Australia Pacific LNG Project

Volume 5:Attachments

Attachment 17: Aquatic Ecology, Water Quality and Geomorphology Impact Assessment –

Gas Fields

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Australia Pacific LNG Project

Aquatic Ecology, Water Quality and Geomorphology Impact Assessment – Gas Fields

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 transmission pipeline and a Liquified Natural Gas (LNG) facility and associated infrastructure near Gladstone. The Project is divided into two elements – upstream and downstream. The upstream element addresses the gas fields and the associated infrastructure (roads, high pressure pipeline network, etc) that extend beyond the tenement area and main transmission pipeline to the LNG facility. The downstream element addresses the LNG facility 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 fields impact assessment. The impact assessment for the main gas transmission pipeline is provided in Volume 5, Attachment 28 of 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 gas field areas potentially impacted by the Project;
- Characterise the key aquatic habitats occurring within the gas field 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 2009);
- Identify rare, threatened or otherwise noteworthy aquatic flora and fauna species, communities and habitats occurring within the gas field 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 gas field areas potentially impacted by the Project;
- Assess the potential impacts on aquatic ecology, water quality and fluvial geomorphology during the construction, operation and decommissioning phases of the Project;

- Identify measures to mitigate adverse impacts to aquatic ecology, water quality and fluvial geomorphology, where possible;
- Identify strategies to manage any residual impacts following mitigation; and
- Identify monitoring programs to assess the effectiveness of proposed management strategies during the construction, operation and decommissioning phases of the Project.

Existing Environment

The Project could potentially impact aquatic environments within the Condamine-Balonne, Dawson and Border Rivers catchments. Two dry season water quality surveys and one dry season aquatic ecology and geomorphology survey were undertaken at sites throughout these catchments. Information collected during the dry season surveys was used to supplement existing literature to describe the aquatic environment and assess the potential impacts associated with development of the proposed gas fields.

Most of the sites throughout the study area were found to be in a degraded condition, with moderate to poor water quality (elevated nutrients, turbidity, suspended sediment and metals), high geomorphic disturbance and poor aquatic and riparian habitat.

No rare, endangered or otherwise noteworthy fish, macroinvertebrates or aquatic macrophytes were recorded from the sites sampled. However, seven significant species of fish (the EPBC Act listed Murray cod, as well as Silver perch, Purple spotted gudgeon, Olive perchlet, Spotted barramundi, Leathery grunter and Darling River hardyhead) and two species of aquatic macrophytes (the EPBC Act listed Salt pipewort and Artesian milfoil) are known to occur throughout the region, where suitable habitat exists.

Two important wetlands were identified as potentially being impacted by the proposal – Lake Broadwater (wetland of national importance) and the Narran Lakes Nature Reserve (Ramsar listed wetland). In addition, communities associated with artesian mound springs are listed as endangered under the EPBC Act. Numerous artesian springs are known to occur in the vicinity and could potentially be impacted by the Project.

Potential Impacts

Several construction and operation mechanisms were identified that could impact on water quality, aquatic ecology or fluvial geomorphology.

The post mitigation construction risks to the aquatic environment were considered to be low for all impact mechanisms.

The key risks identified during the operational phase were associated with boron concentrations in the proposed permeate discharges and overflows of contaminated water from brine ponds (both assessment as medium risks post mitigation).

Elevated boron concentrations in the permeate discharge could potentially be toxic to aquatic organisms. Toxicity testing should be undertaken and local, specific species sensitivity curves should be established to determine suitable concentrations based on 90 – 95 % species protection levels, in consultation with DERM.

The potential for chemical contamination from brine pond overflow was identified as a medium risk. Detailed stormwater and waste management plans, effective design controls for flooding and adequate vegetated buffers are required to ensure that contaminated water does not enter local watercourses.

Potential Impacts to Matters of National Environmental Significance (MNES)

The risk of impact to MNES was assessed to be low. The residual risk of impact to Murray cod associated with increased sediment delivery and temporary diversion of watercourses during construction was assessed to be low. This was due to this species' natural tolerance to high levels of suspended sediment and turbidity, ongoing stocking programs and the likelihood of rapid recolonisation following barrier removal. Increased flows resulting from permeate discharge are unlikely to directly impact Murray cod populations as spawning requires a combination of elevated temperature (>15 °C) and flow. Their main food resources are frogs, small fish and crayfish, which are unlikely to be directly impacted by elevated flows.

The residual risk of impact to Salt pipewort and Artesian milfoil associated with construction activities was assessed to be low, provided that actively flowing discharge springs are avoided. Potential impacts associated with groundwater drawdown were assessed to be low.

The residual risk of impact to the Narran Lakes wetland, in relation to operational discharges, was assessed to be low. In the absence of detailed modelling, it was inferred that any discharge water that reached E. J. Beardmore Dam would have undergone substantial mixing and assimilation. The additional water could be beneficial to the Narran Lakes.

The residual risk of impact to Lake Broadwater was assessed to be low. Hydraulic modelling is recommended to determine the level of connectivity between Gilbert Gully and Lake Broadwater.

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

Summary of Monitoring Recommendations

The following monitoring recommendations were made:

- Water quality, aquatic biology, aquatic habitat and geomorphic monitoring upstream and downstream of the road and pipeline crossings, prior to and during construction;
- Monthly water quality, quarterly geomorphic and bi-annual biological monitoring upstream and downstream of permeate discharges during operation (to be reviewed after two years)
- A study to determine potential ecotoxicity of the brines; and
- Annual monitoring of geomorphic processes during operation, upstream and downstream of pipeline and road crossings (to be reviewed after two years).

Australia Pacific LNG Project

Aquatic Ecology, Water Quality and Geomorphology Impact Assessment – Gas Fields

March 2010

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ABBREVIATIONS

Abbreviation	Meaning
Al	Aluminium
ANZECC	Australian New Zealand Environment and Conservation Council
Australia Pacific LNG	Australia Pacific Liquified 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
B	Boron
BACI	Before-After-Control-Impact
BGA	Blue Green Algae
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
BAMM	Biodiversity Assessment and Mapping Methodology
Ca	Calcium
CAMBA	China-Australia Migratory Bird Agreement (Cth)
CBWC	Condamine-Balonne Water Committee
CCMA	Condamine Catchment Management Association
Chl*a*	Chlorophyll *a*
Cl^-	Chloride
cm	Centimetre
CPOM	Coarse Particulate Organic Matter
CRCFE	Cooperative Research Centre for Freshwater Ecology
Cu	Copper
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
EECO	Environmental Engineering Company
EFO	Environmental Flow Objectives
EIS	Environmental Impact Statement
EM	Ecology Management
EMP	Environmental Management Plan

Abbreviation	Meaning
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
Fe	Iron
Fisheries Act	Fisheries Act, 1994 (Qld)
FPZs	Functional Process Zones
FRP	Filterable reactive phosphorus
GAB	Great Artesian Basin
GLNG	Gladstone Liquefied Natural Gas
HCO^{-}_{3}	Bicarbonate
HEC-RAS	Hydrologic Engineering Centre River Analysis System
HP	High Pressure
IAS	Initial Advice Statement
ILUA	Indigenous land use agreement
IPA	Integrated Planning Act, 1997 (Qld)
IQQM	Integrated Quantity and Quality Model
IUCN	International Union for Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
K	Potassium
km^2	Square Kilometre
LB	Left Bank
LWD	Large Woody Debris
MDBC	Murray-Darling
Mg	Magnesium
mg/L	milligram per Litre
mg/m^3	milligram per cubic metre
ML / day	mega litres per day
Mn	Manganese
Na	Sodium
NCR	Nature Conservation Regulation
NLWRA	National Land and Water Resources Audit
NO_x	Nitrate + Nitrite
NSW	New South Wales
NTU	Nephelometric Turbidity Units

Abbreviation	Meaning
°C	Degrees Centigrade
OCPs	Organochlorine Pesticides
OPPs	Organpphosphate 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
RFU	Relative Flourescence Units
ROP	Resource Operations Plan
RoW	Right of Way
SA	South Australia
SEAP	Stream and Estuarine Assessment Program
SO_4	Sulphate
SRA	Sustainable Rivers Audit
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TPH	Total Petroleum Hydrocarbons
TSS	Total suspended solids
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.
Australia Pacific LNG joint venture description	Origin and ConocoPhillips are joint owners of Australia Pacific LNG. 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.
Associated water	Underground water taken by a petroleum tenure holder from a gas well. Examples include underground water necessarily or unavoidably taken during the drilling of a gas well or water observation bore; or during gas production.
Baseflow	The amount of groundwater flowing into a river.
Biodiversity	totality of genes, species, and ecosystems of a region
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	Water containing between 1 000 – 35 000 mg/L of dissolved solids.
Brine	Water that contains more than 35 000 mg/L of dissolved solids.
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 determine whether an action is likely to have an impact on matters of national environmental significance. If a project is declared a 'controlled action', development approval is required from the Minister for Environment, Heritage and the Arts.
Downstream component	The main gas delivery pipeline downstream of the Narrows and the LNG plant and associated infrastructure.
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

Descriptor	Preferred wording/meaning
	species 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.
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	Animals.
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 Course Particulate Organic Matter (CPOM).
Flora	Plants.
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 Mechanism	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
Permeate	Treated water discharged after treatment using reverse osmosis
Pipeline	Gas transmission pipeline.
Predators	An Ecological Functional Feeding Group of macroinvertebrates. Predators are animals that require live prey. Some ingest whole animals, others tear off and swallow large pieces, or pierce their prey in order to suck up the body fluids.
Proponent	Australia Pacifica LNG Pty Limited
Quaternary	Geologic time unit covering the past 2.5 million years.

Descriptor	Preferred wording/meaning
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	A person or organisation with an interest or stake in a project.
Stream Power	The rate of energy dissipation against the bed and banks of a river or stream
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.
Project	Australia Pacific LNG project
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.

The Walloons coal seam gas fields cover an area of 570 000 ha in the Queensland Western Downs region. Australia Pacific LNGs development plan will include up to 10,000 wells over a 30 year project lifespan. Gas and water gathering systems will be developed for delivery to gas plant facilities and water treatment facilities respectively. Associated infrastructure will include roads and access tracks, storage ponds, camps, communication infrastructure and other logistics support areas.

Hydrobiology was commissioned by WorleyParsons on behalf of Australia Pacific LNG Pty Limited to describe the existing environmental values and assess the potential impacts of the upstream components of the Project on aquatic ecology, water quality, aquatic habitat and fluvial geomorphology. This report presents the outcomes of the gas fields impact assessment. The impact assessment for the main gas transmission pipeline is provided inVolume 5, Attachment 28 of 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 gas transmission pipeline (approximately 450 km) extending from the northern Walloons area to the proposed LNG facility; and
- Associated infrastructure, such as access roads, accommodation camps, equipment stores, power and communications systems.

1.1.2 Water management

Given the large volumes of associated water that will be produced as part of the Project, a thorough understanding of the proposed water management strategy is of key importance to identifying the potential impacts on the aquatic environment. Options for water management have been identified

and a preferred water management option is currently being developed. For the purposes of this impact assessment, the following represents our understanding of the proposed water management strategy at the time of writing:

- Associated water will be conveyed via transmission pipelines to water treatment facilities within a low pressure gathering network;
- Seven potential sites (including the existing Talinga site) have been identified for the construction of water treatment facilities;
- Water will be treated using a range of processes, including desalination by reverse osmosis (RO);
- Treated water (permeate) will be managed in a sustainable manner. This may include reuse for irrigation, municipal and/or industrial purposes; or disposal by aquifer reinjection and/or discharge to streams, and
- Treatment wastes, such as brine, will be stored in lined evaporation ponds.

1.2 Scope and Objectives

This report describes the existing environment and provides an assessment of potential impacts associated with the gas fields components of the Project on aquatic ecology, water quality, aquatic habitat and fluvial geomorphology. The report does not address the potential impacts associated with the main gas transmission pipeline or the LNG facility. These are addressed in separate documents as part of the EIS (Volume 5, Attachments 28 and 34).

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 25).

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 2009);
- 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 condition1 (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; and
- Identify suitable 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 of the following assumptions and limitations:

- Only one round of (dry season) ecological and geomorphic and two rounds of (dry season) water quality monitoring have been undertaken. An additional wet season survey is proposed;
- Due to delays in field surveys and project scope variations, some data were not available for inclusion in this report. This has been noted throughout the report and results will be included as they become available; and
- The impact assessment was based on knowledge of the known locations and details of the Project components at the time of writing. It is assumed that additional analysis and impact assessment will be required as more information (e.g. modelling outcomes) become available.

1.4 Relevant Legislative Framework

Relevant Commonwealth and Queensland policies and legislation applicable to the management of aquatic ecology, water quality and geomorphology for the gas fields component of the Project are summarised in Table 1-1.

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

Table 1-1 Relevant Policies 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

Policy or legislative instrument	Description	Relevant
		2000 provides the framework for the sustainable allocation of water 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 gas fields component of the Project was lodged with DEWHA on 6 July 2009 (referral number: 2009/4974).

On 3 August 2009, the Project was declared a Controlled Action which included the potential impacts on Wetlands of International Importance (Sections 16 and 17B) and Listed threatened species and ecological communities (Sections 18 and 18A). In relation to aquatic ecology, the following MNES could potentially be impacted by the Project:

- Maccullochella peelii peelii (Murray cod);
- The Narran Lakes Wetland Complex; and
- Great Artesian Basin Spring Communities - specifically, Eriocaulon carsonii (Salt pipewort or button grass) and Myriophyllum artesium (Artesian milfoil).

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 Sections 0 and 4.5.3.

2. Location and study sites

2.1 Gas Fields

The Walloons coal seam gas fields cover an area of 570 000 ha in the Queensland Western Downs region (Figure 2-1). The following eight gas fields will be progressively developed over a period of 30 years:

- Combabula/Ramyard;
- Wooleebee;
- Carinya;
- Condabri;
- Talinga/Orana;
- Dalwogan;
- Kainama; and
- Gilbert Gully.

The majority of the gas fields development footprint (including gas wells, gas and water gathering pipelines, gas plants, water storage and water treatment facilities) are located within the Condamine-Balonne and Dawson catchments, with a portion of the southern development area (Gilbert Gully) located within the Border Rivers catchment. Streams within these catchments generally experience long periods of low or zero flows during which the larger systems (e.g. the Condamine River, Dawson River Dogwood Creek etc) reduce to a series of pools and waterholes and smaller tributaries (e.g. Weimbulla Creek, Yuleba Creek etc) completely dry up.

2.2 General Catchment Descriptions

2.2.1 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).

There are numerous water storages and weirs along the Condamine River, with the largest being Leslie Dam (107 000 Ml) and Cooby Creek Dam (23 100 Ml) (Clayton *et al.* 2008). Water infrastructure within or in close proximity to the Project area includes:

- Chinchilla and Warra Weirs (Condamine River);
- Chinchilla Town Weir (Charley's Creek);

- Brigalow Creek Weir (Brigalow Creek);
- Wallumbilla Weir (Wallumbilla Creek); and
- Dogwood Creek and Gilmore Weirs (Dogwood Creek).

In addition, there are considerable water allocations within the catchment, including:

- A mean annual diversion upstream of Chinchilla of around 30-35% of mean natural flow, including diversions for water-harvesting, area "hectare" licences, Upper Condamine and Chinchilla Weir Irrigation Projects and other demands (CCMA 1999); and
- A maximum of 86.4 ML/d extraction for most Condamine River catchment properties.

Surface and groundwaters in the Condamine Catchment are considered to be at maximum capacity or over allocated (Clayton *et al.* 2008)

2.2.2 Dawson River Catchment

The Dawson River catchment is a sub-catchment of the Fitzroy Basin. It has a total area of about 50 800 km^2 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. From here, 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.

2.2.3 Border Rivers Catchment

The Border Rivers catchment is located on the Queensland / New South Wales (NSW) border and covers about 50 000 km^2. The south-eastern headwaters drain the Great Dividing Range in NSW, whereas the north-west headwaters border the southern section of the Condamine River catchment near Millmerran. The catchment comprises several major sub-catchments. These are:

- Weir River, which drains the north-eastern section of the catchment;
- Macintyre River, which drains the southern part of the catchment;
- Dumaresq River which drains the eastern section of the catchment; and
- Macintyre Brook which also drains part of the eastern section of the catchment.

No major project infrastructure occurs within the Project area in the Border Rivers catchment.

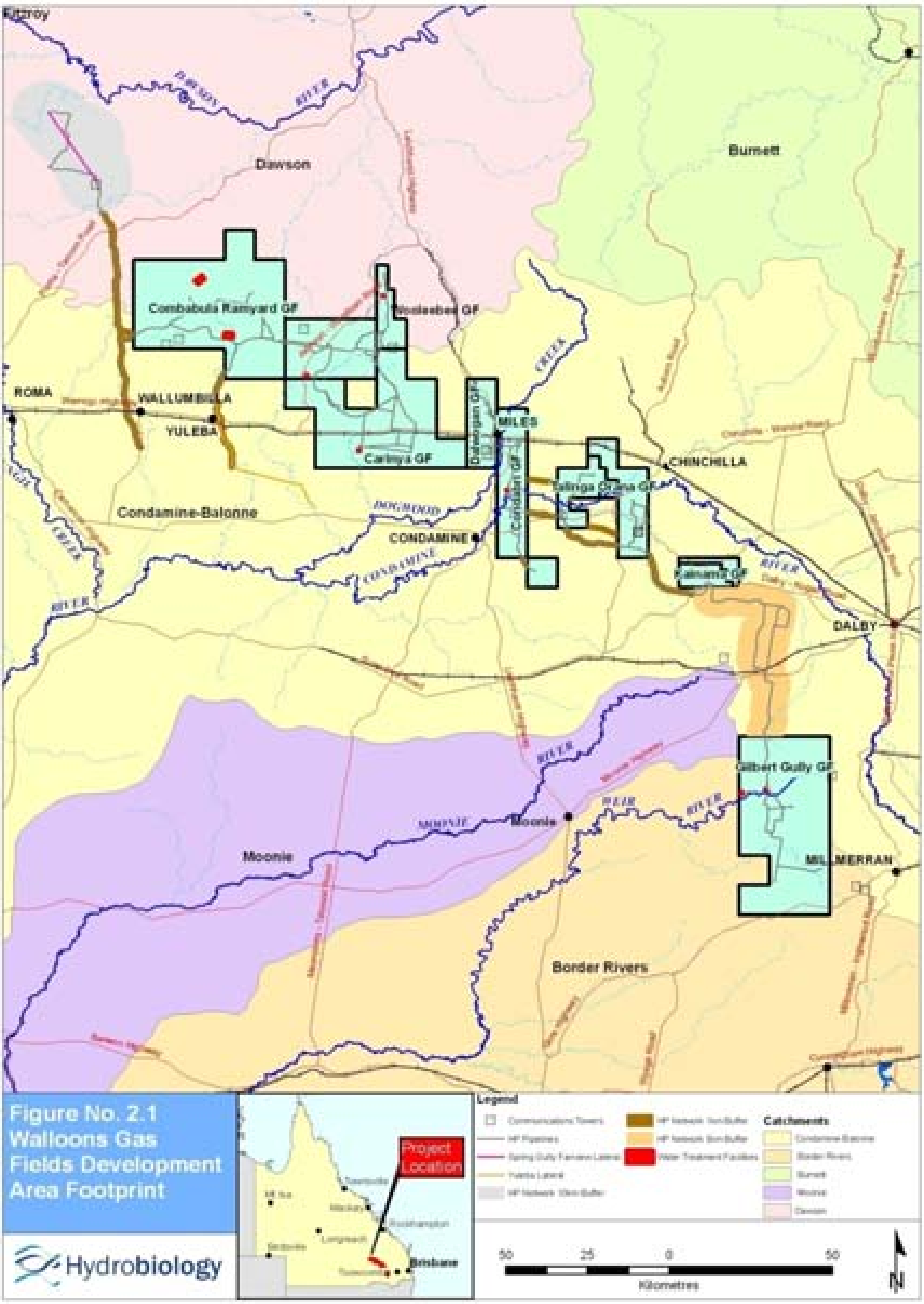

Figure 2-1 Walloons Gas Fields Development Area Footprint

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 suitable waterbodies to be sampled according to habitat features, accessibility and availability of water.

The initial study design was based on the principles of the before-after-control-impact (BACI) study design. However, the selection of suitable reference (and in some cases impact) sites proved difficult due to existing land use practices and/or land access constraints. Final sampling sites were selected to provide representative examples of stream types, habitats and ecological features and to adequately assess the range of potential impacts throughout the gas fields. Reference sites were selected, where possible.

Due to changes in scope, additional sites were added to the survey program in late August 2009 to assess potential impacts associated with the high pressure (HP) pipeline network (including the network linking Walloons Gas Fields to the existing Spring Gully and Fairview Gas Fields) and network connection to the Gilbert Gully gas development area.

Sampling site locations are provided in Figure 2-2.

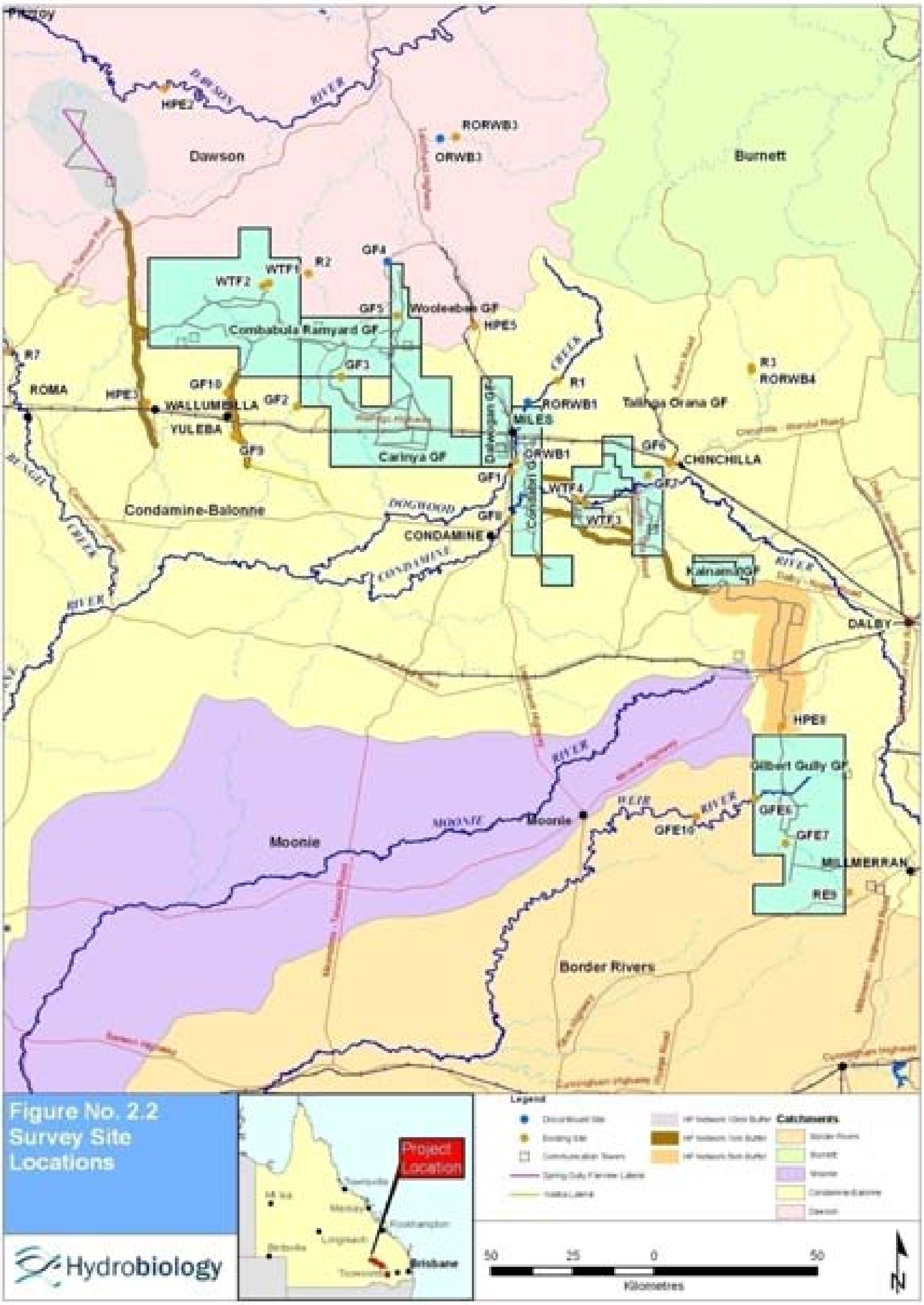

Figure 2-2 Survey Site Locations

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 in 2009:

- 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.

During the above dates, each site (where suitable habitat existed and site access was granted) was surveyed once for aquatic ecology, once for geomorphology and twice for water quality. A summary of survey dates and types is provided in Table 3-1.

With the exception of spring fed streams (e.g. HPE2), most waterways in the gas fields area were ephemeral or intermittent and a number of sites were dry during sampling. Where water was present, sampling was generally confined to small (non-flowing) pools.

A key issue in designing monitoring programs for intermittent waterbodies 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 habitat is lost (surface area / volume) and physical and chemical extremes occur (e.g. high temperatures, low dissolved oxygen, concentrated salinity and nutrients etc (Arthington *et al.* 2005, Masgoulick 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, pH, Chlorophyll *a* (Chl*a*) and blue green algae (BGA)) 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, Ca, Mg, Na, Cl, SO4, HCO3);
- Total and dissolved nutrients (TN, TP, FRP, NO2 + NO3, NH4);
- Pesticides (OCPs, OPPs);
- Hydrocarbons (BTEX, TPH, PAH); and
- Total and dissolved metals (B, Al, Cu, Fe, Mn).

Samples were also collected at four sites for laboratory analysis of Chl*a* and blue green algae identification and enumeration. Samples collected for blue green algae were preserved with Lugols iodine. Samples collected for Chl*a* were filtered in the field using 0.45 µm filters. Filter papers were stored in foil and kept in the dark prior to delivery to the laboratory.

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

All 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	River	Site Type	Date	Fish	Macroinvertebrates	Water Quality	Geomorphology	Habitat
Dawson Catchment								
WTF1	Horse Creek	Water Treatment Facility	30/06/09 (Reconnaissance); 29/07/09 (Geomorphology)	-	-	-	✓	-
WTF2	Horse Creek	Water Treatment Facility	30/06/09 (Reconnaissance)	-	-	-	-	✓
GF5	Wooleebee Creek	Gasfield	6/08/2009; 28/07/09 (Geomorphology)	✓	✓	✓	✓	✓
R2	Horse Creek	Gasfield (Reference)	29/07/2009	-	-	-	✓	-
HPE2	Dawson River	HP Pipeline	2/10/2009	✓	✓	✓	✓	✓
HPE5	Juandah Creek	HP Pipeline	8/09/2009; 30/9/09 (Geomorphology)	-	-	-	✓	-
GF4	Wooleebee Creek	Gasfield	Not sampled	-	-	-	-	-
Condamine-Balonne Catchment								
WTF3	Condamine River	Water Treatment Facility	24/06/2009	✓	✓	✓	✓	✓
WTF4	Condamine River	Water Treatment Facility	23/06/2009	✓	✓	✓	✓	✓
GF1	Dogwood Creek	Gasfield	26/06/2009; 25/06/09 (Geomorphology)	✓	✓	✓	✓	✓
GF2	Tchanning Creek	Gasfield	6/08/2009; 28/07/09 (Geomorphology)	✓	✓	✓	✓	✓
GF3	Tchanning Creek	Gasfield	27/06/2009; 26/05/09 (Geomorphology)	✓	✓	✓	✓	✓
GF6	Charleys Creek	Gasfield	24/06/2009; 31/07/09 (Geomorphology)	✓	✓	✓	✓	✓
GF6a	Rocky Creek	Gasfield	23/06/09 (Geomorphology)	-	-	-	✓	-
GF7	Charleys Creek	Gasfield	5/08/2009; 01/08/09 (Geomorphology)	✓	✓	✓	✓	✓
GF8	Condamine River	Gasfield	26/06/2009; 25/06/09 (Geomorphology)	✓	✓	✓	✓	✓
GF9	Yuleba Creek	Gasfield	29/06/2009; 30/07/09	✓	✓	✓	✓	✓

Site	River	Site Type	Date	Fish	Macroinvertebrates	Water Quality	Geomorphology	Habitat
			(Geomorphology)					
GF10	Yuleba Creek	Gasfield	30/06/2009; 30/07/09 (Geomorphology)	✓	✓	✓	✓	✓
ORWB1	Adjacent to Dogwood Creek	Gasfield (ORWB)	25/06/09 (Geomorphology)	-	-	-	✓	-
RORWB 4	Adjacent to Charleys Creek	Gasfield (Reference ORWB)	25/06/2009; 24/06/09 (Geomorphology)	✓	✓	✓	✓	✓
R1	Dogwood Creek	Gasfield (Reference)	27/06/2009; 26/06/09 (Geomorphology)	✓	✓	✓	✓	✓
R3	Charleys Creek	Gasfield (Reference)	25/06/2009; 24/06/09 (Geomorphology)	✓	✓	✓	✓	✓
R7	Bungil Creek	Gasfield (Reference)	1/07/2009; 31/07/09 (Geomorphology)	✓	✓	✓	✓	✓
HPE3	Wallumbilla Creek	HP Pipeline	30/09/2009	-	-	-	✓	-
HPE8	Wilkie Creek	HP Pipeline	29/09/09	-	-	✓	✓	✓
RE9	Western Creek	Gasfield (Reference)	28/09/2010	-	-	-	✓	-
RORWB 1	Adjacent to Dogwood Creek	Gasfield (Reference ORWB)	Not sampled	-	-	-	-	-
Border Rivers Catchment (note that all sites were dry at the time of sampling)								
GFE6	Weir River	Gasfield	29/09/2009	-	-	-	✓	-
GFE7	Western Creek	Gasfield	28/09/2009	-	-	-	✓	-
GFE10	Weir River	Gasfield	30/09/2009	-	-	-	✓	-

Table 3-2 Analytical methods and detection limits

Analyte	Method	Detection Limits
Total Metals (Al, Cu, Mn, B, Fe)	USEPA 6020 (ICP-MS)	Al (0.01 mg/L); Cu (0.001 mg/L); Mn (0.001 mg/L); B (0.05 mg/L); Fe (0.05 mg/L)
Dissolved Metals (Al, Cu, Mn, B, Fe)	USEPA 6020 (ICP-MS)	
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	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

Analyte	Method	Detection Limits
(PAH)		(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 xylenes (BTEX)	US EPA 5030/8260 GC/MS	Benzene (1 µg/L); Toluene (2 µg/L); Ethylbenzene (2 µg/L); meta- & para-Xylene (2 µg/L); ortho-Xylene (2 µg/L).
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 metal and FRP results from this trip were not used. These filters were also used in June/July for P1, P5, and P7 and so FRP results were not reported for those samples;
- The temperature probe malfunctioned during the August field trip and therefore these data were not available;

pH was recorded only on the second sampling occasion for sites GF2, GF10 and GF9;

- Blanks from June/July indicated contamination with TPHs (C6-C9). Analysis of the original water used for blanks did not indicate any contamination and analysis of the blank water by a secondary laboratory did not detect any TPH (C6-C9). This may be due to the time delay in before analysis (TPH are semi-volatile). However, no TPHs (C6-C9) were detected in the samples and so it is likely the blank water was the source;
- It was not possible to calibrate the Chla and BGA probes on the YSI as laboratory Chla concentrations were very low for all except one data point. Laboratory measured concentrations of Chla were generally at or below 1 mg/m3 (see Figure 2-1). Additional Chla samples will be collected during the wet season sampling to attempt retrospective calibration and reporting.

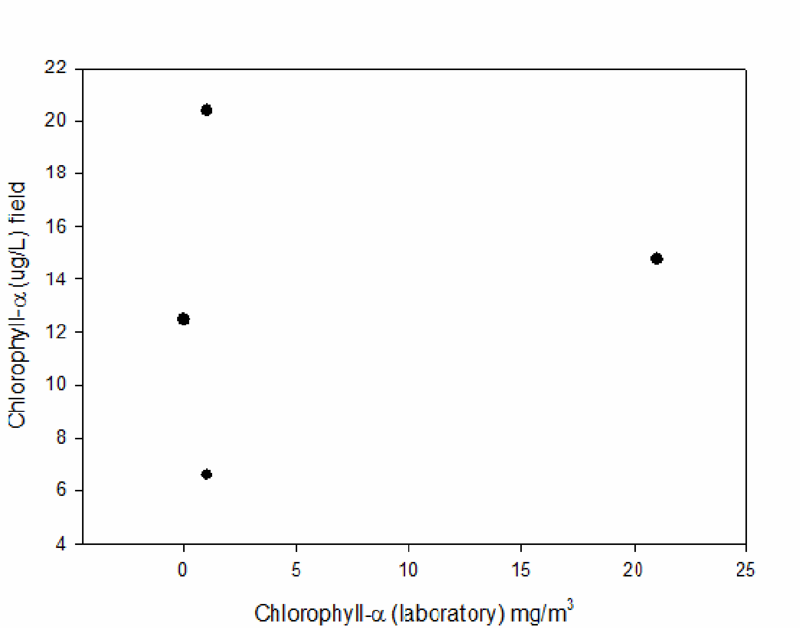

Figure 3-1 Relationship between field and laboratory Chla

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 suspended materials. TDS is usually between 0.5 and 1.0 times the electrical conductivity.

There was no significant relationship between TDS and conductivity (Figure 3-2). The reasons for this were not clear. Further analysis will be undertaken on data collected during the wet season sampling.

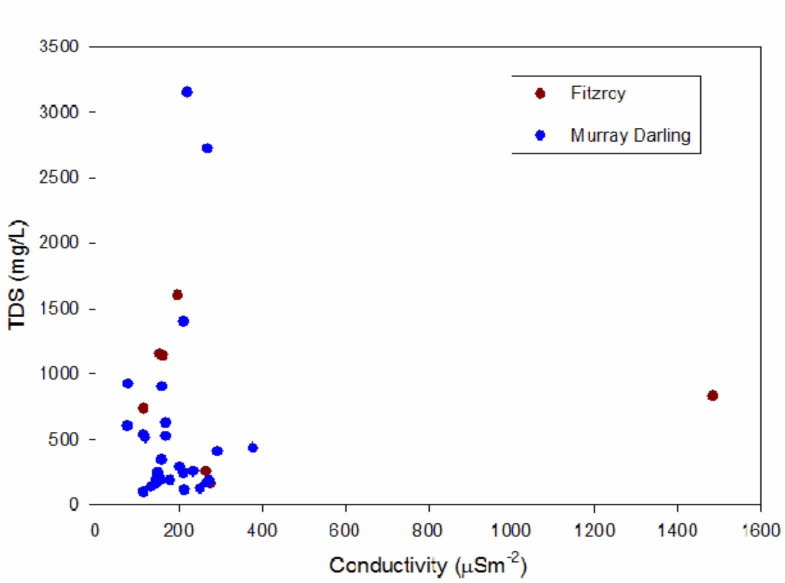

Figure 3-2 Relationship between TDS and conductivity

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 and (ANZECC / ARMCANZ, 2000) and the Queensland Water Quality Guidelines (DERM 2009). Comparisons were also made to historical data collected by NRW (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 were set at each site for a period of two hours. Traps were set according to scientific permitting conditions.

Fish and macrocrustaceans were identified to species level in the field, weighed and measured. 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), biomass and 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 to 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, Nemertea 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 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 abundace 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.

There was a relatively poor representation of Caenidae specimens [4 nymphs] in the live-pick from WTF4, as they were the most abundant taxon in the residue (present in hundreds). Therefore, results from this site should refer to taxa richness only rather than abundance.

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

3.5 Fluvial 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, Condamine 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).

At potential water treatment facility sites, an investigative geomorphic assessment was conducted in conjunction with the above rigid proforma-based methods. The assessment entailed a traverse of the stream for approximately one kilometre downstream of the proposed discharge points to characterise the current geomorphic condition and to identify active processes and trends in consideration of the potential impacts from releasing water into the channels.

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, according to 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 projct. The potential impacts associated with each mechanisms were described and the information was used for 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. In order to maintain consistency with other technical areas, Hydrobiology was required to use the Project Risk Matrix. However, the consequence descriptors were tailored to better reflect the potential consequences 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 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 suitable 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, two rounds of dry season water quality sampling have been undertaken for this study. Samples were collected from 17 sites. An additional 13 sites were either dry, did not contain sufficient water to sample or for which no site access was granted (refer to Table 3-1). All sites within the Border Rivers Catchment were dry at the time of sampling.

During the various sampling periods, the waterways throughout the study area were generally either dry or had receded to a series of unconnected pools. The only exception to this was HPE2 located on the Upper Dawson River, which was presumed to be spring fed. Standing waterbodies 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 waterbody starts to refill. In addition, higher temperatures increase microbial decomposition and oxygen demand, resulting in remobilisation of dissolved nutrients and metals (Smith *et al*. 2004).

Given that ephemeral and intermittent waterbodies experience natural seasonal changes in chemical and physical status, an accurate comparison of sampling data to the relevant national and state water quality guidelines was not possible. These guidelines were established mainly for flowing waters within streams, estuaries and marine waters, or standing water bodies within wetlands and lakes. Notwithstanding this, a comparison was made to gain an understanding of the physical and chemical condition of the waterbodies at the time and how this changed throughout the dry season. Further wet season sampling is proposed during January-February 2010 (weather dependent).

The Queensland Water Quality Guidelines 2009 (QWQG) generally adopts 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 (2009) guidelines relevant to the study area. Generally, the QWQG (2009) refer users to the ANZECC /ARMCANZ (2000) guidelines for rivers within the Murray-Darling basin, as there is insufficient information for the region to develop local guidelines. In accordance with the QWQG, The Condamine-Balonne and Border Rivers are classified as Upland rivers within the Murray-Darling Coast and the Dawson River classified as an

Upland river within the Central Coast. For the purposes of this assessment, the QWQG was used as the default guidelines for comparison, where no Queensland guideline value existed.

Table 4-1 ANZECC / ARMCANZ and QWQG relevant to the Walloons Gas Field Development Area

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
Chlorophyll-a mg/L		-	
DO % saturation	90-110	90-110	ANZECC
Turbidity NTU	2-25	25	ANZECC
pH	6.5-7.5	6.5-7.5	ANZECC
Conductivity µS/cm at 25°C	30-350	340	500 (Condamine)

Table 4-2 lists the dissolved metals of concern for this study, with the relevant ANZECC/ARMCANZ (2000) trigger levels for the 95% protection level for biota. These figures were used in the absence of relevant QWQG.

Table 4-2 ANZECC / ARMCANZ 95 % protection levels for biota (dissolved metals)

Parameter	95 % Protection Level
Aluminium mg/L	0.055
Boron mg/L	0.37
Copper mg/L*	0.0014
Iron mg/L	-
Manganese mg/L	1.9

*ANZECC/ARMCANZ default trigger level suitable for soft waters

4.1.2 Temperature and dissolved oxygen

Surface water temperature increased by several degrees between the two dry season surveys (survey dates are provided in 3.1 and Table 3-1). Temperature ranged between 9.8 °C and 16.3 ºC during the first dry season survey and 15.9 ºC and 22.9 °C during the second dry season survey (Figure 4-1 and Figure 4-2). The greatest increase was for site GF8 on the Condamine River (9 ºC). However, temperatures increased by 1-2 degrees at most sites. This was caused by a combination of higher

ambient air temperatures during the second dry season survey, reduced water volumes and diurnal variations.

Dissolved oxygen concentrations were lower than the QWQG range of 90-110 % saturation at all sites during the first dry season survey (Figure 4-1 and Figure 4-2). The lowest dissolved oxygen concentrations were recorded at GF7 on Charleys Creek (28.6 %) and ROWRB4 adjacent to Charleys Creek (34.9 %). The highest was at GF6 on Charleys Creek (85.6 %). This is expected as none of the sites (with the exception of HPE2 on the Upper Dawson River) were 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).

Similarly low dissolved oxygen concentrations were recorded during the second dry season survey at most sites, although HPE2 (Upper Dawson River), GF5 (Wooleebee Creek) and R1 (Dogwood Creek) were within the QWQG. Dissolved oxygen was supersaturated (123 %) at RORWB4 in September. Dissolved oxygen concentrations undergo diurnal variation in response to cycles of photosynthesis and respiration and are generally lowest first thing in the morning and highest in the late afternoon. It was postulated that the high concentrations of dissolved oxygen recorded at this site in the second survey may have been a result of diurnal variation. Another cause could be increased algal metabolism at higher temperatures, resulting in a phytoplankton blooms. However, this is not reflected in the pH (as this was higher during the first survey). The reasons for the increased dissolved oxygen concentrations at sites HPE2, GF5 and R1 between sampling occasions is not known, but could be a result of diurnal changes (GF5 and HPE2 only as R1 was sampled at a similar time on both occasions) or from enhanced mixing due to recent inflows. Smith *et al.* (2004) point out that high dissolved oxygen is a common penultimate stage for temporary waters.

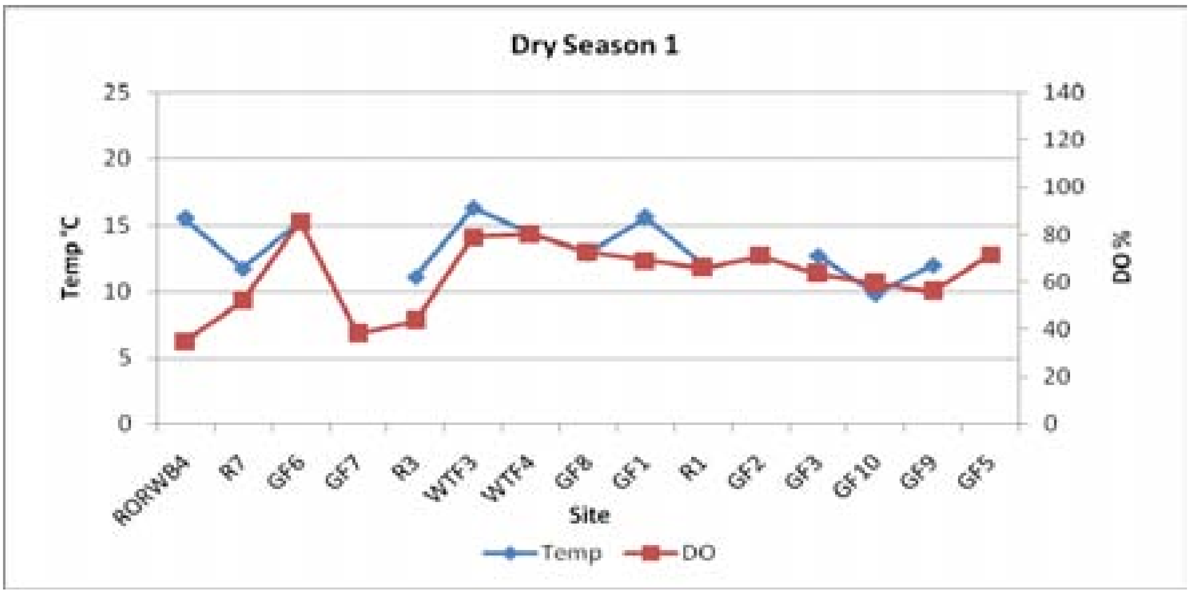

Figure 4-1 Temperature and dissolved oxygen Dry Season 1

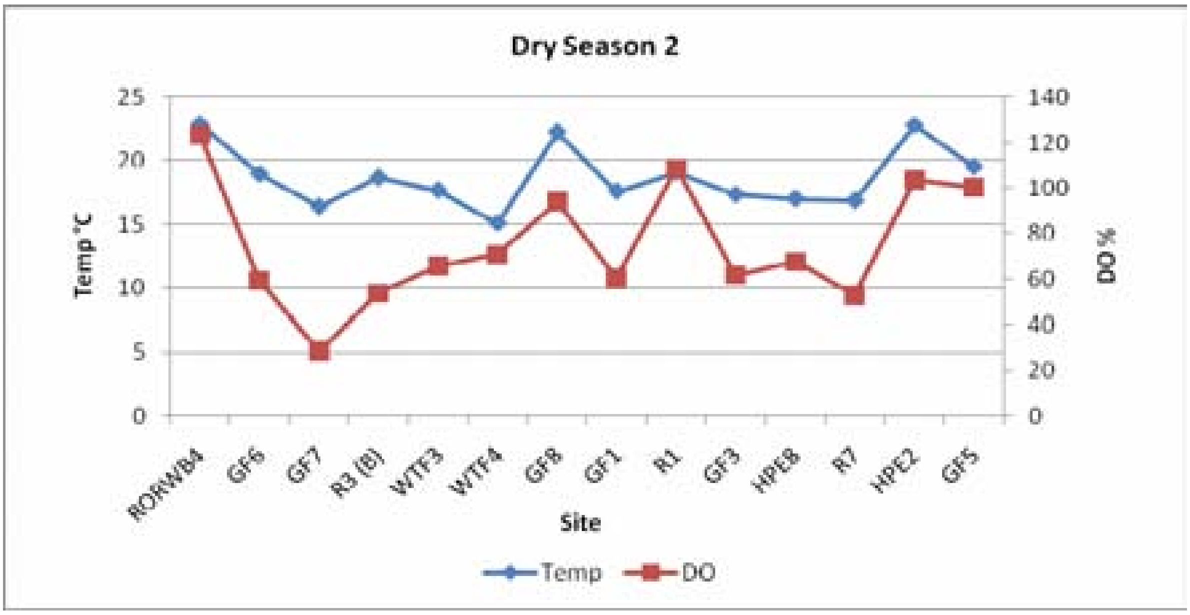

Figure 4-2 Temperature and dissolved oxygen Dry Season 2

4.1.3 Salinity

Conductivity was within QWQG for all sites within the Condamine-Balonne and Dawson catchments (Figure 4-3 and Figure 4-4). WTF3 on the Condamine River, reported the highest conductivity level (378 µs/cm), but was still well within the guideline level for the Condamine of 500 µs/cm. TDS was elevated at GF7 (Charleys Creek) on both sampling occasions, although this did not appear to correspond with conductivity levels at this site. As reported earlier, there appears to be no correlation between conductivity and total dissolved solids. Further assessment should be carried out following the wet season surveys.

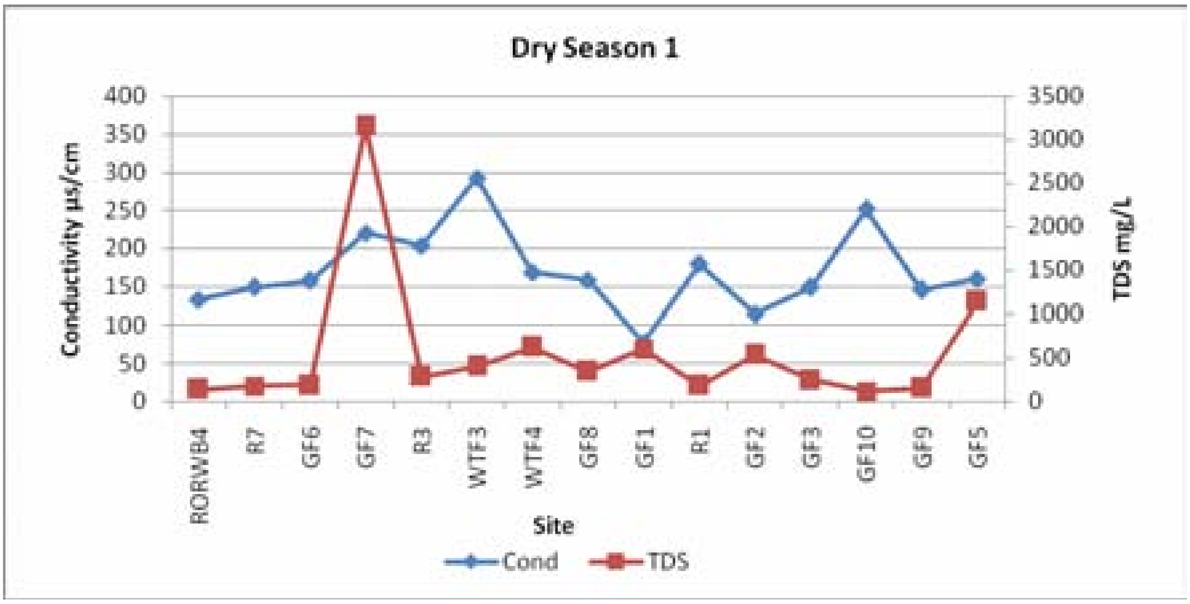

Figure 4-3 Conductivity and TDS – Dry season 1

The low conductivity and TDS (and low concentrations of other parameters) at HPE2 did not appear to indicate that there was a good hydraulic connection between surface and groundwater at this site, despite the less turbid water and sustained flow. Further investigations as to the source of water within the Upper Dawson should be undertaken during the wet season surveys.

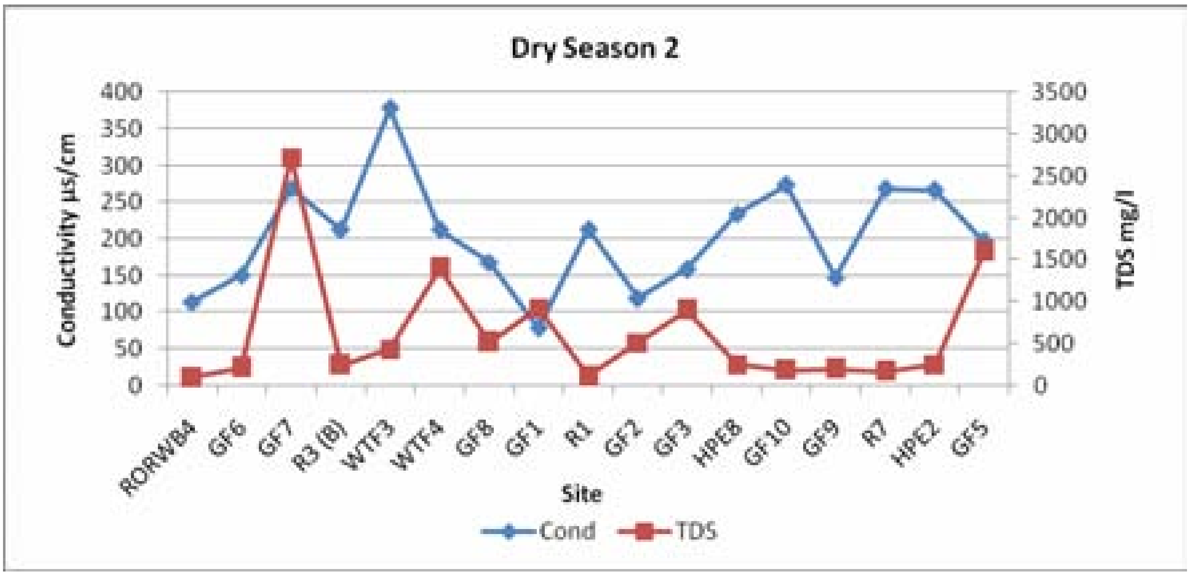

Figure 4-4 Conductivity and TDS - Dry Season 2

Both the Dawson and Condamine-Balonne catchments had a reasonably well balanced mix of magnesium, sodium and calcium with bicarbonate predominating over chloride (Figure 4-5). This is expected in actively weathering catchments that receive water from multiple surface runoff and groundwater sources.

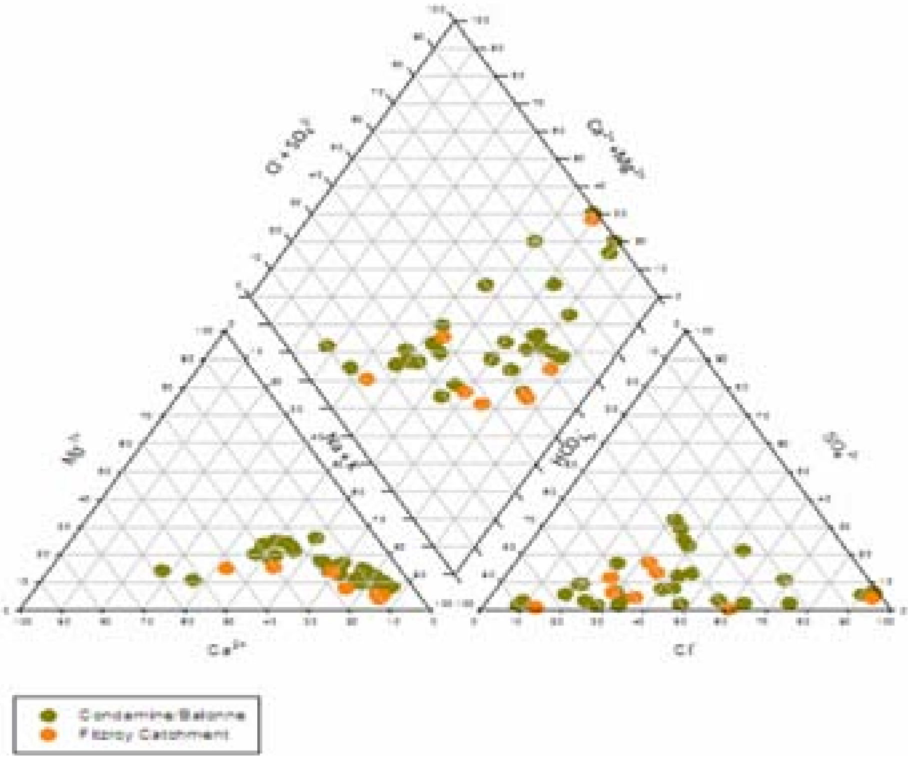

Figure 4-5 Proportion of major cations and anions in the Condamine-Balonne and Fitzroy catchments.

4.1.4 pH

pH ranged between 5.4 units (R1 in September) and 8.4 units (GF8 on the Condamine River in June) (Figure 4-6 and Figure 4-7. The majority of sites were outside the QWQG range of 6.5 to 7.5 during the first dry season survey. However, while most sites were within the QWQG range during the second dry season survey, RORWB4 (adjacent to Charleys Creek), GF1 (Dogwood Creek) and R7 (Bungil Creek) were slightly elevated (7.5, 7.8 and 7.7, respectively) and R1 was low (see above). Further monitoring should be considered to further define baseline pH and long term trends within the catchments.

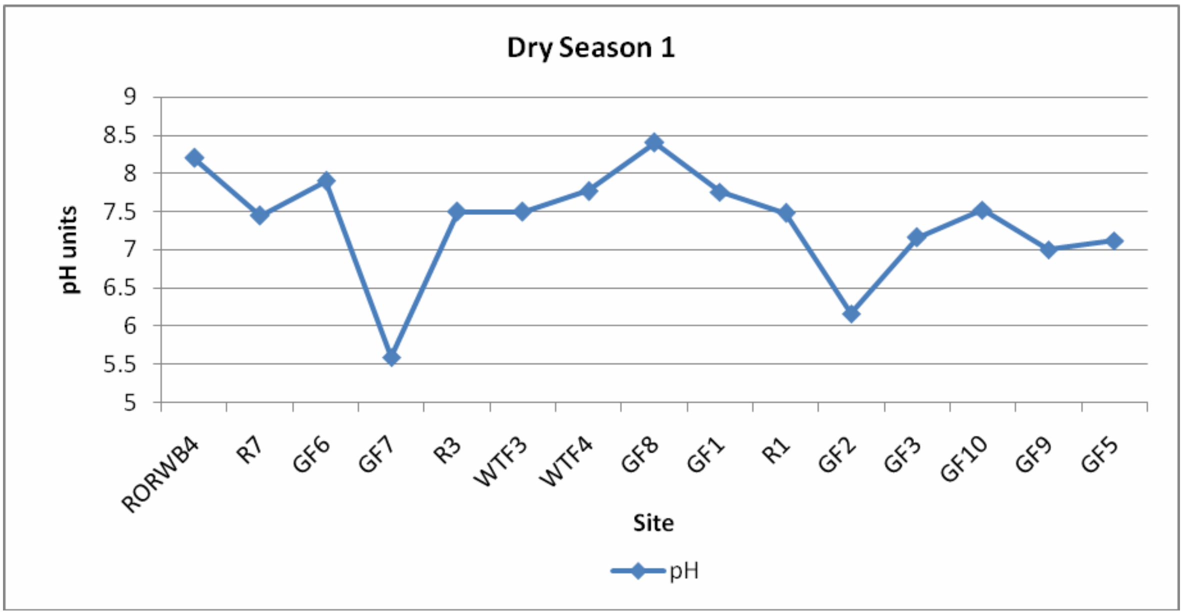

Figure 4-6 pH - Dry Season 1

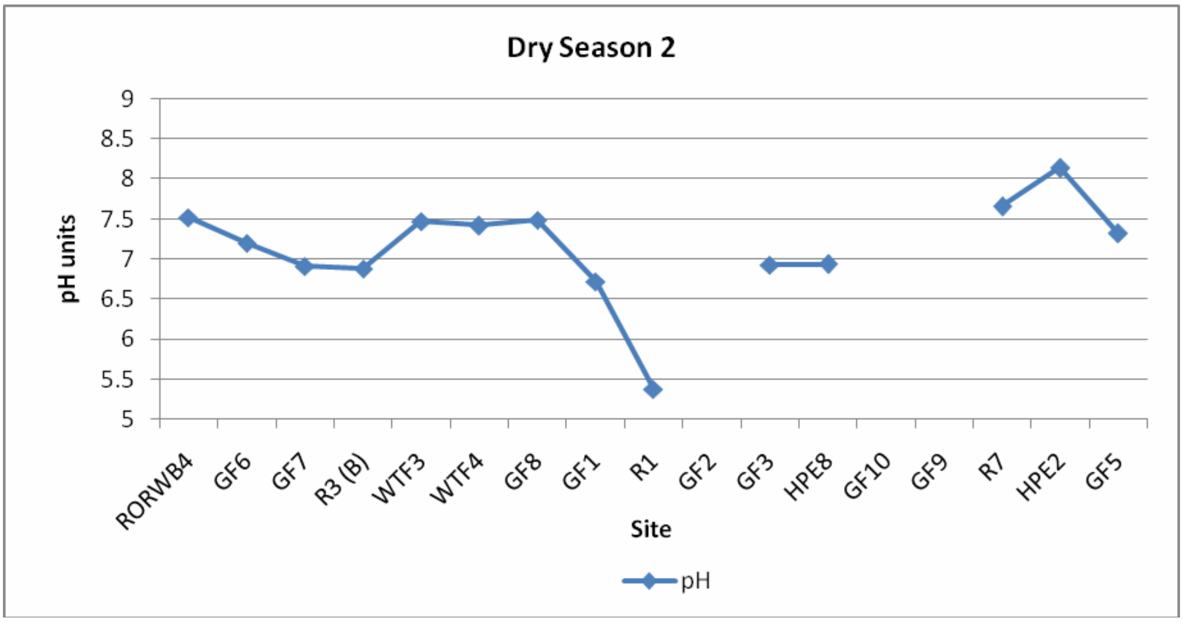

Figure 4-7 pH - Dry Season 2

4.1.5 Turbidity and Suspended Solids

Turbidity exceeded the QWQG at all sites within the Condamine-Balonne catchment, with the exception of R3 (Charleys Creek) and WTF4 (Condamine River) in June (2 and 1 NTU, respectively). Site GF5 (Wooleebee Creek) in the upper Dawson River also reported very low turbidity levels (3.5 NTU) in September (Figure 4-8 and Figure 4-9). However, these levels were unusually low in comparison to other sites (and the same sites on different sampling occasions) and did not provide an accurate reflection of the conditions observed at these sites when sampled. Therefore, it was concluded that these results were either reported incorrectly or the turbidity probe malfunctioned at

these times. GF7 on Charleys Creek recorded the highest turbidity levels on both sampling occasions (1 195 NTU in June and 1 198 NTU in September), which corresponded to the highest levels of total suspended solids (TSS) throughout the study area (476 mg/L in June and 1 290 mg/L in September).

These high 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 only site that recorded turbidity levels within the QWQG (1.3 NTU) was HPE2 on the Upper Dawson River near Injune. TSS was similarly low at this site (14 mg/L). HPE2 is located downstream from known artesian springs and was the only site flowing at the time of sampling, indicating that this site may be spring fed, which is reflected in the low turbidity and TSS levels (although not in other parameters – see 4.1.3).

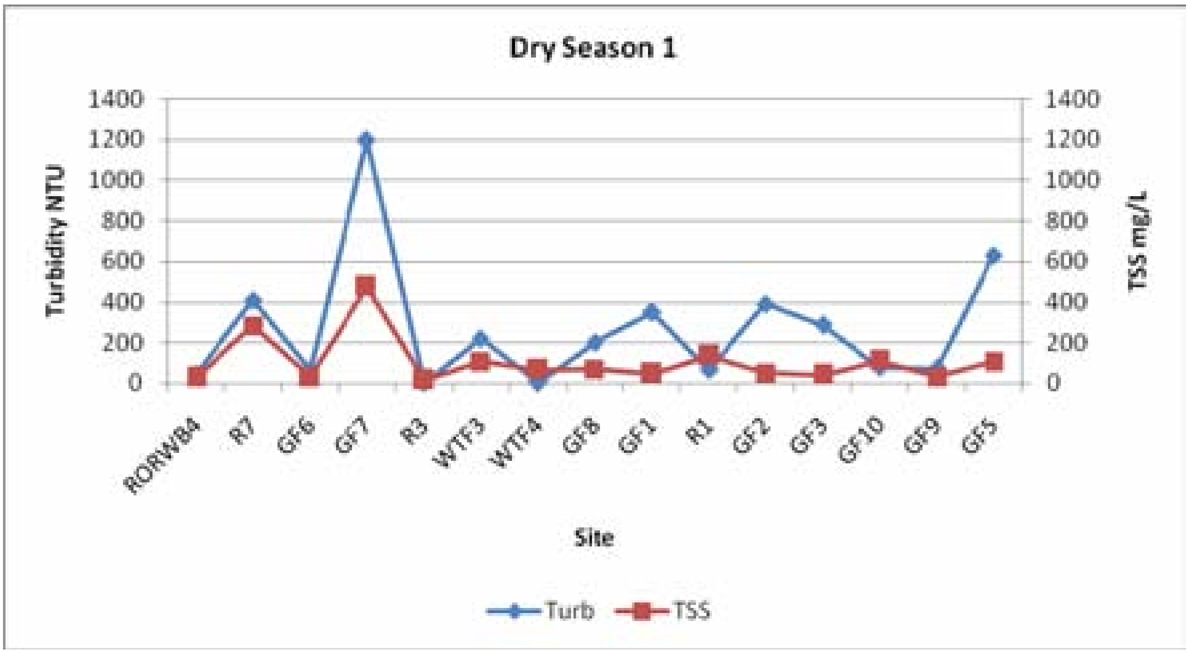

Figure 4-8 Turbidity and TSS - Dry Season 1

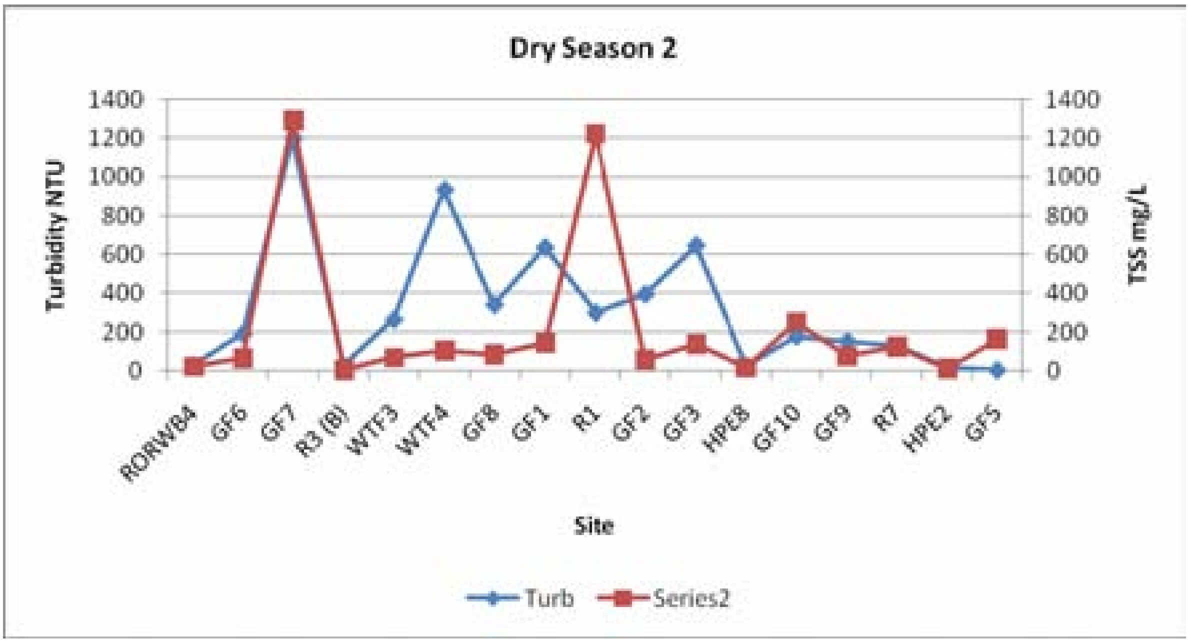

Figure 4-9 Turbidity and TSS - Dry Season 2

4.1.6 Nitrogen

Total nitrogen exceeded QWQG levels at all sites and the majority of this was Kjeldahl nitrogen, indicating that most nitrogen was present in organic form (Figure 4-10 and Figure 4-11). Very high concentrations of total nitrogen were recorded at sites GF7 (Charleys Creek), R1 (Dogwood Creek) and GF5 (Wooleebee Creek) during the second dry season survey (6.2, 6.4 and 10.1 mg/L, respectively). The large difference between total nitrogen and total kjeldahl nitrogen at GF5 during the second dry season survey indicated that a large proportion of the nitrogen was inorganic (mainly NOx). NOx and NH_4 are the preferred sources of nitrogen for biological metabolism.

Ammonia exceeded the QWQG at the majority of sites during the first dry season survey, with the exception of RORWB4, GF6, R3 (Charleys Creek), WTF3, WTF4 (Condamine River) and GF1 (Dogwood Creek), which were all less than detection limits. Ammonia exceeded the QWQG at all sites during the second dry season survey. Similarly, NOx exceeded the QWQG for most sites except GF6 (June) and RORWB4 (June and September) and R1 (September) and was several orders of magnitude higher than guideline values at GF5 (6.78 mg/L) during the second survey (Figure 4-12 and Figure 4-13).

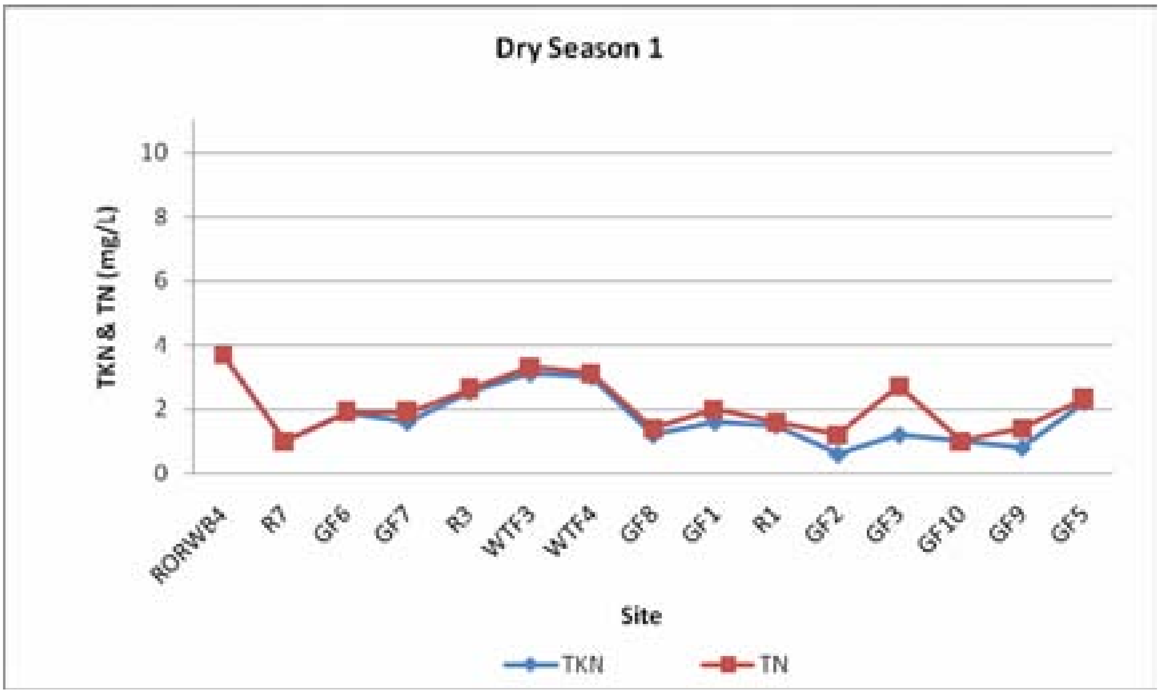

Figure 4-10 TN and TKN - Dry Season 1

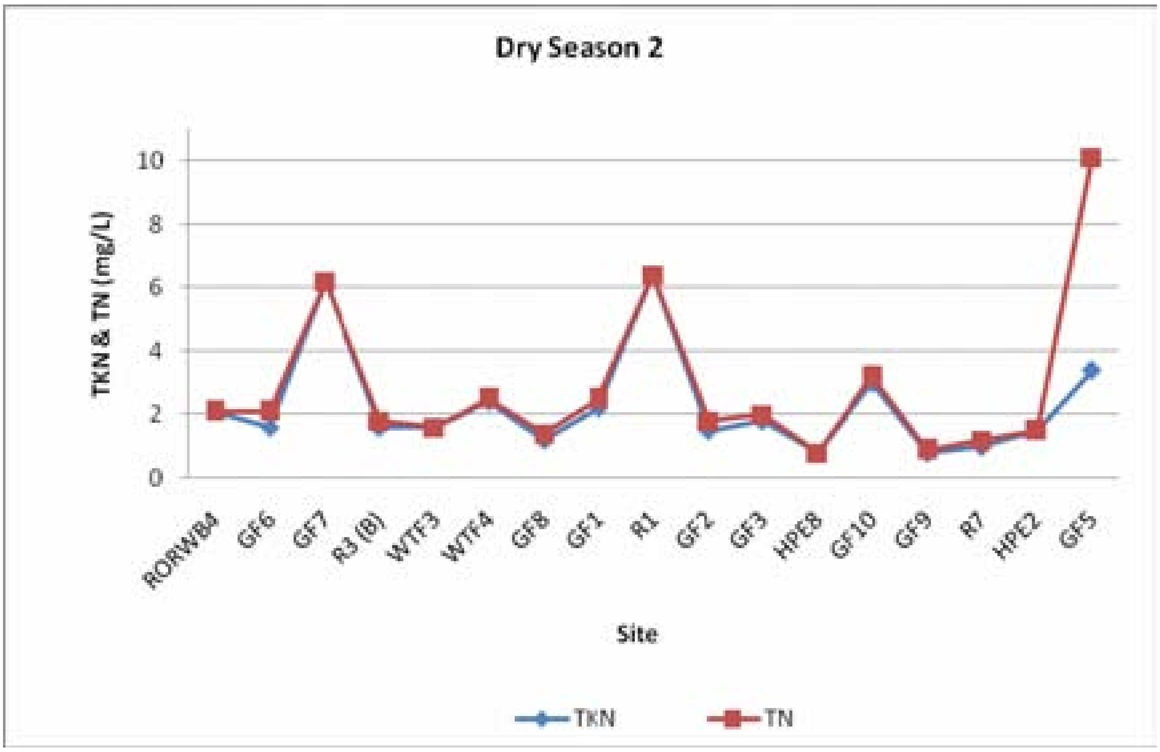

Figure 4-11 TN and TKN – Dry Season 2

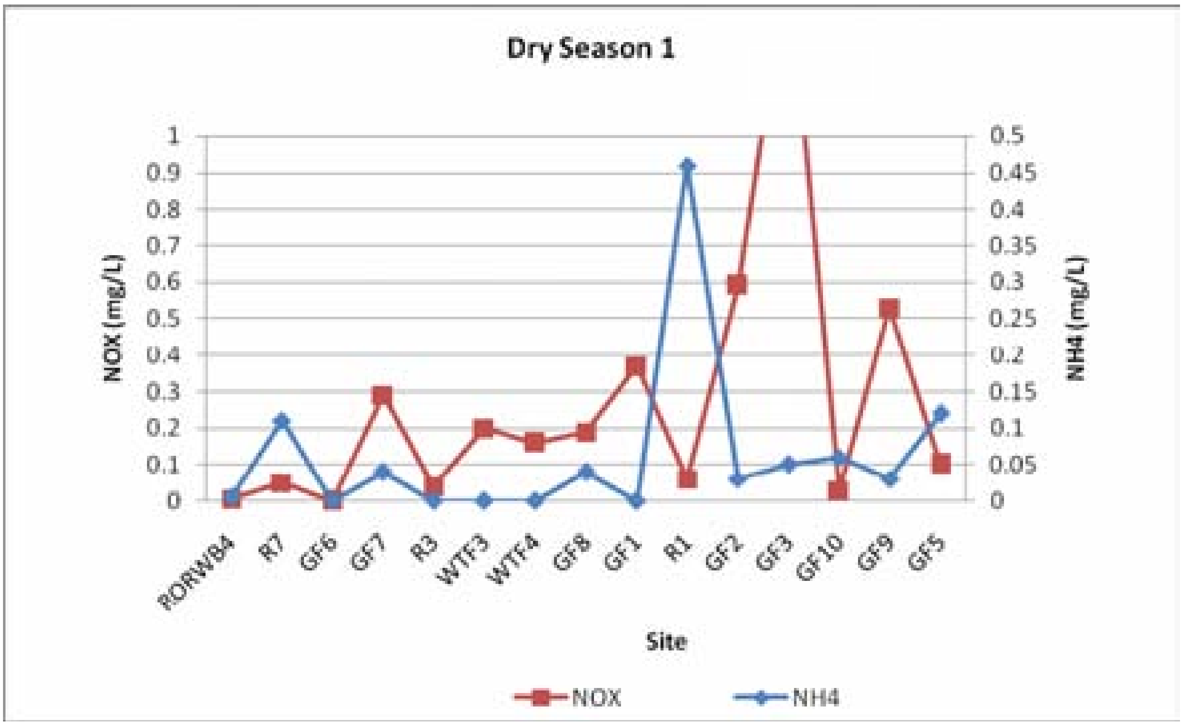

Figure 4-12 NH$_4$ and NOx – Dry Season 1

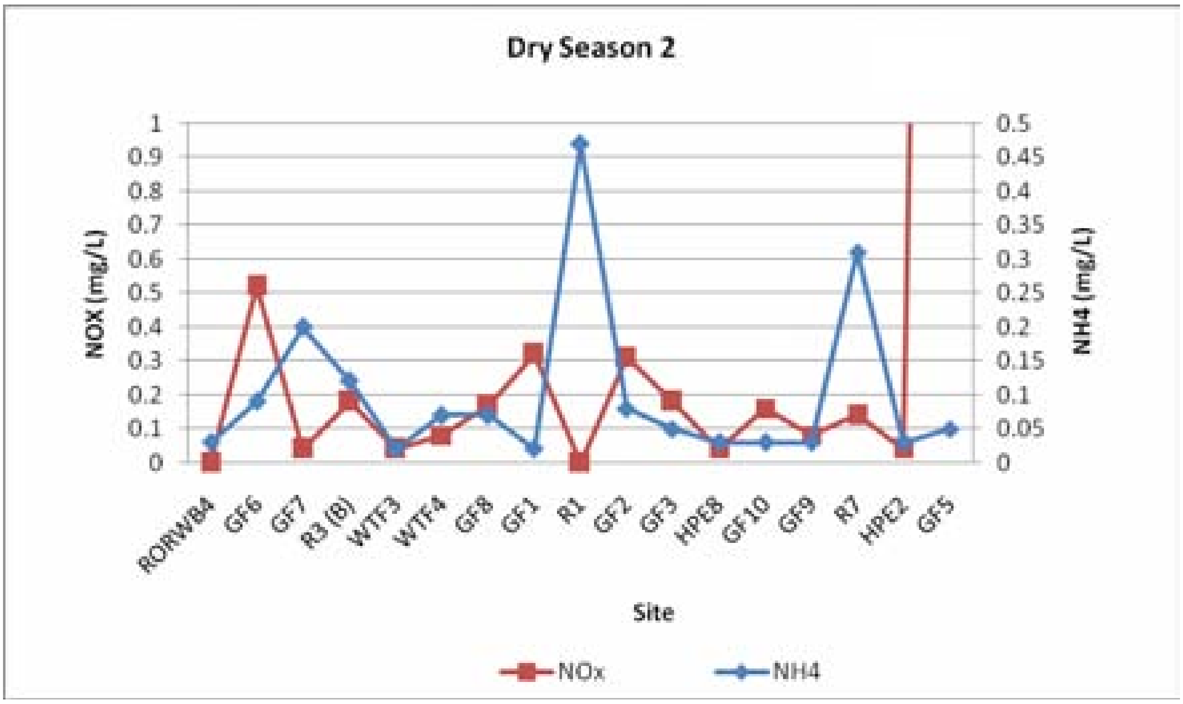

Figure 4-13 NH$_4$ and NOx – Dry Season 2

4.1.7 Phosphorus

Total phosphorus concentrations exceeded the QWQG at all sites with the exception of R1 on Dogwood Creek (June) and GF9 on Yuleba Creek (June) (Figure 4-14 and Figure 4-15). FRP concentrations also exceeded guidelines at a number of sites in June (RORWB4, GF6 and R3 on Charleys Creek, GF8and WTF3 on the Condamine River and GF1 on Dogwood Creek) and September (GF6 and WTF3), though most sites recorded 0.01 mg/L or below. However, some of the syringe filters used during the August and September sampling rounds were later found to be faulty, so these results need to be viewed with caution. The results indicate that the majority of phosphorus was derived from diffuse (agricultural) sources such as fertilisers and was delivered to the waterways in particulate form, associated with sediment runoff, although further sampling would be required to determine baseline phosphorus conditions with any level of confidence.

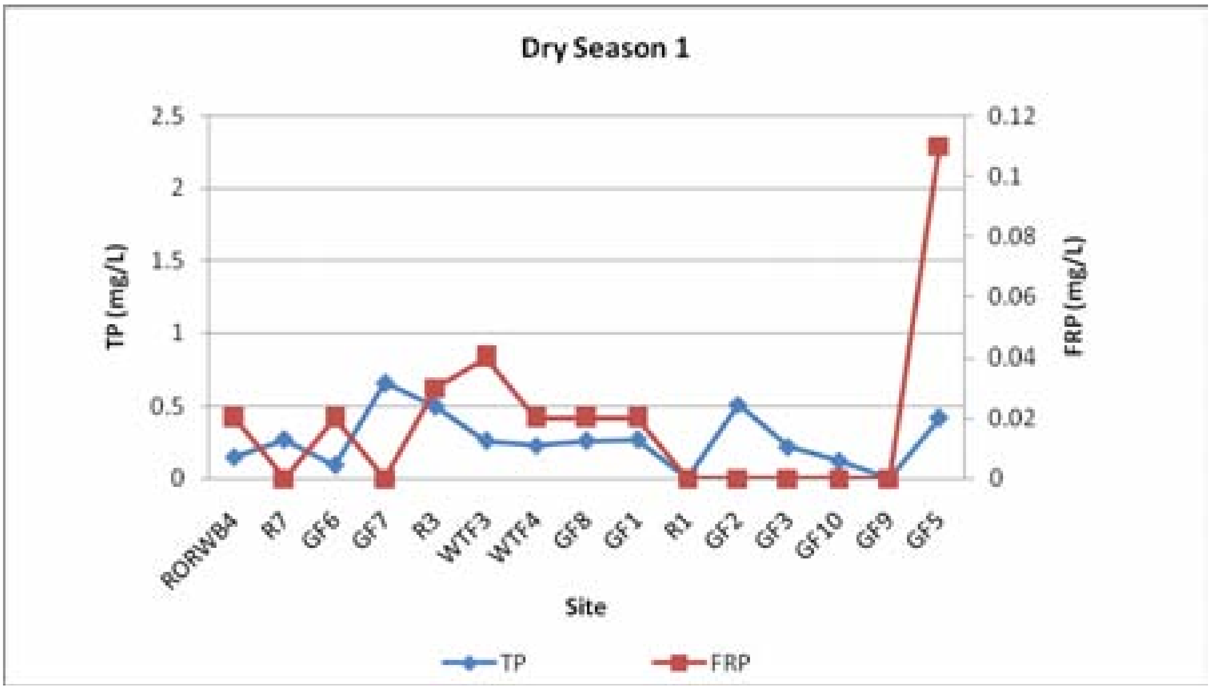

Figure 4-14 TP and FRP – Dry Season 1

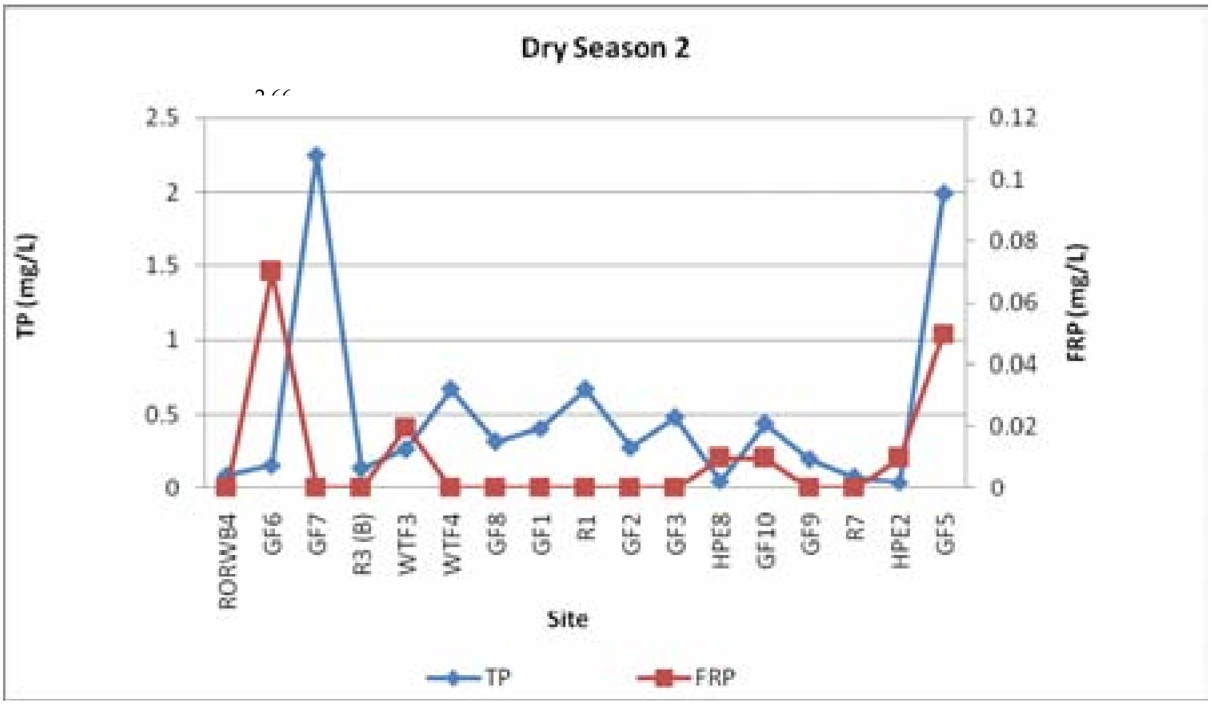

Figure 4-15 TP and FRP – Dry Season 2

4.1.8 Metals

Dissolved aluminium and copper concentrations exceeded the ANZECC / ARMCANZ (2000) 95 % Protection Limit guidelines for most sites (Figure 4-16 to Figure 4-21). This could be a result of the combination of regional geology and anthropogenic sources. The elevated aluminium concentrations were expected due to the presence of clayey soils within the region. It is likely that the majority of the dissolved aluminium fraction were associated with colloidal clays (which can pass through a 0.45 µm filter) and are not present in a bioavailable form. However, further examination would be required to determine the reasons for the elevated copper throughout the catchment. Sediments with naturally occurring elevated metal contents can influence the levels within the water column as the sediments are eroded and moved within the waterway. Additionally, other physico-chemical parameters, such as pH and reduction / oxidation potential (redox), can lead to the reduction of some metals (e.g. iron and manganese) bound to particulate matter and remobilisation of dissolved (bioavailable) forms. All other metal concentrations were within ANZECC / ARMCANZ guidelines (Appendix 2).

The syringe filters used in the field during June and July 2009 were later found to be faulty. This is particularly evident in samples collected from GF9 and GF10 (Yuleba Creek), where dissolved manganese was recorded in higher concentrations than total manganese. Therefore, the dissolved metals results for the first dry season surveys should be discarded.

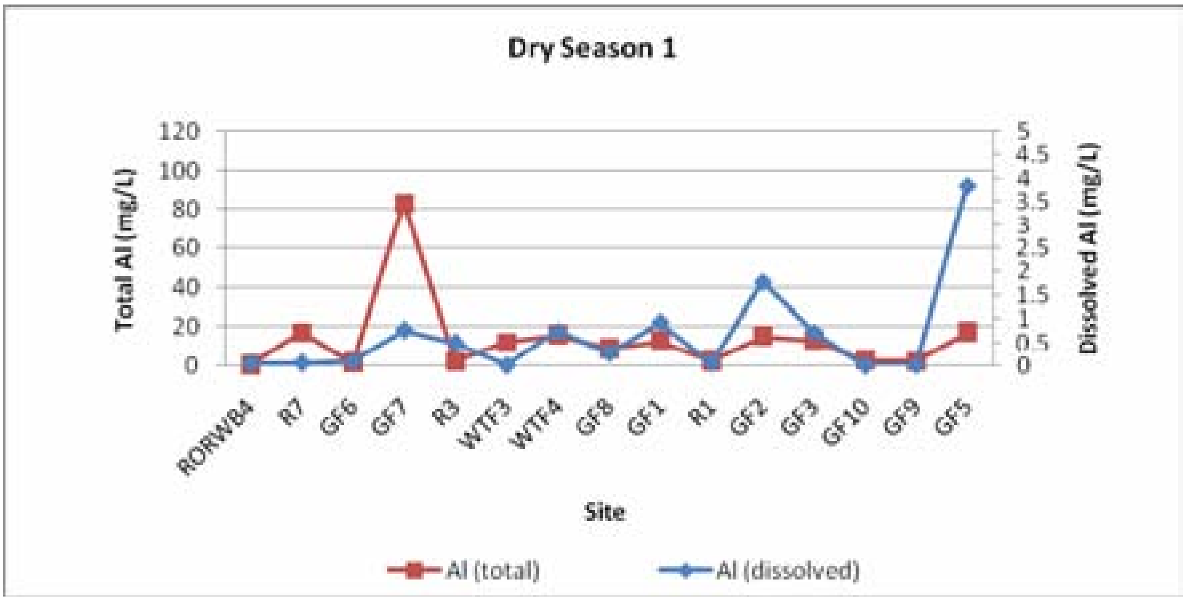

Figure 4-16 Total and dissolved aluminium – Dry season 1

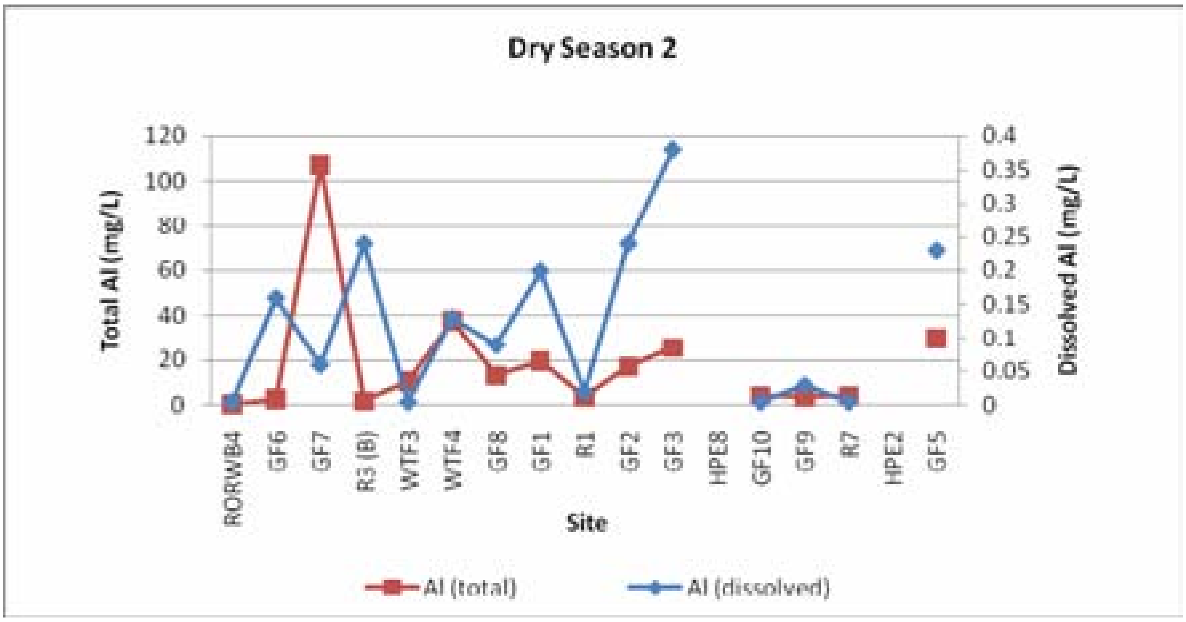

Figure 4-17 Total and dissolved aluminium – Dry season 2

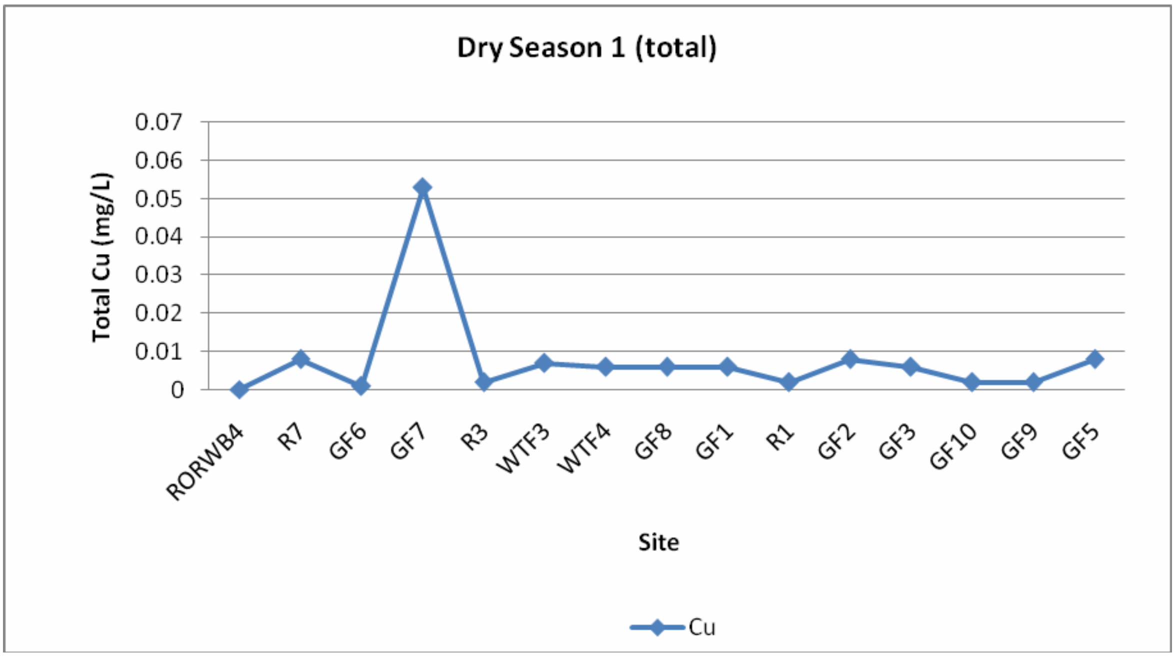

Figure 4-18 Total Cu - Dry season 1

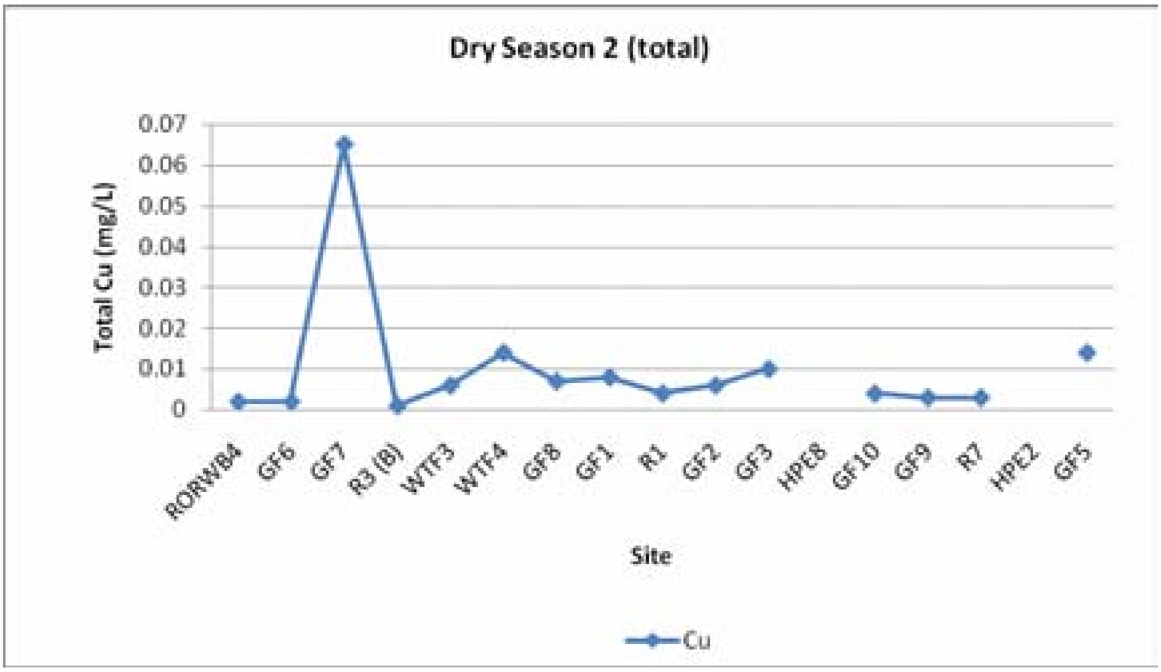

Figure 4-19 Total Cu – Dry season 2

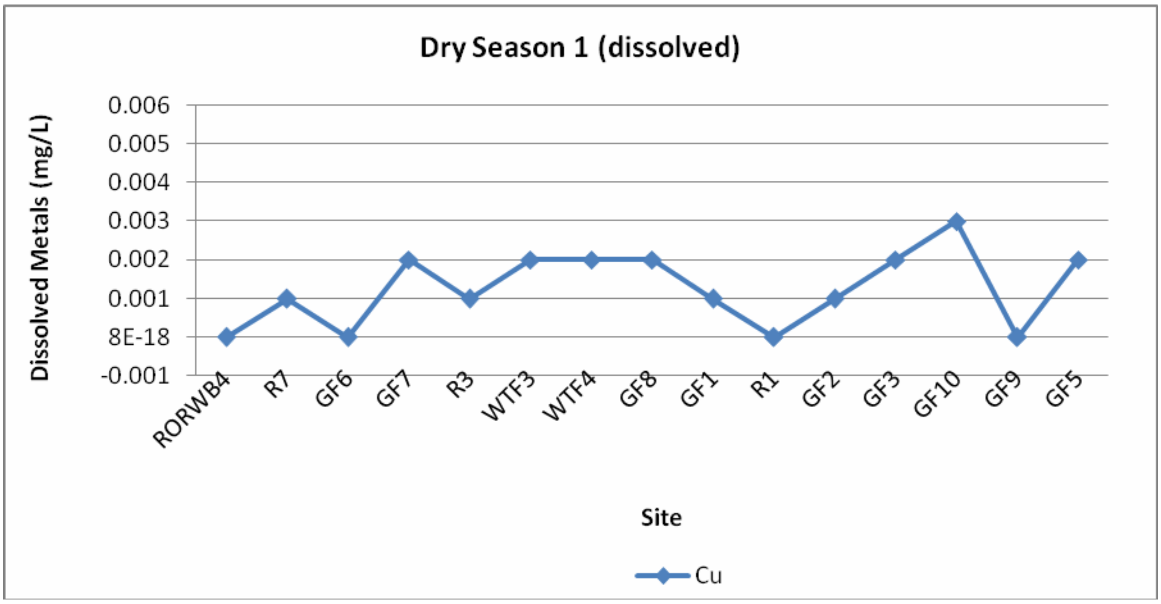

Figure 4-20 Dissolved Cu – Dry season 1

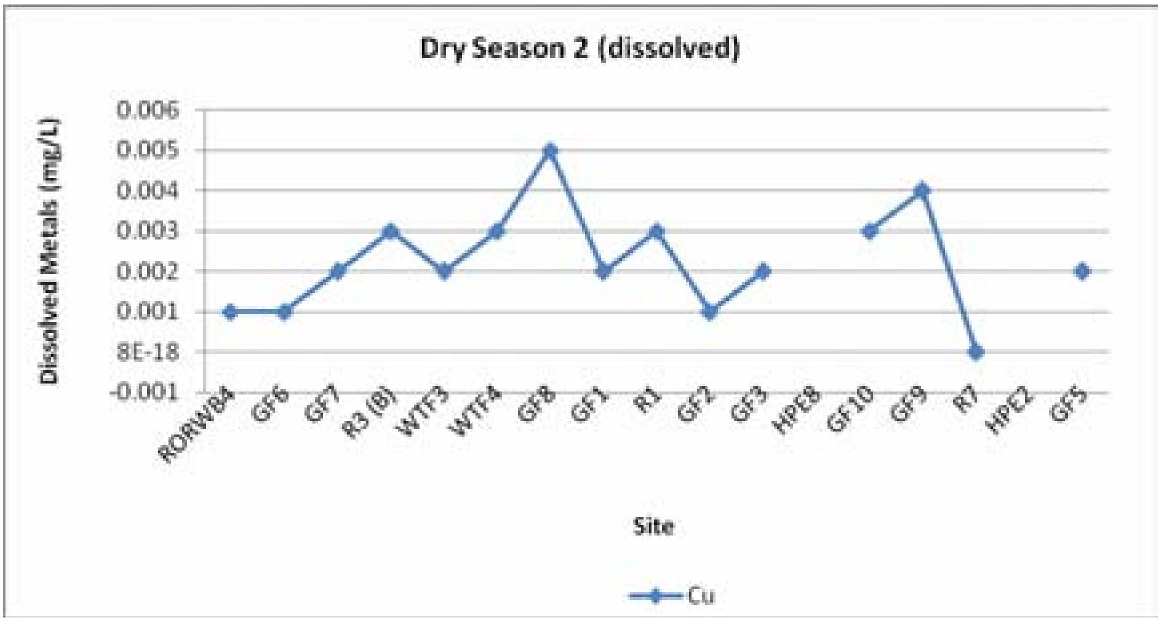

Figure 4-21 Dissolved Cu - – Dry season 2

4.1.9 Hydrocarbons

A number of sites recorded elevated TPH concentrations in June 2009. Subsequently, a silica gel cleanup was conducted on the samples within the laboratory. All TPH results from the additional testing were less than detection limits, 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).

4.1.10 Pesticides

Pesticides were not found in detectable concentrations at any site for both sampling occasions (Appendix 2). This is not unexpected given the very dry antecedent conditions. Given the agricultural nature of the catchments, particularly in areas of intense cropping (e.g. cotton), some pesticides would be expected following rainfall (see 4.1.11.1).

4.1.11 Regional Perspective

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). No pesticides were detected during our dry season surveys. However, this is more likely a reflection of the antecedent drought conditions than lack of presence of pesticides throughout the catchment. Further sampling (pulsed and passive) during summer would be required to establish seasonal variations in pesticide concentrations.

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).

Fitzroy (Dawson)

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).

Border Rivers

The Border Rivers catchment is characterised by low conductivity, moderate turbidity and moderate Chl*a*. Total phosphorus and NOx varies throughout the catchment, with low concentrations reported in the upper McIntyre River near Stanthorpe, to moderateconcentrations in the Weir and Moonie Rivers (DNR 1999).

DNR data are reported for one monitoring site on the Weir River. The site showed median conductivity of <500 μs/cm, turbidity ranging between 5 and 50, moderate concentrations of total phosphorus (0.05 mg/L to 0.1 mg/L) and moderate concentrations of NOx (0.04 mg/L to 0.3 mg/L) (DNR 1999).

4.2 Fish and macrocrustaceans

4.2.1 Results

A total of 1893 fish belonging to 15 species (12 native and three introduced) were recorded at 16 sites surveyed during the dry season in the Condamine-Balonne and Dawson catchments. All sites located in the Border Rivers catchment were dry at the time of sampling. An additional 14 sites were dry, did not contain sufficient water to sample or for which no site access was granted. Fish and crustacean abundance and species richness are summarised in Table 4-3. The proportion of native and exotic fish species is shown on Figure 4-22. Raw fish distribution and abundance data are provided in Appendix 3.

Table 4-3 Abundance and species richness of fish and macrocrustaceans in the Condamine-Balonne and Dawson catchments (dry season surveys)

Catchment	Site	No. fish	No. species	No. crustaceans	No. species
Condamine-Balonne	R7	39	4	11	1
	GF10	116	6	0	0
	GF9	0	0	0	0
	GF3	10	5	4	1
	GF2	27	6	0	0
	R1	55	6	0	0
	GF1	1	1	0	0
	GF8	153	8	0	0

Catchment	Site	No. fish	No. species	No. crustaceans	No. species
	WTF4	87	7	3	1
	WTF3	16	5	0	0
	GF7	23	6	0	0
	GF6	82	2	2	1
	RORWB4	1272	4	0	0
	R3	12	2	0	0
TOTAL		1893	12	20	2
Dawson	HPE2	5	4	65	1
	GF5	0	0	10	1
TOTAL		5	4	75	2

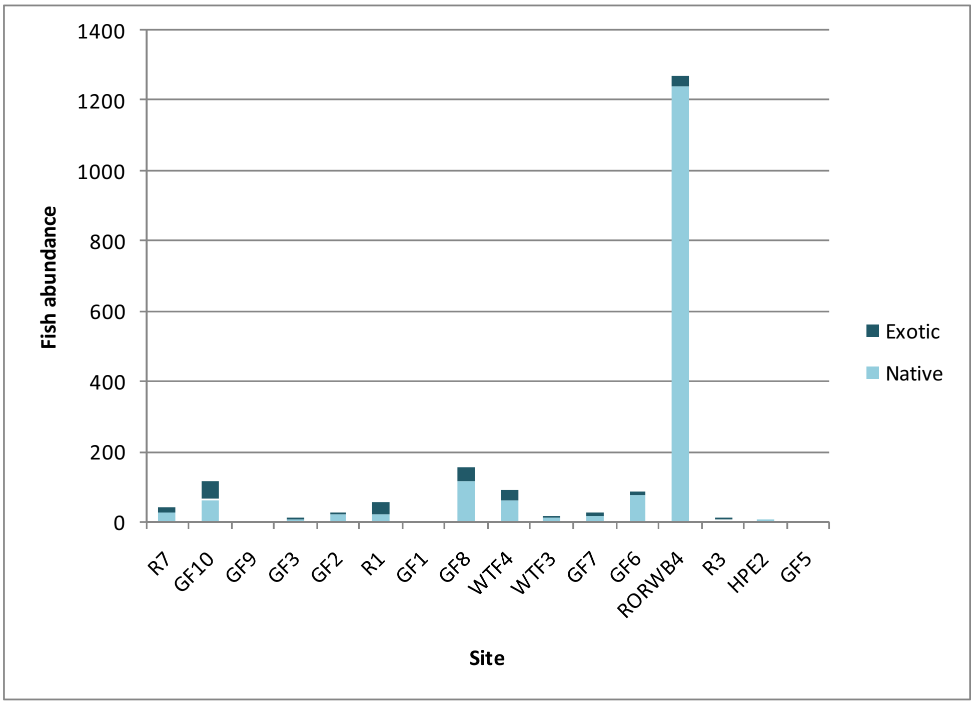

Figure 4-22 Fish abundance at each site, showing proportion of native vs exotic species

The fish assemblage at all sites was dominated by native species. *Hypseleotris* spp. (gudgeons) were the most common species encountered. Gudgeons were found in very high numbers within the off-river water body RORWB4, which may indicate that this site could be a dry season refuge for this species, or simply be a concentration factor.

Fish biomass at a number of sites within the Condamine-Balonne River catchment (e.g. R7, GF10 and R1) was influenced by high numbers of the large bodied exotic species *Carassius auratus* (Goldfish). It is notable that two of these sites are reference sites. *Cyprinus carpio* (Common carp) was recorded in low numbers at two sites (GF7 and GF3). *Gambusia holbrooki (*Eastern gambusia) was also recorded in moderate numbers throughout the Condamine-Balonne River catchment. No exotic fish species were

recorded from the Dawson River catchment during the dry season sampling. However, it is highly likely that exotic species, especially Gambusia, are present throughout the catchment where suitable habitat and conditions are available.

A single *Pseudomugil signifier* (Pacific blue eye) was caught at site HPE2, which was presumed to be a clear water spring fed site located on the Upper Dawson River. Pacific Blue eyes are generally found in coastal streams (within 15-20 km of the sea) between northern Queensland and southern NSW (Allen *et al*. 2002). The species has not been recorded in the area previously and it is likely that it has been released from aquaria or farm dams. Although the Pacific Blue eye is not an exotic fish *per se*, it does not naturally occur in this area and any fish, regardless of its origin, moved to a new stream where it does not naturally occur, could cause significant environmental changes (Burrows 2004). Arthington (1991) concluded that translocation of native fishes could potentially be as damaging as the introduction of exotic species.

A total of 95 crustaceans, belonging to three species was recorded throughout the Condamine-Balonne and Dawson catchments. *Macrobrachium* spp. (prawns) were only recorded at one site (HPE2). The translocated species *Cherax quadricarinatus* (Red claw) was recorded at two sites in the Condamine-Balonne River catchment (R7 and GF3) and one site in the Dawson River catchment (GF5). *Cherax* spp. (Yabbies) were recorded in low numbers at two sites in the Condamine-Balonne River catchment (WTF 4 and GF6). Red claw has been shown to outcompete native *Cherax* spp. and has been implicated in significant changes in upstream habitats in the Burdekin River catchment (Connolly 2002).

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

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

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity
Nematalosa erebi	Bony bream	Widespread and abundant. Were the most abundant native fish species in Pilot Sustainable Rivers Audit (SRA).	Lowland rivers. Diet consists of microalgae, detritus and microcrustaceans.	Very hardy fish. Tolerates high temperatures, salinity and turbidity. Sensitive to cold water pollution.
Hypseleotris spp.	Carp gudgeons	Widespread and common in mid and lower altitudes of coastal drainage basins from central NSW to north Qld. Spawn in shallow water at temperatures above 22.5°C. Eggs are deposited on submerged macrophytes or twigs.	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 microcrustacea, and small insects, worms and snails.	Very hardy fish, tolerates high turbidity.
Philypnodon grandiceps	Flathead gudgeon	Widespread in coastal drainage basins between the Burdekin River (Qld) and Murray-Darling River (SA). Spawn between spring and summer. Absent from upland areas.	Benthic species, which prefers slow flowing and still waters with mud bottoms and macrophytes. Diet consists of small fishes, insects and tadpoles.	Very hardy fish.
Melanotaenia fluviatilis	Murray River rainbowfish	Widespread in Murray-Darling River from Roma (Qld) to SA. Spawn between spring and summer when temperatures exceed 20°C.	Prefers slow flowing streams and backwaters, billabongs, ponds and reservoirs. Diet consists of aquatic and terrestrial invertebrates and filamentous algae.	Hardy fish. Population has declined in lower Murray-Darling. Potential threats include predation from eastern gambusia, loss of macrophytes and cold water pollution.
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.
Tandanus tandanus	Freshwater catfish	Widespread distribution throughout coastal drainage basins from central coast of NSW to northern Qld. Common in Murray-Darling basin. Spawns between spring and mid-summer	Benthic species and prefers sandy or gravel substrate in slow flowing or still water (ponds and lakes) with fringing vegetation. Gravel /rocky substrata required for breeding. Mainly bottom	Reasonably hardy fish but declining numbers in recent years in Murray-Darling are linked to competition from common carp, altered flow regimes, cold water pollution, salinity and

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity
		between 20 to 24°C.	feeders preying on small crustaceans, insects, snails and juvenile fish (e.g. gudgeons).	degradation of breeding habitat.
Pseudomugil signifer	Pacific blue-eye	Common and widespread from north Qld to southern NSW, usually between 15 to 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.
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.
Leiopotherapon unicolor	Spangled perch	Most widespread native fish. Occurs in most coastal drainage basins. Common in Murray-Darling catchment north of Condobolin. Spawns in summer on soft substrates between 20-25°. Flooding maximises recruitment enabling dispersion via sheet flow during the wet season.	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.	Very hardy fish.
Macrobrachium sp.	Prawn species	Widespread native species.	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 outcompete native *Cherax* spp. For invertebrate food sources.

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity
Cherax sp.	Crayfish species	Probably *C. destructor* but not field identified to species level. Widespread in eastern Australia. Hardy. Able to survive drying out of aquatic habitats by retreating to burrows, which also form important dry season refugia for other aquatic invertebrates.	Diet consists of microcrustacea, phytoplankton, detritus, carrion and invertebrates.	Very tolerant to competition and poor water quality (high temperatures, low DO, high salinity and high nutrient loads).

References: Allen *et al.* (2002), Clayton *et al.* (2008) and Lintermans (2009).

4.2.2 Regional perspective

Comparison with other studies

The number of fish species caught in the Condamine-Balonne and Dawson River catchments during the dry season surveys were generally consistent with relevant data and literature (Clayton *et al.* 2008, EM 2008, EM 2004, MDBC 2003, Hydrobiology 2006, Berghuis and Long 1999)) (Table 4-5). 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.

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. This is consistent with our findings. Berghuis and Long (1999) did not record any exotic species from the Dawson River sites, but commented that goldfish were still regularly captured in the Dawson River. Pacific blue eye (translocated species) was recorded, although the occurrence of this species was found to be reduced from a previous study undertaken by in 1979 (Berghuis and Long 1999).

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.

Limited information on fish species of the Border Rivers catchment was available. However, Dr. Stephen Balcombe (Senior Lecturer, Griffith University) provided a list of species caught during the Cooperative Research Centre for Freshwater Ecology (CRCFE) funded Dryland Refugium project. All sites were dry in the Border Rivers catchment at the time of sampling for the study reported herein.

Therefore, no data from this study are available for comparison. Additional data will be reported following the wet season surveys.

An overview of fish species recorded from the Condamine-Balonne, Border Rivers and Dawson catchments is provided in Table 4-5.

Table 4-5 Presence of fish species recorded in the Condamine-Balonne, Border Rivers and Dawson catchments

Species	Common name	Condamine-Balonne*	Border Rivers**	Dawson***
Nematalosa erebi	Bony bream	✓	✓	✓
Hypseleotris spp.	Carp gudgeons.	✓	✓	✓
Philypnodon grandiceps	Flathead gudgeon	✓	-	✓
Gadopsis marmoratus	River blackfish	✓	-	-
Hypseleotris klunzingeri	Western carp gudgeon	✓	-	-
Hypseleotris sp. A	Midgleys gudgeon	✓	-	-
Mogurnda adspersa	Purple-spotted gudgeon	✓	-	-
Hypseleotris galii	Firetail gudgeon	✓	-	-
Craterocephalus amniculus	Darling River hardyhead	✓	-	-
Melanotaenia splendida	Eastern rainbowfish	-	-	✓
Melanotaenia duboulayi	Crimson spotted rainbowfish	✓	-	-
Melanotaenia fluviatilis	Murray River rainbowfish	✓	✓	-
Maccullochella peeli peeli	Murray cod	✓	✓	-
Macquaria ambiqua	Golden perch / Yellowbelly	✓	✓	✓
Galaxias olidus	Mountain galaxias	✓	-	-
Tandanus tandanus	Freshwater catfish	✓	✓	✓
Neosilurus hyrtlii	Hyrtl's tandan	✓	-	-
Pseudomugil signifer	Pacific blue-eye	-	-	✓
Retropina semoni	Australian smelt	✓	✓	-
Leiopotherapon unicolor	Spangled perch	✓	✓	✓
Craterocephalus	Fly specked hardyhead	✓	✓	-
Neoarius graeffei	Lesser salmon catfish	-	-	✓
Ambassis agassizii	Agassiz's glassfish / olive	✓	✓	✓
Bidyanus bidyanus	Silver perch	✓	-	-
Amniataba percoides	Barred grunter	-	-	✓
Scortum hillii	Leathery grunter	-	-	✓
Scleropages leichardti	Saratoga / Spotted Barramundi	-	-	✓
Hypseleotris compressa	Empire gudgeon	-	-	✓
Glossamia aprion	Mouth almighty	-	-	✓
Oxyeleotris lineolata	Sleepy cod	-	-	✓
Cyprinus carpio	Common carp	✓	✓	-
Carassius auratus	Goldfish	✓	✓	-
Gambusia holbrooki	Gambusia	✓	✓	-

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

**Raw data provided by Dr. Stephen Balcombe (Griffith University)

***Berghuis and Long (1999)

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. Four notable taxa known to occur in the Condamine-Balonne River catchment were not found – Murray cod, Purple-spotted gudgeon, *Bidyanus bidyanus* (Silver Perch) and Agassiz's glass fish. Murray cod is listed as Vulnerable under the EPBC Act 1999 and Silver Perch is listed as Vulnerable on the IUCN Redlist of Threatened Species™ and Vulnerable under the *NSW Fisheries Management Act 1994*. Purple-spotted gudgeon is listed as endangered under the *NSW Fisheries Management Act 1994* (although not listed in Queensland). Murray cod was identified as 'rare and threatened' while Purple spotted gudeon, Silver perch and Eel tailed catfish were indentified as priority fauna in the Aquatic Conservation Assessments (ACA) study using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) (Clayton *et al.* 2008).

Murray Cod is regularly stocked (around 1000 fingerlings each year) into the Condamine River by the Chinchilla Amateur Fishing Club as a direct implication of their recreational fishing value (Hydrobiology 2006). Silver Perch had also been stocked in the past, but this was not conducted on a regular basis (Hydrobiology 2006). It is also likely that populations of Murray cod and Silver Perch are artificially maintained as part of the Native Fish Strategy for the Murray-Darling Basin 2003-2013 (Murray-Darling Basin Ministerial Council 2003).

Purple-spotted gudgeon and *Craterocephalus amniculus* (Darling River Hardyhead) are notable species known to occur in the Border Rivers catchment. Darling River Hardyhead is listed as Vulnerable on the IUCN Redlist of Threatened Species™.

Scleropages leichardti (Saratoga, 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) is also reported as 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 4-6.

Table 4-6 Overview of significant fish species known to be found in the Condamine-Balonne, Dawson and Border Rivers catchments

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity/Significance	IUCN	NCR	EPBC
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 temperatures exceed 15°C.	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 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.	X	X	✓
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
Mogurnda adspersa	Purple spotted gudgeon	Known to be present in coastal streams from northern NSW to north Qld. Common in coastal Qld, but its distribution	Benthic species, usually associated with rocks or riffles in slow moving or still waters of creeks, wetlands, rivers and	Numbers have declined significantly in recent years. Potential threats include altered flow regimes and predation by alien	X	X	X

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity/Significance	IUCN	NCR	EPBC
		within the Murray Darling Basin is restricted to a few rivers on the NSW/QLD border, including the Condamine. Spawn in summer when temperatures exceed 20°C. Females spawn several times during a spawning season. Males guard the nest and developing fry and breed less frequently.	billabongs. Diet consists of small fish, worms, aquatic insects and tadpoles. Requires hard substrate for breeding.	species. Listed as least concern (IUCN and NCR) in Qld due to secure populations in coastal areas. 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 these species within the Murray-Darling Basin through formal listing of these species under the EPBC Act 1999.			
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 abundant in Condamine-Balonne and Border Rivers.	Prefers vegetated edges of lakes, creeks, swamps, wetlands and rivers. Often associated with snags and aquatic vegetations. Diet consists of microcrustaceans, aquatic and terrestrial insects (including mosquitos), small arachnids and small fish.	Numbers have declined significantly in recent years. Potential threats include altered flow regimes, cold water pollution and predation by alien species. 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.	X	X	X
Scleropages leichardti	Saratoga, Spotted barramund	Endemic to upper reaches of Fitzroy (Dawson) River System, where it is	Prefers billabongs or pools in slow flowing, turbid streams. Diet	Not listed as threatened, but endemic and uncommon in Fitzroy Basin. Favoured by recreational	X	X	X

Species	Common Name	Distribution and abundance	Habitat and Food	Sensitivity/Significance	IUCN	NCR	EPBC
	i	relatively uncommon.	consists of frogs, fish, invertebrates and crustaceans.	fishers and populations maintained in several impoundments in Queensland by stocking.			
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
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), Clayton *et al.* (2008), Faulks *et al.* (2008) and Lintermans (2009).

4.3 Macroinvertebrates

4.3.1 Results

Macroinvertebrate composite bed samples were collected at 16 sites during the dry season in the Condamine-Balonne (14 sites) and Dawson catchments (two sites). Suitable edge habitat was only available at 10 sites (nine in the Condamine-Balonne catchment and two in the Dawson catchment). All sites located in the Border Rivers Catchment were dry at the time of sampling. An additional 18 sites were dry, did not contain sufficient habitat to sample or for which no site access was granted. A summary of the type of sample collected at each of the 16 sites is provided in Table 4-7. Complete macroinvertebrate data are shown in Appendix 4.

Table 4-7 Summary of macroinvertebrate samples collected during the dry season surveys

			Sample type	
Site	Location	Catchment	Edge sweep	Composite bed
GF1	Dogwood Creek	Condamine-Balonne	✓	✓
GF2	Tchanning Creek	Condamine-Balonne	✓	✓
GF3	Tchanning Creek	Condamine-Balonne	✓	✓
GF5	Wooleebee Creek	Dawson	✓	✓
HPE2	Dawson River	Dawson	-	✓
GF6	Charleys Creek	Condamine-Balonne	-	✓
GF7	Charleys Creek	Condamine-Balonne	✓	✓
GF8	Condamine River	Condamine-Balonne	✓	✓
GF9	Yuleba Creek	Condamine-Balonne	✓	✓
GF10	Yuleba Creek	Condamine-Balonne	-	✓
R1	Dogwood Creek	Condamine-Balonne	-	✓
R3	Charleys Creek	Condamine-Balonne	-	✓
R7	Bungil Creek	Condamine-Balonne	✓	✓
RORWB4	Adjacent to Charleys Creek	Condamine-Balonne	-	✓
WTF3	Condamine River	Condamine-Balonne	✓	✓
WTF4	Condamine River	Condamine-Balonne	✓	✓

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 groupings[2].

[2] 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

Richness and abundance (edge data)

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

Taxa richness ranged between 13 and 35 across all sites for edge samples. The highest richness and abundance were recorded at GF2 on Tchanning Creek (35 and 299, respectively) and GF5 on Wooleebee Creek (28 and 327 respectively). Microcrustaceans (copepods and ostracods) were the dominant taxa at these sites. WTF4 on the Condamine River also had good richness (30) and a higher abundance of sensitive taxa (mainly Leptoceridae). WTF4 had good aquatic and riparian habitat in comparison to other sites in the Condamine River. It should also be noted that the laboratory QA / QC on a residue from this site found that the dominant taxa was Caenidae, which was under-represented in this sample. It is not clear why GF2 and GF5 had high richness as both of these sites were heavily degraded.

The lowest richness and abundance was recorded at sites GF3 (15 and 58, respectively), R7 (16 and 52, respectively), GF1 (15 and 74, respectively) and WTF3 (13 and 85, respectively).

Table 4-8 Summary data for macroinvertebrate richness and abundance from edge samples

Site	Abundance	Richness	No. PET Taxa
R7	52	16	1
GF9	207	24	1
GF3	58	15	3
GF2	299	35	3
GF1	74	15	0
GF8	97	23	4
WTF4	139	30	4
WTF3	85	13	2
GF7	141	24	2
GF5	327	28	3

R7 (Bungil Creek) was originally selected as a reference site for the Balonne catchment as it was located outside of the gas tenement areas. However, the site was located near a road crossing and was in a very degraded condition, with poor riparian and in-stream habitat and high turbidity. The area available for sampling consisted of a shallow turbid pool approximately 100 m long, with limited edge habitat. The low richness and abundance and the dominance of tolerant taxa (Hemiptera and Diptera) at this site reflects the poor aquatic habitat condition. Therefore, this site should not be viewed as a reference site. Based on the field surveys undertaken to date, no suitable reference site was identified in the Balonne catchment due to existing land uses.

GF1, GF3 and WTF3 also had poor aquatic and riparian habitat, which is reflected in the low taxa richness at these sites.

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published data are available. Enquiries as to the development of the indices should be directed to DERM.

PET richness (egde 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 (DERM 2009). 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. PET richness of 4 for lowland freshwater and 5 for upland freshwater).

PET richness ranged between 0 and 4 throughout the study area. No PET taxa were recorded at site GF1 and only one Caddisfly family (Leptoceridae) was recorded at sites R7 and GF9. Leptocerids were collected at all sites (in varying numbers), with the exception of GF1. WTF4 and GF8 had the highest PET taxa richness and abundance (mainly Leptocerids). Leptocerid abundance was also high at WTF4 (44 individuals).

A small number of Mayflies (Baetidae and Caenidae) and Caddisflies (Ecnomidae) were collected at various sites, with the highest abundance of eight Caenids at GF8.

SIGNAL 2 scores (edge data)

The SIGNAL 2 index 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 are influencing 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 4-23). The SIGNAL 2 family bi-plot is provided in Figure 4-24.

SIGNAL 2 (family)		
	QUADRANT 3 Results in this quadrant often indicate toxic pollution or harsh physical conditions (or inadequate sampling)	QUADRANT 1 Results in this quadrant usually indicate favourable habitat and chemically dilute waters
	QUADRANT 4 Results in this quadrant usually indicate urban, industrial or agricultural pollution, or downstream effects of dams	QUADRANT 2 Results in this quadrant often indicate high salinity or nutrient levels (may be natural)

Number of macroinvertebrate families

Figure 4-23 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, insufficient data did not enable specific boundaries to be set for this study. Instead, boundaries used

were those suggested by Chessman (2001) for Australian freshwaters (Dawson River) and the Murray Darling Basin between 400 m and 200 m elevation (Condamine River).

SIGNAL 2 scores were low for all sites, ranging from 2.8 to 3.75 (with no abundance weighting). All sites fall within either quadrant 2 or quadrant 4. This may indicate that water quality and aquatic habitat is impacted throughout the study area from a range of landuses, (e.g. river regulation, agriculture, clearing of vegetation and urban development) or that temporary waters in the Murray Darling require different quadrant boundaries. Most sites fall within quadrant two, potentially indicating high levels of turbidity, salinity or nutrients. Water quality results indicated that nutrients and turbidity were elevated for most sites, although salinity was generally low. Turbidity and nutrients may be high due to natural sources (e.g. regional geology and soils) 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.

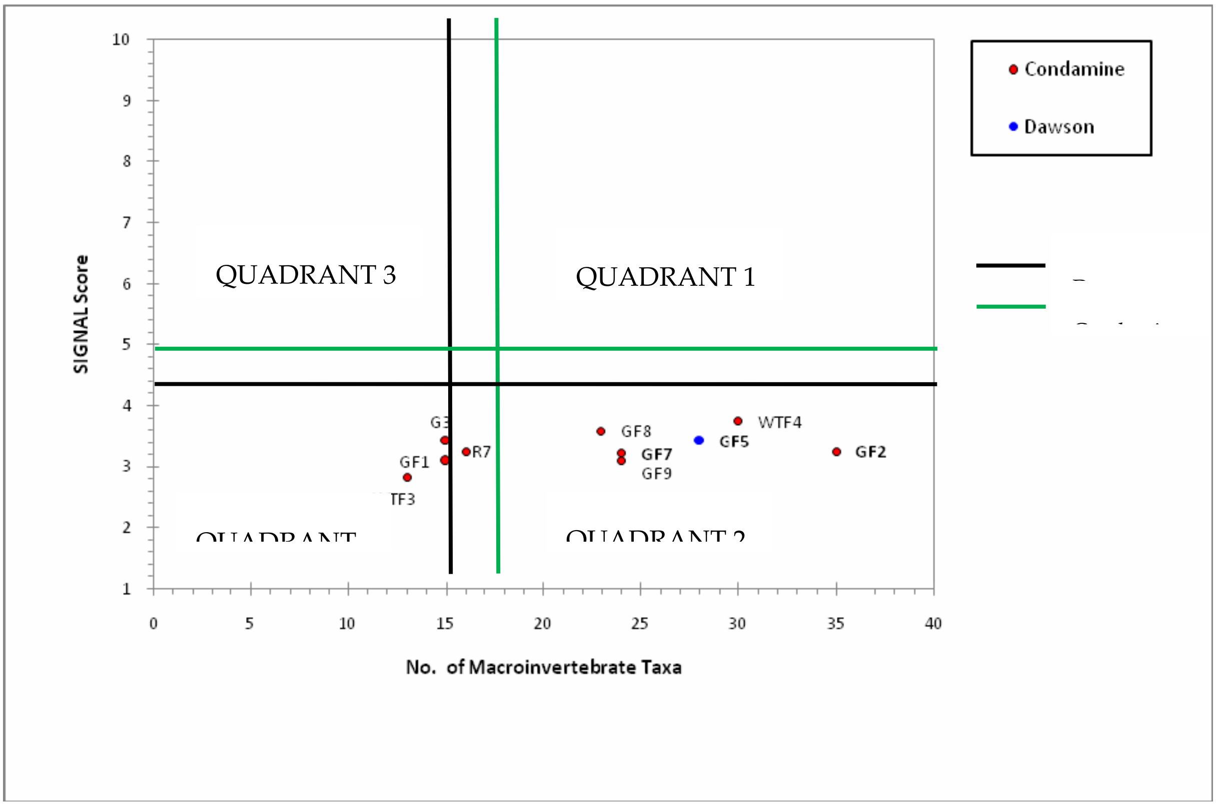


Figure 4-24 SIGNAL 2 (family) Bi-plot

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 generalists, such as predators, gatherers, filter feeders and scavengers are more tolerant to pollution (Rawer-Jost *et al.* 2000).

The relative proportion of macroinvertebrate functional feeding groups for sites sampled during the dry season varied considerably between sites (Figure 4-25). For the purpose of this assessment, scavengers and deposit feeders were included in the generalist “Gatherer/Collector” group. Predators were generally found to be the dominant feeding group throughout the Condamine catchment, with the exception of WTF3 and GF9. This is likely to be associated with inefficient sampling methods (i.e. use of 250 μm mesh net and live field picking) resulting in some of the smaller taxa, such as microcrustacea, being under-represented in the samples, rather than a true reflection of functional feeding group dominance. This was demonstrated by the results of the laboratory QA / QC, which found a number of the smaller taxa only in residue samples (refer to Section 3.4.2).

The sites located on the main Condamine River (WTF3, WT4 and GF8) had a higher proportion of shredders than sites located on the tributaries, especially WTF3. A single Trichopteran family (Leptoceridae) accounted for the high proportion of shredders at these sites. The higher abundance of Leptocerids at WTF3 (44 individuals) is unusual as the site had degraded riparian vegetation, providing limited sources of coarse particulate organic matter (CPOM), which is the principal food source for shredders. It may be that they are feeding on CPOM transported from upstream or; there was limited input of riparian CPOM, but limited competition. The low richness and abundance at this site provided support for the field observations. WTF4 was also in a moderately degraded condition, although it had narrow, but continuous riparian vegetation. This site had higher richness and abundance than WTF3, reflecting the comparatively improved riparian and in-stream habitat quality (see Table 4-12).

Scrapers were only present at site GF1 located on Dogwood Creek (tributary of the Condamine River). This group consisted of one gastropod family (Physidae – 15 individuals). Scrapers rely on algae and periphyton as their in-stream food resources and the presence of this family may be linked to the presence of higher amounts of phytoplankton and filamentous algae observed at this site. However, it should be noted that the site had a low richness and abundance and was dominated by generalist groups, such as predators, gatherers and filter feeders. Shredders were notably absent from this site, which was considered unusual as it had good fringing and overhanging vegetation.

The functional group composition at Site R7 located on Bungil Creek (tributary of the Balonne River) was dominated by gatherers, filter feeders and predators. The low richness and abundance at this site and presence of generalist feeders supports the degraded nature of the site.

Sites located on Tchanning Creek (GF2 and GF3) and Yuleba Creek (GF9 and GF10) (all north western tributaries of the Condamine River) had similar functional group composition, dominated by generalist feeders (predators, filter-feeders and gatherer/collectors) and a low proportion of shredders.

Feeding group composition was found to be similar (but more evenly distributed) at site GF5 on Wooleebee Creek in the upper Dawson catchment to those on Tchanning and Yuleba creeks. Unfortunately, this was the only site located in the Dawson catchment that had suitable edge habitat for the collection of macroinvertebrates. Therefore, comparison with other sites in the Dawson catchment is not possible at this stage. However, further data will be collected during the wet season and results will be reported as they become available.

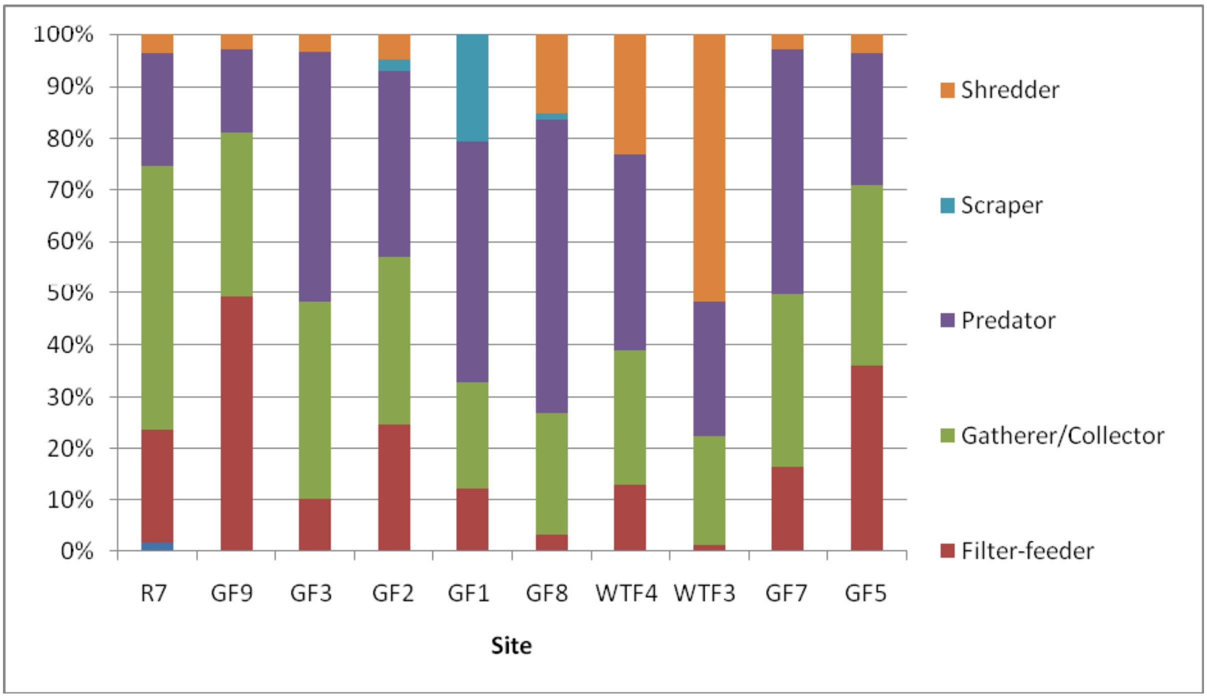


Figure 4-25 Proportion of functional feeding groups

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:

- 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 4-26 and Figure 4-27, respectively.

All sites were dominated by taxa with a weak preference for fine substrate (sand/silt) or taxa that showed no preference (Figure 4-26). Similarly, all sites were dominated by taxa with either no flow preference or a preference for low/no flow (Figure 4-27). These results are not surprising given that all sites 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.

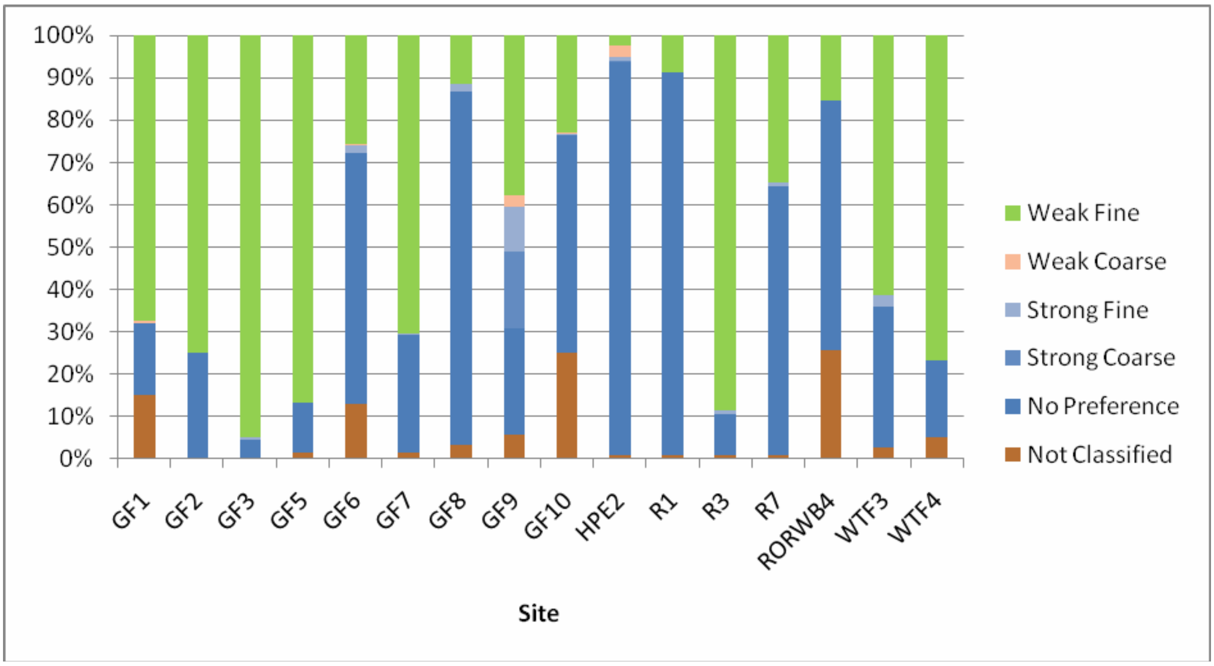


Figure 4-26 Proportion of substrate preference groups

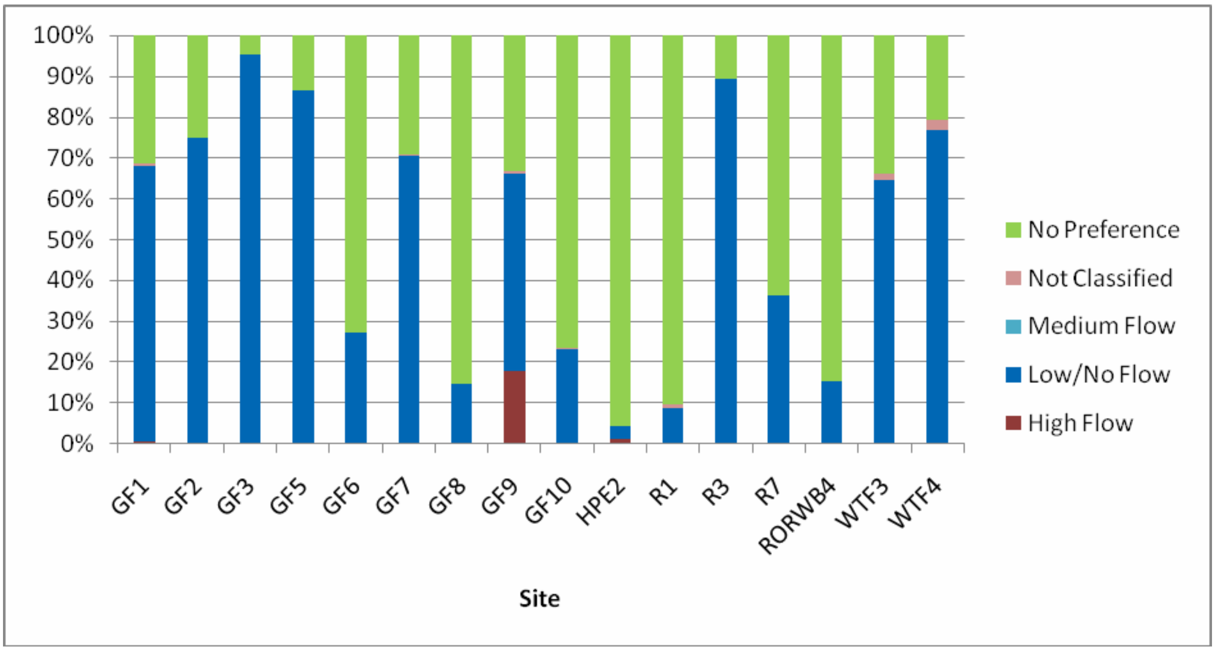


Figure 4-27 Proportion of flow preference groups

4.3.2 Regional Perspective

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.

Dawson River

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 (1997b) 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).

Only one edge sample was collected from the Dawson River in the current study as all other sites were dry at the time of sampling. GF5 showed good richness and fairly good PET richness (3), although SIGNAL 2 scores were low, indicating a dominance of tolerant taxa.

Border Rivers

The SRA recorded 63 macroinvertebrate families from 34 sites in the Border Rivers catchment. The Border Rivers Valley was reported to be in moderate condition, which was the highest score of all the valleys (MDBC 2008). There was significant variation between sites, with the lowland and slopes zones having more expected communities than the Upland and Montane zones. Overall, richness was high, mean of 26 families per site (MDBC 2008).

Schiller *et al.* (1999) recorded 81 taxa (mainly families). The highest richness was found in the upper unregulated reaches of the Severn River, while the smaller, temporary streams had low diversity. Macroinvertebrate richness was reduced during drought years (1994 and 1995), suggesting that good flow conditions improved macroinvertebrate communities. Sites located on the Weir River were reported to have macroinvertebrate communities in 'reasonable but vulnerable' condition, which suggested minor flow related impacts were apparent but that there was a risk of substantial impacts from disturbance (flow regulation and vegetation clearing).

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 13 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 drier trend in recent times.

The hydrology of the streams and rivers within the study area largely reflect 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 study area are characterised by extended periods of no to low flow;
- The streams and rivers within the study area are generally intermittent; and
- Regardless of the intermittent nature of the larger rivers, examples of large pools exist within the Dawson, Condamine and Balonne rivers that persist throughout the dry season.

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 4-9) (Condamine Alliance 2004).

Table 4-9 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 4-10. The Condamine-Balonne River catchment consisted of confined, armoured, anabranching, mobile, meandering and distributary zones (Figure 4-28). Comparing the distribution of these zones with the distribution of geomorphic units listed in Table 4-10 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 km^2 of Source Zone, 70 820 km^2 of Transport Zone and 122 641 km^2 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:

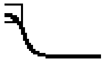
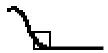
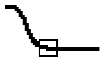
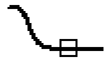
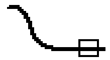
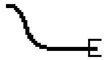
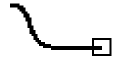
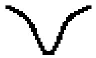
- A wide valley floor compared with the remainder of the catchment (5 – 15 km wide), comprising mainly quaternary alluvium set within clay plains with slopes typically < 5 % that were derived by erosion and slope wash from the weathered sedimentary rocks;
- An irregularly meandering channel that shifted 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 4-30).

Table 4-10 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	?

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
Function (sediments, nutrients, organics)	Relatively immobile source area	Highly mobile source area	Mobile source area	Mobile transfer area	Highly mobile transfer area. Some deposition of finer particles	Deposition	Deposition distributary	Deposition
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, macrophyte s
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 groundwate r

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
								interception

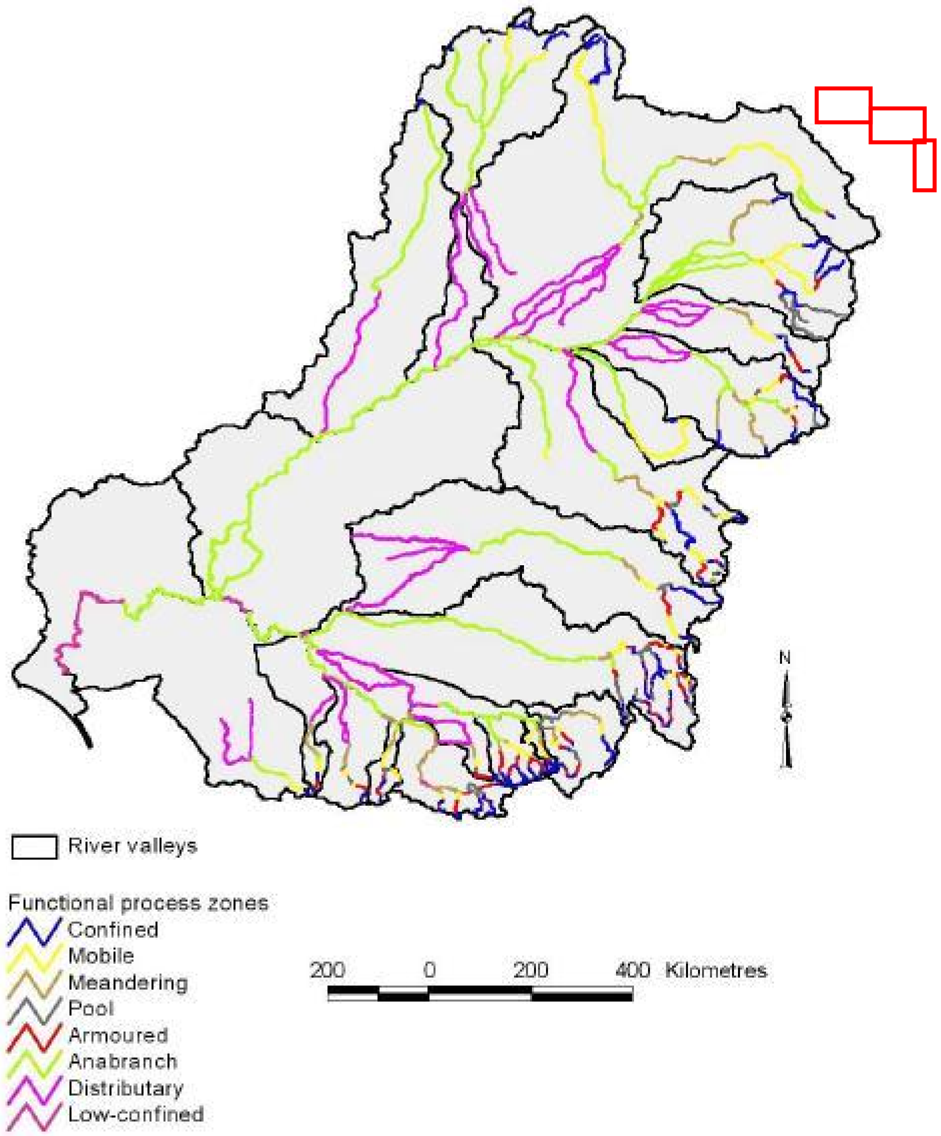


Figure 4-28 Functional Process Zones within the Murray-Darling Basin (Reproduced from: Whittington *et al*. 2001). Red boxes show approximate location of Project areas.

Only two Wetlands of National Importance occur within the Condamine-Balonne River catchment (Balonne River Floodplain Complex including Narran Lakes and Lake Broadwater) (see Section 4.5). In addition to these nationally important wetlands, a series of Off River Water Bodies (ORWB) adjacent to the main Condamine-Balonne channel formed from avulsions and meander bend cutoffs occur throughout the mobile, meandering, anabranching and distributary zones. However, the density of wetlands remote from the channel has significantly reduced as a product of agricultural and urban development within the catchment.

The Project area was contained within three sub-catchments identified in Van Manen (2001). These sub-catchments were Condamine River (Dalby to Chinchilla), Condamine River (Downstream of

Chinchilla) and Upper Balonne River. The Van Manen (2001) assessment identified the following major features within and adjacent to the Project area:

- The reach environs within the majority of the eastern streams and rivers were rated as good to very good;
- The Dogwood Creek catchment reach environments were moderate to very good;
- Poor reach environs were observed in most streams within the Upper Balonne River sub-catchment. These included upper Wallumbilla Creek which was considered to be poor, upper Yuleba Creek which was rated as very poor and upper Tchanning Creek which was considered to be poor to very poor;
- The majority of streams in the Chinchilla, Miles and Dalby sections of the Study area were considered to be stable, with general trends towards eroding;
- Upper Yuleba Creek was considered to be unstable (eroding), while lower Yuleba was considered to be unstable (aggrading);
- In terms of bed stability, there were a mixture of eroding and aggrading reaches, although aggrading reaches dominated. However, most reaches were considered to be stable;
- Areas of concern in terms of bed stability included downstream reaches of Tchanning Creek; upstream reaches of Wambo Creek and downstream reaches of Wilkie Ck; and
- Most reaches were considered to have very low or low channel diversity, a product of bed aggradation.

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 located within the Project area was either 50 – 100 times and greater than 100 times natural conditions (Figure 4-29) (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/km^2 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.

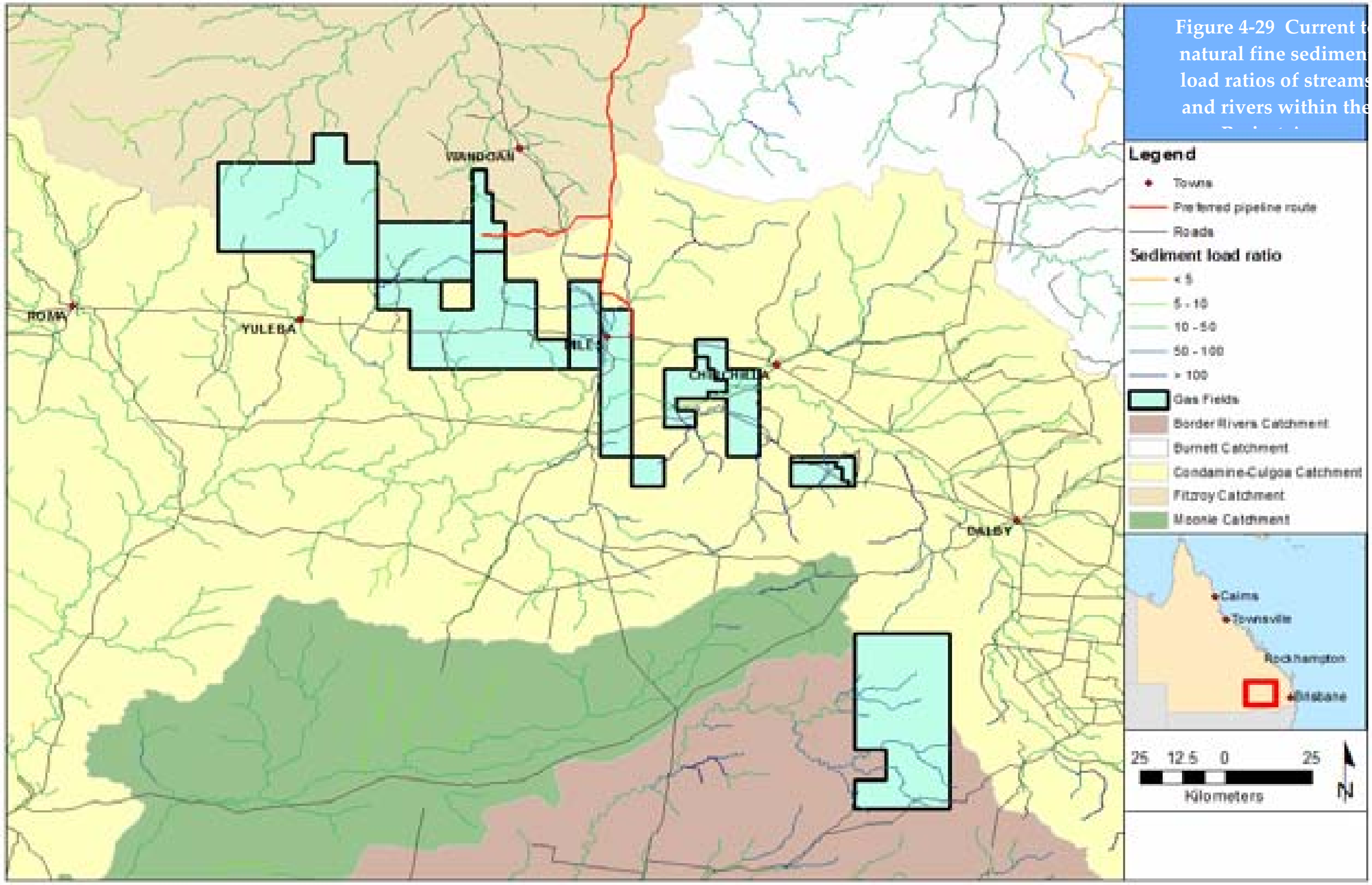


Figure 4-29 Current to natural fine sediment load ratios of streams and rivers within the Project Area (Source: NLWRA 2001)

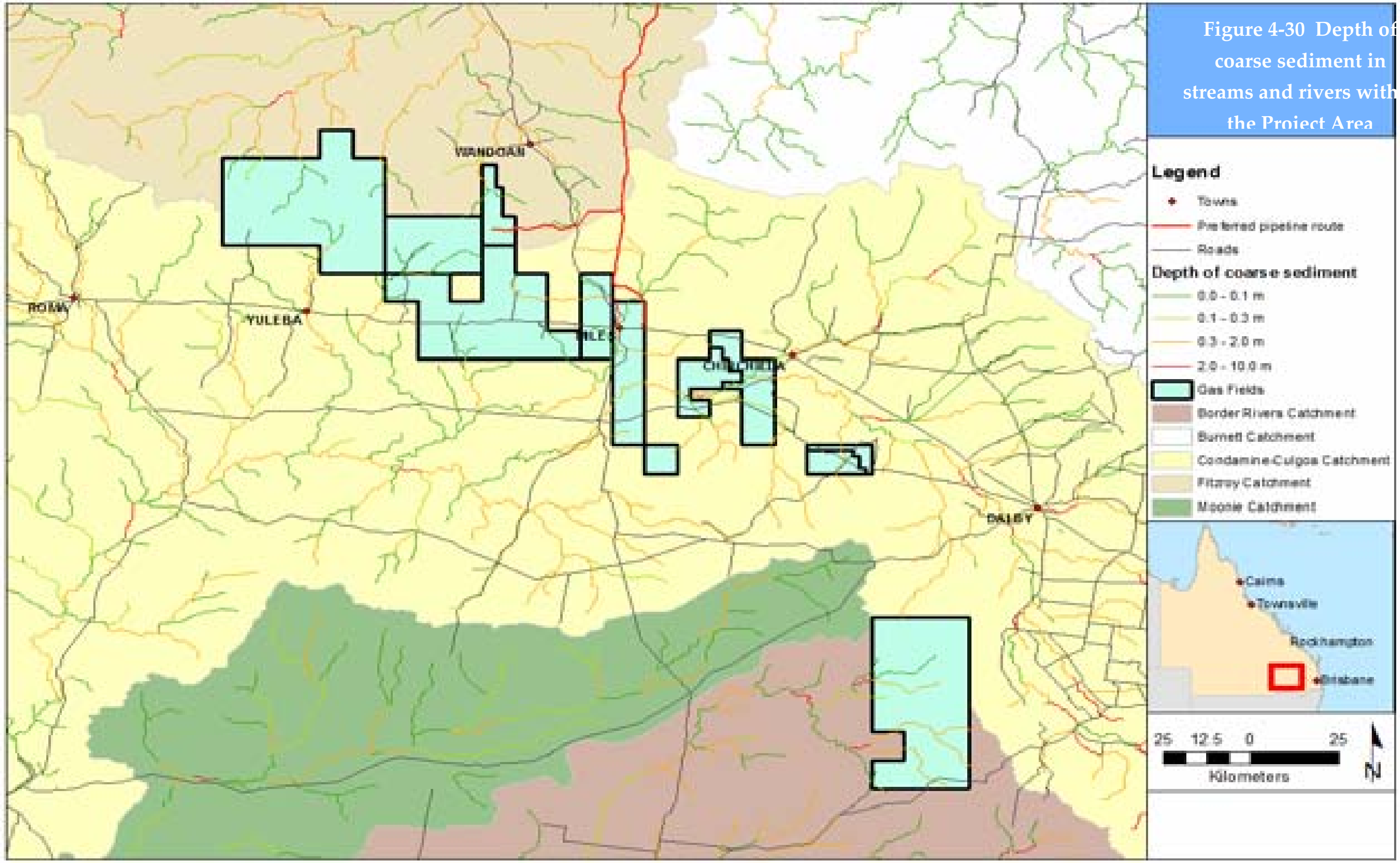


Figure 4-30 Depth of coarse sediment in streams and rivers within the Project Area (Source: NLWRA 2001)

Dawson Catchment

General catchment and Project Area 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 Sub-humid, 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 upper Dawson River. However, geomorphology generally reflected the summer dominated, variable hydrology discussed above (sacrificial bars/benches in places, multi-staged banks, large bankfull channel). It was 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). The southern tributaries showed similar features, with deposition resulting from increased sediment-laden runoff from the surrounding catchment the major issue within the area.

Mean annual bank erosion was shown to be relatively low throughout the southern Dawson River catchment (NLWRA 2001). However, coarse sediment depth was shown to be considerable (0.3 – 2 m) in the small southern tributaries, indicative of infilling processes resulting from sediment-laden runoff entering streams (Figure 4-30).

The State of the Rivers assessment of the Dawson River and tributaries was conducted by Telfer (1995). The gas development areas and assessed sites were all within the Upper Dawson or Southern Tributaries sub-catchments. The Upper Dawson River catchment had moderate to very good reach environs, with some highly disturbed sites. Grazing was identified as the major contributor to disturbance. Other identified features of this sub-catchment were:

- Stream banks were stable to very stable, although erosion was observed at irregular locations and at bends at all sites;
- Stock incursion and vegetation clearance were the major factors influencing bank and bed stability;
- Highly stable beds, although bed erosion and aggradation occurred at 29 % and 71 % of sites respectively;
- Bed sediments were understandably variable, ranging from silt to boulders, with rock outcropping observed at some sites;
- A range of habitat types, bed sediment and channel width-depth ratios were observed; and

There was variable riparian vegetation (very poor to very good) dependent on surrounding land use.

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.

Catchment sediment processes

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 of both the Dawson and its southern tributaries were shown to be 10-50 times higher than natural conditions (Figure 4-29) (NLWRA 2001).

Border Rivers Catchment

General catchment and Project Area fluvial geomorphology

The Project area was located within the upper reaches of the Weir River sub-catchment. Figure 4-28 shows that the upper Weir River comprised both Confined and Meandering FPZs. The Project area consisted of reaches identified as Confined (with exception of site GFE10) (Thoms and Sheldon 2002). This zone was characterised by high energy streams and rivers with high slopes (>0.01) and high stream powers, sand-dominated bed material, restricted floodplain development and unstable bed conditions. Site-based observations partly agreed with these descriptions, but Western Creek was undergoing severe aggradation and Weir River had flat uniform beds at the visited sites, indicating excessive sediment supply to the stream. NLWRA (2001) supported this observation, with coarse sediment depths on Western Creek and upper Weir River being between 0.3 and 2 m, with a short reach at the Western Creek-Weir River confluence having coarse sediment depths > 2 m depth (Figure 4-30). Mean annual bank erosion was shown to be relatively low throughout the upper Weir River

sub-catchment (NLWRA 2001), although Johnson (1999) showed bank erosion was providing significant sediment to the channels. Gullying was also observed to be a major sediment input.

Johnson (1999) identified the following major features within and adjacent to the Project Area:

- Reach environs were generally rated good or very good except for two small reaches with poor environs;
- Banks were generally eroding, with large sections of Western Creek and its tributaries and some tributaries of Weir River (e.g. Waar Waar Creek) being rated as unstable or very unstable;
- Beds were generally infilling, with the majority of Weir River being rated as unstable. Waar Waar Creek and parts of Paddy Creek were also rated as unstable; and
- Channel diversity was generally rated as poor to very poor. Some tributaries of Western Creek and Weir River and downstream reaches of Weir River were rated as having moderate diversity.

Catchment sediment processes

National-scale resource mapping showed that the existing fine sediment load within the upper reaches of the Border Rivers catchment was much higher than natural conditions. The fine sediment load of the streams within the Project Area was shown to be > 50 times higher than natural conditions (Figure 4-29) (NLWRA 2001).

4.4.2 Results of site-specific assessment

A summary of assessed geomorphic condition at all sites is provided in Table 4-11. Full results are provided in Appendix 5.

Condamine River (GF8, WTF3, WTF4)

There were three sites assessed on the Condamine River. As described in Section 3.5, the two WTF sites involved an extended assessment that entailed a 1 km traverse of the stream downstream of the proposed release point. In addition, there was a reach assessment of another proposed Condamine River permeate-discharge release point. The results of these extended assessments are included in this section. The reaches that flowed through or adjacent to the Project area were generally highly disturbed. The floodplain was cleared except for isolated sections, with riparian areas severely thinned and cleared. Some good patches of riparian vegetation existed (e.g. WTF4); however, the trees were not dense, the bank toe was often unprotected and weeds dominated (mostly grasses) (Figure 4-31). The floodplains were extensive and contained examples of raised relict terraces and old channels (paleochannels), many of which were highly modified due to agricultural land uses.

Within-channel features included mobile bars (mostly lateral and mostly increasing in size from gully and bank erosion inputs); low, recently formed benches; elevated benches and older terraces (Figure 4-31); flood runners; levees; and isolated riffle habitat. There were extensive pools (which have infilled to some degree) separated mostly by sediment deposition at the confluences of gullies (Figure 4-31). Pools were generally filled with highly turbid water. While this has been exacerbated by upstream vegetation clearance and land degradation, the Condamine River is a naturally turbid system, a point noted by Ludwig Leichhardt during his explorations of the Condamine River

catchment (Leichhardt 1847). The dominant source of impact was sediment-laden runoff and stock incursion into the stream.

Boundary material was characterised by banks with high clay content (some with dispersive / slaking properties) and occasional sand lenses. Bed material was generally a silty sand texture, with large patches of gravel content, particularly at gully outfalls. Occasional rock outcropping was noted in the banks and bed (Figure 4-31). Bank stability was variable within and between sites, indicative of the variable bank sediments. Banks varied between moderately unstable and stable. Overall, the bed was undergoing moderate aggradation, with obvious signs of increased sediment (e.g gully outfalls) and reduced bed variability. The rock outcropping observed in the bed and banks provided stability in sections.

Northern-eastern Condamine tributaries (GF1, R1, GF6, GF6a, GF7, R3)

The lower reaches of these tributaries 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. These reaches showed evidence of historical incision with more recent infilling resulting from vegetation clearance, gullying, stock incursion and, in the case of GF6 and GF6a, the depositional environment created by Charley's Weir. Most reaches typically had benches / terraces, with raised flood channels / floodouts (within and above channel) at locations on both sides. Gullying was evident at all sites (Figure 4-32).

The general trend within all downstream assessment sites was one of infilling, exacerbated at GF6 and GF6a by the presence of Charley's Weir (Figure 4-32). All sites were undergoing moderate aggradation, mostly sourced from gullying. Banks varied in stability from moderately unstable to stable. Dogwood Creek at GF1 was particularly unstable in sections due to erodible bank material (dispersive clays) (Figure 4-32). Few bank stability issues existed at GF6 and GF6a due to the decreased stream power.

Upstream reaches of these tributaries were in better condition than the downstream reaches. Riparian vegetation was generally in a better condition, although the surrounding landscape was still largely cleared (Figure 4-33). 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 4-33). The dominant impacts were from vegetation clearance and sediment-laden runoff.

	
(a) WTF3 bank failure	(b) WTF3 Downstream sediment accumulation and pool
	
(c) WTF4 Extensive pool and good riparian vegetation	(d) WTF4 Raised bench and sediment accumulation
	
(e) GF8 Gully	(f) GF8 Gully outfall

(g) GF8 Bank rock outcropping

(h) GF8 Extensive pool

Figure 4-31 Photographs showing geomorphic condition for Sites GF8, WTF3 and WTF4

(a) GF1 bank instability

(b) GF1 Continuous vegetation

(c) R1 Bed sedimentation

(d) R1 Bank instability

	
(e) GF6 Weir pool, poor lower bank vegetation	(f) GF6 Tributary/gully confluence, poor riparian vegetation
	
(g) GF6a Scattered vegetation	(g) GF6a Deposition upstream of weir pool
	
(g) GF7 Patches of good and poor riparian vegetation	(h) GF7 Gullying

Figure 4-32 Photographs showing geomorphic condition of Sites GF1, GF6, GF 6a and GF7

	
(a) R3 Lower bank erosion, good riparian vegetation	(b) R3 Small pool, good and poor vegetation

Figure 4-33 Photographs showing geomorphic condition of R3

North-western Condamine tributaries (GF2, GF3, GF9, GF10)

The north-western tributaries were also highly disturbed in terms of floodplain and riparian clearance. Riparian vegetation was very poor in most places, with some patches of good vegetation. GF9 was an exception, with continuous (but narrow – to the top of the bank) upper storey vegetation (Figure 4-34). Two main characteristics were driving instability – gullying and the related lack of vegetation. In places where vegetation existed, banks were generally stable. As a result, GF9 and GF10 were generally stable (due to their more continuous riparian vegetation), while GF2 and GF3 consisted of very unstable banks (Figure 4-34). The beds at most sites were currently infilling (mostly from gullying), resulting in reduced geomorphic variability within the channel by flattening of the bed and infilling pools (Figure 4-34). However, in sections, gully outfalls also resulted in damming of pools and increasing their depth. These tributaries were mostly U-shaped channels, although some small benches were observed.

Banks generally consisted of high clay content (some dispersive qualities), with isolated changes in bank material. Some sandier / cobbly banks (e.g. GF2 and GF3) were observed, particularly where the channel dissected older tertiary deposits, providing some variability in bed material.

Southern Condamine tributaries (HPE8)

The southern tributaries (in the Gilbert Gully region) drained State Forest land and, as such, were generally less disturbed than the remainder of the catchment. While grazing and forestry activities still provided disturbance, their impact was less prominent. Riparian and floodplain vegetation consisted of regrowth forest which provided stability to banks (Figure 4-35). Bed material was largely a loamy texture with some very sandy sections (Figure 4-35). Floodplain water storages were evident throughout this region, including the nationally important Lake Broadwater (Refer Section 0).

	
(a) GF2 bed deposition	(b) GF2 Eroding, unvegetated bank
	
(c) GF3 Bed sedimentation	(d) GF3 Bank instability
	
(e) GF9 Stable, well vegetated banks	(f) GF9 Terrace and flood channel

	
(g) GF10 Bed deposition	(h) GF10 Good riparian vegetation and LWD

Figure 4-34 Photographs showing geomorphic condition of Sites GF2, GF3, GF9 and GF10

	
(a) HPE8 Large pool, dense upper riparian vegetation	(b) HPE8 Bed deposition

Figure 4-35 Photographs showing geomorphic condition of HPE8

Balonne tributaries (HPE3, R7)

These streams were highly to extremely disturbed, with extensive sections with little to no substantial riparian vegetation and no floodplain vegetation (with exception of exotic grasses). As a result, while some banks were stable (generally those which were vegetated), there were sections where banks were highly unstable, undergoing considerable erosion (e.g. HPE3) (Figure 4-36). Gullying was also evident, particularly at HPE3. Moderate aggradation was occurring at both visited sites (Figure 4-36), although bed material at HPE3 consisted of much higher clay content, reflecting higher clay content in the banks and floodplain sediments.

Rock outcropping provided stability and some bed variability at R7, but the fine, sandy and fairly uniform bed indicated moderate infilling. Both channels were U- or box-shaped, with one example of a multi-stepped channel at R7, consisting of very sandy benches provided by the adjacent gully.

Dawson River and tributaries (GF5, HPE2, HPE5, R2, WTF1)

The assessment of WTF1 involved an extended 1 km walk-through downstream of the proposed discharge release point. This extended assessment has informed the existing environment descriptions contained within this section.

The main Dawson River floodplain and riparian zones within the upstream reaches were in good condition relative to the remainder of the Project Area. Channel condition reflected the improved surrounds. While some signs of deposition were still evident (sandy deposits at gully outfalls), the bed was variable, with pools, runs and riffles evident within the assessed reach (Figure 4-37). Banks were also reasonably stable, but erosion and gullying occurred where there was no vegetation. Multi-staged banks were evidence of historic incision into the landscape, as discussed above, while the greater channel was relatively confined by upper relict terraces and the surrounding rolling hills (Figure 4-37).

All Dawson River tributaries within the Project area drained from the Great Dividing Range in the south of the catchment. All were highly modified streams with very sandy infilled beds, reflecting the source geology (Figure 4-38). Stream types varied according to their location within the catchment. However, all assessed sites appeared to be either flat U-shaped or widened and infilled channels, reflecting the moderate to severe aggradation that had occurred within the bed. This aggradation had merged the bed with pre-existing bars and benches, reducing geomorphic variability within the channel. There were highly unstable banks at all sites, with gullying, undercuts, slips and toppling failures all observed (e.g. GF5) (Figure 4-38). Lateral movement was slowed in sections where the channel dissected cemented tertiary deposits (e.g R2).

Border Rivers tributaries (GFE6, GFE7, GFE10, RE9)

The Project area only occurred within the far north-eastern headwater section of the Border Rivers catchment. All reaches were highly disturbed, with major infilling occurring. Western Creek was undergoing moderate to severe aggradation, resulting in infilled, flat beds, while Weir River was also undergoing moderate aggradation in sections (Figure 4-39). Most banks were moderately stable, with GFE7 on Western Creek an exception. Rock outcropping provided stability at some sites (GFE6), while observed cracking clays (GFE6, GFE7, RE9) indicated some stability risks (Figure 4-39). Weir River banks were multi-staged, with prominent bench formations, although infilling was occurring and masking benches to some degree. While the beds were generally infilling, some sandstone outcropping was evident in the Weir River, indicating historical incision.

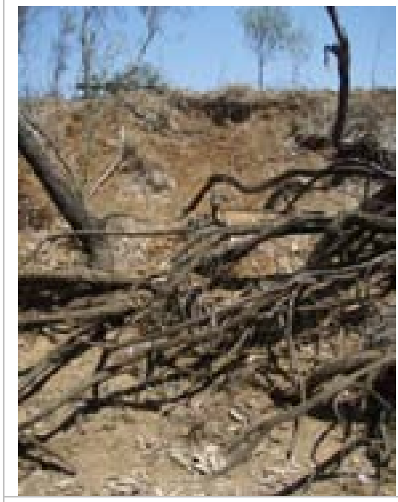
	
(a) HPE3 Poor bank condition	(b) R7 Rock outcropping
	
(c) R7 Bed sedimentation	(d) HPE3 Bed sedimentation

Figure 4-36 Photographs showing geomorphic condition of Sites HPE3 and R7

	
(a) GF5 Severe aggradation, poor riparian vegetation	(b) GF5 Bank failure
	
(c) HPE2 Shallow pool, good riparian vegetation	(d) HPE2 Run
	
(e) HPE5 Severe aggradation	(f) HPE5 Bank erosion, poor vegetation

Figure 4-37 Photographs showing geomorphic condition of Sites GF5, HPE2, HPE5

(a) R2 Infilling, bank erosion

(b) Failed blocks

(c) WTF1 Bank failure

(d) WTF1 Bed deposition

Figure 4-38 Photographs showing geomorphic condition of Sites R2 and WTF1

	
(a) GFE6 Bed deposition	(b) GFE6 Bank instability
	
(c) GFE7 Bed deposition	(d) GFE7 Bank instability
	
(e) GFE10 Bed deposition	(f) GFE10 Riparian vegetation

	
(g) RE9 Bed infilling	(h) RE9 Bank instability

Figure 4-39 Photographs showing geomorphic condition of Sites GFE6, GFE7, GFE10 and RE9

Table 4-11 A summary of the geomorphic assessment results for gas field and associated infrastructure sites.

Site	Stream	Channel shape	Valley Shape	LB Shape Dominant	RB Shape Dominant	Bed stability rating	Dominant Disturbance	Overall Disturbance Rating	Average Width	Bank Stability Rating (/4)	Average RB Riparian Width	Average LB Riparian Width
Balonne Catchment (Condamine – Balonne basin)												
HPE3	Wallumbilla Creek	Box	Symmetrical floodplain	Convex	Convex	Stable to moderate aggradation	Clearing vegetation	Extreme	17	2.33	2	2
R7	Bungil Creek	U shape	Symmetrical floodplain	Concave	Convex	Moderate aggradation	Clearing vegetation	Very high	22	3.00	3	2
Condamine Catchment (Condamine – Balonne basin)												
GF1	Dogwood Creek	Two stage	Broad valley	Stepped	Stepped	Moderate aggradation	Clearing vegetation	High	77	2.33	40	30
GF2	Tchanning Creek	Flat u shape	Symmetrical floodplain	Convex	Concave	Moderate aggradation	Sediment-laden runoff	Very high	50	2.33	10	7
GF3	Tchanning Creek	U shape	Broad valley	Concave	Concave	Moderate aggradation	Stock	Very high	56	1.33	19	3
GF6	Charleys Creek	Flat u shape	Symmetrical floodplain	Concave	Concave	Moderate aggradation	Clearing vegetation	High	67	4.00	43	37
GF6a	Rocky Creek	Widened or infilled	Flat u shape	Convex	Stepped	Moderate aggradation	Sediment-laden runoff	High	81	3.00	20	37
GF7	Charleys Creek	U shape	Assymetrical flood plain	Concave	Convex	Stable to moderate aggradation	Clearing vegetation	High	48	2.00	23	35
GF8	Condamine River	Two stage	Shallow valley	Convex	Concave	Moderate aggradation	Sediment-laden runoff	Very high	83	2.00	50	20
GF9	Yuleba Creek	U shape	Symmetrical floodplain	Convex	Convex	Stable to moderate aggradation	Upstream sediment runoff	High	26	3.50	10	5
GF10	Yuleba Creek	U shape	Symmetrical floodplain	Concave	Concave	Moderate aggradation	Sediment-laden runoff	Very high	21	3.00	7	5
HPE8	Wilkie Creek	U shape	Broad valley	Concave	Concave	Stable	Clearing vegetation	Moderate	26	3.33	37	37
R1	Dogwood Creek	U shape	Shadow valley	Stepped	Stepped	Moderate erosion	Sediment-laden runoff	Moderate	57	2.67	40	50
R3	Charleys Creek	Deepened u shape	Broad valley	Convex	Convex	Moderate erosion	Clearing vegetation	High	36	3.00	22	28
WTF3	Condamine River	Two stage	Shallow valley	Stepped	Stepped	Moderate aggradation	Sediment-laden runoff	Very high	66	2.67	47	22
WTF4	Condamine River	Multi stage	Broad valley	Convex	Convex	Moderate aggradation	Stock	High	60	3.33	28	40
Border Rivers Catchment												
GFE6	Weir River	Two stage	Broad valley	Concave	Stepped	Stable to moderate aggradation	Clearing vegetation	Very high	71	3.00	8	30
GFE7	Western Creek	Widened or infilled	Shallow valley	Convex	Convex	Severe agradation	Clearing vegetation	Very high	39	2.33	18	20
GFE10	Weir River	Two stage	Shallow valley	Stepped	Stepped	Moderate aggradation	Clearing vegetation	Very high	29	3.67	5	7
RE9	Western Creek	Flat u shape	Broad valley	Convex	Convex	Moderate aggradation	Stock	High	21	3.33	37	35
Dawson Catchment (Fitzroy basin)												
GF5	Wooleebee Creek	Flat u shape	Broad valley	Concave	Concave	Severe aggradation	Sediment-laden runoff	Extreme	28	1.33	0	0
HPE2	Dawson River	Multi stage	Shallow valley	Stepped	Stepped	Stable	Clearing vegetation	Moderate	41	3.00	13	13
HPE5	Juandah Creek	Widened or	Broad valley	Convex	Wide	Moderate to severe	Clearing vegetation	Extreme	143	2.33	0	2

		infilled			lower bench	aggradation						
R2	Horse Creek	Widened of infilled	Widened of infilled	Convex	Convex	Moderate aggradation	Clearing vegetation	High	40	2.00	13	3
WTF1	Horse Creek	Widened or infiled	Shallow valley	Concave	Concave	Moderate aggradation	Gullying, runoff	Very high	60	1.33	22	12

4.5 Aquatic Habitat

4.5.1 Results

The outcomes of the aquatic habitat assessment are provided in Table 4-12. 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 4-12. 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).

The majority of sites throughout the Condamine-Balonne, Dawson and Border rivers had poor or very poor aquatic habitat. Five sites located in the Condamine-Balonne catchment; Yuleba Creek (GF9), Dogwood Creek (ORWB1) the Condamine River (WTF4) and Charley's Creek (RORWB4 and R3) and one site on the Upper Dawson River (HPE2) had a good aquatic habitat rating. This was a result of good channel and habitat diversity, minimal surrounding land use impact and good riparian connectivity and shading. The reference site located on Dogwood Creek (R1) was the only site to record an aquatic habitat rating of high.

Very few aquatic macrophytes were recorded throughout the surveys. Macrophytes were observed at the following sites:

- GF9 – Phragmites australis (Common reed) covering approximately 1% of the creek margins;
- GF2 – Cyperacea spp. (sedges) and the exotic weed Urochloa mutica (Para grass) covering approximately 1 % of the creek margins;
- GF6 and GF6a – Ludwigia spp. Covering approximately 20 % of the in-stream habitat and creek margins; and
- GF5 – Cyperacea sp. (sedges) covering approximately 1 % of the creek margins.

No notable macrophyte species were recorded during the dry season surveys.

4.5.2 Regional perspective

Condamine-Balonne catchment

As stated previously (Section 0) 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.

Dawson catchment

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 landuses, 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.

Table 4-12 A summary of the habitat assessment results for gas field and associated infrastructure 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					
Border Rivers Catchment																
GFE6	Weir River	Very Poor			Grazing (cleared)	No Passage	Very Restricted	2	0	0	3	Very High	55	15	54	- very poor site with obvious upstream influences on bed condition - incised historically, but now infilling - sandy bed (with sandstone outcropping) - rock outcropping in banks - typical sodic soils on LB - cracking, rilling, tunnels etc
GFE7	Western Creek	Very Poor	Dams and diversions		Grazing (cleared)	No Passage	Partly Restricted	1	0	0	0	Very High	64	52	53	- landuse upstream resulting in highly sandy bed - few habitat values - very highly disturbed site - upstream landuse evidently contributing to increased sediment delivery to channel - very sandy infilled bed with little to no geomorphic variability - cracking clays evident
GFE10	Weir River	Poor		Ford	Grazing (cleared)	No Passage	Very Restricted	3	0	0	12	Very High	9	9	41	- highly disturbed site - historic incision evident, but now infilling with sand - gullying major issue - major issue of sand in bed
Condamine-Balonne Catchment																
GF1	Dogwood Creek	Poor	Revegetated		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 - little LWD - good rip zone on RB with some sect of LB also having good rip veg
GF2	Tchanning Creek	Poor			Grazing (cleared)	No Passage	Moderately Restricted	5	1	0	17	Very High	0	28	43	- No flow. Long isolated pool (>400m) - Surface scum present on downstream half - Algal scum present - Low levels detritus - Poor canopy cover - Slight bank overhang (paragrass); some fringing macrophytes - little LWD, very little fringing vegetation - channel geomorphic variability reduced by infilling from

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					
																gullying - flattened infilled beds
GF3	Tchanning Creek	Poor	Desnagged		Grazing (cleared)	No Passage	Partly Restricted	5	0	7	17	Very High	13	18	48	- patches of good rip veg along reach - lots of sand deposits - extremely bad habitat at TS3: no rip veg, no LWD - Low value channel - very similar habitat throughout reach - infilled - deepening - some good rip vegetation maintaining some stability - deposition of sediment relative to gullying associated with lack of vegetation - major active process: run off from surrounding landscapes, bank failure, deposition of large amounts of sediments downstream of failures - huge infilling issues in sections, - gullying
GF6	Charleys Creek	Poor	Dams and diversions	major weir	Grazing (cleared)	Good Passage	Unrestricted	2	20	77	3	High	68	84	39	- turbid - Slight bank overhang vegetation - moderate macrophytes - scattered LWD - lower bank vegetation cleared for weir - increase in sediment - increased infilling of weir
GF6a	Rocky Creek	Poor	Dams and diversions	major weir	Grazing (cleared)	Good Passage	Unrestricted	5	10	23	18	High	36	86	55	- very turbid water - local grazing - major weir causing some deposition - cleared both sides with patches of good vegetation on RB - weir pool keeps veg away from low water but continuity and density is generally ok with sections of poor connectivity - minor infilling of channel ass with weir - a lot of aquatic vegetation but looks to be exotic (photo 28-32)
GF7	Charleys Creek	Poor	Dams and diversions	bridge, ford	Grazing (cleared)	No Passage	Moderately Restricted	2	< 1	0	15	High	47	27	48	- 2 isolated pools (each 50 m long), 30 cm deep - Some LWD, lots of LWD downstream - Riparian veg 20m wide (RB), 15m (LB) – some regrowth - poor canopy cover - No algae or detritus - Para grass on margins - Slight bank overhang veg - Local landuse – extensive cattle grazing, stock watering - very poor aquatic habitat values - gullying infilled pool, little shading
GF8	Condamine River	Poor			Grazing (cleared)	No Passage	Good Passage	11	0	38	2	Very High	0	3	43	- Light cattle grazing/cropping - poor canopy cover - no algae or detritus

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					
																- very turbid water - isolated logs provide habitat - major infilling of pools by gully washout at TS1 - highly modified in terms of riparian and floodplain vegetation - poor LWD and habitat features although a rock within the channel provides habitat at d/s reaches - major issues: gullying; veg clearance; runoff
GF9	Yuleba Creek	Good			Grazing (cleared)	Unrestricted	Unrestricted	2	1	47	33	High	36	72	78	- Straight section of creek, deep, turbid, no flow - Good riparian vegetation (>20m) - No macrophytes in water, but phragmites on margins - Moderate LWD - - scattered logs and branches - high velocities (in a deep channel) would transport smaller stuff downstream - No algae or detritus - Moderate bank overhang - gully downstream evidence of grazing pressure - floodplain vegetation cleared both sides - some pool infilling occurring - runoff from overland flow and gullies providing sediment to channel
GF10	Yuleba Creek	Poor			Grazing (cleared)	No Passage	Moderately Restricted	21	0	0	73	Very High	29	31	51	- Dense callistemon cover on both banks, <5m - 70% canopy cover - No algae - Lots of detritus - Local landuse – cattle grazing - No bank overhang veg - No macrophytes - Moderate LWD - infilling of run at TS2 has reduced habitat values - TS1 - lots of LWD - cleared floodplain contributing to gullying into stream - otherwise relatively stable banks - obvious stock tracks down banks
HPE3	Wallumbilla Creek	Poor			Grazing (cleared)	No Passage	No Passage	4	0	0	10	Extreme	0	12	34	- severely modified creek with major gullying adjacent to stream - not as much sand in bed - indicative of high clay content in soils - obvious growth of bars in section with incised thalweg - erosive unstable banks
HPE8	Wilkie Creek	Poor		Ford	Grazing (thinned)	No Passage	Moderately	7	0	12	17	Moderate	91	92	79	- Large isolated pool, 200m long, 1m deep

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					
					Forestry		Restricted									- Dense riparian vegetation - Canopy cover 2% - Extensive bank overhang - Lots of detritus - No algae - No macrophytes - Limited disturbance, some 4WD track and light cattle grazing, state forest - low disturbance compared to other sites within the same region - forestry has had some impact on riparian and floodplain vegetation
ORWB 1	Dogwood Creek	Good			Grazing (cleared)	N/A	N/A	0	0	0	0	High	0	0	N/A	- dry ORWB with dense dying grasses - dry paleochannel that would provide good habitat in wet - poss connected to channel in high flows via over bank flow
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
R3	Charleys Creek	Good	De-snagged		Small crops / vines	No Passage	Moderately Restricted	4	0	0	43	High / Moderate	55	69	78	- Series of shallow, turbid, isolated pools, 0.2-0.4m deep - No macrophytes - No bank overhang vegetation - No algae, moderate detritus - Non irrigated cropping and grazing - few habitat values in terms of LWD - generally unmodified creek except for surrounding landscape - variety in habitat is quite good - upper section more riffle-like with TS2 and TS3 more incised pools - relatively incised with levees in section, flood runners between bank top and upper terrace
R7	Bungil	Poor			Grazing	No	No	2	0	3	12	Very High	6	0	56	- Isolated pool, turbid

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					
	Creek				(cleared)	Passage	Passage									- Limited riparian vegetation - Limited edge habitat - No macrophytes - Slight bank overhanging vegetation - No algae or detritus - Grazing and near road - little LWD - fine sandy fairly uniform bed (except against rock bank indicates some infilling) - cleared floodplain, riparian vegetation severely disturbed along most of the length of creek - some habitat values at high rock bank - deep pool but generally flat bottomed
RE9	Western Creek	Very Poor		culvert	Grazing (cleared)	No Passage	Moderately Restricted	1	0	0	12	High	30	46	41	- very highly disturbed site - upstream landuse evidently contributing to increased sediment delivery to channel - very sandy infilled bed with little to no geomorphic variability
RORWB4	Charleys Creek	Good			Grazing (sown pasture)	N/A	N/A	1	17	50	0	Moderate	0	0	N/A	- No fringing vegetation - 0% canopy cover - No bank overhang - No algae or detritus - Melon farm - permanent waterhole
WTF3	Condamine River	Poor	Dams and diversions		Grazing (cleared)	Good Passage	Good Passage	29	0	60	10	Very High	24	0	36	- Riparian zone sparse – dominated by exotic grasses - Large pool, no flow, turbid - Algal scum - No macrophytes - Canopy cover 10% - Local landuse – adjacent to aquaculture facility, grazing - Slight bank overhang - No algae or detritus - several large collections of LWD, providing some bed variability - bedrock at site - large pool with probably little connectivity with u/s and d/s pools
WTF4	Condamine River	Good	Desnagged		Grazing (cleared)	Moderately Restricted	Good Passage	8	0	17	15	High	0	13	64	- moderate canopy cover - No macrophytes

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					
																- No algae - Low levels of detritus - long pool, though is shallow - highly disturbed site with grazing and cleared land on LB and mod disturbance on RB - rip veg not dense but continuous, some disturbance of canopy with intrusion of invasive grasses - flat bed with little variability in habitat
Dawson Catchment																
GF5	Wooleebee Creek	Very Poor			Grazing (cleared)	No Passage	Very Restricted	0	0	0	0	Extreme	0	4	6	- Riparian and floodplain vegetation almost entirely absent - 3 small isolated pools, less than 30cm deep, turbid - Some fringing sedges, no other macrophytes - No algae or detritus - No canopy cover - Local landuse – light cattle grazing - dry sandy bed - no LWD - severely infilled channel with no bed variability
HPE2	Dawson River	Good		culvert	Grazing (cleared)	Partly Restricted	Partly Restricted	2	0	3	25	Moderate	40	41	79	- Near road crossing, grazing - Canopy cover 40% - Moderate bank overhang - No algae - Some macrophytes and detritus - stream in good condition, particularly reaches further upstream - while some signs of deposition are evident (sandy bed), it is fairly minor - probably due to fewer upstream influences - banks are reasonably stable, but erosion and gullying occurs where there's no vegetation
HPE5	Juandah Creek	Very Poor		bridge	Grazing (cleared)	No Passage	Very Restricted	1	0	0	2	Extreme	0	0	0	- highly modified stream that has been infilled with sand (old gully maybe) - deposition has led to growth of bars and benches, with grass colonisation leading to increases in bar sizes - bed is mostly coarse sand
R2	Horse Creek	Poor			Grazing (cleared)	No Passage	Very Restricted	1	0	0	8	High	31	39	42	- few habitat values throughout an infilled reach - lots of water-resilient plants in infilled channel - broad, flat channel that is widening at points, particularly where banks are sandy - patches of floodplain vegetation that are regrowing - bank vegetation generally young - infilled sandy channel - bars prominent low flow channel clearly infilled in most sections

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					
WTF1	Horse Creek	Poor			Grazing (cleared)	No Passage	Very Restricted	3	0	0	5	Very High	51	43	42	- large wide channel with few habitat values - enlarged bars - widening - slightly incised meandering through flow channel within depositional bars - few pieces of LWD - highly disturbed creek with high amounts of sediment stored in bed - sandy environment combined with vegetation clearance, gullying etc to considerable deposition within the creek

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.

Border Rivers catchment

Land use in the Upper Weir River catchment was dominated by grazing and forestry. Grazing was responsible for the majority of local disturbance and to a lesser extent; road infrastructure, forestry, sand and gravel extraction, discharges and cultivation (Johnson 1999).

Ratings for channel diversity, riparian vegetation condition and aquatic habitat varied depending on location, ranging from very poor to good. Generally, the Upper Weir River had poor channel diversity and moderate to very good riparian vegetation. The riparian zone had good cover with only 10% bare of vegetation, on average. Very low abundances of aquatic plants were recorded, resulting in a rating of very poor to poor throughout the catchment. Where aquatic vegetation was recorded, it was dominated by *Myriophyllum* spp. (Water milfoil) filamentous algae, *Vallisneria* spp., *Marsilea mutica* (Nardoo), *Azolla* spp. (water fern) and *Nymphaea* spp. (Waterlilies) (Johnson 1999).

Aquatic habitat varied considerably throughout the catchment, ranging from very poor to good. Fifteen of the possible 18 in-stream habitat types were recorded throughout the catchment, with the most common habitat being individual logs (76 % of sites). Canopy cover and bank vegetation overhang were generally good, occurring at 98 % and 81 % of sites, respectively (Johnson 1999).

4.5.3 Important wetlands

Several wetlands of national importance occur within the Condamine-Balonne River catchment, of which only Lake Broadwater (located 25 km south west of Dalby) and the Balonne River Floodplain complex, including the Ramsar listed Narran Lakes in the lower Balonne are relevant to the Project.

Numerous Great Artesian Basin (GAB) spring wetlands are located within and adjacent to the gas fields development and and could potentially be impacted by the Project.

These wetlands are described in further detail below.

Narran Lakes

Narran Lakes Nature Reserve has an area of 5 531 ha and forms part of a large terminal wetland of the Narran River (at the end of the Condamine River) in NSW. It is located approximately 500 km downstream of the Project area. Narran Lakes Nature Reserve is listed as a wetland of international importance under the RAMSAR Convention, is internationally significant for waterbird breeding and as habitat for species including a number listed under the Japan-Australia and China-Australia Migratory Bird Agreements (JAMBA and CAMBA). Narran Lakes Nature Reserve is also listed as a wetland of national importance as a major breeding site for waterbirds and as it contains a variety of flora associations considered to be threatened in NSW (Ramsar Information Sheet, NSW NPWS 2000).

Waterbird breeding is stimulated by inundation of the wetlands and successful breeding is influenced by a number of factors, including: inundation area, duration, frequency, timing and depth.

One of the objectives of the Narran Lakes Nature Reserve Plan of Management is "maintenance of diverse, healthy and productive wetland habitat and the value of the reserve as a major waterbird breeding area". Adequate inundation is recognised as being of fundamental importance to achieve this objective (NSW NPWS 2000).

Section 40 of the *Water Resource (Condamine and Balonne) Plan 2004* provides rules for managing Narran Lakes filling flow events in order to improved water availability for bird breeding. The rules must ensure that:

"If a flow event of a volume sufficient to fill the Narran Lakes Ramsar site under the pre-development flow pattern occurs during the winter bird breeding months, water harvesting must be reduced to 90% for the period of the flow event up to a maximum period of 10 days"

"The rules must also ensure that if both the following happen, water harvesting must be reduced to 90% for the period of the flow event up to a maximum period of 10 days: a) the Narran Lakes Ramsar site has filled during the winter bird breeding months and b) within 4 months after the sites has filled, a flow event that would re-fill the site under the pre-development flow pattern occurs".

Great Artesian Basin Spring Wetlands

Great Artesian Basin (GAB) spring wetlands 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, Fensham *et al.* 2007, Fensham *et al.* 2004).

The location of known springs in Queensland in relation to the gas fields development footprint is provided in Figure 4-40.

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). Although neither of these species were found during the dry season surveys, 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).

More than $90 million has been spent on rehabilitation (capping and piping) of GAB springs since 1989, which has resulted in significant improvements in water use efficiency and flow rates (EPA 2007, EPA 2005). In 2006 the *Water Resource (Great Artesian Basin) Plan* came into force in order to provide a legislative framework for the sustainable management and taking of water. The Plan aims to:

- Protect the flow of water to springs and baseflow to watercourses that support significant cultural or environmental values;
- Protect existing users; and
- Provide water within sustainable limits for new users.

The Great Artesian Basin ROP provides the mechanisms for achieving these aims.

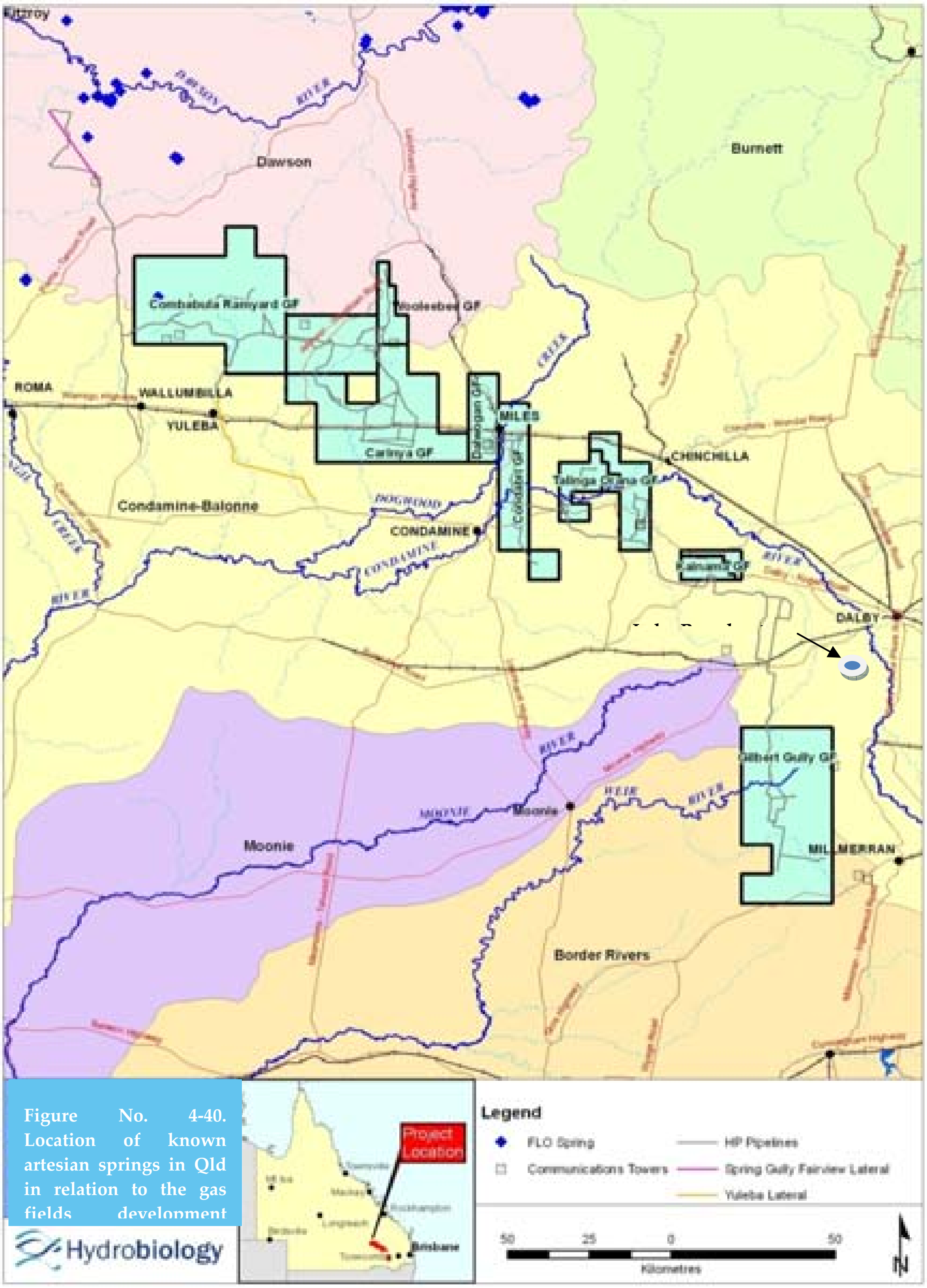


Figure 4-40 Location of known artesian springs in Queensland in relation to the gas fields development footprint (Source: DERM wetlands springs database)

Lake Broadwater

Lake Broadwater is situated at the border of the Condamine Valley and its water is supplemented by flows from Wilkie Creek and Broadwater Gully in the southwest and the Condamine River from the south via the Long Swamp – a series of swampy flood flow channels that fill during Condamine River floods.

Lake Broadwater is listed on the Directory of Important Wetlands as being a good example of a semi-permanent freshwater lake in an area where these are rare (DEWHA 1993). The lake also supports seasonally diverse and abundant flora and fauna, including species protected under JAMBA and CAMBA. The lake has good water quality and is wholly contained within the Lake Broadwater Conservation Park. The lake is used for low intensity recreation (boating, camping and fishing) and low intensity grazing. Potential threats include irrigation or hydrological changes (DEWHA 1993).

Lake Broadwater is located outside of the Project area. However, a small component of the Gilbert Gully gas field is located within the catchment and is connected to the lake by the floodplain during floods.

5. Assessment of Potential Impacts

5.1 Overview of Potential Impacts

Waterways within the study area could potentially be impacted during the construction phase through the installation of gas wells, construction camps, construction of water storages and treatment facilities, construction of roads and pipelines, construction gas processing facilities and associated infrastructure. The main impact mechanism likely to affect the aquatic environment during this phase is sediment mobilisation through the clearing of vegetation adjacent to waterways and bank or bed excavation. However, other activities may also impact aquatic biota, such as accidental chemical spillages, effluent generated from construction camps, direct removal of aquatic flora and fauna from excavation and a range of geomorphic impacts. Temporary standing waterbodies and pools created during the construction phase may also provide suitable mosquito and biting midge breeding habitat.

The potential operational impacts associated with well dewatering, treated water discharges, wastewater management, processing plant operation and permanent camps are more complex. Water management will be the main consideration during the operational phase.

5.2 Potential 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 MNES and other notable fish species associated with increased TSS and turbidity from pipeline and road construction;
- 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; and

Enhanced breeding of mosquitoes through ponding of water during construction.

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

- Erosion from exposed areas;
- Alteration of flow regimes from permeate discharge;
- Low calcium concentrations in permeate discharge;

- Elevated contaminant concentrations (boron) in permeate discharge;
- Erosion of exposed surfaces at permeate discharge points;
- Disturbance to threatened artesian spring communities associated with aquifer draw down from well water extraction;
- Contamination of Lake Broadwater from gas field operation;
- Chemical or wastewater contamination from accidental spills;
- Chemical contamination of watercourses resulting from brine pond overflows;
- Altered low flow hydrology / hydraulics resulting from road crossings; and

Enhanced breeding of mosquitoes from brine ponds.

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 MNES and other notable fish species associated with increased TSS and turbidity from pipeline and road construction	A number of notable fish species occur within the Condamine-Balonne, Dawson and Border Rivers catchments, although none were caught during the dry season surveys. All of these are adapted to high turbidity and suspended solids levels as a response to the highly variable and intensive rainfall patterns, soil instability and land uses within the catchments. As mentioned in impact mechanism 1, increased sediment delivery can lead to scouring or in-filling of fine scale habitat structure and smother food resources. The majority of streams in the study area are intermittent and are dry, or recede to a series of unconnected pools, for a large part of the year. Appropriately timed construction should avoid sediment related impacts. For permanent water bodies, particularly in the less turbid streams in the Dawson catchment, some impacts to fish populations may occur, although this is likely to be short lived. Reid and Anderson (undated) reported that fish catches dropped by 95% within the Little Miami River immediately after pipeline construction. However, fish abundances had returned to 50% of pre-construction levels within one month and within a year, fish densities were slightly higher than pre-construction. They went further to say that based on a review of 27 case studies (mainly from America and Canada), short term effects as a result of construction of open cut pipelines and roads could occur, but that recovery generally occurred within one year.
4	Disturbance to threatened artesian spring communities associated with pipeline and road construction	No known artesian springs are crossed by the pipeline corridors or roads, although the HP pipeline connecting Spring Gully to Fairview is located in the vicinity of known springs (see Figure 4-40). Given that the HP pipeline route from Spring Gully to Fairview 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 vicinity of the gas fields. 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.
5	Temporary diversion of watercourses during construction of road and pipeline crossings	Temporary diversion of watercourses during construction of roads and pipeline crossings could enhance sediment transport and present a temporary barrier to fish passage. The majority of streams in the study area are intermittent and, assuming that construction is timed to avoid wet season flows, the majority of waterways 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 would accumulate upstream of the crossing and scour would occur downstream of the crossing. However, any impacts are likely to be temporary.
6	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. 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 waterways, the potential impacts should be minor. 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.
7	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.

No.	Potential Impact Mechanism	Potential Impacts
		Care will be required throughout construction to ensure that exposed areas are managed appropriately to minimise the initiation or exacerbation of gullying.
8	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 (e.g. Yuleba Creek); and • Particular issues relating to construction on or adjacent to dispersive soils.
9	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 study 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 study area. 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 kms) 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

	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 operational impacts resulting from this mechanism include: • Bank instabilities, including gully initiation or enhancement; • Increased sediment delivery to 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	Alteration of flow regimes from permeate discharge	There are currently seven alternative options for the location of the release of permeate discharge – two locations in the Condamine River (including the already approved Talinga WTF), one each in Yuleba, Tchanning, Wooleebee and Dulacca creeks and one in an unnamed stream. While the existing Talinga discharge of 35 ML/day is not part of this EIS, it requires assessment in the context of the additional proposed discharge at this site and in combination with the other proposed discharge volumes. Talinga Discharge The Talinga discharge represents a minor impact in terms of overall annual flow, contributing only 2.66 % to the 480 GL/year discharge at Chinchilla (EECO 2009a). It has also been shown to have negligible impacts to moderate and low flows within the Condamine River and negligible impacts to stream powers. However, this discharge will increase the occurrence of low flow scour, particularly considering the clear nature of the water and that it will change an intermittent river into a permanent one (with a base flow of 35 ML/day in the reaches downstream of the release point. EECO 2009a reported that, compared with the natural flow regime, any impacts would be minor and are expected to become insignificant well upstream of E. J. Beardmore Dam . Unapproved Discharges Final discharge volumes and timing are currently unknown and, as such, the assessment has been conducted over a range of possible discharge volumes. These include up to 235 Ml/day into the Condamine River, 80 Ml/d into Yuleba and the unnamed creek, 40 Ml/d into Woleebee and Dulacca creeks and 20Ml/d into Tchanning Creek the assessment has provided guidance on discharge regimes predicted to have minimum impact. However, this discussion also considered the likely reduction in impacts based on both continuous discharge of lower rates during the first 3 years and seasonal adapted discharges. It is also noted that it is likely that reuse options are proposed to be implemented within the first 3 years - although this is uncertain. The impacts from the release of permeate discharge will vary in magnitude and severity according to several factors, discussed below: The size of stream in which the water will be discharged. Larger streams are generally more capable of conveying greater volumes of water and, as such, the relative impact of releasing flows decreases within increasing stream size. For example, at the proposed point of release at Yuleba Creek, the planned 80 Ml/d discharge is about 2 % of bankfull flow, whereas at the Condamine release point, the planned 235 Ml / day is about 0.3 % of bankfull flow. These relative differences have large follow on impacts on those flow parameters that define the likelihood for geomorphic and ecological change (e.g. velocity, stream power, shear stress); The type of stream in which the water will be discharged. Incised streams with steep, high banks are more likely to be affected by increased discharge than those with more gradually sloped banks; Boundary conditions of the stream at, and downstream of, the release point. Bank and bed sediment type (particularly with regard to any dispersive qualities) and the presence and abundance of riparian and aquatic vegetation are important controls of channel stability; The final volume of water to be released each day; and The timing of release (i.e. wet season release versus continual release). The release of water during drier periods will have greater relative impacts on hydraulics than release during periods of higher flow. Release of water during periods normally exposed to low / no flow will also reduce the variability of the flow regime, altering a system adapted to ephemeral conditions to a more permanent one. The Water Resource (Condamine-Balonne) Plan (2004) stated that all performance indicators (low flow, summer flow, beneficial flooding flow, one in two-year flood and one in 10-year flood) be no greater than 133 % or no less than 66 % of the pre-development flow pattern following impact. Preliminary IQQM indicated that if a constant discharge equal to 50 Ml/d released from the proposed upstream Condamine discharge location or 65 Ml/d from the proposed downstream Condamine discharge location will meet the Environmental Flow Objectives (EFO) (refer Volume 5, Attachment 31).. However, a constant discharge regime may substantially alter low flow regimes. This is demonstrated through analysis of the flow duration curves provided in Appendix 7 and Volume 5, Attachment 30. Preliminary flow exceedence curves indicated that discharges would need to cease for approximately 30% of the time on the Condamine River and up to 85 % of the time on smaller tributaries to minimise alteration to low flow regimes and that the discharge volumes may need to be limited to ensure that the resulting flows are not increased above 133% of the pre-development (pre weir) flow patterns. This has implications for geomorphology and aquatic ecology. Any additional discharge would need to be considered in the context of the existing Talinga discharge. Further

	Potential Impact Mechanism	Potential Impacts
		IQQM modelling using a range seasonal release scenarios indicates that impacts to low flow regimes could be minimised by better mimicking the pre-development flow regime (refer Volume 5, Attachment 30).

Potential Impacts to aquatic ecology

The aquatic flora and fauna of intermittent streams have adapted life history strategies in direct response to the natural flow regimes (Bunn and Arthington, 2002, Smith *et al.* 2004). Periods of low and / or no flow are critical to the maintaining the community structure within intermittent streams as they enable high rates of primary production, facilitate litter breakdown and nutrient cycling and can exclude invasive species (Bond and Cottingham 2008, Bunn and Arthington 2002). Many macroinvertebrate taxa have specific requirements for current velocity or flow ranges and changes in community structure could occur directly as a result of altered flow or indirectly as a result of changes to habitat availability (Bunn and Arthington 2002, Extance *et al.* 1999). Bunn and Arthington (2002) stated that sudden increases in flow, such as those below hydropower discharges, can cause catastrophic downstream drift. The main impacts associated with increased baseflows to macroinvertebrates would be increased macroinvertebrate drift downstream of the discharge point (although this is likely to be short-term, with recolonisation following sustained increases in baseflow), loss of habitat and potential loss of recruitment (e.g. some microcrustacean species lay their eggs in sediment and require drying and re-wetting of the sediment to facilitate hatching (Thoms *et al.*, 2002). The increased flow may favour taxa adapted to perennial streams, and impact those that have competitive advantage in intermittent waters (for example, macroinvertebrates with aestivating life stages, and those that are initial colonisers of newly inundated water bodies). There are conflicting opinions within the scientific community as to whether changes to community structure resulting from increased discharges during the low (or no) flow period would impact the waterways positively or negatively. However, it is clear from the literature that maintenance of aquatic refugia and hydrological variability, which is sufficiently natural to maintain life-cycle processes, are important factors for maintaining ecological structure and function.

Macroinvertebrate communities would be expected to recover within 12 months of completion of the project, when seasonal discharge is resumed. The impacts associated with sustained discharges are unlikely to directly impact the fishes within the study area as all of the fishes likely to be present within the study area spawn during spring and / or summer, when flows are elevated and temperature is exceeds 15-20 °C. However, fish could be indirectly impacted by loss of food resources and potential competition from exotic species.

Potential Impacts to Geomorphology

Preliminary hydrological modelling of the impact of the maximum flow releases discussed above showed varied impacts on stream power within the streams. Stream power is frequently quoted as being a good indicator for the potential for geomorphic change (ACARP 2002). The table below shows the modelled percentage increases in stream power for a range of exceedence flows resulting from the proposed release of permeate discharge. Percentage increases could not be calculated for the lower flows (exceedence flows between 20 % and 75 %) in the smaller streams because they ceased to flow for about 85 % of the time. As such, these cells have been left blank. Of most note with regards to stream power, were the following details:

Relative impacts were much greater during periods normally exposed to low flow, but diminished markedly with increasing flow size (See Table below) (Refer to Volume 5, Attachment 30 for further formation on surface water hydrology);

The modelled release of permeate discharge for the low / no flows in the smaller streams only showed an increase of stream power from 0 to between 0.25 and 3 W m^{-2};

While relative impacts shown in the table below look large, actual stream power values post-discharge are minor compared with those experienced during bankfull flows; and

Of most concern are the impacts associated with the prolonged release of flows with these stream powers.

General geomorphic impacts relating to these flow releases may include:

Exacerbation of existing gullying at the gully confluence with the main channel, particularly those more recently formed examples

Notch erosion resulting from reduced variability of flows downstream of the release points;

Increased bank failures resulting from notch erosion;

Increased bank instabilities resulting from increased wetting of banks consisting of dispersive clays;

Exacerbated meander migration resulting from permeate discharge close to meander bends

Increased entrainment of bed sediments, resulting in redistribution downstream.

Table indicating percentage increases to stream powers for particular exceedence flows

Exceedence flow	Condamine (%)	Yuleba (%)	Unnamed (%)	Tchanning (%)	Woleebee (%)	Dulacca (%)	Weir
75	12442.1						
60	687.3						
40	176.2						
20	39.8						
15	24.8	525.9	2357.8	241.5	517.3	602.3	9086.7
10	11.7	262.8	1278.8	66.9	129.2	167.4	1601.2
5	4.0	46.4	279.0	9.0	20.1	25.9	220.9
1	0.9	3.3	22.2	0.7	1.2	2.2	11.3

	Potential Impact Mechanism	Potential Impacts
		Potential Impacts to Narran Lakes Nature Reserve The Narran Lakes Nature Reserve is located approximately 500 km downstream of the proposed discharge point on the Condamine River. The Condamine and Balonne Draft Resource Operations Plan (ROP) (DERM 2007) sets out the water allocation and sharing rules for the Condamine and Balonne Plan Area. It is expected that a significant amount of transmission loss (e.g. through extraction, storage and evaporation) would occur prior to reaching E.J. Beardmore Dam. EJ Beardmore Dam is located on the Balonne River approximately 17 km north-west of St. George and forms part of the St. George Water Supply Scheme. The potential for additional flows to reach Narran Lakes is not yet known as the limit of the preliminary IQQM is the upstream extent of E.J Beardmore Dam. The IQQM model indicates that additional flows within the river system comply with the EFO at the downstream extent of the model (Volume 5, Attachment 31).
3	Low calcium concentrations in permeate discharge	Calcium (Ca) concentrations in permeate discharge from Spring Gully were shown to be less than practical quantification limits (PQL) (EECO 2009b). All crustaceans undertake rapid calcification post moult. Most can store a portion of the Ca withdrawn from the exoskeleton before moulting, but the majority of Ca required for regeneration must be obtained from the surrounding waters. Therefore, lack of Ca can limit the success and distribution of crustaceans (Rukke 2002). EECO (2009b) found significantly reduced populations of zooplankters (cladocerans, ostracods and copepods) in Eurombah Creek at sites downstream of the permeate discharge. Microcustraceans form a major dietary component of many of the fish species within the Condamine-Balonne and Dawson catchments, so any impact on microcrustacean populations could have significant impacts on fish that rely on these taxa as their main food source (e.g. gudgeons). As a precautionary measure, EECO (2009b) recommended increasing Ca concentrations in the permeate discharge to within background levels.
4	Elevated contaminant concentrations (boron) in permeate discharge	Confidential permeate water quality data provided by Australia Pacific LNG for the existing Spring Gully discharge indicate that all parameters are within ANZECC / ARMCANZ (2000) guidelines with the exception of boron, which had mean concentrations slightly above the 95 % protection values for biota. The 95 % trigger value for boron is a high reliability trigger value and is what should be aimed at for slightly to moderately disturbed systems. Based on the Spring Gully permeate data, concentrations of boron in permeate discharges may fall somewhere between the 90-95 % protection level, which would result in a slight increase in the risk of ecosystem detriment. It appears from the toxicity testing results provided in ANZECC / ARMCANZ (2000) that the most sensitive groups are likely to be algae, particularly green algae, which are important primary producers in this system. As a precautionary measure, proposed permeate concentrations should be compared with the relevant species protection levels by using the ANZECC / ARMCANZ (2000) species sensitivity distribution. Where it is not possible to reduce the receiving water concentrations to below the relevant trigger value determine the likely ecosystem response, and the acceptability of that (for example, stakeholders may agree to set a water quality objective of a 94 % protection level).
5	Erosion of exposed surfaces at permeate discharge point/s	Impacts resulting from this impact mechanism are likely to be similar to those discussed in impact mechanism 7 in Table 5-1 and may include: • Bank stability issues during operation of the pipe outfall, including gully initiation; • Increased sediment delivery to the channel; • Localised smothering of riffles and infilling of pools; and • Reduction in bed sediment particle size variability.
6	Disturbance to threatened artesian spring communities associated with aquifer draw down from well water extraction	The cone of depression associated with the extraction of well water has the potential to impact on aquifer pressure and surface water flows within artesian springs. Reduced water pressure has been identified as a serious problem in the GAB (EPA 2007, Fairfax *et al*. 2007, Fensham *et al*. 2004). The EPBC listed Salt pipewort and Artesian milfoil are known to be associated with artesian springs within the vicinity of the gas fields. Both species require actively flowing artesian water for survival. Reduced aquifer pressure as a result of groundwater level drawdown could impact (in varying degrees) on surface water flows or levels of springs located within the cone of depression from CSG activities. Preliminary numerical groundwater modelling undertaken by WorleyParsons indicates that reductions in groundwater levels in the GAB aquifers during the production phase, is expected to be limited to areas within or just beyond the boundaries of the proposed CSG operations (Volume 5, Attachment 29). For a period of time post construction modelling projections indicate an increase in spatial extent of drawdown effect (but decrease in magnitude). WorleyParsons identified that there is likely to be a very low risk of impact to high value discharge spring complexes that may occur near Injune, Taroom and 100 km west of Roma. The spring complexes that occur 25 kilometres north of Roma, in the outcropping areas of Gubberamunda Sandstone, are documented as “recharge” springs and hence are not expected to be affected by any reduced groundwater levels that may occur in this area. The preliminary numerical model projections also indicated that there may be marginal (but localised) effects to groundwater levels within the shallow aquifers of the Cainozoic Units. As such, there is a very low risk that species (partially or opportunistically) dependent upon groundwater in the shallow watertable aquifers associated with drainage lines may be affected. Further details are provided in Volume 5, Attachment 29. Discussions were held with Dr. Rod Fensham of DERM on 18 February 2010 regarding the condition and source of the spring complexes located 25 km to the north of Roma. Dr. Fensham confirmed that these springs are recharge springs and all have been substantially damaged by damming and excavation. DERM classifies recharge springs as those which emanate from shallow, short-flow systems in outcropping regions of the GAB. The springs near Roma emanate from the Gubberamunda sandstone, which is one of the shallower GAB Aquifers. These springs have been classified as recharge springs. Water chemistry data provided by Dr. Fensham indicate that the water associated with these springs is of good quality, with near neutral pH, low mineralisation (as mg/L TDS) and an ionic composition similar to shallow groundwater and surface waters in the region. This further confirms that the springs are derived from shallow, short flow systems (e.g. Gubberamunda sandstone), rather than the deeper GAB aquifers associated with discharge springs.

	Potential Impact Mechanism	Potential Impacts
7	Contamination of Lake Broadwater from gas field operation	Lake Broadwater is located outside of the Project Area, but a small corner of Gilbert Gully lies within the catchment area of the lake. Lake Broadwater is connected to the Condamine-Balonne River by the floodplain and there is potential for contaminated runoff from the gas fields (e.g. sediments, nutrients, drilling chemicals etc) to be transported to the lake during floods. Given the small area of Gilbert Gully associated with the Lake Broadwater catchment, there are likely to be minimal impacts. No water treatments facilities or pipelines are located in the vicinity of the lake.
8	Hydrocarbon, chemical and wastewater contamination from accidental spills	See Impact Mechanism 6 in Table 5-1.
9	Chemical contamination of watercourses resulting from brine pond overflows	There is potential for highly contaminated feed and / or brine water to enter watercourses following periods of heavy rainfall, containment failure, RO plant operation faults or through groundwater leaching. Based on preliminary water quality data (unpublished) provided by Australia Pacific LNG for the feed and brine ponds, it is evident that the ponds contain very high salinities, high concentrations of some heavy elements (e.g. boron, barium, magnesium and Strontium) and high concentrations of nitrates. Substantial detrimental impacts to local biota could occur if this contaminated water was released to local watercourses, through direct toxicity. Indirect, long-term impacts may result from internal loading and cycling of metals/metalloids and nutrients. The dam failure impact assessment undertaken by WorleyParsons indicated that these ponds fell into the “significant hazard category” according to EPA (2009). This was due to high contaminant concentrations within the brine ponds and large storage volumes.The significant hazard category (general environmental) is defined as “The environmental value is lesser significance and harm is possible but not likely, or material or environmental harm is possible” (EPA 2009). The ponds will require careful design, management and controls, including effective geotechnical design of sealing structures, maintenance of suitable amounts of freeboard to account for wetter than average periods, containment designs such that releases under extreme weather scenarios result in sufficient downstream dilution, and stormwater management to ensure adjacent watercourses are not contaminated. It should be noted that the toxicity of the brines has not yet been determined. Therefore, safe dilutions are not known at this stage.
10	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 Study area are intermittent and, would unlikely to be affected for most of the year. For permanent spring-fed streams (e.g. upper Dawson), there is likely to be some minor, localised impacts on sediment transport and potentially considerable impacts on low-flow organism movement.
11	Enhanced breeding of mosquitoes from brine ponds	Information on mosquito habitat and management is provided in construction impact mechanism 10 (Table 5-1-). The potential impacts associated with brine ponds is likely to be similar, although these will be permanent, brackish, impoundments which may encourage mosquito breeding during spring and summer. Depths of more than 0.6m are not suitable for mosquito breeding. Effective management strategies may include a mix of monitoring plus biological and chemical controls, in accordance with Queensland Health (2002).

5.3 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 5.2 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 risk of impacts to aquatic systems from construction related activities was assessed as low for all impact mechanisms following implementation of mitigation measures.

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 effective sediment control measures are strictly adhered to throughout the construction phase to ensure any impacts are minimised.

The risk of impacts to aquatic systems from operational activities was generally low. The following two impact mechanisms were identified as having a medium risk of impact to aquatic systems following implementation of mitigation measures:

- Boron toxicity from permeate discharge; and
- Chemical contamination from brine pond overflows;

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

Permeate discharges have the potential to cause bed scour and bank erosion and alter flow regimes downstream of the discharges. The greatest impact to aquatic ecology would be associated with the altered low flow hydrology, which could change the composition of aquatic macroinvertebrates from those adapted to intermittent waters to more perennial species. Preliminary IQQM modelling indicated that constant discharges 50 Ml/d at the upstream Condamine River discharge location or 65 Ml/d at the downstream Condamine River discharge location would comply with the EFOs. However, analysis of flow duration curves indicated an alteration to low flow regimes. Further modelling using a range seasonal release scenarios indicated that impacts to low flow regimes could be minimised by better mimicking the pre-development flow regime.

Elevated boron concentrations in the permeate discharge could potentially be toxic to aquatic organisms. Toxicity testing is recommended and local, specific species sensitivity curves should be established to determine suitable concentrations based on 90 – 95 % species protection levels.

5.4 Summary of Potential Impacts to MNES

The Potential impacts to MNES are summarised below.

5.4.1 Murray Cod

There is a low risk of impact to Murray cod during construction or operation. The main impact mechanism during the construction phase would be short term increases in sediment delivery, although this was assessed as a low risk following implementation of appropriate mitigation measures. Murray cod are unlikely to be affected by short-term increases in sediment delivery as they are adapted to high levels of TSS and turbidity and populations are artificially maintained in the Condamine-Balonne River, through stocking.

There may be some localised effects associated with temporary diversion of perennial watercourses during road and crossing construction. However, impacts are likely to be short-term and rapid species recolonisation / recovery is expected. Assuming that suitably designed road crossings are constructed (i.e. clear span bridges or large box culverts), impacts to fish passage should be minimal.

Increased baseflows resulting from permeate discharge are unlikely to directly impact Murray cod populations as spawning requires a combination of elevated temperature (>15 °C) and flow. Their main food resources are frogs, small fish and crayfish, which are unlikely to be directly impacted by elevated flows.

5.4.2 Artesian Spring Communities

There is a low risk of impact to artesian spring communities (Salt pipewort and Artesian milfoil) associated with construction or operation activities. The main activities that could affect artesian spring communities during construction are direct excavation and / or sediment delivery from road and pipeline construction. There are currently no pipeline or road crossings located in the immediate vicinity of known springs. 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.

Potential impacts associated with groundwater drawdown from well watering were assessed to be low as all springs located within the area of potential impact (i.e. immediately to the north of Roma) are recharge springs that are in a degraded condition.

5.4.3 Narran Lakes

There is a low risk of impact to Narran Lakes during operation. Narran Lakes is located approximately 500 km downstream of the proposed discharge location on the Condamine River. The potential for additional flows to reach Narran Lakes is not yet known as the limit of the preliminary IQQM is the upstream extent of E.J Beardmore Dam. The IQQM model indicates that additional flows within the river system comply with the EFO at the downstream extent of the model (Volume 5, Attachment 31). Any water that did reach E. J. Beardmore Dam would be used to supplement the St George Water Supply Scheme and potentially be available as compensation flows to the Narran Lakes. This is viewed as a positive benefit.

5.5 Monitoring

The following monitoring is proposed during the construction phase:

- Water quality monitoring upstream and downstream of road and pipeline crossings where water is present, or immediately following inflows, 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 watercourse crossings prior to and during construction;
- Monitor aquatic habitat processes within, upstream and downstream of pipeline crossings prior to and during construction
- Monitor aquatic biology (fish and macroinvertebrates) upstream and downstream of road and pipeline crossings and where adjacent to significant infrastructure.

The following monitoring and / or investigations are proposed during the operation phase:

- Monthly water quality monitoring upstream and downstream of permeate discharges (to be reviewed after two years), for the following parameters:
  - – Temperature;
  - – Conductivity;
  - – Turbidity;
  - – TSS;
  - – pH;
  - – Major cations (Mg^+, Ca^+, Na^+, K^+);
  - – Major anions (CO_3^-, HCO_3^-, Cl^-);
  - – Nutrients (TN, TP, FRP, NH_4, NO_2, TKN);
  - – TPH;
  - – BTEX; and
  - – Boron.
- Implement an investigative study to determine potential ecotoxicity of brine and feed ponds and required dilution rates;
- Monitor geomorphic processes (particularly bank and bed stability) upstream and downstream of pipeline and road crossings on an annual basis (to be reviewed after two years);

- Monitor geomorphic processes (particularly bank and bed stability) upstream and downstream of permeate discharges on a regular (at least quarterly) basis during operation (to be reviewed after two years); and
- Monitor aquatic biology (fish and macroinvertebrates) upstream and downstream of permeate discharges on a bi-annual (wet and dry season) basis during operation (to be reviewed after two years).

The monitoring regime would likely be changed over time according to interpretation of results.

Table 5-3 Risk Assessment – Construction

Note: C = Consequence, L = Likelihood, R = Risk, Min = Minor, Mod = Moderate Sev = Severe, Ser = Serious

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	C-B, D, BR	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	Low
				Roads	Mod	6	High	Min	3	Low	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;	Low
				Gas Wells	Min	2	Low	Min	1	Low	Control sediment runoff from stockpiles and cleared areas around watercourses; Implement sediment control measures downstream of sidecast material where safe and practicable; Prohibit side-casting material directly into waterways where practicable;	Low
				Assoc. Infrastructure	Min	2	Low	Min	1	Low	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	C-B, D, BR	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 Minimise vegetation clearance on banks and bank tops, in accordance with the APIA Code of Environmental Practice.	Low
3	C	Disturbance to MNES species (Murray Cod) associated with increased TSS and turbidity	Aquatic ecology	Pipelines	Min	2	Low	Min	1	Low	Avoid, where possible, undertaking construction activities during forecasted periods of wet weather.	Low
				Roads	Min	2	Low	Min	1	Low		Low
				Gas Wells	Min	2	Low	Min	1	Low	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 (see impact mechanism 1)	Low
				Assoc. Infrastructure	Min	2	Low	Min	1	Low		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		
4	D	Disturbance to threatened artesian spring communities associated with pipeline and road construction	Aquatic ecology	Pipelines	Ser	6	Sev	Ser	6	Sev	Avoid, where possible, undertaking construction activities during forecasted periods of wet weather. Avoid construction of roads or pipelines through or adjacent to artesian mound springs. This may require investigative surveys if known springs are present in the proximity of the road or pipeline waterway crossings. 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 (see impact mechanism 1) Monitor water quality (TSS, turbidity and nutrients) and aquatic ecology (macrophytes, macroinvertebrates and fish) upstream and downstream of representative creek crossings prior to and during construction	Low
				Roads	Ser	6	Sev	Ser	6	Sev		Low
5	C-B, D, BR	Diversion of watercourses during construction of road and pipeline crossings	Aquatic ecology Geomorphology	Pipelines	Min	6	Med	Min	1	Low	Avoid, where possible, undertaking construction activities during forecasted periods of wet weather. Monitor water quality, aquatic ecology and geomorphology upstream and downstream of dams prior to and during construction (where water is available)	Low
				Roads	Min	6	Med	Min	1	Low		Low
6	C-B, D, BR	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 is undertaken in accordance with AS1940 (Storage and Handling of Flammable and Combustible Liquids) and other applicable dangerous goods standards 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
				Gas Wells	Ser	1	Low	Mod	1	Low		Low
				Assoc. Infrastructure	Ser	1	Low	Mod	1	Low		Low
7	C-B, D, BR	Increased bank erosion (gullying) due to inadequate drainage control from exposed areas	Geomorphology	Pipelines	Mod	4	Med	Min	1	Low	Avoid, where possible, undertaking construction activities during forecasted periods of wet weather. 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 (see impact mechanism 1) Monitor geomorphic processes prior to and during construction and implement remedial measures as required	Low
				Roads	Mod	4	Med	Min	1	Low		Low
				Gas Wells	Mod	2	Low	Min	1	Low		Low
				Assoc. Infrastructure	Mod	2	Low	Min	1	Low		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		
8	C-B, D, BR	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, where possible, undertaking construction activities during forecasted periods of wet weather. 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 (see impact mechanism 1) Monitor geomorphic processes prior to and during construction and implement remedial measures as required Routing analysis and adoption of appropriate trenching methodology at sensitive creek crossings (i.e. in proximity to discharge springs).	Low
				Roads	Mod	4	Med	Min	1	Low		Low
				Roads	Ser	3	Med	Ser	2	Med		Low
9	C-B, D, BR	Enhanced breeding of mosquitos through ponding of water during construction	Aquatic ecology	Pipelines	Min	6	Med	Min	6	Med	Monitoring program to establish mosquito prevalence where development within 5 km of major population centres or large natural wetlands Mosquito management plan in accordance with Queensland Mosquito Management Code of Practice (Queensland Health 2002)	Low
				Roads	Min	6	Med	Min	6	Med		Low
				Gas Wells	Min	6	Med	Min	6	Med		Low
				Assoc. Infrastructure	Min	6	Med	Min	6	Med		Low

Table 5-4 Risk Assessment – Operation and decommissioning

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

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	C-B, D, BR	Erosion from from exposed areas	Aquatic Ecology	Pipelines	Mod	2	Low	Mod	2	Low	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 (see impact mechanism 1, Table 5-1). Monitor geomorphic processes at established assessment sites during operational phase on an annual basis (review after two years)	Low
			Water Quality	Roads	Mod	6	High	Mod	6	High		Low
			Geomorphology	Gas Wells	Mod	3	Med	Mod	3	Med		Low
				Assoc. Infrastructure	Mod	3	Med	Mod	3	Med		Low
2	C-B, D	Alteration of flow regimes from permeate discharge	Aquatic Ecology Water Quality Geomorphology	Assoc. Infrastructure	Cri	6	Ext	Maj	6	Sev	Determine appropriate rate and timing of discharges through IQQM to achieve WRP EFOs (where a discharge licence is required) and such that flows mimic (where possible) pre-development flows Ensure discharges are released to the main Condamine River, rather than smaller tributaries Refine existing hydraulic models to identify preferred discharge reaches Ongoing monitoring of flow, aquatic ecology (fish, macroinvertebrates, zooplankton and phytoplankton), water quality (turbidity, temperature, TSS, pH, nutrients) and geomorphology upstream and downstream of discharges (review after two years) Monitor flows to E. J. Beardmore Dam Identify appropriate flow releases in accordance with WRP objectives for Narran lakes. Install flow dissipation structures at release points, where required. Implement bank stabilisation techniques as required Implement effective riparian management plans Monitor channel and bank stability annually. Use existing assessment sites and establish further sites where required (review after two years)	Low
3	C-B, D	Low calcium concentrations in permeate discharge	Aquatic Ecology	Assoc. Infrastructure	Cri	6	Ext	Maj	6	Sev	EECO 2009b recommended increasing Ca concentrations in the permeatedischarged from the Spring Gully RO treatment plant to within background levels. This would be a suitable mitigation measure, although would need to be ensure that concentrations discharged are in line with background cation and anion proportions. Ongoing monitoring of aquatic ecology (fish and macroinvertebrates) and water quality (major ions) upstream and downstream of discharges (review after two years).	LLow
4	C-B, D	Elevated contaminant concentrations in permeate discharge (boron)	Aquatic Ecology	Assoc. Infrastructure	Cri	6	Ext	Maj	6	Sev	Establish locally relevant species sensitivity curves for Boron and determine suitable permeate concentrations based on 90-95 % species protection levels, in accordance with ANZECC / ARMCANZ 2000 and in consultation with DERM. Ongoing monitoring of aquatic ecology (fish and macroinvertebrates) and water quality (Boron) upstream and downstream of discharges (review after two years).	Medium
5	C-B, D	Erosion at permeate discharge points	Geomorphology	Assoc. Infrastructure	Maj	5	Sev	Mod	5	Med	Locate discharge lpoint within geomorphologically stable reach and undertake hydraulic modelling to ensure minimal bank erosion and bed scour. Monitor channel and bank stability annually, using existing assessment sites, and establish further sites where required Implement bed and bank stabilisation techniques as required Implement effective riparian management plans	Low
6	D	Disturbance of threatened artesian	Aquatic Ecology	Pipelines	Min	1	Low	Min	1	Low	Preliminary modelling undertaken by WorleyParsons has indicated that the drawdown	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		
		spring communities associated with aquifer drawdown from well water extraction	Water Quality Geomorphology	Roads	Mod	4	Med	Mod	4	Med	Investigative monitoring of spring complexes located 25 km to the north of Roma to determine: the type of type of spring complex (i.e. "recharge" or "discharge"); existing surface and groundwater quality; Whether it is supporting confined or shallow aquifer system; and the associated species composition of fish, macrophytes and macroinvertebrates. Ongiong monitoring of groundwater level and flow will enable early detection of sustained groundwater level declines, prior to any significant impacts to groundwater users. Mitigation, should this be required, may involve recharge of affected aquifers to reverse declining groundwater level trends). Further details on groundwater monitoring and mitigation are provided in Volume 5, Attachment 29.	Low
				Gas Wells	Min	6	Low	Min	6	Low		Low
				Assoc. Infrastructure	Min	1	Low	Min	1	Low		Low
7	C-B	Contamination of Lake Broadwater from gas field operation		Pipelines	Min	1	Low	Min	1	Low	Undertake hydraulic modelling to determine level of connectivity between Gilbert Gully and Lake Broadwater. Implement Stormwater Management Plan to ensure contaminated runoff does not enter Lake Broadwater.	Low
				Roads	Min	1	Low	Min	1	Low		Low
				Gas Wells	Ser	1	Med	Ser	1	Med		Low
				Assoc. Infrastructure	Min	1	Low	Min	1	Low		Low
8	C-B, D, BR	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
				Gas Wells	Ser	1	Low	Mod	1	Low		Low
				Assoc. Infrastructure	Ser	1	Low	Mod	1	Low		Low
9	C-B, D, BR	Chemical contamination of watercourses resulting from brine pond overflows	Aquatic ecology Water quality	Assoc. Infrastructure	Cri	1	High	Cri	1	High	Ensure ponds are not located within 500 m of watercourses and have vegetated buffers of at least 40 m. Implement a Stormwater Management Plan and Waste Management Plan, which incorporates design controls (dam failure risk assessment) and secondary dams / bunds where necessary Implement investigative ecotoxicological study of brine and feed waters and required dilutions Implement a pond rehabilitation plan upon decommissioning, including contaminated land assessment and effective disposal / management of waste products.	Medium
10	C-B, D, BR	Altered low flow hydrology / hydraulics resulting from road crossings	Aquatic ecology Water quality Geomorphology	Roads	Maj	6	Sev	Maj	6	Sev	Ongoing (bi-annual) monitoring of fish populations within the Condamine-Balonne during operation, upstream and downstream of road crossings (review after two years). Ongoing (bi-annual) monitoring of geomorphic processes upstream and downstream of crossings during operation and provide bank stabilisation (e.g. rock rip rap, concrete mats) where required (review after two years) Design 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 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
11	C-B, D, BR	Enhanced breeding of mosquitos		Pipelines	Min	6	Med	Min	6	Med	Construct ponds to be deeper than 60 cm to prevent mosquito breeding. Implement a	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		
		from brine ponds		Roads	Min	6	Med	Min	6	Med	mosquito management plan in accordance with Mosquito Management Code of Practice for Queensland (Queensland Health 2002). Effective long-term management strategies may include a mix of monitoring plus biological and chemical controls.	Low
				Gas Wells	Min	6	Med	Min	6	Med		Low
				Assoc. Infrastructure	Min	6	Med	Min	6	Med		Low

6. Conclusions and Recommendations

6.1 Conclusions

Two dry season water quality surveys and one dry season aquatic ecology and geomorphology survey were undertaken at sites throughout the Condamine-Balonne, Dawson and Border Rivers 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 Project.

Most of the sites throughout the study area were found to be in a degraded condition, with moderate to poor water quality (elevated nutrients, turbidity, suspended sediment and metals), high geomorphic disturbance and poor aquatic and riparian habitat.

No rare, endangered or otherwise noteworthy fish, macroinvertebrates or aquatic macrophytes were recorded from the sites sampled. However, seven significant species of fish (the EPBC listed Murray Cod, as well as Silver Perch, Purple Spotted Gudgeon, Olive Perchlet, Southern Saratoga, Leathery Grunter and Darling River Hardyhead) and two species of aquatic macrophytes (the EPBC listed Salt pipewort and Artesian milfoil) are known to occur throughout the region, where suitable habitat exists.

Two important wetlands were identified as potentially being impacted by the proposal. Lake Broadwater (wetland of national importance) and the Narran Lakes Nature Reserve (Ramsar listed wetland). In addition, communities associated with artesian mound springs are listed as endangered under the EPBC Act. Numerous artesian springs are known to occur in the vicinity of the project and could potentially be impacted by the Project.

Several construction and operation mechanisms were identified that could impact on water quality, aquatic ecology or geomorphology. Risks to the aquatic environment were determined in consideration of the combination of consequences (including vulnerability) and likelihood. The potential impacts associated with each mechanism are summarised in Section 5. The outcomes of the impact assessment were used to inform the detailed risk assessment. The risks to the aquatic environment associated with construction and operation activities (following mitigation) were generally considered to be low. Increased sediment delivery to watercourses from road and pipeline crossing construction was identified as a medium risk during the construction phase, as a result of excavation and vegetation clearing within and adjacent to watercourses. Care will be needed to ensure that effective sediment control measures are strictly adhered to throughout the construction phase to ensure these impacts are minimised. Each individual construction activity is a concentrated, relatively short phase of the project. While the potential sediment related impacts associated with this construction related activities were considered to be medium, they should be short-lived and localised.

The key risks identified during the operational phase were associated with the proposed permeate discharges. Continuous discharge would alter flow regimes downstream of the discharge location. This could impact on downstream aquatic communities and result in bed scour and bank erosion. The impacts are likely to be greater on smaller tributaries than the main Condamine River. Any water discharged should comply with EFOs established under the Water Resource (Condamine-Balonne)

Plan (2004). Preliminary IQQM modelling indicated that constant discharges 50 Ml/d at the upstream Condamine River discharge location or 65 Ml/d at the downstream Condamine River discharge location would comply with the EFOs. However, analysis of flow duration curves indicated an alteration to low flow regimes. Further modelling using a range seasonal release scenarios indicated that impacts to low flow regimes could be minimised by better mimicking the pre-development flow regime and the residual risks were assessed as low.

Elevated boron concentrations in the permeate discharge could potentially be toxic to aquatic organisms. Toxicity testing should be undertaken and local, specific species sensitivity curves should be established to determine suitable concentrations based on 90 – 95 % species protection levels.

The potential for chemical contamination from brine pond overflow was identified as a medium risk. Effective toxicity testing, detailed stormwater and waste management plans, effective flooding design controls and adequate vegetated buffers are required to ensure that contaminated water does not enter local watercourses.

Medium risks were also identified in relation to inadequate drainage control and altered low flow hydrology from road crossings. The potential impacts associated with crossings for roads can be further mitigated by implementing good practice design and drainage control.

The residual risk of impact to Murray Cod associated with increased sediment delivery and temporary diversion of watercourses during construction was assessed to be low. This was due to their natural tolerance to:

- High levels of TSS and turbidity;
- Artificial population maintence through stocking; and
- Likelihood of rapid recolonisation following watercourse re-instatement.

Increased baseflows resulting from permeate discharge are unlikely to directly impact Murray cod populations as spawning requires a combination of elevated temperature (>15 °C) and flow. Their main food resources are frogs, small fish and crayfish, which are unlikely to be directly impacted by elevated flows.

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. Potential impacts associated with groundwater drawdown were assessed to be low. However, further investigation of the spring complex located 25 km north of Roma is recommended to verify that there are no "discharge' springs in this area and assess existing condition of known recharge springs.

The residual risk of impact to Narran Lakes in relation to operational discharges was assessed to be low. Preliminary IQQM modelling indicated that additional flows within the river system comply with the EFO at the downstream extent of the model (above E. J. Beardmore Dam) (Volume 5, Attachment 31). In the absence of detailed modelling, it was inferred that any discharge water that reached Beardmore Dam would have undergone substantial mixing and assimilation and the additional water would form part of the ROP rules for the St George Water Supply Area. This could improve water availability to Narran Lakes.

The residual risk of impact to Lake Broadwater was assessed to be low, although hydraulic modelling is recommended to determine the level of connectivity between Gilbert Gully and Lake Broadwater.

The impact assessment undertaken for this study was based on limited dry season data. As the majority of streams in the study 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.

6.2 Summary of Monitoring Recommendations

The following monitoring recommendations are made:

- Water quality, aquatic biology, aquatic habitat and geomorphic monitoring upstream and downstream of the road and pipeline crossings, prior to and during construction;
- Investigative studies to identify the location, type (i.e. recharge or discharge) and existing condition of artesian springs north of Roma;
- Monthly water quality, quarterly geomorphic and bi-annual biological monitoring upstream and downstream of permeate discharges during operation (to be reviewed after two years)
- A study to determine potential ecotoxicity of the brines; and
- Annual monitoring of geomorphic processes during operation, upstream and downstream of pipeline and road crossings (to be reviewed after two years).

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Appendix 1. Geomorphology and Field Proforma

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 [ ]

Pilot Sustainable Rivers Audit – Physical Habitat Theme Technical Report 75

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			

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 or river which [illegible] It is immediately linked with the stream both in providing leaf and branch [illegible] litter to the stream and being affected by the rising groundwater [illegible] visible, it is the distinct vegetation zone along the stream. The strip [illegible] hence should be relatively homogeneous. Disturbed zones may be very thin.

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.			

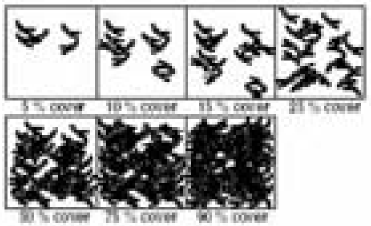
Stream Shading	1	2	3
Estimate the percentage of the stream shaded at midday in each transect.			

Visibility too poor for accurate assessment, estimate made ☐

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 od 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 larg 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 (relatively dense; mix of size of snags which are not newfall; stable undercut banks), cobbles (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.

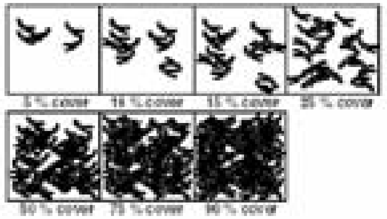
Basin | Sub-section | Site | Date (dd/mm/yy) | Recorder

INSTREAM DEBRIS COVER

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



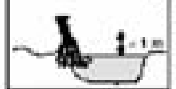
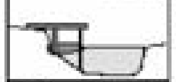
Comment

APPENDIX 4 continued

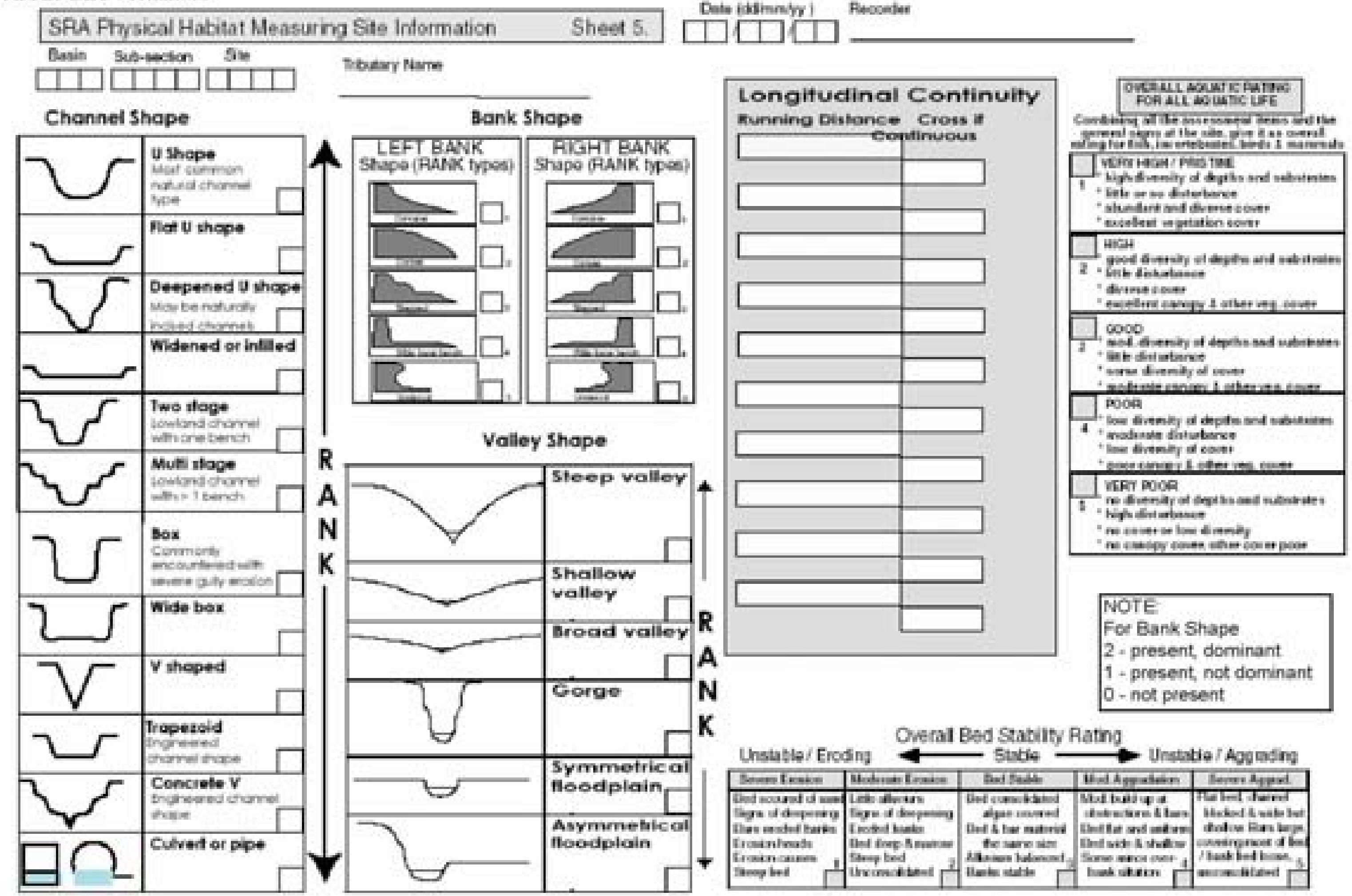
SRA Physical Habitat Transect Measurement Sheet 4.

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

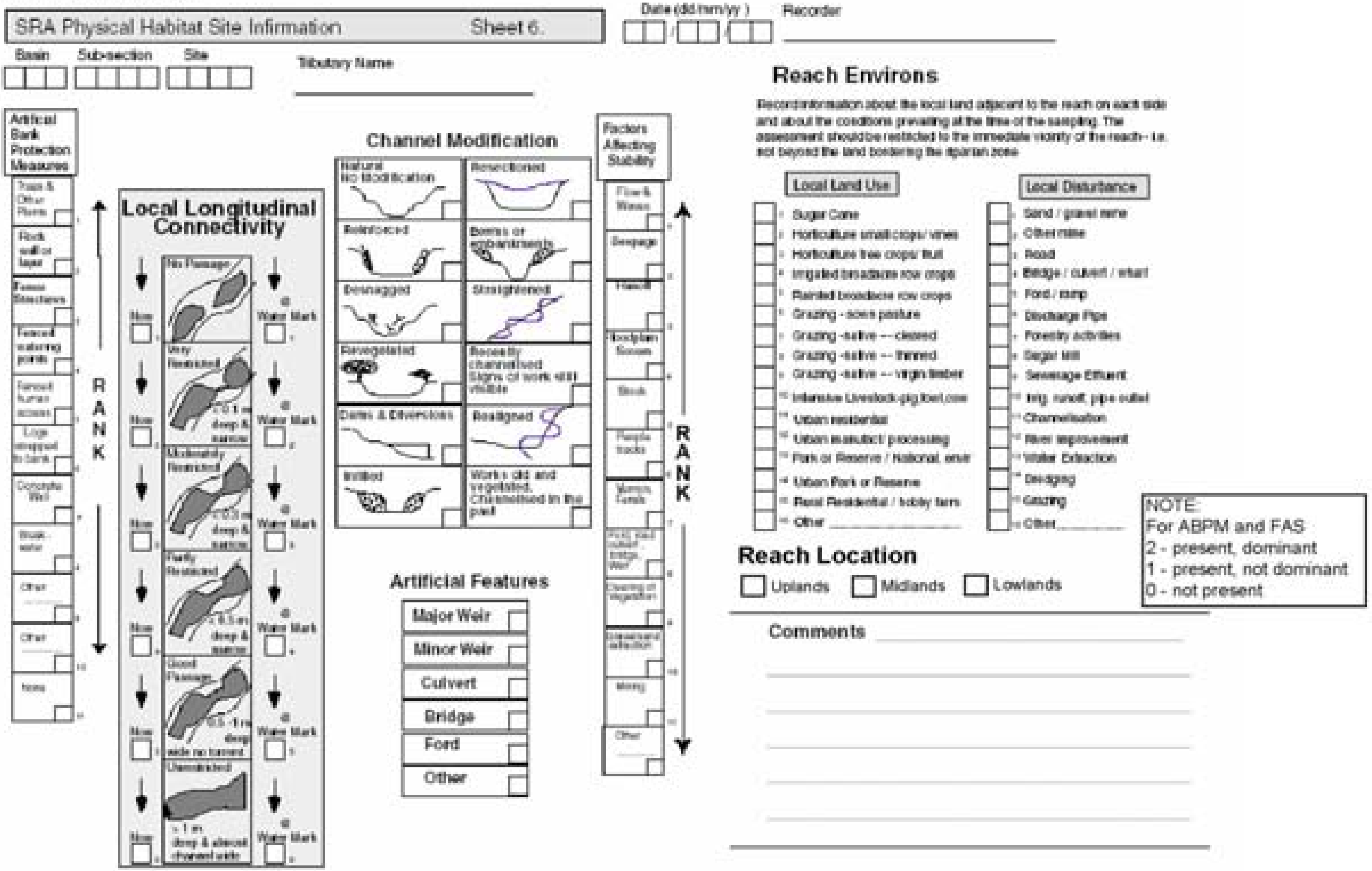
Basin ___ Sub-section ___ Site ___ Tributary Name ____________

Overhanging Vegetation	Transect 1 LEFT BANK	Transect 1 RIGHT BANK	Transect 2 LEFT BANK	Transect 2 RIGHT BANK	Transect 3 LEFT BANK	Transect 3 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	% 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	% 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	% 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



APPENDIX 4 continued.



SRA Physical Habitat Site Information Sheet 6.

Date (dd/mm/yy) Recorder

Basin Sub-section Site

Tributary Name

Artifical Bank Protection Measures

Traps & Other Plants

Rock wall or layer

Timber Structures

Fenced watering points

Fenced human access

Logs strapped to bank

Concrete Wall

Break-water

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

Now

@ 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

Runoff

Floodplain Scours

Stock

People tracks

Vermin Tunnels

Rock, sand, 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

1 Sugar Cane
2 Horticulture small crops/ vines
3 Horticulture tree crops/ fruit
4 Irrigated broadacre row crops
5 Rainfed broadacre row crops
6 Grazing - sown pasture
7 Grazing - native -- cleared
8 Grazing - native -- thinned
9 Grazing - native -- virgin timber
10 Intensive Livestock-pig,feedlot,cow
11 Urban residential
12 Urban manufact/ processing
13 Park or Reserve / National, state
14 Urban Park or Reserve
15 Rural Residential / hobby farm
16 Other

Local Disturbance

1 Sand / gravel mine
2 Other mine
3 Road
4 Bridge / culvert / wharf
5 Ford / ramp
6 Discharge Pipe
7 Forestry activities
8 Sugar Mill
9 Sewerage Effluent
10 Irrig. runoff, pipe outlet
11 Channelisation
12 River improvement
13 Water Extraction
14 Dredging
15 Grazing
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.

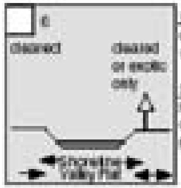
Date (dd/mm/yy) __/__/__ Recorder ____________

Basin ___ Sub-section ____ Site ____ Tributary Name ____________

OVERALL DISTURBANCE RATING

Tick one box for the overall rating

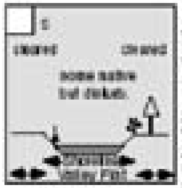
EXTREME DISTURBANCE



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.

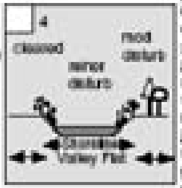
VERY HIGH DISTURBANCE



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.

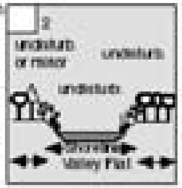
Note. Sites with valley flat vegetation cleared BOTH sides, but with shoreline vegetation in good condition, for example when it is fenced off, should be included in this category.

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.

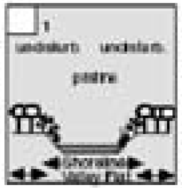
LOW DISTURBANCE



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, course 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

		Condamine /Balonne	Condamine /Balonne	Condamine/ Balonne	Condamine/ Balonne	Condamine /Balonne	Condamine /Balonne	Condamine/ Balonne	Condamine/ Balonne	Condamine /Balonne	Condamine /Balonne	Condamine /Balonne
		Adjacent to Charleys Creek	Adjacent to Charleys Creek	Bungil Creek	Bungil Creek	Charleys Creek	Charleys Creek	Charleys Creek	Charleys Creek	Charleys Creek	Charleys Creek	Condamine River
		RORWB4	RORWB4	R7	R7	GF6	GF6	GF7	GF7	R3	R3 (B)	GF8
	Date	24/06/2009	9/09/2009	1/07/2009	4/09/2009	23/06/2009	9/09/2009	5/08/2009	9/09/2009	24/06/2009	9/09/2009	25/06/2009
	Time	12:20	15:46	8:30	9:05	16:20	13:55	13:15	12:30 PM	10:15	16:51	8:45
YSI	Temperature (C)	15.5	22.93	11.72	16.86	15.3	18.98	-	16.4	11.1	18.68	12.9
	Conductivity (microS/cm)	133	114	149	268	157	151	220	269	203	212	158
	pH	8.2	7.52	7.45	7.66	7.9	7.2	5.59	6.91	7.5	6.88	8.4
	Turbidity (NTU)	42.8	27.6	411	126.5	63.1	188.9	1195	1197.5	2	21.9	203
	chlorophyll (ug/L)	20.4	4.9	94.5	69.4	20.5	32.1	177.4	110	1258	25.8	39
	chlorophyll (RFU)	4.6	1.2	22.1	16.4	4.8	7.5	41.6	14.3	3	6	9.1
	PC c/mL	26000	7268	7950	7962	4800	5290	22050	41542	2770	2063	15800
	PC RFU	13.5	3.4	3.7	3.7	2.2	2.5	10.1	16.1	1.3	1	2.7
	DO %	34.9	123.3	52	52.8	85.6	59	38	28.6	43.5	53.5	72.6
	DO (mg/L)	3.5	10.62	5.67	5.09	8.49	5.49	3.88	2.54	4.64	4.96	7.67
HANNA	T		23				20.5		17.6		19.3	
	Conductivity (microS/cm)		110				145		263		205	
	pH		7.42				7.24		7.06		6.62	
	EA015: Total Dissolved Solids											
	Total Dissolved Solids @180°C	137	97	176	166	189	217	3150	2720	289	244	344
	EA025: Suspended Solids											
	Suspended Solids (SS)	28	23	284	125	32	66	476	1290	15	5	69
	ED037P: Alkalinity by PC Titrator											
	Hydroxide Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Carbonate Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Bicarbonate Alkalinity as CaCO3	29	18	68	129	53	48	55	69	24	25	43
	Total Alkalinity as CaCO3	29	18	68	129	53	48	55	69	24	25	43
	ED040F: Dissolved Major Anions											
	Sulfate as SO4 2-	<1	<1	2	2	<1	1	7	29	2	2	3
	ED045G: Chloride Discrete analyser											
	Chloride	16	19	4	7	12	14	28	135	44	41	35
	ED093F: Dissolved Major Cations											
	Calcium	2	1	16	34	5	5	5	17	6	6	8
	Magnesium	1	1	2	5	3	3	3	18	3	4	5
	Sodium	18	17	10	12	17	18	34	74	28	23	20
	Potassium	5	4	5	11	6	6	5	6	6	9	5
	EG020F: Dissolved Metals by ICP-MS											
	Aluminium	0.05	<0.01	0.05	<0.01	0.1	0.16	0.76	0.06	0.49	0.24	0.28
	Copper	<0.001	0.001	0.001	<0.001	<0.001	0.001	0.002	0.002	0.001	0.003	0.002
	Manganese	0.005	0.002	0.007	0.164	0.004	0.009	0.034	0.465	0.083	0.084	0.003
	Boron	0.06	0.06	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05
	Iron	<0.05	<0.05	0.09	<0.05	0.06	0.15	0.5	0.05	2.8	3.8	0.23
	EG020T: Total Metals by ICP-MS											
	Aluminium	0.22	0.06	17.4	3.74	1.38	2.53	83.3	107	2.32	1.6	8.71
	Copper	<0.001	0.002	0.008	0.003	0.001	0.002	0.053	0.065	0.002	0.001	0.006
	Manganese	0.036	0.015	0.236	0.355	0.037	0.08	2.46	4.22	0.111	0.107	0.073
	Boron	0.06	0.06	<0.05	<0.05	<0.05	<0.05	0.06	0.08	<0.05	<0.05	<0.05
	Iron	0.99	0.28	18.3	4.24	2.5	4.37	109	143	7.17	6.61	10.1
	EK040P: Fluoride by PC Titrator											
	Fluoride	<0.1	<0.1	0.1	0.2	<0.1	<0.1	0.1	0.1	0.2	<0.1	<0.1
	EK055G: Ammonia as N by Discrete Analyser											
	Ammonia as N	<0.01	0.03	0.11	0.31	<0.01	0.09	0.04	0.2	<0.01	0.12	0.04
	EK059G: NOX as N by Discrete Analyser											
	Nitrite + Nitrate as N	<0.01	<0.01	0.05	0.14	<0.01	0.52	0.29	0.04	0.04	0.18	0.19
	EK061: Total Kjeldahl Nitrogen (TKN)											
	Total Kjeldahl Nitrogen as N	3.7	2.1	1	1	1.9	1.6	1.6	6.2	2.5	1.6	1.2
	EK062: Total Nitrogen as N											
	Total Nitrogen as N	3.7	2.1	1	1.2	1.9	2.1	1.9	6.2	2.6	1.8	1.4
	EK067G: Total Phosphorus as P by Discrete Analyser											
	Total Phosphorus as P	0.15	0.09	0.27	0.08	0.09	0.16	0.66	2.25	0.5	0.14	0.26
	EK071G: Reactive Phosphorus as P by discrete analyser											
	Reactive Phosphorus as P	0.02	<0.01	<0.01	<0.01	0.02	0.07	<0.01	<0.01	0.03	<0.01	0.02
	EN055: Ionic Balance											
	Total Anions	1.03	0.88	1.51	2.83	1.4	1.4	2.04	5.8	1.77	1.7	1.91
	Total Cations	1.08	0.98	1.52	2.92	1.4	1.41	2.08	5.7	1.91	1.84	1.82
	Ionic Balance								0.87			
	EP008: Chlorophyll a											
	Chlorophyll a	1										
	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

		Condamine /Balonne	Condamine /Balonne	Condamine /Balonne	Condamine/ Balonne	Condamine /Balonne	Condamin e/Balonne	Condamine /Balonne	Condamin e/Balonne	Condami ne/Balon ne	Condami ne/Balon ne	Condami ne/Balon ne
		Condamine River	Condamine River	Condamine River	Condamine River	Condamine River	Dogwood Creek	Dogwood Creek	Dogwood Creek	Dogwood Creek	Tchannin g Creek	Tchannin g Creek
		GF8	WTF3	WTF3	WTF4	WTF4	GF1	GF1	R1	R1	GF2	GF2
	Date	8/09/2009	24/06/2009	9/09/2009	23/06/2009	10/09/2009	25/06/2009	8/09/2009	26/06/2009	8/09/2009	6/08/2009	7/09/2009
	Time	15:20 PM	16:00	10:45	11:00	10:30	14:15	13:40 PM	10:30	10:37 AM	2:30	4:45 PM
YSI	Temperature (C)	22.29	16.3	17.69	14.4	15.09	15.6	17.61	12	19.13	-	-
	Conductivity (microS/cm)	168	292	378	168	212	77	78	179	213	114	119
	pH	7.49	7.5	7.47	7.77	7.42	7.76	6.72	7.48	5.38	6.16	-
	Turbidity (NTU)	340.6	221.4	264.1	1.5	932	350	635.6	65.9	298.4	390.8	395.1
	chlorophyll (ug/L)	57.6	42	28.3	52	137.8	60.6	99.8	70	16.8	63.4	62.9
	chlorophyll (RFU)	13.6	9.7	4.7	12.1	32.4	14.2	23.3	16.1	4.1		15
	PC c/mL	5864	5150	14169	67000	13807	8500	969.1	7200	14720	7143	7178
	PC RFU	2.7	2.4	5.7	3.3	6.5	3.9	4.6	3.4	7.1	3.3	3.5
	DO %	94	79.1	65.6	80	70.7	69.1	60.2	65.9	108.6	70.9	-
	DO (mg/L)	7.98	6.9	5.98	8.1	7.01	6.89	5.75	7.08	9.97	7.53	-
HANNA	T	23.9		21.5		18.1		21.6		18.6		19.2
	Conductivity (microS/cm)	162		361		205		68		201		113
	pH	7.49		7.56		7.43		6.62		5.2		7.4
	EA015: Total Dissolved Solids											
	Total Dissolved Solids @180°C	522	407	434	627	1400	602	924	186	112	535	513
	EA025: Suspended Solids											
	Suspended Solids (SS)	85	107	70	67	106	47	145	137	1220	50	57
	ED037P: Alkalinity by PC Titrator											
	Hydroxide Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Carbonate Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Bicarbonate Alkalinity as CaCO3	48	110	128	44	47	16	9	3	1	21	22
	Total Alkalinity as CaCO3	48	110	128	44	47	16	9	3	1	21	22
	ED040F: Dissolved Major Anions											
	Sulfate as SO4 2-	4	4	6	5	10	4	6	3	5	11	14
	ED045G: Chloride Discrete analyser											
	Chloride	13	21	38	20	25	10	11	36	52	12	12
	ED093F: Dissolved Major Cations											
	Calcium	7	15	17	4	5	2	1	2	4	2	2
	Magnesium	4	9	11	3	4	1	<1	2	2	2	2
	Sodium	17	31	42	22	29	12	11	20	26	17	18
	Potassium	5	5	5	3	4	3	3	6	8	4	4
	EG020F: Dissolved Metals by ICP-MS											
	Aluminium	0.09	0.01	<0.01	0.75	0.13	0.92	0.2	0.05	0.02	1.78	0.24
	Copper	0.005	0.002	0.002	0.002	0.003	0.001	0.002	<0.001	0.003	0.001	0.001
	Manganese	0.003	0.052	0.03	0.006	0.003	0.017	0.022	0.078	0.193	0.004	0.008
	Boron	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	0.1	<0.05	<0.05
	Iron	0.1	<0.05	0.12	0.47	0.25	0.64	0.32	0.11	0.06	1.35	0.26
	EG020T: Total Metals by ICP-MS											
	Aluminium	12.8	12.1	10.4	15.8	37.4	12.3	19.4	2.19	3.24	15	16.8
	Copper	0.007	0.007	0.006	0.006	0.014	0.006	0.008	0.002	0.004	0.008	0.006
	Manganese	0.113	0.152	0.198	0.139	0.366	0.146	0.242	0.112	0.245	0.098	0.119
	Boron	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	0.09	<0.05	<0.05
	Iron	13.4	14.2	11.6	16.7	29.2	19.5	24.4	6.13	5.97	18.3	16.8
	EK040P: Fluoride by PC Titrator											
	Fluoride	0.1	0.2	0.2	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
	EK055G: Ammonia as N by Discrete Analyser											
	Ammonia as N	0.07	<0.01	0.02	<0.01	0.07	<0.01	0.02	0.46	0.47	0.03	0.08
	EK059G: NOX as N by Discrete Analyser											
	Nitrite + Nitrate as N	0.17	0.2	0.04	0.16	0.08	0.37	0.32	0.06	<0.01	0.59	0.31
	EK061: Total Kjeldahl Nitrogen (TKN)											
	Total Kjeldahl Nitrogen as N	1.2	3.1	1.6	3	2.4	1.6	2.2	1.5	6.4	0.6	1.5
	EK062: Total Nitrogen as N											
	Total Nitrogen as N	1.4	3.3	1.6	3.1	2.5	2	2.5	1.6	6.4	1.2	1.8
	EK067G: Total Phosphorus as P by Discrete Analyser											
	Total Phosphorus as P	0.32	0.26	0.27	0.23	0.67	0.27	0.41	<0.01	0.67	0.51	0.28
	EK071G: Reactive Phosphorus as P by discrete analyser											
	Reactive Phosphorus as P	<0.01	0.04	0.02	0.02	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
	EN055: Ionic Balance											
	Total Anions	1.42	2.86	3.74	1.56	1.86	0.69	0.61	1.13	1.57	0.98	1.08
	Total Cations	1.54	2.97	3.71	1.47	1.94	0.79	0.62	1.26	1.69	1.13	1.18
	Ionic Balance			0.44								
	EP008: Chlorophyll a											
	Chlorophyll a											
	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

		Condamin e/Balonne	Condami ne/Balon ne	Condamine /Balonne	Condamin e/Balonne	Condami ne/Balon ne	Condamin e/Balonne	Condamine /Balonne	Fitzroy	Fitzroy	Fitzroy
		Tchanning Creek	Tchannin g Creek	Wilkie Creek	Yuleba Creek	Yuleba Creek	Yuleba Creek	Yuleba Creek	Dawson River	Wooleebee Creek	Wooleebee Creek
		GF3	GF3	HPE8	GF10	GF10	GF9	GF9	HPE2	GF5	GF5
	Date	26/06/2009	5/09/2009	29/09/2009	30/06/2009	7/09/2009	29/06/2009	7/09/2009	2/10/2009	6/08/2009	5/09/2009
	Time	14:00	9:30 AM	11:00	8:45	11:30 AM	9:15	10:30 AM	14:00	8:20	12:34 PM
YSI	Temperature (C)	12.7	17.35	17.03	9.82	-	12	-	22.85	-	19.55
	Conductivity (microS/cm)	149	159	234	251	273	145	147	266	160	196.6
	pH	7.16	6.93	6.94	7.52	-	7	-	8.14	7.12	7.32
	Turbidity (NTU)	286	646.2	26.5	78.9	177	71.3	150.6	13.5	632.3	3.5
	chlorophyll (ug/L)	55.7	103.8	3.9	59.4	560	12.5	27.3	1.1	97.1	2.5
	chlorophyll (RFU)	12.9	24.3	0.5	6.72	13.6	2.9	6.2	0.2	22.4	0.6
	PC c/mL	6700	9863	3693	3030	7770	6500	8302	354	10294	20131
	PC RFU	3.1	4.6	1.5	1.4	3.8	2.8	3.6	0.2	4.8	9.4
	DO %	63.5	61.5	67.5	59.4	-	56	-	103.6	71.7	100.2
	DO (mg/L)	6.7	5.87	6.52	6.72	-	5.46	-	8.91	7.29	9.19
HANNA	T		20.1			18.9		17.6			22.4
	Conductivity (microS/cm)					268		130			
	pH		6.32					7.31			7.17
	EA015: Total Dissolved Solids										
	Total Dissolved Solids @180°C	248	902	255	122	184	158	199	253	1140	1600
	EA025: Suspended Solids										
	Suspended Solids (SS)	41	139	17	110	252	32	75	14	108	166
	ED037P: Alkalinity by PC Titrator										
	Hydroxide Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Carbonate Alkalinity as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Bicarbonate Alkalinity as CaCO3	25	34	1	88	88	51	48	2	38	45
	Total Alkalinity as CaCO3	25	34	1	88	88	51	48	2	38	45
	ED040F: Dissolved Major Anions										
	Sulfate as SO4 2-	12	24	4	9	20	3	5	3	8	12
	ED045G: Chloride Discrete analyser										
	Chloride	15	17	46	14	22	7	8	47	16	17
	ED093F: Dissolved Major Cations										
	Calcium	2	2	8	16	16	8	7	8	3	4
	Magnesium	2	2	4	6	6	4	3	4	1	1
	Sodium	22	28	30	22	26	11	11	32	26	35
	Potassium	4	4	10	8	10	7	7	10	4	5
	EG020F: Dissolved Metals by ICP-MS										
	Aluminium	0.72	0.38		<0.01	<0.01	0.02	0.03		3.85	0.23
	Copper	0.002	0.002		0.003	0.003	<0.001	0.004		0.002	0.002
	Manganese	0.006	0.024		0.239	0.811	0.182	0.032		0.012	0.034
	Boron	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05		<0.05	<0.05
	Iron	0.57	0.4		<0.05	<0.05	0.1	0.08		1.54	0.16
	EG020T: Total Metals by ICP-MS										
	Aluminium	13.2	25.3		2.66	3.89	2.46	3.64		17	29.7
	Copper	0.006	0.01		0.002	0.004	0.002	0.003		0.008	0.014
	Manganese	0.076	0.164		0.387	1	0.271	0.173		0.17	0.364
	Boron	<0.05	<0.05		<0.05	0.06	<0.05	<0.05		<0.05	<0.05
	Iron	14.4	23.8		5.01	6.45	5.74	6.17		9.87	19.5
	EK040P: Fluoride by PC Titrator										
	Fluoride	<0.1	0.1		0.2	0.2	0.1	0.1		<0.1	0.1
	EK055G: Ammonia as N by Discrete Analyser										
	Ammonia as N	0.05	0.05	0.03	0.06	0.03	0.03	0.03	0.03	0.12	0.05
	EK059G: NOX as N by Discrete Analyser										
	Nitrite + Nitrate as N	1.47	0.18	0.04	0.03	0.16	0.53	0.08	0.04	0.1	6.78
	EK061: Total Kjeldahl Nitrogen (TKN)										
	Total Kjeldahl Nitrogen as N	1.2	1.8	0.8	1	3	0.8	0.8	1.5	2.2	3.4
	EK062: Total Nitrogen as N										
	Total Nitrogen as N	2.7	2	0.8	1	3.2	1.4	0.9	1.5	2.3	10.1
	EK067G: Total Phosphorus as P by Discrete Analyser										
	Total Phosphorus as P	0.22	0.48	0.05	0.12	0.44	<0.01	0.2	0.04	0.42	1.99
	EK071G: Reactive Phosphorus as P by discrete analyser										
	Reactive Phosphorus as P	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	0.01	0.11	0.05
	EN055: Ionic Balance										
	Total Anions	1.18	1.67		2.33	2.79	1.28	1.29		1.4	1.63
	Total Cations	1.35	1.6		2.49	2.72	1.36	1.25		1.48	1.95
	Ionic Balance										
	EP008: Chlorophyll a										
	Chlorophyll a						0				
	EP068A: Organochlorine Pesticides (OC)										
	alpha-BHC	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Hexachlorobenzene (HCB)	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	beta-BHC	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	gamma-BHC	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	delta-BHC	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Heptachlor	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Aldrin	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Heptachlor epoxide	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	trans-Chlordane	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	alpha-Endosulfan	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	cis-Chlordane	<0.6	<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	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<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	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<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	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<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	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<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	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endrin aldehyde	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Endosulfan sulfate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4.4`-DDT	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endrin ketone	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methoxychlor	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
EP068B: Organophosphorus Pesticides (OP)																																
Dichlorvos	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Demeton-S-methyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Monocrotophos	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dimethoate	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Diazinon	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyrifos-methyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Parathion-methyl	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Malathion	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fenthion	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorpyrifos	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Parathion	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Pirimphos-ethyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorfenvinphos	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bromophos-ethyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Fenamiphos	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Prothiofos	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethion	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbophenothion	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Azinphos Methyl	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons																																
Naphthalene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b)fluoranthene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
EP080: BTEX																																
Benzene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
meta- & para-Xylene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
EP071 SG: Total Petroleum Hydrocarbons - Silica gel cleanup																																
C10 - C14 Fraction		<50		<50		<50	<50	<50		<50		<50		<50		<50		<50		<50	<50	<50		<50	<50	<50	<50	<50	<50	<50	<50	<50
C15 - C28 Fraction		<100		<100		<100	<100	<100		<100		<100		<100		<100		<100		<100	<100	<100		<100	<100	<100	<100	<100	<100	<100	<100	<100
C29 - C36 Fraction		<50		<50		<50	<50	<50		<50		<50		<50		<50		<50		<50	<50	<50		<50	<50	<50	<50	<50	<50	<50	<50	<50
EP080/071: Total Petroleum Hydrocarbons																																
C6 - C9 Fraction	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20		<20		<20	<20	<20	<20
C10 - C14 Fraction	<50	<50	<50	<50	<50	<50		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50		<50	<50	<50	<50	<50	<50	<50	<50	<50		<50
C15 - C28 Fraction	**900**	**1200**	<100	<100	**200**	**200**		<100	**500**	**200**	**100**	**100**	<100	<100	**200**	**100**	**100**	**100**	**400**	**500**		<100	<100	<100	**530**	<100	**200**	<100	<100	**610**		**100**
C29 - C36 Fraction	**290**	**180**	<50	<50	**120**	**70**		<50	**280**	**130**	**80**	<50	<50	<50	**90**	**50**	**50**	<50	**200**	**220**		<50	<50	<50	**250**	<50	**100**	<50	<50	**290**		<50

ANZECC/ARMCANZ exceedances

QWQG (2009) exceedances

Red Text Unreliable Data

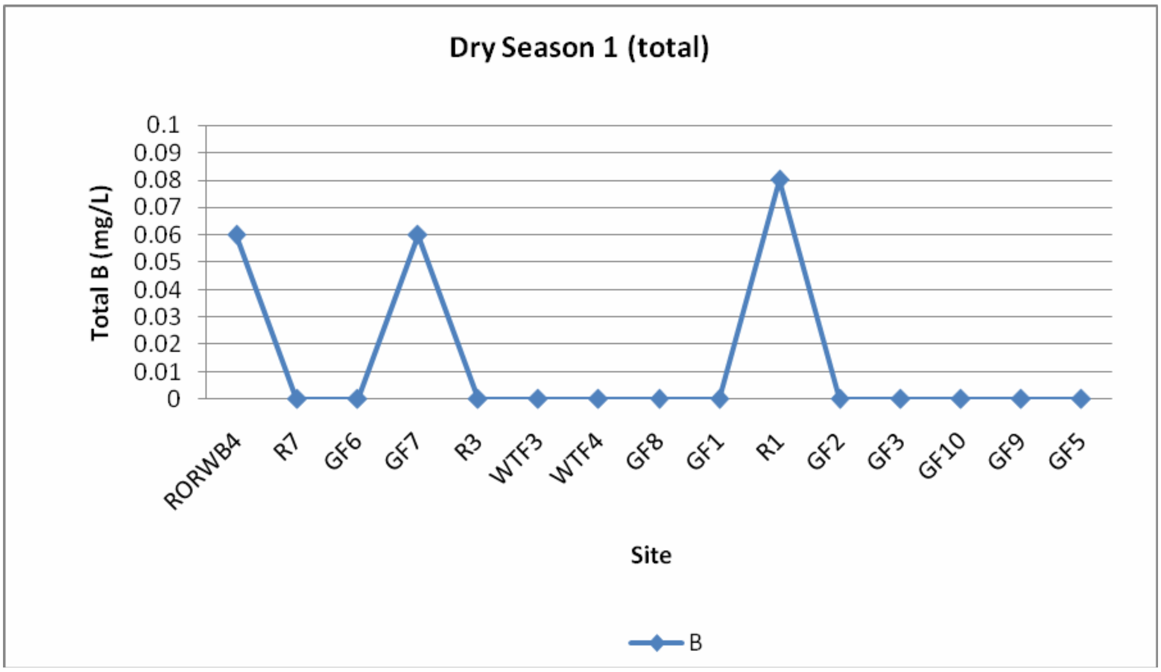


Figure A4-1 Total B - Dry season 1

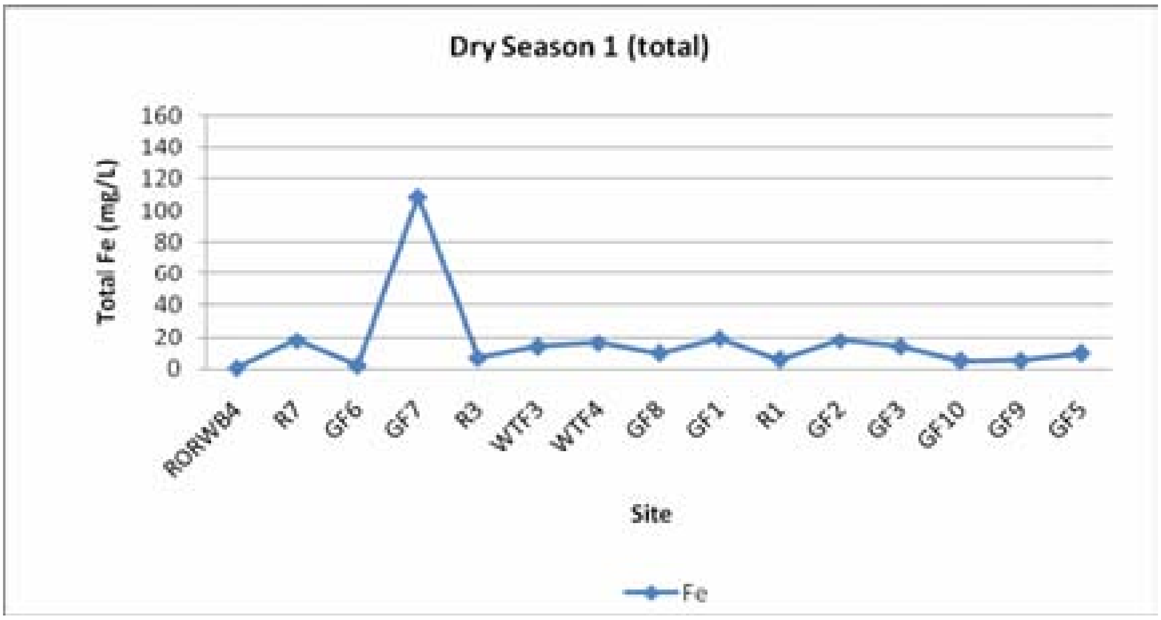


Figure A4-2 Total Fe – Dry season 1

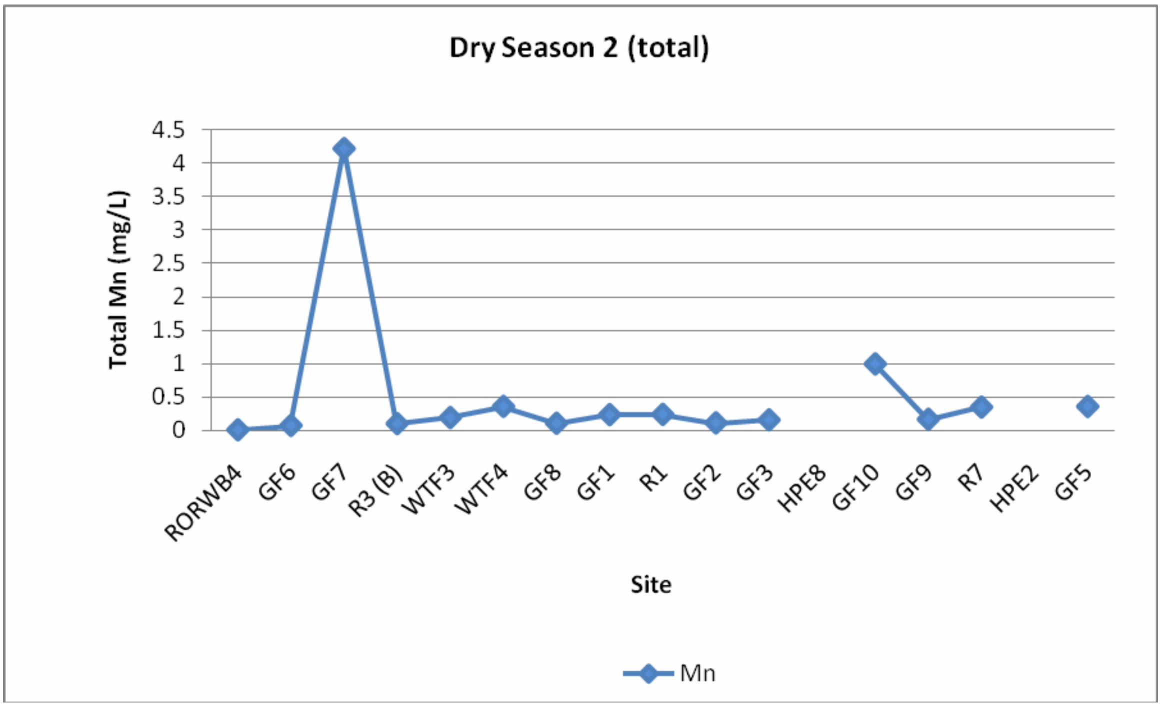


Figure A4-3 Total Mn – Dry season 2

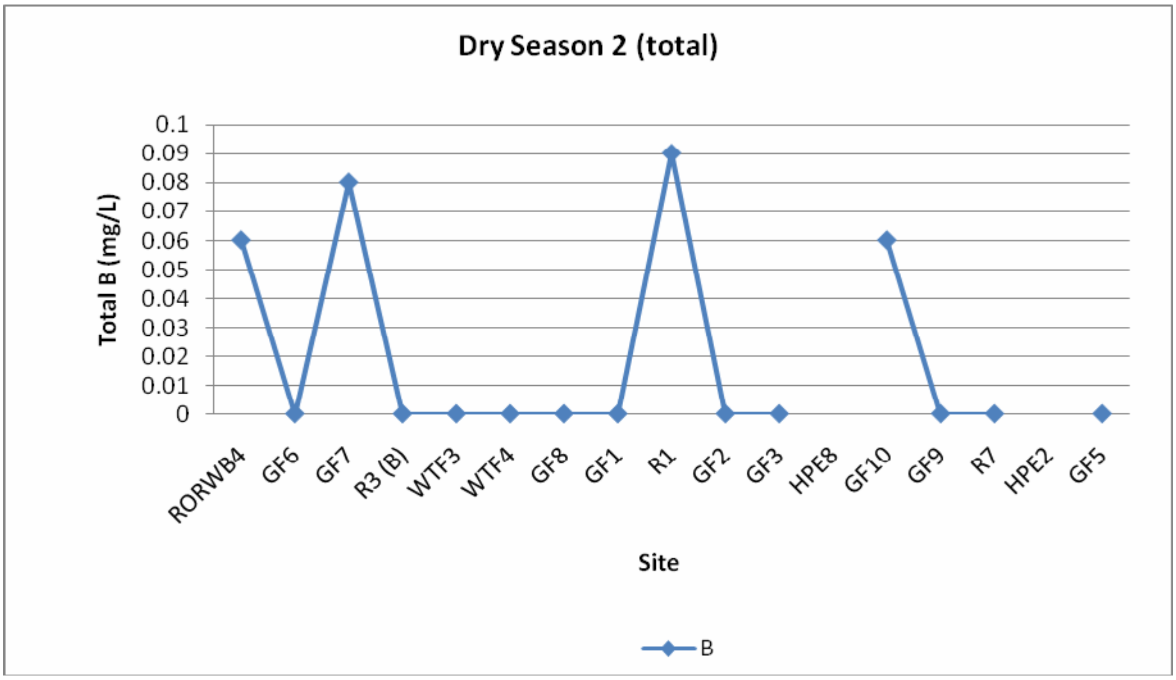


Figure A4-4 Total B – Dry season 2

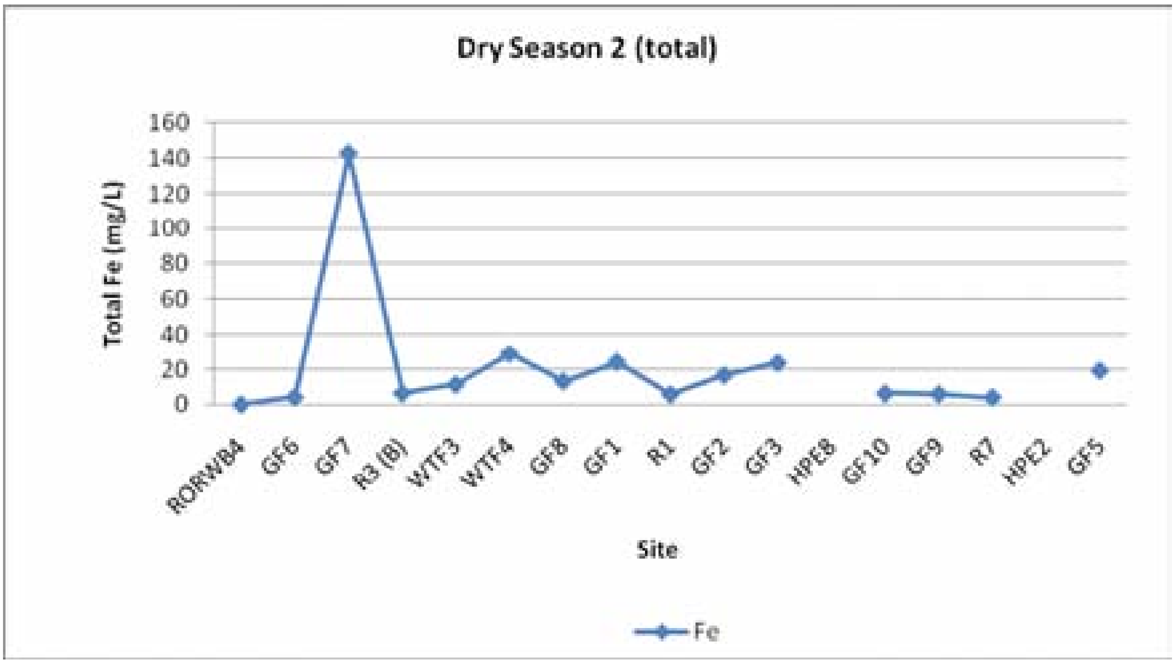


Figure A4-5 Total Fe – Dry season 2

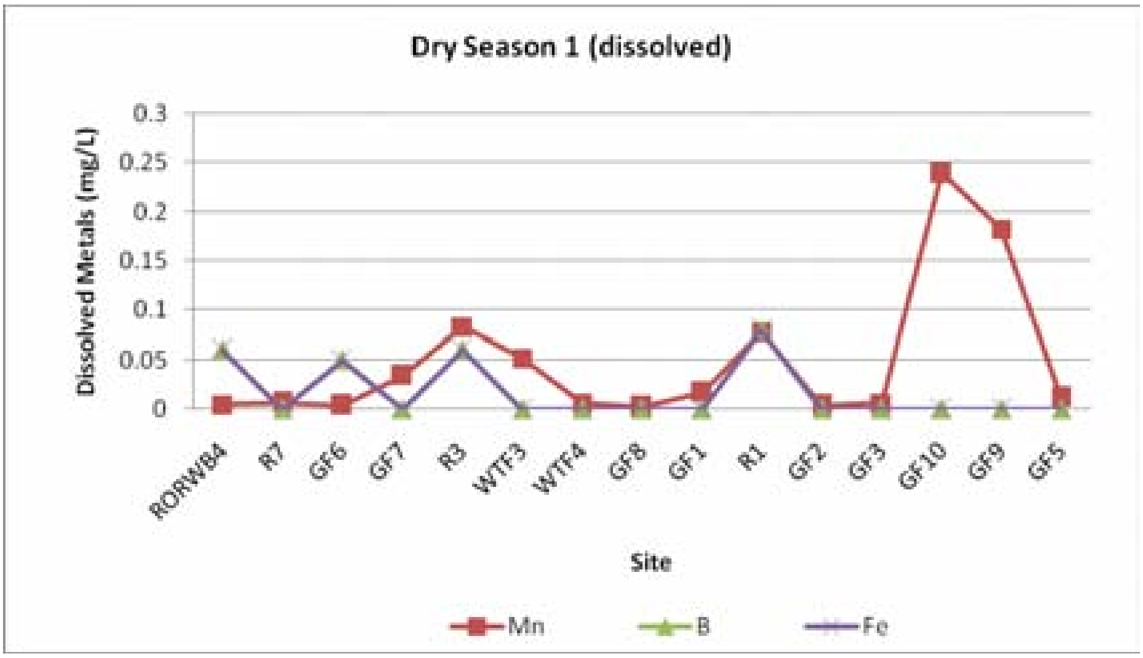


Figure A4-6 Dissolved Mn, B and Fe – Dry season 1

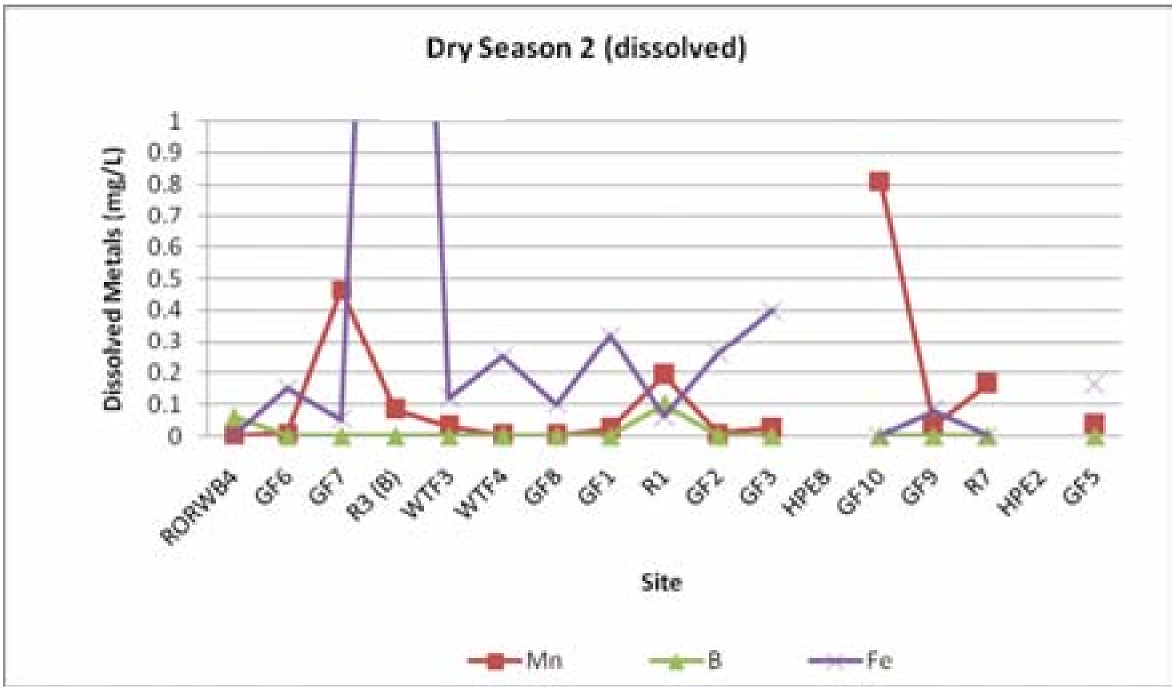


Figure A4-7 Dissolved Mn, B and Fe – Dry season 2

Appendix 3. Raw Fish Data

Table A4-1 Fish diversity and abundance – gas fields

Fish Family	Fish Species	Common name	Condamine / Balonne														Dawson	
			R7	GF10	GF9	GF3	GF2	R1	GF1	GF8	WTF4	WTF3	GF7	GF6	ROR WB4	R3	HPE2	GF5
Clupeidae	*Nematalosa erebi*	Bony Bream	21	12		2	1		1	47	26	2	1		34			
Cyprinidae	*Carassius auratus*	Gold fish	12	47		2	1	26		1			5					
	Cyrinus carpio	Common carp				1							3					
Eleotridae	*Hypseleotris spp.*	Gudgeon species	4	44		4	18	11		31	15	5	11		1187	3	2	
	Philypnodon granidceps	Flathead gudgeon									2							
Melanotaeniidae	*Melanoteania fluviatilis*	Murray River Rainbowfish		1						2								
Percichthydidae	*Macquaria ambiqua*	Golden Perch / Yellowbelly						5		6	1	1	2				1	
Plotosidae	*Tandanus tandanus*	Freshwater catfish															1	
Poecilidae	*Gambusia holbrooki*	Eastern Mosquitofish		6			3	10		36	28	5	1	6	29	9		
Pseudomugilidae	*Pseudomugil signifer*	Pacific blue-eye															1	
Retropinnidae	*Retropinna semoni*	Australian smelt					3	2		27	6	3		76	22			
Terapontidae	*Leiopotherapon unicolor*	Spangled perch	2	6		1	1	1		3	9							
Crustacean Family	Crustacean Species	Common name																
Palaemonidae	*Macrobrachium sp.*	Prawn species															65	
Parastacidae	*Cherax quadricarinatus*	Red claw	11			4												10
	Cherax sp.	Crayfish species									3			2				

Appendix 4. Raw Macroinvertebrate Data

Table A4-1 Macroinvertebrate diversity and abundance – gas fields (edge data)

Catchment	Condamine									Dawson	
Macroinvertebrate Family	Functional Feeding Group	R7	GF9	GF3	GF2	GF1	GF8	WTF4	WTF3	GF7	GF5
Hydridae	Predator		1		1						
Temnocephalidea	Predator	1						5		8	3
Nematoda	Predator		1		4		1			6	2
Dugesiidae	Gatherer/collector					8					
Oligochaeta	Gatherer/collector		3		6			1	1	1	1
Glossiphoniidae	Predator		1								
Physidae	Scraper					15	1				
Planorbidae	Scraper				3						
Lymnaeidae	Scraper				2						
Hydrobiidae	Scraper										
Thiaridae	Scraper										
Ancylidae	Scraper				1						
Sphaeriidae	Filter-feeder										
Corbiculidae	Filter-feeder										
Acarina	Predator		1	1		2	4	14			2
Copepoda	Gatherer/collector	21	45	17	61	6	9	6	4	38	78
Cladocera	Filter-feeder		77		37	8	1	9		6	94
Ostracoda	Filter-feeder	1	2		3		1			4	4
Isop-Cirolanidae	Gatherer/collector							1	2		
Atyidae	Gatherer/collector	1	5		14		5	3	10	3	
Palaemonidae	Gatherer/collector	1	11		3		4	16			5
Parasticidae	Shredder			1				1		2	8
Collembola	Gatherer/collector	5				1	3	2			3
Leptophlebiidae	Gatherer/collector										
Baetidae	Gatherer/collector			3	4		1	2			2
Caenidae	Gatherer/collector			2			8	4	1		
Anisoptera	Predator										
Aeshnidae	Predator							1			
Gomphidae	Predator				1		4				
Corduliidae	Predator					1		2			
Libellulidae	Predator										
Zygoptera	Predator		1				2			1	
Coenagrionidae	Predator			2	3		7	3	1		

Catchment	Condamine									Dawson	
Isostictidae	Predator		12		5	1	2		9	2	
Protoneuridae	Predator										
Corixidae	Predator			1			22	6	7	1	9
Naucoridae	Predator				2						
Nepidae	Predator		1	2							1
Notonectidae	Predator			2					2		4
Pleidae	Predator		1		1	1		2		14	1
Hydrometridae	Predator	1		2	3	4	2	4			
Gerridae	Predator	1	3								
Veliidae	Predator	2	2	8	23	10		5		9	15
Ochteridae	Predator						1				
Sisyridae	Predator										
Coleoptera	Predator				1			1		4	
Gyrinidae	Predator										
Dytiscidae	Predator	2		10	5	1		1		2	19
Hydrophilidae	Predator	1			3	9		2	1	10	2
Hydraenidae	Gatherer/collector	1	1		9					5	24
Scirtidae	Filter-feeder			2				1			12
Staphylinidae	Predator				2			1			4
Curculionidae	Shredder									1	
s-f Tanypodinae	Predator	1	5		16		3	1	2	1	2
s-f Orthocladiinae	Gatherer/collector				1			1			
s-f Chironominae	Filter-feeder		20	4	29	1	1	8	1	13	8
Ceratopogonidae	Predator	3	4		24	6	1	2		3	2
Culicidae	Filter-feeder	8	2		3						
Tipulidae	Gatherer/collector										1
Psychodidae	Gatherer/collector		1								
Sciomyzidae	Predator				6						
Leptoceridae	Shredder	2	6	1	15		13	31	44	1	4
Ecnomidae	Predator				1		1	3		3	1
Calamoceratidae	Shredder										
Anostraca	Filter-feeder										
Bryozoa	Filter-feeder		1		1						
Pisauridae	Predator				4					3	16
Hemicordulidae	Predator				2						
	TOTAL Abundance	52	207	58	299	74	97	139	85	141	327
	TOTAL Richness	16	24	15	35	15	23	30	13	24	28

Table A4-2 Macroinvertebrate diversity and abundance – gas fields (bed data)

Site	Flow pref	Substrate pref	GF1	GF2	GF3	GF5	GF6	GF7	GF8	GF9	GF10	HPE2	R1	R3	R7	RORWB4	WTF3	WTF4
Temnocephalidea	L/NF	NP													10			
Nematoda	NP	NC	440			10	80	6	10	110	1460	20		20	10	400	20	10
Dugesiidae	HF	WC	20								20							
Oligochaeta	NP	NP	340	200		60	150	79	120	470	1380	290	220	40	30	20	330	
Glossiphoniidae	NP	NP								10								
Physidae	L/NF	SF									2						1	
Planorbidae	L/NF	WF								30	1			10				
Thiaridae	NP	NP																
Ancylidae	L/NF	NC						1	10								30	
Sphaeriidae	L/NF	SF							1			20						
Corbiculidae	NP	NP																
Hyriidae	L/NF	SF							10								90	
Acarina	NP	NP							30		10	10		20		80		
Copepoda	L/NF	WF	1960	1660	2600	140	20	379			980	30	20	1600	460	160	1970	280
Cladocera	L/NF	WF	80	200	30	380	60	1	10	430	160	10	70	530		40	190	
Ostracoda	L/NF	WF		40	20		70	3	30	320	60	10				20	330	10
Atyidae	L/NF	WF		1	1		10	2								20	8	1
Palaemonidae	NP	NP							1						40			1
Parasticidae	L/NF	SF					10											
Collembola	L/NF	SF			10										10			
Anisoptera	NC	NC															10	

Site	Flow pref	Substrate pref	GF1	GF2	GF3	GF5	GF6	GF7	GF8	GF9	GF10	HPE2	R1	R3	R7	RORWB4	WTF3	WTF4
Gomphidae	NP	NP									1							
Corduliidae	L/NF	NP								1								
Libellulidae	NP	NP																
Zygoptera	NC	NC	10														40	
Coenagrionidae	L/NF	WF															2	
Isostictidae	L/NF	WF															1	
Megapodagrionidae	MF	SF						1										
Corixidae	L/NF	WF							30		130							10
Naucoridae	NP	NP								40								
Notonectidae	L/NF	SF									10			20				
Hydrometridae	L/NF	SF								10								
Gerridae	L/NF	WF										10						
Veliidae	L/NF	WF		10														
Dytiscidae	L/NF	WF				10					10			10				
Elmidae	HF	WC										20						
Psephenidae	HF	SC																
Ptilodactylidae	HF	SC								10								
Hydraenidae	L/NF	SF															10	
Noteridae	L/NF	SF								10								
Chironomidae s-f Tanypodinae	NP	NP	100	130	20	1	30	35	60		260	140	20	20		20	190	
Chironomidae s-f Orthocladiinae	NP	WC								60		50						
Chironomidae s-f Chironominae	NP	NP	70	220	60		180	29	150		1260	1400	400	150	280	200	370	30

Site	Flow pref	Substrate pref	GF1	GF2	GF3	GF5	GF6	GF7	GF8	GF9	GF10	HPE2	R1	R3	R7	RORWB4	WTF3	WTF4
Simuliidae	HF	SC								300								
Ceratopogonidae	NP	NP		90	40	1		9	70		50	390	260		480	240	200	30
Culicidae	L/NF	SF								200								
Tabanidae	HF	SC								10		10						
Chaoboridae	NC	NC									10		10					
Ephydridae	NC	NC						1										
Leptoceridae	NP	NP		1				1	50		1		10	10		140	70	10
Hydropsychidae	HF	SC								50								
Ecnomidae	NP	WC					2											
Calamoceratidae	NP	NP																
Baetidae	NP	NP				10					50		10				10	
Caenidae	NP	NP			10		10		30			60				220	190	
Ameletopsidae	L/NF	NC																
Clavidae	NC	NC																10
Bryozoa	NC	NC															10	
Mesostigmata	NC	NC								10								
Hydrochidae	NC	NC	8															

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 Rating			Bottom substrate	Embeddedness	Velocity/depth category	Channel alteration	Bottom scouring and deposition	Pool/riffle, run/bend ratio	Bank stability	Bank vegetative stability	Streamside cover	
GFE10	30/09/2009	Weir River	two stage	deepend U-Shape		shallow valley				2	1				2	1			poor	mod aggradation			floodplain scours	stock	runoff	Ford	grazing (cleared)	road, ford, grazing	uplands	very high disturbance	9%	9%										- highly disturbed site - historic incision evident, but now infilling with sand - gullying major issue - major issue of sand in bed
GFE6	29/09/2009	Weir River	two stage	flat U-Shape	U-Shape	broad valley			1	2	2				2	1			very poor	bed stable to mod aggradation			clearing of vegetation	runoff	Stock		grazing (cleared)	grazing	uplands	very high disturbance	55%	15%	15	13	5	5	7	4	5	4	5	- very poor site with obvious upstream influences on bed condition - incised historically, but now infilling - sandy bed (with sandstone outcropping) - rock outcropping in banks - typical sodic soils on LB - cracking, rilling, tunnels etc
GFE7	28/09/2009	Western Creek	widened or infilled			shallow valley				1				2	1		3		very poor	severe agradation		dams and diversions	clearing of vegetation	runoff	Stock		grazing (cleared)	road, grazing	uplands	very high disturbance	64%	52%										- landuse upstream resulting in highly sandy bed - few habitat values - very highly disturbed site - upstream landuse evidently contributing to increased sediment delivery to channel - very sandy infilled bed with little to no geomorphic variability - cracking clays evident
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
GF10	30/07/2009	Yuleba Creek	U-Shape	2 stage		symmetrical floodplain	asymetrical floodplain	broad valley	1	2				1					poor	mod aggradation			runoff	clearing of vegetation	stock/ gullying		grazing (cleared)	grazing	midlands/lowlands	very high disturbance	29%	31%	5	3	9	3	4	7	6	5	9	- infilling of run at TS2 has reduced habitat vaues - TS1 - lots of LWD - cleared floodplain contributing to gullying into stream - otherwise relatively stable banks - obvious stock tracks down banks

Site	Date	Tributary name	Channel Shape 1	Channel Shape 2	Channel Shape 3	Valley Shape 1	Valley Shape 2	Valley Shape 3	Left bank shape: Concave	Left bank shape: Convex	Left bank shape: Stepped	Left bank shape: Wide lower bench	Left bank shape: Undercut	Right bank shape: Concave	Right bank shape: Convex	Right bank shape: Stepped	Right bank shape: Wide lower bench	Right bank shape: Undercut	Overall Aquatic life rating	Overall Bed Stability Rating	Artificial Bank Protection Measures	Channel modification	Factors affecting stability 1	Factors affecting stability 2	Factors affecting stability 3	Artificial Features	Reach Environs: Local Land Use	Reach Environs: Local Disturbance	Reach Environs: Reach Location	Reach Environs: Disturbance Rating	LB Connectivity	RB Connectivity	Habitat Assessment: Bottom substrate	Habitat Assessment: Embeddedness	Habitat Assessment: Velocity/depth category	Habitat Assessment: Channel alteration	Habitat Assessment: Bottom scouring and deposition	Habitat Assessment: Pool/riffle, run/bend ratio	Habitat Assessment: Bank stability	Habitat Assessment: Bank vegetative stability	Habitat Assessment: Streamside cover	Summary
GF2	28/07/2009	Tchanning Creek	flat U-Shape	2 stage	trapezoid	symmetrical floodplain	broad valley			1				1	1				poor	mod aggradation			runoff	floodplain scours	stock		grazing (cleared)	grazing	midlands/lowlands	very high disturbance	0%	28%	3	5	6	4	7	5	3	5	5	- very poor aquatic habitat values - no LWD, very little fringing vegetation - some fringing macrophytes - channel geomorph varability reduced by infilling from gullying - some geomorph variability with sedimentation from gullying causing the creation (or expansion) of large pools - however in the locations where this sediment has occurred, geomorph variablity and integrity severely deimished - flattened infilled beds - poor aquatic habitat values
GF3	26/05/2009	Tchanning Creek	U-Shape	flat U-Shape	deepend U-Shape	broad valley			1	2				1	2				poor	mod aggradation		desnagged	stock/clearing of vegetation	stock/clearing of vegetation			grazing (cleared)		midlands	very high disturbance	13%	18%	5	5	8	8	5	5	4	4	4	- patches of good rip veg along reach - lots of sand deposits - extremely bad habitat at TS3: no rip veg, no LWD - Low value channel - very similar habitat throughout reach - infilled - deepening - some good rip vegetation maintaining some stability - deposition of sediment relative to gullying associated with lack of vegetation - major active process: run off from surrounding landscapes, bank failure, deposition of large amounts of sediments downstream of failures - huge infilling issues in sections, - gullying
GF6	31/07/2009	Charleys Creek	flat U-Shape			symmetrical floodplain			1					1					poor	Mod aggradation		dams and diversions	clearing of vegetation	clearing of vegetation	stock	major weir	grazing (cleared)	water extraction, grazing, weir	midlands/low lands	high disturbance	68%	84%	6	4	1	4	7	1	8	3	5	- scattered LWD - lower bank vegetation cleared for weir - increase in sediment - increased infilling of weir
GF6a	23/06/2009	Rocky Creek	flat U shape	widened or infilled		shallow valley			2	1	1			2	2	1			poor	mod aggradation	concrete wall	dams and diversions	runoff	gullying		major weir	grazing (cleared)	sewage effluent		high disturbance	36%	86%	10	5	2	4	7	5	7	6	9	- very turbid water - local grazing - major weir causing some depositon - cleared both sides with patches of good vegation on RB - weir pool keeps veg away from low water but continuity and density is generally ok with sections of poor connectivity - minor infilling of channel ass with weir - alot of aquatic vegetation but looks to be exotic (photo 28-32)

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 Rating			Bottom substrate	Embeddedness	Velocity/depth category	Channel alteration	Bottom scouring and deposition	Pool/riffle, run/bend ratio	Bank stability	Bank vegetative stability	Streamside cover	
GF7	1/08/2009	Charleys Creek	U-Shape	2 stage	Box	assymetrical flood plain			1	1				2	1	1			poor	bed stable to mod aggradation		dams and diversions	clearing of vegetation	stock		bridge, ford	grazing (cleared)	bridge/culvert/wharf, grazing	midlands/lowlands	high disturbance	47%	27%	3	2	8	6	7	7	6	4	5	- regrowth of rip vegetation - lots of LWD downstream - very poor aquatic habitat values - gullying infilled pool, no LWD, little shading - regrowth of rip vegetation increases condition - infilling pool, result of lack of vegation on bank
GF8	25/06/2009	Condamine River	deepend U-Shape	two stage		shallow valley			2	1				1	2	2			poor	mod aggradation			runoff	clearing of vegetation	gullying		grazing (cleared)	water extraction	midlands	very high disturbance	0%	3%	6	3	2	6	6	6	6	4	4	- very turbid water - isolated logs provide habitat - major infilling of pools by gully washout at TS1 - great LWD but no overhanging veg or other rip veg at TS3 - highly mod in terms of rip and floodplain veg - poor LWD and habitat geatures although a rock w/in channel provides habitat at d/s reaches - major issues: gullyinh; veg clearance; runoff
GF9	30/07/2009	Yuleba Creek	U-Shape			symmetrical floodplain				1			2		1	2		3	good	bed stable to mod aggradation			runoff	stock	clearing out vegetation		grazing (cleared)	grazing	midlands/lowlands	high disturbance	36%	72%	11	11	7	11	8	9	7	5	9	- slightly infilled pool - gully downstream evidence of grazing pressure - floodplain veg cleared both sides - good rip veg strip on both sides (though narrow) providing stability to old deep channel - some pool infilling occuring - runoff from overland flow and gullies providing sediment to channel - no major LWD - scattered logs and branches - high velocities (in a deep channel) would transport smaller stuff downstream
HPE3	1/10/2009	Wallumbilla Creek	Box	U-shape		symmetrical floodplain	broad valley			1				2	1	3			poor	bed stable to mod aggradation			clearing of vegetation	floodplain scours	runoff		grazing (cleared)	grazing	midlands	extreme distrubance	0%	12%										- severely modified creek with major gullying adjacent to stream - not as much sand in bed - indicative of high clay content in soils - obvious growth of bars in section with incised thalweg - erosive unstable banks
HPE8	29/09/2009	Wilkie Creek	U-Shape	flat U-Shape		broad valley			1	2				1	2				poor	bed stable	fence structures		clearing of vegetation	ford	Runoff	Ford	grazing (thinned), forestry	forestry activities, grazing	uplands	moderate disturbance	91%	92%	11	10	10	9	8	9	9	5	8	- low disturbance compared to other sites within the same region - forestry has obviously impacted riparian and floodplain vegetation - past grazing and clearance
ORWB1	25/06/2009	Dogwood Creek	widened or infilled			broad valley			1										good	bed stable			clearing of vegetation	clearing of vegetation			grazing (cleared)		midlands	high disturbance	0%	0%										- dry ORWB with dense dying grasses - dry paleochannel that would provide good habitat in wet - poss connected to channel in high flows via over bank flow

Site	Date	Tributary name	Channel Shape 1	Channel Shape 2	Channel Shape 3	Valley Shape 1	Valley Shape 2	Valley Shape 3	Left bank shape: Concave	Left bank shape: Convex	Left bank shape: Stepped	Left bank shape: Wide lower bench	Left bank shape: Undercut	Right bank shape: Concave	Right bank shape: Convex	Right bank shape: Stepped	Right bank shape: Wide lower bench	Right bank shape: Undercut	Overall Aquatic life rating	Overall Bed Stability Rating	Artificial Bank Protection Measures	Channel modification	Factors affecting stability 1	Factors affecting stability 2	Factors affecting stability 3	Artificial Features	Reach Environs: Local Land Use	Reach Environs: Local Disturbance	Reach Environs: Reach Location	Reach Environs: Disturbance Rating	LB Connectivity	RB Connectivity	Habitat Assessment: Bottom substrate	Embeddedness	Velocity/depth category	Channel alteration	Bottom scouring and deposition	Pool/riffle, run/bend ratio	Bank stability	Bank vegetative stability	Streamside cover	Summary
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
R3	24/06/2009	Charleys Creek	deepened U-Shape	two stage		broad valley			2	1				2	1				good	moderate erosion		desnagged	clearing of vegetation	clearing of vegetation			horticulture small crops/vines	agriculture	midlands	high/moderate	55%	69%	12	9	13	7	7	8	8	6	8	- few habitat values in terms of LWD and riparian input - sparsely pop rip vegetation community - few LWD but excellent margin habiat - generally unmodifued ck except for surrounding landscape - variety in habitat is quite good - upper section more riffly with TS2 and TS3 more incised pools - relatively incised with levees in section, flood runners between bank top and upper terrace
R7	31/07/2009	Bungil Creek	U-Shape	2 stage		symmetrical floodplain	asymetrical floodplain		1	2				2	1	3			poor	bed stable to mod aggradation			clearing vegetation	runoff	stock		grazing (cleared)	sand/gravel mine	midlands/lowlands	very high disturbance	6%	0%	6	5	7	6	6	8	7	6	5	- few LWD or rip veg overhanging - fine sandy fairly uniform bed (except against rock bank indicates some infilling) - cleared floodplain, rip vegetation severly disturbed along most of the length of creek - some habitat values at high rock bank - deep pool but generally flat bottomed
RE9	28/09/2009	Western Creek	flat U-Shape	widened or infilled	two stage	broad valley				1				2	1	3			very poor	mod aggradation			stock	clearing of vegetation	runoff	culvert	grazing (cleared)	culvert, grazing	uplands	high disturbance	30%	46%										- very highly disturbed site - upstream landuse evidently contributing to increased sediment delivery to channel - very sandy infilled bed with little to no geomorphic variability
RORWB4	24/06/2009	Charleys Creek	flat U-Shape			broad valley			2	2									good	bed stable			runoff	clearinf of vegetation			grazing - sown pasture	water extraction	uplands/midl ands	moderate disturbance	0%	0%										
WTF3	24/06/2009	Condamin e River	two stage	deepend U-Shape		shallow valley			2	2	1								poor	mod aggradation		dams and diversions	runoff	clearing of vegetation			grazing (cleared)	water extraction, grazing	midlands	very high disturbance	24%	0%	6	5	2	5	5	4	3	2	4	- deep pool w/ little fringing/floating veg and only a few pieces of LWD - several large collections of LWD - bedrock at site - large pool with prob little connectivity with u/s and d/s pools - rip veg dominated by exotic grasses - high disturbance, no veg on lower banks - veg on tops of banks (sparse) - LWD provides some geomorph, variability

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 Rating			Bottom substrate	Embeddedness	Velocity/depth category	Channel alteration	Bottom scouring and deposition	Pool/riffle, run/bend ratio	Bank stability	Bank vegetative stability	Streamside cover	
WTF4	23/06/2009	Condamine River	multi stage			broad valley			2	1				2	1				good	mod aggradation		desnagged	stock	clearing of vegetation			grazing (cleared)	other mine - minor gas	midlands/lowlands	high disturbance	0%	13%	10	7	6	5	9	7	8	7	5	- long pool, though is shallow ' highly disturbed site with grazing and cleared land on LB and mod dist on RB - rip veg not dense but continuous, some disturbance of canopy with intrusion of invasive grasses - growth of bars at upstream transect - flat bed with little variablity in habitat
GF5	28/07/2009	Wooleebee Creek	flat U-Shape	widened or infilled		broad valley			1	2			2	1	1			2	very poor	severe agradation			runoff/clearing of vegetation	stock	floodplain scours		grazing (cleared)	grazing	uplands	extreme distrubance	0%	4%	0	0	0	1	0	3	1	0	1	- dry sandy bed - no wood or fringing vegetation - severely infilled channel with no bed varability - no floodplain or riparian vegetation - stream in very poor condition as a result
HPE2	2/10/2009	Dawson River	two stage	U-shape		shallow valley			2	3	1				2	1			good	bed stable			clearing of vegetation	floodplain scours	runoff	culvert	grazing (cleared)	Road, culvert, grazing	uplands	moderate disturbance	40%	41%	12	9	13	7	7	9	7	6	9	- stream in good condition, particularly reaches further upstream - while some signs of deposition are evident (sandy bed), it is fairly minor - probably due to fewer upstream influences - banks are reasonably stable, but erosion and gullying occurs where there's no vegetation
HPE5	1/10/2009	Juandah Creek	Widened or infilled	flat U-Shape		broad valley				1	2	3	4		2		1	3	very poor	Moderate to severe aggradation			clearing of vegetation	runoff	stock	bridge	grazing (cleared)	bridge, grazing	midlands	extreme distrubance	0%	0%										- highly modified stream that has been infilled with sand (old gully maybe) - deposition has led to growth of bars and benches, with grass colonisation leading to increases in bar sizes - bed is mostly coarse sand
R2	29/07/2009	Horse Creek	widened of infilled	flat U shape		symmetrical floodplain	asymetrical floodplain		2	1			2	2	1			2	poor	mod aggradation			clearing of vegetation	runoff	stock		grazing (cleared)	grazing (cleared)	midlands	high disturbance	31%	39%	4	5	5	4	3	6	6	4	5	- few hab values throughout an infilled reach - lots of water-resilient plants in infilled channel - broad, flat channel that is widening at points, particularly where banks are sandy - patches of floodplain vegetation that are regrowing - bank vegetation generally young - infilled sandy channel - bars prominent low flow channel clearly infilled in most sections

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 Rating			Bottom substrate	Embeddedness	Velocity/depth category	Channel alteration	Bottom scouring and deposition	Pool/riffle, run/bend ratio	Bank stability	Bank vegetative stability	Streamside cover	
WTF1	29/07/2009	Horse Creek	widened or infiled	2 stage		shallow valley			1	2				1	2				poor	mod aggradation			gullying	runoff	clearing of vegetation		grazing (cleared)	grazing	uplands/midlands	very high disturbance	51%	43%	5	5	6	5	4	6	2	4	5	- large wide channel with few habitat values - enlarged bars - widening - slightly incised meandering through flow channel within depositional bars - few pieces of LWD - highly disturbed creek with high amounts of sediment stored in bed - sandy environment combined with vegetation cleareance, gullying etc to consid deposition within the creek

Table A5–2 Transect-based geomorphic assessment results

Site	Date	Stream/River	Transect	CHANNEL CONDITION								IN-STREAM DEBRIS COVER																									OVERHANGING VEGETATION																							
												Indivi d. 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									LEFT BANK												RIGHT BANK											
				Bed Stability	Channel Width (m)	Stream Width (m)	Stream Shading (%)	Riparian Width (RB) (m)	Riparian Width (LB) (m)	Habitat	Bank Stability	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	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)	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)	Overhanging	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)	Overhanging	Average width (m)
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
GF10	30/07/09	Yuleba Creek	1	2	24	3	70	5	5	3	4		52	1	5									>10	10												70	2	10	1									60	2	5	1								
			2	2	23	8	60	10	<5	2	2													>10	<1												50	1.5	5	<1									90	3	10	3								
			3	3	17	6	90	5	5	3	3	3	2	1	5									6	1												90	3	5	1									70	3	5	1								
GF2	28/07/09	Tchanning Creek	1	2	41	10	30	5	10	2	4	2	10	1	2																		1				20	1	20	<1									10	3										
			2	0	48	3-10	10	20	10	1	2							1	<1													<2							10	<1									<5	<1	5	<1								
			3	2	61	1.5	10	5	0	2	1							2	<1																				10	1									50	1.5	5	1								
GF3	26/05/09	Tchanning Creek	1	2	69	8	20	10	5	2	2	2	2	1	5			5	<1			2	<1														40	<0.5	5	1									30	0.5	5	1								
			2	2	30	4	15	8	5	1	2	1	<1											1	2										20		10	2											30	1	2	0.5								
			3	0	68	1	15	40	0	1	0	1	2					3	1	1	2																10	0.5																						
GF5	28/07/09	Wooleebee Creek	1	0	26		0	0	0	0	2																												2	0.5											2	0.5								
			2	0	30		0	0	0	0	0																																								1	0.3								
			3	0	28		0	0	0	0	2																										5	0.5																						
GF6	31/07/09	Charleys Creek	1	2	28-70	14	5	0-50	0-20	1	4							1	<1												30				80																									
			2	2	68	22	0	0-50	0-40	2	4							7	<2												20				80																									
			3	2	64	14	5	0-30	0-50	1	4	1	<1					2	<1												10				70		5	<1																						
GF6a	23/06/09	Rocky Creek	1	2	86	15	5	20	10	1	2	4	2																30	20											2	0.5							5	5										
			2	2	46	15	40	5	50	2	4	6	5					1	<2											10																			75	5			2							
			3	2	110	15	10	36	50	2	3	5	<5											1	<1									2	70						<5	1							15	1										
GF7	1/08/09	Charleys Creek	1	3	50	10	10	30	50	2	2	5	<1					>10	2						<1												20	<1											50	<1										
			2	2	37	7-15	5	10	25	1	1							>10	<1																		15	1.5																						

CHANNEL CONDITION

Site	Date	Stream/River	Transect	Bed Stability	Channel Width (m)	Stream Width (m)	Stream Shading (%)	Riparian Width (RB) (m)	Riparian Width (LB) (m)	Instream Physical Habitat	Bank Stability
			3	2	57	8	30	30	30	1	3
GF8	25/06/09	Condamine River	1	0	86	25	5	50	25	2	2
			2	2	84	25	0	50	25	1	2
			3	2	78	25	0	50	10	2	2
GF9	30/07/09	Yuleba Creek	1	4	24	18	30	10	5	2	3
			2	4	27	21	40	10	5	2	4
			3	4	41	28	30	10	5	2	4
GFE10	30/09/09	Weir River	1	2	19	5	15	5	5	2	4
			2	2	33	6	10	5	5	2	3
			3	2	36	8	10	5	10	2	4
GFE6	29/09/09	Weir River	1	2	94	20	5	5	50	1	4
			2	3	83	17	5	5	10	1	1
			3	2	36-129	17	0	15	30	1	4
GFE7	28/09/09	Western Creek	1	1	37	6	<5	10	5	0	1
			2	1	35	20	<5	15	5	0	3
			3	1	45	20	<5	>30	50	1	3
HPE2	2/10/09	Dawson River	1	3	31	12	30	30	5	2	2
			2	3	33	18	20	0	5	2	4
			3	3	59	15	25	10	30	3	3
HPE3	1/10/09	Wallumbilla Creek	1	4	18	5	25	0	5	1	2
			2	2	10	5	5	5	0	0	3
			3	2	22	2	0	0	0	1	2

IN-STREAM DEBRIS COVER

Site	Transect	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)
	3							>10	1	2	1															
GF8	1	4	5																						15	
	2	3	5					2	2																50	
	3	6	20									1	2												50	
GF9	1	2	<1							1	<1			4	<1			3	<1						70	
	2	2	<1					3	<1														<1		70	
	3	2	<1															1	<1							
GFE10	1	2	2					>10	2			1	2	>10	1											
	2							>10	2					5	1											
	3	3	1							1	<1			>10	1											
GFE6	1	2	<1											>10	<1											
	2			1	5									5	<1											
	3													5	<1											
GFE7	1	1	<1					2	<1																	
	2							1	<1																	
	3							1	<1																	
HPE2	1							4	1	2	1															
	2	2	1											>10	1											
	3	3	1					4	1			1	1	>10	2										10	
HPE3	1	2	1					4	<1			1	1	>10	1											
	2	1	1					6	<1					>10	1											
	3	3	1							1	<5			>10	1											

OVERHANGING VEGETATION

Site	Transect	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)	Overhanging	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)	Overhanging	Average width (m)
	3	20	1	20	4									50	1	70	4								
GF8	1	5	1.5											10	2	5	2								
	2	5	0.5											10	2										
	3																								
GF9	1	50	5			15	<0.5							90	8	30	5								
	2	90	10-70m	20	10									70	6	10	1.5			70	<0.5				
	3	50	8											90	5	5	1								
GFE10	1	15	1	5	<0.5									15	2	5	<1								
	2	20	1	50	<1											80	<1								
	3	40	2	30	1											5	<1								
GFE6	1	10	<1											5	<1										
	2	5	1	10	<1									5	1										
	3	10	<1											5	<1										
GFE7	1	10	1																						
	2													10	1										
	3	50	1											10	1										
HPE2	1	40	2	5	1											45	<0.5	5	<0.5						
	2	60	2	25	1							15	1	5	1.5	5	1								
	3			30	2									40	3	15	4							10	6
HPE3	1	25	2											10	1										
	2													5	<1										
	3													5	<0.5										

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
HPE5	1/10/09	Juandah Creek	1	0	25-175	5	0	0	0	0	1							1	<1										
			2	2	12-180	6	5	0	5	1	2	1	1	1	<1														
			3	2	74	6	0	0	0	0	4																		
HPE8	29/09/09	Wilkie Creek	1	2	12	3	30	50	50	2	3	2	1					>10	2					>10	20				
			2	4	33	Feb-15	10	50	50	2	4	4	5					>10	1	1	5			>10	20				
			3	4	33	23	10	10	10	2	3	5	5					5	<1					>10	5				
ORWB1	25/06/09	Dogwood Creek	1	2																									
			2		35	3	0	30	50	2	4	5	<1																
			3		>350																								
R1	30/06/09	Dogwood Creek	1	2	83	10	20	50	50	2	2	2	5					3	10					5	10				
			2	2	44	8	20	20	50	3	3			3	50									10	10				
			3	2	44	10	50	50	50	3	3	5	20							3	20			>10	30				
R2	29/07/09	Horse Creek	1	2	42	15	10	10	10	1	2	2	<1							1	<1								
			2	2	29	8	5	30	0	1	3																		
			3	2	50	6		0	0	1	1																		
R3	24/06/09	Charleys Creek	1	4	34	1	70	50	50	3	4	1	<5																
			2	2	29	2.5	40	10	15	1	3	1	2							2	2			1	5				
			3	2	46	6	20	5	20	2	2	2	2											1	2				
R7	31/07/09	Bungil Creek	1	2	22	8-10	25	<5	<5	2	3	4	<2																
			2	2	23	8	5	0	0	2	4	1	<1					9	<1						5				
			3	3	20	6	5	<5	0	1	2							6	<1										
RE9	28/09/09	Western Creek	1	2	23	6	15	50	50	1	2													1	<1				
			2	2	19	7	10	10	50	1	4							2	<1										
			3	2	20	6	10	50	5	1	4	1	<1					3	<1										
RORWB4	24/06/09	Charleys Creek	1	2			0	50	50	3	4	5	<1																

Site	Transect	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)	Overhanging	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)	Overhanging	Average width (m)
HPE5	1																				2	1										
	2								5	1			5	0.5	5	0.5																
	3																															
HPE8	1								30	1											10	1										
	2								20	2											15	2										
	3						35		60	2											20	1										
ORWB1	1																															
	2								90	2																						
	3																															
R1	1								50	3											50	2										
	2								50	3											10	1										
	3								60	3											50	4										
R2	1								70	1											40	3										
	2																				20	2	10	1								
	3																				5	1										
R3	1				15				30	1											20	1										
	2								40	1					30	0.2					5	0.5					30	0.2				
	3					20			20	2	60	0.5	50	0.2	50	0.2					20	3	90	0.5			50	0.1				
R7	1								40	3											50	3										
	2				<1		10		20	2			70	<0.5	50	<0.5					5	4										
	3																				30	3										
RE9	1								10	1											30	2.5										
	2								15	1											5	1										
	3								25	1											50	1.5										
RORWB4	1		50				50																									

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)	Overhanging	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)	Overhanging	Average width (m)
WTF1		29/07/09	Horse Creek	1	2	10	10		50	20	2	1	3	<1					2	<1	1	1																30	2	5	2									20	2										
				2	2	105	10		10	5	1	2	3	<1					3	<1	1	<1																																							
				3	2	65		5	5	10	1	1			1	<2																						20	<0.5											20	0.5	20									
WTF3		24/06/09	Condamine River	1	4	91	20	5	50	20	1	3	3	57																					2	70		5	1																						
				2	2	51	16	5	50	20	1	2	3	5					3	<10														1	2	70				5	1.5	5	1																		
				3	2	56	24	20	40	25	2	3	6	15																				2	20	40		15	5	25	3	10	0.2							20	2	15	1	30	0.2						
WTF4		23/06/09	Condamine River	1	2	37	15	5	30	50	2	3	3	<5					5	<5																25		5	1																						
				2	2	56	10	10	50	20	1	4																								25														5	1										
				3	2	87	5	30	first 10 then 5	50	2	3	4	10					3	<5																		10																							

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 tanks, gully dams) calculated by surface area	10.0
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)	10.0

	within the spatial unit	
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 group to which the wetland belongs within the sub-catchment (management groups ranked least common to most common)	8.1
	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

Appendix 7. Flow Duration Curves and EFOs

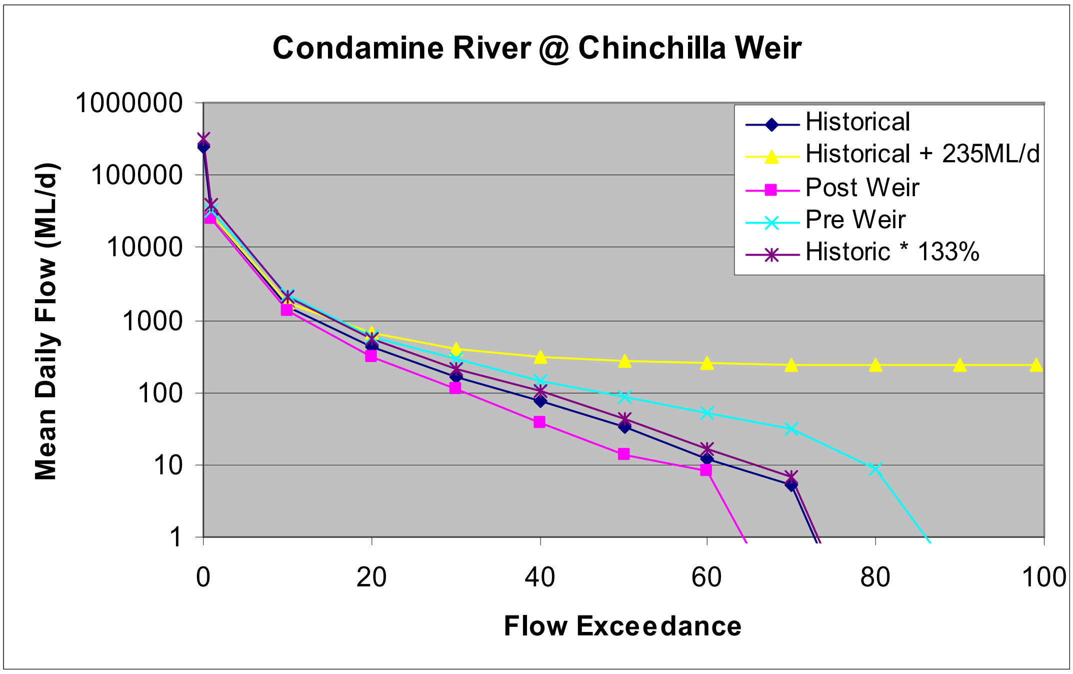


Figure A6-1. Condamine River at Chinchilla – Historic Stream Records

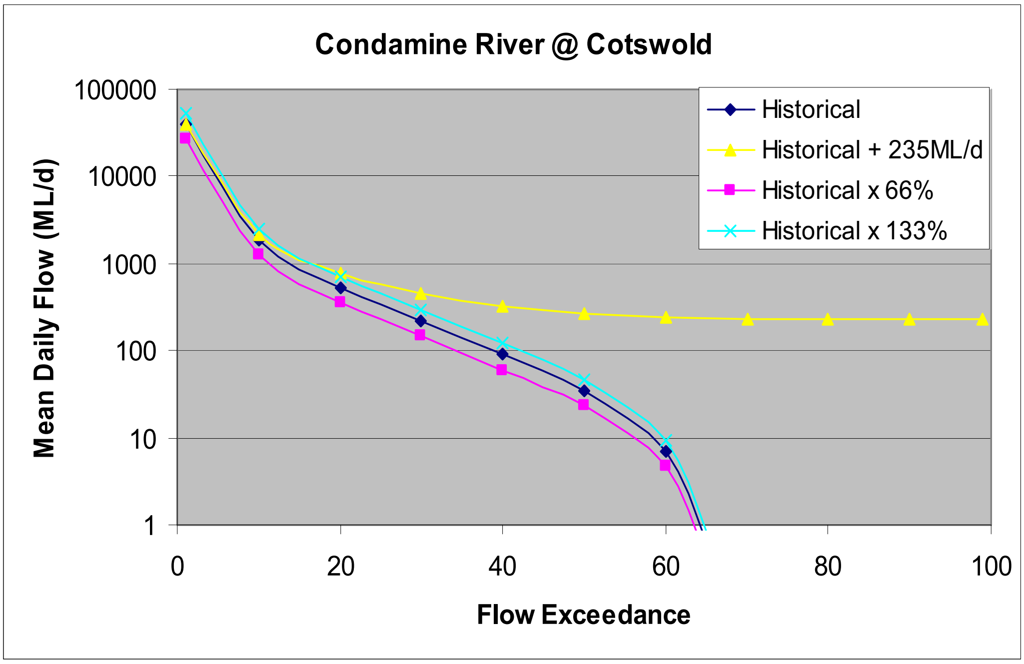


Figure A6-2. Condamine River at Cotswold

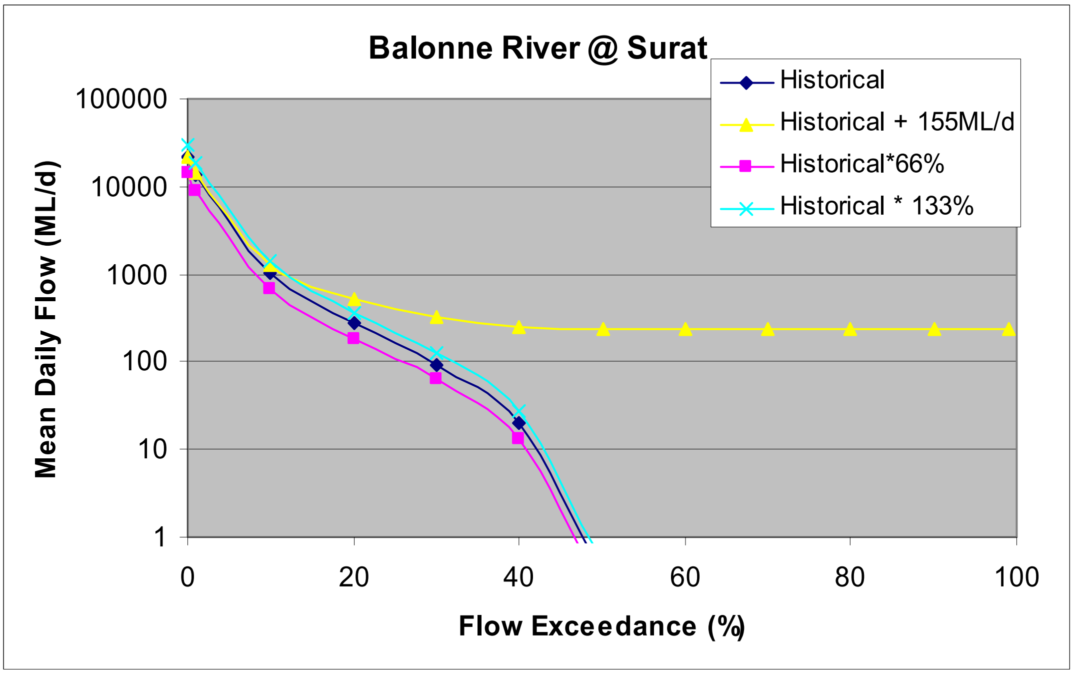


Figure A6-3. Balonne River at Surat

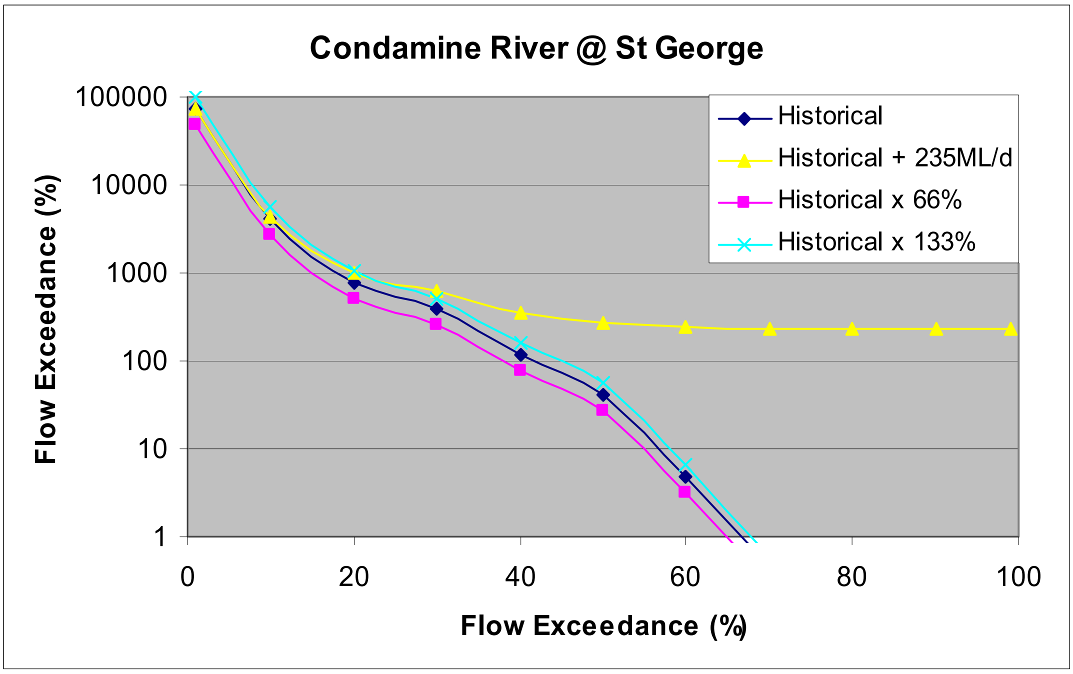


Figure A6-4. Condamine River at St George

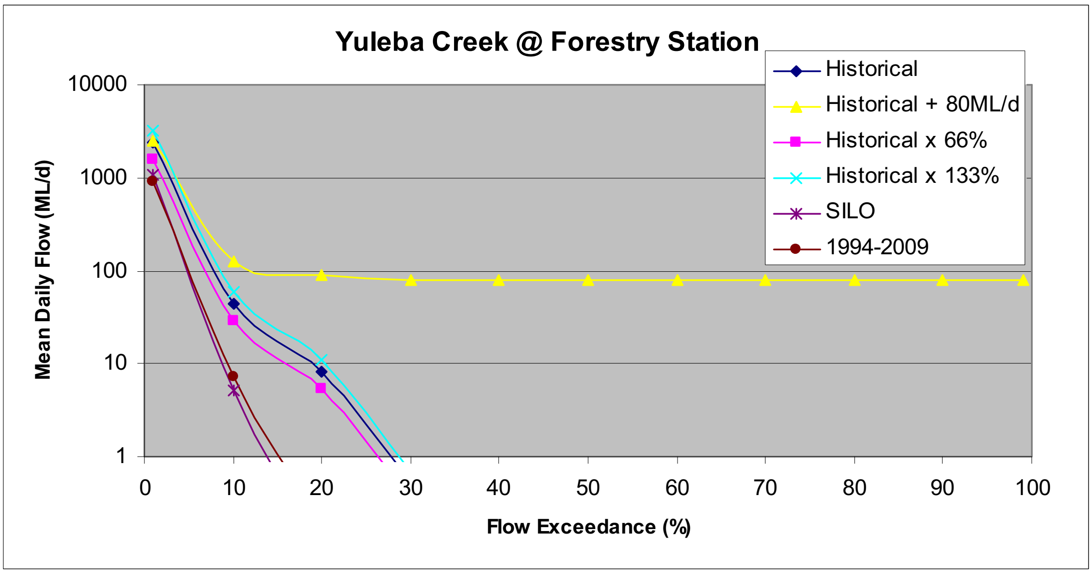


Figure A6-5. Yuleba Creek at Forestry Station

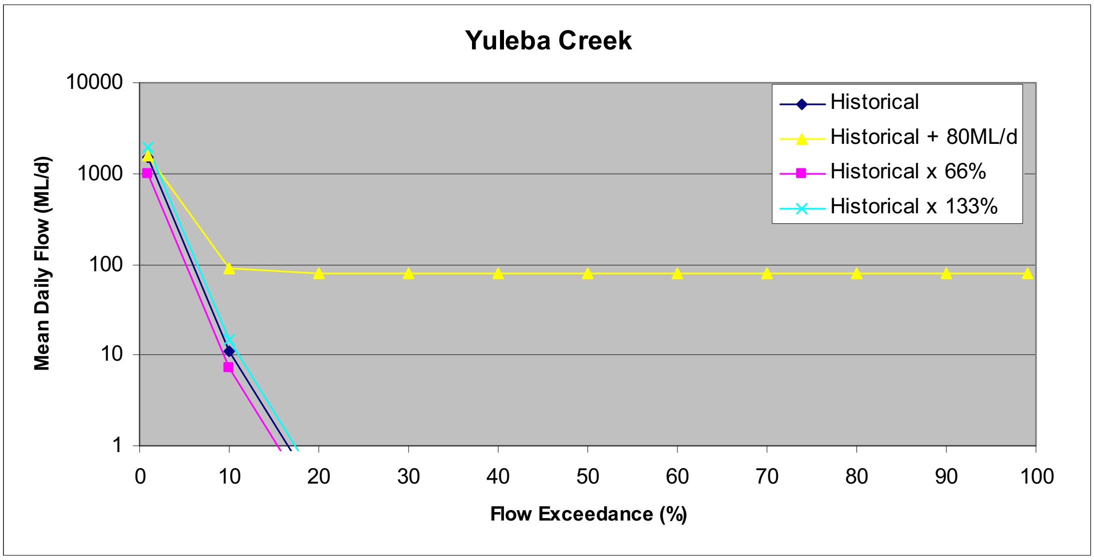


Figure A6-6. Proposed WTF discharge location on Yuleba Creek (Flows created using an AWBM model calibrated to the Yuleba Creek at Forestry Station gauge records and SILO rainfall data within the local catchment)

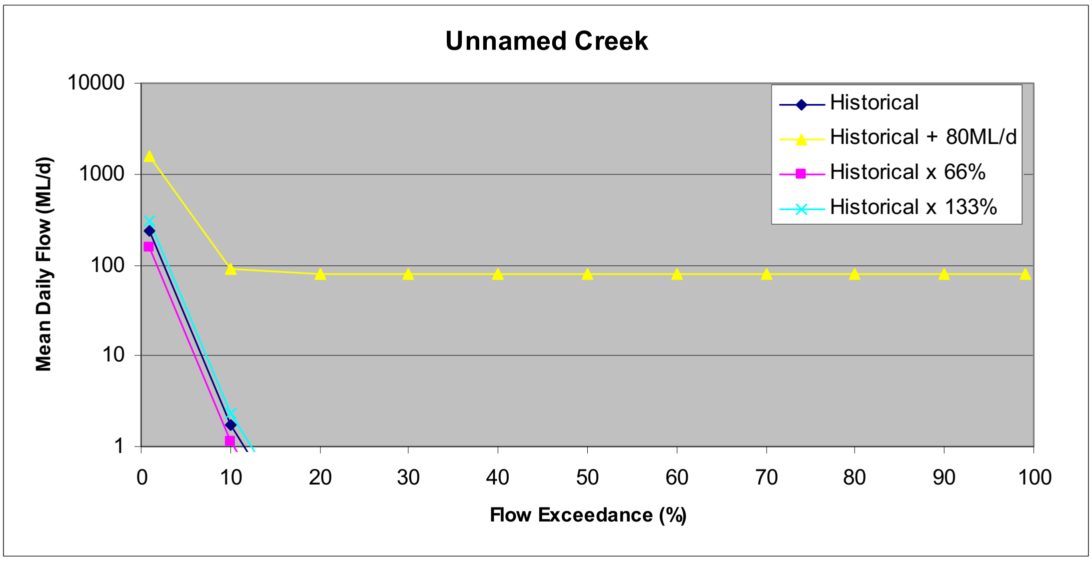


Figure A6-7. Proposed WTF discharge location on Unnamed Creek (Flows created using an AWBM model calibrated to the Yuleba Creek at Forestry Station gauge records and SILO rainfall data within the local catchment)

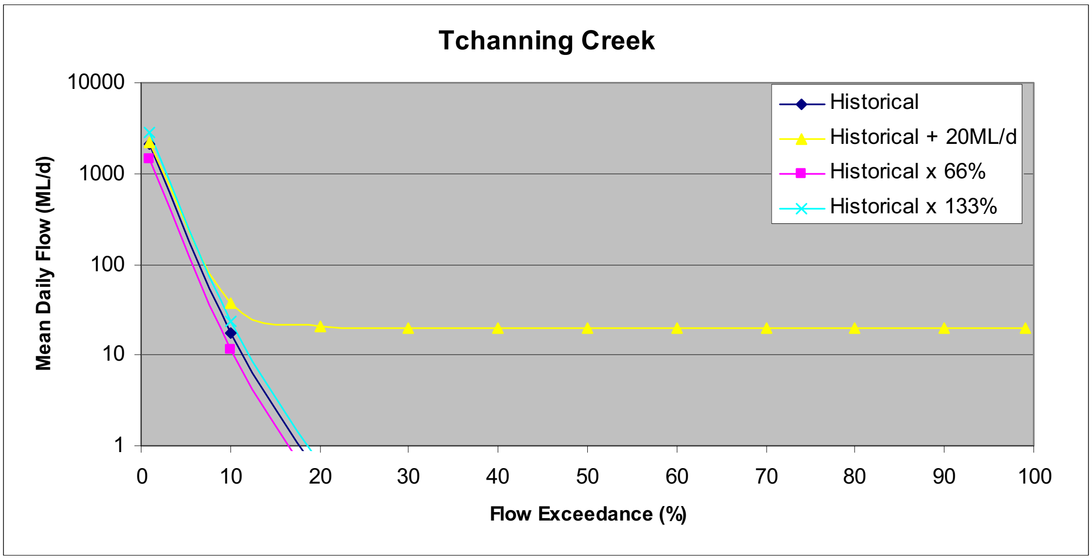


Figure A6-68 Proposed WTF discharge location on Tchanning Creek (Flows created using an AWBM model calibrated to the Yuleba Creek at Forestry Station gauge records and SILO rainfall data within the local catchment)

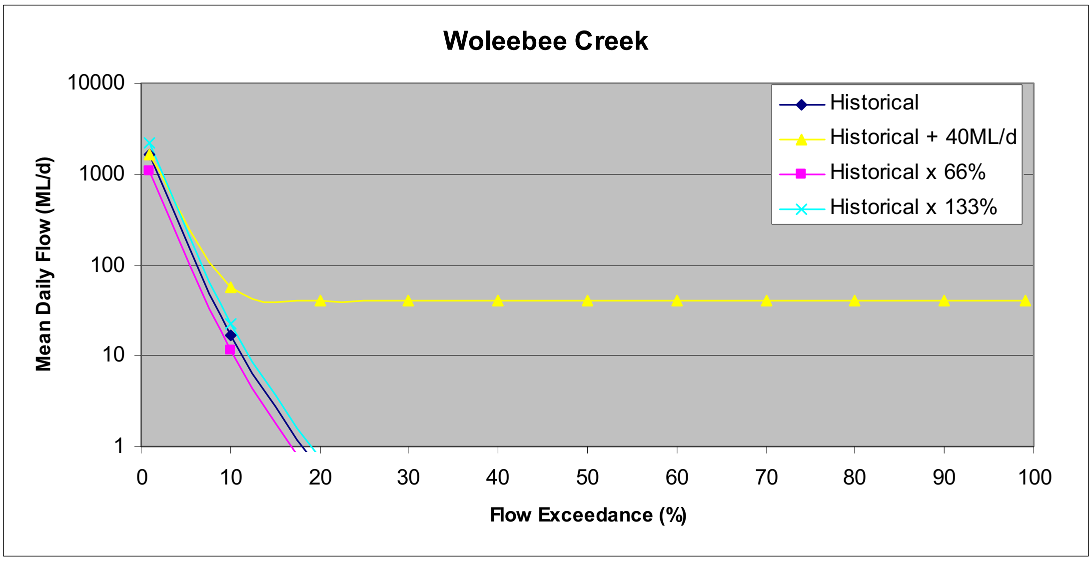


Figure A6-9. Proposed WTF discharge location on Wooleebee Creek (Flows created using an AWBM model calibrated to the Yuleba Creek at Forestry Station gauge records and SILO rainfall data within the local catchment)

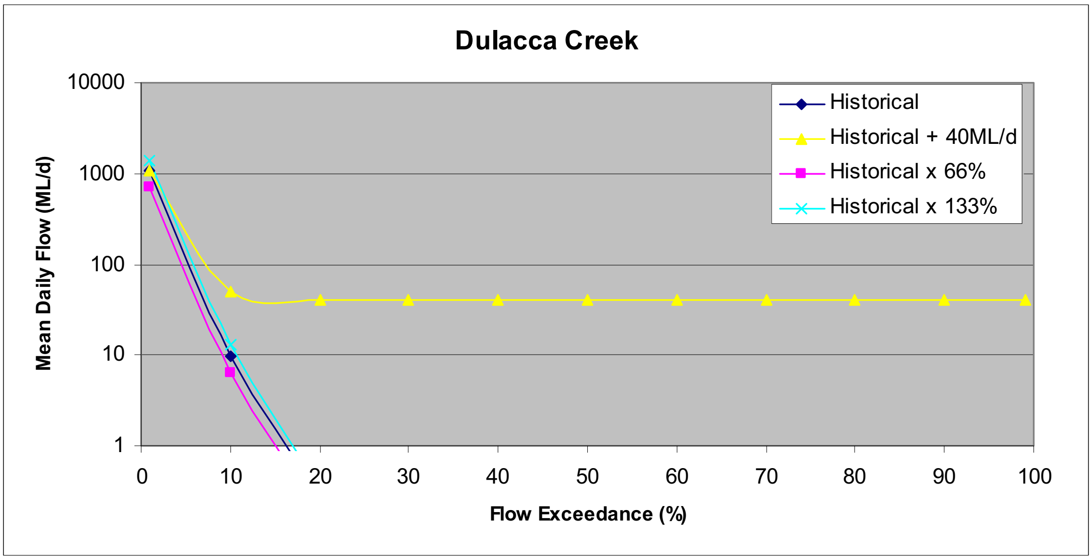


Figure A6-10. Proposed WTF discharge location on Dulacca Creek (Flows created using an AWBM model calibrated to the Yuleba Creek at Forestry Station gauge records and SILO rainfall data within the local catchment)