turbidity. Sensitive to cold water pollution.
Mogurnda adspersa	Purple-spotted gudgeon	Occurs along the east coast from central Cape York to the Clarence River (NSW). Is reported as being widespread but not overly abundant in the Fitzroy and Calliope River.	Occurs in slow moving or still waters of creeks, rivers, wetlands and billabongs, and prefers slower flowing, deeper habitat. Is generally associated with good cover in the form of rocks, woody debris and submerged vegetation. They are predators, consuming fish and aquatic insects, worms and tadpoles. Spawning occurs in summer when water temperature exceeds 20°C.	They are a very hardy fish tolerating temperatures >30°C, pH between 5.6-8.8, DO 0.6mg/L, turbidity up to 200NTU and salinities up to 14.8ppt.

Species	Common Name	Distribution and abundance	Habitat, Food and Reproduction	Sensitivity
			Eggs are adhesive and are attached to rocks or woody structures.	
Melanotaenia splendida	Eastern rainbowfish	Usually common across its entire range. This subspecies occurs along the east coast of QLD from central Cape York to Gladstone.	Occurs in small to large streams, wetland habitats and floodplain lagoons. It prefers areas of reduced flow and close proximity to cover. They predominantly feed on algae but insects also make up a large portion of their diets. Breeding may occur year round, although, peak spawning occurs during the wet season. Eggs are adhesive and are attached to aquatic plants or root masses.	A very hardy fish that can tolerate temperatures in as high as 32.5°C, pH between 5.13-8.47, low DO levels, turbidity up to 520 NTU and conductivities between 6-13 500 us/cm. No potential threats are known, although, Gambusia may compete for habitat and food with them and are therefore a potential threat.
Pseudomugil signifer	Pacific blue-eye	Common and widespread from north Qld to southern NSW, usually between 15-20kms from the coast.	Occurs in wide range of habitats and salinities (ranging from freshwater to sea water). Common in mangroves and Clear forest streams.	Very hardy fish. Prefers well oxygenated (>3.6 mg/L), acidic water (although able to tolerate pH 4.5-9.1) with good clarity (mean of 5.6 NTU)
Macquaria ambigua	Golden perch / Yellowbelly	Widespread throughout the Murray-Darling, Dawson and Fitzroy catchments. Spawn during floods when temperature exceeds about 20°C.	Prefers lowland, turbid, slow flowing rivers. Often associated with snags or other cover.	Hardy fish, tolerant to a range of temperatures and salinities. Decline in numbers in Murray-Darling linked to river regulation (barriers to movement) and cold water pollution.
Retropinna semoni	Australian smelt	One of most widespread and abundant native fish species in low and mid altitudes. Spawning occurs at about 11-15°C. Common throughout south-eastern Australia from Fitzroy River (Qld) to Murray River (SA).	Pelagic species and prefers slow flowing or still water (e.g. rivers, wetlands and lakes). Diet consists of terrestrial and aquatic insects (including mosquitoes) and microcrustacea.	Very fecund but sensitive to handling.
Tandanus tandanus	Freshwater catfish	Widespread distribution throughout coastal drainage basins from central coast of NSW to northern Qld.	Benthic species and prefers sandy or gravel substrate in slow flowing or still water (ponds and lakes) with	Reasonably hardy fish but declining numbers in recent years in Murray-Darling are linked to competition

Species	Common Name	Distribution and abundance	Habitat, Food and Reproduction	Sensitivity
			fringing vegetation. Gravel / rocky substrata required for breeding. Mainly bottom feeders preying on small crustaceans, insects, snails and juvenile fish (e.g. gudgeons). Spawns between spring and mid-summer between 20-24°C.	from common carp, altered flow regimes, cold water pollution, salinity and degradation of breeding habitat.
Macrobrachium sp.	Prawn species	Widespread native genus.	Opportunistic scavengers foraging on detritus, algae, invertebrates and small fish	Very hardy.
Cherax quadricarinatus	Red claw	Native to north Queensland (Gulf of Carpentaria and northern Cape York Peninsula) and Northern Territory. Redclaw farming is a significant industry in Qld. Optimal growth occurs between 26 and 29°C with lethal limits estimated to be around 9-10°C and 34-35°C.	Occurs in wide range of habitats including flowing streams, lakes, dams and billabongs. Diet consists of microcrustacea, phytoplankton and invertebrates.	Very tolerant to competition and poor water quality (high temperatures, low DO, high salinity and high nutrient loads). Translocated species that is known to out-compete native *Cherax* spp. For invertebrate food sources.

References: Allen et al. (2002), Lintermans (2009) and Pusey et al. (2004)

4.2.2 Regional perspective

An overview of fish and crustacean species recorded from Calliope, Fitzroy (Dawson and Don Rivers) and Condamine (Dogwood Creek) catchments is provided in Table 4-4.

Dawson and Don Rivers

The fish species caught in the Dawson and Don River catchments during the dry season surveys were consistent with relevant data and literature (Berghuis and Long 1999) (Table 4-4). Berghuis and Long (1999) reported that the Fitzroy catchment has an overlap of species from the temperate Murray-Darling River and the tropical NE coast drainage.

A number of native taxa recorded as being caught by Berghuis and Long (1999), were not caught during our surveys including; Neosilurus hyrtlii (Hyrtl's Tandan), Mouth almighty, Blue catfish, Hypseleotris sp.1 (Midgley's carp gudgeon), Philypnodon grandiceps (Flathead gudgeon), Oxyeleotris lineolata (Sleepy cod), Arrhamphus sclerolepis (Southeast snub-nosed garfish), Pacific blue-eye, Barred grunter, Scortum hillii (Leathery grunter), Macquaria ambigua oriens (Fitzroy yellowbelly) and Scleropages leichardti (Southern saratoga / spotted barramundi).

However, with this in mind, it should be noted that this was a one-off dry season survey at a small number of sites using electrofishing and bait trapping methods only. In comparison, the Berghuis and Long (1999) sampling program was run over a three year period, used a range of gear types (bait trapping, gill netting, and seine netting), and sampled the lower section of the Dawson and Don Rivers where a greater range of habitats were present than the headwaters that were sampled during the 2009 dry season survey. Of these species, all but Blue catfish, Midgley's carp gudgeon, Leathery grunter and Barred grunter were recorded in very low abundances within the Dawson and Don River catchments. Blue catfish and Leathery grunter are medium to large bodied, highly mobile fish and are not readily caught by electrofishing. Barred grunter are more commonly found in lowland main channel habitat than in high gradient tributary streams like those sampled during the 2009 dry season survey (*Pusey* et al. 2004). Overall the species caught during the 2009 dry season survey were consistent with what was naturally expected to occur within the part of the Dawson and Don River catchment that was sampled.

Both the Hydrobiology (2009) dry season survey and Berghuis and Long (1999) did not record any exotic species from the Dawson and Don River sites, although, Berghuis and Long (1999) commented that goldfish were still regularly captured in the Dawson River. It is likely that they would also be in the Don River due to its close proximity.

The high abundance of Bony bream captured during surveys undertaken by Berghuis and Long (1999) was found to be consistent with other studies of this species throughout its range. They suggested that the population increase had resulted because the species does not have a reliance on floods or flows for reproduction.

Calliope River

A total of 34 fish species and three crustacean species have been recorded from the freshwater reaches of the Calliope River system (C & R 2005). Marine vagrants and diadromous migratory species make up a large portion of the fish community and include 14 fish species and 2 crustacean species. It is also important to note that the only introduced species recorded was the translocated Sooty grunter

(*Hephaestus fuliginosus*). The comparatively good health of the Calliope River fish communities was attributed to the persistence of good habitat diversity and fish passage and perennial baseflows across most of the system (C & R 2005).

Only one site was sampled on the Calliope River during the dry season sampling program undertaken for the present study and the results should be treated as a snapshot indication of community structure at that site. However, with this in mind a total of 11 species were recorded within a 100 m sampling area which encompasses a substantial portion (32 %) of the known community. No exotic fish species were recorded, which is consistent with data reported by C & R (2005). Most fish species that were not caught during the dry season surveys were large, highly mobile species, temporary marine vagrants or cryptic species that are not readily caught by backpack electrofishing. These species include; *Megalops cyprinoides* (Oxeye herring), *Neoarius graeffei* (Blue catfish), *Strongylura kreffti* (Freshwater longtom), *Lates calcarifer* (Barramundi), *Scatophagus argus* (Spotted scat), *Herklotsichthys castelnaui* (Southern herring), *Thryssa hamiltoni* (Hamilton's anchovy), *Glossogobius giurus* (Flathead goby), *Redigobius bikolanus* (Speckled goby), *Arrhamphus sclerolepis* (Southeast snub-nosed garfish), *Lutjanus argentimaculatus* (Mangrove Jack), *Mugil cephalus* (Sea mullet), *Liza subviridis* (Flat-tailed mullet), *Neosilurus hyrtlii* (Hyrtl's tandan), *Notesthes robusta* (Bullrout), *Acanthopagrus australis* (Yellowfin bream) and *Hephaestus fuliginosus* (Sooty grunter). The results indicated the fish community in the Calliope River remains robust and healthy.

C & R (2005) reported two species of macrocrustacean in the freshwater reaches of the Calliope River - Prawns and *Caridina indistincta* (Brush-clawed shrimp). No crustacean species were recorded during the 2009 dry season survey, although this is most likely due to time constraints on sampling.

Condamine River

Clayton *et al*. (2008) reported that there were 19 native fish species found in the freshwaters of the Condamine River catchment, with a further five alien species recorded. With the exception of Murray cod (listed as Vulnerable under the EPBC Act 1999), all were recorded as 'least concern' under the *Queensland Nature Conservation Ac*t 1992.

A number of native taxa recorded as being caught within either the SmartRivers or SRA program (Condamine-Balonne), were not caught during our surveys – Murray cod, *Mogurnda adspersa* (purple spotted gudgeon), A*mbassis agassizii* (olive perchlet) , *Craterocephalus stercusmuscarum* (fly-specked hardyhead) and *Neosilurus hyrtlii* (Hyrtl's tandan). However, it should be noted that this was a one-off dry season survey at a small number of sites using electrofishing and bait trapping methods only. In comparison, the Smart-Rivers program has been run over several years, surveyed a larger number of sites and used a range of gear types (e.g. bait trapping, gill netting, fyke netting and seine netting). Within the five years of data (2000-2004) reported in the SmartRivers review of data these species were only caught on rare occasions (EM 2004), although Hyrtl's tandan was reported as common, but localised (favoured particular habitats and generally only caught in fyke nets – not readily caught by electrofishing). Similarly, the SRA Fish Theme Technical Report stated that olive perchlet, purple-spotted gudgeon and Hyrtl's tandan were only recorded from a single site, while Murray cod was rarely caught (MDBC 2003). Fly-specked hardyhead, Purple spotted gudgeon and Hyrtl's tandan were all recorded in the Upper Condamine (source zone) and the species caught during these surveys would accord with what was naturally expected to occur within the part of the Condamine-Balonne River catchment sampled (EM 2004).

In both the SmartRivers and SRA programs, three exotic species (common carp, goldfish and gambusia) were recorded, which generally accounted for around <20% of the catch.

A comparison of fish species reported in previous studies as being present in the Calliope, Dawson, Don and Condamine-Balonne Rivers is provided in Table 4-4.

Table 4-4 Presence of fish species recorded in the Calliope, Fitzroy (Dawson and Don Rivers) and Condamine-Balonne catchments

Fish Species	Common Name	Calliope	Dawson	Don	Condamine Balonne
		*	**	**	***
Megalops cyprinoides	Oxeye herring	✓	-	-	-
Ambassis agassizii	Agassiz's glassfish / Olive	✓	✓	-	✓
Ambassis vachelli	Vachelli's	✓	-	-	-
Anguilla reinhardtii	Longfinned eel	✓	-	-	-
Glossamia aprion	Mouth almighty	✓	✓	✓	-
Neoarius graeffei	Blue catfish	✓	✓	✓	-
Craterocephalus	Fly-specked	✓	✓	✓	-
Strongylura kreffti	Freshwater	✓	✓	✓	-
Lates calcarifer	Barramundi	✓	-	-	-
Scatophagus argus	Spotted scat	✓	-	-	-
Nematalosa erebi	Bony Bream	✓	✓	✓	✓
Herklotsichthys	Southern herring	✓	-	-	-
Morgunda adspersa	Purple-spotted	✓	-	✓	✓
Gobimorphus	Striped gudgeon	✓	-	-	-
Hypseleotris galii	Firetailed	✓	-	-	✓
Hypseleotris spp	Carp gudgeons				✓
Hypseleotris sp.A	Midgley's carp	✓	✓	✓	✓
Hypseleotris	Empire gudgeon	✓	✓	✓	-
Philypnodon	Flathead	-	✓	-	✓
Oxyeleotris lineolatus	Sleepy Cod	-	✓	✓	✓
Thryssa hamiltoni	Hamilton's	✓	-	-	-
Glossogobius giurus	Flathead goby	✓	-	-	-
Redigobius bikolanus	Speckled goby	✓	-	-	-
Arrhamphus sclerolepis	Southeast snub-nosed garfish	✓	-	-	-
Lutjanus	Mangrove jack	✓	-	-	-
Melanotaenia	Eastern	✓	✓	-	-
Mugil cephalus	Sea mullet	✓	-	-	-
Liza subviridis	Flat-tailed mullet	✓	-	-	-

Fish Species	Common Name	Calliope	Dawson	Don	Condamine Balonne
		*	**	**	***
Mugilidae spp.	Mullet	✓	-	-	-
Gadopsis marmoratus	River blackfish	-	-	-	✓
Hypseleotris klunzingeri	Western carp gudgeon	-	-	-	✓
Craterocephalus	Darling River	-	-	-	✓
Melanotaenia duboulayi	Crimson spotted rainbowfish	-	-	-	✓
Melanotaenia	Murray River	-	-	-	✓
Maccullochella peeli	Murray cod	-	-	-	✓
Macquaria ambiqua	Golden perch / Yellowbelly	-	-	-	✓
Galaxias olidus	Mountain	-	-	-	✓
Tandanus tandanus	Freshwater	-	-	-	✓
Retropina semoni	Australian smelt	-	-	-	✓
Craterocephalus stercusmuscarum	Fly specked hardyhead	-	-	-	✓
Bidyanus bidyanus	Silver perch	-	-	-	✓
Cyprinus carpio	Common carp	-	-	-	✓
Carassius auratus	Goldfish	-	-	-	✓
Gambusia holbrooki	Gambusia	-	-	-	✓
Pseudomugil signifer	Pacific blue-eye	✓	✓	-	-
Tandanus tandanus	Freshwater	✓	✓	✓	✓
Neosilurus hyrtlii	Hyrtl's tandan	✓	-	✓	✓
Notesthes robusta	Bullrout	✓	-	-	
Acanthopagrus	Yellowfin bream	✓	-	-	
Amniataba percoides	Barred grunter	✓	✓	✓	
Scortum hillii	Leathery grunter	-	✓	✓	✓
Leiopotherapon	Spangled perch	✓	✓	-	✓
Hephaestus	Sooty grunter	✓	-	-	✓
Macquaria ambigua oriens	Fitzroy yellowbelly /	-	✓	✓	-
Scleropages leichardti	Southern saratoga /	-	✓	✓	-
Macrobrachium sp.	Prawn	✓	-	-	✓
Caridina indistincta	Brush-clawed	✓	-	-	-
Cherax	Red Claw	✓	-	-	✓

*C & R (2005)

**Berghuis and Long (1999)

***Clayton et al. (2008), FRC (2009), Hydrobiology (2006), EM 2005 and 2008, DPI & F (2007)

Notable fish species

No fish species listed under the EPBC Act 1999 or Queensland Nature Conservation (Wildlife) Regulation 2006 legislation were caught during the surveys.

Scleropages leichardti (Southern saratoga or Spotted barramundi) is endemic to the upper reaches of the Fitzroy River System, where it is reported to be 'relatively uncommon' (Allen *et al.* 2002, Berghuis and Long 1999), although is not on any threatened species lists. *Scortum hillii* (leathery grunter) and the subspecies *Macquaria ambigua oiriens* (Fitzroy yellow belly) are also endemic to the Fitzroy.

Although not caught during these surveys, these species may be present throughout the catchments, where suitable habitat exists. An overview of the habitat requirements and sensitivity / significance of these species is provided in Table 4-5.

Table 4-5 Overview of significant fish species known to be found in the Fitzroy (Dawson and Don Rivers), Calliope and Condamine-Balonne catchments

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity/Significance	IUCN	NCR	EPBC
Scleropages leichardti	Saratoga, Spotted barramundi	Endemic to upper reaches of Fitzroy (Dawson) River System, where it is relatively uncommon.	Prefers billabongs or pools in slow flowing, turbid streams. Diet consists of frogs, fish, invertebrates and crustaceans.	Not listed as threatened, but endemic and uncommon in Fitzroy Basin. Favoured by recreational fishers and populations maintained in several impoundments in Queensland by stocking.	X	X	X
Scortum hilii	Leathery grunter	Endemic to upper reaches of Fitzroy (Dawson) River System, where it is reported to be uncommon.	Prefers freshwater streams and still pools in clear or turbid water. Specialised feeder. Diet consists of mostly mussels and algae.	Not listed as threatened, but endemic and uncommon in Fitzroy Basin.	X	X	X
Macquaria ambigua oriens	Fitzroy Yellow belly / Golden Perch	Endemic to the Fitzroy River System, where it is reported to be relatively common.	Specific information regarding this subspecies is not available. Prefers warm, slow moving, turbid sections of streams and is also found in lakes, backwaters and impoundments	Not listed as threatened, but endemic to the Fitzroy River Basin. Is favoured by recreational fishers and some populations are maintained in several impoundments within the catchment. It is considered relatively common throughout the catchment.	X	X	X
Maccullochella peeli peeli	Murray cod	Formally abundant throughout most of Murray-Darling Basin, but now uncommon. Migrates (up to 120km) upstream to spawn. Spawns in spring and early summer when	Prefers deep holes and habitats with instream cover (e.g. large woody debris, undercut banks or overhanging vegetation). Diet consists of fish, crayfish and frogs.	Relatively abundant throughout their range, but recruitment to the adult population is believed to be unsustainably low. Listed as vulnerable under the EPBC Act 1999. Habitat	X	X	✓

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity/Significance	IUCN	NCR	EPBC
		temperatures exceed 15°C.		destruction through sedimentation, altered flow regimes, overfishing and thermal pollution have contributed to declining numbers. Culturally very important to local indigenous groups as a food source and in mythology. Favoured by recreational fishers and regularly stocked in many localities within the Murray-Darling catchment.			
Bidyanus bidyanus	Silver perch	Originally present throughout Murray-Darling Basin, now restricted to upper reaches. Not expected to occur upstream of Dalby-Chinchilla.	Prefers areas of rapid flow in rivers, lakes and reservoirs. Diet consists of insects, molluscs, phytoplankton and annelid worms.	Numbers have declined significantly. Listed as Vulnerable on the IUCN Redlist. Only small populations remaining. Potential threats include river regulation (migration barriers). Tolerates a wide temperature range. Irregularly stocked in many localities within the Murray-Darling catchment.	✓	X	X
Ambassis agassizii	Agassiz's glassfish (Olive perchlet)	Known to be present in coastal streams from northern NSW to north Qld. Only known from a few localities in the Darling River Basin (upstream of Bourke), but locally	Prefers vegetated edges of lakes, creeks, swamps, wetlands and rivers. Often associated with snags and aquatic vegetations. Diet consists of microcrustaceans, aquatic	Numbers have declined significantly in recent years. Potential threats include altered flow regimes, cold water pollution and predation by alien species.	X	X	X

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity/Significance	IUCN	NCR	EPBC
		abundant in Condamine-Balonne and Border Rivers.	and terrestrial insects (including mosquitos), small arachnids and small fish.	Listed under State legislation of New South Wales (endangered), Victoria (extinct) and South Australia (extinct) and recent submission to the Commonwealth Government have recommended protection of this species within the Murray- Darling Basin through formal listing of these species under the EPBC Act 1999.			
Craterocephalus amniculus	Darling River hardyhead	Relatively common but confined to upper reaches of Darling River near NSW-Qld border. Spawns mid to late summer.	Prefers slow flowing, shallow, clear water in small creeks and streams with good vegetation. Diet consists of macroinvertebrates and microcrustaceans.	Listed as Vulnerable on the IUCN Redlist. Potential threats include water abstraction, altered flow regimes, habitat destruction and predation / competition from alien species.	✓	X	X

References: Allen et al. (2002), Pusey et al. (2004)Clayton et al. (2008), Faulks et al. (2008) and Lintermans (2009).

4.3 Macroinvertebrates

4.3.1 Results

Macroinvertebrate egde sweep samples were collected at 5 sites during the dry season in the Calliope (one site), Dawson (three sites) and Condamine (one site) catchments. Composite bed samples were collected at seven sites (four in the Dawson, one in the Calliope and two in the Condamine catchments). An additional 6 sites were dry, did not contain sufficient habitat to sample, or could not be sampled as site access was not granted. A summary of the type of sample collected at each site is provided in Table 4-6. Complete macroinvertebrate data are shown in APPENDIx 4 .

Table 4-6 Summary of macroinvertebrate samples collected during the dry season surveys

			Sample type	
Site	Location	Catchment	Edge sweep	Composite bed
P1	Calliope River	Calliope	✓	✓
P4LL	Don Creek	Dawson (Fitzroy)	-	✓
P5	Dawson River	Dawson (Fitzroy)	-	-
P7	Juandah Creek	Dawson (Fitzroy)	✓	✓
P8	Bungaban Creek	Dawson (Fitzroy)	✓	✓
P3CE10	Bungaban Creek	Dawson (Fitzroy)	-	✓
P3CE11	Cockatoo Creek	Dawson (Fitzroy)	✓	-
P3CE12*	Pump Creek	Dawson (Fitzroy)	-	-
ORWB3*	Adjacent to Bungaban Creek	Dawson (Fitzroy)	-	-
RORWB3*	Adjacent to Bungaban Creek	Dawson (Fitzroy)	-	-
GF1	Dogwood Creek	Condamine	✓	✓
R1	Dogwood Creek	Condamine	-	✓

*Sites were dry at time of sampling

Edge data were described in terms of overall richness and abundance, PET richness, SIGNAL 2 scores and proportion of functional feeding groups.

Composite bed sample data were described in terms of the DERM substrate and flow preference groupings3.

Richness and abundance (edge data)

It should be noted that although abundance data have been reported, the method used to collect edge samples is qualitative (timed picking) and should be used for broad comparative purposes only.

[3] Flow and substrate group memberships were provided by Dr. Jonathan Marshall, DERM Principal Scientist. It should be noted that these indices have been recently developed by DERM and no published data are available. Enquiries as to the development of the indices should be directed to DERM.

Taxa richness ranged between 15 and 40 across all sites for edge samples. The highest richness and abundance were recorded at P3CE11 on Cockatoo Creek (40 and 705, respectively) and the highest number of sensitive taxa. Non-biting midges (Diptera: Chironominae and Tanypodinae) were the dominant taxa at these sites. Sites P1 (Calliope River) and P3CE11 (Cockatoo Creek) had the highest richness and were the least degraded sites.

The lowest richness and abundance was recorded from site GF1 (Dogwood Creek) in the Condamine catchment. This was substantially lower than all sites within the Dawson or Calliope catchments, with the next lowest taxa richness of 27 recorded at site P8 on Bungaban Creek (Dawson catchment).

Table 4-7 Summary data for macroinvertebrate richness and abundance

Site	Abundance	Richness	No. PET Taxa
P1	173	34	3
P7	201	29	3
P8	346	27	0
P3CE11	705	40	4
GF1	71	15	0

PET richness (edge data)

PET are considered to be the orders most sensitive to pollution and are recognised as an indicator of freshwater ecological health in the QWQG. In the absence of regional guidelines in relation to macroinvertebrate composition the guidelines for PET richness for South-east Queensland freshwaters was adopted (i.e. 4 for lowland freshwater and 5 for upland freshwater).

PET richness was 3, 3, 0, and 4 for sites P1 P7, P8, and P3CE11 respectively. No PET taxa were recorded at site P8 (Bungaban Creek) or GF1 (Dogwood Creek). Chironominae and Tanypodinae (both Diptera; Chironomidae) were the most and third-most abundant groups (174 and 122, respectively) with copepoda as the second-most abundant taxa (158). These high abundance results were largely from sites P3CE11 and P7. P3CE11 (Dawson River) had the highest PET taxa richness and abundance (40 and 705 respectively).

A small number of Mayflies (Leptophlebiidae, Caenidae) and Caddisflies (Ecnomidae) were collected at various sites, with the highest abundance being nine Caenidae at P3CE11.

Site P3CE11 had the highest PET Richness and abundance score. It contained the greatest number of individuals from both the caddisflies (Trichoptera) and mayflies (Ephemeroptera), although no stoneflies (Plecoptera) were recorded at any of the sites.

SIGNAL 2 scores (edge data)

SIGNAL 2 uses a simple scoring system to provide an indication of water quality and ecosystem health. When used in conjunction with richness, SIGNAL 2 can provide an indication of the types of pollution and other physico-chemical factors that have influenced macroinvertebrate community structure and function. SIGNAL 2 scores were calculated for edge data, based on Chessman (2003). Results are reported in relation to the quadrant diagram described by Chessman (2003) (Figure 4-17). The SIGNAL 2 family bi-plot is provided in Figure 4-18.

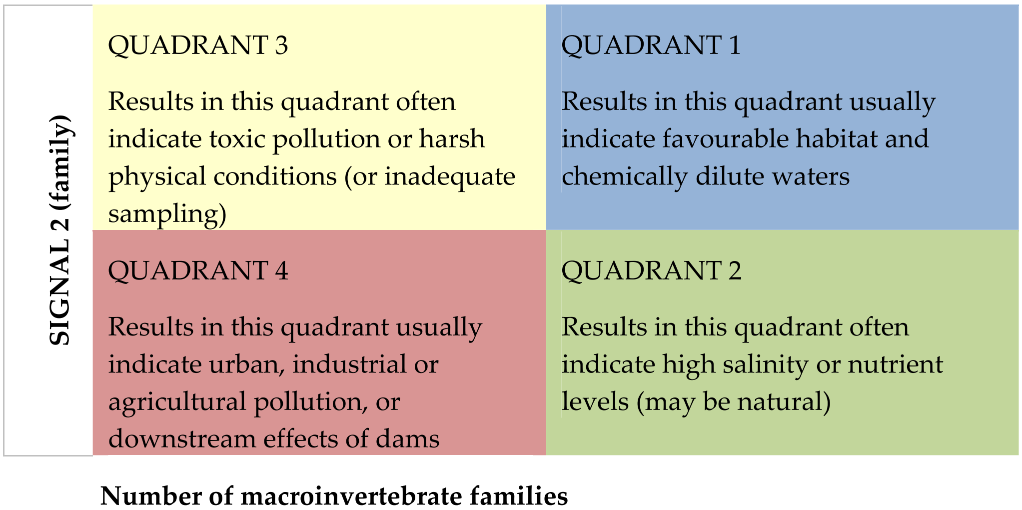


Figure 4-17 The quadrant diagram for the family version of SIGNAL 2 (reproduced from Chessman 2003).

Chessman 2003 states that "*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, data available for this study were insufficient for setting specific boundaries . Instead, boundaries used were those suggested by Chessman (2001) for Australian freshwaters (Dawson and Calliope catchments) and the Murray Darling Basin between 400 m and 200 m elevation (Condamine catchment).

SIGNAL 2 scores were low for all sites, ranging from 2.8 to 3.75 (with no abundance weighting). All sites within the Dawson and Calliope catchments fell within quadrant 2. GF1 (Dogwood Creek) in the Condamine catchment fell into quadrant 4. This may indicate that water quality and aquatic habitat was impacted throughout the study area from a range of land uses (e.g. river regulation, agriculture, and clearing of vegetation) and potentially indicated high levels of turbidity, salinity or nutrients. Water quality results indicated that nutrients were elevated for most sites. Salinity was generally low in the Dawson and Don catchments, with the exception of P3CE11 (groundwater influenced). The one site sampled on the Calliope River (P1) showed elevated salinity and nutrients. Salinity and nutrients may be high due to natural sources (e.g. regional geology and soils), as is the case for sites P3CE11 and P1, or anthropogenic sources, or a combination of sources. However, it is not possible to distinguish between natural and anthropogenic sources based on the interim boundaries. SIGNAL 2 is unable to differentiate between stressors, so the low scores may or may not reflect degraded water quality or habitat quality.

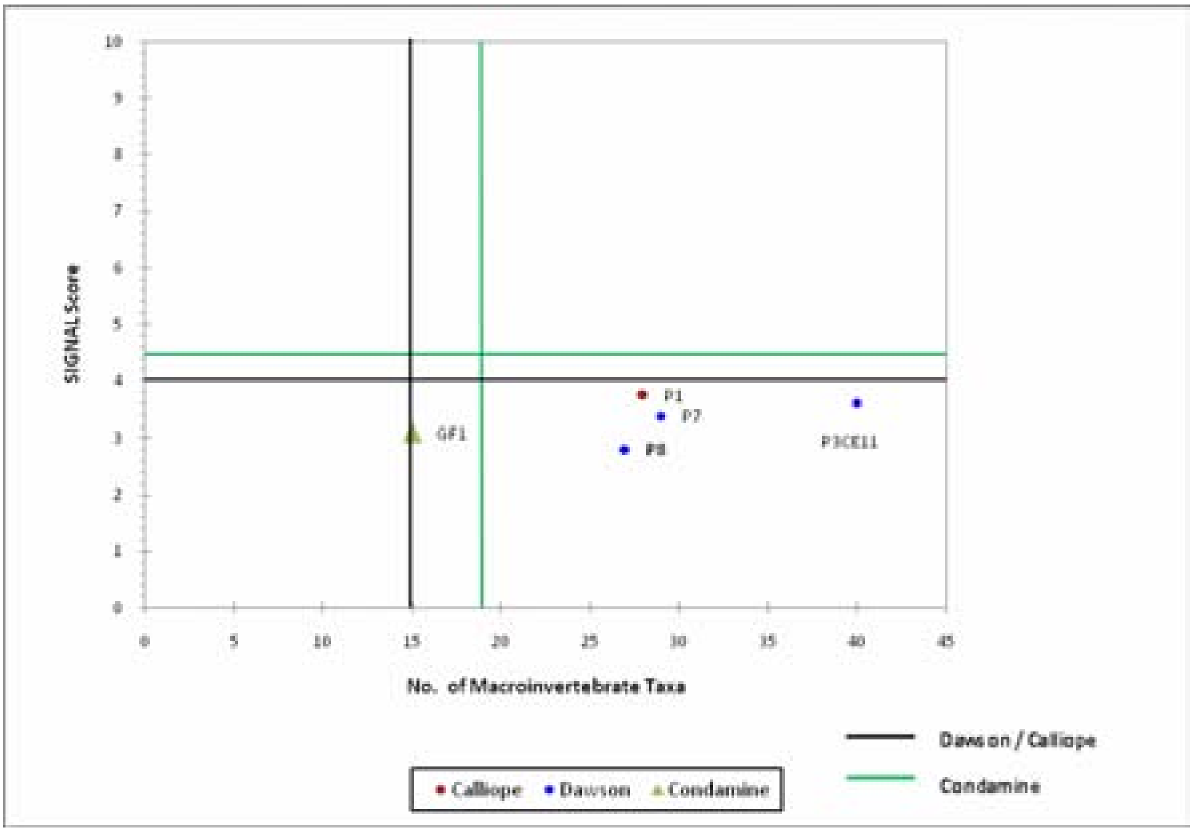


Figure 4-18 SIGNAL 2 (family) Bi-plot

Functional feeding group structure (edge data)

Macroinvertebrates can be assigned to different functional groups based on their morphological and behavioural mechanisms for acquiring food resources (Cummins *et al*. 2005). The relative proportion of the different macroinvertebrate functional feeding groups present at a site can provide an indication of broad scale ecosystem health by assessing how the main taxa interact with their environment. Specialist feeders, such as shredders and scrapers are more sensitive to perturbation, while generalised feeders, such as predators, gatherers, and scavengers are more tolerant to pollution (Rawer-Jost *et al.* 2000).

The macroinvertebrate functional feeding group composition for sites sampled during the dry season varied somewhat between sites (Figure 4-19). For the purpose of this assessment, scavengers and deposit feeders were included in the generalist "Gatherer/Collector" group. P1 was the only sampling site in the Calliope River catchment making within catchment comparisons impossible there.

Scrapers were present at all sites. However, they were higher in proportion at sites GF1 (Dogwood Creek, a tributary of the Condamine River), P1 (Calliope River) and P3CE11 (Cockatoo Creek, a tributary of the Dawson River). Scrapers rely on algae and periphyton as their in-stream food resources and the absence of this group may be linked to the absence of phytoplankton and filamentous algae observed at these sites. However, it should be noted that these sites had low 'in-stream debris' and were dominated by generalist groups, such as predators, gatherers and filter feeders. There was a higher proportion of shredders at sites P1 and P3CE11 compared to other sites,

likely due to their good fringing and overhanging vegetation. Shredders were notably absent from site GF1, which was considered unusual as it had good fringing and overhanging vegetation.

Predators were the dominant feeding group at site GF1. Sites P7 (Juandah Creek) and P8 (Bungaban Creek) contained very few Shedders and Scrapers, with site P7 having nearly equal proportions of predators, gatherers/collectors, and filter-feeders. Site P8 had a small number of gatherers/collectors and roughly equal numbers of predators and filter-feeders. The low numbers of shredders and scrapers could be attributed to the scarcity of riparian vegetation at these two sites. Both of these sites had a very high overall disturbance rating along their banks and riparian connectivity rating ranging from none to very poor. Feeding group composition was found to be more evenly distributed at sites P1 and P3CE11 in comparison to the other sites. P1, the only site on Calliope River, and P3CE11, on the Dawson River, both had very good riparian connectivity.

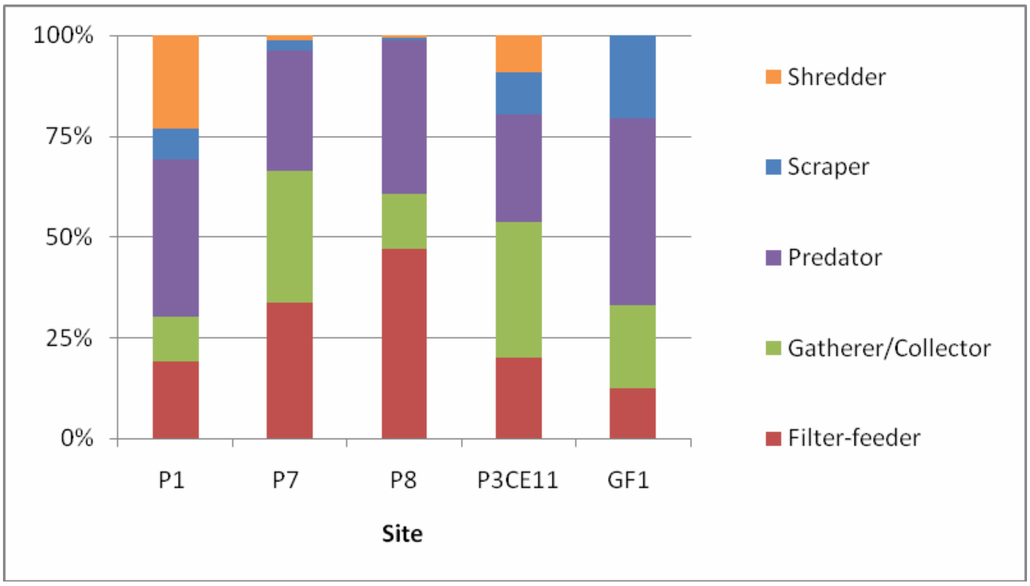


Figure 4-19 Proportion of functional feeding groups.

Flow and substrate preference groups (composite bed data)

DERM has recently developed indices to determine the flow and substrate preferences of macroinvertebrate taxa, according to the following preference groups:

Substrate preference groups – weak coarse, weak fine, strong coarse, strong fine and no preference (note: some taxa reported from the laboratory had no classification and were assigned as 'not classified');

Flow preference groups – low/no flow, medium flow, high flow and no preference (note: some taxa reported from the laboratory had not classification and were assigned as 'not classified').

The proportions of taxa within each of the substrate reference and flow preference groups are provided in Figure 4-20 and Figure 4-21 respectively.

All sites were dominated by taxa with a weak preference for fine substrate (sand/silt) or taxa that showed no preference (Figure 4-20). Site P1 (Calliope) showed greater variability in substrate preference groups than other sites. Similarly, all sites were dominated by taxa with either no flow preference or a preference for low/no flow (Figure 4-21). Site P1 was the only site to have a small

proportion (10%) of taxa preferring high flows. These results were not surprising given that all sites (with the exception of P1) had sandy/silty substrate, were dominated by taxa tolerating a range of environmental conditions and food resources and there was very low or no flow at the time of sampling. Site P1 was the only site that was flowing at the time of sampling. The site also showed higher substrate, flow and habitat variability in comparison to other sites.

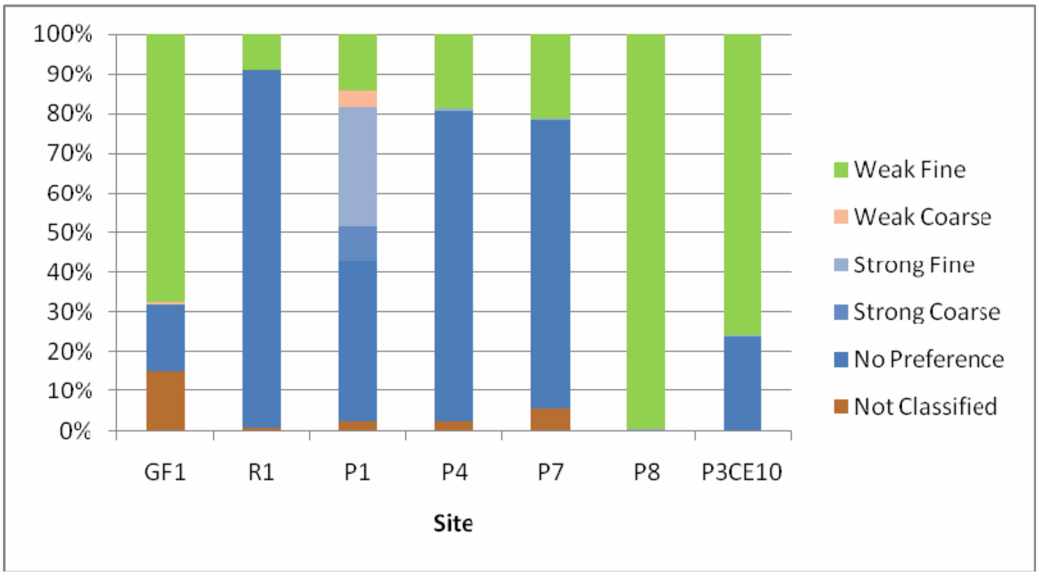


Figure 4-20 Proportion of substrate preference groups

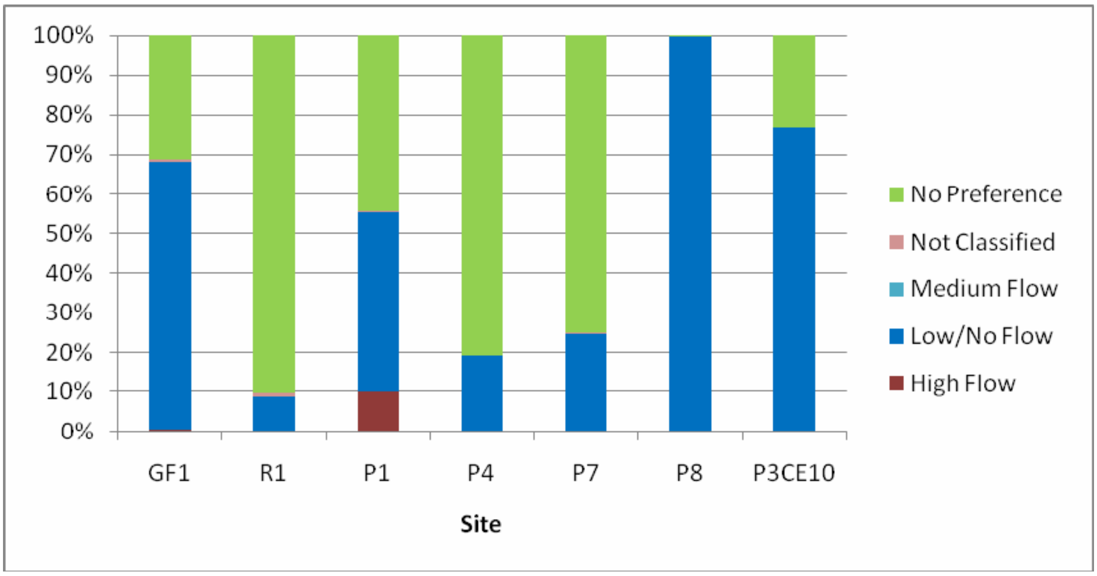


Figure 4-21 Proportion of flow preference groups

4.3.2 Regional Perspective

Dawson and Don

Taxonomic Richness was recorded to be low for the Dawson River with a mean richness of 10.5 for edge habitats, although PET results indicated that the macroinvertebrate community was in fairly good condition (FRC 2009). Duivenvoorden and Roberts (1997) reported that the high abundance and diversity of Trichopteran and Ephemeropteran families suggested that water quality was relatively good in the Fitzroy catchment. DNR (1997) reported that most sites in the Fitzroy catchment were in moderate (slightly impaired) condition in relation to habitat and presence of sensitive taxa and that lower diversity and tolerant fauna were found in areas with poor aquatic habitat (e.g. sandy beds, pools and bare edges).

Aquatic habitat conditions within the Don subcatchment are generally poorer than other sections of the Dawson River catchment (Telfer 1995) and taxonomic richness would be expected to proportionally poorer.

Calliope

The Gladstone Area Water Board (1999) and C & R Consulting (2005) found that macroinvertebrate assemblages in the Calliope River were generally diverse and abundant. A total of 69 taxa from 91 samples was recorded from riffle habitats and 39 taxa from 68 samples were recorded from pool habitats. The maintenance of rich and abundant macroinvertebrate assemblages within the Calliope River likely reflects the persistence of good in-stream microhabitat structure and diversity such as perennial riffle habitat, abundant and diverse macrophyte communities and remnant riparian vegetation (C & R Consulting 2005).

NRM monitoring data also indicated that the macroinvertebrate assemblages sampled in the Calliope River were generally taxa rich and had high occurrences of expected taxa (C & R Consulting). Sensitive PET taxa were also present in all samples with up to 7 taxa per habitat. However, all but 3 edge samples and all riffle samples taken from the two Calliope River sites had SIGNAL scores in quadrant 2 (high richness but low average SIGNAL grade). Chessman (2003) suggests that results in this quadrant often indicate high salinity or nutrient levels. This may be an artefact of the catchments naturally high mean salinity, although it may also reflect the extensive modification of the catchment area for agriculture.

Condamine-Balonne

The SRA recorded 55 macroinvertebrate families from 35 sites across two zones in the Condamine-Balonne catchment. Overall, richness was low (mean of 18 families per site) and the expectedness scores indicated a moderate to substantial loss of expected families (MDBC 2008). FRC (2009) also recorded very low taxa richness for the Condamine-Balonne catchment, with a mean richness of 9.3 for edge habitats. In contrast, DNR (2002) reported that the ecological condition, based on macroinvertebrate community structure was 'mainly good' in both the Upper Condamine and Lower Condamine River.

The ACA AquaBAMM study reported that diversity and richness (incorporating fish, macroinvertebrates, reptiles, birds, waterbirds, macrophytes and amphibians) varied throughout the catchment, although the majority of riverine sites fell within the low (59 %) and medium (29 %) categories (Clayton *et al.* 2008). This was reported to be in line with expectations due to agricultural

and development pressures in the catchment and the patchy nature of species records in all landscapes. Non riverine wetlands also showed a range of values, although criterion scores for naturalness (aquatic and catchment) and diversity and richness showed a large proportion of wetlands with a high or very high conservation value.

The SmartRivers program recorded a total of 94 macroinvertebrate taxa between 2000 and 2004 in the Lower Balonne catchment, although richness and abundance varied widely between sampling dates depending on the number of sites sampled and habitats encountered (EM 2005). It was found that macroinvertebrates in this area generally favoured edge habitats, particularly where associated with benthic algal films, macrophytes and trailing tree roots (EM 2005). It was concluded that habitat availability was a major determinant in macroinvertebrate distributions.

Hydrobiology (2006) reported that richness and abundance varied markedly between sampling methods for sites located on the Condamine River. Dip net samples recording higher richness (11-27 taxa) and abundance (50->600) than surber samples (richness, 9-12 and abundance 40-150). Generalist feeders, such as predators and collectors were reported to the be dominant functional groups in all cases (Hydrobiology 2006), which is generally consistent with our findings.

The current study recorded a mean taxa richness of 17.2 families per site, which is consistent with the SRA findings, but substantially higher than the richness reported by FRC (2009). SIGNAL 2 scores from this study were similar to FRC (2009) (between 3 and 4), although most of our sites ordinate into quadrant two, while FRC sites ordinated into quadrant four due to the lower richness recorded in their study. The low SIGNAL 2 scores for both studies indicate a dominance of more tolerant species, which may indicate degradation or could simply be a reflection of the temporary nature of the waterbodies.

Macroinvertebrate abundance and diversity varies considerably depending on season and habitat availability. The inconsistencies in macroinvertebrate community structure reported in the literature emphasise the importance on not drawing conclusions based on one round of sampling. While it is apparent that the community is dominated by more tolerant species, further data are needed, over a range of seasons to provide a more robust picture of macroinvertebrate condition within the Condamine-Balonne catchment.

4.4 Geomorphology

4.4.1 Regional Perspective

Regional climate and hydrology

A detailed climatic and hydrological description was not part of the scope of this study. Volume 5, Attachment 23 of the EIS provides detailed descriptions of climate and hydrology. However, broad-scale assessments were required to provide a hydrological context for the geomorphology section. From the discussions in the EIS, it is evident that while expected natural rainfall variability exists between regions, all show very similar characteristics. These include sub-tropical rainfall volumes, clear summer-dominated rainfall regimes, moderate intra-annual variability and moderate to high inter-annual variability. Further, while wet and dry trends tend to vary between rain gauge locations, all regions have been subjected to a long dry period in recent times.

The hydrology of the streams and rivers within the Project Area largely reflects the rainfall regime. As such, it can be inferred that:

- Summer-dominated flows occur within the catchments, reflecting the intra-annual variation in rainfall;
- There is considerable inter-annual variation in flows in all catchments, with many years of above- and below-average flow;
- The rivers and streams within the Dawson and Don catchments are generally intermittent and characterised by extended periods of no to low flow;
- Regardless of the intermittent nature of the larger rivers in the Don and Dawson catchments, examples of large pools exist, which persist throughout the dry season; and
- The Calliope River is generally considered to be perennial. A stable baseflow is maintained through its connection to shallow aquifers.

General Fitzroy Catchment (Dawson and Don Sub-Catchments) fluvial geomorphology

The historical geomorphology of the catchment was complex but was characterised by several geomorphological processes. These were:

- Early Tertiary – The present elevated country was formed following incision of the uplifted Mesozoic plains. Deep weathering of this surface occurred. Extensive lowlands also developed as a result of this incision;
- Later in the Tertiary – Terrestrial deposits and basalt flows overlaid lowlands. Deep weathering continued resulting in lateritic plains; and
- Late Tertiary to early Quaternary – Dissection of the lateritic plains resulted in gently undulating plains and the formation of colluvial fans at the base of ranges. These (and alluvial) deposits were reworked, drainage rejuvenation occurred and extensive floodplains were formed adjacent to rivers and streams.

These processes have resulted in four broad landforms within the catchment: Level alluvial plains, gently undulating to undulating plains and rises, very gently undulating plateaus and plains and hills, mountains and dissected plateaus (Shields and Gillespie 1991). The upper Dawson River catchment was characterised by a number of plateau surfaces surrounded by rolling to steep hills, whereas further downstream and to the eastern side of the catchment, slopes were generally more gradual, with occasional steep hills towards the eastern headwaters. Williams *et al.* (2002) further described the Dawson River catchment as occurring within the Subhumid, Subtropical Slopes and Plains Agro-ecological zone, characterised by plains divided by low but frequently rugged ranges, widespread cracking clay soils and mostly cleared Brigalow and open eucalyptus forests.

As indicated by Telfer (1995), little work has been conducted on historical or current hydrology or fluvial geomorphology of the Dawson River and its tributaries. However, geomorphology generally reflected the summer dominated, variable hydrology discussed above (sacrificial bars/benches in places, multi-staged banks, large bankfull channel). The streams within the catchment were also influenced by surrounding land clearance, water abstraction and agricultural land uses, with in-stream characteristics including increased sediment loads and related features (increased bar /bench

sizes, flattening of bed), increased erosion of banks and decreased geomorphic variability (Telfer 1995).

National-scale resource mapping showed that the existing fine sediment load within the Dawson River catchment was much higher than natural conditions. The fine sediment loads in most of the eastern Dawson and Don tributaries were shown to be 10-50 times higher than natural conditions (Figure 4-22) (NLWRA 2001).

Mean annual bank erosion was shown to be relatively low throughout the eastern Dawson River and Don catchments along the proposed pipeline route (NLWRA 2001). This was attributed to the upper-catchment location of most of these tributaries. Coarse sediment depth was shown to be minimal in many of the eastern Dawson catchment tributaries, again partially attributed to their upstream location within the catchment. However, Castle Creek in the eastern Dawson subcatchment (0.3 – 2 m) and small reaches of Grevillea (0.3 – 2 m), Kroombit and Kariboe Creeks in the Don subcatchment (2 – 10 m) showed considerable depths of coarse bed sediment, indicative of infilling processes resulting from sediment-laden runoff entering streams (Figure 4-23).

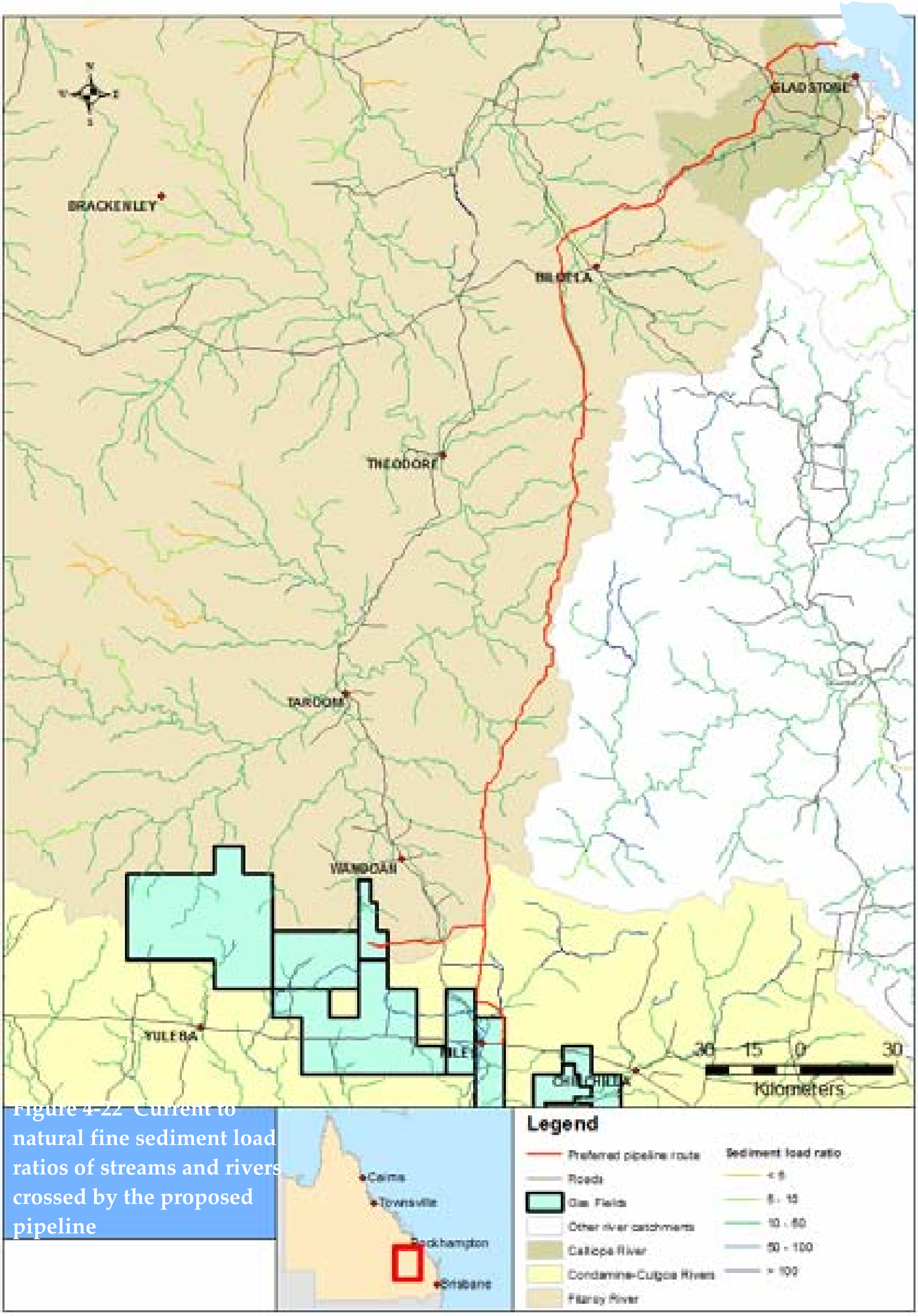


Figure 4-22 Current to natural fine sediment load ratios of streams and rivers crossed by the

proposed pipeline (Source: NLWRA 2001)

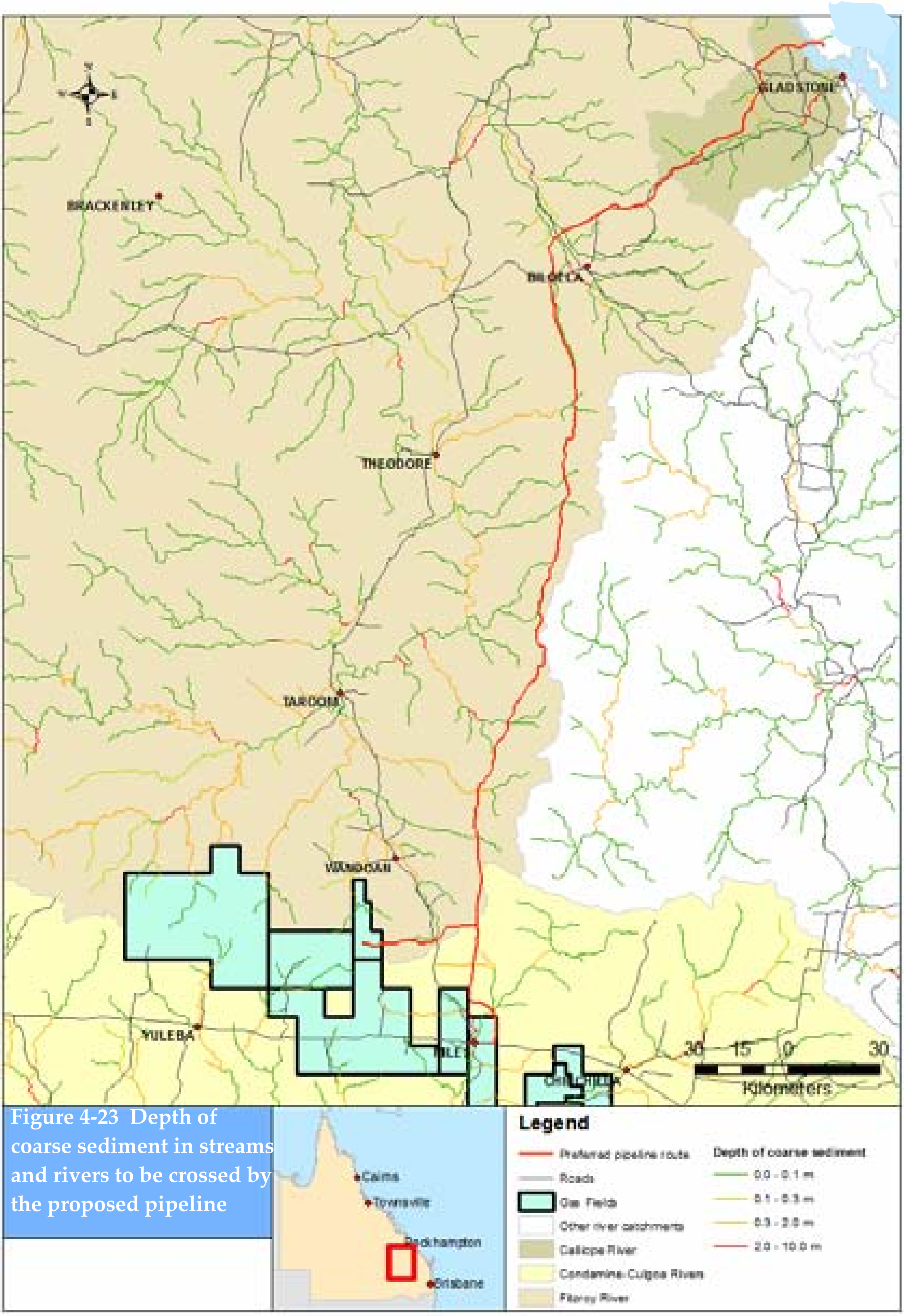


Figure 4-23 Depth of coarse sediment in streams and rivers to be crossed by the proposed pipeline

Figure 4-23 Depth of coarse sediment in streams and rivers to be crossed by the proposed pipeline (Source: NLWRA 2001)

The State of the Rivers assessment of the Dawson River and tributaries was conducted by Telfer (1995). The proposed pipeline routes and assessed sites were all within the Southern, Eastern or Don-Callide Tributaries subcatchments. Characteristics of the southern tributaries identified by Telfer (1995) were:

- 89 % of sites were highly to extremely disturbed, with grazing the major impact;
- 89 % of the stream length was in poor or moderate condition, reflecting the condition of the surrounding catchment;
- Banks were generally stable, but 96 % of sites were undergoing bank erosion at some point and 53 % of sites were undergoing slumping, affected mainly by grazing and vegetation clearance;
- 41 % of sites were recorded as aggrading, impacted by grazing and bank erosion; and
- Run habitat was the dominant habitat type which was indicative of aggrading conditions.

Characteristics of the Don-Callide Tributaries subcatchment were:

- 89 % of sites were recorded as moderately to highly disturbed, with grazing a major cause of this disturbance;
- All sites surveyed were rated as having moderately to very stable bank conditions. Sixty-seven percent of sites were observed to have low to minimal instability, no slumping was recorded at any site and bedrock outcrops were observed at 33% of the sites;
- 92 % of sites had moderate to very stable stream bed conditions; and
- Pool and run habitats were dominant, being recorded at 69 % and 60 % of sites respectively.

Characteristics of the Eastern Tributaries were:

- Bank erosion was recorded at 98 % of the sites, with clearing and thinning of forests the major impacts;
- 50 % of sites exhibited moderate to high bank instability with 12 % of sites exhibiting slumping at seepage points or irregularly along the reach;
- 51 % of sites were recorded as aggrading, impacted by grazing and bank erosion;
- Bed aggradation was recorded at 72 % of sites impacted by grazing (88 % of the sites) and bank erosion (41% of sites;
- Major stabilising factors affecting the bed and bar conditions were fallen trees (39 % of sites) and rock outcrops (18 % of sites); and
- Run habitat was the dominant habitat type, occurring at 73 % of the sites and indicative of aggrading conditions.

Calliope River Catchment

C & R Consulting (2005) reported that the upper reaches of the catchment were largely volcanic with exposed bedrock channels and sedimentary sequences with river floodplain along alluvial sediments. The middle reaches consisted of sedimentary rocks of marine to shallow marine origin with igneous intrusions. The channel was characterised by "floodplain controlled' pool-riffle sequences interspersed by extensive bedrock and bank outcropping. In "floodplain controlled" sections, bed material consisted of alluvial sediments (mainly sand and gravel) overlying coarser bed-material. Granitic and arenitic bedrock in the upper and mid reaches of the catchment provided material for the alluvial sediments which made up the Calliope River floodplain in the lower reaches. The coastline was a typical sequence of mangrove flats, mud flats and saltpans with alluvium consisting of gravel, sand, silt and clay (C & R Consulting 2005).

Historical data suggest that the Calliope River has experienced near perennial base-flow, with only occasional no-flow periods since 1936 (C & R Consulting 2005). The near constant flow regime of the Calliope River has been attributed to groundwater percolation through alluvial sands and fractured rocks within the catchment, extending periods of low flow and base flow that have maintained waterholes and riffle habitats. It has also experienced high flood variability, with flood levels 8-10 m above low flow channel levels (C & R Consulting 2005, Fluvial Research 1999). It has been a non-equilibrium river, and has relied on these infrequent flood flows (and tidal flows in the estuary) to control channel form and processes. However, due to the general dry conditions and corresponding lack of large channel forming flows experienced since 1978, the river was reported to be in a depositional phase (C & R Consulting 2005). This inherent stability appears to have contributed to lower bed material transport rates since 1978 (C & R Consulting 2005).

Brown & Root (2001) estimated that 6,000 m3/year of bed material sediment is delivered to the Calliope River mouth. This estimated figure is considered to be a broad-brush average derived from using the Universal Soil Loss Equation (USLE) and from a wide-range of existing results (Belperio 1993 – 16 000 m3/year, Hunter *et al.* 1996 – 16 000 m3/year, Moss 1993 - 10 000 m3/year). Delivery of this sediment occurs in pulses, with much larger amounts delivered during catastrophic events during wet phases. Fluvial Research (1999) used a range of sediment transport formulae and modelled daily flow data to develop a sediment rating curve. From the modelling, Fluvial Research (1999) estimated that the mean bed material transport rate was approximately 30,000 t / year. The maximum recorded flood in the catchment was about 4 000 m3/s (Castlehope gauge) (DERM 2009b) which would have increased by about 30% (5 200 m3/s) by the time it reached the mouth of the Calliope River (BHP *et al.* 1980).

Since European settlement, the sediment load of the Calliope River was estimated to have increased by 10 to 50 times (NLWRA 2001) with some isolated reaches increasing 50 to 100 times in the same period. However, sediment bed material transport rates have generally reduced over recent times (particularly in the latest dry phase), suggesting comparatively low recent rates of geomorphic change.

Condamine-Balonne Catchment

Catchment and Project area fluvial geomorphology

The catchment can be broken into several major geomorphic units. Sandstone hills and slopes dominate the western and north-western boundaries, while there are basaltic uplands to the east and

north and undulating clay downs downstream of Dalby. Quaternary deposited alluvium occurs along the Condamine River and major tributaries, becoming more extensive towards and downstream of Chinchilla (Table 4-8) (Condamine Alliance 2004).

Table 4-8 Condamine River Catchment Geomorphic Units (Source: Condamine Alliance 2004)

Geomorphic Unit	Location	Total Area (ha)	Total Area (%)
Sandstone hills and slopes	Widespread, most prominent along the western and north western boundaries	851923	34
Alluvium	East of Warwick to west of Chinchilla	637297	26
Basaltic uplands and slopes	Eastern and northern slopes, south east of Killarney to north west of Dalby	478166	19
Undulating clay downs	Mainly downstream of Dalby	359274	14
Traprock hills and slopes	South and west of Warwick	110224	4
Granite hills and slopes	Around Warwick and Killarney	44193	2
Water bodies	Throughout catchment	1425	<1

The condition and characteristics of the rivers, streams and other water bodies within the catchment reflected the geomorphic unit through which they flowed. Whittington *et al.* (2001) and Thoms and Sheldon (2002) broke the Murray Darling catchment into Functional Process Zones (FPZs) that described lengths of river with similar discharge and sediment regimes, gradient, stream power, valley dimensions and boundary material. A full list of these zones and descriptions of their characteristics are outlined in Whittington *et al.* (2001) and are summarised in Table 4-9. The Condamine-Balonne River catchment consisted of confined, armoured, anabranching, mobile, meandering and distributary zones (Figure 4-24). Comparing the distribution of these zones with the distribution of geomorphic units listed in Table 4-9 showed that the more mobile FPZs (mobile, meandering, anabranching and distributary zones) were generally situated within the alluvium unit, whereas the less mobile zones were obviously located within more restrictive units.

Whittington *et al.* (2001) also broke the Murray-Darling catchment into Valley Process Zones (VPZs) (source, transport, deposition) that described similar regions within a river valley, generally described by the sediment transport characteristic. Within the Condamine-Culgoa catchment, there were 14 347 km2 of Source Zone, 70 820 km2 of Transport Zone and 122 641 km2 of Deposition Zone.

The Project Area was largely within the transport VPZ and, further, was mostly within the mid-Condamine mobile FPZ and immediately upstream of the mid-Condamine meandering zone, with the anabranching, meandering and distributary zones further downstream. Thus, the Condamine River in the vicinity of the Project Area had the following characteristics typical of mobile and meandering zones:

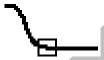
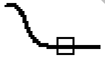
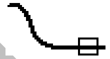
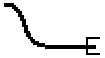
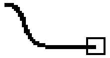
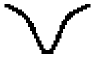
- A wide valley floor compared with the remainder of the catchment (5 – 15 km wide), comprising mainly quaternary alluvium set within clay plains with slopes typically < 5 % that were derived by erosion and slope wash from the weathered sedimentary rocks;
- An irregularly meandering channel that shifted to a relatively active, unrestricted meandering river channel at about 15 km downstream of the Leichhardt Highway crossing;

- Well-developed floodplain features, including former channels (paleochannels), flood channels, avulsions, meander cut-offs and minor anabranching, particularly downstream of the Leichhardt Highway crossing;
- Well developed inset floodplain features, including point and lateral bars, benches (at various levels), levees and networks of flood runners;
- Predominantly U-shaped channels with concave, convex and stepped banks (MDBC 2003);
- Moderately to highly stable beds and banks (MDBC 2003);
- Distinct high and low flow channels;
- Relatively mobile bed sediment, contributing to high rates of sediment transport;
- Significant storage areas within the channel;
- Bank sediments of fine sands, silt and clays contributing to relatively flow resistant banks; and
- A prominence of highly sodic soils within the catchment, with many banks consisting of sediments with some sodicity. More than 70 % of soils catchment-wide had some sodicity, with about 30 % being strongly sodic (Condamine Alliance 2004).

Thoms and Parsons (2003) looked at hydrological characteristics of different reaches of the Condamine-Balonne River and found that the 'reference' scenario hydrological zones corresponded well with the geomorphological zones outlined in Thoms and Sheldon (2002), suggesting a multivariate relationship between flow and morphology. However, the hydrological zones developed for the current water-resource development scenario did not match quite so well, indicating homogenised flow regimes in response to water extraction. Geomorphological changes were also becoming evident, including increasing bar and bench sizes, encroachment of vegetation onto bars, general infilling of channels and in some cases, notch erosion of banks.

Mean annual bank erosion was shown to be relatively low throughout the catchment (NLWRA 2001). Coarse sediment depth was shown to be variable but generally didn't exceed a depth of 2 m (except for isolated reaches) (Figure 4-23).

Table 4-9 Functional Process Zones and Valley Process Zones within the Murray-Darling Basin (Reproduced from: Whittington *et al*. 2001)

Characteristic	Upland Zones (sediment supply)			Mid-Slope Zones (sediment transfer)		Lowland Zones (sediment deposition/storage)		
	Pool	Upland Gorge	Armoured	Mobile	Meander	Anabranch	Distributary	Lowland Gorge
Valley gradient/ Long profile								
Valley profile								
Floodplain features	No floodplain	No floodplain	Minimal floodplain development. Some high level terraces.	Point and lateral bars, terraces, incised benches, former channels, avulsions, floodrunners	Point and lateral bars, terraces, incised and inset benches, former channels, avulsions, floodrunners	Low level floodrunners, anabranch channels, extensive floodplain	Distributary channels	Floodplain independent of main channel
Planform	Valley Controlled Sinuosity =< 1.2	Valley Controlled Sinuosity = < 1.2	 Sinuosity = 1.4	 Sinuosity = 1.4 - 1.6	 Sinuosity = 1.6 - 1.8	 Sinuosity = > 1.8	 Sinuosity = > 1.8	Valley Controlled Sinuosity = < 1.2
Stream power	Low	Very high	High	Moderate	Moderate-Low	Low	Low	Moderate?
Dominant sediments	Bedrock, boulder	Bedrock, boulder, cobble	Cobble & gravel surface layer with poorly sorted finer sub-sediments	Bimodal distribution of gravel/pebble and finer particles	Sand	Sand, silt, clay	Silt and clay	?
Function (sediments,	Relatively	Highly mobile	Mobile source	Mobile transfer	Highly mobile	Deposition	Deposition	Deposition

Characteristic	Upland Zones (sediment supply)			Mid-Slope Zones (sediment transfer)		Lowland Zones (sediment deposition/storage)		
	Pool	Upland Gorge	Armoured	Mobile	Meander	Anabranch	Distributary	Lowland Gorge
nutrients, organics)	immobile source area	source area	area	area	transfer area. Some deposition of finer particles		distributary	
Key aquatic habitats	Pool, riffle chutes	Riffle and pool substratum	Riffle and pool substratum, high flow floodrunners, riparian vegetation, snags	Riffle and pool substratum, point and lateral bars, incised benches, floodrunners, woody debris (snags), macrophytes	Pool substratum, point and lateral bars, former channels, avulsions, incised and inset benches, woody debris, macrophytes	Pools, anabranch channels, billabongs, woody debris, macrophtyes	Pool substratum, billabongs, woody debris (snags), macrophytes	Pools, wetlands adjacent to channel, macrophytes
High flow	Pool depth increases, flushing flows, valley restricts lateral connection	Riparian vegetation inundated, scouring and flushing flows	Small floodrunners inundated increasing habitat, flushing and scouring flows	Floodrunners, in-channel benches and terrestrial environment inundated increasing habitat and food resources	Floodrunners, in-channel benches and anabranches inundated increasing habitat and food resources	Floodrunners, in-channel benches and anabranches inundated increasing habitat and food resources	Floodrunners, in-channel benches, anabranches and bifurcating channels inundated	Pool depth increases, valley restricts lateral connection
Low flow	Pool depth decreases, no major habitat loss	Habitat area decreases	Habitat area decreases	Riffles and deep pools, sandy point bars, emergent vegetation	No riffles, large pools, sandy point bars, emergent vegetation	Riffles, large pools, sandy point bars, habitat reduced to main channel	Deep pools and riffles, some point bars, habitat reduced to main channel	Water salinity increases from groundwater interception

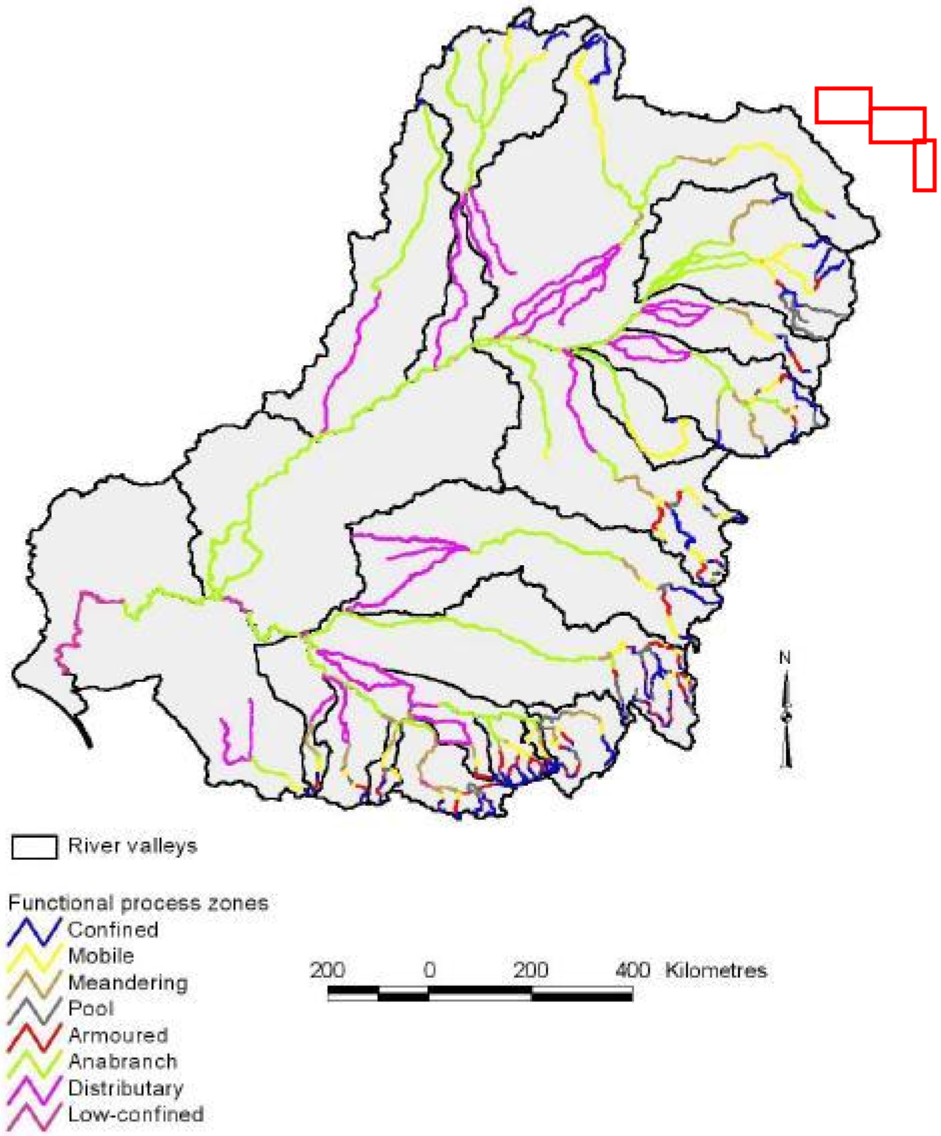


Figure 4-24 Functional Process Zones within the Murray-Darling Basin (Reproduced from: Whittington *et al*. 2001). Red boxes show approximate location of Project areas.

Dogwood Creek is located in the Condamine River catchment, downstream of Chinchilla (Van Manen 2001). The Van Manen (2001) assessment rated the reach environs in the Dogwood Creek as ranging from moderate to very good.

Catchment sediment processes

National scale resource mapping showed that existing fine sediment load within the Project area was much higher than natural conditions. The fine sediment load of the Condamine River was 10-50 times higher than natural conditions, while the load in many of the tributaries of the Condamine River was either 50 – 100 times and greater than 100 times natural conditions (Figure 4-22) (NLWRA 2001).

Basin-scale sediment balance modelling of the Condamine River catchment was carried out by the National Land and Water Resources Audit (NLWRA) (www.audit.ea.gov.au). The audit indicated that

the river's sediment load was broadly derived from river bank, gully and hillslope erosion in equal proportions, and that the contribution from hillslope erosion was somewhat higher than the Australia-wide mean value (NLWRA 2001). Further work by Hughes and Prosser (2003) indicated that this assessment had significantly overestimated the contribution of bank erosion to the overall sediment budget of the Murray-Darling catchment. Their new model suggested that riverbanks supplied less than half of the original NLWRA prediction and supplied 30 % less sediment than gully erosion. While this assessment was conducted for the entire Murray-Darling catchment, maps of the Condamine River sub-catchment reflected this assessment, with large reductions in bank erosion between the original and revised models.

Gully density in the Condamine-Balonne River catchment was generally low, but patches of densities between 0.1 and 0.5 km/km2 existed, particularly in the mid- to upper-Condamine (Hughes and Prosser 2003). CCMA (1999) stated that much of the Condamine River catchment was affected by gullying and that it was the most common form of erosion of streambanks, particularly in areas where riparian lands had been cleared. Gullying was also exacerbated by the presence of sodic soils within the catchment, as described above. This has resulted in significant areas of siltation within the Condamine River.

4.4.2 Results of site-specific assessment

A summary of assessed geomorphic condition at all sites is provided in Table 4-10. Full results are provided in APPENDIx 5 . Results for Dogwood Creek (sites GF1 And R1) are presented in the gas fields technical report (Volume 5, Attachment 27).

Fitzroy Basin (Dawson and Don rivers' tributaries) (P5, P7, P8, P3CE10, P3CE11, P3CE12 and RORWB3)

The geomorphic characteristics and condition of the seven assessed pipeline sites within the Dawson and Don subcatchments were variable. Photographs of these sites are shown in Figure 4-25 and Figure 4-26. The characteristics of each site are described below:

- P5 consisted of largely stable banks, attributed to the large weir pool that extended the entire length of the reach and the dense riparian vegetation on both banks, dominated by native trees on the left bank and introduced grasses on the right bank. Overall disturbance at the site was high, with little to no floodplain vegetation. Notch erosion was not observed as the weir pool had drowned the lower bank, but it is likely to occur in sections at, or just below, water level. Bed condition could not be reliably assessed with the rapid assessment method, but it was likely that some minor aggradation had occurred due to the effects of the downstream weir;
- P7 consisted of a narrow, sparse riparian strip, with the majority of the assessed reach consisting of either no trees, or a one-tree-wide strip. Regardless, banks were generally stable, with only minor undercutting observed and only one instance of gullying occurring. Bank sediments were not dispersive, which provided added bank stability. The bed was currently stable, with reasonable variability in depths and substrate. The presence of small amounts of LWD provided additional variability to the bed;
- P8 was a very highly disturbed site, consisting of no surrounding floodplain vegetation and a very narrow, poorly connected riparian strip. This resulted in moderately stable banks, with numerous examples of scour and failures present. Moderate bed aggradation was occurring,

infilling pools with sandy material and reducing geomorphic variability. Considerable piles of LWD were present within the reach which provided some bed variability;

- P3CE10 was very highly disturbed, consisting of little surrounding floodplain vegetation. A narrow, sparsely vegetated riparian strip bordered the stream. Bank stability was moderate, with isolated scour and old failures. Bed stability was largely stable, attributed to bed and bank rock outcropping. However, deposition of sands had created a flat uniform bed throughout the reach. Limited LWD was present;
- P3CE11 was within a large, two-staged channel that consisted of a low-flow channel with wide, low benches and, in some locations, raised benches within the greater bankfull channel. The low benches were typical of a stream that receives perennial low flows. The reach was rated as moderately to highly disturbed, largely attributed to the lack of surrounding floodplain vegetation. The stream was spring-fed and consisted of good fringing macrophytes. Riparian vegetation was variable. The low benches were generally poorly vegetated (other than with pasture grasses) reflecting the narrow riparian widths reported in Table 4-10. However, sections of the lower and raised benches consisted of moderately dense riparian vegetation. These sections weren't reflected in Table 4-10 as they did not coincide with any of the transects conducted within the reach. Upper bank vegetation was also moderately dense, particularly in the upstream sections of the reach and further upstream. The bed was stable, although deposition of fines was occurring on the low benches. Banks were also stable. Rock outcropping in the bed and banks (particularly on the right bank) throughout the reach increased stability;
- P3CE12 was highly disturbed, consisting of no substantial surrounding floodplain vegetation. In-stream vegetation was dense for the majority of the reach, consisting of Leptospermum spp. (tea trees). However, little to no vegetation was present on the upper banks. A small low-flow channel (thalweg) was present throughout the reach, bordered by wide, low benches. Substrate was similar in both sections of the channel, consisting of coarse sands to cobble-sized material, indicative of bed aggradation. Large deposits of sand were also observed throughout the reach, also indicative of aggradation. Banks were stable, but isolated examples of scour were evident; and
- RORWB3 was surrounded by a poorly vegetated floodplain. It was an ephemeral waterbody that appeared to only become wet following rain events. It was a floodplain wetland that appeared to have no links to the adjacent Bungaban Creek, except during extreme events.

Calliope River (P1)

P1 was the only assessed reach within the Calliope catchment. Photographs of features of the reach are shown in Figure 4-27. It consisted of stable bed and banks, with no major bank erosion or bed aggradation / erosion. Riparian vegetation extended for more than 20 m on both banks and consisted of dense exotic vegetation on the lower banks and sparser native vegetation on the upper banks. Moderate bed variability was evident, with extensive pools interspersed by runs and riffles. The channel was generally U-shaped, but lower benches were evident within run and riffle sections.

Condamine Catchment (Dogwood Creek) (GF1 and R1).

The lower reaches of Dogwood Creek consisted of similar floodplain features as the Condamine River, considering their close proximity. Floodplain vegetation was similarly poor. However, these reaches

generally displayed more continuous vegetation that provided added stability to banks. The reaches on Dogwood Creek showed evidence of historical incision with more recent infilling resulting from vegetation clearance, gullying and stock incursion. Most reaches typically had benches / terraces, with raised flood channels / floodouts (within and above channel) at locations on both sides. Gullying was evident at both sites (Figure 4-28).

Dogwood Creek at GF1 was particularly unstable in sections due to erodible bank material (dispersive clays) (Figure 4-28). R1 (upstream) was in better condition than the downstream sites, with better riparian vegetation condition, although the surrounding landscape was still largely cleared. Flood runners, levees and benches were still present, although were not as common or prominent as in the downstream reaches. Banks were generally stable, except in locations where dispersive sediments occurred. Bed sedimentation was still occurring, although variability existed in the bed, with pools and riffles evident (Figure 4-28). The dominant impacts were from vegetation clearance and sediment-laden runoff.

	
(a) P5 weir pool	(b) P5 Native and exotic riparian vegetation
	
(c) P7 Poor riparian vegetation	(d) P7 Pool

	
(e) P8 Old bank failure	(f) P8 LWD

Figure 4-25 Photographs showing geomorphic condition of Sites P5, P7 and P8

	
(a) P3CE10 Rock outcropping	(b) P3CE10 Flat, uniform bed
	
(c) P3CE11 Large channel with benches	(d) P3CE11 Bank rock outcropping

(e) P3CE11 Bedrock outcropping

(f) P3CE12 Infilled bed and good within-channel vegetation

(e) P3CE12 Poor floodplain vegetation

(f) RORWB3

Figure 4-26 Photographs showing geomorphic condition of Sites P3CE10, P3CE11, P3CE12 and RORWB3

(e) P1 Pool

(f) P1 Riffle

	
(e) P1 Dense, exotic lower bank vegetation, sparse, native upper bank vegetation	(f) P1 Lower bench

Figure 4-27 Photographs showing geomorphic condition of Site P1

	
(a) GF1 bank instability	(b) GF1 Continuous vegetation
	
(c) R1 Bed sedimentation	(d) R1 Bank instability

Figure 4-28 Photographs showing geomorphic condition of Sites GF1 and R1

Table 4-10 A summary of the geomorphic assessment results for the main gas transmission pipeline sites.

Site	Stream	Channel shape	Valley Shape	LB Shape Dominant	RB Shape Dominant	Bed stability rating	Dominant Disturbance	Overall Disturbance Rating	Average Width (m)	Bank Stability Rating (/4)	Average RB Riparian Width (m)	Average LB Riparian Width (m)
Fitzroy Basin (Dawson and Don Sub-Catchments)												
P5	Dawson River	U shaped	symmetrical floodplain	convex	convex	stable to moderate aggradation	Clearing vegetation	high	184	3.67	8	50
P7	Juandah Creek	U shaped	symmetrical floodplain	convex	convex	stable	Clearing vegetation	very high	37	3.67	3	5
P8	Bungaban Creek	U shaped	symmetrical floodplain	convex	convex	stable to moderate aggradation	Clearing vegetation	very high	18	2.37	8	8
P3CE10	Bungaban Creek	U shaped	shallow valley	convex	convex	stable	Clearing vegetation	very high	16	3	2	8
P3CE11	Cockatoo Creek	two stage	shallow valley	stepped	concave	stable to moderate aggradation	Clearing vegetation	high	45	3.67	18	8
P3CE12	Pump Creek	flat U shape	shallow valley	wide low bench	wide low bench	moderate aggradation	Clearing vegetation	high	26	3.67	10	12
RORWB3	Bungaban Creek	widened or infilled	shallow valley	stepped	stepped	stable	Clearing vegetation	high	400	4	N/A	N/A
Calliope Basin												
P1	Calliope River	U shaped	symmetrical floodplain	convex	convex	stable	Clearing vegetation	high	117	4	22	23
Condamine Basin												
GF1	Dogwood Creek	Two stage	Broad valley	Stepped	Stepped	Moderate aggradation	Clearing vegetation	High	77	2.33	40	30
R1	Dogwood Creek	U shape	Shadow valley	Stepped	Stepped	Moderate erosion	Sediment-laden runoff	Moderate	57	2.67	40	50

4.5 Aquatic Habitat

4.5.1 Results

The outcomes of the aquatic habitat assessment are provided in Table 4-11. The data within the table were obtained using results from the geomorphology field proforma (Appendix 1) and AUSRIVAS Macroinvertebrate and Habitat Assessment Sheets. Some further calculations were required for some attributes in Table 4-11. These are listed below:

- Percent bed cover of in-stream debris at each site was calculated by totalling percent bed cover of all debris types (individual logs, log jams, individual branches, branch piles) within all three transects at each site then dividing the value by three;
- Percent bed cover of macrophytes at each site was calculated by totalling percent bed cover of all macrophyte types (large submerged vegetation, floating vegetation and emergents) within all three transects at each site then dividing the value by three. Thus the macrophyte column refers largely to aquatic rather than fringing macrophytes;
- Percent bed cover of permanent pool habitat at each site was calculated by totalling percent bed cover of pool habitat (> 1 m) within all three transects at each site then dividing the value by three;
- Percent bed cover of stream shading at each site was calculated by totalling percent bed cover of vegetation shading within all three transects at each site then dividing the value by three; and
- Riparian connectivity measures the connectivity of vegetation (> 5 m width, > 20 % density and longitudinal continuity) along the entire length of the stream / river at the site (400 m);

Habitat quality assessment is the total of all habitat variables in the River Bioassessment Program section of the geomorphology proforma (Appendix 1).

Four of the nine sites (P5, P7, P8, and P3CE10) located in the Dawson River Catchment had poor overall aquatic life rating. There were a variety of causes for this such as extensive bank erosion, cattle droppings in creek bed, and significant upstream development (including a weir). The remaining three sites in the Dawson catchment (P4LL, P3CE11 and P3CE12) and the single site located on the Calliope River (P1) all had good ratings. These were a result of minimal upstream development, an absence of dams or weirs on the river, limited erosion, light grazing use, and good riparian vegetation cover.

The reference site located on Dogwood Creek (R1) was the only site to record an aquatic habitat rating of high.

Very few macrophytes were recorded throughout the study area during the dry season surveys, with the exception of site P1 on the Calliope River, which had a good coverage and richness of submerged, floating and emergent taxa (20 %), compared to other sites surveyed (Table 4-12). Site P3CE11 also recorded good fringing emergent macrophyte coverage (10 %), although the community consisted of two main species - *Juncus usitatus* (Common rush) and *Typha orientalis* (Cumbungi). No notable macrophyte species were recorded during the dry season surveys.

4.5.2 Regional perspective

Fitzroy (Dawson and Don Rivers)

Extensive land clearing has occurred in the Dawson catchment since the 1920s and many areas have been cleared to the waters' edge resulting in increased siltation (DNR 1998). Catchment land uses, such as grazing, urban development and mining have altered in-stream habitats and increased loads of sediment and nutrients to watercourses. River regulation has reduced habitat availability through drowning out riffles, degrading water quality and isolating fish and macroinvertebrate communities.

Duivenvoorden (1992) reported that the number of aquatic plants in the Fitzroy catchment was considered low as a result of the generally arid climate, high turbidity and grazing pressure and that species diversity and abundance varied between seasons. Dessication tolerant species dominated in May and June samples, while a larger number of floating and submerged species were found in October. Telfer (1995) also found low to very low abundances of aquatic macrophytes and linked this to very dry conditions at the time of the survey and high turbidity levels. Aquatic vegetation that was recorded was dominated by filamentous algae and emergent rushes and sedges.

Telfer (1995) rated riparian vegetation along 83 % of the stream length of the Dawson River and its major tributaries to be poor or very poor condition, although some streams in the Upper Dawson catchment displayed the highest condition ratings. Overall habitat value for aquatic life in the Upper Dawson was rated as good or very good. Channel diversity throughout the catchment was low, resulting from a combination of natural features (e.g. topography, geology, weathering etc) and anthropogenic processes (channelization, erosion and aggradation) (Telfer 1995). Aquatic fish and macroinvertebrate diversity has been shown to be moderate to good in the Dawson catchment, which may indicate that the catchment has naturally poor channel and habitat diversity, which supports an aquatic community adapted to these conditions.

Land use in the Don catchment is dominated by grazing and thinned forested areas (Telfer 1995). Telfer (1995) reported that the overall reach environs within the Don/Callide tributaries ranged between very poor to very good condition, with the majority of stream lengths being in moderate condition. Eighty nine % of sites were recorded as moderately to very highly disturbed. Channel diversity ranged from very low to moderate, with more than 50 % of stream receiving very low ratings. Similarly, most stream lengths recorded a very low riparian zone condition rating, poor aquatic habitat and very low abundance of aquatic vegetation. Duivenvoorden (1992) reported that 97% of sites within the Don/Callide catchments were moderately to extremely disturbed. This reflects the extensive clearing in the area for grazing, cropping and intensive livestock production (Telfer (1995).

Calliope River

Extensive land clearing has occurred within the Calliope River catchment, although there is still an almost continuous, narrow riparian vegetation corridor along the extent of the Calliope River which comprises a significant portion of native flora. However, a number of significant weed species are also present, including canopy vines and exotic pasture grasses that have contributed to degraded condition in several reaches (C & R 2005).

The Calliope River system floodplain has been substantially reduced by land clearing throughout the catchment. Smaller, isolated floodplain remnants were reported by C & R (2005) as being in poor condition, although some larger remnants in the lower reaches were considered to be in good

condition. CRC (2004) identified two dominant, flow dependent regional ecosystem types of the alluvial plains (wetlands) including, *Eucalyptus platyphylla, Corymbia* spp. woodland and *Eucalyptus tereticornis* tall woodland as being "endangered" and "of concern" respectively. Another less dominant ecosystem, *Eucalyptus populnea* woodland was also listed as "of concern".

One of the outstanding features of the freshwater reaches of the Calliope River system is the extent and diversity of aquatic macrophyte assemblages. A total of 47 species, four of which are weeds, Salvinia (*Salvinia molesta*), Watercress (*Rorippa nasturtium-aquaticum*), Fanwort (*Cambomba caroliniana*) and Paragrass (*Urochloa mutica*), have been identified within the catchment (C& R 2005). These macrophyte beds form important microhabitat for a range of biota and are important sites of instream productivity (C&R 2005). Another unique feature is the presence of persistent riffles, which are rare in the region. The riffle assemblages are distinct, and hence rare in the region.

The flow regime is a major factor in shaping the aquatic habitats and floodplain features of the Calliope River catchment. This can be generally characterised by unimpeded, perennial, or near perennial base flow, seasonal (wet season) mid-level flows, and irregular high flow, flood events, each of which help to maintain a particular set of ecological values (C&R 2005). The persistent base flow acts to maintain riffle, glide and deep pool habitat, the riparian fringe and the diversity of macrophyte stands throughout the dry season. The seasonal mid-level flows act to flush the base flow habitats and would have positive implications for the dispersal of fish, macroinvertebrate and macrophytes throughout the catchment (C&R 2005). The irregular high flow events would create over bank flows which are necessary to rejuvenate floodplain habitat by delivering moisture and nutrients and maintaining pool depth by providing scouring flows.

Condamine-Balonne catchment

The ACA AquaBAMM study reported varied diversity and richness scores throughout the Condamine catchment. The criteria for naturalness (aquatic and catchment), connectivity and special features also varied throughout the catchmnent, although all were generally medium, high or very high on the Main Condamine River and triburaties downstream from Chinchilla (Clayton *et al.* 2008). Both the special features and connectivity criteria were reported to be low upstream of Chinchilla (Charleys Creek) (Clayton *et al.* 2008). The criteria, measures and weightings assigned to the ACA AquaBAMM study are provided in APPENDIx 6 .

ACA AquaBamm Scientific Panel identified two aquatic flora species listed as rare under the NCA Act that are possibly present in the Condamine Catchment, these were:

- Aponogeton queenslandicus (although there are no records of this species occurring in the Condamine catchment), and
- Fimbristylis vagans.

The Panel also identified six priority aquatic species, namely:

- Bacopa monnieri (Herb of grace);
- Ceratophyllum demersum (Hornwort);
- Ludwigia peploides subsp. Montividensis (Water primrose)
- Nymphaea gigantea var. gigantea (Common waterlily)
- Triglochin procerum (Water ribbons); and

- Vallisneria nana (Ribbonweed).

All of the above species are listed as 'Least Concern' under the NCA Act (Clayton *et al*. 2008). No rare or priority species were observed during the current study.

Van Manen (2001) rated the reach environs of most stream lengths of the Upper Condamine as in very poor to moderate condition. Grazing and cropping were considered the major contributors to reach disturbance and to a lesser extent; roads, bridges/culverts, water extraction and river trust activities (e.g. de-snagging).

Most stream lengths had very poor to poor channel diversity (dominated by pools) and riparian vegetation in very poor condition. A very low abundance of aquatic vegetation was observed resulting in all sites being rated as poor or very poor. The lack of aquatic vegetation was attributed to the dry conditions at the time of survey and antecedent drought period. 61% of the stream lengths were rated as having aquatic habitat in very poor to poor condition, reflecting the poor instream cover and habitat diversity and high turbidity (Van Manen 2001).

Reach environs within the main Condamine River were generally in moderate condition. Bank stability was influenced by stock access and watering and clearing of vegetation. The condition of the aquatic habitat was generally poor, reflecting the poor channel habitat and riparian condition (Van Manen 2001). Hydrobiology (2006) recorded moderate to good instream habitat at a number of sites in and adjacent to the Chinchilla Weir pool area, which is consistent with the findings of Van Manen (2001) for these areas.

Table 4-11 A summary of the habitat assessment results for the gas transmission pipeline sites.

Site	Tributary name	Overall Aquatic Life Rating	Channel Modification	Artificial Features	Local Land Use	Local Longitudinal Connectivity		Transect Habitat Averages (% Bed Cover)				Overall Disturbance Rating	LB Riparian Connectivity (%)	RB Riparian Connectivity (%)	Habitat Quality Assessment (/135)	Summary Notes
						Time of Observation	Water Mark	In-Stream Debris	Macrophytes	Permanent pool habitat >1m	Stream Shading					
Calliope River Catchment																
P1	Calliope River	good		ford	grazing native - cleared	N/A	N/A	1	20	53	18	High	34	10	79	- Despite cleared surrounding land w/in stream veg in relatively good condition - Habitat diversity, stable beds for banks, little obvious signs of runoff (except for occasional gully) - Riffle zone evident - Considerable examples of loose LWD above current WL - Good deep pools with LWD
Fitzroy Basin (Dawson and Don Sub-Catchments)																
P4LL*	Lilly Lagoon				grazing				0							- Isolated lagoon - surrounded by light cattle grazing with direct access - Queensland Gas Limited were installing gas pipe ~200m upstream resulting in significant disturbance - 80m by 25m by 1m -Filamentous and macro algae observed
P5	Dawson River	poor	dam and diversion	major weir	grazing native – cleared, urban residential	no passage	moderately restricted	2	0	95	5	High	96	14	59	- Deep weir pool with LWD - Weir dominates disturbance - Good riparian vegetation particularly on LB - Introduced species (paragrass or similar) on RB providing stability
P7	Juandah Creek	poor	ford	ford	grazing native - cleared	unrestricted	unrestricted	4	0	0	0	very high	0	3	55	- Deep pool (1.5-2m) with scattered LWD - Severely modified vegetation - Less turbid than other streams
P8	Bungaban Creek	poor			grazing native - cleared	good passage	unrestricted	8	0	0	7	very high	0	5	47	- Little LWD present except at TS3 - One pool - all infilled to <1m - Major impacts from grazing and vegetation clearance
P3CE10	Bungaban Creek	poor			grazing native – cleared	moderately restricted	partly restricted	1	0	0	5	very high	0	0	55	- Stream is in reasonable condition considering cleared land - Narrow, deep channel within terraces

Site	Tributary name	Overall Aquatic Life Rating	Channel Modification	Artificial Features	Local Land Use	Local Longitudinal Connectivity		Transect Habitat Averages (% Bed Cover)				Overall Disturbance Rating	LB Riparian Connectivity (%)	RB Riparian Connectivity (%)	Habitat Quality Assessment (/135)	Summary Notes
						Time of Observation	Water Mark	In-Stream Debris	Macrophytes	Permanent pool habitat >1m	Stream Shading					
																- some historic incision - Bed currently stable with some deposition - Pools shallow - Sandy clay bed and banks
P3CE11	Cockatoo Creek	good		culvert	grazing native – cleared	no passage	very restricted	1	10	5	20	high	9	80	75	- Channel incised into a 'floodplain' within the greater channel - Indicative of decreased flushing flows and a system that has adapted to continual low flows - Spring-fed continual flows - Bed composed of bed rock outcropping overlaid by coarse sand / gravel mixed with clays
P3CE12	Pump Creek	good		culvert	grazing native – cleared	moderatel y restricted	partly restricted	9	0	0	32	high	56	35	73	- Within stream bench vegetation provides good habitat, native vegetation has been cleared previously - Bank and valley vegetation is sparse - Reasonable diversity of substrate and LWD provides depth variability - Obvious signs of aggradation - increase in bench size - Generally sandy benches and a cobble / sand thalweg
RORWB 3	Bungaba n Creek	good			grazing native - cleared	no passage	partly restricted	1	0	0	60	high	51	43	N/A	- Narrow to non-existent fringing vegetation
Condamine Basin (Dogwood Creek Sub-Catchment)																
GF1	Dogwoo d Creek	Poor	Reveget ated		Grazing (cleared)	No Passage	Good Passage	5	0	37	23	High / Moderate	12	63	66	- Steep banks, very turbid - No flow. Long pool 0.5-1.5m deep, turbid - Filamentous green algae along edge; Algal scum present - Moderately high levels of detritus - good canopy overhang in sections - Local landuse – grazing, but fenced and good riparian zone - No macrophytes - isolated infilling from gullies

Site	Tributary name	Overall Aquatic Life Rating	Channel Modification	Artificial Features	Local Land Use	Local Longitudinal Connectivity		Transect Habitat Averages (% Bed Cover)				Overall Disturbance Rating	LB Riparian Connectivity (%)	RB Riparian Connectivity (%)	Habitat Quality Assessment (/135)	Summary Notes
						Time of Observation	Water Mark	In-Stream Debris	Macrophytes	Permanent pool habitat >1m	Stream Shading					
																- little LWD - good rip zone on RB with some sect of LB also having good rip veg
R1	Dogwood Creek	High			Grazing (thinned)	No Passage	Good Passage	35	0	0	30	Moderate	54	42	80	- 2 shallow pools, 0.5m deep - Some LWD - Moderate bank overhang - No algae or detritus - Canopy cover 80% - Riparian zone 5m wide - No macrophytes - bank held together by dense grasses and mod dense rip veg that is relatively continuous - deepening around LWD w/ isolated patches of deposition occurring

*Note: Access for geomorphic surveys was not available at Lilly Lagoon. Basic aquatic habitat assessment was completed using the AUSRIVAS macroinvertebrate field sheets. Therefore, details aquatic habitat data are not available for this site.

Table 4-12 A summary of the macrophytes observed at the gas transmission pipeline sites during the dry season surveys.

Native Species	Calliope		Dawson				
	P1	P4LL	P5	P7	P8	P3CE 10	P3CE 11
Spiny headed matrush (Lomandra Longifolia)	-	-	-	-	-	◎	-
Common rush (Juncus usitatus)	-	-	-	-	-	◎	◎
Cumbungi (Typha orientalis)	-	-	-	-	-	-	◎
Azolla spp.	◎	-	-	-	-	-	-
Duckweed (Lemna spp.)	◎	-	-	-	-	-	-
Hornwort (Ceratophyllum demersum.)	◎	-	-	-	-	-	-
Pondweeds (Potamogeton spp.)	◎	◎	-	-	-	-	-
Water ribbon (Triglochin procerum)	◎	-	-	-	-	-	-
Sedge (Cyperus spp.)	◎	-	◎	-	-	-	-
Slender Knotweed (Persicaria decipiens)	-	◎	-	-	-	-	-
Exotic Species							
Para Grass (Urochloa mutica)	-	-	◎	-	-	-	-

4.5.3 Important wetlands

The only wetlands of national importance known to occur in the vicinity of the gas transmission pipeline corridor are the GAB spring wetlands. These occur on the outer edge of the GAB in Queensland, NSW and South Australia. The GAB springs are characterised into twelve "Supergroups". Each Supergroup comprises smaller spring groups and spring complexes. The Project Area is located within the Springsure Supergroup, Brigalow Belt Complex (EPA 2005, Fairfax*et al.* 2007 and Fensham *et al.* 2004). The location of known springs in Queensland in relation to the main gas delivery pipeline route is provided in Figure 4-29.

The community of native species dependent on the natural discharge of groundwater from the Great Artesian Basins is listed as an endangered community under the EPBC Act (1999). A number of species are also listed under the Queensland *Nature Conservation Act 1992* (NC Act) or the IUCN Redlist (DEWHA 2001, EPA 2005). Of these, two species of plant; Artesian milfoil and Salt pipewort are known to occur within the Springsure Supergroup (DEWHA 2001). Salt pipewort requires active or flowing mound springs with alkaline soil. The species is highly opportunistic and regular colonisation and extinction events occurring within spring complexes. Local extinctions have been linked to competition with other plants (DEWHA 2001). Salt pipewort has been impacted by reduced spring flow, trampling by feral animals and excavation (EPA 2005). Artesian milfoil has also only been found in wetlands fed by flowing artesian water (Fensham *et al.* 2004). Both of these species are known to occur in Cockatoo Creek (EPA 2005). Although neither of these species was found during the dry season surveys at site P3CE11 on Cockatoo Creek, they could be present where there are actively flowing mound springs.

Only the communities associated with discharge springs are listed under national legislation. The Springsure Supergroup is located within a recharge area and contains both recharge and discharge springs (DEWHA 2001). DEWHA 2001 states that an assessment of the individual spring is required to determine whether it is associated with the listed ecological community (i.e. whether it is a discharge or recharge spring).

Water pressure in the GAB has declined substantially since the late 1800s due to uncontrolled extraction of bore water (EPA 2007, Fairfax *et al*. 2007, Fensham *et al*. 2004). EPA (2007) reported that 16% of active spring-group wetlands have been totally destroyed and more than 40% have been damaged by excavation to create dams, wells and drains. Damaged springs have very poor representation of endemic species normally associated with artesian water and it is often impossible to restore wetlands to a functioning condition following excavation or dredging (EPA 2007).

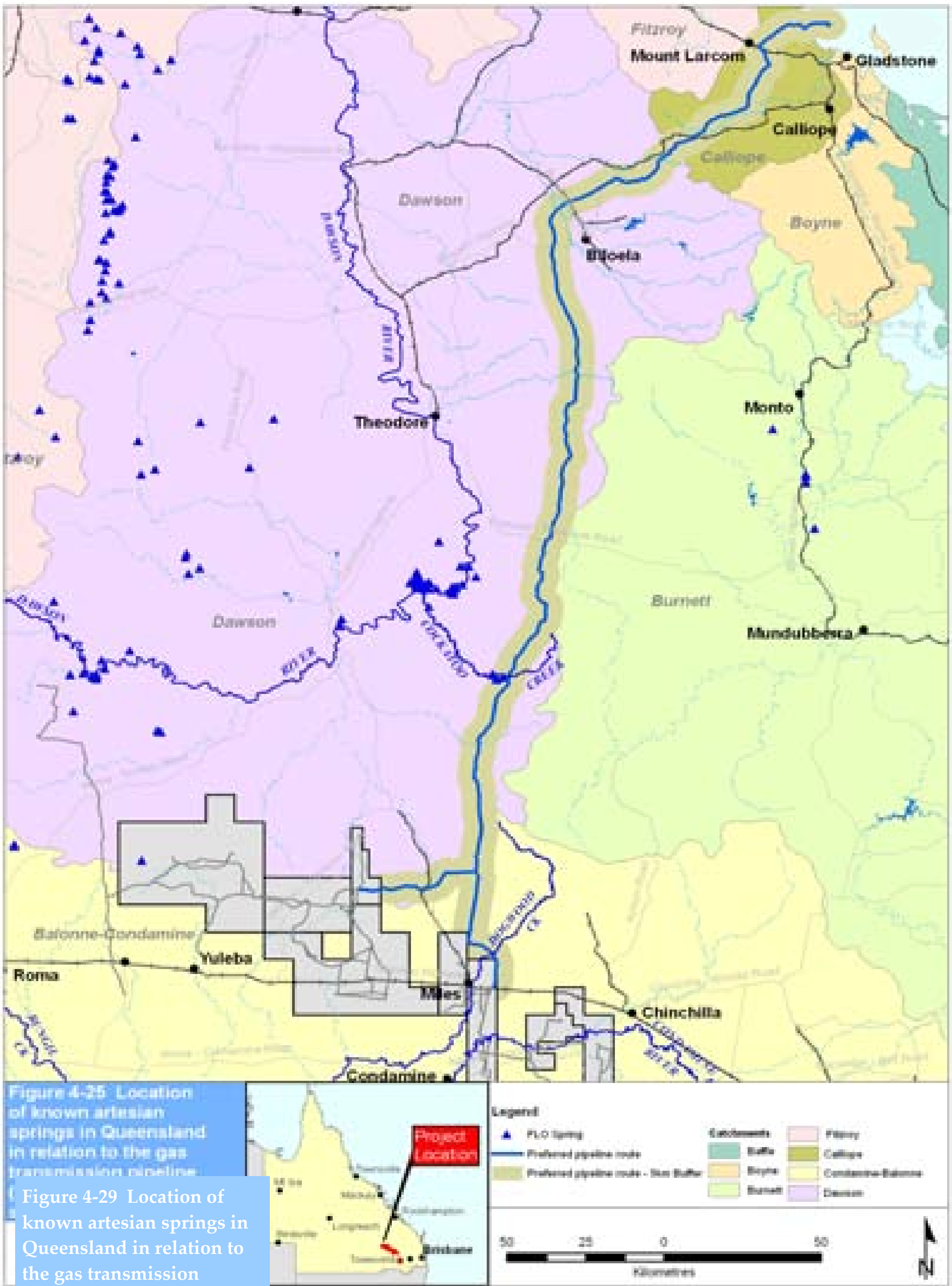


Figure 4-29 Location of known artesian springs in Queensland in relation to the gas transmission pipeline (Source: DERM wetland springs database)

Fig[...] **own artesian springs in Queensland in relation to the gas transmission pipeline (Source: DERM wetlands springs database)**

5. Assessment of Potential Impacts

5.1 Potential Impact Mechanisms

The potential impacts to the receiving watercourses can be summarised into several impact mechanisms. The potential impact mechanisms related to construction are listed below:

- Increased delivery of sediments and nutrients to watercourses resulting from vegetation clearing and construction within and adjacent to water courses;
- Direct removal of aquatic flora and fauna during excavation of road and pipeline crossings (rain-fed systems);
- Disturbance to threatened artesian spring communities associated with pipeline and road construction;
- Temporary diversion of watercourses during construction of road and pipeline crossings;
- Hydrocarbon, chemical or wastewater contamination from accidental spills;
- Bank erosion (gullying) from exposed areas;
- Trenching and re-laying of bank and bed sediments during construction of pipelines;
- Enhanced breeding of mosquitoes through ponding of water during construction.

The potential impact mechanisms related to operation phases are listed below:

- Erosion from exposed areas;
- Hydrocarbon, chemical or wastewater contamination from accidental spills; and
- Altered low flow hydrology / hydraulics resulting from road crossings.

The potential impacts resulting from these mechanisms to aquatic ecology, water quality and geomorphology of the receiving watercourses are discussed in Table 5-1 and Table 5-2.

Table 5-1 Overview of potential impacts associated with each impact mechanism - Construction

No.	Potential Impact Mechanism	Potential Impacts
1	Increased delivery of sediments and nutrients to watercourses resulting from vegetation clearing and construction within and adjacent to water courses.	Sediment input to waterways is considered to be the main stressor associated with the construction phase of the Project. The most likely causes of sediment mobilisation will be Right of Way (RoW) earthworks adjacent to watercourses and the construction of open-cut pipelines and road crossings within watercourses. Watercourse crossing construction could increase sediment mobilisation through a combination of heavy equipment use and trampling effects in the vicinity of banks and the removal of riparian vegetation in the RoW corridor. Sediment from side-cast materials from pipeline trenches that are positioned near waterways may be mobilised if heavy rainfall occurs during construction. Heavy rainfall during the construction phase may erode exposed sediments on these slopes into waterways, a process that would be exacerbated where highly erodible soil types exist. This could result in short term increases in turbidity, suspended solids and nutrients, scouring or smothering / infilling of fine-scale habitat structure or modification of in-stream habitat. Depending on the level of disturbance and timing of construction, this has the potential to contribute to raised bed levels and associated increased flood levels and localised bank instability. Some examples of poor road and pipeline construction methods and inadequate sediment management were observed throughout the catchments during the dry season field surveys (these were not necessarily associated with any current activities of the Proponent). This raised some concerns as to the potential impacts associated with construction of roads and pipelines in relation to this study. Strict adherence to the mitigation controls (see Table 5-3) will be required to ensure minimal risks to the aquatic environment. Given the degraded nature of habitats throughout the study area and assuming adequate mitigation controls are in place, impacts will generally be short lived and localised. The potential impacts are likely to be higher in habitats characterised by lower turbidity, such as spring-fed streams (see impact mechanism 4). Fauna and flora in these habitats are generally adapted to clear-water conditions and are therefore considered less tolerant of sediment impacts.
2	Direct removal of aquatic and riparian flora and fauna during excavation of road and pipeline crossings (rain fed systems)	Riparian habitat is a key component of aquatic ecosystems, providing stream shading, structural habitat (e.g. tree root habitat, snag habitat and macroinvertebrate emergence habitat), stream bank stabilisation (erosion protection) and detrital food sources. Riparian vegetation will need to be cleared at RoW watercourse crossings during construction, which could result in reduced habitat diversity and habitat fragmentation. Riparian vegetation was generally found in poor to moderate condition throughout the Project area and direct species related impacts are likely to be minimal and localised. Vegetation clearing may also result in short-term, localised increases in sediment delivery to watercourses (see impact mechanism 1). Very few aquatic macrophytes were present within watercourses during the study and no notable species are known to occur in rainwater fed systems throughout the Project Area. Impacts associated with removal of aquatic macrophytes during construction are likely to be negligible. Some localised removal of aquatic flora is likely during pipeline construction on the Calliope River. However, no notable species were recorded at the Calliope River site and any impact is expected to be minimal on the regional scale.
3	Disturbance to threatened artesian spring communities associated with pipeline and road construction	No known artesian springs are crossed by the gas delivery pipeline corridor or roads. However, the route crosses Cockatoo Creek in the vicinity of known springs (Figure 4-29**Error! Not a valid result for table.**). Given that the gas delivery pipeline route has not yet been confirmed, there is potential for disturbance to artesian spring communities via direct excavation or increased sediment and turbidity. The likely impacts on the water quality and aquatic ecology of spring fed streams would be greater than rain fed streams in the catchments as the communities have not adapted to high levels of turbidity. The EPBC listed Salt pipewort and Artesian milfoil are known to be associated with artesian springs within Cockatoo Creek. Increased delivery of sediments and nutrients associated with road or pipeline crossings could reduce light availability and smother habitats. Based on the current location of the pipeline corridor, the likelihood of impacts occurring would be minimal, although further investigation would be required to ensure the pipeline does not cross any GAB springs.
4	Temporary diversion of watercourses during construction of road and pipeline crossings	Diversion of watercourses during construction of roads and pipeline crossings could inhibit sediment transport and present a temporary barrier to fish passage. The majority of streams in the Project Area are intermittent and, assuming that construction is timed to avoid wet season flows, the majority of streams are unlikely to be flowing during the construction period. For permanent streams, there is likely to be some short term impacts associated with sediment mobilisation. Sediments may accumulate upstream of the crossing and scour may occur downstream of the crossing. However, any impacts are likely to be temporary. Sites P3CE11 (Cockatoo Creek) and P1 (Calliope River) are perennial, groundwater fed streams. Temporary diversion of these watercourses is likely to be required during pipeline construction. This is anticipated to have some short term impacts on fish populations, although rapid recovery is expected following construction (see Impact Mechanism 3).
5	Hydrocarbon, chemical or wastewater contamination from accidental spills	Accidental chemical and wastewater spills associated with the Project are likely to primarily involve hydrocarbons such as oils, petrol and grease, drilling fluids or sewage wastewater. Corrosion inhibitor, oxygen scavenger and biocide compounds may be added to hydrotesting water to reduce rusting and biofouling of the pipeline. These compounds may enter watercourses, possibly resulting in toxicity to fauna. Small quantities of untreated foaming agents, corrosion inhibitors, and possibly bentonite clay and polymers may be released during drilling in some areas. These agents may enter groundwater and, subsequently escape into surface waters, or be accidentally released for sumps directly in to surface waters, potentially resulting in toxicity to fauna. The potential impacts depend on the size of spillages, but with good practice environmental management and special consideration to the risks associated with construction vehicles working in or near streams, the potential impacts should be minor.
6	Bank erosion (gullying) from exposed areas	Overland runoff and resulting gullying is already a common occurrence throughout the Project Area, particularly in cleared sections. As such, there is potential for construction activities to initiate or exacerbate existing gullying (and resulting sediment-laden runoff and bank instabilities), particularly in relation to open-cut pipelines and road crossings within and adjacent to the channel. The impacts are likely to be greater within more incised streams, as they typically consist of high, steep banks that are prone to instabilities and in streams consisting of highly erodible soils (cracking / dispersive clays). Other potential impacts associated with this impact mechanism include smothering of riffle habitat, pool infilling and reduction in bed sediment particle size variability. Care will be required throughout construction to ensure that exposed areas are managed appropriately to minimise the initiation or exacerbation of gullying.

No.	Potential Impact Mechanism	Potential Impacts
7	Trenching and re-laying of bank and bed sediments during construction of pipelines	Impacts resulting from this mechanism are either related to direct bank or bed destabilisation by construction activities or via sediment entrainment by flows that may occur during construction. Impacts may include: Localised rilling and gullying down banks; Direct fluvial scour of exposed surfaces; Failure of banks without vegetation enhancement; Increased sediment entrainment, resulting in increased sediment delivery to the channel and increased sedimentation; Particular issues for incised stream types with high steep banks; and Particular issues relating to construction on or adjacent to dispersive soils.
8	Enhanced breeding of mosquitoes through ponding of water during construction	Factors that influence mosquito breeding include rainfall, temperature and humidity (Queensland Health, 2002). Mosquito breeding is likely to be higher in areas of high rainfall, temperatures and humidity. The highly variable climate associated with the project area is not likely to provide ideal habitat for mosquito breeding, particularly if construction activities are undertaken during the winter months when rainfall is low. Mosquitoes are unlikely to tolerate ambient air temperatures <10 °C, although breeding may still continue in warmer, stagnant waters. Macroinvertebrate sampling undertaken during the dry season collected few mosquito larvae (Family: Culcidae) throughout the Project Area, although 45 individuals were recorded from site P8 in Bungaban Creek. The Queensland Health Guidelines to minimise mosquito and biting midge problems in new development areas states that the problems associated with mosquitoes are higher in areas within 5 km of significant concentrations of people or a significant mosquito breeding site (e.g. large natural wetlands). The impact of mosquito breeding as a result of construction is likely to be low due to a combination of lack of breeding habitat, low population densities and lack of large natural wetlands within the Project Area. However, monitoring should be undertaken in areas where construction is in close proximity (i.e. within 5 km) to population centres or natural wetlands to determine mosquito prevalence and distribution. A mosquito control plan should be prepared in accordance with the Mosquito Management Code of Practice for Queensland (Local Government Association of Queensland Inc. 2002).

Table 5-2 Overview of potential impacts associated with each impact mechanism – Operation and decommissioning

No.	Potential Impact Mechanism	Potential Impacts
1	Erosion from exposed areas	Impacts relating to this mechanism are likely to be similar to the impacts during the construction phase, although they are likely to be longer lasting. While impacts are likely to be more apparent during the construction phase, long-term erosion of exposed surfaces during operation, particularly adjacent to waterways could potentially impact on within channel geomorphology. Un-rehabilitated pipeline RoWs and exposed road surfaces are of concern, particularly in areas crossing particularly erodible soils (cracking / dispersive clays). Potential further impacts resulting from this mechanism may include: Bank instabilities, including gully initiation or enhancement; Increased sediment delivery to the channel (see construction impact mechanism 1); Reduction in channel capacity; Smothering of riffle habitat; Pool infilling; and Reduction in bed sediment particle size variability. As discussed in Table 5-1 (impact mechanism 1), some concerns were raised during the field surveys relating to the long term impacts associated with poorly constructed road and pipeline crossings. Strict adherence to the mitigation controls (see Table 5-3) will be required to ensure minimal risks to the aquatic environment
2	Hydrocarbon, chemical and wastewater contamination from accidental spills	See Impact Mechanism 6 in Table 5-1.
3	Altered low flow hydrology / hydraulics resulting from road crossings	Road crossings have the potential to hinder downstream flow conveyance which will concomitantly affect downstream sediment transport and could provide a barrier to organism passage. Sediments could accumulate upstream of the crossing and bed scour could occur downstream of the crossing. Altered low flow hydraulics could also result in channel widening downstream of the crossing. However, the majority of streams in the Project Area are intermittent and, would be unlikely to be affected for most of the year. For permanent spring-fed streams (e.g. Cockatoo Creek), there is likely to be some minor, localised impacts on sediment transport and potentially considerable impacts on low-flow organism movement Impacts would be minimised through implementation of good crossing design.

5.2 Risk Assessment

The outcomes of the risk assessment, including proposed mitigation measures for the construction and operation / decommissioning phases are provided in Table 5-3 and Table 5-4, respectively.

The overall risk of potential impact to water quality, aquatic ecology and geomorphology was assessed for each impact mechanism identified in Section 5.1 and for each of the relevant construction and operation activities. The extent of potential impacts was also assessed on a local and regional scale. For each impact mechanism, the default risk was the highest risk associated with all receptors (i.e. water quality, aquatic ecology and geomorphology), in accordance with precautionary principles.

The post mitigation risk of impacts to aquatic systems from construction related activities was assessed as low for all impact

As stated previously, the main impact mechanism likely to affect the aquatic environment during the construction phase is sediment mobilisation. Even with mitigation measures in place, excavation and vegetation clearing within and adjacent to watercourses will be required for construction of road and pipeline crossings. Care will be needed to ensure that appropriate good practice sediment control measures are strictly adhered to throughout the construction phase to ensure any impacts are minimised.

The post mitigation risk of impacts to aquatic systems from operational activities was assessed as low for all impact mechanisms.

The chosen construction method for road crossings will be key to ensure adequate provision for low flow hydrology and subsequent aquatic fauna passage. Good practice drainage control will be required throughout the operational phases and may include incorporation of swales, bunds or soakaways.

5.3 Summary of Potential Impacts to MNES

The gas transmission pipeline corridor crosses Cockatoo Creek, which is known to be associated with GAB spring communities. No EPBC listed communities were recorded during the dry season survey, although they could be present where suitable habitats (i.e. actively flowing springs) exist. The main activities that could affect artesian spring communities on Cockatoo Creek are direct excavation and / or sediment delivery from road and pipeline construction. However, further investigation would be required to ensure that roads and pipelines are not constructed through or adjacent to artesian springs within the Project Area, such as may occur at Cockatoo Creek.

5.4 Monitoring

The following monitoring is proposed during the construction phase:

- Further investigation to determine the location of artesian springs in the vicinity of Cockatoo Creek;
- Monitor water quality upstream and downstream of pipeline crossings where water is present, or immediately following inflows. Monitoring should occur at least once prior to and during construction, for the following parameters:

- Temperature;
- Conductivity;
- Turbidity;
- TDS;
- TSS;
- TPH ;
- BTEX
- Total nitrogen; and
- Total phosphorus.

- Monitor geomorphic processes within, upstream and downstream of roads and pipeline crossings at least once prior to and during construction, according to the proforma in Appendix 1;
- Monitor aquatic habitat condition within, upstream and downstream of pipeline crossings at least once prior to and during construction, according to the proforma in Appendix 1; and
- Monitor aquatic biology (fish and macroinvertebrates) upstream and downstream of road and pipeline crossings and where adjacent to significant infrastructure, at least once prior to and during construction.

In addition, operation phase monitoring should focus on geomorphic processes and condition (particularly bank and bed stability) upstream and downstream of pipeline crossings and should occur on an annual basis (to be reviewed within two years).

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Table 5-3 Risk Assessment – Construction

Impact Mechanism No.	Catchment*	Potential Impact Mechanism	Impacts (default to highest)	Activity#	Local			Regional			Mitigation Measures	Residual Risk
					C	L	R	C	L	R		
1	Dawson, Don, Calliope, Condamine	Increased delivery of sediments and nutrients to watercourses resulting from riparian and floodplain vegetation clearing and construction within and adjacent to water courses.	Aquatic ecology Water quality Geomorphology	Pipelines	Mod	6	High	Min	3	Low	Avoid, where possible, undertaking construction activities during forecasted periods of wet weather. Implement appropriate weed management protocols to avoid introduction or translocation of aquatic or riparian weeds Implement appropriate erosion and sediment control measures are implemented in accordance with the Queensland Guidelines for Erosion and Sediment Control and the Australian Pipeline Industry Association (APIA) Code of Environmental Practice 2009. These measures may include: Prohibit stockpiling spoil and topsoil materials close to waterways; Control sediment runoff from stockpiles and cleared areas around watercourses; Implement sediment control measures downstream of side-cast material where safe and practicable;	Low
				Roads	Mod	6	High	Min	3	Low	Prohibit side-casting material directly into waterways where practicable; Grade pipeline ROW/roadway alignments adjacent to streams away from watercourses; Monitor and maintain erosion and sediment control measures until adequate soil stabilisation has been achieved; Install diversion drains to intercept uncontaminated surface runoff around facilities and away from construction areas; Install sediment control structures to intercept sediment-laden surface runoff to reduce sediment delivery to watercourses; Monitor for and rectify areas of problematic erosion at reclaimed watercourse crossings; and Monitor water quality, ecology and geomorphology at established assessment sites.	Low
2	Dawson, Don, Calliope, Condamine	Direct removal of aquatic flora and fauna during excavation of road and pipeline crossings	Aquatic ecology Geomorphology	Pipelines	Min	3	Low	Min	1	Low	Avoid, where possible, undertaking construction activities during forecasted periods of wet weather. Implement good practice to minimise construction footprint	Low
				Roads	Min	3	Low	Min	1	Low	Undertake rapid backfilling and stabilisation and revegetation of riparian corridors (where possible) within and adjacent to waterway crossings	Low
				Roads	Min	2	Low	Min	1	Low	Minimise vegetation clearance on banks and bank tops, in accordance with the APIA Code of Environmental Practice 2009.	Low
3	Dawson	Disturbance to threatened artesian spring communities associated with pipeline and road construction	Aquatic ecology	Pipelines	Ser	6	Sev	Ser	6	Sev	Avoid construction of roads or pipelines through or adjacent to artesian mound springs in the vicinity of Cockatoo Creek Implement erosion and sediment control measures in accordance with the Queensland Guidelines for Erosion and Sediment Control and APIA Code of Environmental Practice (2009) (see impact mechanism 1)	Low
				Roads	Ser	6	Sev	Ser	6	Sev	Appropriate pipeline construction (e.g. via directional drilling) recommended if springs and potential habitat for MNES species cannot be avoided. Monitor water quality (TSS, turbidity and nutrients) and aquatic ecology (macrophytes, macroinvertebrates and fish) upstream and downstream of creek crossings prior to and during construction	Low
4	Dawson, Don, Calliope,	Temporary diversion of watercourses during construction of road and	Aquatic ecology Geomorphology	Pipelines	Min	6	Med	Min	1	Low	Avoid construction of roads or pipelines through or adjacent to artesian mound springs in the vicinity of Cockatoo Creek	Low

Impact Mechanism No.	Catchment*	Potential Impact Mechanism	Impacts (default to highest)	Activity#	Local			Regional			Mitigation Measures	Residual Risk
					C	L	R	C	L	R		
	Condamine	pipeline crossings		Roads	Min	6	Med	Min	1	Low	Monitor water quality, aquatic ecology and geomorphology upstream and downstream of dams prior to and during construction (where water is available)	Low
5	Dawson, Don, Calliope, Condamine	Hydrocarbon, chemical or wastewater contamination from accidental spills	Aquatic ecology Water quality	Pipelines	Ser	1	Low	Mod	1	Low	Ensure all machinery and vehicles free from fuel and oil leaks Implement storage, handling and spill containment / response in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids) Implement an adaptive water quality and aquatic ecology monitoring program in accordance with EMP Implement good practice management of on-site sewage Implement a Stormwater Management Plan in accordance with the EMP	Low
				Roads	Ser	1	Low	Mod	1	Low		Low
6	Dawson, Don, Calliope, Condamine	Increased bank erosion (gullying) from exposed areas	Geomorphology	Pipelines	Mod	4	Med	Min	1	Low	Avoid construction of roads or pipelines through or adjacent to artesian mound springs in the vicinity of Cockatoo Creek Implement erosion and sediment control measures in accordance with the Queensland Guidelines for Erosion and Sediment Control and APIA Code of Environmental Practice (2009) (see impact mechanism 1) Monitor geomorphic processes prior to and during construction and implement remedial measures as required, in accordance with guidelines by Rutherford et al. (2000)	Low
				Roads	Mod	4	Med	Min	1	Low		Low
7	Dawson, Don, Calliope, Condamine	Trenching and re-laying of bank and bed sediments during construction of road and pipeline crossings	Geomorphology	Pipelines	Mod	4	Med	Min	1	Low	Avoid construction of roads or pipelines through or adjacent to artesian mound springs in the vicinity of Cockatoo Creek Implement erosion and sediment control measures in accordance with the Queensland Guidelines for Erosion and Sediment Control and APIA Code of Environmental Practice (2009) (see impact mechanism 1) Monitor geomorphic processes prior to and during construction and implement remedial measures as required, in accordance with guidelines by Rutherford et al. (2000) Routing analysis and consideration of directional drilling (rather than trenching) of sensitive creek crossings (e.g. P3CE11 on Cockatoo Creek).	Low
				Roads	Mod	4	Med	Min	1	Low		Low
				Roads	Ser	3	Med	Ser	2	Med		Low
8	Dawson, Don, Calliope	Enhanced breeding of mosquitoes through ponding of water during construction	Aquatic ecology	Pipelines	Min	6	Med	Min	6	Med	Implement monitoring program to establish mosquito prevalence where development within 5 km of major population centres or large natural wetlands	Low
				Roads	Min	6	Med	Min	6	Med	Mosquito management plan in accordance with Queensland Mosquito Management Code of Practice (LGAQ 2002)	Low

Note: C = Consequence, L = Likelihood, R = Risk, Min = Minor, Mod = Moderate, Med = Medium, Maj = Major, Cri = Critical, Ext = Extreme

Table 5-4 Risk Assessment – Operation and Decommissioning

Impact Mechanism No.	Catchment *	Potential Impact Mechanism	Impacts (default to highest)	Activity#	Local			Regional			Mitigation Measures	Residual Risk
					C	L	R	C	L	R		
1	Dawson, Don, Calliope, Condamine	Erosion from exposed areas	Aquatic Ecology Water Quality Geomorphology	Pipelines	Mod	2	Low	Mod	2	Low	Implement erosion and sediment control measures in accordance with the Queensland Guidelines for Erosion and Sediment Control and APIA Code of Environmental Practice (2009) (see impact mechanism 1 in Table 5-1) Monitor geomorphic processes at established assessment sites during operational phase on an annual basis (to be reviewed after two years)	Low
				Roads	Mod	6	High	Mod	6	High		Low
2	Dawson, Don, Calliope, Condamine	Hydrocarbon, chemical or wastewater contamination from accidental spills	Aquatic ecology Water quality	Pipelines	Ser	1	Low	Mod	1	Low	As per mitigation measures for impact mechanism 6 in Table 5-3	Low
				Roads	Ser	1	Low	Mod	1	Low		Low
4	Dawson, Don, Calliope, Condamine	Altered low flow hydrology / hydraulics resulting from crossings	Aquatic ecology Water quality Geomorphology	Roads	Mod	2	Low	Mod	2	Low	APLNG has advised that all road crossings will be temporary and will be removed following pipeline construction. Design temporary crossings to reduce any impediment to flow (e.g large box culverts, single span bridges or low profile, sealed fords that maintain the profile of the creek bed). Design temporary road crossings with an invert level at least 150 mm below the existing bed level to allow for sedimentation within the culvert and to allow for organism passage during low flows.	Low

Note: C = Consequence, L = Likelihood, R = Risk, Min = Minor, Mod = Moderate, Med = Medium, Maj = Major, Cri = Critical, Ext = Extreme

6. Summary and Conclusions

Two dry season water quality surveys and one dry season aquatic ecology and geomorphology survey were undertaken at sites throughout the Dawson, Don and Calliope catchments. Information collected during the dry season surveys was used to supplement reported literature in order to describe the existing aquatic environment and assess the potential impacts associated with the gas transmission pipeline component of the Project.

No rare, endangered or otherwise noteworthy fish, macroinvertebrates or aquatic macrophytes were recorded from the sites sampled. However, three fish species endemic to the Fitzroy River system (Saratoga / Dawson River Salmon, Leathery Grunter and Fitzroy yellowbelly) have been recorded and two species of aquatic macrophytes (the EPBC listed Salt pipewort and Artesian milfoil) are known to occur in Cockatoo Creek.

Several construction and operation mechanisms were identified that could impact on water quality, aquatic ecology or geomorphology. The outcomes of the impact assessment were used to inform the detailed, qualitative risk assessment. Risks to the aquatic environment were determined in consideration of the combination of consequences (including vulnerability) and likelihood. The risks to the aquatic environment associated with construction and operation activities (following mitigation) were considered to be low. Care will be needed to ensure that effective good practice sediment control measures are strictly adhered to throughout the construction phase to ensure any impacts are minimised. Each individual construction activity is a concentrated, relatively short phase of the project, and while the potential sediment related impacts associated with this construction related activities were considered to be medium, they should be short-lived on the local scale.

The residual risk of impact to artesian spring communities (Salt pipewort and Artesian milfoil) associated with construction activities was assessed to be low, provided that actively flowing discharge springs are avoided by pipeline and / or road construction across Cockatoo Creek.

As the majority of streams in the Project Area are intermittent, water quality and aquatic ecology would exhibit large seasonal variations. Further monitoring during the wet season is recommended to establish seasonal variations in water quality and aquatic ecology.

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APPENDIX 1 Geomorphology and Field Proforma

APPENDIX 4 – Field Sheets for Pilot SRA

SRA Physical Habitat Site Information Sheet 1.

Date (dd/mm/yy) / / Recorder Assistant

Organisation

Basin Sub-section Site

Tributary Name Flows into Flows into

Location Name Access Details Location Description (how to find it again)

Type of Site
- Assessment (Test)
- Best Available (Reference)

Map Scale 1:

Grid Reference E N

Latitude Longitude GPS ? Stream Order Slope (Deg.)

Distance from Source

Map Name Map Number Map Zone AMTD (from map) Total U/S Distance (add AMTD's) Altitude (m)

Catchment Area (sq. km)

Sketch : Show location of survey, access points, landmarks and key features such as roads, houses and other buildings. Also show the key features about the stream environs and its location. Also mark the boundaries for the survey (the reach). Include an arrow for NORTH and also indicate the direction of flow. Also mark the position where the GPS latitude and longitude were determined. The sketch should be adequate for quickly finding the site again for future follow-up surveys.

Nearest RF Station Nearest Weather Station

Photographs - The standard set consists of: one shot looking **Upstream**, one **Downstream**, one **Lateral Left** (at the left bank along the bank line from top of the right bank to the left bank on the cross-section), one **Lateral Right** (at the right bank along the bank line from the top of the left bank on the cross-section).
Reach Environs and **Distant View** can also add information.

	Film No.	Shot	Shot	Shot	Shot
Upstream					
Downstream					
Lateral Left					
Lateral Right					
Reach Environs					
Distant View					
Feature ______					
Feature ______					

Landholder/Manager
Name
Address

Phone : Fax :

Permission / Key Required ?
Granted Verbally [ ]
In Writing [ ]
Notify Prior to Sampling [ ]
Key Needed for Access [ ]

APPENDIX 4 continued

SRA Physical Habitat Transect Measurement Sheet 2

Basin | Sub-section | Site | Date (dd/mm/yy) | Recorder

BED STABILITY Description	Rating	Transect 1	2	3
Stable bed Typical features: no evidence of infilling. For example, there is no erosion or deposition of fine sediment.	4			
Limited bed instability / deepening Typical features: minor erosion of both banks; little mobile fine sediment (sand, silt) in bed; moderately steep bed. or **Limited bed instability / infilling** Typical features: some fine sediment on bed as bars; channel capacity reduced marginally by fine sediment accumulation; accumulation of fine sediment at obstructions e.g. snags; bed tending to flat and uniform.	2			
Extensive bed instability / deepening Typical features: extensive erosion of both banks; steep bed; no mobile fine sediment in bed; low width to depth ratio. or **Extensive bed instability / infilling** Typical features: channel largely blocked by fine sediment; flat bed; overbank siltation; waterlogging of adjacent land; high width to depth ratio.	0			

Channel and Stream Width	1	2	3
Channel Width (m) Width of the channel from top of one bank to top of the other.			
Stream Width (m) Width of the stream at water level.			

Visibility too poor for accurate assessment, estimate made ☐

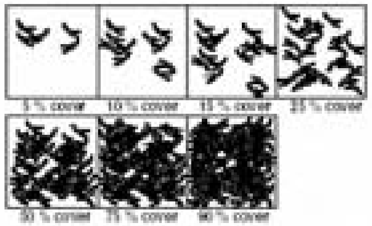
Stream Shading	1	2	3
Estimate the percentage of the stream shaded at midday in each transect.			

Riparian Width	1	2	3
Right bank (m) (up to 50 m)			
Left bank (m) (up to 50 m)			

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream [illegible] is immediately linked with the stream both in providing leaf [illegible] litter to the stream and being affected by the [illegible] [illegible] visible, it is the distinct vegetation zone along the stream. The [illegible] should be relatively homogeneous. Disturbed zones may be very thin.

BANK STABILITY RATING Description	Rating	Transect 1	2	3
Stable Typical features: very few local bank instabilities, none of which are at the toe of the bank; continuous cover of woody vegetation; gentle batter; very few exposed roots of woody vegetation; erosion resistant soils.	4			
Limited Erosion Typical features: some isolated bank instabilities, though generally not at the toe of the bank; cover of woody vegetation is nearly continuous; few exposed roots of woody vegetation.	3			
Moderate Erosion Typical features: some bank instabilities that extend to the toe of the bank (which is generally stable); discontinuous woody vegetation; some exposure of roots of woody vegetation.	2			
Extensive Erosion Typical features: mostly unstable toe of the bank; little woody vegetation; many exposed roots of woody vegetation.	1			
Extreme Erosion Typical features: unstable toe of bank; no woody vegetation; very recent bank movement (trees may have fallen into stream); steep bank surface; numerous exposed roots of woody vegetation; erodible soils.	0			

INSTREAM PHYSICAL HABITAT — Lowland Reaches	Rating	Transect 1	2	3
Excellent Habitat Typical Features: abundant debris from indigenous species. Site probably never desnagged and streamside vegetation probably never cleared.	4			
Good Habitat Typical features: numerous pieces of large woody debris from indigenous species. Perhaps limited large woody debris from exotic species present also. Limited impact of desnagging or streamside vegetation clearing.	3			
Marginal Habitat Typical features: moderate visible pieces of large woody debris from indigenous species in channel, or abundant pieces of exotic large woody debris in channel; moderate impact of desnagging or streamside vegetation clearing.	2			
Poor Habitat Typical Features: few visible pieces of large woody debris in channel (either from indigenous or exotic species).	1			
Very Poor Habitat Typical Features: no large woody debris visible.	0			
Upland Reaches	**Rating**	**1**	**2**	**3**
Excellent Habitat (Greater than 50% of stable habitat) Typical Features: distribution of snags is relatively dense, mix of size of snags which are not newfall; stable undercut banks; cobble (stones between 64 mm & 250 mm); or other stable habitat.	4			
Good Habitat (30 - 50% mix of stable habitat) Typical features: some large woody debris with presence of some newfall; some undercut banks (most of which are stable); bed material mostly course and stable.	3			
Poor Habitat (10 - 30% mix of stable habitat) Typical Features: habitat available less than desirable; substrate frequently disturbed or removed; few snags of limited size range.	1			
Very Poor Habitat (Less than 10% stable habitat) Typical Features: lack of habitat is obvious; substrate unstable or lacking.	0			

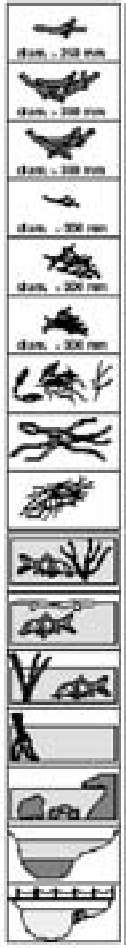


APPENDIX 4 continued

SRA Physical Habitat Transect Measurement Sheet 3.

Basin | Sub-section | Site | Date (dd/mm/yy) | Recorder

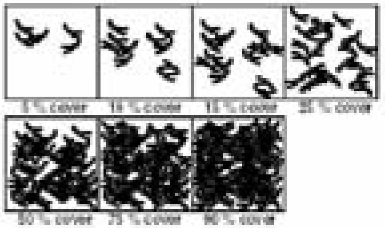
INSTREAM DEBRIS COVER



Transect 1	Transect 2	Transect 3
Individual log patches (record No.) % bed cover	Individual log patches (record No.) % bed cover	Individual log patches (record No.) % bed cover
Log jam < 50% dense patches % bed cover	Log jam < 50% dense patches % bed cover	Log jam < 50% dense patches % bed cover
Log jam > 50% dense patches % bed cover	Log jam > 50% dense patches % bed cover	Log jam > 50% dense patches % bed cover
Individual Branch patches % bed cover	Individual Branch patches % bed cover	Individual Branch patches % bed cover
Branch pile < 50% dense patches % bed cover	Branch pile < 50% dense patches % bed cover	Branch pile < 50% dense patches % bed cover
Branch pile > 50% dense patches % bed cover	Branch pile > 50% dense patches % bed cover	Branch pile > 50% dense patches % bed cover
Terrestrial leaves & twigs patches % bed cover	Terrestrial leaves & twigs patches % bed cover	Terrestrial leaves & twigs patches % bed cover
Macrophyte Fragments % bed cover	Macrophyte Fragments patches % bed cover	Macrophyte Fragments patches % bed cover
Algal clumps and debris patches % bed cover	Algal clumps and debris patches % bed cover	Algal clumps and debris patches % bed cover
Large / deep submerged veg. Freshwater % bed cover	Large / deep submerged veg. Freshwater % bed cover	Large / deep submerged veg. Freshwater % bed cover
Large patches of Floating veg. % bed cover	Large patches of Floating veg. % bed cover	Large patches of Floating veg. % bed cover
Emergents perm. water > 0.5 m deep % bed cover	Emergents perm. water > 0.5 m deep % bed cover	Emergents perm. water > 0.5 m deep % bed cover
Tree Roots % bed cover	Tree Roots % bed cover	Tree Roots % bed cover
Rock faces, boulders, cobbles % bed cover	Rock faces, boulders, cobbles % bed cover	Rock faces, boulders, cobbles % bed cover
Pools, pool hab. deeper than 1 m % bed cover	Pools, pool hab. deeper than 1 m % bed cover	Pools, pool hab. deeper than 1 m % bed cover
Man made structures and debris % bed cover	Man made structures and debris % bed cover	Man made structures and debris % bed cover

Water too turbid to estimate
pres. only recorded

Assessment is made in terms of the % cover of the surface area for the zone specified for each type.



Comment

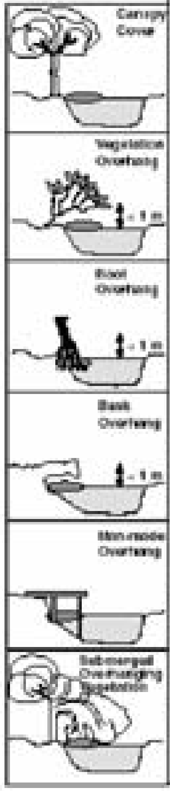
APPENDIX 4 continued

SRA Physical Habitat Transect Measurement Sheet 4.

Date (dd/mm/yy) __/__/__ Recorder ____________

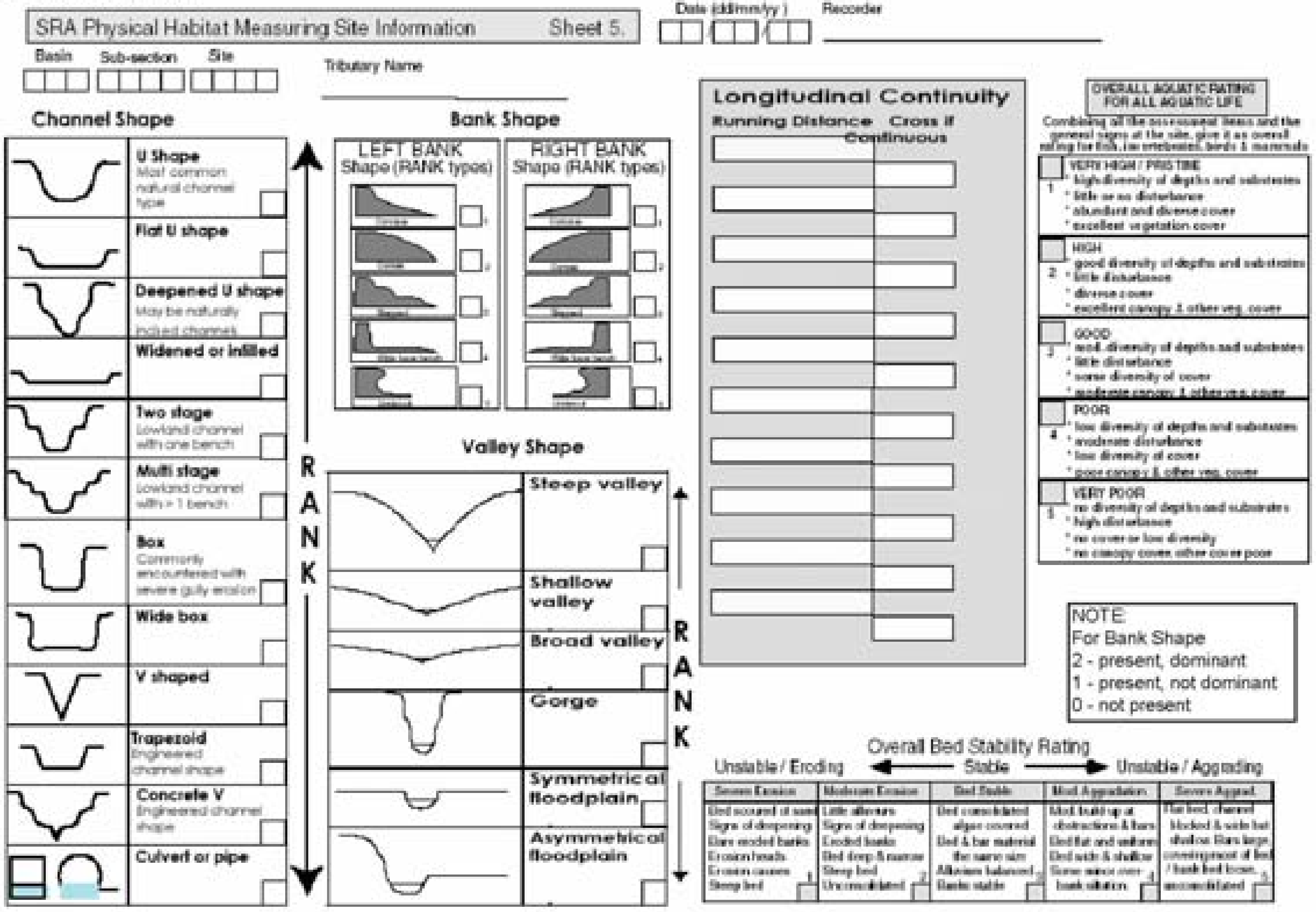
Basin ___ Sub-section ___ Site ___ Tributary Name ____________

Overhanging Vegetation



	Transect 1		Transect 2		Transect 3	
	LEFT BANK	RIGHT BANK	LEFT BANK	RIGHT BANK	LEFT BANK	RIGHT BANK
Canopy Cover	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)
Vegetation Overhang (< 1 m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)
Root Overhang (< 1 m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)
Bank Overhang (< 1 m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)
Man-made Overhang	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)
Submerged Overhanging Vegetation	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)	% bank length type present Est. Av. width (m)

APPENDIX 4 continued



SRA Physical Habitat Measuring Site Information Sheet 5.

Date (dd/mm/yy) Recorder

Basin Sub-section Site

Tributary Name

Channel Shape

- U Shape – Most common natural channel type
- Flat U shape
- Deepened U shape – May be naturally incised channels
- Widened or infilled
- Two stage – Lowland channel with one bench
- Multi stage – Lowland channel with > 1 bench
- Box – Commonly encountered with severe gully erosion
- Wide box
- V shaped
- Trapezoid – Engineered channel shape
- Concrete V – Engineered channel shape
- Culvert or pipe

RANK

Bank Shape

LEFT BANK Shape (RANK types)

RIGHT BANK Shape (RANK types)

Valley Shape

- Steep valley
- Shallow valley
- Broad valley
- Gorge
- Symmetrical floodplain
- Asymmetrical floodplain

RANK

Longitudinal Continuity

Running Distance Cross if Continuous

OVERALL AQUATIC RATING FOR ALL AQUATIC LIFE

Combining all the assessment items and the general signs at the site, give it an overall rating for fish, invertebrates, birds & mammals

1. VERY HIGH / PRISTINE
   - high diversity of depths and substrates
   - little or no disturbance
   - abundant and diverse cover
   - excellent vegetation cover
2. HIGH
   - good diversity of depths and substrates
   - little disturbance
   - diverse cover
   - excellent canopy & other veg. cover
3. GOOD
   - mod. diversity of depths and substrates
   - little disturbance
   - some diversity of cover
   - moderate canopy & other veg. cover
4. POOR
   - low diversity of depths and substrates
   - moderate disturbance
   - low diversity of cover
   - poor canopy & other veg. cover
5. VERY POOR
   - no diversity of depths and substrates
   - high disturbance
   - no cover or low diversity
   - no canopy cover, other cover poor

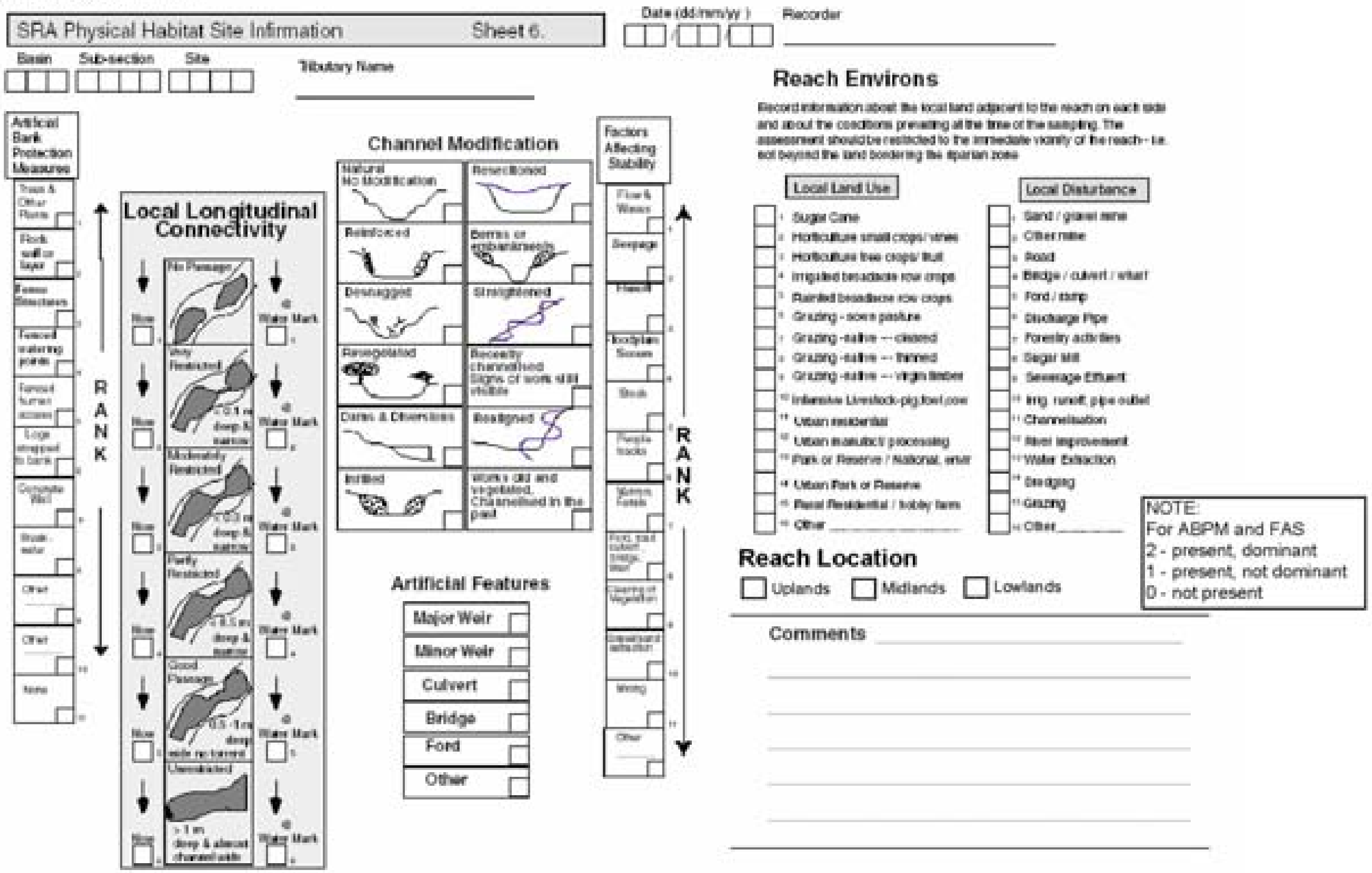
NOTE
For Bank Shape
2 - present, dominant
1 - present, not dominant
0 - not present

Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand. Signs of deepening. Bars eroded banks. Erosion heads. Erosion causes steep bed. 1	Little alluvium. Signs of deepening. Eroded banks. Bed deep & narrow. Steep bed. Unconsolidated. 2	Bed consolidated, algae covered. Bed & bar material the same size. Alluvium balanced. Banks stable. 3	Mod. build up at obstructions & bars. Bed flat and uniform. Bed wide & shallow. Some minor over bank siltation. 4	Flat bed, channel blocked & wide but shallow. Bars large, consignment of bed / bank bed loose, unconsolidated. 5

APPENDIX 4 continued.


SRA Physical Habitat Site Infirmation Sheet 6.

Date (dd/mm/yy) Recorder

Basin Sub-section Site Tributary Name

Artificial Bank Protection Measures: Trees & Other Plants; Rock wall or layer; Timber Structures; Fenced watering points; Fenced human access; Logs strapped to bank; Concrete Wall; Stone - work; Other; Other; None

RANK

Local Longitudinal Connectivity: No Passage; Very Restricted (< 0.1 m deep & narrow); Moderately Restricted (< 0.3 m deep & narrow); Partly Restricted (< 0.5 m deep & narrow); Good Passage (0.5 - 1 m deep, wide no torrent); Unrestricted (> 1 m deep & almost channel wide). Flow / Water Mark

Channel Modification: Natural No Modification; Resectioned; Reinforced; Berms or embankments; Desnagged; Straightened; Revegetated; Recently channelised, Signs of work still visible; Dams & Diversions; Realigned; Infilled; Works old and vegetated, Channelised in the past

Artificial Features: Major Weir; Minor Weir; Culvert; Bridge; Ford; Other

Factors Affecting Stability: Flow & Waves; Seepage; Flood; Floodplain Scours; Stock; People tracks; Vehicle Fords; Ford, road culvert, bridge, weir; Clearing of Vegetation; Sand and gravel extraction; Mining; Other

RANK

Reach Environs

Record information about the local land adjacent to the reach on each side and about the conditions prevailing at the time of the sampling. The assessment should be restricted to the immediate vicinity of the reach - i.e. not beyond the land bordering the riparian zone

Local Land Use	Local Disturbance
1 Sugar Cane	1 Sand / gravel mine
2 Horticulture small crops / vines	2 Other mine
3 Horticulture tree crops/ fruit	3 Road
4 Irrigated broadacre row crops	4 Bridge / culvert / wharf
5 Rainfed broadacre row crops	5 Ford / ramp
6 Grazing - sown pasture	6 Discharge Pipe
7 Grazing - native — cleared	7 Forestry activities
8 Grazing - native — thinned	8 Sugar Mill
9 Grazing - native — virgin timber	9 Sewerage Effluent
10 Intensive Livestock-pig,fowl,cow	10 Irrig. runoff, pipe outlet
11 Urban residential	11 Channelisation
12 Urban industrial processing	12 River improvement
13 Park or Reserve / National, etc.	13 Water Extraction
14 Urban Park or Reserve	14 Dredging
15 Rural Residential / hobby farm	15 Grazing
16 Other ____	16 Other ____

Reach Location

Uplands Midlands Lowlands

NOTE:
For ABPM and FAS
2 - present, dominant
1 - present, not dominant
0 - not present

Comments

APPENDIX 4 continued

SRA Physical Habitat Site Information Sheet 7.

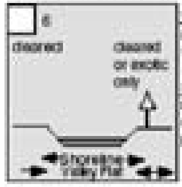
Date (dd/mm/yy) __/__/__ Recorder __________

Basin ___ Sub-section ____ Site ____ Tributary Name __________

OVERALL DISTURBANCE RATING

Tick one box for the overall rating

EXTREME DISTURBANCE



Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

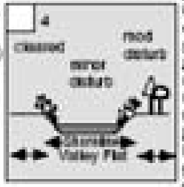
Shoreline Vegetation - Absent or severely reduced. Vegetation present is extremely disturbed - i.e. dominated by exotic species. Native species rare or completely absent.

VERY HIGH DISTURBANCE

Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines, etc.).

Shoreline Vegetation - Some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of introduced species. Native species severely reduced in numbers and cover.

HIGH DISTURBANCE



Valley Flat Vegetation - Agricultural land and/or cleared on ONE side, native vegetation on the other clearly disturbed or with a high percentage of introduced species present.
Shoreline Vegetation - Bank vegetation moderately disturbed by stock or through the intrusion of introduced species, though native species remain.
Note: Sites with valley flat vegetation cleared BOTH sides, but with shoreline vegetation in good condition, for example when it is fenced off, should be included in this category.

MODERATE DISTURBANCE

Valley Flat Vegetation - Agricultural land and/or cleared on ONE side, native vegetation on the other in reasonably undisturbed state.

Shoreline Vegetation - Native vegetation on BOTH sides with canopy intact or with native species widespread and common in the shoreline zone. The intrusion of introduced species is minor and of moderate impact.

LOW DISTURBANCE

Valley Flat Vegetation Native vegetation present on BOTH sides of the river with a virtually intact canopy. Minor disturbances present through introduced species.

Shoreline Vegetation Native vegetation on BOTH sides of the river is generally in good condition with few introduced species present. Any disturbance is minor.

V.LOW DISTURBANCE

Valley Flat Vegetation Native vegetation present on both sides of the river with an intact canopy. Introduced species are absent or insignificant. No evidence of outside interference. Representative of natural vegetation in excellent condition.

Shoreline Vegetation Native vegetation on both sides of the river in an undisturbed state. Introduced species are rare or insignificant. Representative of natural vegetation in excellent condition.

NOTES:

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | | | |] SITE NAME: ____________________

Date: __/__/____ Time (24 hrs): [| | |] GPS: ____________________ Project Name: ____________________

Habitat Variable	CATEGORY			
	Excellent	Good	Fair	Poor
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. "Raw" areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score	

1. LONGITUDINAL PROFILE SKETCH OF STREAM REACH

Scale: ____________________

Please indicate
1. Biological sampling sites for each habitat type and % of reach.
2. Water quality measurement and water sample collection sites.
3. Location from where photograph(s) taken.
4. Location of cross-sectional profile sketch.

2. CROSS-SECTIONAL PROFILE SKETCH OF STREAM REACH

Scale: ____________________

Please indicate
1. Approx. bank height/bank width (overflow), stream width and depth.
2. Approx. riparian vegetation height.

3. COMMENTS

(Office use only) **Entered into Hydsys on** ___/___/___ **By** ____________________

Checked on ___/___/___ **By** ____________________

APPENDIX 2 Raw Water Quality Data

Table A2-1. Water quality data.

	Don River	Don River	Calliope	Calliope	Fitzroy	Condamine	Condamine	Condamine	Condamine	Fitzroy	Fitzroy
	Kroombit Creek	Kroombit Creek	Calliope River	Calliope River	Bungaban Creek	Dogwood Creek	Dogwood Creek	Dogwood Creek	Dogwood Creek	Bungaban Creek	Cockatoo Creek
	Central Coast	Central Coast	Central Coast	Central Coast	Central Coast	Murray Darling	Murray Darling	Murray Darling	Murray Darling	Central Coast	Central Coast
	P4LL	P4LL	P1	P1	P8	GF1	GF1	R1	R1	PC3E10	P3CE11
Date	8/08/2009	2/09/2009	4/07/2009	2/09/2009	7/08/2009	8/09/2009	25/06/2009	8/09/2009	26/06/2009	3/10/2009	5/09/2009
Time	15:30	12:29	8:00	9:12	13:03	13:40	14:15	10:37	10:30	11:00	4:00 PM
Temperature (C)		23.07	15.27	20.8		17.61	15.6	19.13	12	20.82	21.65
Conductivity (microS/cm)	529	501	1343	1379	115	78	77	213	179	154	1484
pH	8.39	8.53	7	7.76	5.76	6.72	7.76	5.38	7.48	7.14	7.97
Turbidity (NTU)	17.2	62.9	0.9	1	618.4	635.6	350	288.4	65.9	15.6	22.1
DO %	125	108.9	63	72.8	43.9	60.2	69.1	108.6	65.9	5.8	1
EA015: Total Dissolved Solids											
Total Dissolved Solids @180°C	297	288	764	874	735	924	602	112	186	1150	830
EA025: Suspended Solids											
Suspended Solids (SS)	23	40	8	3	84	145	47	1220	137	1650	10
ED037P: Alkalinity by PC Titrator											
Hydroxide Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	157	184	315	326	38	9	16	1	3	62	352
Total Alkalinity as CaCO3	167	184	315	326	38	9	16	1	3	62	352
ED040F: Dissolved Major Anions											
Sulfate as SO4 2-	16	14	18	22	3	6	4	5	3	9	3
ED045G: Chloride Discrete analyser											
Chloride	46	48	266	305	10	11	10	52	36	15	314
ED093F: Dissolved Major Cations											
Calcium	29	32	77	83	4	1	2	4	2	7	28
Magnesium	18	18	53	59	2	<1	1	2	2	2	10
Sodium	42	48	128	140	14	11	12	26	20	28	302
Potassium	12	11	2	2	8	3	3	8	6	14	10
EK055G: Ammonia as N by Discrete Analyser											
Ammonia as N	0.05	0.32	0.04	0.06	0.09	0.02	<0.01	0.47	0.46	0.46	0.05
EK059G: NOX as N by Discrete Analyser											
Nitrite + Nitrate as N	<0.01	0.01	<0.01	<0.01	0.19	0.32	0.37	<0.01	0.06	0.2	0.1
EK061: Total Kjeldahl Nitrogen (TKN)											
Total Kjeldahl Nitrogen as N	1.1	1	0.3	0.2	0.7	2.2	1.6	6.4	1.5	0.4	0.3
EK062: Total Nitrogen as N											
Total Nitrogen as N	1.1	1	0.3	0.2	0.9	2.5	2	6.4	1.6	0.6	0.4
EK067G: Total Phosphorus as P by Discrete Analyser											
Total Phosphorus as P	<0.01	0.16	0.04	0.11	1.94	0.41	0.27	0.67	<0.01	1.54	0.06
EK071G: Reactive Phosphorus as P by discrete analyser											
Reactive Phosphorus as P	0.02	0.04	<0.01	0.02	0.08	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
EN055: Ionic Balance											
Total Anions	4.96	5.34	14.2	15.6	1.1	0.61	0.69	1.57	1.13		16
Total Cations	5.04	5.47	13.8	15.1	1.16	0.62	0.79	1.69	1.26		15.6
Ionic Balance	0.82	1.22		1.41							1.15
EP068A: Organochlorine Pesticides (OC)											
alpha-BHC	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hexachlorobenzene (HCB)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
beta-BHC	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
gamma-BHC	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
delta-BHC	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aldrin	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Heptachlor epoxide	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
trans-Chlordane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
alpha-Endosulfan	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
cis-Chlordane	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dieldrin	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4.4'-DDE	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
beta-Endosulfan	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4.4'-DDD	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

APPENDIX 3 Raw Fish Data

Table A3-1 Fish diversity and abundance – gas transmission pipeline

Fish Family	Fish species		Colliape	Dawson					Condamine	
		Common name	P1	P3CE10	P8	P7	P4LL	P3CE11	GF1	R1
Ambassidae	Ambassis agassizii	Agassiz's Glassfish	34			3		12		
	Ambassis sp.	Glassfish species					2			
Anguillidae	Anguilla reinhardtii	Marbled Eel	4							
Apogonidae	Glossamia aprion	Mouth almighty	10							
Atherinidae	Craterocephalus stercusmuscarum	Fly-speckled Hardyhead	13					53		
Clupeidae	Nematalosa erebi	Bony Bream				17			1	
Eleotridae	Hypseleotris spp.	Gudgeon species	8	3		78	94	78		11
	Hypseleotris compressa	Empire Gudgeon	25				1			
	Morgunda adspersa	Purple-spotted Gudgeon	5				1	3		
Melanotaeniidae	Melanoteania splendida	Eastern Rainbowfish	10			11	1	93		
Pseudomugilidae	Pseudomugil signifer	Pacific blue-eye	2							
	Macquaria ambigua	Golden Perch / Yellobelly								5
	Retropinna semoni	Australian smelt								2
Plotosidae	Tandanus tandanus	Freshwater catfish	2			1				
Poecilidae	Gambusia holbrooki	Eastern Mosquitofish		4		2	5	3		10
	Carassius auratus	Gold fish								26
Terapontidae	Amniataba percoides	Barred grunter	4							
	Leiopotherapon unicolor	Spangled perch	13	7		1	1			1
Crustacean Family	Crustacean Species	Common name								
Palaemonidae	Macrobrachium sp.	Prawn species		35				2		
Parastacidae	Cherax quadricarinatus	Red claw		37						

APPENDIX 4 Raw Macroinvertebrate Data

Table A4-1 Macroinvertebrate diversity and abundance – gas fields

Catchment		Calliope	Dawson			Condamine
Macroinvertebrate Family	Functional Feeding Group	P1	P7	P8	P3CE11	GF1
Acarina	Predator	3			4	2
Ancylidae	Scraper		5		1	
Anisoptera	Predator	1				
Anostraca	Filter-feeder			2		
Atyidae	Gatherer/Collector	11	1		10	
Baetidae	Gatherer/Collector		3		21	
Caenidae	Gatherer/Collector		2		9	
Calamoceratidae	Shredder	8				
Caridea	Gatherer/Collector				11	
Ceratopogonidae	Predator	2	3	2	5	6
s-f Chironominae						1
Cladocera	Filter-feeder		6	96	14	8
Coenagrionidae	Predator	7			5	
Collembola						1
Copepoda	Gatherer/Collector	1	39	32	86	6
Corbiculidae	Filter-feeder	15	3			
Corduliidae	Predator	2				1
Corixidae	Predator		6	4	1	
Culicidae	Filter-feeder			45	4	
Dugesiidae	Gatherer/Collector	1				8
Dytiscidae	Predator	1	5	13	2	1
Ecnomidae	Predator	1				
Gerridae	Predator			2		
Gomphidae	Predator	2	1			
Gyrinidae	Predator		2	1		
Hydraenidae	Gatherer/Collector	1	1	7	7	
Hydridae	Predator				4	
Hydrobiidae	Scraper	5			20	
Hydrochidae	Shredder				20	
Hydrometridae	Predator	1		4		4
Hydrophilidae	Predator	2	3	7	2	9
Hydroptilidae	Predator				34	
Hydryphantidae	Predator				7	
Isostictidae	Predator		1			1

Leptoceridae	Shredder	32	1		46	
Leptophlebiidae	Gatherer/Collector	1				
Libellulidae	Predator	1				
Lymnaeidae	Scraper			2	4	
Mesostigmata	Predator				1	
Mesoveliidae	Predator				2	
Naucoridae	Predator	1				
Nematoda	Predator		5	19	4	
Nepidae	Predator		2			
Notonectidae	Predator		5	1	1	1
Oligochaeta	Gatherer/Collector	3	12	1	82	
Oribatida	Predator				4	
Ostracoda	Filter-feeder	2	4	12	1	
Palaemonidae	Gatherer/Collector	1	11	7	1	
Parasticidae	Shredder		2	2		
Physidae	Scraper					15
Pisauridae	Predator			9		
Planorbidae	Scraper	1			26	
Pleidae	Predator	15	2		6	
Porifera	Filter-feeder				1	
Protoneuridae	Predator	7				
Sciomyzidae	Predator			3		
Scirtidae	Filter-feeder		1	7		
Chironominae	Filter-feeder	7	46	1	120	
Orthocladiinae	Gatherer/Collector				5	
Tanypodinae	Predator	5	24	1	92	
Sisyridae	Predator	1				
Sphaeriidae	Filter-feeder	9				
Staphylinidae	Predator		1	5		
Stratiomyidae	Gatherer/Collector				5	
Temnocephalidea	Predator		4	19		
Thiaridae	Scraper	7			21	
Veliidae	Predator	2		42	8	10
Zygoptera	Predator	14			8	
	Total Abundance	173	201	346	705	
	Total Richness	34	29	27	40	

APPENDIX 5 Geomorphic Assessment Results

Table A5–1 Reach-based geomorphic assessment results

Site	Date	Tributary name	Channel Shape			Valley Shape			Left bank shape					Right bank shape					Overall Aquatic life rating	Overall Bed Stability Rating	Artificial Bank Protection Measures	Channel modification	Factors affecting stability			Artificial Features	Reach Environs				LB Connectivity	RB Connectivity	Habitat Assessment									Summary
			1	2	3	1	2	3	Concave	Convex	Stepped	Wide lower bench	Undercut	Concave	Convex	Stepped	Wide lower bench	Undercut					1	2	3		Local Land Use	Local Disturbance	Reach Location	Disturbance			Bottom substrate	Embeddedness	Velocity/depth category		Bottom scouring and deposition	Pool/riffle, run/bend ratio	Bank stability	Bank vegetative stability	Streamside cover	
P1	3/08/09	Calliope River	U-Shape			symmetrical floodplain	broad valley			1	3	2			1	2	3		Good	Bed stable			clearing of vegetation	stock	runoff	Ford	grazing native - cleared	grazing	Midlands	High Disturbance	34%	10%	14	10	13	9	8	7	7	6	5	- despite cleared surrounding land w/in stream veg in rel good condition - Habitat diversity, stable beds for banks, little obvious signs of runoff (except for odd gully) - Riffle zone evident - considerable examples of loose LWD above current WL - good deep pools with LWD
P5	2/08/09	Dawson River	U-Shape			symmetrical floodplain				1				2	1				poor	mod aggradation		dam and diversions	clearing of vegetation	clearing of vegetation	runoff	major weir	cleared, urban	road, water extraction, grazing	Midlands / lowlands	high disturbance	96%	14%	13	6	0	6	8	3	8	7	8	- deep weir pool with LWD - weir dominates disturbance - good rip vegetation particularly on LB - introduced spp (paragrass or similar) on RB prov stab
P7	2/08/09	Juandah Creek	U-Shape			symmetrical floodplain				1					1				poor	bed stable		ford	clearing of vegetation	runoff	stock	ford	native, cleared	grazing	Midlands / lowlands	very high disturbance	0%	3%	9	5	5	7	7	6	8	5	3	- deep pool (1.5-2m) with scattered LWD - severely modified vegetation - less turbid than other streams
P8	1/08/09	Bungaban Creek	U shape/V shaped			symmetrical floodplain	broad valley			1					1				poor	mod aggradation			clearing of vegetation	runoff	stock		native, cleared	grazing	midlands	very high disturbance	0%	5%	6	5	5	6	6	4	5	5	5	- little LWD (except at TS3) - same pool - all infilled to <1m - major impacts from grazing and vegetation clearance
P3CE10	3/10/09	Bungaban Creek	U-Shape			shallow valley				1	2				1	2			poor	bed stable			clearing of vegetation	floodplain scours	runoff		grazing - native - cleared	grazing	midlands	very high disturbance	0%	0%										- stream is in reasonable condition considering cleared land - narrow, deep channel within terraces - some historic incision - bed currently stable with some deposition - pools shallow - sandy clay bed and banks
P3CE11	4/10/09	Cockatoo Creek	two stage	flat U-Shape		shallow valley				3	1	2		1	2	4	3		good	mod aggradation			clearing of vegetation	runoff	stock	culvert	grazing - native - cleared	culvert, grazing	midlands	high disturbance	9%	80%	12	11	12	7	7	8	8	5	5	- channel incised into a 'floodplain' within the greater channel - indicative of decreased flushing flows and a system that has adapted to continual low flows - spring-fed continual flows - bed composed of bed rock outcropping overlaid by coarse sand / gravel mixed with clays

Site	Date	Tributary name	Channel Shape			Valley Shape			Left bank shape					Right bank shape					Overall Aquatic life rating	Overall Bed Stability Rating	Artificial Bank Protection Measures	Channel modification	Factors affecting stability			Artificial Features	Reach Environs				LB Connectivity	RB Connectivity	Habitat Assessment									Summary
			1	2	3	1	2	3	Concave	Convex	Stepped	Wide lower bench	Undercut	Concave	Convex	Stepped	Wide lower bench	Undercut					1	2	3		Local Land Use	Local Disturbance	Reach Location	Disturbance			Bottom substrate	Embeddedness	Velocity/depth category		Bottom scouring and deposition	Pool/riffle, run/bend ratio	Bank stability	Bank vegetative stability	Streamside cover	
P3CE12	5/10/09	Pump Creek	flat U-Shape	two stage		shallow valley				3	2	1			3	2	1		good	mod aggradation			clearing of vegetation	runoff	stock	culvert	grazing - native - cleared	culvert, grazing	midlands	high disturbance	56%	35%	16	16	8	6	7	3	6	5	6	- within stream bench vegetation provides good habitat, native vegetation has been cleared previously - bank and valley vegetation is sparse - reasonable diversity of substrate and LWD provides depth variability - obvious signs of aggradation - increase in bench size - generally sandy benches and a cobble / sand thalweg
RORWB3	21/08/09	Bungaban Creek	widened or infilled			shadow valley													good	bed stable			clearing of vegetation	stock	runoff		native, cleared	grazing		high disturbance	51%	43%										- narrow/non-existent fringing vegetation
GF1	25/06/2009	Dogwood Creek	deepened U-Shape	two stage		broad valley				2	2				2	2			poor	mod aggradation	fence structures	revegetated	clearing of vegetation	clearing of vegetation	gullying		grazing (cleared)		midlands	high/mod disturbance	12%	63%	12	6	9	4	6	10	6	6	7	- isolated infilling from gullies - little LWD - infilling of pool - rip veg zone fenced off providing prot to bank - good rip zone on RB with some sect of LB also having good rip veg - both banks undergoing scour of lower bank (at water line) - most scour appears to be as a results of historic incision - largely stable site despite obv presence of bank undercut fed by incised nature of stream and despite naturally erodible banks - failure of some of upper LB fed by overland flow - lots of isolated sed sources providing to system
R1	26/06/2009	Dogwood Creek	U-Shape			shadow valley				2				2					high	moderate erosion	fence structures		runoff	stock	clearing of vegetation		grazing (thinned)		midlands	moderate disturbance	54%	42%	11	8	10	8	9	10	7	8	9	- good LWD - bank held together by dense grasses and mod dense rip veg that is rel continuous - deepening around LWD w/ isolated patches of depos occurring

Table A5–2 Transect-based geomorphic assessment results

Site	Date	Stream/River	Transect	CHANNEL CONDITION: Bed Stability	Channel Width (m)	Stream Width (m)	Stream Shading (%)	Riparian Width (RB) (m)	Riparian Width (LB) (m)	Instream Physical Habitat	Bank Stability	IN-STREAM DEBRIS COVER: Individ. Log: Number of Patches	Individ. Log: % Bed Cover	Log Jam <50% Dense: Number of Patches	Log Jam <50% Dense: % Bed Cover	Log Jam >50% Dense: Number of Patches	Log Jam >50% Dense: % Bed Cover	Individ. Branch: Number of Patches	Individ. Branch: % Bed Cover	Branch pile <50% dense: Number of Patches	Branch pile <50% dense: % Bed Cover	Branch pile >50% dense: Number of Patches	Branch pile >50% dense: % Bed Cover	Leaves & twigs: Number of Patches	Leaves & twigs: % Bed Cover	Macrophyte fragments: Number of Patches	Macrophyte fragments: % Bed Cover	Algal clumps and debris: Number of Patches	Algal clumps and debris: % Bed Cover	Deep submerged veg (% Bed Cover)	Floating vegetation (% Bed Cover)	Emergents in >0.5m depth (% Bed Cover)	Tree roots (% Bed Cover)	Rock faces, boulders, cobbles (% Bed Cover)	Perm. Pool >1m deep (% Bed Cover)	Man-made structures & debris (% Bed Cover)	OVERHANGING VEGETATION: LEFT BANK: Canopy Cover	Average width (m)	Vegetation Overhang	Average width (m)	Root Overhang	Average width (m)	Bank Overhang	Average width (m)	Man Made Overhang	Average width (m)	Submerged Overhanging Vegetation	Average width (m)	RIGHT BANK: Canopy Cover	Average width (m)	Vegetation Overhang	Average width (m)	Root Overhang	Average width (m)	Bank Overhang	Average width (m)	Man Made Overhang	Average width (m)	Submerged Overhanging Vegetation	Average width (m)
P1	3/08/09	Calliope River	1	4	115	35	0	20	40	2	4					>10	<1																		80		30	0.5	70	2											90	2								
			2	4	107	1	50	30	10	2	4					>10	<1							>10	2.5										0		40		50	1.5									20	1	30	1								
			3	4	130	30	5	15	20	2	4	6	2																			<1	1		80		10	2	10	1											55	1							10	2
P5	2/08/09	Dawson River	1	2	200	90	5	5	50	2	4	9	<1																						95		90	5	10	2									30	<1										
			2	2	169	81	5	10	50	2	3	7	<1					4	<1																95		95	5	10	<1									10	1										
			3	2	184	80	5	10	50	2	4	>10	1					>10	<1																95		70	5	20	2																				
P7	2/08/09	Juandah Creek	1	4	38	13-15	0	<5	<5	2	4	8	5											1										1		80	20	2											40	2			20	<0.5						
			2	4	35	11-15	0	0	<5	1	4	4	2					8	1															1		80	20	2			3	<0.5																		
			3	4			0	<5	<5	1	3	7	2							2	1			1												70	20	1											15	1										
P8	1/08/09	Bungaban Creek	1	2	12	2-6	10	10	20	1	2	2	<1					1	<1						<1												60	1		5	<0.5								26	2										
			2	3	11	2/6	10	10	0	1	3													1	<1												15	<1											25	1										
			3	2	30	6	0	<5	<5	2	3					1	20	4	<1																		6	<1																						
P3CE10	3/10/09	Bungaban Creek	1	3	20	4	0	2	0	1	3	4	2					3	<1																		5	<1											10	<1										
			2	3	12	4	10	5	20	1	3													>10	2												5	<1											40	2										
			3	4	15	2	5	0	5	1	3							1	<1					>10	2												15	<1											5	<0.5										
P3CE11	4/10/09	Cockatoo Creek	1	4	30	1	30	30	10	3	4							1	<1														2	90			5	0.3											10	<1	50	1.5								
			2	3	37	16	30	30	10	3	4							1	<1							>10	5					10			15														5	1.5	5	<1								
			3	4	67	5	0	5	15	1	3							1	<1													15																			2	<1								

Site	Date	Stream/River	Transect	CHANNEL CONDITION								IN-STREAM DEBRIS COVER																									OVERHANGING VEGETATION																							
				Bed Stability	Channel Width (m)	Stream Width (m)	Stream Shading (%)	Riparian Width (RB) (m)	Riparian Width (LB) (m)	Instream Physical Habitat	Bank Stability	Individ. Log		Log Jam <50% Dense		Log Jam >50% Dense		Individ. Branch		Branch pile <50% dense		Branch pile >50% dense		Leaves & twigs		Macrophyte fragments		Algal clumps and debris		Deep submerged veg (% Bed Cover)	Floating vegetation (% Bed Cover)	Emergents in >0.5m depth (% Bed Cover)	Tree roots (% Bed Cover)	Rock faces, boulders, cobbles (% Bed Cover)	Perm. Pool >1m deep (% Bed Cover)	Man-made structures & debris (% Bed Cover)	LEFT BANK												RIGHT BANK											
												Number of Patches	% Bed Cover	Number of Patches	% Bed Cover	Number of Patches	% Bed Cover	Number of Patches	% Bed Cover	Number of Patches	% Bed Cover	Number of Patches	% Bed Cover	Number of Patches	% Bed Cover	Number of Patches	% Bed Cover	Number of Patches	% Bed Cover								Canopy Cover	Average width (m)	Vegetation Overhang	Average width (m)	Root Overhang	Average width (m)	Bank Overhang	Average width (m)	Man Made Overhang	Average width (m)	Submerged Overhanging Vegetation	Average width (m)	Canopy Cover	Average width (m)	Vegetation Overhang	Average width (m)	Root Overhang	Average width (m)	Bank Overhang	Average width (m)	Man Made Overhang	Average width (m)	Submerged Overhanging Vegetation	Average width (m)
P3CE12	5/10/09	Pump Creek	1	4	40	6	50	20	20	2	3	10	5					>10	2					>10	5												60	1.5	20	<1									60	1.5	20	<1								
			2	4	22	3.5	25	5	10	2	4	5	1					>10	2					>10	2												30	1	5	2									20	1	5	2								
			3	4	15	3	20	<5	5	2	4					3	15	>10	2					>10	2												40	1.5	10	1									15	1	10	1								
RORWB3	21/08/09	Bungaban Creek	1	4	500		60				4	>10	<1					>10	<1																																									
			2		300					2/3																																																		
			3																																																										
GF1	25/06/09	Dogwood Creek	1	2	72	23	5	20	30	1	2	1	1							1	2														50														10	1	20	6								
			2	2	70	19	40	50	30	3	2	2	5																						50		5	1									5	13	90	6	50	8								
			3	2	88	14	25	50	30	2	3	2	2							1	5														10														5	1	70	3							5	4
R1	30/06/09	Dogwood Creek	1	2	83	10	20	50	50	2	2	2	5					3	10					5	10												50	3											50	2										
			2	2	44	8	20	20	50	3	3			3	50									10	10												50	3											10	1										
			3	2	44	10	50	50	50	3	3	5	20							3	20			>10	30												60	3											50	4										

APPENDIX 6 ACA AquaBAMM Criteria and Measures

Table A6-1 Criteria, Measures and Weighting used in the ACA AquaBAMM study

Naturalness Aquatic		Average
Exotic flora/fauna	1.1.1 Presence of 'alien' fish species within the spatial unit	9.6
	1.1.2 Presence of exotic aquatic and semi-aquatic plants within the spatial unit	7.6
	1.1.4 Presence of feral/exotic vertebrate fauna (other than fish) within the wetland	9.6
Aquatic communities / assemblages	1.2.6 Wetland condition - as measured by an acknowledged condition metric	10.0
Habitat features modification	1.3.6 Snag removal within the spatial unit	5.6
	1.3.7 % area of wetland REs in the spatial unit relative to preclear extent	9.7
Hydrological modification	1.4.4 Mean annual extraction (or addition) (ML/year)	8.6
	1.4.5 Hydrological disturbance/modification of the wetland	8.4
Water quality	1.5.1 Median Total Phosphorous (ug/L)	8.9
	1.5.2 Median Total Nitrogen (ug/L)	8.0
	1.5.3 Median Turbidity (ug/L)	6.7
	1.5.4 Median Conductivity (ug/L)	8.0
	1.5.5 Median pH	5.8
Naturalness Catchment		
Exotic flora/fauna	2.1.1 Presence of exotic terrestrial plants in the spatial unit	10.0
Riparian disturbance	2.2.5 % area of remnant vegetation relative to preclear extent within buffered non-riverine wetland: 500m buffer for wetlands >= 8Ha, 200m buffer for smaller wetlands	10.0
Catchment disturbance	2.3.1 % "agricultural" land-use area (i.e. cropping and horticulture)	8.9
	2.3.2 % "grazing" land-use area	8.4
	2.3.3 % "vegetation" land-use area (i.e. native veg + regrowth)	8.5
	2.3.4 % "settlement" land-use area (i.e. towns, cities, etc)	7.0
Flow modification	2.4.1 Farm storage (overland flow harvesting, floodplain ring	10.0

	tanks, gully dams) calculated by surface area	
Diversity and Richness		
Species	3.1.2 Richness of native fish	9.7
	3.1.3 Richness of native aquatic dependent reptiles	8.4
	3.1.4 Richness of native waterbirds	7.1
	3.1.5 Richness of native aquatic plants (macrophytes)	8.4
	3.1.6 Richness of native amphibians (non-riverine wetland breeders)	8.9
Communities / assemblages	3.2.1 Number of macroinvertebrate taxa (Family level taxonomy)	10.0
Habitat	3.3.2 Richness of wetland types within the local catchment (e.g. SOR1 sub-section)	7.5
	3.3.3 Richness of wetland types within the subcatchment	9.5
Threatened Species and Ecosystems		
Species	4.1.1 Presence of rare or threatened aquatic ecosystem dependent fauna species – NCAct7, EPBCAct8	10.0
Communities / assemblages	4.1.2 Presence of rare or threatened aquatic ecosystem dependent flora species - NCAct6, EPBCAct7	9.9
	4.2.1 % area of "of concern" or "endangered" wetland REs relative to preclear extent	10.0
Priority Species and Ecosystems		
Species	5.1.1 Presence of aquatic ecosystem dependent 'priority' fauna species (Expert Panel list/discussion or other lists such as ASFB9, WWF10, etc)	10.0
	5.1.2 Presence of aquatic ecosystem dependent 'priority' flora species (Expert Panel list/discussion)	8.6
	5.1.3 Habitat for, or presence of, migratory species (Expert Panel list/discussion and/or JAMBA11 / CAMBA12 agreement lists)	7.3
	5.1.4 Habitat for significant numbers of waterbirds (Expert Panel data/discussion)	7.7
Ecosystems	5.2.1 Presence of 'priority' aquatic ecosystem as per Expert Panel lists and/or discussions	10.0
Special Features		
Geomorphic features	6.1.1 Presence of distinct, unique or special geomorphic features (Expert Panel list/discussion)	10.0

Ecological processes	6.2.1 Presence of (or requirement for) distinct, unique or special ecological processes (Expert Panel list/discussion)	10.0
Habitat	6.3.1 Presence of distinct, unique or special habitat (including habitat that functions as refugia or other critical purpose) (Expert Panel list/discussion)	9.4
	6.3.2 Significant wetlands identified by an accepted method such as Ramsar or listed under the Australian Directory of Important Wetlands	8.0
	6.3.3 Ecologically significant wetlands identified through expert opinion and/or documented study	7.9
Hydrological	6.4.1 Presence of distinct, unique or special hydrological regimes (eg. Spring fed stream, ephemeral stream, boggomoss) (Expert Panel list/discussion)	10.0
Connectivity		
Significant species or populations	7.1.2 Possibility for migratory or routine 'passage' of fish and other fully aquatic species (upstream, lateral or downstream movement) within the spatial unit	10.0
Floodplain and wetland ecosystems	7.3.2 Extent to which the wetland retains critical ecological and hydrological connectivity, where it should exist, with floodplains, rivers, groundwater, etc. (Expert Panel)	10.0
Terrestrial ecosystems	7.4.1 The contribution of the spatial unit to the maintenance of terrestrial ecosystems with significant biodiversity values, including those features identified through Criteria 5 and/or 6.	10.0
Estuarine and marine ecosystems	7.5.1 The contribution of the spatial unit to the maintenance of estuarine and marine ecosystems with significant biodiversity values, including those features identified through Criteria 5 and/or 6.	10.0
Representativeness		
Wetland protection	8.1.1 The percent area of each wetland type* within Protected Areas (National Park, State Forest, Conservation Park, Nature Refuge) under the Nature Conservation Act and/or relevant environment or conservation reserves under the Land Act.	10.0
	8.1.2 The percent area of each wetland type* within a coastal/estuarine area subject to the Fisheries Act, Coastal Management Act or Marine Parks Act.	2.0
Wetland uniqueness	8.2.1 The relative abundance of the wetland management group to which the wetland belongs within the catchment or study area (management groups ranked least common to most common)	9.1
	8.2.2 The relative abundance of the wetland management	8.1

	group to which the wetland belongs within the sub-catchment (management groups ranked least common to most common)	
	8.2.3 The size of each wetland relative to others of its management group within the catchment or study area	7.3
	8.2.4 The size of each wetland type* relative to others of its type within a sub-catchment	6.8
	8.2.5 Wetlands representative of the catchment – identified by expert opinion (Expert Panel list/discussion)	6.8
	8.2.6 The size of each wetland type* relative to others of its type within the catchment or study area	8.5