FINAL REPORT

GLNG Gas Field Development - Associated Water Discharge Study

Prepared for

Santos Limited

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Glossary, Acronyms and Abbreviations

Executive Summary

The discharge of associated water to surface streams is just one of a portfolio of management options being considered for the development of the well fields of the Gladstone Liquefied Natural Gas (GLNG) project. This report considers this option utilising an ecological risk assessment framework. The core of the framework is the identification of a conceptual model of the in-stream ecosystems and the identification of potential hazards.

Potential hazards include:

- Changes in habitat availability or biological triggers related to increased water flows.
- Impacts on water quality, particularly salinity, dissolved oxygen content, temperature, sodium, fluoride, boron.
- Weed growth.
- Erosion.
- Aquifer contamination.

Each of these hazards is addressed in turn through the report.

Recent data on the quality of associated water from the Fairview and Roma fields (Fairview Environmental Management Plan, May 2008) shows that associated water from most wells will not meet guideline trigger levels for the protection of aquatic ecosystems without significant dilution in stream. While discharge to grade may be an option for some wells, it is clear that the majority of associated water will require treatment before discharge to ephemeral stream systems.

The Dawson River downstream of Dawson's Bend is an exception as it has been found that this section of river is perennial as it is maintained by significant spring flows arising from the river bed and adjacent to the stream. However, the assimilative capacity of the Dawson River is also limited in the dry season. In order to maintain the Dawson River within the trigger value for salinity any future development of the Fairview Field will require associated water to be treated to appropriate standards.

Even if treated, associated water discharges to ephemeral streams will be controversial from an environmental perspective. It is recognised that treatment then pumping water to discharge locations will be expensive and there may be better local alternatives for the water use that do not involve significant pipelines. Nevertheless, the report considers a range of options for discharge to a) minimise the footprint of discharges and b) target locations where discharges are likely to add to existing ponded water and disturbed ecosystems.

Key options include:

<table>
<tr><td>Roma:
Discharge to three creeks (Bungil, Yuleba, Wallumbilla)
Discharge to Bungil Creek only
Discharge to Surat Weir (Balonne River)
Discharge to Dawson River</td><td rowspan="2">Arcadia:
Discharge to three locations in the catchment
Discharge to one central location
Discharge to Dawson River
Discharge to Lake Nuga Nuga
Discharge to Lake Maraboon</td></tr>
<tr><td>Fairview:
Discharge to Dawson River</td></tr>
</table>

Introduction Section 1

URS has been engaged to develop the Environmental Impact Statement (EIS) for the GLNG project, which will develop coal seam gas reserves in the Bowen and Surat basins in Queensland, Australia. Studies include the investigation and mitigation of all non-beneficial environmental aspects of Coal Seam Gas (CSG) field development in western Queensland, pipeline construction and operation, and the development of processing train and port facilities at Gladstone.

Associated water is typically a by-product of CSG development and its management is an integral aspect of the GLNG project. The project is considering a range of water management options including stock watering, discharge to grade, treatment, injection, irrigation, and beneficial reuse.

The focus of this report is on discharge to grade and the potential for adaptive water management to minimise any risks associated with this management option. The term “discharge to grade” refers to the release of associated water to the surface environment. Under previous ownership of the site discharge was directed to the ground surface in and around wells. Santos has collected water from one or more bores and directed discharge to existing dry gullies at points that minimise erosion hazards.

Adaptive water management is dependent on careful planning to ensure minimal risks arise from a management action, then monitoring the consequences of those actions to ensure that any changes that do occur are within the bounds of what is planned. Where deviations from the plan occur, further investigations are triggered and/or adjustments may be made to management actions to ensure that the planned outcomes are met. While many variants of adaptive management are to be found in the literature the basic tenet is to plan, implement, monitor and review. Since risk is taken into account during the initial planning stage, operations would normally not be halted should adjustments in management arrangements need to be made.

Planning is dependent upon identifying those elements of the environment that need to protected (environmental values), identifying potential hazards and resultant risks to these environments from the release of associated water, identifying which risks are real or perceived and, where possible, quantifying those risks which are most evident. To aid in these considerations it is useful to develop a conceptual model of the environment which identifies those processes or end-points of most concern.

This project has adopted an investigative approach to quantifying risks from the release of associated water to the surface environment. The key steps taken are listed below and discussed in the following sections:

1) Engagement with DNRW and EPA in the development of a conceptual model and identification of key risks
2) Review of the sensitivity of biota to salinity
3) Assessment of the importance of macroinvertebrate drift
4) Review of existing water quality in streams and from wells
5) Assessment of the potential for weed growth from increased discharges
6) Consideration of the erosion potential of discharges
7) Review of the potential impacts on surficial aquifers
8) Assessment of hydrological change from discharges to streams
9) Consolidation of risks
10) Review of associated water discharge opportunities

Section 2 Background

2.1 Associated Water Production

Methane trapped in coal is adsorbed onto the coal surface in cleats and joints or micropores and held in place by reservoir and water pressures. To access the methane it is typically necessary to reduce the pressure by first removing water. Consequently, in CSG development water production is often initially high before dropping off, and gas production is initially low before rising to a plateau that can be maintained for a number of years depending on the capacity of the reservoir.

Typically water production is higher earlier in the life of a CSG field and drops as gas production increases (Figure 2-1). The combined production curves of a well field average out the variations in individual curves and prolong the life of the field.

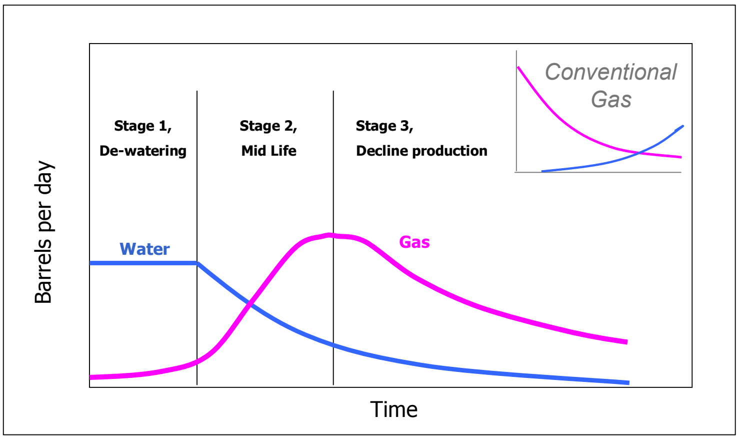

Figure 2-1 Stages of CSG Water and Gas Production

Figure 2-2 shows the water production for Well 1 at Fairview Field approximately 150 km north of Roma in Queensland. Similar behaviour is typically seen from other wells producing water in the field.

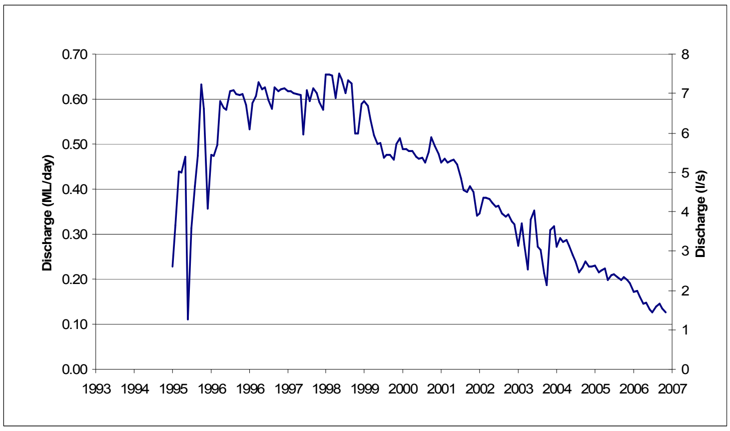

Figure 2-2 Water Production Curve at Fairview Field - Well 1

CSG development is by its nature an incremental activity involving modelling, exploration, proving and establishment of gas wells in a step-wise fashion. For this reason, the exact location, timing, quality and volumes of water discharges are unknown until investigations are complete. For example, despite modelling indications to the contrary, a number of the wells at the existing Fairview Field north of Roma have been found to be dry and do not require the removal of water to access gas reserves.

2.2 Overseas Experience

Active exploration or production of CSG is taking place in the United States, Canada, Western Europe, Japan, Australia and New Zealand (Talkington, 2002; Johnson, 2004). Natural gas exploration and development is expanding worldwide due to the demand for a clean and economical energy source (King, 2001).

The disposal of associated water has been a significant challenge for CSG production for some time now (Mount *et al.*, 1993). The potential for wasting useable groundwater (though generally requiring treatment) and the disposal of associated water are considered serious social and environmental issues.

According to Mount *et al.* (1993), based on a number of research studies in Alabama, the disposal of associated water to streamlines can avoid environmental consequences provided it is managed and monitored appropriately. Certainly 'discharge to grade' is widely used in the industry in the USA. In large part this appears to be driven by the remoteness of the activities from population centres, and by the low cost of disposal compared with treatment.

Considerable research has been completed in the Powder River Basin in Wyoming where discharge to grade occurs widely from both conventional oil and gas operations as well as CSG operations (e.g. Boelter *et al.* 1992; Rice *et al.* 2000; McBeth *et al.* 2003; Patz *et al.* 2004; Stearns *et al.* 2005; Jackson and Reddy 2007; Johnson 2007; Wang and Yang 2008). A number of environmental concerns arising from discharge to grade have been investigated including (e.g. King, 2001):

- Changes to stream hydrology (variation in surface water discharges).
- Effects of CSG production water discharge on water quality (temperature, salinity, pH, dissolved oxygen, Sodium Adsorption Ratio).
- Effects of CSG waters on biological diversity (fish and macroinvertebrates).
- Damage to instream aquatic vegetation.
- Stream bank erosion
- Sedimentation

The impact of associated water discharges on instream environments is considered to be proportional to the relative difference between the water quality of the associated water and the target stream. However, the quality of the associated water is highly variable in composition between development sites. This might be expected given the wide range of formation characteristics, oil and gas hydrocarbon compositions, and the range of well development and maintenance activities adopted by companies (Hayes and Arthur, 2004).

The physical characteristics and flow regimes of streams to which associated water is discharged will also have a large bearing on the environmental outcomes from discharge to grade.

The applicability of transferring results from US research to the Australian environment is therefore uncertain, and investigations of local water quality and hydrology are required to investigate the potential environmental outcomes from associated water discharges.

2.3 The Quality of Associated Water

Hayes and Arthur (2004) provide an overview of emerging technologies for associated water treatment prior to disposal or reuse in North America. Key parameters for treatment in associated water produced in North America were identified as:

- Oil and grease removal
- Salinity (TDS)
- Benzene
- Biological Oxygen Demand (due to soluble organics)
- Suspended solids
- Total and faecal coliforms
- Special constituents of concern that restrict a beneficial use (e.g. boron or fluoride might limit irrigation use)
- Sodium Adsorption Ratio (SAR) adjustment

Table 2-1 provides an approximate comparison of average water quality between the Fairview Field and US fields. The comparison is approximate since multiple sources were combined to represent some fields or states in the US; because the available water quality parameters are limited in some cases; and because averages have been used. Nevertheless, the table highlights the high degree of water quality variability between and within CSG fields. The quality of associated water currently discharged at Fairview is considerably better than overseas experience. Salinity and sodium concentrations are typically an order of magnitude less than overseas, chloride and magnesium concentrations are two orders of magnitude lower, sulphate and calcium concentrations are two to three orders of magnitude lower and the remaining constituents including bicarbonate are of a similar order of magnitude or are very low compared with discharge water quality standards. The temperature at Fairview is considerably higher than overseas and coliforms are effectively non-existent, perhaps suggesting that the processes generating gas from the coal may be different (i.e. thermogenesis vs biogenesis). pH is also considerably higher than the overseas data cited here.

2.4 The Study Area

The proposed CSG field development area consists of a number of regions in central Queensland: Roma, Fairview, Arcadia Valley, Denison, Comet and Mahalo. These areas are defined by either Production Leases (PLs) or Authorities to Prospect (ATPs) and are situated within a number of different surface water catchments. In order to provide an assessment of surface water environments it is necessary to consider catchments as a whole. This report therefore makes reference to three catchments; the Condamine-Balonne River Catchment (part of the Murray Darling Basin), the Upper Dawson River Catchment and Comet River Catchment (forming part of the Fitzroy Basin). Figure 2-3 shows the extent of each catchment and the proposed GLNG field development area. A detailed discussion of each catchment and relevant environmental values is provided in Appendix E.

2.4.1 Condamine-Balonne Catchment

The Roma CSG field area lies within the Condamine-Balonne catchment. The main towns in the vicinity of the CSG field area are Roma (population 7,000), Mitchell (population 2,000) located to the east on the Maranoa River and Surat (population 500) located on the Balonne River.

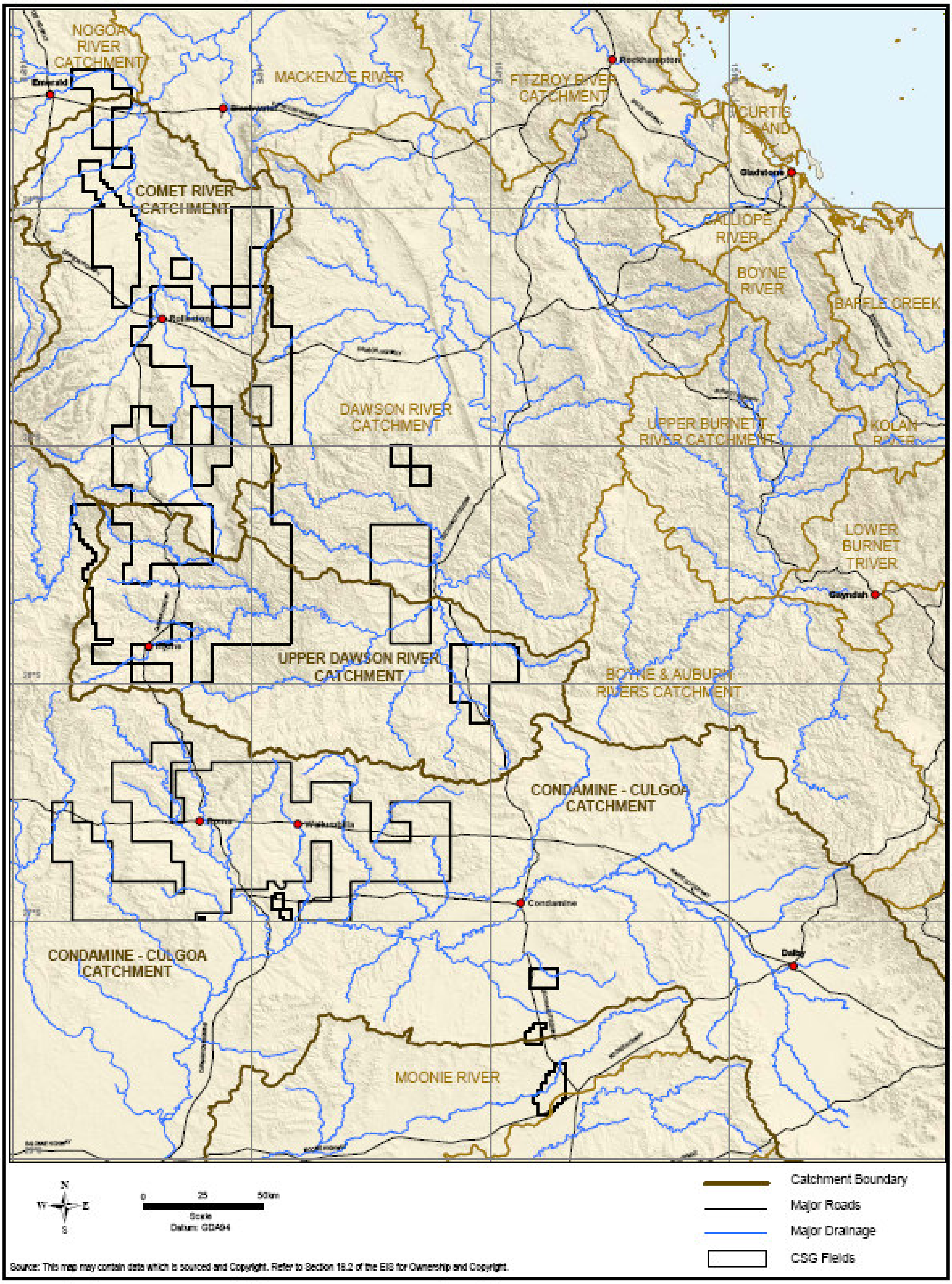

Figure 2-3 Surface water catchments and study area

Table 2-1 Comparison of Average (Mean) Water Quality from Fairview Field vs Overseas

	WQ Parameter	Units	GLNG	Overseas Site Comparisons			USGS National Production Water Database (f)				
			Fairview	Powder R (a, b, c)	Alabama (d, e)	San Juan (e)	New Mexico	Oklahoma	Kansas	Wyoming	Alaska
Field Meters	Electrical Conductivity	µS/cm	1998	3150a 1300c	900 – 44500h	400 – 6800h	144300h	255500h	169500h	22600h	43500h
	Temperature	°C	37.9	22b 19.6c							
	pH	log [H+]	8.8 (median)	7.8a 7.1b 7.3c	3.7 – 9.2	7.4 – 8.8	7.16	6.45	6.9	7.8	7.19
	Dissolved O_2	mg/L	5.1	0.58b							
	Redox Potential	mV	-175 to +247								
Accredited Laboratory Analysis	Total Dissolved Solids	mg/L	1279	850c	550 - 26700	263 – 4050	86564	153282	101689	13531	26095
	Total Suspended Solids	mg/L	66 (j)								
	Total Alkalinity	mg/L	892	950c							
	Bicarbonate Alkalinity		823		76 - 12000	7.8 - 1450	749	164	263	1343	800
	Carbonate Alkalinity		68								
	Hydroxyl Alkalinity		0.4								
	Free CO_2		3.4								
	Sodium	mg/L	491	300c	0 - 6800	26 - 1290	11523	43273	28825	4348	6213
	Sodium Adsorption Ratio	-	149 (i)	33a 12c			108	290	244	123	96
	Chloride	mg/L	136	13c	<1 – 15000	1 – 720	51330	94321	61779	6075	15211
	Calcium	mg/L	10 (i)	32c			4214	9347	5408	501	1884
	Magnesium	mg/L	3 (i)	16c			1484	1812	1576	128	202
	Sulphate	mg/L	1.5 (i)	2.4c	ND – 650	ND - 2700	1900	328	1197	1633	175
	Manganese	mg/L	149 (i)	0.046b	0.005 – 3.8	NA					
	Fluoride	mg/L	2.2	0.75b 0.92c	ND - 20	0.1 – 3.6					
	Boron	mg/L	0.8	0.159b							
	Lead	mg/L	0.01	<0.1c							
	Mercury	mg/L	<0.1	<0.1c							

WQ Parameter	Units	GLNG	Overseas Site Comparisons			USGS National Production Water Database (f)				
		Fairview	Powder R (a, b, c)	Alabama (d, e)	San Juan (e)	New Mexico	Oklahoma	Kansas	Wyoming	Alaska
Zinc	mg/L	0.01	1c	0 - 0.36	NA					
Total Iron	mg/L	0.6	3b 0.8c	0.005 - 246	ND – 5					
Ammonia N	mg/L	0.7	2.4c							
Total Petroleum Hydrocarbons				1 - 62	NA					
C1 to C6 (BTEX)	mg/L	ND								
C6 to C9	mg/L	ND								
C10 to C14	mg/L	0.01								
C15 to C28	mg/L	0.09								
C29 to C36	mg/L	0.01								

Notes:

(a) Johnson, 2007
(b) Patz *et al.*, 2005
(c) Rice *et al.*, 2001
(d) Mount et al, 2000
(e) Rogers RE 1994 Coalbed methane: principles and practice, PTR Prentice Hall, Englewood Cliffs, NJ 345p quoted in Peterson *et al.* (2002)
(f) http://energy.cr.usgs.gov/prov/prodwat/data2.htm
(g) All Fairview water quality is from the Fairview EMP (URS, 2008) or Coal-bed Methane Water Treatment Technology Assessment, URS, August 2007
(h) Approximate electrical conductivities were calculated from TDS by dividing a 0.6 conversion factor and rounding to the nearest 100 µS/cm. For high salinities (>35,000 TDS) this relationship may not be appropriate.
(i) Figures from combined field data see Section 6
(j) Average biased upwards by results in a single well

The catchment contains extensive but largely ephemeral or intermittent stream networks with summer rainfall dominant and periods of low to zero flow during which time the streams become a series of waterholes. The topography is predominantly flat with wide alluvial floodplains. Major streams within the Upper Balonne River Catchment include Bungil Creek, Wallumbilla Creek, Yuleba Creek and minor tributaries. Bungil Creek flows roughly north to south. Wallumbilla and Yuleba Creeks flow to the south-southwest. The three creeks discharge to the Balonne River which in turn flows to the Murray Darling Basin. Another principal stream, Bungeworgorai Creek, is located in the western portion of proposed CSG field operations and flows in a south-westerly direction discharging into Bungil Creek.

2.4.2 Upper Dawson River Catchment

The Fairview project area lies within the Upper Dawson River catchment that extends upstream and westwards from Taroom, encompassing the townships of Injune and Wandoan. The catchment contains extensive but largely ephemeral or intermittent stream networks. Major streams in the area are the Dawson River, Hutton Creek, Baffle Creek, Juandah Creek, Eurombah Creek, Commissioner Creek and Broken Creek.

Since the initial settlement of Taroom circa 1850, the primary land use in the Dawson River catchment has traditionally been sheep and cattle grazing. This remains the predominant land use in the Upper Dawson River circa the Fairview and Springwater homesteads.

Downstream of Hutton Creek, grazing, forestry and cropping are widespread. A number of water storages and weirs are located on the Dawson River from Taroom downstream and are used for irrigation and recreational purposes supporting regional industry and urban communities.

Coal Seam Gas (CSG) production at Fairview has occurred since at least 1993, initially under the control of the Tri-Star Petroleum Company (1993 – 2002), then Tipperary Oil and Gas (Australia) Pty Ltd. (TOGA, 2002 – 2005). In 2005 TOGA was purchased by Santos Ltd.

Associated water discharge to grade has occurred throughout this period into small, often intermittent streamlines or gullies that, in turn, discharge to Baffle Creek, the Dawson River or Hutton Creek. Santos currently captures associated water with salinity greater than 3,500 µS/cm and uses it for plant works or for injection into the basement Timbury Hills Formation.

2.4.3 Comet River Catchment

The Arcadia Valley, Denison, Comet and Mahalo project areas are within the Comet-Brown Catchment area, extending from the Carnarvon Ranges north to Emerald. The Comet-Brown sub-catchment is part of the larger Fitzroy Basin, which comprises almost 10% of the agriculturally productive land in Queensland. The primary river within the basin, the Fitzroy River, discharges into the marine environment at the southern end of the Great Barrier Reef, near the major urban centre of Rockhampton.

The primary land uses in the catchment include grazing and cropping. The catchment contains extensive but largely ephemeral or intermittent stream networks with summer rainfall dominant. The major stream in this part of the CSG field area is the Brown River, which becomes the Comet River in the vicinity of Rolleston, flowing north and discharging to the McKenzie River. Major tributaries enter the Comet-Brown River from the east and west. The only township in the Arcadia Valley, Rolleston, is situated on the Comet River.

3.1 Introduction

Risk is an often used, and often misused concept. Hazards, risks and consequences are often confused.

For people living downstream of a dam, a **hazard** might be the failure of the dam wall. The **consequence** arising from the occurrence of the hazard would be the death and destruction to people and property that would occur downstream as water is released and rushes downstream.

The **risk** of the hazard occurring (i.e. damage arising from a dam break) is proportional to both i) the consequences that would occur if the hazard is realised and ii) to the likelihood of failure of the dam wall. The likelihood of dam wall failure is dependent on the design criteria used, the appropriateness of engineering techniques used in planning and construction, geology, flooding and storage operation amongst other things.

Since risk is proportional to both likelihood and consequence, it is defined as:

Risk = Likelihood x Consequence

3.2 Ecological Risk Assessment Framework

For this project, the Ecological Risk Assessment (ERA) framework outlined by Webb and Hart (2004) was adopted to assess the risks of discharge to grade (Figure 3-1). ERA is the application of the principles of risk assessment to the environment and concentrates on the consequences of management decisions and the likelihood of these consequences arising.

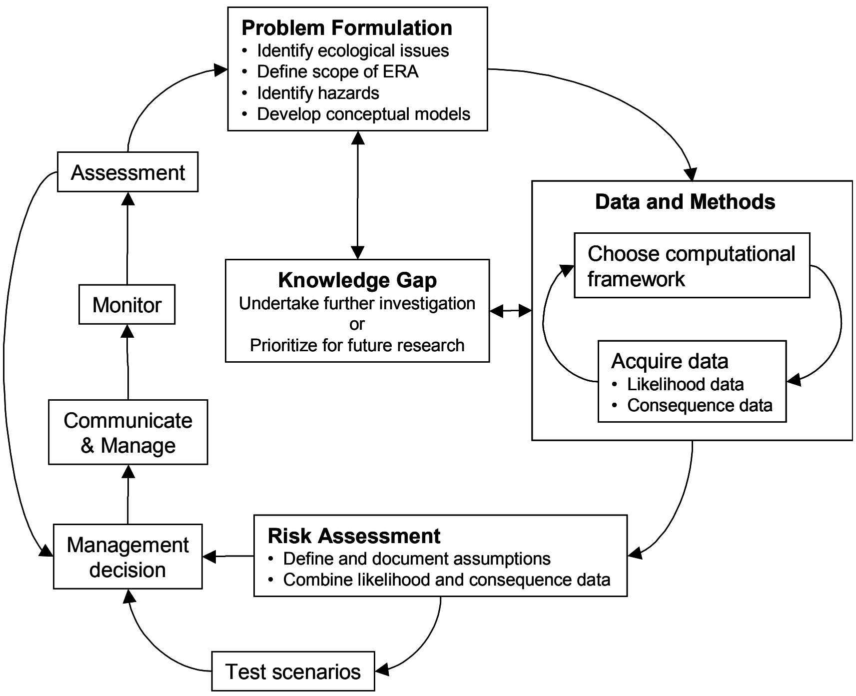

Figure 3-1 The Risk Management Cycle (reproduced from Webb and Hart (2004))

Key components of the ERA framework are:

Problem formulation	Where a conceptual model of the environment is developed to aid in the definition of hazards and potential system end points. A core component of the framework is the identification of ecosystem hazards and defining the scope of the ERA.
Identification of Data and Methods	To quantify risk it is necessary to consider both the likelihood and consequence of a hazard occurring. Take account of combinations of risks in considering overall risks.
Filling Knowledge gaps	By further research, data collection and modelling, fill the gaps in knowledge as far as possible
Risk Assessment	For various management scenarios use the risk framework to quantify risks of undesirable outcomes

This framework was discussed in a one day workshop at Indooroopilly with representatives of the Queensland Department of Natural Resources and Water (DNRW) and the Queensland Environmental Protection Agency (EPA). Details of the workshop are provided in the workshop report (Appendix A). Key findings are presented below.

In developing the risk management framework consideration was given to earlier work for the Fitzroy Basin (Duivenvoorden et al, 2001) as well as local work undertaken for Fairview Project Area and a recent application to amend the existing Environmental Authority for the Pony Hills development. It also takes into account existing salinity risk assessment models developed by the Co-operative Research Centre (CRC) for Freshwater Ecology and the availability of information to inform models.

3.3 Conceptual Ecosystem Model

A broad conceptual model was developed during the workshop to highlight the conceptual linkages between three key stressors thought to arise from the discharge of associated water and ecosystem responses for both perennial and ephemeral streams. The model is focussed on the aquatic environment recognising that this is the likely area of most significant impact. Terrestrial fauna or opportunistic water bird use of the flowing streams are not considered in this document.

The conceptual model has been updated based on further feedback from EPA and DNRW during the review of the Santos Fairview Project Area Environmental Management Plan to include concerns regarding “salt bulges” in near stream aquifers; by highlighting the linkage between diatoms and macroinvertebrates[1], and by more clearly delineating issues such as assemblage shifts and toxic effects that might occur from salinity (Figure 3-2).

The three key stressors considered to arise from associated water discharge are:

[1] Diatoms are a food source for macroinvertebrate grazers as well as fish.

- Changes (typically increases) in flow
- Changes (typically increases) in salinity; and
- Changes (typically increases) in water temperature.

The assumption that associated water discharge only leads to 3 key stressors needs to be challenged and/or confirmed prior to considering water management options. This is particularly true if the associated water contains chemicals in sufficient concentration to harm humans, stock or the local ecology.

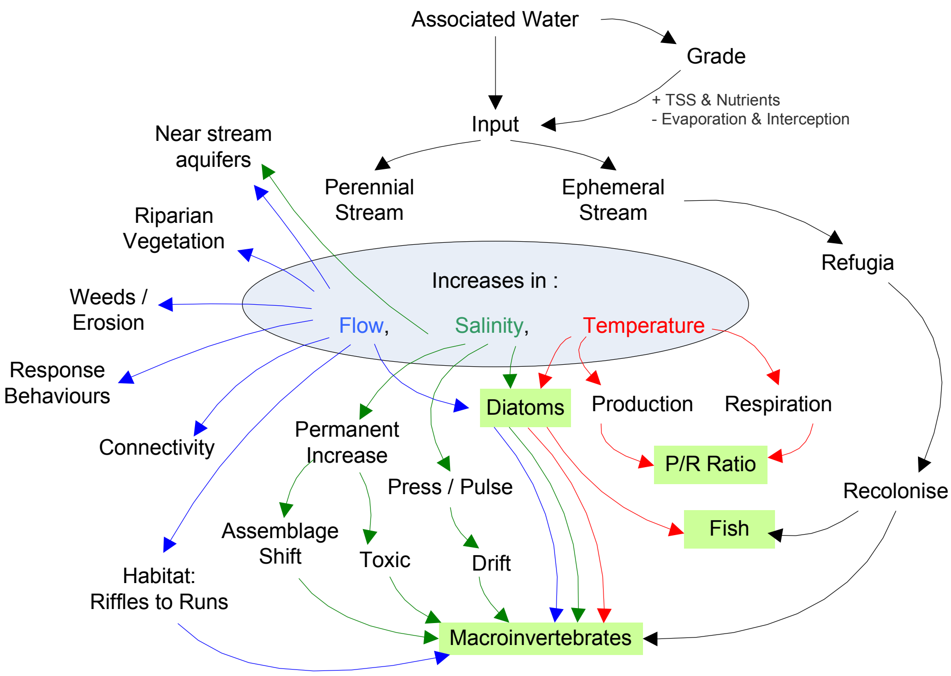

Figure 3-2 Conceptual Model of Ecosystem Responses to Associated Water Discharge

3.3.1 Potential impacts of changes in flow

Potential impacts of changes in flow include:

- Associated water discharges are unlikely to change the flood regime of streams since the relative volumes of discharge are very small compared with flood events.
- Discharges are likely to change ephemeral streams into perennial streams for the life of the discharge.
- Changes in flow regimes will change habitat availability for macroinvertebrates and instream flora and will increase the connectivity of the stream systems for ephemeral streams. It may also affect the behaviour of species by removing initiation-of-flow and cessation-of-flow triggers.
- If flow regimes are changed markedly then ecological responses to flow triggers (e.g. fish movement and breeding) may also be affected.
- Weeds and erosion might also be increased due to prolonged flow periods. Erosion might also be affected by inadequate management of discharge points (i.e. lack of protection), increased velocities and chemical constituents of the associated water.

- Riparian vegetation may be affected by changes in the availability of water, or by the salinity or other chemical constituents.
- Near stream aquifers might be recharged and saline water may intrude.

3.3.2 Potential impacts of changes in salinity

Changes in salinity lead to ecosystem responses in a variety of ways.

- Significant shifts (presses) in salinity below toxic levels may shift species abundances of macroinvertebrates, diatoms and fish.
- Sudden changes (pulses) in salinity might lead to increases in drift events leading to a reduction in instream fauna.
- Toxic concentrations of salinity may lead to death of fauna and flora.
- Opportunistic fish breeding may not be significantly affected because of existing boom/bust cycles of eggs.
- Potential for increases of salinity in refugia to toxic levels.

3.3.3 Potential impacts of changes in temperature

Changes in temperature may lead to:

- Homogenised temperature regimes (press response) may lead to preferential conditions for certain species. A species shift may occur under constant temperature flows.
- Less variable temperature regimes lead to slowed growth (lower productivity) of waterways.
- If water is released intermittently then pulse responses (e.g. thermal shock) might occur with fauna deaths or major drift events.
- Diurnal variation in temperature is identified as a fundamental requirement for ecosystem health.

3.3.4 Endpoints and indicators

The conceptual model identifies four primary endpoints – diatoms, fish, macroinvertebrates, and primary and secondary respiration. The endpoints identify those elements of the ecosystem which might be used as indicators to measure ecosystem response to associated water discharge.

- Macroinvertebrates were identified as the preferred indicators due to the availability of existing methods for assessing river health using these species, existing data sets, their use in previous ecological risk assessments and the small spatial range within which an individual would normally exist.
- Diatoms where identified as a potentially useful indicator for ephemeral systems where there would be limited availability of macroinvertebrates during dry periods.

3.4 Knowledge Gaps

Based on the above analysis, the project identified the following studies and actions to quantify the consequences and likelihood of ecosystem responses to associated water discharges. These studies are discussed in the next Section.

Table 3-1 Identified Actions to Fill Knowledge Gaps

Knowledge Gap	Action
Resilience to salinity	Review existing databases (AUSRIVAS Qld, Bailey and Boon) and derive species sensitivity distributions to salinity (after ANZECC & ARMCANZ 2000 and Webb & Hart 2004).
	Update Hart *et al.* (1991) review of salinity tolerances of Australian fauna through a literature review
	Review existing salinity and ecological data at Fairview.
Macroinvertebrate drift	Literature review of macroinvertebrate drift especially for ephemeral streams.
	Review of salinity impacts on stream biota with a particular focus on ephemeral/arid streams and the ranges of salinity that can cause impacts on diatoms, fish, macroinvertebrates, algae, riparian vegetation and algae.
Review water quality	Examine water quality results against defined (Queensland EPP & ANZECC & ARMCANZ 2000) trigger values to identify any potential issues. If considered an issue, define appropriate method for its assessment.
Macroinvertebrate relationships with other variables	Review local data for trends in species associated with gradients in temperature, turbidity, flow or other environmental variables
Review AUSRIVAS model availability	Contact and review DNRW AUSRIVAS models
Potential for spread of aquatic weeds	Identify the occurrence of weeds in the project area and their relative preferences for flowing water / perennial streams.
Threatened species	Check if there are any threatened species or communities that could be impacted by the development. [being completed as part of broader EIS]
Diatom assemblages	Review whether changes in diatom assemblages matter to the fish as a food supply.
Stratification in pools	Assess likely impacts on pool refugia from associated water discharge to grade by sampling at Fairview
Infiltration to surficial (near river) aquifers	Assess potential for infiltration increase and movement of constituents
Assess the magnitude and frequency of changes in ecosystem drivers (i.e. flows and water quality)	Utilise E2 and/or other appropriate modelling tools to assess changes in flows, salinity and temperature.

Section 4 Sensitivity of Biota to Salinity

This section examines the sensitivity of freshwater flora and fauna to salinity and discusses sensitivity to various inorganic ions such as sodium, chloride, potassium, and bicarbonate. Threshold levels and ecotoxicology reports are investigated before data from Fairview field is used as a case study in Queensland, and conclusions are drawn.

4.1 Background

For streams typical of those observed across the CSG field project area, the Central Queensland water quality guideline for electrical conductivity (EC) is 340 µS/cm. This guideline value is consistent with observed typical water quality data in the region (see Appendix E and Appendix F). However, the variability of EC in the CSG field project area streams is very large. Observed continuous electrical conductivity data shows regular excursions to <100 µS/cm and as high as circa 1000 µS/cm. But typically EC ranges from circa 200 – 400 µS/cm. Spot electrical conductivity readings have been recorded as high as 1647 µS/cm in Bungil Creek (Appendix E).

Salinity exerts impacts on aquatic systems via three mechanisms (Kozlowski 1997, Bailey *et al*. 2006)

- Direct toxic impacts arising from the accumulation of Na^+ and Cl^- in cells, and to a lesser extent by the disruption of the uptake of other essential ions (e.g., Ca^{++} and Mg^{++}) by the presence of high external NaCl concentrations;
- Direct osmotic impacts caused by the effect of dissolved salts on the availability of water to plant and animal cells; and
- Indirect impacts arising from the effects of salinity on physio-chemical characteristics of water and/or aquatic systems.

The data that are available on the salt sensitivity of the Australian freshwater biota come from relatively few primary sources. The reviews by Hart *et al*. (1990, 1991) provide primary meta-data sources but are now dated. These reviews were updated by Bailey *et al*. (2002) in a report that is available on the website of Land & Water Australia. More recently, the *Australian Journal of Botany* devoted an entire issue to the topic of salinisation (e.g. James *et al*. 2003, Nielsen *et al*. 2003) and a book chapter has been published recently on the impacts of secondary salinisation on arid and semi-arid zone systems in Australia (Bailey *et al*. 2006).

Professor Paul Boon (Dodo Environmental) was engaged to identify the literature published on the ecological impacts of salinity on the Australian aquatic biota since 2000 (roughly when the Bailey *et al*. (2002) review ceased its inspection of the literature), and to provide an overview of salinity impacts on Australian biota (Appendix B). Key findings of Professor Boon's review are discussed below.

4.2 Direct Impacts of Salinity on the Biota of Australia

4.2.1 Microbes

No literature was found on the impacts of salinity on microbes and Boon concludes that there has been little advance in this area since the review by Hart *et al.* (1991).

4.2.2 Algae

There is little information on the salinity tolerance of freshwater phytoplankton. Recent data indicates blue-green alga *Microcystis aeruginosa* was largely unaffected by salinity up to about 10,000 mg L^{-1} and it could temporarily endure salinities of up to 17,500 mg L^{-1}. Similarly data on macroscopic charophytes indicates that 10,000 mg L^{-1} is an upper limit for *Chara* and *Nitella*.

4.2.3 Aquatic Vascular Plants

Hart *et al*. (1990) concluded that the majority of macrophyte species in fresh waters were salt sensitive and that changes in plant performance and decreased botanical diversity commenced at salinities of about 1,000 mg L^{-1}. A salinity of about 4,000 mg L^{-1} was proposed in Hart *et al*. (1990) as the upper limit tolerated by most species of freshwater macrophytes, such as *Myriophyllum propinquum*, *Triglochin procera*, *Crassula helmsii* and *Isoetes muelleri*. It was noted, however that sub-lethal effects, such as reduced vigour, were likely to operate at salinities less than the maximum that were tolerated by the adults of a given species.

The species richness, but not necessarily the productivity, of aquatic vascular plant communities decreases with increasing salinity (Hart *et al*. 1991). Bailey *et al.* (2002) found that plant genera from a range of sources were restricted to salinities < 5,000 mg L^{-1} which is consistent with Brock and Lane (1983) who concluded that freshwater macrophytes occur at salinities < 4,000 – 5,000 mgL^{-1}. Nevertheless, many vascular freshwater plants occur at much higher salinities.

4.2.4 Zooplankton

Zooplankton is a diverse group and it is not possible to generalise the salinity response of this group.

- Rotifers are critical in food webs and have been collected in field surveys in waters ranging from less than 1,000 mgL^{-1} to greater than 15,000 mgL^{-1} (Hart *et al.*, 1991). Bailey *et al.* (2002) suggest that there is a bimodal response to salinity by rotifers with one group preferring salinities < 500 mgL^{-1} and another group preferring salinities in the range 7,000 to 8,000 mgL^{-1}.
- Similarly, cladocerans are often restricted to waters with salinities less than 1000 mgL^{-1}, and some may be restricted to waters with salinities less than 500 mgL^{-1}.
- Copepods also appear to be bimodal in behaviour with some groups preferring salinities less than 1,000 to 2,000 mgL^{-1}, while other groups prefer more saline waters (Hart *et al.*1991, and Bailey *et al.*2002).
- Many ostracods are found in highly saline waters (> 35,000 mgL^{-1}) but freshwater species are rarely found at salinities greater than 1,000 mgL^{-1} (Hart et al, 1991). Data from Bailey *et al.* (2002) indicates that the abundance of ostracod genera peaks at salinities less than 500 mgL^{-1}.

4.2.5 Macroinvertebrates

Aquatic macroinvertebrates are the best studied group of the Australian freshwater biota in terms of salt tolerance. Some generalisations are possible due to the wealth of data available (Table 4-1).

Table 4-1 Macroinvertebrate Salinity Tolerances

Macroinvertebrate	Salinity Tolerances
Molluscs	Can be divided into two groups: one group is limited to salinities <3,000 mgL^{-1}, and another is found in waters >8,000 mgL^{-1}. Some species were limited to salinities less than 1,000 mgL^{-1}.
Aquatic cnidaria	Seem to be limited to waters with salinities <2,000 mgL^{-1}.
Annelid worms	Seem to be restricted to salinities of less than 1,000 mgL^{-1} (Hart *et al.*, 1991).

Macroinvertebrate	Salinity Tolerances
Mayflies	Generally not reported at salinities >6,000 mgL^{-1} , 45% of genera are only found at salinities <500 mgL^{-1}.
Dragonflies and damselflies	Most found in waters less than 1,000 mgL^{-1}. However, some dragonflies survive over a very wide salinity range.
Water bugs	Restricted to waters with salinity <6,000 mgL^{-1}, some genera restricted to waters with salinity <1,000 mgL^{-1}
True flies	Can be found across a wide range of salinities, though some species are restricted to salinities <1,000 mgL^{-1}.

4.2.6 Fish

Most Australian fish have a high salinity tolerance. Bailey *et al.* (2002) concluded that no fish had a salinity maximum below 4,000 mgL^{-1} and over 80% of reported genera had a maximum salinity tolerance of >8,000 mgL^{-1}.

4.2.7 Amphibians

No Australian studies of salt tolerance have been found. However, data from overseas suggests that most adult frogs are probably intolerant to salinity. Smith *et al.* (2007) suggests that tadpoles in south-eastern Australia should not be affected by salinities of up to ~1,800 mgL^{-1}, but most will be excluded if salinities exceed 3,600 mgL^{-1}.

4.3 Local Data on Macroinvertebrate Sensitivity to Salinity

4.3.1 Salinity tolerances

Local salinity tolerances of macroinvertebrates were developed using the approach of Webb and Hart (2004) for the combined dataset from the National River Health Program in Queensland (Condamine-Balonne and Fitzroy River data only) and biological sampling completed at Fairview (Simmonds and Bristow, various). Details of this procedure and results for individual taxa are provided in Appendix C.

Many of the macroinvertebrate families in Queensland were found at salinities higher than preferences identified by Webb and Hart (2004). Figure 4-1 shows that 25% of the taxa are found at or below electrical conductivities of 340 µS/cm, 50% are found below 1,000 µS/cm, and 65% are found below 1,500 µS/cm.

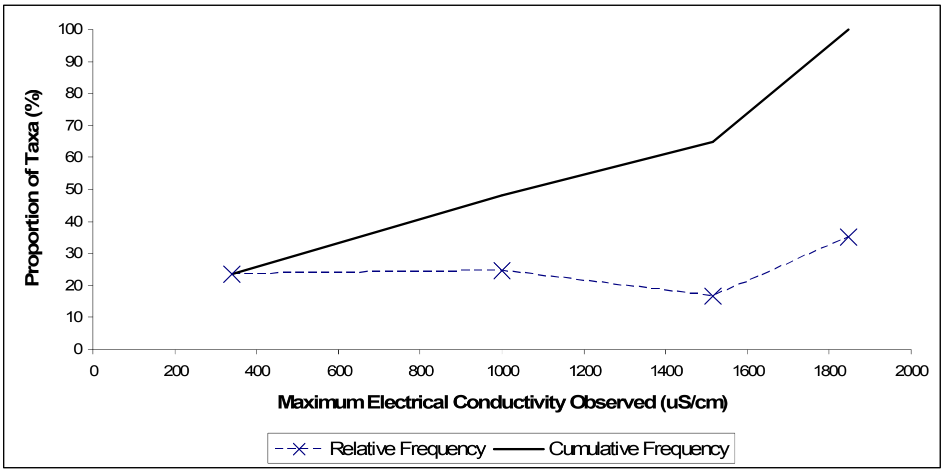

Figure 4-1 Frequency of observed Queensland macroinvertebrates with salinity

(Horrigan *et al.* 2005) demonstrated changes in macroinvertebrate communities in Queensland, with a salinity-based index decreasing rapidly as salinities increased to approximately 800–1000 µS cm^{-1} and thereafter decreasing at a slower rate as salinities further increased.

4.3.2 Relationships between macroinvertebrates and salinity

Univariate and multivariate analyses of Queensland data were undertaken by Dr Angus Webb from Melbourne University (Appendix C). Results show that

- There is a weak grouping of macroinvertebrate assemblages between sites suggesting small but real differences; and
- There are no major correlations of assemblages with environmental variables including EC, temperature, turbidity and flow. The greatest correlation appears to be with EC, although this is weak (Spearman's rank correlation coefficient < 0.2) and is not reflected in the results of the univariate analyses.

These results suggest that there are small but significant regional differences in macroinvertebrate assemblages possibly caused by:

- differences in underlying geology and water chemistry which was not able to be tested using the broad physical variables tested;
- the nature of streams in terms of depth, spring flow, connectedness, water regulation, etc.;
- the riparian zone condition; or
- instream habitat availability.

4.4 Ecotoxicology

4.4.1 Literature review

In the U.S., *Ceriodaphnia dubia* (water flea) and fathead minnows (*Pimphales promelas*) have been used to investigate the toxicity of associated water in accordance with US EPA guidelines. *C. daphnia* has also been used.

- Boelter et al. (1992) investigated the instream toxicity of associated waters and found that *C. dubia* were sensitive but *P. promelas* were not sensitive to test conditions. Toxicity could not be related to sulphides, trace metals or nonpolar organic compounds but was related to the major inorganic ions K^+, Na^+, Cl^-, HCO_3^- and CO_3^{2-}.Exposure of *C. daphnia* to associated waters was found to significantly reduce survival and reproduction compared with an upstream control, and increased as flow decreased and was increasingly dominated by associated water.
- Mount *et al.* (1993) found no toxicity effects instream when chloride concentrations were at or below 519 mgL^{-1} which is considerably higher than 1988 USEPA guidelines (230 mgL^{-1}). They also found that toxicity tests in laboratories were consistent with the results of instream studies suggesting that the laboratory results could be used to predict the instream effects of associated water. Boelter et al. (1992) sites where toxicity effects were observed all had chloride concentrations well above 1000 mgL^{-1}.
- In the laboratory, Mount et al. (1993) found the toxicity of individual ions (chloride and sulphate) to vary considerably for *C. dubia* and it was concluded that the toxicity of TDS was dependent on the ionic

composition of associated water. Fat head minnows were not acutely sensitive to the associated water and had no significant mortality at chloride concentrations as high as 2160 mgL^{-1} (*ibid.*).

- Bicarbonate is often present in associated waters, and may have toxicity independent of or concurrent with chloride. Consequently, Mount *et al.* (1993) conducted further laboratory experiments to investigate the toxicity of bicarbonate while maintaining chloride at the USEPA guideline level. Chronic bicarbonate toxicity of *C. daphnia* was found to occur at alkalinity 588 mgL^{-1} (as $CaCO_3$). It was suggested that operators maintain alkalinities below 400 – 500 mgL^{-1} (as $CaCO_3$) after dilution to 230 mgL^{-1} chloride to protect instream fauna while meeting Alabama discharge guidelines for chloride.
- Mount *et al.* (2003) further found that relative *C. daphnia* ion toxicity in the laboratory was $K^+ > HCO_3^- > Mg^{2+} > Cl^- > SO_4^{2-}$. For *Daphnia magna* similar relative ion toxicities were evident though magnesium toxicity was slightly higher than bicarbonate.
- Johnson (2007) investigated the toxicity of associated water to instream plants and animals in the Powder River Basin. He found that toxicity was mitigated by instream biogeochemical reactions (discussed in Section 6.1.2).
- USGS (2006, cited in Johnson (2007) concluded that 96-h LC50s for early life stage fish exposed to simulated Powder River associated waters were 1100 to 1600 mgL^{-1} $NaHCO_3$.

4.4.2 Tests at Fairview

Envirotest Pty Ltd (2004) reported results from an ecotoxicology investigation of associated water at Fairview Field. Envirotest engaged Ecotox Services Australia Pty Ltd (ESA) to undertake the laboratory studies.

- ESA utilised *Ceriodaphnia dubia* as the indicator species and tested for both chronic and acute toxicity in both dilute mineral water and Dawson River water dosed with associated water. Doses of associated water were applied to achieve 6.25%, 12.5%, 25%, 50%, 75% and 100% of solution.
- Acute toxicity testing over 48 hours (and chronic toxicity – survival testing over 7 days) identified a Lowest Observable Effect Concentration at 75% dilution equivalent to an electrical conductivity ~3135 µS/cm. The No Observable Effect Concentration was identified at 50% dilution (~2130 µS/cm).
- Chronic toxicity testing for reproduction over 7 days identified No Observable Effect Concentration at 12.5% dilution (~690 µS/cm) and Lowest Observable Effect Concentration at 25% dilution (~1210 µS/cm). The 7 day Inhibition Concentration was estimated as 14.5% dilution (~753 µS/cm).

These results are consistent with those reported in Section 4.2.5 for other water bugs.

4.5 Indirect Impacts of Salinity on Biota

Indirectly, salinity may exert influences on dissolved oxygen (DO) concentrations, pH and altered availability of other dissolved material, especially sulphate. In the case of soils, increased salinity may cause an indirect effect via modification of soil structure.

- Dissolved oxygen levels reduce with temperature and increasing salinity. However, reductions in dissolved oxygen concentration are less than 3% between 0 and 5000 mg/L TDS and circa 5% between 5000 and 10,000 mg/L TDS.
- Increased salinity may be associated with increased rates of acidification (reduced pH) due to water drawdown in wetlands (Bailey *et al.*, 2006).

- Saline disposal waters and saline groundwater often contains salts other than the NaCl that is most commonly responsible for toxic-ion and osmotic effects. Ecological impacts may arise from elevated concentrations of these other ions. Loads and/or concentrations of sulphate (SO_4^{2-}), for example, are often elevated in salinised systems and the increased availability of SO_4^{2-} has serious ramifications for decomposition pathways in wetland sediments; sulphate-reduction can result in the production of phytotoxins such as H_2S and the subsequent generation of acid-sulphate soils.

4.6 Ecological Responses to Press and Pulse Salinity Changes

Boon (Appendix B) notes that the way that salt is introduced to aquatic systems is a critical, but often neglected, aspect of secondary salinisation.

- Nielsen *et al*. (2007) grouped aquatic plants and zooplankton into five groups according to how they responded to salinity increases that were delivered as pulse increases or as press increases. The emergence of aquatic plants and zooplankton from resting stages in sediments did not seem to be affected by short pulses of high salinity; although such pulses could prompt some zooplankton taxa to hatch.

- Marshall & Bailey (2004) compared the effect of press and pulse salinisation on macroinvertebrates in the ephemeral Hughes Creek of central Victoria. The abundance of the gastropod *Ferrissia tasmanica*, the mayfly *Baetis* spp. and scraper and predator functional groups were significantly reduced at a salinity of 1,500 mg L^{-1}, and the effect was strongest in the pulse treatment. However, the abundance of 49 other macroinvertebrate taxa, composition of collector-gatherer functional groups, and species diversity were unaffected by the way salt was increased in the creek system. Marshall & Bailey (2004) concluded that delivering multiple, short pulses of salt was more detrimental than delivering the same salt load at a low concentration over a longer duration.

4.7 Fairview Biomonitoring Case Study

AUSRIVAS national macroinvertebrate sampling protocols have been used to monitor river health across a range of sites at Fairview since 2003.

River health at a given site is measured as the ratio of the observed fauna to the expected fauna at the site based on sampling from reference streams. Reference sites are typically influenced by human activities such as land clearing, but are relatively unaffected in other respects. Different models are used to predict expected fauna at pool and edgewater habitats both of which were sampled at Fairview.

- Results indicated a high degree of variability in river health indices at sites upstream of associated water discharges as well as at sites downstream. It seems likely that this variability may be related to the ephemeral nature of the streams in the area and the occurrence of some large floods which significantly altered instream and riparian habitat (Simmons and Bristow, various).

- Comparison of river health indices across the field (collected between 2003 and 2007) provides evidence of improvement downstream of Fairview Field. Interpretation of this result is complicated by the existence of spring inflows downstream of the Dawson River and Hutton Creek confluence (see Appendix D). Nevertheless, investigation of water quality data under low flow conditions suggests that macroinvertebrate impacts may be expected along Hutton and Baffle Creeks downstream of associated water discharges.

4.8 Summary and Conclusions

Many aquatic vascular plants are salt sensitive and salinities of 1,000 - 2,000 mgL^{-1} could be lethal to these salt-sensitive taxa. Of the animal taxa, invertebrates seem the most sensitive to increases in salinity and some species would show adverse effects from salinities as low as 1,000 mgL^{-1} (Hart *et al*. 1991). The most sensitive insects seem to be stoneflies, some mayflies, caddisflies, dragonflies and damselflies, and some species of water bugs.

Examination of regional Queensland macroinvertebrate data suggests that there are some regional differences in assemblages found across sites. These regional differences are not explained by differences in salinity but 50% of families are only found in waters below 1000 µS/cm, and 25% of families are only found when electrical conductivity is below 340 µS/cm.

International literature and local ecotoxicology data indicates that fish are unlikely to be affected if salinities are maintained below 4000 µS/cm, although care needs to be taken since impacts on early life stages (eggs, larvae) have not been investigated.

The international literature also strongly indicates that the toxicity of associated water is related to the ionic mix rather than simply the total salinity of discharge water. For *C. daphnia* it was found that the relative toxicity of ions was $K^+ > HCO_3^- > Mg^{2+} > Cl^- > SO_4^{2-}$. However, the relative toxicity is likely to alter for different species.

Investigations of associated water from Fairview indicates that *C. dubia* experiences acute impacts within 48 hours if electrical conductivity is greater than ~2130 µS/cm. Chronic testing of reproduction over 7 days indicates that inception of observable effects occurs when electrical conductivity reaches ~753 µS/cm.

Johnson (2007) notes that toxicity is mitigated by biogeochemical reactions related to interactions with soils and surface water (see Section 6.1.2 for further discussion).

Based on the above research it is concluded that:

- The Central Queensland trigger level of 340 µS/cm is very conservative.
- It is likely that there are limited impacts on instream fauna or flora when electrical conductivity is maintained below ~700 µS/cm.
- There is a need to investigate the ionic balance in associated water in order to assess toxicity to salinity.

Figure 4-2 provides an approximate risk profile for biota to increasing salinity based on the above review.

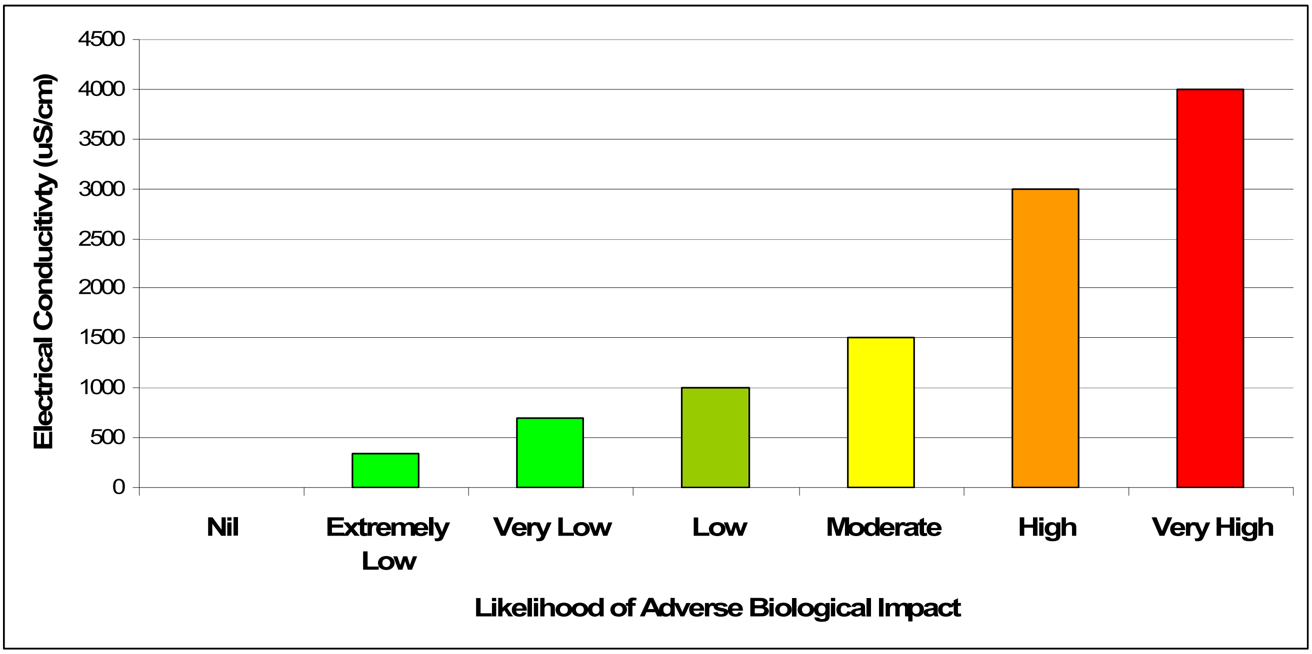

Figure 4-2 Biological Risk Profile for Salinity

Section 5 Macroinvertebrate Drift

This Section examines the causal factors and consequences of macroinvertebrate drift by examining the available literature. Conclusions are drawn with respect to the likelihood and consequence of macroinvertebrate drift corresponding to associated water discharges.

5.1 Literature Review

A short literature review of macroinvertebrate drift due to changes in salinity, temperature, turbidity or flow was undertaken by Dr Peter Newall (Consulting Aquatic Ecologist) (Appendix C). The focus was on key triggers for drift in ephemeral streams during dry season periods. Aquatic macroinvertebrate drift is a phenomenon in which the invertebrate fauna of a flowing stream enters the water column from the benthic zone and drifts with the water current (Newall, 2008).

Newall found there is little literature on the drift fauna of subtropical, ephemeral Australian streams and no information on the influences of salinity, temperature and sediment inputs to drift in these streams. The review was therefore restricted to international literature on drift.

5.1.1 Macroinvertebrate Fauna in Ephemeral Streams

The invertebrate fauna of a stream system includes the bottom-dwelling fauna (‘benthic fauna’) and the fauna that inhabits the subsurface waters below rivers and their banks (‘hyporheic fauna’) (Clinton *et al.* 1996; Del Rosario & Resh 2000). The drift community within a stream is normally the portion of the benthic fauna that enters the main water body. The hyporheic fauna do not typically form part of the drift (Clinton *et al.* 1996).

In ephemeral rivers during prolonged dry spells when there are periods of no surface water (i.e. not even in intermittent ponds), a benthic fauna is not normally supported (Del Rosario & Resh 2000). However, hyporheic fauna may be supported at, or near the water table. Under such circumstances it is unlikely that any significant drift events would be caused by associated water discharges during dry periods.

Where ephemeral streams retreat to isolated refugia (pools, wetlands) some macroinvertebrate drift might be expected due to changes in flow or water quality.

The benthic community in an ephemeral stream during a wet season most likely originates through colonisation from nearby habitats (including refugia) and upstream areas, rather than from dormant stages of the fauna (Miller & Golliday 1996; Stanley *et al.* 1994). However, a small percentage of the fauna (primarily zooplankton) may survive dry periods in the egg stage of the life cycle (e.g. URS, 2006).

Many of the small streams receiving discharge to grade are more episodic (event-driven) rather than ephemeral (seasonal). A number of drainage lines at Fairview Field have been observed to flow for less than 2 days after rain events in wet season. There is unlikely to be substantial colonisation of fauna under these conditions. For these streams there is unlikely to be any significant macroinvertebrate drift due to associated water discharge.

For larger streams, where wet season flows allow colonisation by macroinvertebrate benthos, the drift response to changes in flow, temperature and turbidity could conceivably be similar to responses seen in the literature as described in the following sections.

5.1.2 Responses to Changes in Flow

The influence of flow changes on invertebrate drift has long been recognised with a substantial number of studies showing that an increase in flow volumes or velocity leads to increased drift (Brittain & Eikeland, 1988). Studies of stream flow influences on macroinvertebrate drift include those that assess the effects of reduced flows (e.g. Corrarino & Brusven 1983; Clinton *et al.* 1996; Del Rosario & Resh 2000), increased flows (e.g. Brooker & Hemsworth 1978; O'Hop & Wallace 1983; Matthei *et al.* 1997) and both increased and decreased flows (e.g. Perry & Perry 1986; Miller & Golladay 1996). Many studies have reported an increase in drift during 'river freshes', with some taxa drifting in the initial phases of the fresh whereas other taxa drift following the flow peak (Brittain & Eikeland, 1988).

In a study examining the effects of flow reduction on invertebrate drift, Corrarino & Brusven (1983) demonstrated that catastrophic drift was created by substantial reductions in stream flows, although the drift response was influenced by season, channel shape and time of day. Observation of the drying phase of an intermittent prairie stream in Oklahoma, USA indicated that the drying phase led to a lower diversity of taxa by preventing flow dependent taxa from completing their life-cycle (Miller & Golladay, 1996). The study did not test for drift migration of invertebrates from riffles to pools during the drying period, but noted that this phenomenon has been reported in several studies, including one study in Australia (Boulton & Lake, 1992). In contrast, a study of intermittent streams in northern California, USA showed that the invertebrates did not migrate to either pools or the hyporheos to avoid stream drying (Del Rosario & Resh, 2000).

A study of drift in an Australian tropical stream (Benson & Pearson 1987) noted that there was a distinctly seasonal drift pattern, with greater drift during the wet (summer) season and that this was related to life-cycles rather than disturbance. The authors suggest that this drift pattern was therefore dispersive, distributing young nymphs to new habitats while conditions were favourable. No flood events occurred during the study or in the few months prior to sampling. Therefore, impacts of event flows could not be assessed.

5.1.3 Responses to Changes in Suspended Solids

Results of several studies have been mixed, with authors reporting that the importance of streamflow versus suspended sediment loads are difficult to separate as drift triggers. Some researchers suggest that suspended sediment cannot be separated from flow as the cause of drift (O'Hop & Wallace, 1983). Others have used elevated suspended sediment concentrations to mimic high flow events and found drift increased significantly in number of individuals and number of taxa (Doeg & Milledge, 1991). One study of an artificial discharge downstream of an impoundment reported a dramatic increase in drift with the increased flow and noted that although this was accompanied by a large increase in the total *load* of suspended sediment, although the actual concentration never increased above 6 mgL^{-1} (Brooker & Hemsworth, 1978).

5.1.4 Responses to Temperature Changes

Studies of the influence of temperature on macroinvertebrate drift have often concentrated on the differences between night and day, or on seasonal differences. Brittain & Eikeland (1988) note that one author had suggested that rising temperatures may be a trigger for species that drift during the daytime, whereas another author had found a negative correlation between rising temperatures and drift.

Svendsen *et al.* (2000) state that in general, stream temperature has not been shown to have a primary influence on stream drift, but secondary drift might occur due to increases in insect activity. A complicating factor in considering effects of temperature on drift is the multiple confounding with season, photoperiod and flow rates.

5.1.5 Responses to Changes in Salinity

Wood & Dykes (2002) recorded increased in drift response to salt solution injections in a groundwater dominated river regardless of discharge. Drift was also increased in a regulated river, but under high flows drift was not significantly different due to the change in flow.

Silva & Davies (1999) reported difficulty in distinguishing between the effect of a salinity “spike” on drift and the effects of a specific “trigger” salinity concentration.

5.2 Summary and Conclusions

Drift is a natural feature of macroinvertebrate behaviour and has been observed in response to flood flows in ephemeral streams under Australian conditions.

The literature is heavily governed by studies of regulated river systems and drift responses to increases in flow which have been found to be significant under some circumstances. It remains unclear whether there is a specific drift response to suspended solids or whether this is related to the changes in flow that also occur on initiation of a river ‘fresh’ or flood.

Some authors have examined the effects of reductions in flow rates or dropping water levels and have noted either no drift response, or retreat to pool or wetland refugia.

There is little evidence for increased drift related to temperature changes within the literature. However, substantial episodic increases in temperature might be expected to induce dissolved oxygen slumps and possibly trigger an onset of drift.

Responses to changes in salinity have been observed regardless of flow suggesting that episodic changes in salt are likely to increase drift. It also appears likely that drift might increase as a salinity threshold is reached, though the literature is silent on this.

It is concluded that:

- Most drift responses are related to rapid changes in an environmental variable.
- It is unlikely that continuous associated water discharges will result in increased drift events compared with natural flow conditions in the study area.
- If a continuous and consistent salinity discharge regime is maintained it is unlikely that any significant change in the frequency of drift events will be observed.
- If episodic releases of associated water are made, drift responses will be determined by the relative volume and salinity of the discharge to that instream.
- If this ratio is large then a significant drift response might be expected due to increased flow or salinity or both. If the ratio is small, the relative flow change will be small and mixing will restrict the footprint of impacts from changes in salinity.

This Section examines the quality of associated water, potential chemical changes on discharge and the key water quality parameters of interest when compared with local stream water quality data. Water quality of streams in the CSG field study area is presented and consideration is given to the likely changes in instream water quality if associated water is discharged. Examination of existing discharge to grade at Fairview is used as a case study before conclusions are drawn.

Much of the discussion on the existing water quality of surface waters, and on the quality of associated water, is based on the detailed work and information presented in Appendix E. The Fairview case study is presented in Appendix F.

6.1 Associated Water Quality

A brief discussion of associated water quality in Section 2 placed the quality of associated water from the CSG fields in the context of overseas developments. It was found that:

- Average salinity and sodium content in the CSG field associated water under consideration is typically an order of magnitude less than overseas;
- Average chloride and magnesium concentrations are around two orders of magnitude lower than overseas;
- Average sulphate and calcium concentrations are two to three orders of magnitude lower than overseas; and
- Other water quality parameters are of a similar order of magnitude.

In Section 2 it was also noted that there is considerable variability both between fields and within fields. Many of the studies in the Powder River Basin show considerable variability in salinity, sodium, chloride, calcium and magnesium contents. The following section discusses the variability of associated water quality in the study area.

6.1.1 Variability in Associated Water Quality

CSG field developments are incremental and the quality of the associated water arising from a particular point is unknown until exploration is completed. Water quality samples are only available from the Fairview and Roma well fields (Appendix E). No data is available from the Arcadia Field in the Comet-Brown River catchment.

The water quality data for individual parameters at Fairview and Roma is often significantly skewed with a few large outliers, though parameters such as pH, bicarbonate, total alkalinity and dissolved oxygen are symmetrically distributed. In assessing the suitability of associated water for various uses, this study has utilised median values and also considered the distribution and range of observations.

The quality of associated water is similar between the two fields. However, Roma is typically more saline and contains higher chloride levels than Fairview water (Figure 6-1). Regardless, both fields have few wells that can meet trigger values for the protection of aquatic ecosystems without dilution. Dilution is obviously a challenge in ephemeral stream systems.

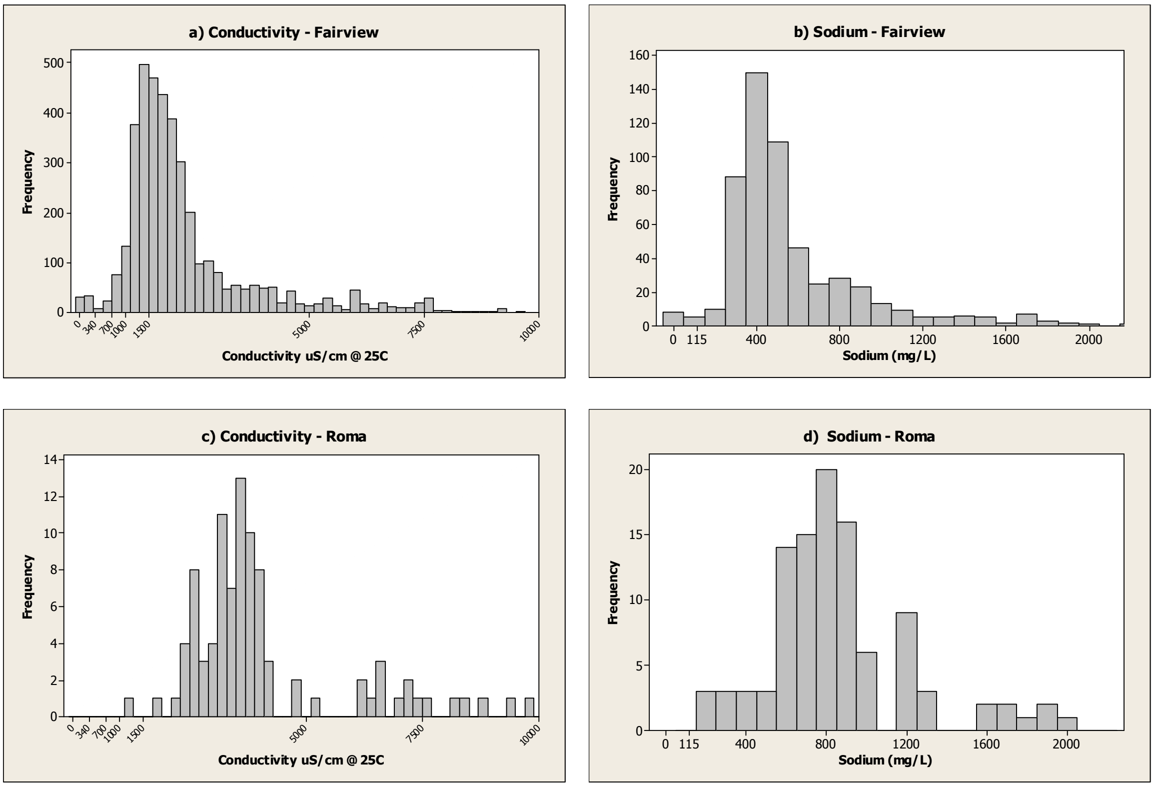

Figure 6-1 Distribution of electrical conductivity and sodium at Roma and Fairview fields

Distributions of a wide range of parameters are investigated in Appendix E. It is concluded that associated water typically has:

- High pH, low dissolved oxygen and low to moderate salinity;
- Moderately high temperature (~40ºC);
- Elevated sodium, fluoride and boron concentrations;
- Trace hydrocarbons;
- No coliforms;
- Elevated ammonia concentrations (compared with Queensland guidelines) but well below national guidelines);
- Elevated lead, copper or zinc concentrations at some wells;
- Low phosphorus and iron concentrations from most wells; and
- Low nutrients (with the exception of ammonia and phosphorus).

6.1.2 Longitudinal Changes in Associated Water Quality

Wellhead water quality has the potential to change once the water reaches the surface. A number of studies are described in the literature and they provide some understanding of how the chemistry of associated water changes when exposed to the surface environment in the Powder River Basin (e.g. Sessoms *et al.* 2002; McBeth *et al.* 2003; Patz *et al.* 2004, Jackson and Reddy 2006).

Sessoms *et al.* (2002) indicate that when associated water high in sodium bicarbonate is exposed to air it undergoes the following transformations:

$$NaHCO_3 \rightarrow H^+ + CO_3^- + Na^+$$

This allows free calcium from the water or soil to form calcium carbonate – a precipitate, plus water and carbon dioxide.

$$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3^+ + H_2O + CO_2$$

The pH of the water can also increase since the dissolution of the sodium bicarbonate also leads to the formation of sodium hydroxide as:

$$Na^+ + H^+ + CO_3^- \rightarrow NaOH + CO_2$$

McBeth *et al.* (2003) found that Sodium Adsorption Ratio, electrical conductivity, TDS and pH increased between wellheads and retention ponds in the Powder River Basin. They postulated that precipitation of $CaCO_3$ was the underlying cause of the observed changes.

Patz *et al.* (2004) investigated downstream changes in chemical composition of production water as atmospheric and sediment interactions occurred. They observed increases in pH, TDS and total alkalinity in the downstream channel and a decrease in calcium concentration, due to precipitation of calcium carbonate. It was postulated that increases in pH were in response to degassing of CO_2.

Jackson and Reddy (2006) also investigated differences in chemistry between wellhead discharges and associated water ponds across a range of catchments in the Powder River Basin. They found significant natural differences in the chemistry of each watershed. Responses to the introduction of associated water lead to more significant chemical changes in some watersheds than others. However, the basic chemical changes between wellhead and pond are that pH, alkalinity, electrical conductivity, and sodium increased; and calcium decreased. No significant changes in magnesium concentrations were observed. These results are consistent with the chemistry identified above.

Johnson (2007) considered the acute toxicity effects of ammonia and sodium bicarbonate in laboratory and field experiments. He found that super saturated CO_2 in the associated water maintained lower pH at the discharge point where ammonia was elevated. As water flowed downstream the CO_2 degassed and pH began to increase, but only gradually due to the precipitation of $CaCO_3$ and subsequent buffering to around pH 8.0 – 8.5. Johnson (2007) also noted that the dissolution of gypsum ($CaSO_4$) resupplies Ca^{2+} ions allowing more $CaCO_3$ precipitation and formation of barite ($BaSO_4$) decreasing concentrations of Ba^+ as associated water flows downstream.

It is not unreasonable to expect that these simple chemical reactions will also occur in the associated waters of the GLNG project.

URS (2008) completed a survey of minor streamlines (dry gullies) at Fairview to investigate physical chemistry, loss rates and biological changes relating to associated water discharge. Results showed increases in pH and possibly EC as water moves downstream from wellheads presumably due to similar reactions to those discussed above. The results also showed that dissolved oxygen rapidly increases from low to high levels within around 500m of the discharge point, and temperature equilibrates to background levels within a similar distance. Observations of the instream benthic environment noted “powdery sediments”. Some white encrustations were also noted on rocks in contact with associated waters. These observations are consistent with the presence of precipitates.

In summary, it is expected that the chemistry of associated water will change once it is delivered to the surface environment. These changes include precipitation of calcium carbonate, barium sulphate, and the release of carbon dioxide with associated increases in pH and salinity. Chemical reactions for existing small associated water flows in dry gullies appear to equilibrate within a short distance downstream of the discharge point suggesting that these reactions may be relatively local to the discharge point.

6.2 Instream Water Quality

6.2.1 Catchment Water Quality

Appendix E describes URS’ compilation and collection of water quality information from the CSG field study area. Data sources include DNRW spot and continuous water quality data, Queensland Murray Darling Commission (QMDC) community monitoring program, data collected by other consultants, and data collected under this study (spot and continuous data). Generally the available data (prior to the conduct of URS’ water quality sampling program) was limited in spatial coverage and appears to have been subject to variable quality control arrangements.

The review shows that:

- The majority of waters sampled fall in the 6.5 – 8.5 pH range consistent with the protection of all environmental values. However, some pH readings around 9.0 were observed. These readings are slightly higher than recommended for recreation and drinking water supply, but are still consistent the protection of irrigation use.
- All systems are subject to significant dissolved oxygen sags which correspond with the high levels of chemical and biological oxygen demand measured. The observed DO levels are well below those recommended for recreation, drinking water supply or the maintenance of aquatic ecosystems.
- All catchments are subjected to a wide range of electrical conductivity (EC - a surrogate for salinity) over time and space. However, most streams typically have EC levels consistent with the recommended trigger level (340 µS/cm).
- Sodium is normally found in the range 30 – 40 mg/L which is well below the trigger values for irrigation, recreation or drinking water supply. There is no trigger value for the protection of aquatic ecosystems.
- Chloride has a wider range in the Condamine – Balonne system (1 – 40 mg/L) compared with the Upper Dawson and Comet-Brown catchments (10 – 20 mg/L). All chloride concentrations are below the recommended trigger values for irrigation, recreation and raw water drinking water supply. There are no trigger values for stock watering or the protection of aquatic ecosystems.
- Fluoride concentrations are usually below the recommended trigger levels for stock, irrigation and drinking water supply. There are no trigger values for the protection of aquatic ecosystems or for recreation.

- Boron concentrations are usually below the recommended trigger levels for the protection of all environmental values (aquatic ecosystems, stock, irrigation, recreation and drinking water supply).
- Surface waters across all catchments are nutrient enriched (eutrophic) with concentrations of nitrogen, phosphorus, and ammonia above recommended trigger levels for the protection of aquatic ecosystems.
- Turbidity and suspended solids concentration are orders of magnitude above the recommended trigger values for the protection of aquatic ecosystems.
- At least 25% of all samples have copper concentrations higher than the relevant trigger value for the protection of aquatic ecosystems, but substantially lower than the trigger values for stock watering, irrigation, recreation and the taking of raw water for drinking water supply.
- Iron concentrations are often well above the recommended trigger levels for irrigation, recreation and the taking of raw water for drinking water supply.
- Zinc concentrations regularly exceed the trigger level for the protection of aquatic ecosystems across all catchments. The observed maximum concentration is below the trigger levels for stock watering, irrigation, recreational use and the taking of raw water for water supply.
- Lead concentrations are above the trigger level for the protection of aquatic ecosystems in approximately 50% of samples. However, the maximum recorded lead concentration is well below the relevant trigger levels for stock watering, irrigation, recreational use and the taking of raw water for water supply.

These results suggest that the Queensland water quality guidelines are overly conservative with respect to a range of parameters observed in the streams of the GLNG CSG field catchments. The results also suggest a considerable influence from regional land clearing and stock access on water quality (particularly nutrients).

6.2.2 Instream water quality changes due to associated water discharge

The changes in the water chemistry of streams to which associated water is discharged will vary in accordance with the chemistry of the associated water at the wellhead, any changes that occur during transit or storage, the chemistry of stream waters, and the relative volumes of associated water and streamflow. For example, Patz *et al.* (2004) found no significant changes in water quality upstream and downstream of an influent stream in Powder River due to the relative volumes of flow in the mainstream compared with the influent.

For ephemeral streams, associated water discharges are likely to be the main component of flow during the dry season. Under such circumstances the quality of the discharge would be dominated by associated water quality and it is reasonable to assume that there is either no dilution or limited dilution in residual pools. This is examined at Fairview in the following case study (Section 6.3).

For perennial streams it is likely that there is an upper bound in terms of the dilution capacity of the stream to avoid significant water quality changes. This upper bound will be limited during the dry season when flows are at a minimum, be much greater during wet season, and be much greater still during flood events. The consideration of this assimilative capacity needs to be completed on a whole-of-catchment basis to ensure the cumulative effects of development are accounted for.

Water quality issues are examined by parameter in Table 6-1 below.

Table 6-1 Potential instream water quality changes from discharge of associated water

Water Quality Parameter	Associated Water Comparison With Trigger Values	Existing Surface Water Quality
pH	Generally suitable for aquatic ecosystems, stock, irrigation, recreation and raw drinking water supply.	The pH of associated water is typically more alkaline than existing surface waters, but well within the range of variability. No significant impacts are expected.
Dissolved oxygen (DO)	Suitable for stock, irrigation, recreation and drinking water supply.	DO levels are low, but typically equilibrates within 500 m downstream of discharge. Surfaces waters across all catchments experience very low DO levels, therefore associated water discharges considered unlikely to lead to any significant instream impacts.
Temperature	Provided discharges are small compared with instream flows, associated water temperature will be suitable for most purposes.	Temperature is significantly higher than surface waters, particularly during the dry season, but equilibrates within approximately 500 m of discharge point for small discharges.
Electrical Conductivity (EC)	Generally suitable for stock watering. Greater than trigger levels for protection of aquatic ecosystems, irrigation and drinking water supply	EC is typically well above background levels instream.
Sodium	No trigger values exist for aquatic ecosystems or stock watering. Majority of wells above trigger levels for irrigation, drinking water supply and recreation.	Surface waters generally below trigger value for irrigation, drinking water supply and recreation.
Chloride	No trigger levels exist for aquatic ecosystem protection or stock watering. Concentrations at Fairview below trigger levels for irrigation, drinking water and recreation. Concentrations at Roma are higher than trigger levels for irrigation, drinking water supply and recreation.	Significant dilution or treatment of associated water is required at Roma Field
Fluoride	No trigger values for recreation or the protection of aquatic ecosystems. Associated water from approximately 50% of wells from Fairview and Roma fields contains fluoride concentrations above the guideline trigger value for raw drinking water supply and stock watering. Trigger level for irrigation is also regularly exceeded.	Concentrations generally higher than existing environment.
Boron	Suitable for stock watering and raw water for drinking water supply. Concentrations regularly exceed trigger values for irrigation and recreation purposes. Concentrations at Fairview often greater than trigger value for protection of aquatic ecosystems.	Due to the turbidity of surface waters in the project area it is likely that toxicity will be reduced, but significant dilution of associated water would be required for conservative management.

Water Quality Parameter	Associated Water Comparison With Trigger Values	Existing Surface Water Quality
Nutrients	Ammonia levels in associated water are above Queensland guideline values but below National guidelines for protection of aquatic ecosystems. No trigger values provided for recreation, stockwater or irrigation.	Concentrations within the current range in surface waters in the region. High pH reduces toxic effects associated with the ammonium ion, therefore it is unlikely that discharges of associated water would significantly alter the nutrient regime or toxicity of surface waters.
Copper	The majority of samples have concentrations below the (modified[2]) trigger level for protection of aquatic ecosystems. Concentrations are below all other trigger values.	There is potentially a small risk of toxic effects due to copper in associated water.
Iron	Greater than recommended trigger values for irrigation. No trigger value for protection of ecosystems or stockwater.	Iron concentrations in associated water are similar in range to those observed in surface waters. Iron does not present a risk to livestock or ecosystem health at the concentrations detected. High levels of iron in irrigation water may result in precipitation and biofouling resulting in blockages of equipment (ANZECC & ARMCANZ, 2000).
Zinc	Concentration in majority of samples below the (modified) trigger value for protection of aquatic ecosystems. Associated water from most wells below trigger value for stock watering, irrigation, recreation and raw water drinking water supply.	Background zinc concentrations are variable, but generally less than in associated water. Unlikely to be any significant effects on aquatic ecosystems due to zinc in associated water.
Lead	Concentrations generally below the (modified) trigger value for aquatic ecosystems. Concentrations below the trigger values for stockwatering, irrigation and recreation.	Concentrations of lead across all catchments are variable, generally greater than the trigger value for aquatic ecosystems (limited data available). Unlikely to be any significant effects due to lead in associated water.

6.2.3 Key water quality parameters

Based on the above review the key water quality parameters of concern in associated water are:

- Salinity (electrical conductivity)
- Sodium
- Chloride
- Fluoride
- Boron

[2] Toxicity of copper, zinc and lead decreases with increasing hardness of water, therefore trigger values are modified in accordance with ANZECC & ARMCANZ (2000) to 0.026 mg/L, 0.07 mg/L and 0.08 mg/L respectively.

In addition, due care needs to be taken to manage pH, dissolved oxygen, suspended solids and temperature.

6.3 Fairview Case Study

The release of associated water at the Fairview Field for approximately 15 years provides a case study to investigate the real effects of discharges on river systems in Central Queensland. Details of the case study are provided in Appendix F. The following provides a summary of the findings.

6.3.1 Existing Associated Water Discharges

Considerable discharges have been released into the Baffle Creek, Hutton Creek and Dawson River circa the Fairview property since 1993. Records on these releases are historically limited but qualitative evidence suggests that discharges were not controlled early in the life of the development, with considerable erosion from uncontrolled wellhead discharge. Discharge is now better controlled in terms of erosion with black polythene pipes used to convey water considerable distances to points of stable rock formations or bedrock in formerly dry gullies.

Discharging associated water to dry gullies is advantageous since chemical reactions have time to occur (see Section 6.1.2), dissolved oxygen and temperature equilibrate to background levels, and losses due to infiltration, pondage and evaporation occur before discharges reach the main creek systems.

Attempts have been made over time to restrict the salinity of waters discharged with an operational aim to maintain salinity in the Dawson River below 1500 µS/cm[3].

Ultimately discharges occur to Baffle Creek, Hutton Creek and Dawson River in what are believed to be ephemeral areas.

6.3.2 Observed Water Quality Changes

Appendix F investigates the statistical changes in river health and median water quality across a range of sites upstream and downstream of associated water discharges. The following conclusions are drawn:

Water Quality Grab Samples Upstream and Downstream of Discharges

- There is no significant change in water temperature between sites in the Dawson River upstream and downstream of associated water discharges with the exception of the Dawson River at Arcadia site (upstream of associated water discharge) which had a higher temperature, probably associated with its small cross-section and lack of riparian cover.
- There is a statistically significant increase in median EC between Dawson River at Arcadia (215 µS/cm) and Dawson River downstream of Baffle Creek (876 µS/cm).
- There is a statistically significant decrease in median EC between Dawson River downstream of Baffle Creek and Dawson River at Yebna Crossing (247 µS/cm).

For some sites there is insufficient information to consider upstream to downstream changes, but there is sufficient information to compare water quality pre and post associated water discharges. At the Dawson River

[3] From Fairview Interim Water Management Procedure, Document Number: 1697-20-001. 10 May 2007

at Utopia gauging station, data has been collected since 1964. Comparison of water quality between the periods 1964-1985 (pre discharge) and 1985-2007 (post discharge) found:

- Statistically significant reductions in EC, TDS, calcium, magnesium, alkalinity, chloride, and sulphate;
- A statistically significant increase in boron concentrations.
- No significant differences in the number of exceedances of Central Queensland trigger levels for EC and suspended solids.

Continuous EC Records at Utopia

- Review of continuous EC records at the Utopia gauging station (1997 – 2007) does not show any significant step changes or increasing trends.
- Records show significant reductions in EC on the rising limbs of hydrographs consistent with substantial dilution as flows increase. EC returns to pre-flood levels after approximately 20 days.

Other Continuous Water Quality Records

Continuous multi-parameter data loggers were deployed upstream and downstream of associated water discharges on Baffle Creek and Hutton Creek, and at Dawson's Bend and Yebna Crossing on the Dawson River. Electrical conductivity, turbidity, water depth, dissolved oxygen and pH were recorded at 0.5 - 1 hour intervals between June and August 2008.

- EC at the site on Hutton Creek downstream of discharges is approximately 300 µS/cm higher than upstream, and shows less variation during floods. Both traces show an initial peak in EC on the rising limb of a small flood event possibly related to flushing of pools.
- EC at the site on Baffle Creek downstream of discharges is approximately 1200 µS/cm higher than upstream, until a small flood passes, at which time EC reduces to approximately 200 µS/cm higher than upstream. After that point salinity gradually increases once more consistent with increased salinisation of the small ponds at the downstream site from associated water discharges.
- pH at upper and lower Hutton Creek sites remain circumneutral and within 0.5 units of each other. The upstream site shows some evidence of increasing pH as a small fresh passes through the section, while the lower site shows some evidence of a reduction in pH as the fresh passes.
- pH at the upper Baffle Creek site is approximately 8 prior to a small flood when it reduces to circumneutral. pH at the lower Baffle Creek sites is approximately 1 unit higher but shows a similar degree of variation to the upstream site.
- Dissolved oxygen concentrations at the upper and lower Hutton Creek sites show significantly lower DO concentrations and less diurnal variation downstream than upstream. In response to the passage of a small flood flow the dissolved oxygen levels rise significantly.
- Dissolved oxygen concentrations at the upper and lower Baffle Creek sites show reduced diurnal variation downstream than upstream but much lower DO at the upstream site. Both sites show a significant reduction in dissolved oxygen in response to a minor flood following the flood peak suggesting organic matter may be disturbed and scavenging oxygen from the water column.

Dawsons Bend and Yebna Crossing

- Temperature is approximately 2°C higher at Dawsons Bend compared with Yebna Crossing but shows a similar diurnal variation.
- EC is approximately 10% lower at Yebna Crossing compared with Dawson's Bend.

6.3.3 Stratification in Pools

Stratification of pools in Hutton Creek, Baffle Creek and the Dawson River was investigated during a single dry season field sampling run using a multi-parameter probe lowered through the vertical profile at 0.1 m intervals.

- At Upper Hutton Creek there is no discernable stratification in pH, DO, EC, temperature or Redox potential. At Lower Hutton Creek there is evidence of a chemocline between 1 m and 2 m depth, with a significant reduction in DO to anoxic conditions and a 200 µS/cm increase in EC.
- At Dawson's Bend, pH and DO remain relatively constant through the vertical profile. EC increases steadily to approximately 1.2 m depth then remains relatively constant until approximately 2.7 m depth, where it reduces steeply to levels seen at the surface. Temperature reduces steeply from surface to approximately 0.8 m depth then reduces more slowly to 3 m depth. Redox potential increases steadily through the profile.
- At Lower Baffle Creek, pH reduces constantly through the profile. EC remains constant to approximately 0.7 m depth at which point it rises sharply. DO reduces slowly to 0.3 m depth, below which it drops to anoxic conditions by 0.7 m depth. Redox remains constant to approximately 0.6 m depth, then drops significantly to 0.8 m, then slowly drops from there down. Temperature drops fairly consistently through the profile.

These single sampling run results suggest that more saline and low dissolved oxygen associated water may be causing stratification in ponds downstream of discharges. However, additional information is required before this can be confirmed.

6.3.4 River Health Data

River health sampling has been undertaken from pool and edgewater habitats at a range of sites across the Fairview area since 2003 (EnviroTest various, Simmonds and Bristow 2007 & 2008). Samples have been taken using the AusRivas macroinvertebrate and habitat sampling protocols. Sites sampled include control sites upstream of impacts, and sites down the Dawson River in an attempt to assess any longitudinal changes in river health.

Results of sampling are highly variable suggesting significant variation in available habitat year to year even at sites upstream of associated water discharges. Variation in results is probably significantly affected by the water at the site at the time of sampling, as well as hydrological events occurring prior to sampling (floods, droughts).

Results suggest that the Lower Hutton Creek site has a significantly lower river health than downstream and upstream sites on the Dawson River. There is some evidence to indicate that river health in Baffle Creek is lower than in the Dawson River downstream. There is evidence to support improving river health in the Dawson River at Dawson's Bend, at Yebna Crossing and at Utopia.

6.3.5 Spring Flows and Assimilative Capacity

Observations of improving water quality and river health downstream of Dawson's Bend suggest that some amelioration of the effects of associated water discharges is occurring at or around this location. A stream flow gauging in October 2007 suggested that low salinity inflows are occurring in this reach.

Water Quality Grab Samples

- A small but significant increase in median EC is evident between Yebna Crossing and Dawson River at Utopia stream gauge (289 S/cm). This may be related to spring flows.
- Median sodium and chloride concentrations are higher at Yebna compared with Dawson's Bend. No associated water discharges are known to occur between these two sites.
- Median pH is higher at Yebna than Dawson's Bend.

Spring Flow & Water Quality Assessment

Release of maps of springs by Queensland EPA in early 2008 confirmed the existence of springs in the area.

A survey of spring flows was initiated to identify the incremental flows and water quality inputs from the springs.

The survey progressed upstream from Yebna Crossing to upstream of Dawson's Bend. Gaugings were taken instream every ~200 m, and springs recorded with flows and water quality measurements taken where possible. Travel further upstream was restricted by topography.

- The survey discovered over 30 springs with various levels of discharge and water quality.
- A number of springs were noted in the stream bed and these appear to contribute the majority of flow in the area.
- Flow at Yebna Crossing was found to be approximately 250% greater than upstream of Dawson's Bend, with the main contribution of flow occurring within 1.5 km downstream of Dawson's Bend.
- Flow at Yebna was 171 litres/second compared with 68 litres/second measured upstream of Dawson's Bend. Peak flow rate measured was 273 litres/second upstream of Yebna pond suggesting losses in or near the pond possibly to extractive farm use.
- Water from the surface springs has a flow weighted EC = 254 S/cm, temperature = 21 ^{o}C and pH = 6.8.
- Surface springs also exhibit higher alkalinity, major ion and fluoride concentrations than the Dawson River.

Spring flows add significantly to the water flowing in the reach of the Dawson River downstream of Hutton Creek. It is estimated that the spring flow is approximately 17 ML/day.

This additional flow offer potential to dilute permeate discharges from the Pony Hills Water Treatment Plant and Central Water Treatment Plant while maintaining EC below the Central Queensland trigger level (Appendix F).

6.4 Summary and Conclusions

Before associated water can be discharged to grade there is a need to carefully consider the range of water quality parameters that exceed recommended trigger levels and the potential for dilution of this water quality in stream. The ability to discharge untreated associated water to streams while protecting aquatic ecosystems is limited unless significant dilution occurs. Nevertheless, associated water is often suitable for stock watering purposes and (with care) for use in irrigation, and for recreational purposes.

Many CSG wells produce associated water with elevated salinity, sodium, chloride, fluoride and boron levels. These parameters are of most concern of all the water quality parameters investigated and warrant treatment where discharges are to be made to watercourses without significant dilution flows. Other parameters such as iron content may also require treatment from time to time.

The degree of impact on chemistry and biota is dependent on flow volumes and dilution in the main stream.

In this Section the limited available literature on riparian vegetation responses to associated water are examined. An assessment is then made of significant weeds within the CSG fields to establish the likelihood and consequence of increased weed problems if associated water is discharged to streams. More details are available in Appendix G.

7.1 Literature Review

The only information found with respect to vegetation and associated water discharge relates to the Powder River Basin in the USA:

- Bergquist *et al.* (2007) reported an investigation of non-native species richness in CSG fields compared with control sites and found increased richness associated with combined primary disturbances (including the development of well pads, roads, pipelines, dams and discharges) and combined "secondary disturbances" (i.e. subplots established adjacent to primary disturbance sites). Although statistical comparisons are made between control sites and discharge areas which indicate non-native species richness is higher in discharge areas, it is unlikely this conclusion can be drawn as control sites include areas which are not drainage lines and which are shown by Bergquist *et al.* (2007) to have significant different native and non-native species richness and soil chemistry.
- Nevertheless, Stearns *et al.* (2005) using data from the same experimental arrangement as Bergquist *et al.* (2007) did compare the vegetation in one control gully with vegetation in another gully subject to associated water discharge. They found that there was a significant difference in both native species richness (lower) and non-native species richness (higher) compared with the control. No significant differences were found between salt tolerant species between the gullies. Although Stearns *et al.* (2005) suggest their results are not conclusive, the results provide supportive evidence that vegetation in gullies subjected to associated water is prone to non-native vegetation invasion.

The reason for the observed change in species composition cannot be inferred from the results presented above. Possible causes include land disturbance, traffic (foot, animal, vehicle) and/or addition of water to a dry environment.

7.2 Queensland Situation

Observations

The CSG field catchments appear to be largely free of aquatic weed species, though five observations of declared species (Alligator Weed, Salvinia, Water Lettuce, Water Hyacinth and Hymenachne) have been recorded in or near the CSG field catchments.

- Lippia (an undeclared species) is known to be widespread in floodplain environments across the catchments and is known to be dispersed by floodwater.
- No observations of aquatic weeds have been made in the Upper Dawson River catchment.
- Alligator Weed (a "Class 1" species) was detected to the south of Roma in 2005 but has not been detected since.
- Weed outbreaks (Lippia, Salvinia) in the Comet – Brown River catchment have generally been in the vicinity of Emerald and to the east of the CSG field catchments.

- Hymenache has been identified in southern Arcadia (Comet-Brown River catchment).
- Salvinia and Water Hyacynth outbreaks have occurred at locations more than 100 km east and south east of Roma.
- Water lettuce was recorded approximately 100 km to the east of the Comet River in 2006, and occasional localised outbreaks have been recorded due east of Roma and south of Roma near the NSW border.

Predicted Distributions

Queensland Department of Primary Industries and Fisheries (DPIF) predictive distribution maps for declared weed species were examined. These maps estimate the distribution of declared weed species based on climate, but do not take into account soil types or other ecological parameters. The maps (Appendix G) grade the CSG field catchments by weed species as follows:

Table 7-1 Suitability of CSG field catchments for declared weed species

Weed	Suitability in GLNG Region
Alligator Weed	Marginal
Water Lettuce	Suitable circa Roma grading to Highly Suitable to north of Emerald
Salvinia	Unsuitable around Roma grading to marginal to Highly Suitable around Comet.
Water Hyacinth	Suitable to Highly suitable north of Comet.
Cabomba*	Highly suitable
Water Milfoil*	Highly – Very Highly suitable

* Cabomba has only been detected in coastal areas of Queensland. Water Milfoil has not been detected in the region.

Appendix G considers the habitat preferences and life cycles of the various weed species.

7.3 Potential for Weed Infestations with Field Development

There is limited evidence for spread of non-native species associated with associated water discharges.

Flowing water is one primary mechanism for weed dispersal but this is normally associated with the large natural seasonal floods in the region (e.g. for Lippia). It is therefore important that any discharges do not significantly alter the frequency of flooding, and are kept at a level that avoids erosion in channel. Since associated water volumes are likely to be insignificant compared with these natural events it appears unlikely that discharge of associated water will increase the likelihood of dispersal via this mechanism.

The introduction of water to previously ephemeral streams may create a favourable habitat for the establishment of aquatic weed species and provide opportunities for changes in species composition. However, the chemistry of associated water is likely to preclude significant weed or native plant growth if untreated.

The primary mitigation measure against weed infestation is careful management of human and vehicular traffic, including the transfer of plant material and soils between areas. Provided these defences are maintained, the likelihood of significant weed infestation is low. The natural turbidity of waters in the area also act to limit the growth of instream vegetation, though temperatures are high and nutrients are readily available there is little macrophyte growth.

Provided flood frequency is maintained and erosion of banks is avoided it is considered unlikely that a significant increase in weed infestation will occur due to associated water discharges.

In this Section, the potential for erosion arising from associated water discharges is examined, firstly through a literature review, then in relation to the GLNG CSG fields under various associated water discharge scenarios.

8.1 Literature Review

The only information found with respect to erosion and associated water discharge relates to the Powder River Basin in the USA:

- In a public notice related to management of discharges, the Wyoming Department of Environmental Quality (Anon., 2006) notes concerns from landholders regarding "discharges …accelerate erosion within Willow Creek and its ephemeral tributaries; unwanted channel cuts, bank de-stabilization, gouging behind spreader dams, beneath road fill, etc; potential for increased sedimentation in flatter areas and increased turbidity in flowing waters".
- This is consistent with comments made in various other articles and references regarding the Powder River associated water discharges (e.g. King 2001).
- Anon. (2006) also refer to stream surveys that have been undertaken to determine constriction points where flows might be expected to exceed channel capacity (i.e. overflow the banks of the streams) or where velocities are expected to be sufficiently high to exacerbate erosion.

These sources indicate that the main concerns relate to the volume and velocity of water discharged rather than to chemical properties of associated water.

Ganjegunte *et al*. (2005 and 2008) studied the effects of repeated irrigation application of sodic associated water on soils in the Powder River Basin and found an accumulation of sodium and salt in the soil profile that led to degradation in the soil structure particularly for fine grain soils. The effects of degradation include increased surface crusting, reduced infiltration and reduced hydraulic conductivity (So & Aylmore 1993; Park & O'Conner 1980 cited in Ganjegunte *et al.* 2005).

However, in the context of discharging associated water to grade, since the beds and banks will remain saturated it is probable that ions (such as sodium and chloride) will move into the soil profile, rather than affecting the surface soils.

8.2 Channel Size and Associated Water Discharges

Streams in the CSG field catchments are typically heavily incised due to the large episodic channel forming flows that occur during wet season. Investigation of flow rates at Fairview (Appendix F) showed that current and 2008/09 planned associated water volumes are many orders of magnitude smaller than flood flows in Hutton Creek and the Dawson River. Further investigations were also made into the relative height changes arising from associated water discharges at known stream gauging locations in these streams.

Appendix H provides a conservative review of average velocity and depths in streams across the CSG field project area under a range of development scenarios and discharges.

Section 8 Erosion

Two methods were used to assess velocities and depths of flow in each stream.

1) Cross-sectional and discharge information was sourced from stream gauging stations and used to estimate flow velocities and depths. While these sites will have similar cross-sections as other locations, they will have different discharge characteristics than other parts of the stream due to downstream hydraulic controls (e.g. weirs, natural bars).

2) Manning's equation was used to estimate depths and velocities assuming a conservative roughness coefficient, bed slope equivalent to average catchment slope, and cross-section as per the relevant gauging station.

Velocities of associated water flows are typically less than 0.1 m/s except in the case of the Dawson River at Utopia where 0.19 m/s was estimated. Natural flood flow velocities are in the range 3 m/s for the region. The estimated velocity for inception of erosion in the sandy-clay soils of the region is in the range (0.3 – 0.5 m/s).

Flows are always maintained within the thalweg[4] of the streams studied even under the most conservative assumption of concentrated flow to individual streams.

8.3 Potential for Erosion with Field Development

The potential for increased erosion from chemical changes to soils in the beds and banks of streams is considered small compared with the potential for erosion by mechanical means due to the discharge of water to ephemeral streams.

Investigation of velocities likely in stream shows that velocities are likely to be well below the range that could cause erosion.

The storage capacity of the stream will only be marginally utilised by associated water discharge and it can be concluded that the frequency of flooding will be maintained.

The main potential for erosion is at the points at which water is discharged to a stream. Any discharge points would be engineered to ensure appropriate protection measures are in place including rocks and geofabric as necessary.

It is concluded that the risk of additional erosion induced by associated water discharges to streams is minimal.

[4] The deepest part of the stream channel

Near River Aquifers Section 9

This Section discusses the potential for contamination of 'near river aquifers' by infiltration from streams within the CSG field development area should associated water be discharged.

9.1 Discussion

The relative contribution of surface water infiltration from ephemeral rivers to regional groundwater recharge has been the subject of a number of studies in recent years. It is clear that infiltration rates vary considerably in both space and time. Infiltration is higher during periods of high flow than low flow, and recent research suggests that consideration of the rising limb of a hydrograph is important in determining the total infiltration volume of a flow event. The effects of soil swelling and pore sealing are also important issues (Mace and Amrheim, 2001).

Higher infiltration rates occur under flood conditions since (from Darcy's Law) the driving head of water above the soil surface, and the cross-sectional area in contact with the soil are both proportional to the rate of infiltration. When floods occur in the CSG field catchments the driving head can increase to 10-20 metres. This may or may not be associated with a significant change in cross-sectional area depending upon the topography.

While low flows in channel will have much lower infiltration rates than flood flows, the duration of low flow discharge is much longer than the flood duration. Infiltration from small continuous associated water discharges can therefore be expected to increase the total annual infiltration that occurs from a stream.

Application of sodic water through irrigation practices has been found to reduce infiltration rates in Darling Downs soils by an approximate factor of 10 (So & Aylmore, 1993). It is unclear whether this would occur in continuously inundated streambeds. Under constant water levels there is potential for vertical infiltration of associated water and constituents into the subsurface. However, adherence to soil particles may allow constituents to settle out of the water column under low velocities.

Recent drilling in the Fairview and Roma areas suggests that the water table is probably some metres (>10m) below the bed of the river channels. This indicates that infiltration will be into the unsaturated zone where contaminants may accumulate over a considerable period of time before scouring during flood or passage to the water table.

Under flood conditions, velocities instream are sufficient to induce scouring that is likely to physically remove any surface crusts returning infiltration rates to normal (Appendix H). However, dissolution may also enhance movement of chemicals into the subsurface on the rising limb of the hydrograph.

Estimates have been made of the relative contributions of infiltration from associated waters vs floods or seasonal flows (typically a ratio of around 1:5 is found), but it is clear that these calculations are subject to considerable errors and are heavily dependent on the assumptions made.

9.2 Conclusions

The variability of soils, and water and chemical processes in the stream and subsurface environment makes it difficult to assess the risks associated with the contamination of near river aquifer systems. The above discussion suggests that the dynamics of flood and seasonal flows will be a significant factor, not only in terms of the scour and movement of chemicals, but also in terms of the potential dilution of infiltrated water.

It is considered that the contamination of near river aquifers is a lower order risk compared with direct contamination of the surface water environment, or changes in hydrology of the system.

Section 9 Near River Aquifers

Should untreated associated water discharge be identified as a management option, then the instrumentation of a river reach and aquifer system would provide useful information to further assess any risks posed. Since associated water has been discharged at Fairview for a considerable period of time, the well field could provide a useful location to investigate this issue.

Hydrological and water quality (EC and temperature) modelling of the three CSG field catchments is reported in Appendices I, J and K.

10.1 Aims

The aims of the modelling were to:

- Develop estimates of natural flows where there was limited data available.
- To extend existing flow records using rainfall data.
- To allow assessment of development hazards (flow, EC, temperature) at selected (i.e. not previously measured) locations in a catchment.
- To investigate various management scenarios.

10.2 Model Development

The two candidate models considered for modelling were IQQM (Integrated Quantity and Quality Model) and E2, both of which are utilised in Queensland. Neither model provides for temperature modelling.

- E2 was chosen as the main modelling platform since it is finding increasing use in Queensland and it was understood that there were difficulties in calibrating electrical conductivity in IQQM.
- Temperature modelling was completed using the US EPA's QUAL2K model.

The Australian Water Balance Model was adopted as the water balance modelling algorithm within E2. Muskingum routing was typically used to transfer water between model nodes[5].

Significant challenges were faced in the development of the E2 models. Key challenges were:

- Limited flow data in some catchments (especially the Condamine-Balonne streams near Roma).
- Inadequacy or incorrectness of SILO rainfall coverages (Queensland Centre for Climate Applications).
- Limited local rainfall information.
- Concerns regarding some rating curves.
- Concerns related to some continuous EC data.
- Limitations of E2 water quality algorithms.

Data validation was completed and modelling progressed by focussing on catchments with the best available datasets then moving to less data rich catchments.

SILO rainfall coverages provide a spatially interpolated set of daily or monthly rainfall data that DNRW recommends for use in E2 modelling. For this project the daily rainfall coverages were used to generate daily flow estimates. Flow estimates were compared with actual records and found to be inadequate for the Upper Dawson River catchment since significant rainfall events were often identified when there was: a) no local

[5] -General Lag and Laurenson non-linear routing was also used where applicable.

record of rainfall; and b) no recorded flood event instream. Similar results were found in other catchments and a decision was made to utilise local data for each subcatchment where possible, and interpolation between rain gauges where necessary using Thiessen polygons.

The limitations of using SILO data on daily time step to generate flows are not unexpected. The SILO data set represents spatial smoothing of recorded rain gauge data and would be expected to perform well in representing monthly rainfall totals rather than daily totals.

Flow modelling was undertaken initially to ensure that water storages and catchment responses were well modelled prior to consideration of salinity. Fitted model parameters were consistently found to be outside the normally recommended range for parameters though not excessively so. It is believed that the "normal" recommended range of parameters reflects fitting models to perennial stream records rather then to ephemeral stream records. The fitted parameter estimates do not contradict any model assumptions nor do they represent unrealistic ranges.

Two checks were used to assess the validity of the fitted model parameters. In the first test, comparisons were made of parameter fits at multiple stream gauges in the Comet River catchment. These fits were all found to be consistent and supported common model parameters on different subcatchments. The second test was to build an identical AWBM model in an alternative modelling package to eliminate any impacts arising from the use of E2. Model calibrations and fitted parameters were found to be identical between the two modelling packages. Since the fitted parameters were found to be consistent across different subcatchments and independent of modelling package they were adopted as being representative of catchment conditions for this study.

Flow calibrations in E2 are generally considered acceptable once the objective function (Nash-Sutcliffe coefficient, CE) is over 0.7. Tests were also made to ensure conservation of mass.

Attempts to model salinity using E2 algorithms were abandoned. E2 provides two basic options for modelling of water quality; neither produced reasonable results for the study catchments. The E2 modelling algorithms are simple and the degree of switching between wet and dry modes in the ephemeral CSG field catchments lead to wild fluctuations in EC.

Continuous and spot EC data were investigated and a consistent empirical model for salinity was developed for all catchments in Excel. Care was taken to ensure that salinity was conservatively estimated and parameters allowed for the different salinity responses in each catchment. Salinity inputs from associated water discharges were then simply added to modelled catchment salinity using a flow weighted algorithm to estimate resulting EC[6]. Conservation of mass was ensured.

Temperature was only modelled in the Upper Dawson River catchment for particular scenarios related to the discharge of cooled (to 5ºC above than the ambient air temperature) associated water into Hutton Creek. Similar results are expected for other sites.

[6] Note that EC and salinity are different concepts but they are linearly related so flow weighting applies to both.

10.3 Calibration

10.3.1 Upper Dawson River

Calibration of flows is excellent with CE = 0.73, and good representation of low flows, hydrograph shapes and timing with the exception of very large floods. Over 26 years the net volume difference in modelled vs observed flows is less than 4%. As large flood events are of less concern to this project the calibration is considered suitable.

EC modelling is conservative and tends to over-estimate the salinity in the system on average over the ten years of available record. Over-estimation was necessary to allow calibration of the peak EC events considered critical for this study.

Temperature modelling is considered appropriate for purpose and provides a good correlation with downstream data.

10.3.2 Comet-Brown River

Calibration of flows is considered excellent with CE = 0.73 and a net volume difference over 31 years of 0.2%. Some difficulties were found in matching all components of the flow regime, and preference was given to matching low flow behaviour as this is more critical for this project.

The EC model was calibrated at three points in the catchment including Arcadia valley, mid catchment and catchment outlet. Only spot data was available for calibration for the Arcadia Valley, but continuous data was available at the other two sites. The models are calibrated conservatively with greater emphasis given to peak EC periods.

10.3.3 Condamine-Balonne Catchment

Calibration of the flow regime is excellent with CE= 0.75 and a net volume difference over 13 years of observed flow record of 0.4%. General fit to hydrograph timing, peak and volumes is good, although flows in the mid - range 30 – 50 m^3s^{-1} are not well fitted. Given the concentration is on low flows for this study the calibration is considered appropriate. However, the model encompasses streams where no flow record is available. Until data is available from these streams the model must be considered preliminary.

No suitable continuous EC records were available so model calibration was completed against limited spot readings taken by DNRW and URS. Parameters were adjusted to achieve the best possible fit but the data is limited.

10.4 Modelling Scenarios and Results

10.4.1 Modelling Scenarios

Scenarios for untreated associated water discharge were developed based upon estimated peak associated water production rates from the fields. This is very conservative since not all water is likely to be of a quality suitable for discharge to grade. For the Roma and Arcadia fields the quality (electrical conductivity) of associated water was assumed to be constant at 3480 µS/cm based on data from Roma. For Fairview the assumed electrical conductivity of untreated associated water was 1998 µS/cm based on data analysed at the time of modelling[7].

For treated water discharge scenarios, volumes were reduced by 25%. For the ephemeral streams in the Roma and Arcadia fields the permeate EC was assumed to be 280 µS/cm. For the perennial Dawson River various permeate salinities were considered.

For the Comet-Brown catchment it was assumed that discharges will occur in the upper, middle and lower catchment, or else be concentrated mid-catchment.

For the Condamine-Balonne catchment discharge was considered to be either concentrated in Bungil Creek, distributed evenly across the three main creeks in the area, or be delivered directly to the Balonne River at Surat Weir.

Further details of the scenarios are provided in Appendices I, J and K.

10.4.2 Upper Dawson River Salinity

Untreated associated water discharge will significantly increase the salinity of streams in the area.

Permeate discharge can be assimilated within the existing flow regime downstream of the springs at Dawson's Bend provided the flows do not exceed certain levels (see Appendix I). For the Pony Hills Treatment Plant (4.5 ML/day) it is reasonable to discharge at up to 500 µS/cm (Environmental Management Plan for Fairview Project Area, May 2008). However, for the proposed Central Water Treatment Plant it would be necessary to reduce the permeate salinity to background levels instream.

10.4.3 Comet-Brown River Salinit y

Modelling shows that untreated discharge of associated water will significantly increase salinity instream from 242-405 mg/L TDS to 2300 mg/L TDS over most flow ranges. Opportunities to discharge into high flow events where concentrations would be significantly diluted are limited and intermittent.

Discharge of treated water at the nominated treatment level would reduce salinities over all flow ranges.

10.4.4 Condamine-Balonne Catchment Salinity

Untreated associated water discharges are shown to significantly increase the salinity of streams in this area across all flow ranges.

Discharges of treated water will maintain the salinity regime of the streams within background levels. However, it is noted that even treating water to background levels may result in a salinity debit being required under the Basin Salinity Management Strategy (BSMS) 2001-2015.

The BSMS supersedes the 1988 Salinity and Drainage Strategy and is the Murray-Darling Basin Ministerial Council's response to the salinity impacts identified in the Salinity Audit (MDBC, 1999). It addresses both dryland and irrigation salinity. The objectives of the BSMS are:

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[7] Electrical conductivity of associated waters from Roma and Fairview were based on data available at the time of modelling. The Water Quality section of this report displays the latest figures available.

Objective 1: Maintain water quality of shared water resources of the Murray and Darling Rivers for all beneficial uses – agriculture, environmental, urban, industrial and recreational;

Objective 2: Control the rise in salt loads in all tributary rivers of the MDB, and through that control, protect their water resources and aquatic ecosystems at agreed levels;

Objective 3: Control land degradation and protect important terrestrial ecosystems, productive farm land, cultural heritage, and built infrastructure at agreed levels Basin-wide; and.

Objective 4: Maximise the net benefits from salinity control across the Basin.

The BSMS contains the 9 Strategic Elements that guide actions to address salinity risks and establish accountability measures.

Element 1: Developing Capacity to Support the BSMS;

Element 2: Identifying Values and Assets at Risk;

Element 3: Setting Salinity Targets;

Element 4: Managing Trade-offs with Available Within-Valley Options;

Element 5: Implementing Salinity and Catchment Management Plans;

Element 6: Redesigning Farming Systems;

Element 7: Targeting Reforestation and Vegetation Management;

Element 8: Constructing Salt Interception Schemes; and.

Element 9: Ensuring Basin-wide Accountability: monitoring, evaluating, and reporting.

Under Element 9 (Ensuring Basin-wide Accountability: monitoring, evaluating, and reporting) a basin salinity register has been developed that accounts for salinity credits (e.g. interception of salt prior to entering the Basin rivers) and debits. Salinity credits represent reductions in the long term discharge of salt to the Basin rivers and can arise from actions such as salt interception schemes or improvements in irrigation efficiency. Salinity debits arise from new inputs of salt to the Basin rivers.

10.4.5 Temperature Modelling

Modelling of instream temperatures was completed as part of the investigations for the Santos Fairview Environmental Management Plan (Upper Dawson River catchment). Modelling shows (Appendix I) the persistence of a temperature effect downstream is related to the volumes of discharge and the relative temperature of the discharge compared with the ambient environment.

Under low-flow scenarios and temperature maintained within +5°C of ambient conditions, the persistence of a 1ºC temperature difference would be at worst case 2.5 km downstream, but most scenarios indicate that temperatures will equalise within 0 – 1 km. Where associated water is released at ~40 °C, the distance required before temperatures return to within 1ºC of ambient are up to 10 km in dry season and 5 km in wet season.

Under high flow scenarios and temperature maintained within +5ºC of ambient, the persistence of a 1ºC temperature difference instream would be at worst case 12.5 km in dry season and ~9 km in wet season.

Since the Dawson River has considerable spring flows circa Dawson's Bend, this offers a significant ameliorating effect on temperature (and other water quality parameters). Modelling suggests that even if the water temperature of associated water is not reduced below 40°C when discharged the spring flows will reduce the plume length to ~1.5 – 2 km. With temperatures of associated water maintained within 5°C of ambient the plume length is reduced to less than 1 km.

10.4.6 Changes in Instream Hydrology

The associated water discharge scenarios used in this study provide for constant flow releases into the bottom of the stream channels (Appendix H). The hydrological regime of these streams will therefore shift upwards by the amount discharged (worst case scenario), or by the unquantified amount of flow remaining instream after infiltration and evaporation losses.

Since the discharge volumes are small they would comprise a very small percentage of the flows under moderate to high flow conditions. Since they are constant they will not alter the variability of the systems significantly except in the low flow regime.

The major change in hydrology is therefore the persistence of instream pools and the increased connectedness between pools as flow is maintained downstream.

10.5 Conclusions

The associated water discharge scenarios used in this study provide for constant flow and constant conductivity releases. As a result the only real change in the hydrologic regime is a shift of all flows up by (worst case scenario) the amount of discharge. The volumes of discharge are small; therefore this shift becomes less significant as flow increases. The only significant change in hydrology is therefore the change in the streams from ephemeral to perennial. This could be expected to shift the types of biota in the stream by providing new habitat.

Discharges of saline associated water will require treatment unless there are considerable flows instream. For the truly ephemeral streams associated with the Roma and Arcadia fields there will be few opportunities to dilute associated water instream.

For the Fairview Field, the perennial nature of the Upper Dawson River downstream of Dawson's Bend provides significant assimilative capacity for existing discharges. However, once associated water discharges reach a certain level they will start to dominate the instream water chemistry. This is true for both temperature and salinity.

Floods are seasonal, intermittent and of short duration. While they offer the advantage of dilution, the practicalities of building storages with sufficient driving head or pumps to discharge during flood conditions may be impractical, and would need to be assessed.

The existence of the BSMS (applicable to the Condamine-Balonne catchment) means that very careful consideration would need to be given to discharging additional salt in the Roma area even if the water is treated to background levels.

Opportunities to discharge treated water would best be limited to those areas where there is perennial flow, or where there are effectively perennial ponds and significant changes in the instream environment have already occurred (see Section 12).

Review of Risks from Associated Water Discharge

Based on the reviews undertaken in the previous chapters the risk framework identified in Figure 3-1 and Figure 3-2 is revisited.

In some cases consequences identified in the framework have been able to be assessed as minor, in other cases they have been reaffirmed and more detailed information on processes and consequences is available than previously.

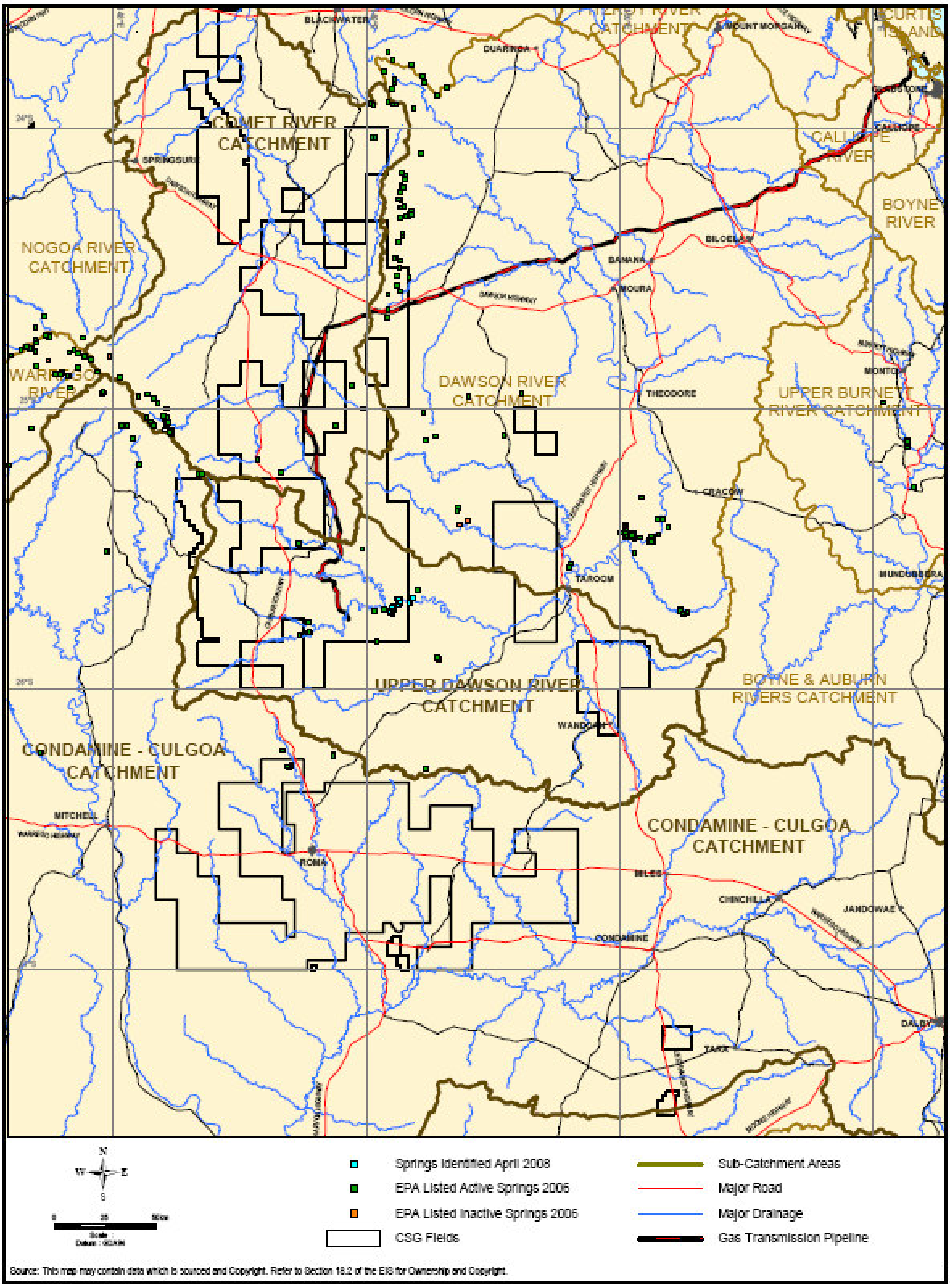
In other cases, the likelihood of a consequence has been assessed as very low, and therefore the potential hazard can be assigned a very low risk (assumed negligible).

- Central Queensland trigger values for EC are probably over-conservative with national literature and local data showing considerable variability in salinity and higher concentrations prior to significant effects on species. A risk profile is proposed in Figure 4-2.
- Catastrophic drift of macroinvertebrates appears unlikely to be a key issue for continuous treated or untreated associated water discharges.
- The chemistry of associated water is highly spatially variable and there are a number of constituents that are of key importance in understanding environmental risks. Where these constituents are at levels below trigger values, or there is sufficient instream flow to dilute concentrations to below trigger values there would be a low ecological risk associated with discharge. Otherwise there will be a moderate-high ecological risk, especially if the water is untreated.
- Characterisation of associated water from the Fairview and Roma fields suggests that the water from most wells will require treatment for sodium, chloride, boron, and fluoride prior to discharge to surface water.
- In addition, the temperature of discharges will need to be managed to ensure diurnal and seasonal variations are maintained in stream.
- Weed growth is likely to be a minor issue.
- Erosion is unlikely to be a significant issue away from the entry point of discharges. This is the case even if associated water is concentrated from a number of wells across a field.
- Contamination of surficial aquifers is considered a low order risk, but should be investigated further should discharge of untreated associated water be identified as a management option.
- Hydrologic regime changes from associated water discharges are limited to low/zero flow periods. The volumes of associated water are very small compared with channel sizes and flood flows so no discernable changes in flood or high flow frequency are predicted.
- The results of modelling indicates the need to treat associated water due to the ephemeral nature of the streams in the area

Section 12 Associated Water Discharge Options

Discharge of untreated associated water is not a viable option for the majority of wells that will be developed for the GLNG Project. This is because the water quality is generally insufficient to protect aquatic ecosystems. However, there are some wells where the quality is sufficient to protect all environmental values, particularly if there are options to dilute the discharge with instream flows.

Since many of the streams in the project area are ephemeral, discharge (especially during dry season) may be limited by regulators to areas where the discharge does not significantly alter the instream environment. Reaches of the Dawson River downstream of Dawson's Bend provide this opportunity since flows in this area are maintained by spring flows. Consideration of other areas where springs are known to occur across the project region



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Section 12 Associated Water Discharge Options

Figure 12-1) indicates that the Upper Hutton Creek (Upper Dawson River catchment), Bungil Creek (Condamine-Balonne catchment) and Carnarvon Creek (Comet-Brown catchment) are the only areas where substantial numbers of springs have been identified. Examination of Bungil Creek and Carnarvon Creek suggests that these streams do not continue to flow during dry season, but can maintain isolated pools possibly supported by groundwater-surface water connections. Access to Hutton Creek in the relevant region is limited. However, investigation of reaches downstream of this area indicates the permanent presence of long shallow pools which may be sustained by seepage flows.

The following sections provide a summary of the options considered viable for associated water discharges (treated or untreated) in the three CSG field catchments. Where streams do not continue to flow during the dry season, consideration is given to minimising the impact of discharges by limiting flows to certain sections/streams or to discharging to areas where water is already ponded artificially or naturally.

No consideration is given in this report to discharging to irrigation dams on farms closer to wells. This might provide a more viable option given pipeline costs.

12.1 Fairview Field

Only limited wells produce associated water that meets trigger levels for the protection of aquatic ecosystems. While this is also true for some parameters in existing streams in the area, the difference between the water quality of current streams and associated water is significant for a range of parameters.

If discharge to grade is contemplated, then treatment will be required. However, the perennial nature of the Dawson River downstream of Dawson’s Bend means that there is continuous assimilative capacity. This capacity is sufficient to meet proposed 2008 development levels while still maintaining instream water quality below trigger levels with a high degree of certainty. However, the capacity will be exceeded under full field development. This will require desalination to 340 µS/cm to ensure the protection of aquatic ecosystems.

Even if treatment is undertaken prior to discharge then it is also considered advisable to provide sufficient ponded storage to ensure that temperatures are suitably reduced to close to ambient to minimise impacts on instream biota.

Full field discharge to the Dawson River will not change the low flow hydrology significantly, nor would it affect flood carrying capacity or frequency in the river.

Discharges to the Dawson River would increase the security of water supply downstream while maintaining all environmental values including stock water supply, protection of aquatic ecosystems, and irrigation.

The identified options for discharge to grade all require treatment. Advantages and disadvantages of each option are provided in Table 12-1.

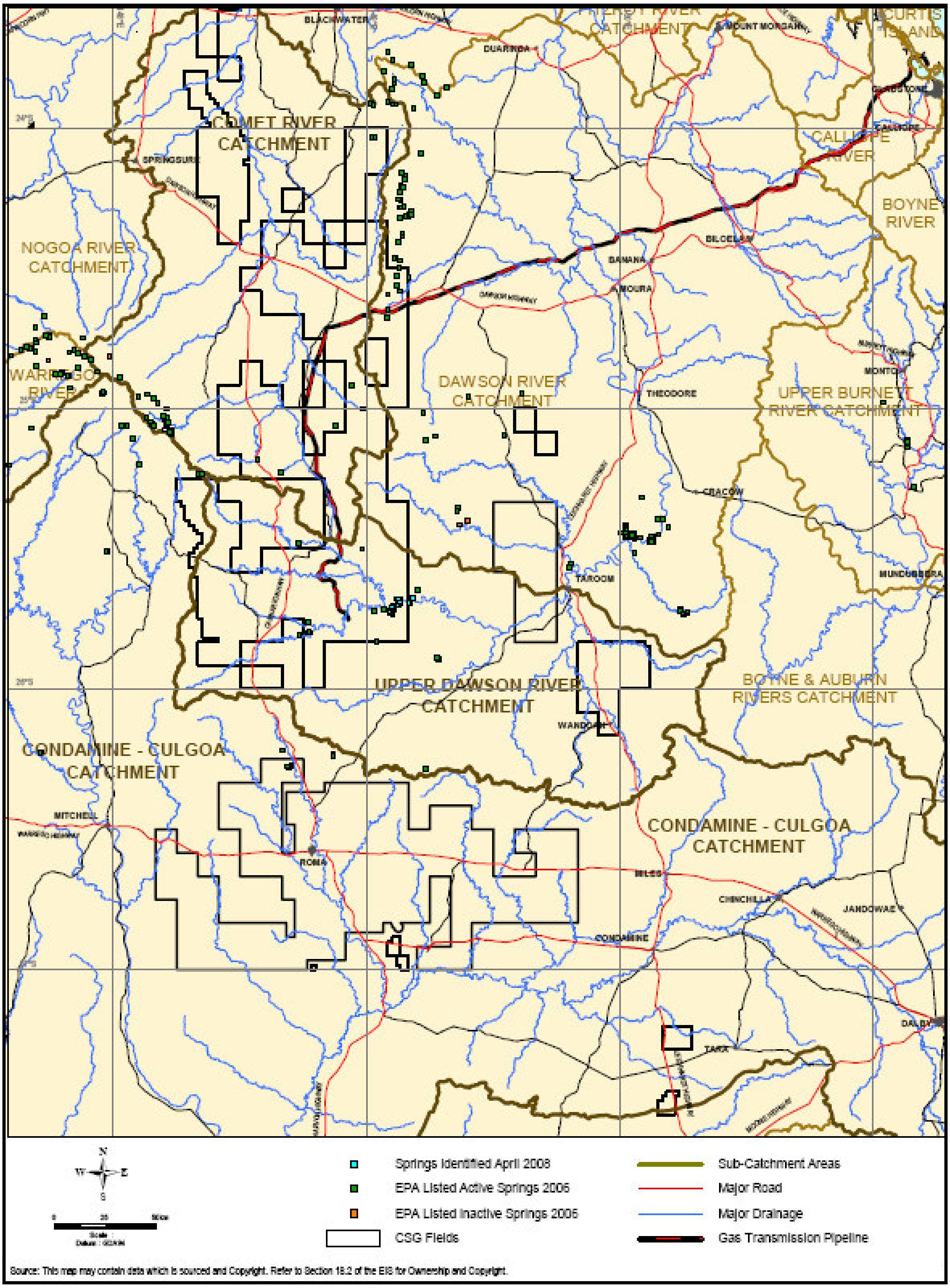

Figure 12-1 Known Spring Locations – CSG Field Catchments

12.2 Roma Field

There is little if any associated water that meets minimum trigger levels for the protection of aquatic ecosystems. While this is also true for some parameters in existing streams in the area, the difference between the water quality of current streams and associated water is significant for a range of parameters.

If discharge to grade is contemplated then treatment will be required to background levels. That is, the permeate would need to have an electrical conductivity in the range 325 – 340 µS/cm for this catchment. However, even at this low salinity negotiations would be required between Santos, the Queensland Government and the Commonwealth regarding discharging water, as salt will be added to the Murray Darling Basin. The Basin Salinity Management Strategy (BSMS) may require accounting for this on the Basin salinity register (as a salinity debit).

If treatment is undertaken prior to discharge then it is also advisable to provide sufficient ponded storage to ensure that temperatures are suitably reduced to close to ambient to minimise impacts on instream biota.

Discharge to streams in the Roma area may change the low flow hydrology and seasonality of flows during the dry season, but is unlikely to change any other part of the hydrologic regime. The main issue will be the maintenance of discharge in streams which normally are either totally dry, or maintain ponds in limited locations. Environmentally, this would result in the creation or enhancement of aquatic habitat availability in the dry season and allow for unseasonable persistence of aquatic biota in ephemeral environments. Such changes would be expected to favour the establishment and proliferation of filamentous algae and exotic flora and fauna, such as mosquito fish, and may reduce the diversity of local aquatic communities. It is highly unlikely that the shift in hydrology will affect the trigger signals for fish which migrate upstream. However, maintenance of wetted streamline would certainly impact on any wet/dry triggers for macroinvertebrate lifecycles.

Discharge to streams offers opportunities for social benefit in downstream communities should DNRW create new allocations for the discharged water. Allocation of the discharge may also remove the issue of the basin salinity register.

The identified options for discharge to grade all require treatment. Pros and cons of each option are provided in Table 12-2.

12.3 Arcadia Field

Based upon existing knowledge of the Fairview and Roma fields, there is likely to be little if any associated water that meets the minimum trigger levels for the protection of aquatic ecosystems from this well field. While this is also true for some parameters in existing streams in the area, the difference between the water quality of current streams and associated water is likely to be significant for a range of parameters.

If discharge to grade is contemplated then treatment will be required to background levels. That is, the permeate would need to have an electrical conductivity at least as low as the trigger value for the protection of aquatic ecosystems which is 340 µS/cm for this catchment.

If treatment is undertaken prior to discharge then it is also advisable to provide sufficient ponded storage to ensure that temperatures are suitably reduced to close to ambient to minimise impacts on instream biota.

Discharge to streams may change the low flow hydrology and seasonality of flows during the dry season, but is unlikely to change any other part of the hydrologic regime. The main issue will be the maintenance of discharge in streams which normally are either totally dry, or maintain ponds in limited locations. Environmentally, this would result in the creation or enhancement of aquatic habitat availability in the dry season and allow for unseasonable persistence of aquatic biota in ephemeral environments. Such changes would be expected to favour the establishment and proliferation of filamentous algae and exotic flora and fauna, such as mosquito fish, and may reduce the diversity of local aquatic communities. It is highly unlikely that the shift in hydrology will affect the trigger signals for fish which migrate upstream. However, maintenance of wetted streamline would certainly impact on any wet/dry triggers for macroinvertebrate lifecycles.

Discharge to streams offers opportunities for social benefit in downstream communities should DNRW create new allocations for the discharged water.

Lake Nuga Nuga is a wetland listed by ANCA (1996) in the Directory of Important Wetlands in Australia. According to ANCA (1996) the lake has a surface area of 2050 ha with a typical depth of 2m (estimated total volume is therefore circa 40,000 ML when full). It had “fallen dry” twice in living memory prior to 1996, and is partially dry at the present time. Land use in the lake bed includes grazing, water extraction, boating, camping and fishing. Examination of Google Earth satellite photos indicates a desiccated and cleared area exists where water once lay. The lake may not have a defined tenure (ANCA, 1996).

With such a large potential storage volume and cleared area, Lake Nuga Nuga could be an important candidate for associated water discharges, though treatment would still be required. Re-establishment of the lake as a tourist area, together with active planting of macrophytes could provide an important bird sanctuary and focal point for the community. However, water balance modelling would be required to assess the potential for the maintenance of the lake water levels through associated water discharges.

Lake Maraboon, near Emerald, also offers a potential on-river discharge site for treated associated water.

Advantages and disadvantages of each discharge option are provided in Table 12-3. It is noted that these are preliminary options only. Other options such as potential discharge to local lakes require further detailed investigation.

Section 12 Associated Water Discharge Options

Table 12-1 Fairview Well Field Treated Discharge Options - Pros and Cons

Well Field	Discharge Option	Advantage	Disadvantage
Fairview	Discharge to Dawson R	Discharge to perennial river system Increased water supply security downstream	-

Table 12-2 Roma Well Field Treated Discharge Options – Pros and Cons

Well Field	Discharge Option	Pros	Cons
Roma	Distributed Discharge (three creeks)	Minimum discharge to creeks Increased water supply security downstream	Maximum footprint Requires decentralised treatment and ponds BSMS salinity debits may arise (credits may be required to offset)
	Discharge to Bungil Creek	Minimises footprint of discharge to creeks Increased water supply security downstream	Footprint (though limited) Increase level of impact in chosen stream BSMS salinity debits may arise (credits may be required to offset)
	Discharge to Balonne River	No discharge to creeks (Minimum footprint) Discharge to wetted area (Surat weir pond) Increased water supply security downstream	Downstream of Surat BSMS EC debits may be required Significant pipeline required
	Discharge to Dawson River	BSMS EC debits not required. Increased water supply security downstream	Cross-basin transfer of water, disinfection may be required to avoid pest or weed transfer May lead to increased erosion (requires close study)

Table 12-3 Arcadia Well Field Treated Discharge Options - Pros and Cons

Well Field	Discharge Option	Pros	Cons
Arcadia	Distributed Discharge (3 points)	Increased water supply security downstream	Maximum footprint Requires decentralised treatment and ponds
	Discharge to Central Location	Increased water supply security downstream	Footprint (though limited) Increase level of impact in chosen stream Significant pipeline required
	Lake Nuga Nuga	Increased bird habitat and opportunities for tourism Potential for social engagement through development of wetland including community planting and management. Large surface area	May disturb natural water regime, but likely to be minimal footprint Likely that successionally development of the wetland will occur with different species dominating but settling down over time. Significant pipeline required
	Lake Maraboon	Increased water supply Dilution may allow lower level of treatment for salinity?	Almost no footprint likely. Significant pipeline required
	Discharge to Dawson R	Increased water supply security downstream	Cross-catchment transfer of water disinfection may be required to avoid pest or weed transfer Significant pumping costs Very significant pipeline required May lead to increased erosion (requires close study)

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Section 14 Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 12 October 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

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Ecological Risk Assessment Workshop

Appendix A

REPORT

Summary Report - Ecological Risk Assessment Workshop

Prepared for

Santos

60 Edward St

Brisbane QLD

21st January 2009

43270896

URS

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…………………………
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David Fuller
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Date:	21 January 2009
Reference:	Summary Report– Ecological Risk Assessment Workshop
Status:	FINAL

Table of Contents

Tables, Figures, Appendices

Tables

Figures

Appendices

1.1 Introduction

1.1.1 Aims and objectives

Santos is considering a range of options for the management of 'associated water', a by-product of coal seam gas production from the Santos Gladstone Liquid Natural Gas Project (GLNG) project. Options include the use of evaporation ponds, water treatment facilities, re-injection and discharges to grade. Santos has engaged URS Pty Ltd to assess the potential risks posed to environmental, social and economic values across the study area.

An Ecological Risk Assessment (ERA) workshop was held to agree on the key features of a framework to assess the likely adverse effects on aquatic assets of the potential discharge of associated water to grade. Risk was defined as:

The product of the probability or likelihood of a hazard occurring and the ecological consequences if that hazard occurs. Risk assessment involves combing information on the probability or likelihood of some hazardous event occurring, the consequence or severity of that event if it occurs, and the sensitivity of the risk to management interventions.

Objectives of the day were to:

- Describe the current understanding of major ecosystem values and current stream conditions, and current investigations;
- Confirm the key issues and risks associated with the management of associated water;
- Agree on the characteristics of conceptual models of disturbance-response relationships;
- Confirm the spatial and temporal scales of disturbance and ecosystem response to be considered during the project;
- Agree on the ERA approach best suited to the each of the key issues/risks; and
- If possible, identify trigger values, thresholds or metrics that will be important for measuring end points.

The Ecological Risk Assessment Workshop was held on Friday 15th February 2008 at the Indooroopilly Sciences Centre, Indooroopilly, Queensland. The workshop brought together a small and focussed group of experts, URS scientists representing Santos, Santos, DNRW and Queensland EPA. Attendees to the workshop included:

- Dr Angus Webb (Melbourne University),
- Dr Neil Tripodi (Queensland EPA),
- Renee Muller (DNRW),
- Emma Hicks (Santos),
- Dr Belinda Lovell (URS),
- David Fuller (URS).

The workshop was facilitated by Peter Cottingham of Peter Cottingham & Associates. An overview of the workshop is presented in Appendix A.

2.1 Background

2.1.1 Study area/values

An overview of the study area and some of its associated values is presented in Appendix B The study area is approximately 300 km by 150 km, and includes tributaries of the Culgoa and Balonne (Murray Darling Basin) and Dawson (Fitzroy Basin) rivers. Seasonal rainfall and runoff patterns mean that many of the streams in the study area are ephemeral.

While URS has put a considerable amount of effort into the review of available information, it recognises that there remains data and information that it has yet to access. For example, there is a Ramsar wetland in the Comet catchment, but it was uncertain whether this would be impacted by the development. The presence of any threatened species or communities across the study area also needs to be confirmed.

Knowledge gaps:

Extent of information on aquatic systems for the study area held by DNRW.

Actions:

DNRW (Renee Muller) to advise on data and information held for the study area.

URS to identify any threatened species or communities that could be impacted by the development.

2.1.2 Operations

An overview of operations was provided and discussed. While Santos is considering a range of management options, the focus of the workshop was to examine discharge to grade (with and without prior treatment). Although discharge to grade is considered by the EPA to be the last choice as a management option, it was agreed that the risks associated with such an option need to be considered.

Outcome of discussion:

The risk assessment needs to consider potential impacts of the associated water being discharged to grade over the 20 year time-frame of operations, amongst other management options.

Risk assessment needs to allow for variability in quantity and quality of associated water produced by each well or group of wells.

2.1.3 Key issues

Some of the key issues associated with discharge to grade are presented in Appendix B Priority issues to be considered during the ERA process, along with other potential issues to be evaluated, are listed in (Table 2-1)

Table 2-1 Issues to be considered during the ERA process

Priority issues	Other potential issues
Increased salinity	Total suspended solids (because of management of discharge sites)
Changes in hydrology (flow) during the dry season/low flows	pH (if beyond 6.8 to 8.5)
Increased temperature	Boron concentration (note Boron can be toxic to citrus)
	Fluoride concentration
	Total Organic Carbon, Biological Oxygen Demand and Chemical Oxygen Demand
	Dissolved Oxygen
	Weeds spread and growth due to additional water

It was noted that there were challenges associated with identifying key issues using pre-defined water quality objectives because they are static, and not well suited to ephemeral systems. An adaptive management/risk based approach was seen as a more useful, as it allows for the protection of economic, social and environmental values.

The hydrological and water quality modelling package E2 (developed by the eWater CRC) was considered useful for determining the likelihood of the key issues (i.e. those related to altered stream salinity, hydrology and temperature). E2 can be used to model salinity, flow and potentially temperature, with results able to be used to help answer questions such as ”Over what length of stream will temperature be raised by > 2°C as a result of associated water discharge?”

Outcome of discussion:

It was agreed that salinity, hydrology and temperature were key issues with respect to discharge of associated water to grade. Other potential issues identified will be further examined to (a) decide whether they should be included in the ERA process and (b) if so, what method is appropriate for their assessment.

2.1.4 Overview of potential analytical approaches

An overview of the ERA process is provided in Appendix C. The risk management cycle involves a repeating sequence of:

- Problem formulation,
- Characterising effects,
- Characterising likelihoods,
- Risk characterisation and associated uncertainties,
- Decision making process,
- Monitoring and evaluation?

These steps are presented diagrammatically below

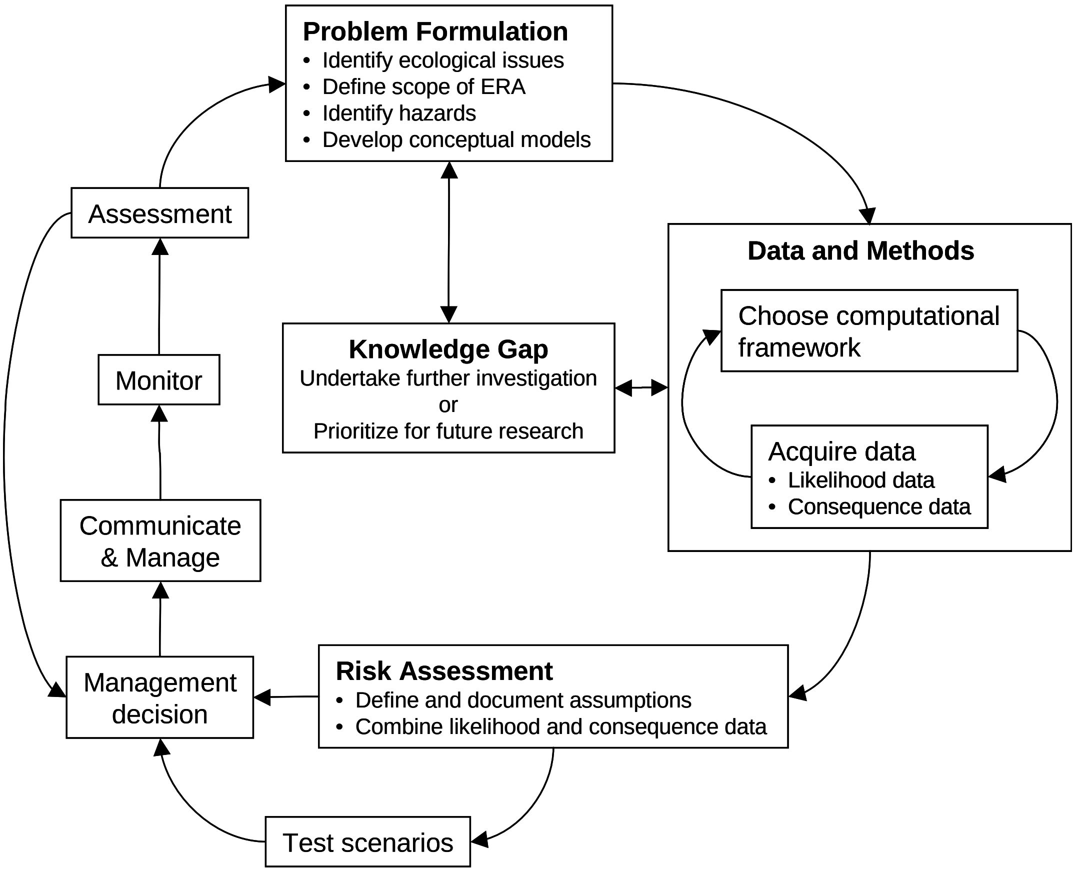

Figure 2-1 The Risk Management cycle. Reproduced from Webb and Hart (2004)

While gaining prominence in Australia in recent years, most ERA projects to date have only addressed the first few steps in the process. The long-term nature of the GNLG project provides a rare opportunity to complete the risk management cycle.

It was recognised that the nature of Santos's operations meant that there was a need to consider local and regional effects. In particular, stakeholders with similar activities[1] in the catchment need to be considered collectively.

The EPA typically adopt a 'conservation/hazard approach' to similar projects whereby a hierarchy is followed to (1) eliminate the hazard, (2) discharge only during wet-season flows, (3) treat associated water so that salinity is not a hazard. However, it was noted that such an approach does not consider the consequences to ecosystems (only the hazard). Additionally, the EPA typically refers to ANZECC/ARMCANZ guidelines as default or develop local water quality objectives as the basis for assessing the effectiveness of mitigation efforts.

[1] It was noted that Origin Energy had conducted an investigation that highlighted the need to discharge production water to a nearby creek only during high flows. An evaporation pond was built to increase storage capacity and avoid discharge to the stream during low flow periods.

3.1 Conceptual modelling

A broad conceptual model was developed at the workshop to provide a shared understanding of the interaction of the key issues (stressors) with ecosystem attributes, as well as to help identify knowledge gaps (see section 3.3). The conceptual model was also used to consider end points for monitoring and assessment of risk. It is also a tool that will be useful for communicating with stakeholders during the ERA process.

3.1.1 Assessment end points

A number of potential assessment endpoints were identified and discussed including:

- Macro-invertebrates (species richness, Signal, observed/expected, EPT) – affected by electrical conductivity.
- Fish (present/absence) – affected by electrical conductivity.
- Diatom assemblages – are affected by flow, temperature and electrical conductivity.
- Rates of production or respiration – affected by temperature.
- Riparian vegetation – affected by flow.

The first three of the endpoints listed above represent major taxonomic groupings. Macroinvertebrates are generally better as assessment endpoints because data are more readily available, previous examples of ERA are available to draw upon and there is a better understanding of likely consequences.

Socio-economic values were also recognised as important considerations for the ERA process. A stakeholder consultation process is to be initiated to complement the assessment of ecosystem risks as an input to the project.

Outcome of discussion:

Examination of assessment end-points was undertaken in the workshop whilst developing the conceptual model. Macroinvertebrate biodiversity was recommended as the major assessment endpoint for the risk assessment.

3.1.2 Characterising likelihoods

The following likelihood data requirements were identified:

- Daily flow,
- Daily electrical conductivity (i.e. robust estimates under different discharge scenarios),
- Daily temperature,
- Habitat area versus discharge relationships (i.e. via stage height).

It was agreed by the group that electrical conductivity and temperature data would be modeled and treated separately for characterising likelihoods, whilst bearing in mind that there may be synergies between the two.

In addition, the following potential issues are to be evaluated and included in the ERA process if warranted:

- Depth/EC profiles in pools (i.e. stratification in pools);
- Boron, fluoride;
- pH;

- Dissolved oxygen;
- Weeds.

3.1.3 Characterising effects

Figure 3-1 provides a conceptual model characterising links between sources of stress (associated water), stressors (EC, Temperature, Flow), and endpoints (e.g. macroinvertebrates) during dry/almost dry conditions. This is when the discharge of associated water is likely to have the greatest influence on the receiving streams; it was agreed that the discharge of associated water would have little influence on water quality during high-flow conditions. The model considers the possibility of discharge of associated water both directly to streams, and to grade. For water discharged to grade, various processes affect the level of nutrients and solids in that water prior to it entering the stream. Both sources of water collectively affect flow, EC and temperature. The major flow effect is that of the associated water making ephemeral streams more perennial. This may lead to potential effects on hydraulic habitat, behavioral responses of biota, the spread of weeds and effects on riparian vegetation. The major single effect of salinity is seen as a direct toxic effect on macroinvertebrates that may lead to permanent changes in the assemblage. Moreover, salinity pulses may induce macroinvertebrates to drift as an escape response. The combination of flow and salinity may affect what were previously refugia in ephemeral streams. These pools may no longer act as refugia during low flow periods due to increased salinity and connectivity. Temperature is seen mainly as an accelerator of ecosystem processes such as primary production and respiration. Lastly, the diatom assemblage is expected to be affected by the combination of stressors. It is unknown whether the resultant change in assemblage's species composition has any ecological implications for the streams. The conceptual model will be refined and reviewed (using expert external reviewers) as the project unfolds.

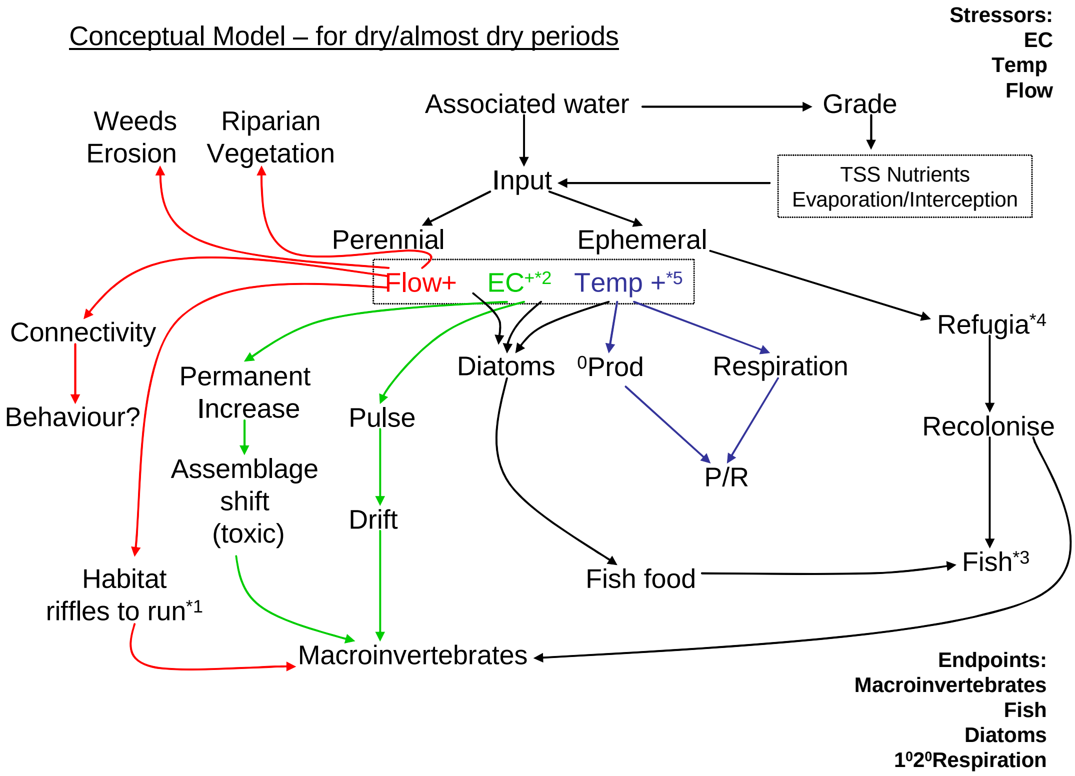

Figure 3-1 Conceptual model

**1 Streams change from ephemeral to perennial.*
**2 Electrical conductivity could become progressively worse downstream if there are no inflows from other areas. Press and pulse response to salinity may lead to a permanent shift in macroinvertebrate assemblages.*
**3 May not see serious effects on fish communities because of boom and bust cycles of eggs. Fish are opportunistic in these kinds of environments.*
**4 If refugia are subjected to increases in salinity over time this may result in a toxic effect, reducing the effectiveness of the refugia.*
**5 The main concern are pulse changes leading to thermal shock. Temperature may also have a homogenizing effect. Work has shown that less variable temperature regimes with the same overall mean temperature lead to slowed growth. Diurnal variation is a requirement.*

A dry-season sampling strategy including recommended assessment endpoints was proposed (Table 1-2) to provide additional data and information to support the ERA process.

Table 3-1 Attributes to be sampled as part of the ERA process

Issues	Pulse Increase		Incremental Increase	
EC and Temp	Drift Macroinvertebrates	Toxic effect Macroinvertebrates Fish Diatoms	Drift Primary production Algae Diatoms	Toxic effect Macroinvertebrates Vegetation (riparian)
Hydraulic habitat	Macroinvertebrates		Algae Diatoms Vegetation (riparian)	

Other points considered relevant to risk characterisation included:

- A probabilistic approach is recommended for assessing potential effect of salinity on macroinvertebrate species assemblages. Such an approach has been previously utilized for assessing the risks of salinity to macroinvertebrates (Webb & Hart 2004), and has a long history of use in Ecological Risk Assessment projects generally.
- ANZECC guidelines recommend that species sensitivity distributions for probabilistic risk analysis include at least 24 species in order to have confidence in the cumulative distribution.
- Utilizing salinity data where the highest salinity at which a species is observed is a conservative approach to characterizing risk as these salinities are almost certainly not the highest level that the species can tolerate (i.e. not all populations have been sampled, there are likely be populations living in higher salinity waters, and it is unlikely that the population was sampled when salinity for that particular water body was at its highest). This assumption can be checked by considering salinity tolerances from laboratory data.
- Confidence intervals are to be included with salinity distributions (not just a threshold value).This is a more robust method, especially with regards to determining where risks differ enough between sites to treat them differently.
- An alternative to using SIGNAL scores for the risk assessment of flow would be assessing effects on species counts. If this option is chosen, a Poisson model of species count, rather than a normal distribution, may be more representative of the data expected when considering the effects of changes to the flow regime.

- A threshold approach was recommended for assessing potential effects of flow. This was based on the fact that we have a poor understanding as to how changes to flow of the type described here may impact biota. Thus, we would attempt to identify a threshold in change to flow that might engender such a change, rather than consider the probability of change continuously. This is due to a lack of detailed understanding of this particular stressor-response relationship.
- Estimating uncertainty in the effects of flow could be done by putting confidence intervals around SIGNAL grade scores for macroinvertebrate assemblages. Research by EPA Victoria has established the approximate uncertainty of individual SIGNAL scores, allowing confidence intervals to be placed upon individual samples. An example of this has been the treatment of EPA Victoria data in order to specify prior uncertainties on SIGNAL scores for a Bayesian modeling study (data custodian Leon Metzeling).
- Frequency of temperature jumps could be determined via a box model instead of E2. ANZECC guidelines could be used as a standard for consequence data. A modified point-wise comparison could be made, whereby the frequency with which temperature exceeds the ANZECC guideline could be used as the measure of risk at that node within the model.

The information from this workshop has been used to scope a range of investigations that will further inform the risk assessment process. The following table provides a summary of the knowledge gaps identified during the workshop process and the activities being undertaken to address these gaps.

Table 4-1 Knowledge gaps and activities to address gaps

Knowledge gap	Activities to address gap
Understanding previous work done, and the impact of increases in salinity, turbidity, temperature and flow on drift of macroinvertebrate species	Review of macroinvertebrate drift due to salinity, temperature, turbidity and flow (i.e. low flows versus moderate flows). The focus of the review, where possible, should be key triggers for drift and catastrophic drift in ephemeral streams during non event times (i.e. dry season/as streams dry). Local information is important because many organisms are expected to be adapted to an ephemeral environment. It is when there are large divergences from normal conditions that there is concern.
	Analysis of existing river health monitoring data to identify if there are different macroinvertebrate species found at different sites and whether this is related to salinity, temperature, turbidity, flow or other environmental gradients.
	Review of salinity impacts on stream biota with a particular focus on ephemeral/arid streams and the ranges of salinity that can cause impacts on diatoms, fish, macroinvertebrates, algae, riparian vegetation and algae.
Likelihood data	Build a process model of EC (E2 model) particularly focussed on the dry season to determine whether EC is likely to exceed tolerances. This model will also inform flow inputs to stream. A separate model will be developed for temperature.
Consequence data	Review of available databases including AUSRIVAS (DNRW data) and Bailey and Boon's salinity sensitivity database, as well as any literature that will aid the construction of macroinvertebrate species sensitivity distributions. In particular, identify: – The highest tolerance levels of salinity (and if there are any particularly sensitive species) for species found in the GLNG area – The maximum and minimum temperature tolerance levels for species found in the GLNG area (and if there are any particularly sensitive species) – Macroinvertebrate species likely to be present in ephemeral streams and non ephemeral streams (and if there are any particularly sensitive species). Tolerance levels will be based on field records rather than laboratory data. In addition, if sufficient information cannot be found for species found the GLNG area, the search might have to use a generic species list for western Queensland.
Other potential issues	Examine water quality results against defined (ANZECC) trigger values to identify any potential issues. If considered an issue, define appropriate method for its assessment. Need to check if there are any threatened species or communities that could be impacted by the development. Need to determine what river health monitoring, AUSRIVAS model

Knowledge gap	Activities to address gap
	development and investigations have and haven't been done by DNRW.
Impacts of water on the spread and abundance of noxious weeds and erosion	Examine work being undertaken for Fairview.
Changes in diatom assemblages	Review whether changes in diatom assemblages matter to the fish as a food supply.
Monitoring	Macroinvertebrate sampling using AUSRIVAS needs to occur 4 to 8 weeks after flooding for ephemeral streams. This is important because if macroinvertebrates haven't recruited following the flow pulse, a false negative result may be obtained. Perennial streams will always have macroinvertebrates present. Undertake testing of salinity profiles in pools (e.g. in the Dawson River)
Ecosystem health monitoring plan	Review annual reports for ecosystem health monitoring.

Limitations Section 5

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Section 6

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Peter Cottingham

Appendix A

Santos GLNG Ecological Risk Assessment Workshop

Discussion points for today

- Background to the project
- Overview of potential analytical approaches
- Scope of salinity risk assessment
- Scope of temperature risk assessment
- Scope of altered hydrology (flow) risk assessment

Agenda

9:00 am	Welcome and workshop objectives
9:10 am	Background to the project
9:40 am	Overview of potential analytical approaches
10:00 am	Risk assessment (salinity)
10:30 am	Morning tea/coffee
10:45 am	Risk assessment (salinity, cont.)
12:30 pm	Lunch
1:00 pm	Risk assessment (temperature)
3:00 pm	Afternoon tea/coffee
3:15 pm	Risk assessment (temperature)
5:00 pm	Close

Workshop objectives

- Describe the current understanding of major ecosystem values and current stream conditions and current investigations
- Confirm the key issues and associated risks associated with the management of 'associated water'.
- Agree on the characteristics of conceptual models of disturbance-response relationships
- Confirm the spatial and temporal scales of disturbance and ecosystem response to be considered during the project
- Agree on the ERA approach best suited to the each of the key issues/risks
- If possible, identify trigger values, thresholds or metrics that will be important for measuring end points.

Background information

- David Fuller

Key issues to be considered

The following have already been identified:

- Salinity
- Temperature
- Changed hydrology (flow)

•Others (e.g. algal blooms)?

Overview of potential approaches

- Angus Webb

Risk assessment - salinity

- Problem formulation
- Characterising effects
- Characterising likelihoods
- Risk characterisation and associated uncertainties
- Decision making process

Salinity – problem formulation

Explore the goals, scale and focus of the ERA:

- What is current condition and are there particular values to be protected:
  - Protection of stream condition?
  - Protection of wetland condition?
  - Protection of biodiversity or icon species?
- What spatial and temporal scales might apply to the ERA?
- What endpoints might be considered (e.g. species richness, O/E scores, other)?

Salinity – characterising effects

- Use conceptual model(s) to agree on key disturbance-ecosystem response relationships
- Identify and quantify potential adverse effects caused by a stressor

Conceptual model for salinity risks:

- Outline a disturbance-response relationship (e.g. cause-effect model, event tree)
- How detailed do we need to be for this project?
- What approach is best suited to assessing effects?
- What data/information/approach is needed to characterize the important elements of the conceptual model and quantify effects?

Salinity – characterising likelihoods

- Assess spatial and temporal aspects of salinity

- What data collection, modelling or analysis is best suited to assessing salinity?

Salinity – characterising risks

- What type of risk analysis? Qualitative
  - Semi-quantitative
  - Quantitative

How best to combine effects and likelihood data to characterise risk?
  - Probabilistic methods?
  - Deterministic models?
  - Bayesian approaches?
  - Other?

How best to deal with uncertainty?
  - Interval analysis?
  - Fuzzy numbers?
  - Monte Carlo?
  - Probability bounds?

Salinity – decision process

- Probably too early in the process to deal with in great detail here. May have bearing on future approaches such as multi-criteria analysis, scenario testing, formulation of risk management plans and communication plans.

- Adapted from Hart et al. (2005):
  - What assets are most at risk?
  - What hazards most threaten the assets and what actions can be taken to protect assets?
  - Are actions acceptable to stakeholders?
  - What actions are the most cost-effective?

  - Also, what monitoring and assessment may be required?

David Fuller

Appendix B

URS

Background to Ecological Risk Assessment Workshop

David Fuller
Project Leader

URS

Overview

- The project
- Water and gas production
- EIS context
- Risk based approach
- Focus of today

URS

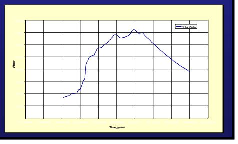
Coal Seam Gas (CSG)

- Current energy market promotes CSG development
- Multiple players in Central Western Queensland
- Santos' Gladstone Liquid Natural Gas (GLNG) Project
- 300km N/S and 150 – 200 km E/W

URS

Basic Principles

- Appraisal wells to prove gas resource.
- Water often but not always associated with gas.
- Generally more water pumped early, less later and vice versa for gas.
- Separation via condensation
- Gas to pipeline, water to where?
- Appropriate water management is critical to achieve project delivery.



URS

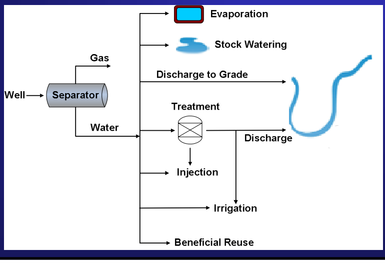
Associated Water

- Analyses suggest relatively consistent quality from each well.
- Significant gradients between wells e.g. salinity
- Key constituents pH, T, EC, sometimes F, B
- Trace hydrocarbons in odd samples.
- Large volumes of water but small in context of rivers?

URS

EIS Context

- A wide range of water management options are being considered.



URS

Focus of this study - discharge

- Untreated or treated
- Timing
- Uncertainties of discharge amounts and qualities
- Mainly, but not always, ephemeral streams.
- WQ objectives aim to protect environmental values, but static compared with highly dynamic systems
- Adaptive water management approach that protects ecological, social and environmental values?

URS

Ecological Risks

- Adaptive water management plans need to consider ecological risk.
- Hydrological and WQ models will be built to generate predicted WQ and flow changes (Likelihood)
- Ecological models needed to define potential hazards (Consequence)
- Need to combine these models to interpret changes in quantity and quality in terms of risk.
- Pathway to investigate alternative management options.
- Discussions may also inform data collection needs.

URS

My focus for today

I would like to see:

- Quantitative ecological risk models (remove individual bias, repeatable, consistent).
- Recognition that some hazards might be treated differently from others.
- Today push as far as possible to get ecological response models
- After today work up and seek comment.

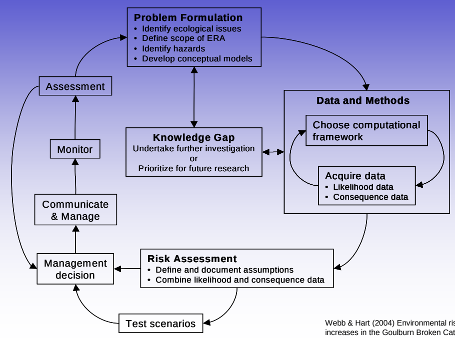
Angus Webb

Appendix C

Risk = Likelihood x Consequence

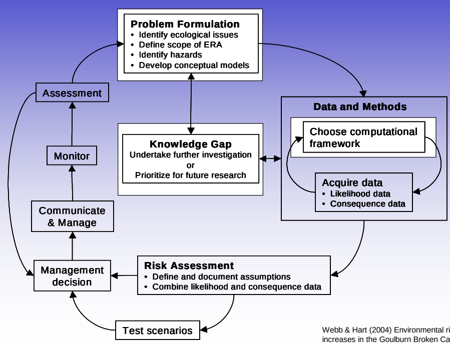
- **LIKELIHOOD** – The probability that an (undesirable) event will occur within the ecosystem being examined
  - e.g. Probability of median salinity reaching 3000 for a certain stretch of the Comet River over the next 30 years
- **CONSEQUENCES** – The consequences if the event occurs
  - e.g. loss of 50% of invertebrate species from the river due to the effects of the rise in salinity

Risk Assessment (and Management) are Iterative



Webb & Hart (2004) Environmental risks from salinity increases in the Goulburn Broken Catchment

Today



Webb & Hart (2004) Environmental risks from salinity increases in the Goulburn Broken Catchment

Problem Formulation – Big Picture

Define project objectives

↓

Define notional temporal & spatial boundaries

↓

Prepare broad- scale Conceptual model of the system

↓

Identify ecological consequences or effects

Broad-Scale Conceptual Model

- A picture of the system
  - Shows spatial relationships
  - Helps to identify issues within the catchment
  - Issues must be converted to assessment endpoints

For Each Ecological Issue

Identify major stressors

↓

Prepare conceptual model for each ecological effect

↓

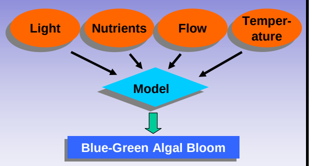
Identify the available data for each model

↓

Identify which additional data are needed and how to obtain

Issue-Specific Conceptual Model

- A map of our understanding (or lack thereof) of how stressors combine to cause the ecological effect
- Helps to identify knowledge gaps in the system (identify research priorities)
- Helps with communication within and outside the ERA project team



Ecological Models for Risk Assessment

- A model is an abstraction of reality
  - "All models are wrong, but some are useful" (George Box)
- We create a model of the system / issue that we are assessing
  - we can then look at the stressors (either singly or in combination) that may lead to an ecological consequence

Model Choice is Dictated by System Understanding and Data

- If we understand a process well, it can be represented as an equation
- We may note a correlation, but have no knowledge of why it exists
- We may have a belief about a relationship between a stressor and endpoint, but have few data to back this up
- We may have insufficient knowledge to employ a quantitative description

Approaches to Risk Assessment

- Qualitative
  - Risk Tables
  - Risk categories with uncertainties
- Quantitative
  - Numerical models
    - Process based
    - Statistical
  - Data Comparisons
    - Point-wise comparisons
    - Distribution comparisons

Risk Tables

- Common method
- Shows tradeoff of likelihood and consequence
- BUT
  - No acknowledgement of uncertainty
  - Probabilities usually subjectively derived

Likelihood of Exposure	Consequences of Effects				
	1 Insig	2 Minor	3 Mod-erate	4 Major	5 Cata-strophic
A – Almost Certain	High	H	Extreme	E	E
B – Likely	Medium	H	H	E	E
C – Possible	Low	M	H	H	E
D – Unlikely	L	L	M	H	H
E – Rare	L	L	L	M	H

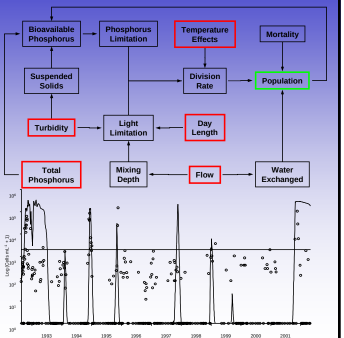
Risk Categories Algal Blooms in Lake Nagambie

- Can be useful when
  - Data are poor
  - Uncertainty is high
- Rolls uncertainty into risk assessment
- Categories may are arbitrary
- May not have sufficient resolution

Scenario	Bloom Likelihood	Uncertainty
Increased FRP	Medium	High
Increased temperature	Low	High
Decreased turbidity	Low	Low
Decreased flow	Low	High

Process-based Model: BGA in Bourke Weir

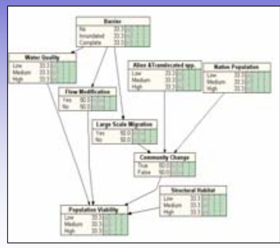
- Each arrow in the conceptual model represents one or more equations
- Monitoring data from the red-bound boxes feeds into the model to create a virtual BGA population
- Relationships and coefficient values taken from the literature or from site specific research



J.A. Webb (2003) Unpublished Manuscript

Statistical Model: Native Fish in Goulburn-Broken

- The relationships are formed from data, and also from expert opinion
  - Expert opinion is often all that we have to go on
- Bayesian Network software allows rapid assessment of probabilities under different scenarios



C.A. Pollino (2004) Unpublished material

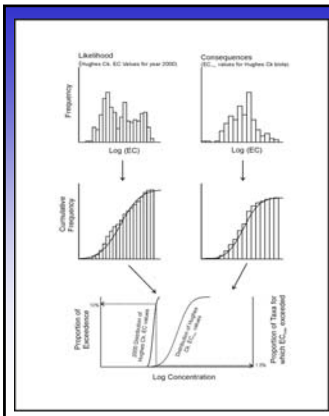
Point-Wise Data Comparison Risk Quotients

- Quick to compute, can provide relative comparisons among a large number of sites / scenarios rapidly
- Don't utilise all the data available.
- No estimate of uncertainty

$$\text{Risk} = \frac{\text{Median EC}}{\text{Threshold}}$$

e.g. EPA Standard

Comparison of data distributions PRA



- Distributions of salinity values available for specific sites (left)
- Distributions of salinity tolerances can be created from databases (right)
- Examine degree of overlap to determine risk to the assessment endpoint (species richness)

Hart et al. (2003) A. J. Bot. 51: 689-702

Risk Management: Putting ERA to use

- ERA can be used to support management decisions
- Natural resource managers must make decisions under uncertainty. They seek to balance possibility of making TWO kinds of mistakes:

  1. False alarm - declaring an impact when there is none

  2. False security - declaring a project is safe when it leads to unacceptable impact

- The ERA will sometimes be wrong
- If the process is done properly we can learn from our mistakes to do a better job in the future

REPORT

Fairview Field - Case Study of Associated Water Discharges

Prepared for

Santos

60 Edward St

Brisbane QLD

21st January 2009

43270896

URS

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…………………………….
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David Fuller
Senior Principal

Date:	21 January 2009
Reference:	Fairview Field – Case Study of Associated Water Discharges
Status:	FINAL

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Tables, Figures and Appendices

Appendices

Executive Summary

The Fairview Field provides a unique opportunity to investigate the impacts of discharge of untreated associated water that has occurred since at least 1993. The field is part of the larger Gladstone Liquid Natural Gas (GLNG) development but any surface water impacts are effectively isolated from other well fields by surface catchment boundaries. The Fairview Field (Petroleum Leases 90, 91, 92, 99, 100 and 232) lies entirely within the Upper Dawson River catchment.

The document is effectively an update of an earlier piece of work submitted to the Queensland EPA as an attachment in support of the Fairview Environmental Management Plan (Santos & URS, 2008).

Key additions are:

- A report on spring flows in and around Dawsons Bend which are believed to maintain flow in the river downstream of this point;
- The capture, interpretation and reporting of continuous water quality information;
- Updates to spot water quality data; and
- The investigation of stratification in pools.
- The report identified the environmental values for all the major streams in the vicinity of the Fairview Field (Dawson River, Hutton Creek and Baffle Creek) as:
- Protection of slightly to moderately disturbed aquatic ecosystems.
- Primary Industries: irrigation, water for farm use, stock watering, and human consumption of wild or stocked fish or crustaceans.
- Recreation & aesthetics: primary recreation with direct contact, and visual appreciation with no contact.
- Industrial uses.

Based on the protection of these values and taking into account local water quality records, a set of minimum guideline trigger levels are recommended in Section 3.

In Section 4, the existing flowing water environment is described in detail. Hutton Creek is largely ephemeral compared with the Dawson River which is found to be a permanently flowing stream maintained by spring flows in the vicinity of Dawsons Bend.

Water quality data is examined in Section 5 to understand the impacts of current associated water discharges to small intermittent streamlines on Baffle Creek, Hutton Creek and Dawson River. Significant differences in salinity concentrations were found between Dawson River waters upstream of associated discharge and downstream of the Hutton Creek outflow. By Yebna Crossing however, dilution is sufficient under existing associated water discharges to reduce salinity to background levels.

Sites receiving associated water discharge on Hutton Creek, Baffle Creek and the Dawson River generally exhibit similar characteristics, with the exception of increased concentrations of one or more of fluoride, sodium, boron, EC and occasional pH.

The river health of major streams is examined in Section 6 and it is concluded that there is some evidence that Hutton Creek at FV66 and Baffle Creek fauna may be affected by associated water discharges. The changes

Executive Summary

are subtle and are not reflected in AusRivas bands. In general, the data set is minimal and differences may simply arise from sampling variability.

In Section 7, consideration is given to the environmental impacts of permeate discharge from the planned Pony Hills Water Treatment Plant (PHWTP) and the possible Central Treatment Plant (CTP). It is concluded that permeate release from PHWTP should be no higher than 500 µS/cm in order to maintain the salinity at Utopia below Central Queensland Guideline value of 340 µS/cm. Moderate improvements in water quality in Hutton Creek are expected from the permeate discharge and little loss of habitat is likely to occur due to increased flows.

For the CTP, the increased volume of permeate means that releases should be no greater than the guideline value if Utopia salinity is to be maintained at this level. Additional investigations are required to understand the environmental impact of releases from this plant.

Introduction and Catchment Context

1.1 Introduction

The Fairview Project Area lies within the Upper Dawson River catchment that extends upstream and westwards from Taroom encompassing the townships of Injune and Wandoan (Figure 1-1). The catchment contains extensive but largely ephemeral or intermittent stream networks. Major streams in the area are the Dawson River, Hutton Creek, Baffle Creek, Juandah Creek, Eurombah Creek, Commissioner Creek and Broken Creek.

Coal Seam Gas (CSG) production at Fairview has occurred since at least 1993 initially under the control of the Tri-Star Petroleum Company (1993 – 2002), then Tipperary Oil and Gas (Australia) Pty Ltd. (TOGA, 2002 – 2005). In September (June) 2005 TOGA was purchased by Santos Ltd.

Associated water discharge to grade has occurred throughout this period into small, often intermittent, streamlines or gullies that, in turn, discharge to Baffle Creek, the Dawson River or Hutton Creek. Santos captures associated water with salinity greater than 3,500 µS/cm for plant works or for injection into the basement Timbury Hills Formation.

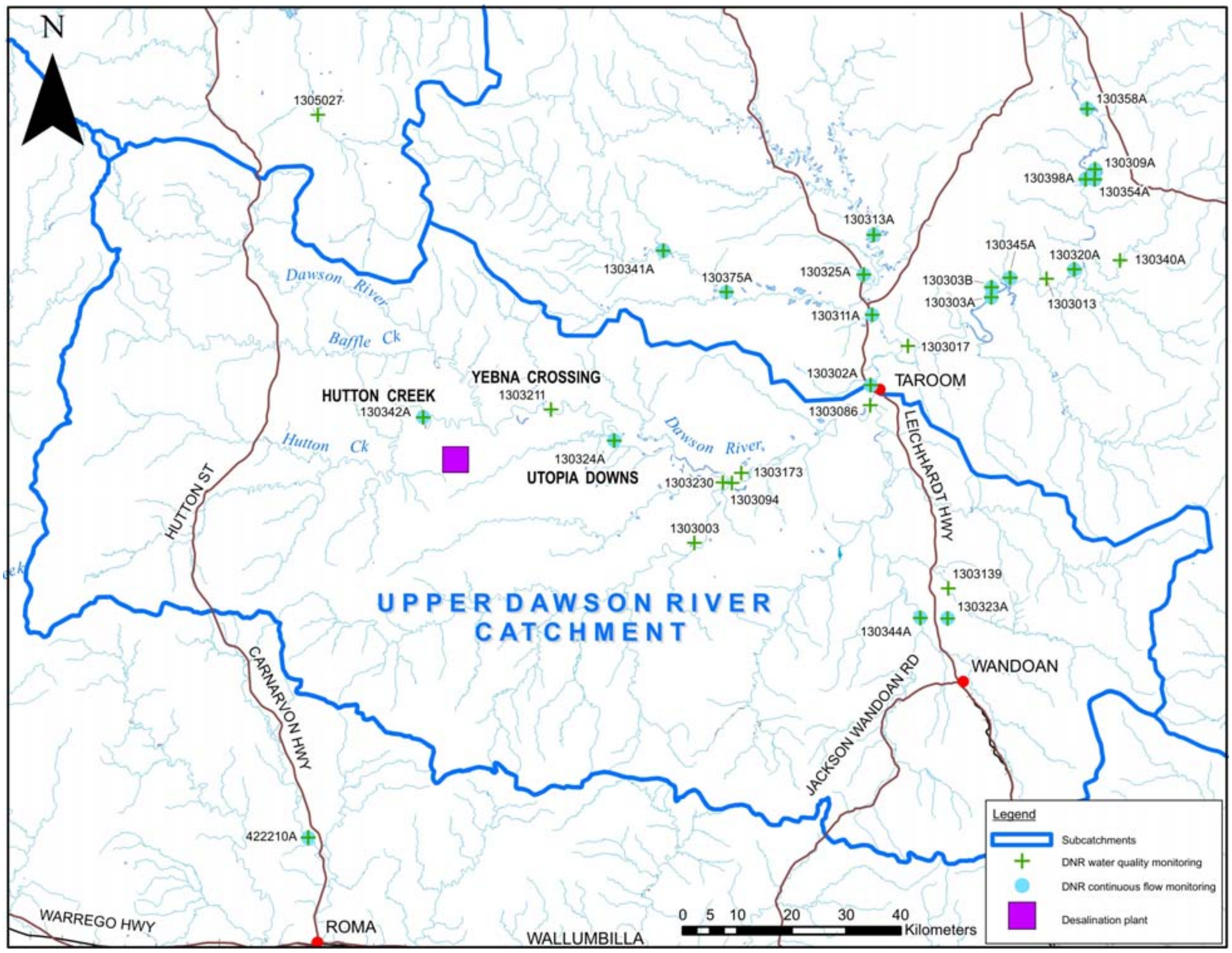


Figure 1-1 Upper Dawson River Catchment

1.2 Catchment Context

Since the initial settlement of Taroom circa 1850, the primary land use in the Dawson River catchment has traditionally been sheep and cattle grazing. This remains the predominant land use in the Upper Dawson River circa the Fairview and Springwater homesteads.

Downstream of Hutton Creek, grazing, forestry and cropping are widespread. A number of water storages and weirs are located on the Dawson River from Taroom downstream and are used for irrigation and recreational purposes supporting regional industry and urban communities.

The State of River report (Telfer, 1995) provides indicators of the physical condition of the Dawson River and its tributaries upstream of Utopia Downs station. In general the condition of land immediately adjacent to the State of River study reaches (i.e. the reach environs index) is rated very good for the Upper Dawson River, moderate for the Hutton Creek, poor for Christmas Creek, and good for Baffle Creek. Only 9% of land was considered in poor condition.

Bed and bar stability has been rated as moderate to very stable along 90% of the catchment stream lengths. However, evidence of both aggradation and erosion is widespread. Large-scale land clearing of native vegetation across the catchment has resulted in land degradation with evidence of sheet, rill and gully erosion on over 80% of the cultivated areas of the catchment (Telfer, 1995).

Although stream bank stabilities in the upper Dawson River catchment area stream banks were ranked as moderate to very stable across approximately 95% of the stream lengths, widespread streambed erosion is common. This has been largely attributed to overgrazing of the streambed and banks, and runoff from cattle pads leading to watercourse or adjacent to streams causing bank scouring (Simmons and Bristow, 2007). Much of the soil displaced as a result of the widespread erosion of cultivated and grazed areas has been deposited in tributaries and alluvial plains in the downstream area.

Riparian vegetation along Dawson River at Yebna crossing has been rated exceptionally high. Baffle Creek and Hutton Creek also have areas of dense riparian vegetation in inaccessible areas. However, in the more accessible areas of these creeks and in agricultural areas of the Dawson River upstream of the confluence with Baffle Creek animal access and clearing has lead to significant degradation of riparian condition. Over 70% of stream lengths in the area are ranked as having moderate to poor aquatic vegetation.

Aquatic vegetation along the entire upper Dawson River catchment is rated as poor to very poor. This is likely due to extreme dry conditions experienced at the time of survey. Aquatic habitats within the region are considered moderate to very good in over 80% of the stream length due to the relatively good riparian vegetation. However instream passage for aquatic organisms over reach lengths is restricted by logs or low to non-existent flows. Numerous road crossings, bridges and fords are also evident throughout the area, which in a number of locations, provide significant barriers to upstream fish movement under low flow conditions (e.g. Yebna crossing).

Scenic and recreational value ratings within the upper Dawson River catchment are predominantly good to very good. This is substantiated by the range of activities recorded as currently being undertaken in the Upper Dawson such as BBQs and picnics, day bushwalking, car camping, shore fishing and swimming. Areas of inherent natural beauty and scenic natural settings were identified in the State of River Report as major factors contributing to the overall scenic value.

Environmental Values

Environmental values are broadly defined in the EPP(Water) as maintaining water quality suitable for the biological integrity of an aquatic ecosystem (modified or pristine); recreational use; minimal treatment before supply as drinking water; agricultural use; and industrial use. Queensland EPA (2005) provides further clarity on the definition of environmental values based on the EPP (Water) and National Water Quality Management Strategy (NWQMS):

- Protection of aquatic ecosystems: ranging from high conservation/ecological value systems, slightly to moderately disturbed ecosystems, and highly disturbed systems.
- Primary Industries: irrigation, water for farm use (such as in fruit packing or milking sheds), stock watering, and human consumption of wild or stocked fish or crustaceans.
- Recreation & aesthetics: primary recreation with direct contact, and visual appreciation with no contact.
- Drinking Water: raw drinking water for human consumption.
- Industrial uses: includes power generation, manufacturing plants.

Dawson River and Hutton Creek and its tributaries do not have prescribed environmental values listed under EPP (Water) Schedule 1. Since similar land uses exist across the entire Upper Dawson River catchment it is expected that the same environmental values will apply to all streams. The relevance of each of the above environmental values to these streams is therefore considered at the catchment scale in the following discussion.

Protection of aquatic ecosystems is applicable to all stream lengths within the proposed development area. The waterways of the upper Dawson River catchment are considered predominantly to consist of “slightly to moderately disturbed ecosystems” based on the State of the River Report for the region (Telfer, 2005). These are “systems that have undergone some changes, with aquatic biological diversity affected to some degree but the natural communities are still largely intact and functioning”.

Water allocations under the Dawson Valley Water Supply Scheme are primarily for the purposes of ‘agriculture’ or ‘any’ (DNRM, 2006). Significant allocations are made along the Dawson River from approximately 20 km downstream of Taroom to the Fitzroy River junction. Some allocations are also made upstream of Taroom approximately 90 km downstream from Fairview. Allocations are for stock watering, irrigation and industrial water use. Between the Hutton Creek Junction and Fairview it is evident from river health surveys (EnviroTest various, Simmonds and Bristow, 2007 & 2008) that stock access waterways in this area from time to time. However, stock access to the Dawson River is generally limited due to steep banks.

Fishing is a widespread recreational activity along the Dawson River including upstream of Yebna Crossing only 12 km downstream of Fairview (Mr Radel pers. comm.). Other recreational activities such as swimming are possible but realistically only along the Dawson River downstream of Yebna Station. Access along the Dawson River is restricted due to steep banks and limited road crossings. Swimming is probably occasional and intermittent. At Taroom, treated groundwater supplies are used to maintain the local swimming pool. Without specific evidence of swimming, primary contact recreation has not been identified as an environmental value.

Along the Dawson River downstream of Taroom, the Glebe Weir is utilised for primary recreation (such as swimming) and secondary recreation purposes (such as canoeing and fishing) (Taroom Shire Council pers. comm.). It is possible that other waterholes upstream and downstream along the Dawson River are also used for local recreational purposes. The aesthetics of the waterways are of relevance with parts of the region considered to be of “inherent natural beauty” (Telfer, 1995).

Section 2 Environmental Values

The towns of Taroom and Injune draw drinking water from an artesian groundwater supply. Water from the Dawson River is used in the urban setting for irrigation of schools and sports fields only. It is understood that residential properties within the catchment but outside of the townships utilise rainwater or borewater for drinking purposes (Taroom Shire Council pers. comm.). On this basis the environmental value of drinking water is not considered to apply to the upper Dawson catchment. Whilst the possibility exists that local properties not connected to water supply will draw water from the river for personal use under riparian rights this is considered unlikely.

The following environmental values have therefore been identified as relevant to the Hutton Tributary, Hutton Creek and Dawson Rivers (Table 2-1).

Table 2-1 Environmental Values for Major Streams - Upper Dawson River

- Protection of slightly to moderately disturbed aquatic ecosystems.
- Primary Industries: irrigation, water for farm use, stock watering, and human consumption of wild or stocked fish or crustaceans.
- Recreation & aesthetics: primary recreation with direct contact, and visual appreciation with no contact.
- Industrial uses.

Water Quality Guidelines and Objectives — Section 3

3.1 Water Quality Guidelines

The National Water Quality Management Strategy (ARMCANZ & ANZECC, 1994) has been adopted in Queensland through the EPP (Water).

The relevant water quality guidelines for Queensland in order of preferred use are:

- Locally derived guideline values;
- Queensland Water Quality Guidelines (QWQG) which provide guideline values tailored to Queensland regions and water types and were published in 2006 (there have been various updates since that time); , or
- Where the QWQG or local guidelines are not available, the default guidelines are the Australian Water Quality Guidelines (AWQG) published by ANZECC & ARMCANZ (2000).

The EPP(Water) specifies WQOs for some water bodies throughout Queensland (Schedule 1). The water bodies within the Fairview field area are not listed, therefore WQOs become are the minimum set of water quality parameter values that will ensure each of the identified environmental values is maintained. However, the derivation of WQOs must also take into account social, economic and current condition factors. In many instances the technical guideline value may prove to be technically and economically unacceptable. Queensland EPA provides guidance on establishing draft WQOs for a waterway (QLD, 2005).

There have been no officially endorsed WQOs developed for the catchments influenced by the GLNG field development. For the purposes of evaluating and comparing the existing surface water quality and the predicted quality of associated water the appropriate guideline trigger values have been used as a point of comparison. Where several trigger values are available to protect different environmental values the most conservative, or minimum trigger value (MTV), has been adopted.

The QWQG defines fresh waterways as either:

- Upland stream: small (first, second and third order) upland streams (surrogate = altitude >250m): moderate-to-fast flowing due to steep gradients, substrate usually cobbles and bedrock, sometimes gravel, rarely sand or mud; or
- Lowland stream: larger (third, fourth and fifth order), slow-flowing and meandering streams and rivers, gradient very slight, substrates sometimes cobble and gravel but more often sand, silt or mud.

The predominant characteristics of the discharge streamlines, Hutton Creek, Baffle Creek and the Dawson Rivers are in keeping with the definition of lowland freshwater waterways.

3.1.1 Water Quality Trigger Values Based on Guidelines

Based on an examination of the Queensland and national water quality guidelines a set of MTVs has been identified for the Dawson River, Baffle Creek and Hutton Creek (**Table 3-2**). Since aquatic ecosystem protection generally provides the most restrictive guidelines which protect all environmental values only those water quality parameters identified for this purpose have been included in the table.

3.1.2 Minimum Trigger Values Based on Local Data

The QWQG also establish a framework for deriving and applying local guidelines for Queensland waters. Development of local guideline values is important as they reflect existing local conditions which may vary substantially from broader guidelines developed at the regional scale. Local guidelines can therefore take into account natural and anthropogenic influences on water quality and flow that would not otherwise be recognised.

The preferred means of establishing local water quality guidelines is to establish reference condition (background condition, most commonly subject to minimal disturbance, but may be modified from natural condition) immediately upstream of an activity, or in the immediate region. Guidelines for reference condition must be derived from a minimum of at least 18 samples from one or more reference sites (QWQG, 2006).

Sufficient spot water quality data is available to establish local guideline values at the sites shown in Table 3-1. Twentieth and eightieth percentile values of water quality data from Dawson River at Utopia Downs are shown in **Table 3-2** for comparison with the guidelines. Cells are shaded where local data exceeds water quality guidelines.

Table 3-1 Spot water quality sampling sites with significant data

Sampling Site	Water Quality Parameter
Upper Baffle Creek[1]	Temp, EC, TDS
Lower Baffle Creek[2]	Temp, EC, TDS
Dawson R d/s Baffle Ck[2]	Temp, EC, TDS
Dawson R at Yebna Crossing[2]	Temp, EC, TDS
Dawson R at Utopia Downs[2]	Temp, pH, DO, EC, TDS, TSS, Na, K, Mg, Ca, HCO3, Cl, F, SO4, TN, TP, NH4, NO3, B, Cu
Dawson R at Taroom[2]	Temp, EC, TDS

Note:

1 upstream of associated water discharges

2 downstream of associated water discharges

It should be noted that while the site Dawson River at Utopia Downs (1964 – 2007) has the most significant set of spot sample water quality data, it also lies downstream of existing associated water discharges. The data from this site were therefore examined for differences in median water quality parameter values before and after associated water discharges commenced using two sided Mann-Whitney U tests at 95% significance. The only water quality parameter with a significant increase in median concentration was Boron. Other parameters with significant shifts in median values were EC, TDS, Ca, Mg, Alkalinity, Cl and SO_4. All these parameters exhibit a reduction in concentration pre to post associated water discharges. Details of the statistical tests are provided in Section **5.4.4**.

The data from Dawson R at Utopia Downs was therefore used to derive 20th and 80th percentile water quality values for comparison with the guideline based water quality objectives (**Table 3-2**). The local data suggests that guideline trigger values should be relaxed for nutrients, turbidity and suspended solids. These parameters are not of particular interest in the following discussion of the impacts of associated water discharges.

Table 3-2 Relevant MTV for major streams in the Upper Dawson River catchment

WQ PARAMETER	UNITS	QWQG 2006[a]		ANZECC GUIDELINES 2000				MTV	Local Data[#]	
		Lowland	Upland	Aquatic Ecosystems[b]	StockWater	Irrigation[c]	Recreation		20%ile	80%ile
Temperature*	^oC	20%ile-80%ile	20%ile-80%ile	NA	NA	NA	15-35	**	14.7	26.1
pH	units	6.5-8.0	6.5-7.5	NA	NA	6-9	6.5-8.5	6.5-8.0	7.56	8.1
Electrical Conductivity (at 25°C)	µS/cm	340[d]	340[d]	NA	NA	<650[e]	NA	340[a]	223	330
Dissolved Oxygen	% Sat.	85-110	90-110	NA	NA	NA	>80	85-110	**72**	86
Total dissolved solids	mg/L	-	-	-	4000[f]	-	1000	1000	131	189
Total suspended solids	mg/L	10	-	NA	NA	NA	1000	10	9	**124**
Turbidity	NTU	50	25	NA	NA	NA	NA	50	7.0	**100**
Sodium	mg/L	-	-			<115[e]	300	<115	24	38.1
Potassium	mg/L							-	3.3	4.7
Calcium	mg/L	-	-		1000	-	-	1000	13.0	21.0
Magnesium	mg/L							-	4.48	8
Alkalinity HCO_3	mg/L							-	104	153
Chloride	mg/L	-	-	-	-	<175[e]	400	<175	18.0	32
Fluoride	mg/L	-	-		2[g]	1		1	0.1	0.16
Sulphate	mg/L	-	-		<1000		400	400	1	3.2
Total nitrogen	µg/L	500	250	NA	NA	5000	NA	500	118	**795.8**
Total phosphorous	µg/L	50	30	NA	NA	50	NA	50	21.7	**146**
Ammonia	µg/L	20[1]	10	900	NA	NA	NA	20	8	**37.3**

[1] It is noted that the Queensland guideline table suggests that trigger values for ammonia-N are equivalent to ANZECC (2000) guidelines. This is incorrect and possibly indicates that EPA has misinterpreted the national guideline triggers for ammonia- N and ammonium ion concentrations.

Section 3 Water Quality Guidelines and Objectives

WQ PARAMETER	UNITS	QWQG 2006[a]		ANZECC GUIDELINES 2000				MTV	Local Data[#]	
		Lowland	Upland	Aquatic Ecosystems[b]	StockWater	Irrigation[c]	Recreation		20%ile	80%ile
Oxidised nitrogen (NOx)	µg/L	60	15	NA	400,000[k]	NA	NA	60	**138**	**524**
Boron	µg/L	-	-	370	5000[i]	500	1000	370	20	100
Copper	µg/L	-	-	1.4	1000[g]	200	1000	1.4	0.02	0.05
Chlorophyll-a	µg/L	5	n/a	NA	NA	NA	NA	5		
Arsenic	µg/L	-	-	24/13[j]	500[g]	100	50	24/13	-	-
Cadmium	µg/L	-	-	0.2	10[g]	10	5	0.2	-	-
Chromium	µg/L	-	-	1.0 (CrVI)	1000[g]	100	50	50	-	-
Iron	µg/L	-	-	300 (interim)	-	200	300	200	-	-
Lead	µg/L	-	-	3.4	100[g]	2000	50	3.4	-	-
Mercury	µg/L	-	-	0.6	2[h]	2	1	0.6	-	-
Nickel	µg/L	-	-	11	1000[g]	200	100	11	-	-
Zinc	µg/L	-	-	8	<20000	2000	5000	8	-	-

NOTES

a Guideline trigger values for protection of aquatic ecosystems (Central Coast Region)

b Values for 95% protection of aquatic ecosystems

c Values for long term irrigation trigger chosen as most conservative

d 75th percentile of EC in relevant salinity zone (Fitzroy Central). Source QWQG (2006)

e For sensitive crops

f Suitable for beef cattle and horses

g May be hazardous to animal health if exceeded

h Mercury may accumulate in edible animal tissues >2 µg/L and may therefore pose a human health risk

i Higher concentrations of Boron (>5000µg/L) may be tolerated for short periods of time.

j AsIII/AsV respectively

k For nitrate

NA indicates not applicable as QWQG take precedence

\- indicates no applicable guideline value

(yellow) These cells are the most conservative parameter values to satisfy all environmental values

(green) These cells are the relevant water quality objectives for streams in the Upper Dawson River catchment.

n/a Not available

^ MTV – minimum trigger value

Based on analysis of data from Dawson R at Utopia (1964 – 2007) DO in mg/L converted to % saturation assuming observed temperatures for samples with DO similar to percentiles

* The QWQG recommends setting temperature guidelines for protection of aquatic ecosystems so that median discharge temperature lies within the 20th and 80th percentiles of observed temperature variations. Significant diel and seasonal variation in temperature are evident within river systems. Ensuring an appropriate data set from which to identify these percentiles is problematic since samples are often collected in particular seasons and during daylight hours.

3.2 Application of Water Quality Guidelines

The guideline trigger values can be used as a benchmark against which potential developments or discharges can be assessed. However, in assessing the impacts of any discharge to the environment the guidelines should not be used on a pass or fail basis, but rather within a risk assessment framework (s3.1.1.3, ANZECC & ARMCANZ, 2000).

The in-stream dynamics of water flow and quality (as well as the interactions between contaminants) make it difficult to make definitive statements regarding the environmental effects of particular levels of water quality. QWQG and AWQG suggest the use of aquatic health measures in preference to physico-chemical measures since ecological systems reflect the full range of conditions encountered including droughts, floods, and episodic changes in water quality.

Setting water quality guideline values for ephemeral streams is problematic and is not dealt with definitively by either by the QWQG or the AWQG. Notes within the QWQG recognise that ephemeral streams and residual pools will have poorer water quality (particularly dissolved oxygen and nutrients) than flowing streams. Due to evaporative concentration of salts within pools, it can be expected that salinity would also be marginally poorer in such systems when compared with flowing waters.

Smith *et. al.* (2004) completed a literature review of the effects of mining discharges to ephemeral waters identifying a wide range of ecological responses to water quality. Responses were dependent upon factors such as the level and continuity of exposure to contaminants, the type of contaminants, and the nature of the fauna.

It is therefore appropriate to consider the ecological risks of any changes in water quality likely to arise from any discharges. There is significant local information on flows, water quality and river health in the Upper Dawson River catchment to support this type of assessment.

Section 4 Existing Environment - Flow Regimes

4.1 Upper Dawson River and Tributaries

Baffle Creek, Dawson River upstream of Baffle Creek and Hutton Creek are predominately ephemeral streams. Under natural dry season conditions, Baffle and Hutton Creeks have dry beds interspersed with reasonably deep freshwater pools that probably act as refugia for flora and fauna. While no flow records are available for Baffle Creek, the nature of the streamline, catchment size, geology, aspect and close proximity to Hutton Creek suggest similar flow regimes can be expected.

The Dawson River dries up above the confluence with Baffle Creek, with some pools observed higher up the catchment. Downstream of Baffle Creek the Dawson River appears to maintain deep pools even during dry periods. Downstream of Hutton Creek, the Dawson River appears to be a continuously flowing stream probably maintained by spring flows.

Minor streamlines that feed these watercourses have intermittent flows and few refugia even during the wet season.

Flow and water quality records are available from a number of DNRW stations in the area (Figure 4-1).

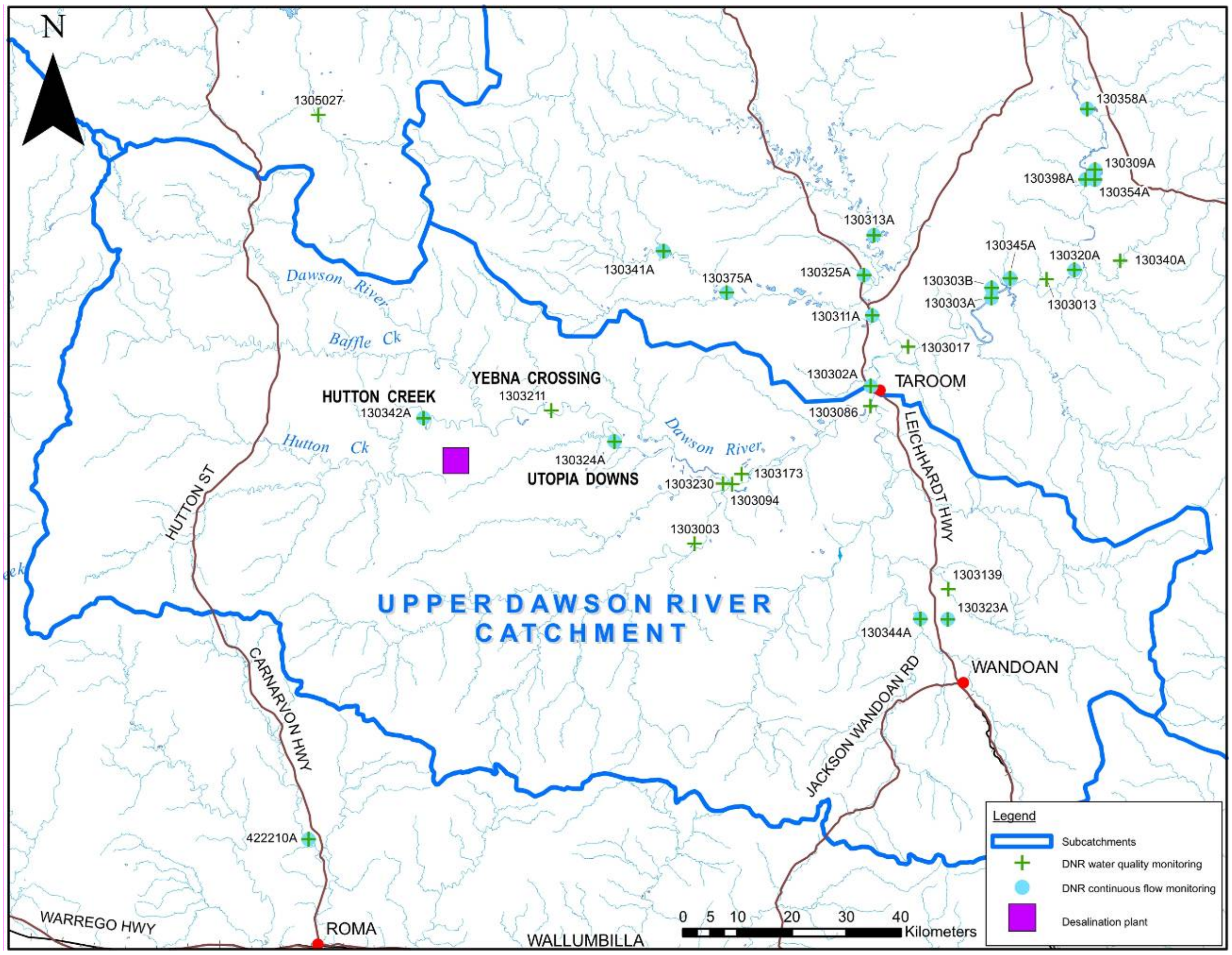


Figure 4-1 DNRW Data Collection in the Upper Dawson Catchment

Existing Environment - Flow Regimes

Flow records from Hutton Creek (1972 - 1988) show substantial seasonal variation in flows. Monthly average flows exceed 33 ML/day (~1000ML per month) in Hutton Creek on average one month in three. For wet season months there is a 50:50 chance of monthly flows exceeding 33 ML/day. Maximum recorded average monthly flow in Hutton Creek is 18,275 ML/day. The maximum recorded peak flow rate in Hutton Creek is 36,542 ML/day.

Flow records from Dawson River at Utopia (1966 – current) and from Dawson R at Taroom also show substantial seasonal variation in flows. The relative magnitude and peakiness of monthly average flows are shown for Hutton Creek, Dawson R at Utopia and Dawson R at Taroom in Figure 4-2.

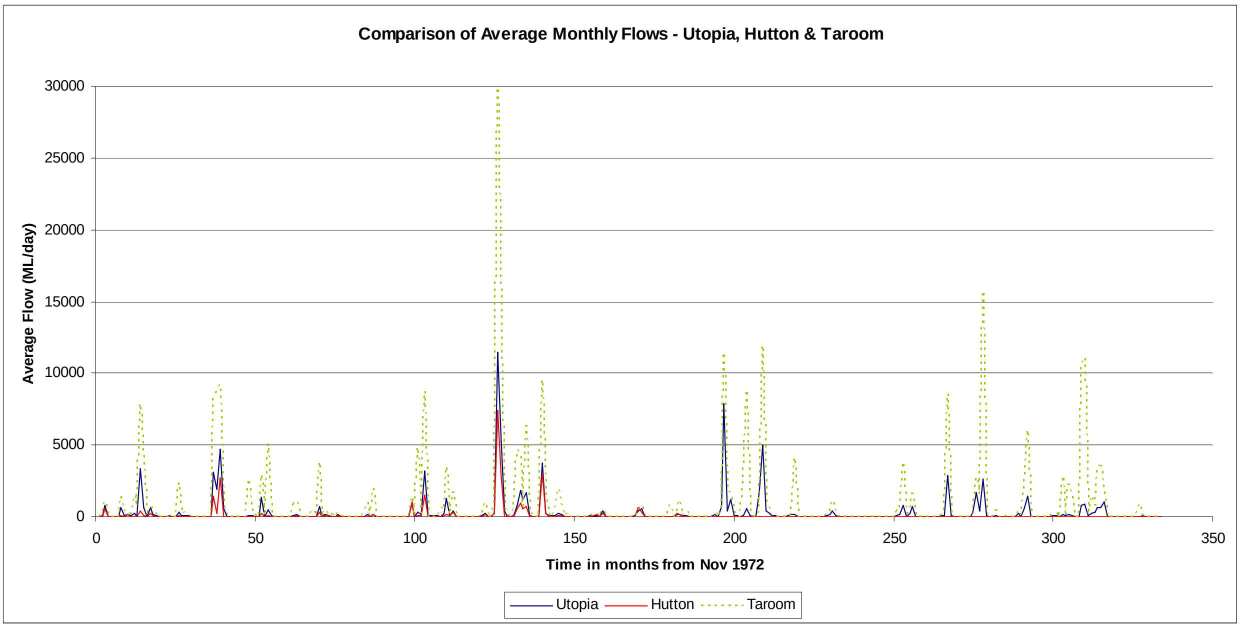


Figure 4-2 Observed Average Monthly flows in Upper Dawson Catchment

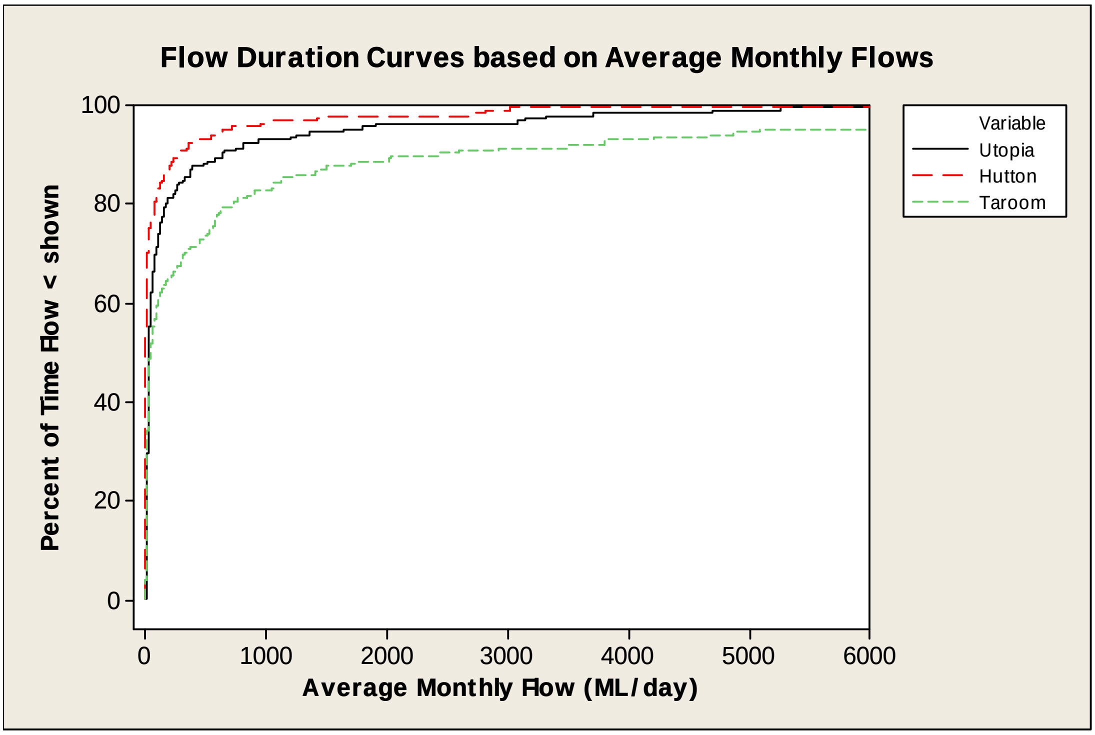
Comparison of flow regimes is difficult from simple time series plots like the one shown above.

Flow duration curves are empirical cumulative distribution functions derived from observed flow data. They demonstrate the proportion of time that flows are less than or greater than particular values.

Figure 4-3a) is the flow duration curve for Hutton Creek, Dawson R at Utopia and Dawson R at Taroom truncated at 6000 ML/day for clarity - it normally extends to 35000 ML/day.

Figure 4-3 b) has been further truncated to demonstrate the low flow behaviour of each of the streams. It is clear that Hutton Creek regularly dries up. Based on the records, Dawson R at Utopia and Dawson R at Taroom are continuously flowing streams.

a) Full Duration Curve



b) Low Flow Portion of Flow Duration Curve

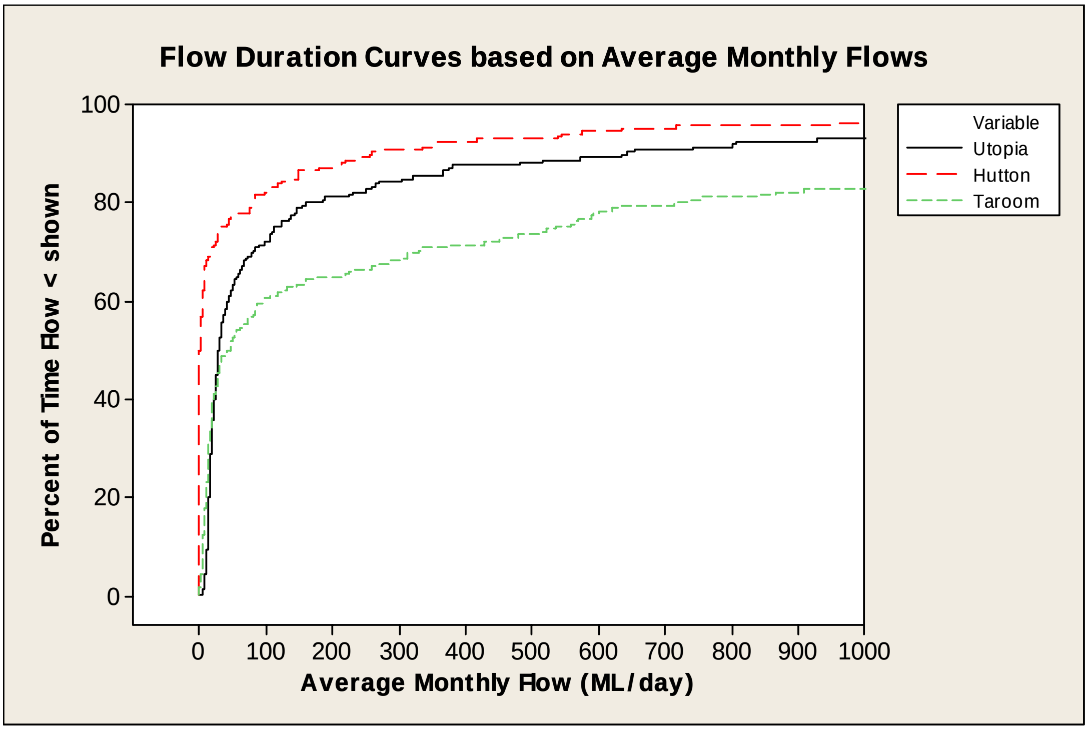


Figure 4-3 Duration Curves for Recorded Flows Upper Dawson River Catchment

4.2 Dawson River Spring Flows

Stream gaugings under baseflow conditions at the end of the 2007 dry season show there are substantial freshwater inputs to the Dawson River downstream of the Hutton Creek confluence (URS, *unpub. data*) with over 80% of the flow (Table 4-1) at Yebna Crossing coming from the shaded area in Table 4-4. According to a local land owner (Radel, pers. comm.) there are significant inflows to the Dawson River from a spring fed creek approximately 2km downstream of the Hutton Creek confluence. Discharges from the Dawson River stream banks have also been observed in this area during river health surveys (S. Anderson, *pers. comm.*). Queensland EPA (2008) provides maps of springs that support these observations (Figure 4-5).

Table 4-1 Low flow gauging and water quality Upper Dawson River, October 2007

Site	Discharge (L/s)	Discharge (ML/day)	Electrical Conductivity (µS/cm)
Dawson d/s Baffle Creek	30	2.6	1500
Hutton u/s Dawson River	7	0.6	1400
Dawson River at Yebna Crossing	210	18.1	290
Estimated Spring Flows[1] Hutton Creek Confluence to Yebna	*173*	*14.9*	*35*

Notes: [1]by mass balance calculation

Spring inflows are fresh, but it seems unlikely that their electrical conductivity (EC) is as low as calculated in Table 4-1. Background EC in the Dawson River at Dawsons Bend at Yebna is normally of the order of 250 µS/cm. This is similar to the median water quality in water bores in the Precipice and Hutton Sandstone aquifers. Nevertheless, continuous EC records have occasionally detected values as low as 57 µS/cm at Utopia (DNRW data). Presumably this reading is representative of locally fresh spring flows, but the possibility of instrument error or incorrect calibration also exists.

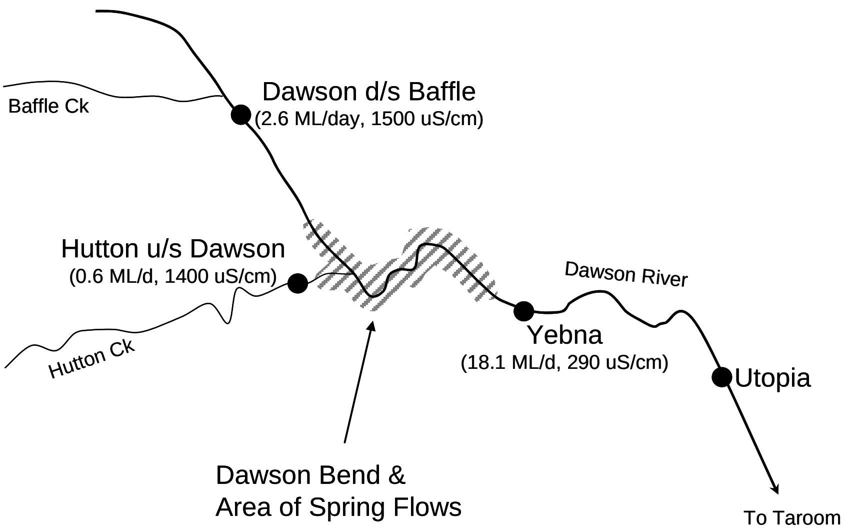


Figure 4-4 Dawson River springs area, flows and salinities, October 2007

Section 4 Existing Environment - Flow Regimes

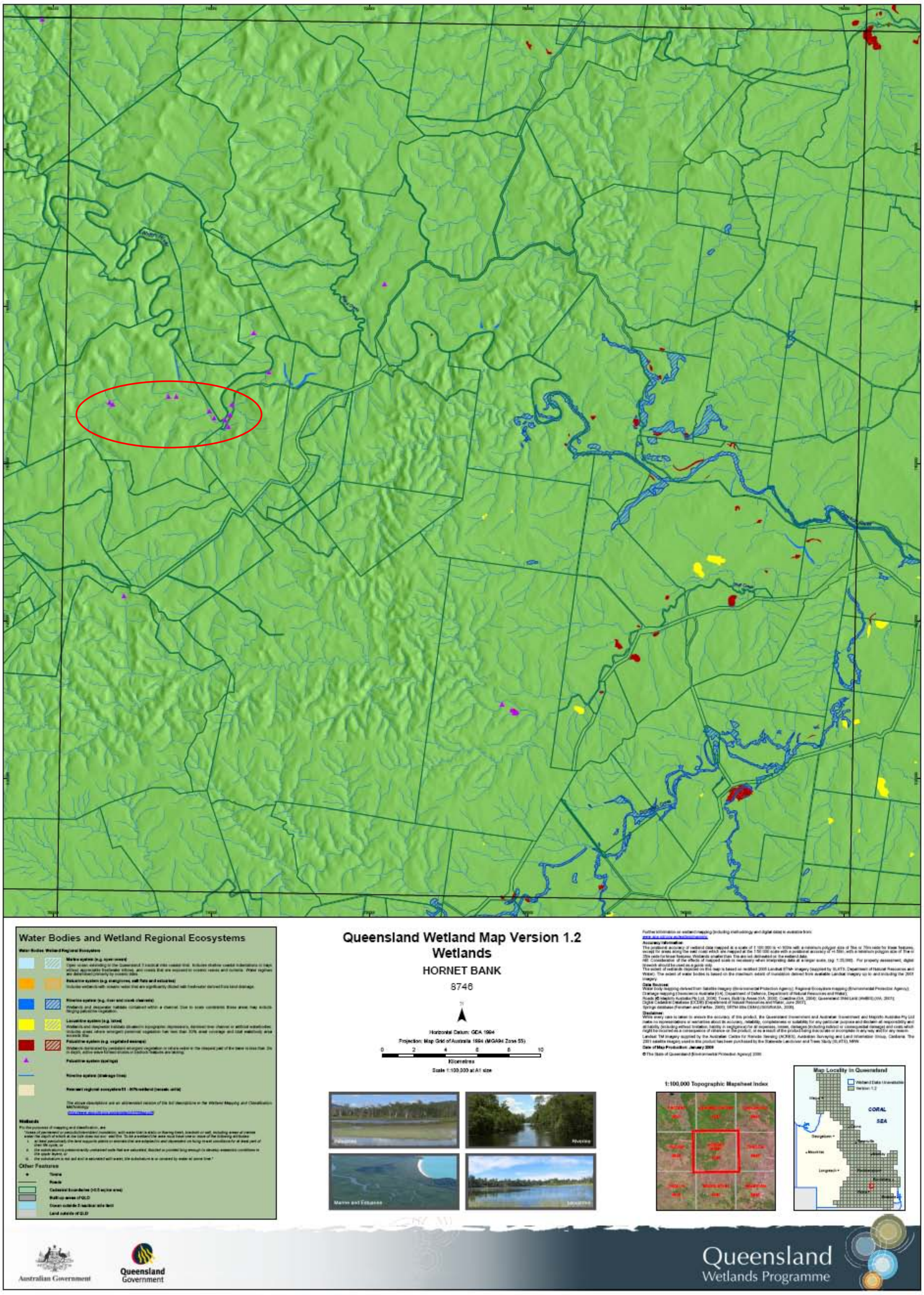


Figure 4-5 Springs in the vicinity of Dawson Bend and Hutton Creek

Existing Environment - Flow Regimes

During March 2008 a detailed investigation was undertaken of the flows and water quality of springs discharging into the Dawson River along the reach extending Yebna Crossing upstream to the outflow of Hutton Creek to Yebna Crossing. Travel further upstream was restricted by topography.

Physical parameters (pH, EC, temperature, turbidity and DO) were measured using a Hydrolab™ MS-5 multiprobe instrument at each spring inflow and at approximately 200 m intervals along the Dawson River. Where sufficient spring flow was present water samples were collected for laboratory analysis of a range of parameters (total metals, physico-chemical parameters, major cations and anions, nutrients indicators).

Flow measurements (gaugings) were taken where possible at springs and at regular intervals along the Dawson River. Gaugings were taken using a current meter to measure velocities at points along a cross section of the stream. Corresponding width and depth measurements were taken to provide an estimate of the flow.

With respect to flow regimes the survey identified[2]:

- More than thirty springs between the outflow of Hutton Creek and Yebna Crossing (Figure 4-6). Spring discharges ranged from very small bank seepages to flows of approximately 0.5 L/s.
- Extensive cattle access was evident particularly towards Yebna Crossing.
- A number of springs were noted in the stream bed and these appear to contribute the majority of flow in the area.
- Flow at Yebna Crossing was found to be approximately 250% greater than upstream of Dawson's Bend with the main contribution of flow occurring within 1.5 km downstream of Dawson's Bend.
- Flow at Yebna was 171 litres/second compared with 68 litres/second measured upstream of Dawson's Bend. Peak flow rate measured was 273 litres/second upstream of Yebna pond suggesting losses in or near the pond possibly to extractive use on the farm.
- Spring flows add significantly to the water flowing in the reach of the Dawson River downstream of Hutton Creek. It is estimated that the spring flow is approximately 17 ML/day.

The water quality of spring flows is discussed further in Section **5.3**.

[2] Raw data from Hydro Tasmania Consulting, 2008, provided in main report.

Section 4 Existing Environment - Flow Regimes

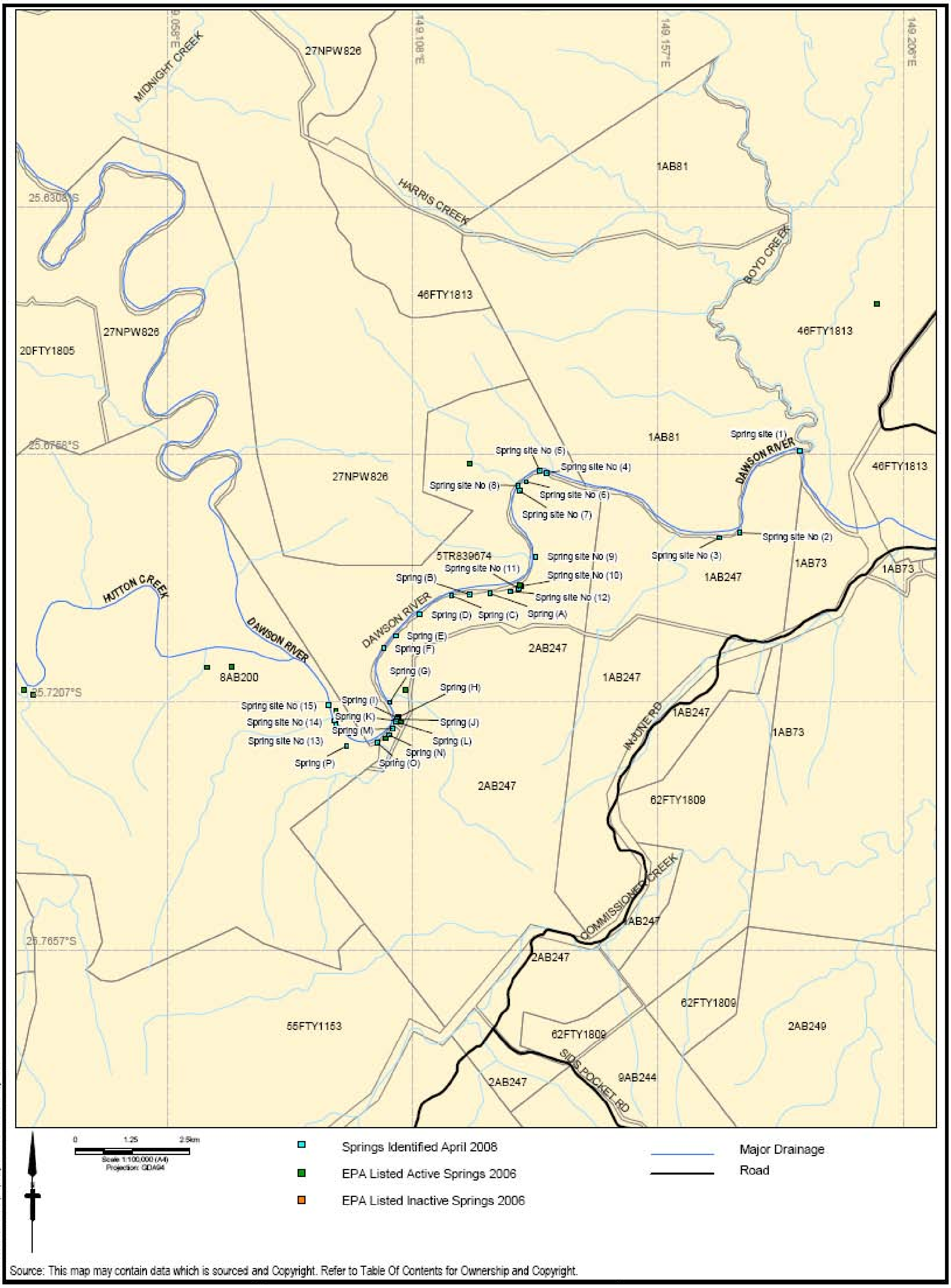


Figure 4-6 Dawson River spring locations

5.1 Overview of General Water Quality

Summaries of all available water quality data from sites upstream and downstream of the Fairview operations are provided in Appendix A. These tables are referred to throughout this section without specific reference.

Data were derived from the following sources:

- Monitoring data provided by Santos (from 1998 to 2002);
- River Health Assessments undertaken for Santos (from 2003 to 2007);
- Department of Natural Resources and Water (DNRW); and
- Spring flow and water quality assessment undertaken on behalf of Santos (URS, 2008).

Measurements of various water quality indicators have been collected including physical parameters, cations, anions, nutrients, trace elements and biological samples. In many instance too few samples are available to provide a fully representative set of water quality data.

5.1.1 Waters upstream of associated water discharges

The Upper Baffle Creek, Upper Hutton Creek and Upper Dawson River water quality monitoring sites lie above any influence from associated water discharge. When compared with the relevant MTVs (Table 3-2) these sites are characterised by:

Low Dissolved Oxygen (DO)

Many of the reported DO values are lower than would be reasonably expected and are likely to not be representative of actual conditions. If present the very low dissolved oxygen concentrations would be expected to cause stress to in-stream fauna and possible fish kills.

High pH

Waters in the Upper Dawson catchment are typically neutral to moderately alkaline (pH~8). However, recent field sampling (URS, 2008 unpub. data) shows some of the tributaries of the Dawson River naturally have pH circa 8.5.

High Boron

Concentrations of Boron were predominantly below the relevant MTV upstream of associated discharges with the exception of two slightly elevated concentrations in Dawson waterhole and upper Baffle creek. Boron is a widespread naturally occurring trace element of igneous rocks and is commonly found in sedimentary rocks of marine origin (ANZECC & ARMCANZ, 2000).

High Zinc

Several concentrations of zinc marginally exceeding the relevant MTV were detected at sites upstream of associated water discharges. Zinc is an essential trace element that adsorbs to suspended material. Toxicity of zinc can increase with low dissolved oxygen (ANZECC & ARMCANZ, 2000). However, levels of organic matter found in most freshwater streams are generally sufficient to remove zinc toxicity. Given the amount of suspended sediment and relatively low zinc concentrations found in these streams it is unlikely that zinc would present a significant water quality issue.

High Iron Content

There were a number of very high iron concentrations observed at sites upstream of associated water discharges. Iron does not present a risk to livestock or ecosystem health at the concentrations detected. The main issues associated with high levels of iron are precipitation and biofouling resulting in blockages of irrigation equipment (ANZECC & ARMCANZ, 2000).

High Suspended Solids (TSS) and High Turbidity

The soils and slopes in the area are susceptible to erosion. This has been exacerbated by the removal of vegetation in agricultural areas, and unrestricted stock access to streams. The nature of flooding in the area is a major factor driving suspended solids transport and erosion processes.

Chlorophyll-a and nutrient enrichment

Nutrient enrichment, high turbidity, high TSS and Chlorophyll a levels at sites upstream and downstream of associated water discharges suggest that these water quality issues are likely to be due to the general erosive nature of soils and existing grazing activities in the catchment.

Other Observations

There was one observation of lead marginally exceeding the MTV. Lead is generally present in very low concentrations in natural waters and is readily adsorbed to suspended matter.

Electrical conductivity readings upstream of associated water discharges are typically in the order of 150 µS/cm, but can range from 70 to 1,800 µS/cm.

5.2 Longitudinal Changes in Dawson River Water Quality

Water quality changes along the Dawson River were examined based upon data from five sites. Table 5-1 provides a summary of water quality data from these sites. Table 5-2 provides a list of significant differences in median water quality utilising a two-sided Mann-Whitney U Test at 95% confidence level[3].

The Upper Dawson River (at Arcadia) is a small stream upstream of any associated water discharges. Wide variation in EC is evident at this site and significant deviations from MTV are evident for TSS, iron and phosphorus/phosphate. High TSS and phosphorus readings at this site may indicate the effects of locally erosive soils, land clearing and/or animal grazing.

A statistically significant decrease in median temperature ($p<0.05$) is evident between Upper Dawson River and Dawson River d/s Baffle Creek. The Upper Dawson River is characterised by wide sand beds with shallow pools compared with deeper pools, narrower channel form and dense riparian vegetation downstream of Baffle Creek. The change in median temperature is within the variation that has been observed between open and shaded

[3] This test was used as water quality data is often significantly skewed and non-normal for some parameters. An alternative test would have been to test sample averages with t-tests after transformation of the data.

areas in the Dawson River (URS, 2008 unpub, data). No other significant changes in median temperatures were identified.

A statistically significant and large increase in median EC is evident between the Upper Dawson River (215 µS/cm) and Dawson River d/s Baffle Creek (876 µS/cm), followed by a statistically significant decrease back to near the Upper Dawson River median EC at Yebna Crossing (247 µS/cm). Between Yebna Crossing and Utopia (289 µS/cm) a statistically significant but small increase in median EC is evident. No statistically significant difference in median EC is evident between Utopia and Taroom. These results suggest there is a significant increase in EC due to associated water discharges from Baffle Creek, but sufficient dilution to return salinity to background levels at Yebna Crossing. This is consistent with the discussion of spring flows in Section 4.2.

The increase in salinity between Yebna and Utopia is small and may be the result of more saline spring flows between these two sites.

Downstream sites on the Dawson River are generally more saline than headwater sites. Median salinity (EC) at Utopia is significantly higher than in the Upper Dawson River. Median total dissolved solids at Yebna Crossing are significantly higher than at Upper Dawson River.

Table 5-1 Longitudinal water quality in the Dawson River

Water Quality Indicator		Units	MTV	Upper Dawson River				Dawson R d/s Baffle Ck				Dawson R at Yebna Xing				Dawson R at Utopia				Dawson R at Taroom			
				Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	340	50	215	1702	12	182	876	1498	24	110	247	435	46	78	289	551	139	87	260	525	288
	pH	Stand	6.5-8.0	6.6	7	7.1	5		7.1		1	7.2	7.75	8	6	7	7.81	8.5	138	6.5	7.6	8.5	228
	Temperature	C		15.4	25.5	28	12	13	23	28	23	12	24	28	43	8	22	77	122	9	23.1	31	182
	Total dissolved solids	mg/L	1000	46	146	194	12	124	596	1019	24	75	168	296	46	58	160	317	130	60	152	306	173
	TSS	mg/L	10	52	75	125	4		32		1	2	8	142	5	0	14.5	2460	114	2	50	4900	126
Inorganic Non-Metallic Parameters	Bicarbonate Alkalinity	mg/L - CaCO3	-	28	95	151	5		130		1	87	113.5	130	6	24	134	289	130				
	Chloride	mg/L	<175	3	8	12	5		20		1	19	20.5	22	6	3	25	70	130	4	20.6	59.9	140
	Fluoride	mg/L	1	0.1	0.1	0.24	5		0.31		1	<0.1	0.13	0.23	6	0.06	0.11	0.4	126	0.08	0.13	0.7	132
	Sulphate	mg/L	400	<1	5	<10	5		<1		1	<1	7.5	<10	6	0	2	13	97	0	2	11	116
Cations	Calcium	mg/L	1000	1	6	18	5		12		1	7	10.8	17	6	5.2	17	40	130	4.3	18	44	140
	Magnesium	mg/L		1	5	6.1	5		3.5		1	4	5.5	6.2	6	1.5	6.5	15	130	1.4	5.2	11.8	140
	Potassium	mg/L		<1	6	10.7	5		7.4		1	3	3.2	6	6	2.2	4	7.7	121	2.4	5.1	7.5	130
	Sodium	mg/L	<115	3	11	22	5		59		1	27	28	33	6	7.5	32.7	112	130	7.7	28	65.8	140
Nutrients	Ammonia-Nitrogen	µg/L	20	10		590	3		93		1	<10	10	14	3	0	20.1	150	56	4.3	31.8	163	53
	Nitrate as (NO_3^-)	mg/L			128		1		305		1		<44		1	2	192	7724	81	160	1080	10000	102
	Total Phosphorous	mg/L - P	50	<10	125	1900	4		76		1	<10	40	280	5	3	55	550	59	4	157	1387	71
Trace elements	Boron	µg/L	370	<100	<100	500	5		480		1	16	<100	600	6	0	20	170	73	10	50	1000	73
	Iron	µg/L	200	4407		5100	2		2300		1	76		390	3	1	165	460	3	10	60	4800	93
	Lead	µg/L	3.4	<1		3	2		<1		2		<1		2		<1		3				
	Zinc	µg/L	8	<1		14	2		20		1	<1		<10	2	<1		<10	2	10	20	700	60

NOTES: [shaded cell] Result greater than relevant MTV

Table 5-2 Differences in median water quality along the Dawson River

Water Quality Parameter Name	Units	Upstream			Downstream			Sig	p
		Site	Median	n	Site	Median	n		
Temperature	C	**Upper Dawson River**	25.5	12	**Dawson R d/s Baffle Ck**	23	24	▼	0.018
		Dawson R d/s Baffle Ck		24	**Dawson R at Yebna Xing**		43	-	0.558
		Dawson R at Yebna Xing		43	**Dawson R at Utopia**		122	-	0.278
		Dawson R at Utopia		122	**Dawson R at Taroom**	23	182	-	0.109
EC	µS/cm at 25C	**Upper Dawson River**	215	12	**Dawson R d/s Baffle Ck**	876	24	▲	0.0002
		Dawson R d/s Baffle Ck	876	24	**Dawson R at Yebna Xing**	247	46	▼	0.0000
		Dawson R at Yebna Xing	247	46	**Dawson R at Utopia**	289	139	▲	0.012
		Dawson R at Utopia		139	**Dawson R at Taroom**	260	288	-	0.719
Total dissolved solids	Mg/L	**Upper Dawson River**	146	12	**Dawson R d/s Baffle Ck**	596	24	▲	0.0000
		Dawson R d/s Baffle Ck	596	24	**Dawson R at Yebna Xing**	168	46	▼	0.0000
		Dawson R at Yebna Xing		46	**Dawson R at Utopia**		130	-	0.234
		Dawson R at Utopia	160	130	**Dawson R at Taroom**	152	173	▲	0.007

NOTES

Medians are only shown where a statistically significant difference has been identified.

Sig indicates statistically significant difference in medians at the 95% confidence level using a Mann Whitney U Test. Mann-Whitney U Test used as tests on variance indicate possible differences.

p indicates actual level of significance e.g. p=0.05 indicates a 95% chance that the medians are the different.

▲ and ▼ indicates an increase/decrease in median values from upstream to downstream.

\- indicates no significant change from upstream to downstream.

5.3 Water Quality circa the Dawson River Springs

Between the outflow of Hutton Creek and Yebna Crossing there are discharges to the Dawson River from freshwater springs. Water quality upstream, in the vicinity of, and downstream of springs is examined for differences. Table 5-3 provides a summary of available water quality data from sites in the vicinity of the Dawson River spring flows. Table 5-4 provides a summary list of statistically significant differences in water quality parameter values between these sites utilising a two-sided Mann-Whitney U Test at 95% confidence level.

Only limited data is available to explore differences in median water quality parameters at Dawson River d/s Hutton #1, Dawson River d/s Hutton #2 and Dawson Bend. These sites are closely spaced downstream of Hutton Creek and lie in the vicinity of the Dawson River spring flows. No statistically significant differences in median water quality parameter values were identified between these sites.

Between Dawson Bend and Yebna Crossing some statistically significant changes in median water quality parameter values are evident.

- Median sodium and chloride concentrations are higher at Yebna although there is no significant difference in median electrical conductivity.
- Median pH is significantly higher at Yebna than at Dawsons Bend.
- Median concentrations of calcium are significantly lower at Yebna based upon the full datasets. However restricting the analysis to data coincident at both sites did not lead to an indication that there is a significant difference in medians. This suggests that the variability of observed data is more limited at Dawson Bend given only six samples are collected. Data at Dawson Bend is from river health sampling and is biased towards conditions at the start and end of wet season when this sampling occurs.
- Additional data is required to clearly understand the implications of these results, however, they appear consistent with the observations of spring inflows in the area.
- A comparison of surface spring water quality with the Dawson River indicates:
- Water from the surface springs has a flow weighted EC 254 µS/cm, temperature 21°C and pH 6.8.
- Surface springs exhibit higher alkalinity, major ion and fluoride concentrations than the Dawson River. Concentrations of iron and zinc are substantially higher in spring flows compared with the Dawson River and lower Hutton Creek, above the MTVs (Table 5-3).

Table 5-3 Dawson River water quality circa spring flows

	Water Quality Indicator	Units	MTV	Lower Hutton Creek				Dawson R d/s Hutton #1				Dawson R d/s Hutton #2				Dawson Bend				Dawson R at Yebna Crossing				Springs			
				Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med^	Max	n
Physico-Chemical	Electrical Conductivity	µS/cm at 25C	340	131	233	**1294**	16	129	265	266	6	134	249	282	5	136	251	273	6	110	247	435	46	132	301	**890**	33
	pH	Units	6.5-8.0	6.6	7.85	**8.3**	16	6.2	6.95	7.4	6	7	7.2	7.6	5	6.4	6.9	7.3	6	7.2	7.8	**8**	6	5.8	7	7.8	33
	Temp	C	na	9.7	23.2	31	15	9.3	18.4	22.5	6	13.8	21.8	25.1	5	16.7	20.2	24.6	6	12	24	28	43	12.9	19.5	26.2	33
	TDS	mg/L	1000	5	28	630	16	88	126	160	6	124	160	922	5	92	129	220	6	75	168	296	46	90	205	605	33
	TSS	mg/L	10	-	-	-	-	3	**12**	**316**	6	3	11	292	5	4	**12**	**366**	4	2	8	**142**	5	-	-	-	-
Major Ions & Alkalinity	Bicarbonate Alkalinity ($CaCO_3$)	mg/L	na	65	100	820	16	54	112	150	6	56	111	150	5	55	118	157	6	87	114	130	6	55	125	280	22
	Chloride	mg/L	175	4	18	355	16	8	12.5	16	6	8	12	14	5	9	13.5	15	6	19	20.5	22	6	13	23	166	22
	Fluoride	mg/L	1	<0.1	0.1	1.4	12	<0.1	0.2	0.21	6	<0.1	0.17	0.21	5	<0.1	0.2	0.28	6	<0.1	0.13	0.23	6	<0.1	**1.2**	**1.3**	22
	Sulphate	mg/L	400	<1	5	170	12	<1	10	<10	6	<1	10	<10	5	<1	7.5	<10	6	<1	7.5	<10	6	<1	<1	64	22
	Calcium	mg/L	1000	5	16	85	16	1	15	21	6	1	14	26	5	1	14	19	6	7	10.8	17	6	4	21	91	22
	Magnesium	mg/L	na	2	5	67	16	2	7.5	9.2	6	2	7	11	5	<1	7.7	9.2	6	4	5.5	6.2	6	1	8	28	22
	Potassium	mg/L	na	2	5	10	16	3	3	5	6	3	3	6	5	2.3	3	5	6	3	3.2	6	6	2	2	9	22
	Sodium	mg/L	115	9	21	**280**	16	15	20.5	23	6	15	20	28	5	15	21	27	6	27	28	33	6	24	28	63	22
Nutrients	Ammonia (as N)	mg/L	0.02	<0.01	0.16	**0.24**	3	<0.01	**0.02**	**0.04**	4	<0.006		<0.01	3	<0.006		<0.01	3	<0.01	0.01	0.014	3	-	-	-	-
	Nitrate as NO_3	mg/L	na	0.1	1.2	4	9		<0.04		1		<0.04		1		<0.04		1		<0.04		1	-	-	-	-
	Total Phosphorous	mg/L	0.05	<0.01	**0.095**	**0.23**	5	<0.01	**0.05**	**0.58**	6	<0.01	**0.05**	**0.68**	5	0.02	**0.05**	**0.75**	5	<0.01	0.04	**0.28**	5	-	-	-	-
Metals	Boron	µg/L	370	<0.1	0.06	**800**	12	16	100	**400**	6	15	100	**400**	5	<0.1	7	**500**	6	<0.1	8	**600**	6	<100	<100	50	22
	Iron	µg/L	200	62	**1700**	**2358**	3	60		**1400**	3	66		**950**	3	23		**1200**	3	76		**390**	3	**140**	**1090**	**14900**	22
	Lead	µg/L	3.4	<1		2	2		<1		2		<1		2		<1		2		<1		2	<1	<1	**4**	22
	Zinc	µg/L	8	<10		1.5	2	<10		**17**	2	<1		<10	2	<1		<10	2	<1		<10	2	2.5	5	**21**	22

NOTES: **BOLD** Result greater than relevant MTV

^ for the purposes of calculating the median, where results are reported as less than the LOR a value of half the LOR has been adopted

Table 5-4 Differences in median water quality Dawson Bend and Yebna Crossing

WQ parameter	Units	Dawson Bend	Yebna Crossing	p	Sig
Electrical Conductivity	µS/cm at 25C	251	247	0.113	-
pH	Stand.	6.9	7.75	0.010	▲
Total Dissolved Solids	mg/L	129	168	0.1254	-
Total Suspended Solids	mg/L	12	8	0.462	-
Sodium	mg/L	21	28	0.010	▲
Potassium	mg/L	3	3	0.472	-
Calcium	mg/L	14.0	11.0	0.423	▼*
Magnesium	mg/L	7.5	5.5	0.066	-
Alkalinity as HCO3	mg/L	118	114	0.522	-
Chloride	mg/L	13.5	20.5	0.005	▲
Fluoride	mg/L	0.19	0.13	0.689	-

NOTES:

p indicates level of significance e.g. p=0.05 indicates a 95% chance that the medians are the different.

Sig indicates direction of statistically significant change.

* restricting data sets to coincident time pairs removes the significance of this result; all other results remain the same.

5.4 Existing impacts on water quality from discharge to grade

Sites that currently receive some associated water on Hutton, Baffle and the Dawson River generally exhibit similar characteristics to upstream sites, with the following exceptions:

Fluoride

At sites downstream of current associated water discharges, fluoride was detected marginally above the MTV. Fluoride occurs naturally usually in the form of the mineral fluorspar. The main environmental impacts related to fluoride compounds are in respect of hydrogen fluoride, which immediately converts to hydrofluoric acid on contact with moisture. Under normal ranges of pH in surface waters reaction to hydrofluoric acid is very unlikely to occur. It is unlikely that the concentrations of fluoride detected would cause significant environmental harm.

Sodium

Elevated concentrations of sodium were observed in the River Health Assessments (2004 to 2007) at Baffle Creek outflow predominantly and occasionally at Upper Hutton Creek (i.e. above petroleum operations) and Hutton Creek but not at other sites downstream.

Electrical Conductivity (Salinity)

Electrical conductivity is typically elevated at those sites that receive associated water compared with upstream sites. Readings in Baffle, Hutton and Dawson Rivers ranged from approximately 150 to 1800 µS/cm.

pH

Occasional high pH readings (pH=9) have been identified during river health sampling in Baffle Creek.

5.4.1 Minor Streamlines

A number of minor streamlines exist on the escarpment amongst the existing CSG operations. These streams typically only contain water during significant rainfall events and have few refugia. They are significantly degraded due to extensive land clearing, removal of riparian vegetation and stock access. The area is highly erosive, and unlimited stock access has denuded riparian vegetation, created erosion points, and provides direct nutrient inputs (Simmons and Bristow, 2007). Streamlines generally exhibit significant bank erosion and are incised in the landscape down to bedrock with slopes significantly greater than surrounding land contours. Some small depositional areas exist, but in general terms once rock has been reached the erosion toe moves upstream.

Due to the intermittent flows, widespread removal of riparian vegetation and active erosion in these streamlines it is highly probable that the ecosystems are under significant stress. In addition to this degradation, some streamlines have received associated water discharge to grade for the last 10 – 15 years. Associated water discharges contribute continuous releases of

low dissolved oxygen, high temperature and moderate salinity water. The status of these streamlines is therefore considered heavily disturbed and this has been supported by a rapid and qualitative ecological survey (URS unpub. data 2008). Further work is planned to assess whether there is a marginal decline in streamline condition between cleared streamlines and cleared streamlines receiving associated water discharges.

A detailed quantitative study into the impacts of associated water discharge on the ecological condition of these streamlines found the addition of associated water changes the streamline environment substantially (URS unpub. data). Streamlines were investigated during the 2008 dry season, where flow was comprised entirely of associated water discharge. Water immediately below the point of discharge was found to exhibit high temperatures and pH, and low dissolved oxygen and turbidity, often dominated by algae. Dissolved oxygen and temperature tended to equilibrate within approximately 500 m. EC remained stable, and pH increased downstream of the discharge point.

Diatoms, sensitive to changes in salinity and temperature, were selected as indicators of ecological health. Diatom diversity was found to be similar between control sites and sites upstream and downstream of associated water discharge. However, a significant difference in species assemblage was observed between upstream sites or control sites, and downstream sites.

5.4.2 Baffle Creek

Two water quality sampling sites have been monitored on Baffle Creek, one upstream and one downstream of associated water discharges. The upstream site exhibits significant variations in water quality between samples possibly suggesting that data may not all come from the same site, or that sporadic contamination of the waters occurs from some upstream activity.

Comparisons of upper and lower Baffle Creek data (Table 5-5) indicate highly significant ($p<0.01$) increases in median salinity, TDS, alkalinity, chloride and sodium downstream. Significant ($p<0.05$) increases in fluoride and boron also occur downstream. Significant ($p<0.05$) decreases in median temperature and magnesium are also observed between upstream and downstream sites.

5.4.3 Hutton Creek

There is insufficient data to allow a valid statistical comparison of upstream and downstream water quality condition along Hutton Creek. However, there is sufficient data to allow a pre (1985 or before) vs post (post 1985) associated water discharge comparison of water quality in Lower Hutton Creek (Table 5-6). Mann-Whitney U tests at 9% significance level identified a significant decrease in median pH and a significant increase in median potassium concentration post associated water discharge to Hutton Creek. No other significant differences in median concentrations/values were apparent.

Table 5-5 Comparison of upstream and downstream water quality Baffle Creek

Water Quality Parameter Type	Water Quality Parameter Name	Units	MTV	Upper Baffle Creek				Lower Baffle Creek				Comparison U/S to D/S	
				Min	Med	Max	n	Min	Med	Max	n	Sig	p
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	340	67	162	1901	27	188	1260	1864	29	▲	0.003
	pH	Stand	6.5-8.0	6.6	7.25	7.8	6	6.9	8.1	8.9	5	-	0.068
	Temperature	C		14	24	32.7	25	12	20	27	23	▼	0.034
	Total dissolved solids	mg/L	1000	43	126	1293	27	128	852	1168	29	▲	0.003
	TSS	mg/L	10	6	48	49	5	10	37	76	5	-	0.835
Inorganic Non-Metallic Parameters	Bicarbonate Alkalinity	mg/L ($CaCO_3$)	-	47	72	99	6	570	694	916	6	▲	0.005
	Chloride	mg/L	<175	<0.5	7	9	6	36	56	93	6	▲	0.005
	Fluoride	mg/L	1	<0.1	0.32	0.43	6	0	1	2	6	▲	0.031
	Sulphate	mg/L	400	<1		<10	6	<1	<10	24	6	-	0.522
Cations	Calcium	mg/L	1000	<1	1	15	6	<1	1	7	6	-	0.174
	Magnesium	mg/L		1.9	4	7	6	1	2	3	6	▼	0.037
	Potassium	mg/L		4.5	6	12	6	4	6	8	6	-	0.689
	Sodium	mg/L	<115	<1	8	17	6	162	290	437	6	▲	0.005
Nutrients	Ammonia-Nitrogen	mg/L	20					0.016	-	0.12	3	NA	-
	Nitrate-Nitrogen	mg/L						<0.01	-	<0.01 2	1	NA	-
	Phosphorus/Phosphate	mg/L - P	50					66	185	350	5	NA	-
Trace elements	Boron 2	µg/L	370	<0.1		500	6	200	450	700	6	▲	0.025
	Iron	µg/L	200	81		1800	3	1300	-	6362	3	-	0.190
	Lead	µg/L	3.4	<1	<1		2	<1	-	8	2	NA	-
	Zinc	µg/L	8	8.3		<10	2	3	-	14	2	NA	-

Table 5-6 Comparison of upstream and downstream water quality Hutton Creek

Water Quality Parameter Type	Water Quality Parameter Name	Units	MTV	Upper Hutton Creek				Lower Hutton Creek				Comparison U/S to D/S		Lower Hutton Creek comparison pre to post					
														Pre (<=1985)		Post (>1985)		Sig	p
				Min	Med	Max	n	Min	Med	Max	n	Sig	p	Med	n	Med	n		
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	340	156		1478	2	131	233	1294	16	NA	-		10		6	-	1.000
	pH	Stand	6.5-8.0	6.6		7.9	2	6.60	7.85	8.30	16	NA	-	7.95	10	7.2	6	▼	0.045
	Temperature	C						9.7	23.2	31.0	15	NA	-		9		6	-	0.377
	Total dissolved solids	mg/L	1000	190		1139	2	5	28	630	16	NA	-		10		6	-	0.704
	TSS	mg/L	10		570		1	-	-	-	-	NA	-		10		6	-	0.129
Inorganic Non-Metallic Parameters	Bicarbonate Alkalinity	mg/L - CaCO3	-		314		1	65	100	820	16	NA	-		10		6	-	0.914
	Chloride	mg/L	<175	6		267	2	4	18	355	16	NA	-		10		6	-	0.871
	Fluoride	mg/L	1	0.1		0.31	2	<0.1	0.1	1.4	12	NA	-		8		6	-	0.273
	Sulphate	mg/L	400	<1		120	2	<1	5.0	170	12	NA	-		9		6	-	1.000
Cations	Calcium	mg/L	1000	20		91	2	5	16	85	16	NA	-		10		6	-	0.129
	Magnesium	mg/L			16		1	2	5	67	16	NA	-		10		6	-	0.588
	Potassium	mg/L			9		1	2	5	10	16	NA	-	4.7	10	7.0	6	▲	0.020
	Sodium	mg/L	<115	14		133	2	9	21	280	16	NA	-		10		6	-	0.481
Nutrients	Ammonia-Nitrogen	mg/L	20		51		1	<.01	0.16	0.24	3	NA	-						
	Nitrate (as NO_3)	mg/L			0.17		1	0.1	1.2	4.0	9	NA	-						
	Phosphorus/Phosphate	mg/L - P	50		170		1	<10	95	230	5	NA	-						
Trace elements	Boron	µg/L	370	32		<100	2	10	50	800	12	NA	-		6		6	-	0.078
	Iron	µg/L	200		1900		1	62	1700	2358	3	NA	-						
	Lead	µg/L	3.4		4.8		1	<1		2	2	NA	-						
	Zinc	µg/L	8		1.5		1	<10		1.5	2	NA	-						

Notes for Table 5-5 and Table 5-6:

(grey shading)	indicates observation exceeds MTV
Sig	indicates statistically significant difference in medians at the 95% confidence level using a Mann Whitney U Test. Mann-Whitney U Test used as tests on variance indicate possible differences.
p	indicates actual level of significance e.g. p=0.05 indicates a 95% chance that the medians are the different.
▲ and ▼	indicates a significant increase/decrease in median value
-	indicates no significant change in medians
U/S to D/S	indicates change is presented as from upstream to downstream
NA	Indicates insufficient data to complete the test

5.4.4 Dawson River at Utopia

The only significant differences in pre to post associated water discharge median spot water quality are as shown in Table 5-7 (Mann-Whitney U test, 95% significance).

Table 5-7 Significant differences in median water quality - Dawson R at Utopia

WQ Parameter	Units	Median (1964 – 1985)	Median (1985 – 2007)	p	Sig
Electrical Conductivity	µS/cm at 25C	311	284	0.0090	▼
Total Dissolved Solids	mg/L	173	153	0.0019	▼
Calcium	mg/L	20.5	16.0	0.0000	▼
Magnesium	mg/L	7.50	6.00	0.0008	▼
Alkalinity as HCO3	mg/L	150	127	0.0000	▼
Chloride	mg/L	29.0	24.0	0.0017	▼
Sulphate	mg/L	3.30	1.72	0.0001	▼
Boron	µg/L	20	100	0.0024	▲

Where:

p indicates level of significance e.g. p=0.05 indicates a 95% chance that the medians are different.

Sig indicates direction of statistically significant change

5.4.5 Continuous Salinity Data

Simultaneous continuous streamflow, temperature and EC data have also been collected by DNRW at the Dawson River at Utopia Downs site for 10 years (1997 – 2007).

Mean EC is 280 +/- 140 µS/cm and median EC is 289 µS/cm suggesting little skew in the data. This is confirmed by Figure 5-1 which shows a reasonably symmetric distribution of hourly EC readings.

The range of observed EC is significant. Minimum recorded EC is 57 µS/cm and maximum is 800 µS/cm. The 90% confidence interval for the data is 163 – 396 µS/cm.

There is evidence of a statistically significant but small reduction in spot EC pre to post associated water discharge (Table 5-7). However, the symmetry of the hourly distribution of continuous EC data and the lack of an obvious step change or trend in hourly EC time *series (*Figure 5-2) suggests this change may be due to sampling bias rather than the influence of associated water discharges.

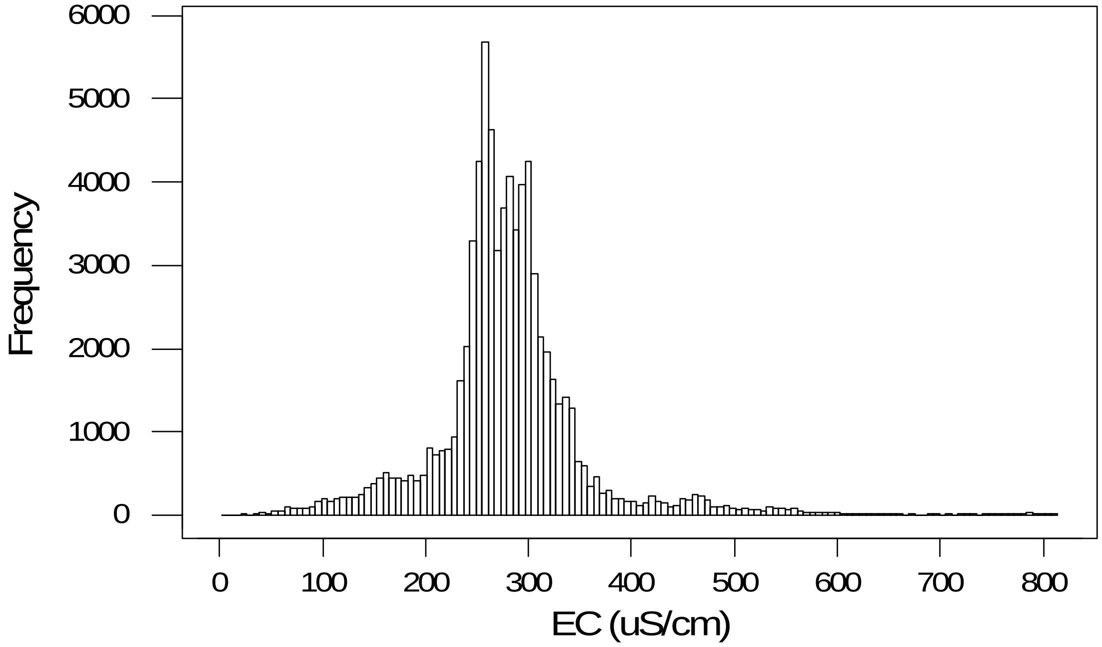


Figure 5-1 Distribution of Hourly Electrical Conductivity, Dawson R at Utopia

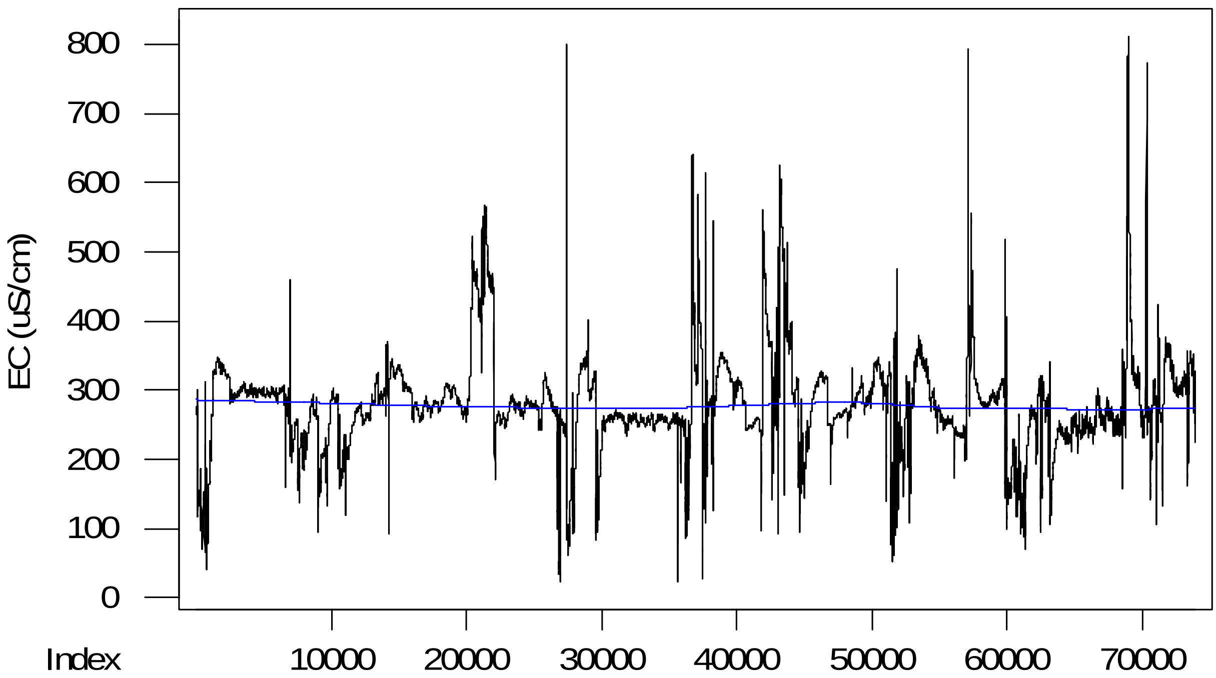


Figure 5-2 EC Time Series Record Dawson River at Utopia Downs, 2003 – 2007

Section 5 Existing Environment - Water Quality

Differences in the binomial proportions of MTV exceedances for electrical conductivity and suspended solids pre- and post-establishment of Tipperary in 1985 were examined at Utopia. The analysis showed there was no statistically significant difference in observations before or after the establishment of Tipperary for both parameters and suggests sufficient dilution exists within the river system to maintain downstream water quality at Utopia under existing associated water discharges.

Significant dilution of salinity occurs on the rising limb of hydrographs during the passage of floods and freshes; sometimes reaching as low as ~60 µS/cm. EC returns to pre-event levels over a period of 20 days or so as flows progressively becomes dominated by interflow, spring flow and/or baseflow. These behaviours are demonstrated in Figure 5-3.

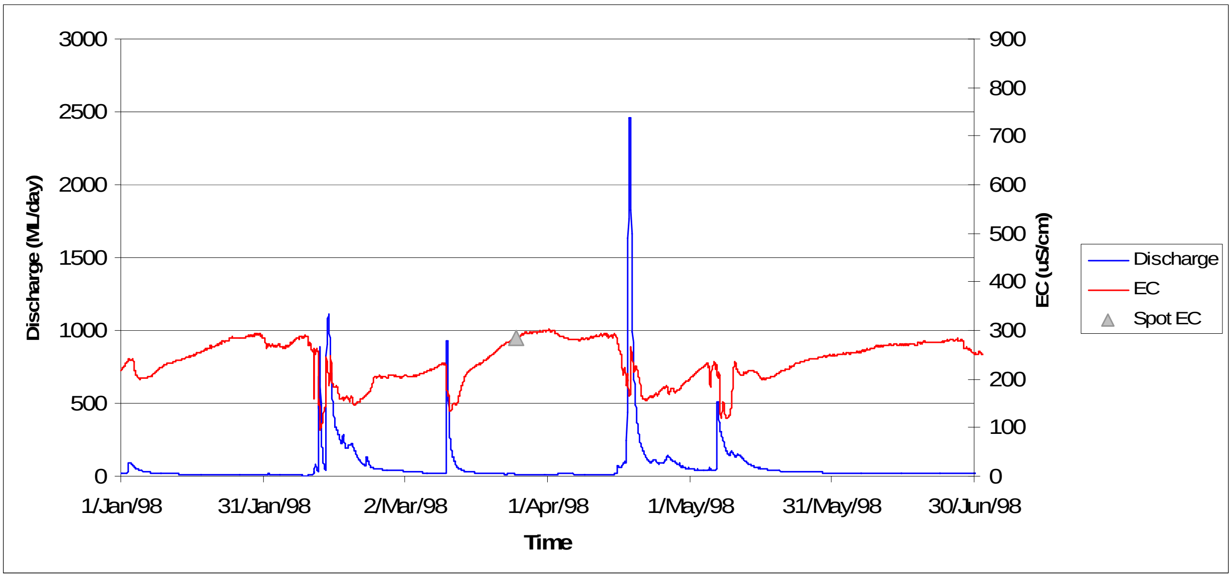


Figure 5-3 Dawson River at Utopia Downs EC and Flow Relationships

5.4.6 Continuous Water Temperature Data

There is a strong seasonal and diurnal range of temperature in the Dawson River at Utopia where a range of 7C to 34C has been observed (Figure 5-4).

In the Dawson River at Taroom a water temperature range of 8C to 26C has been observed with similar seasonal patterns to those at Utopia Downs.

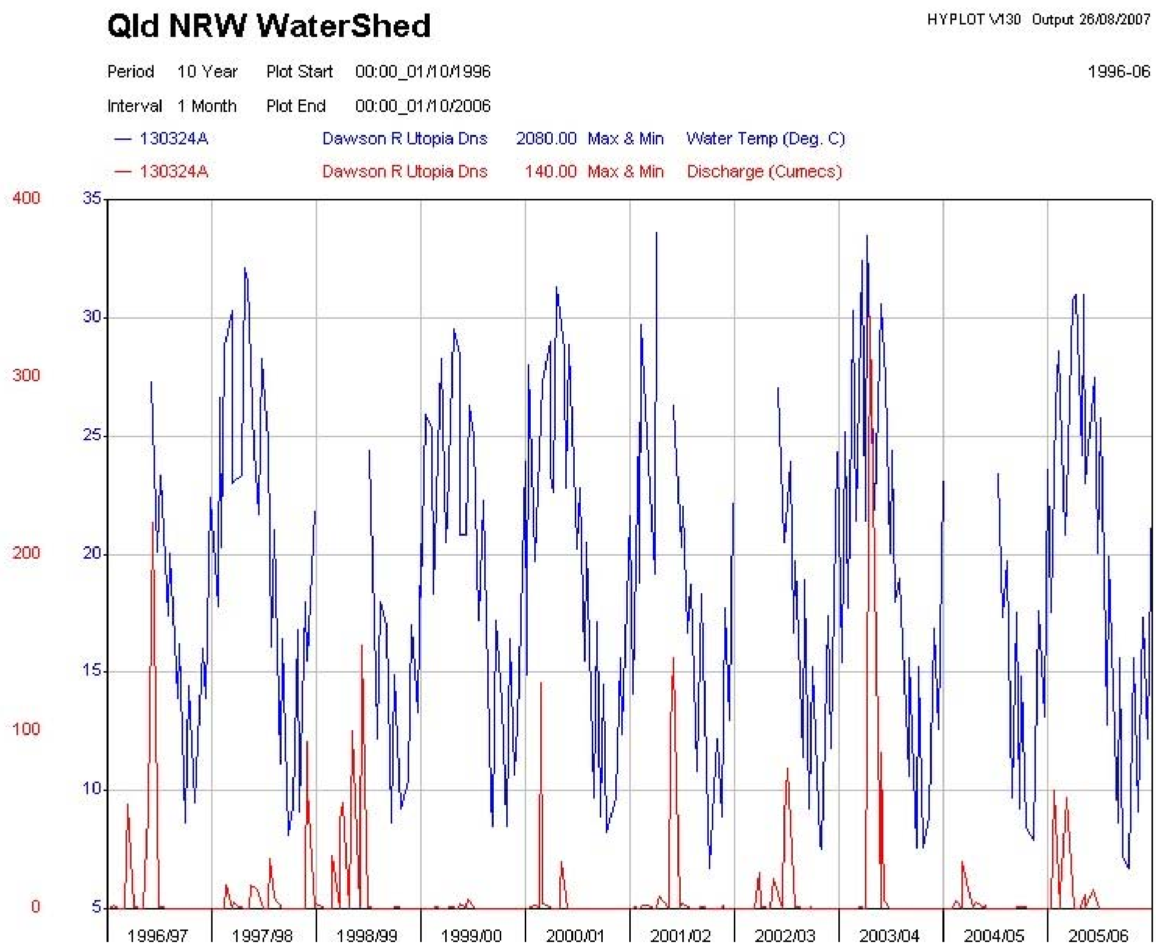


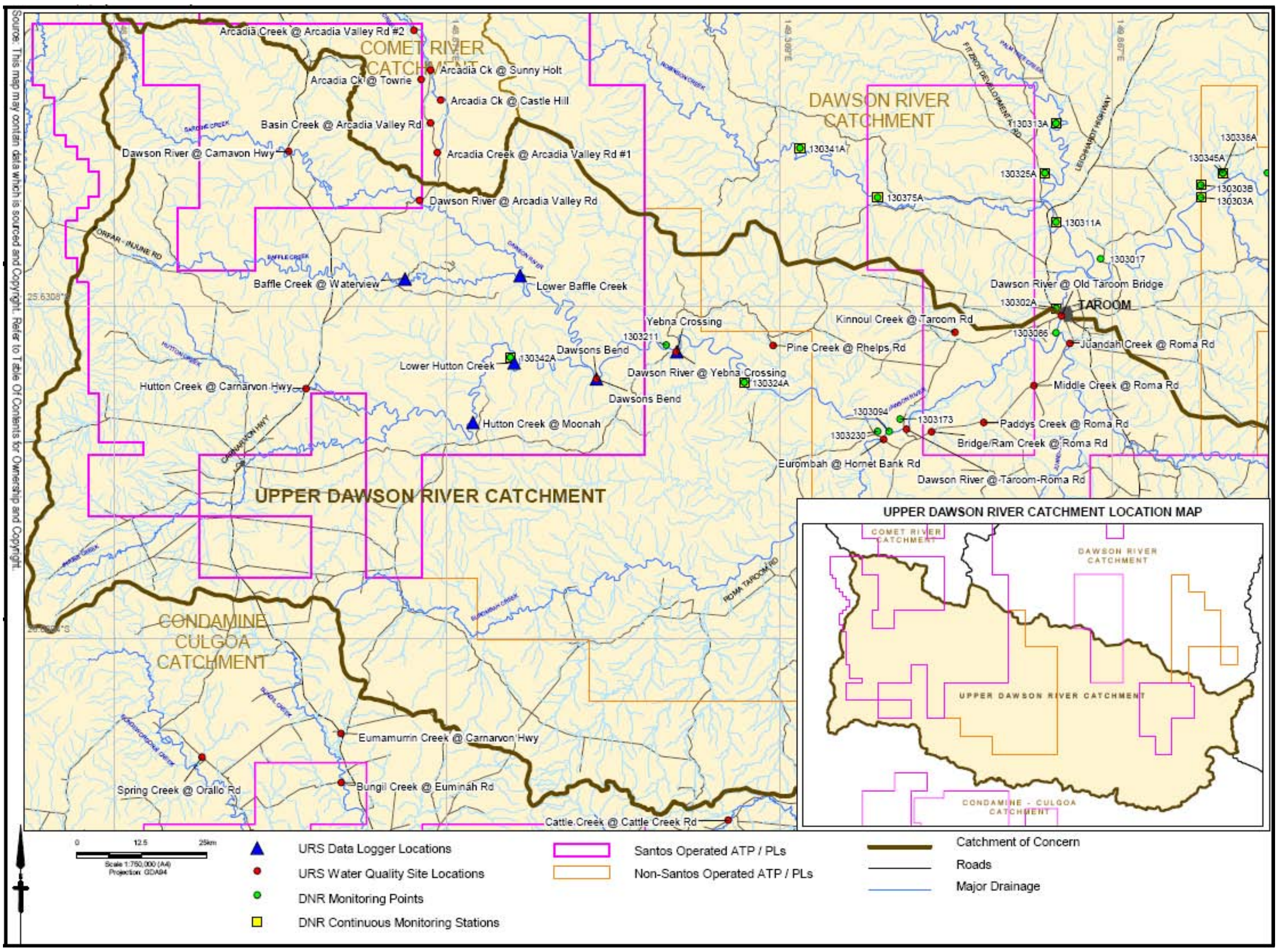
Figure 5-4 Water Temperature and Flow at Dawson River at Utopia Downs

5.4.7 Continuous Water Quality Data at Fairview

URS temporarily deployed six Hydrolab™ data loggers in Baffle and Hutton Creeks, and two locations in the Dawson River, as shown in Figure 5-5 and summarised in Table 5-8 below.

The instruments recorded continuous (1/2 – 1 hourly) measurements between June through Augsut 2008 (ongoing) of EC, pH, DO, turbidity, temperature and relative depth. Prior to initial deployment the instruments were calibrated using standardised solutions. At approximately six week intervals data sets were downloaded, the instruments cleaned, calibrated and re-deployed. Independent water quality measurements were taken for quality control purposes each time the instruments were redeployed using a TPS90FLT multi-parameter water quality instrument.

Section 5 Existing Environment - Water Quality



NB 1 cumec = 86.4 ML/day

Figure 5-5 Water Temperature and Flow at Dawson River at Utopia Downs

Table 5-8 Data Logger Site Locations

Site Name	Easting	Northing	Upstream/Downstream AW Discharge
Baffle Creek @ Waterview	681640	7168024	Upstream
Lower Baffle Creek	698965	7168306	Downstream
Hutton Creek @ Moonah	691576	7146417	Upstream
Lower Hutton Creek	697890	7155260	Downstream
Dawson's Bend	710193	7152667	Downstream
Yebna Crossing	722336	7156534	Downstream

Hutton Creek

EC concentrations in Hutton Creek downstream of associated water discharges are approximately 300µS/cm higher than recorded upstream, and show less variation during floods (Figure 5-6). Conversely pH at both sites is circumneutral, with levels at both sites within 0.5 units.

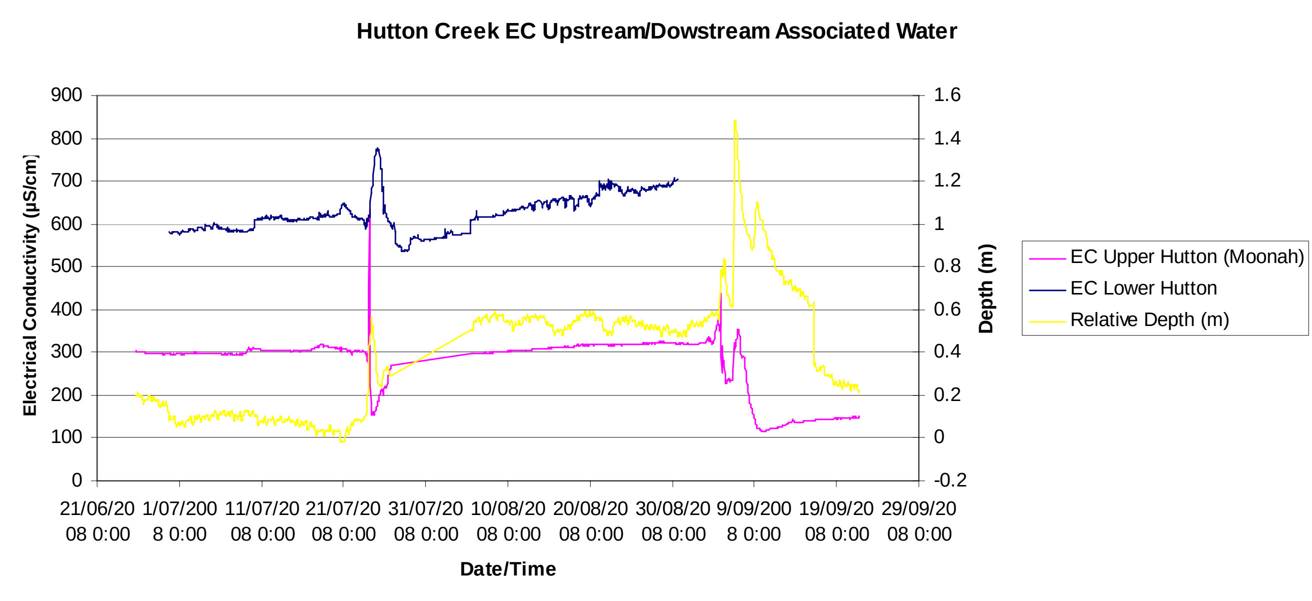


Figure 5-6 Comparison of EC levels upstream and downstream of associated water discharge in Hutton Creek, July – September 2008

Baffle Creek

Electrical conductivity and pH at a site downstream of associated water discharge (Lower Baffle Creek) are consistently higher than upstream (Baffle Creek at Waterview). Comparison of concentrations of EC and pH between the two sites are shown in Figure 5-7 below.

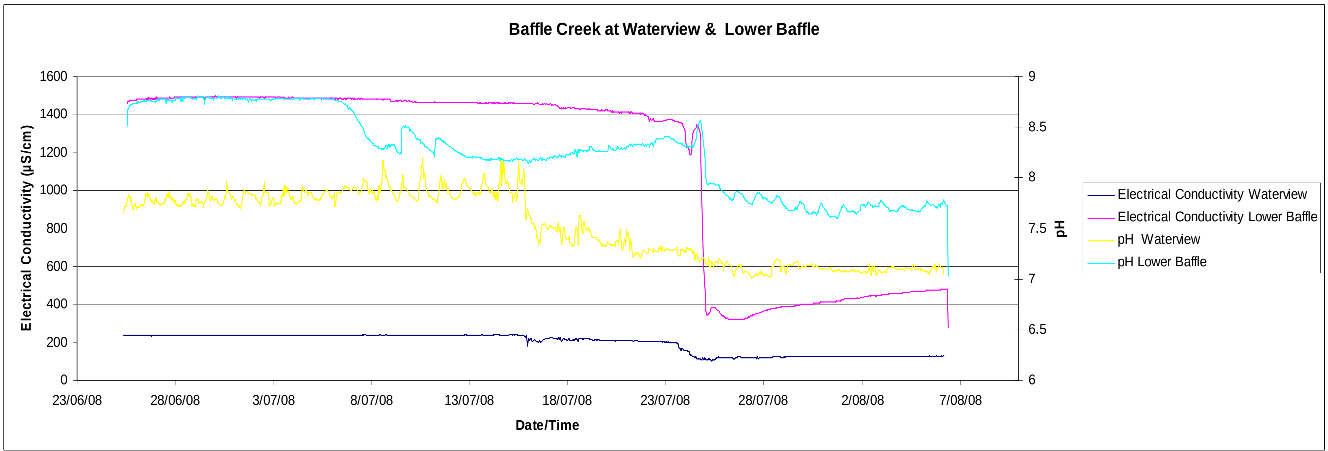
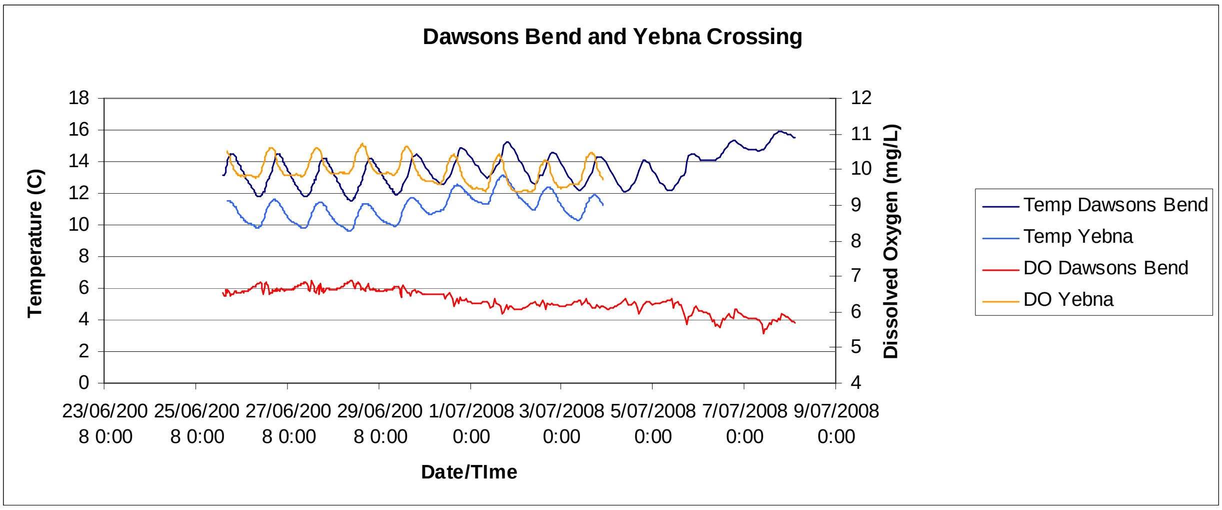


Figure 5-7 Comparison of Upstream/Downstream Baffle Creek EC and pH

Dawson River at Dawson's Bend and Yebna Crossing

Comparison of EC, pH, DO, temperature, turbidity and Eh measurements collected at Yebna Crossing and Dawsons Bend indicates:

- DO and temperature fluctuate diurnally (Figure 5-8). DO measurements at Dawson's Bend are lower and temperature is higher than at Yebna Crossing. DO generally decreases with increasing temperature, consistent with these observations. The higher temperatures recorded at Dawsons Bend may be attributed to the influence of springs, as discussed in Section 22 above.



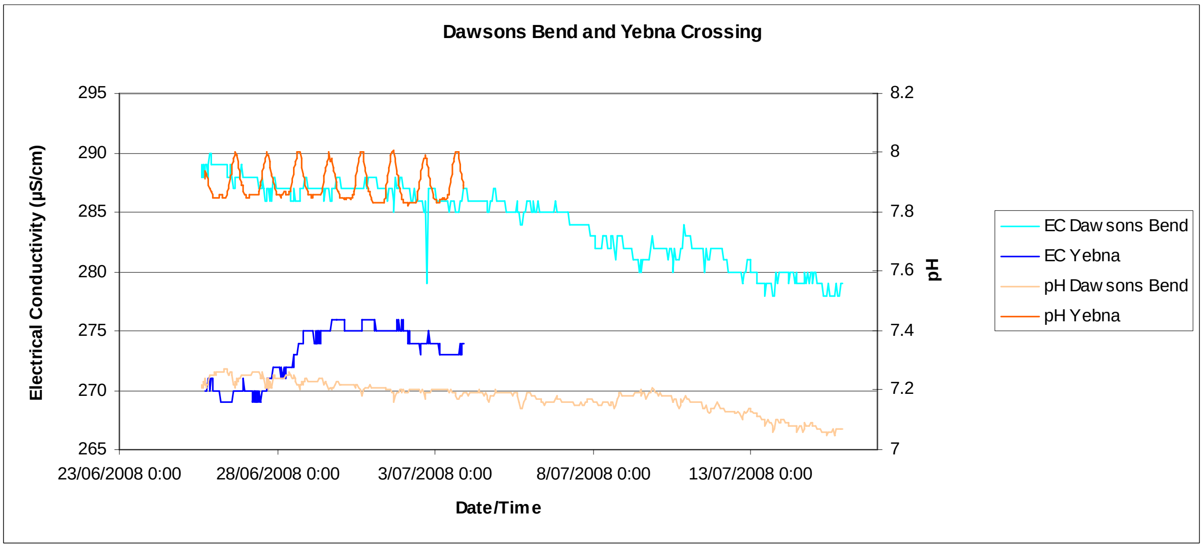


Figure 5-8 Dawson's Bend and Yebna Crossing Temperature and DO Levels

- EC is reasonably consistent at each site Figure 5-8. Although slightly higher at Dawson's Bend than at Yebna Crossing, levels are well within the expected range of variability for EC measurement.
- pH is reasonably consistent at each site, but is consistently higher at Yebna Crossing than at Dawsons Bend.
- Turbidity is variable, largely fluctuating in accordance with varying depth. An increase in turbidity is noted at both sites following a rainfall event.

5.4.8 Water Quality Profiles

Associated water has comparatively high salinity, pH and temperature when compared with the average existing surface water environments. An area of concern therefore is the potential for stratification of the water column in deeper ponded waters receiving associated water discharge. To assess for the presence of halocline (a strong vertical salinity gradient) or thermocline (temperature gradient) vertical profiles were taken at sites downstream of associated water discharges on Baffle Creek and Hutton Creek, and at Dawsons Bend on the Dawson River.

In the thalweg of each ponded area quality parameters including EC, temperature, pH, turbidity, EC, DO and redox were measured at roughly 0.1 m vertical intervals using a Hydrolab™ data logger.

A minimum of two profiles were logged at each location. The deepest profile has been graphed from each site below for comparative purposes. The trends exhibited for each indicator are generally similar for all profiles at a particular site.

Hutton Creek

Profiles collected from Hutton Creek upstream and downstream of associated water discharge are presented in Figure 5-9 below. Distinct differences are evident between the two sites. With the exception of redox potential (Eh) all parameters in the upstream site (Upper Hutton) remain relatively constant with increasing depth. In the Lower Hutton Creek site, however, DO levels decline sharply between 1-2 m depth before stabilising at less than 1 mg/L, a level likely to result in substantial impacts to the aquatic environment. Within the same depth interval EC follows an increasing trend. Eh levels do not mirror the declining DO concentrations as would be expected; the reason for this is not known. pH remains reasonably stable and temperature both show a moderate decline.

The extremely low DO levels suggest that associated water discharge is impacting the aquatic environment during periods of low to no flow. This is only the case during the dry season; periods of high flow will remove any stratification.

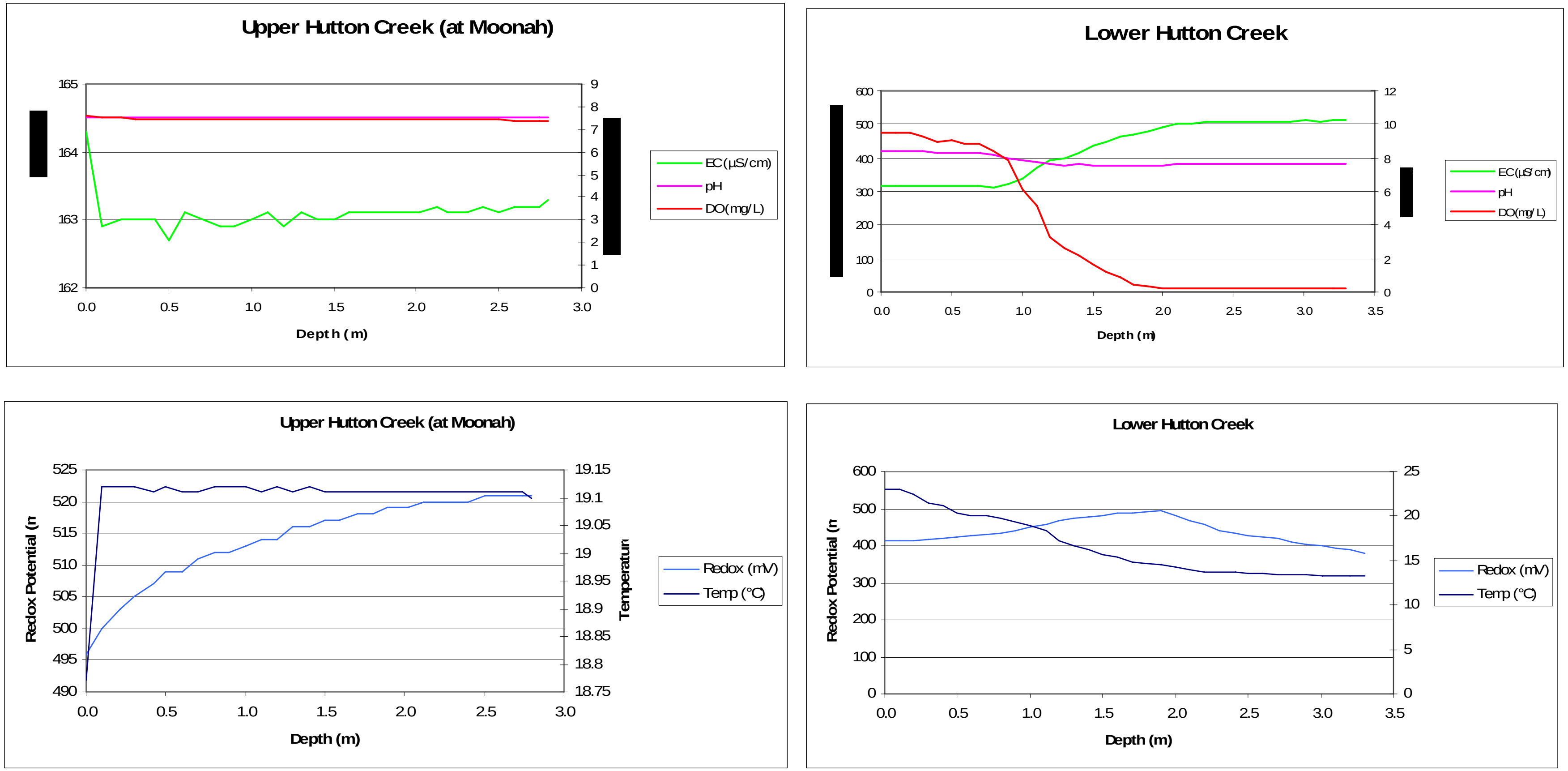
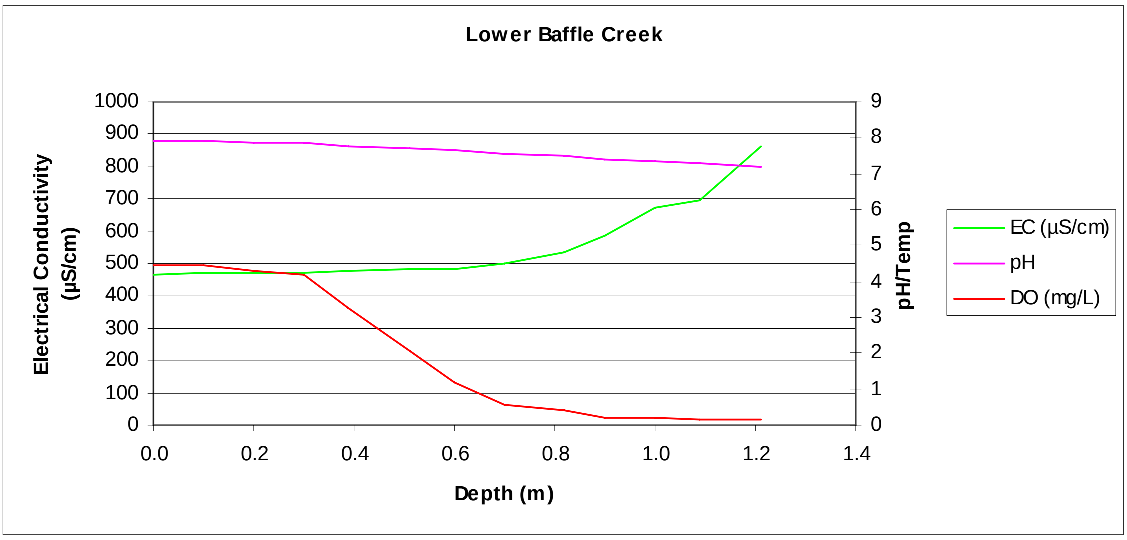


Figure 5-9 Hutton Creek vertical profiles upstream/downstream of associated water discharge

Baffle Creek

Measurement of water quality parameters through a vertical profile was undertaken in a pool located near the outflow of Baffle Creek to Dawson River. Figure 5-10 shows that EC increases with increasing depth, whereas pH and temperature shows a decreasing trend. The temperature gradient is gradual with no indication of a thermocline. More substantial increases in EC are noted from approximately 0.8 m depth. DO shows a sharp decline with depth, reaching levels that would be expected to severely affect the survival of biological communities and result in fish kills. Redox potential (Eh) also decreases with increasing depth, likely as a result of decreasing DO levels.



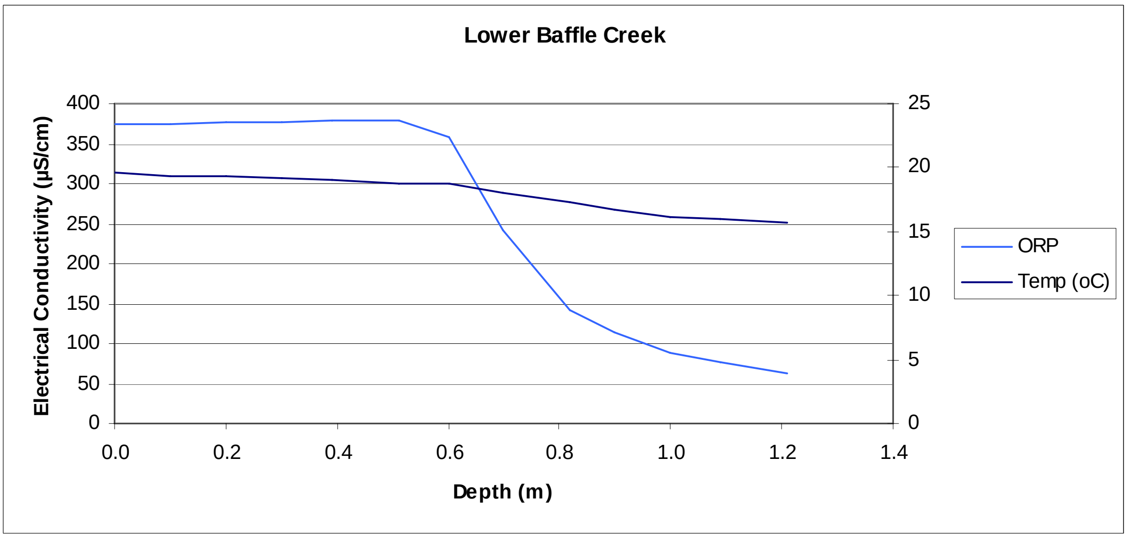
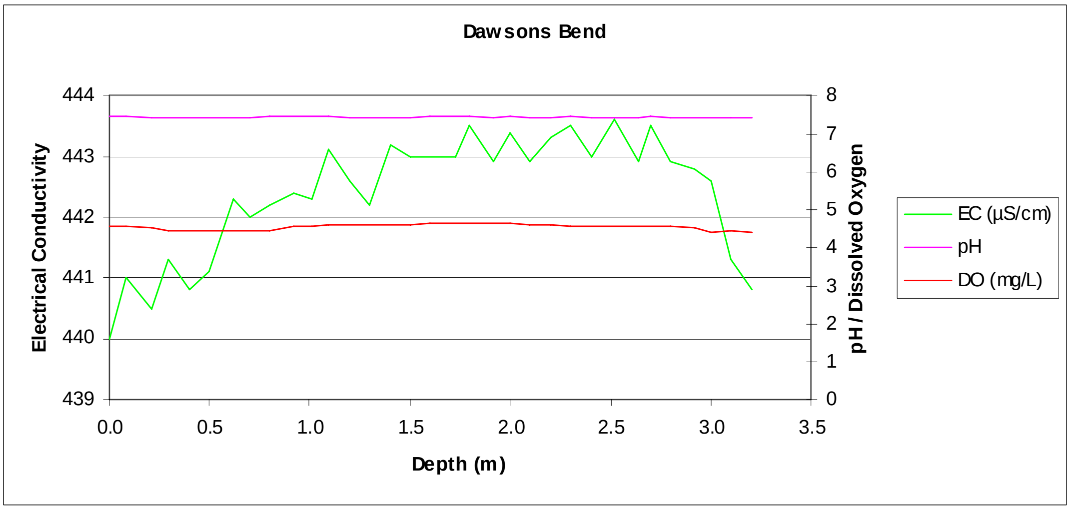


Figure 5-10 Lower Baffle Creek vertical profile

Dawsons Bend

Vertical profiles of water quality parameters taken at Dawsons Bend indicate less variability when compared with sites on Baffle and Hutton Creeks downstream of associated water discharges. Levels of EC, pH and DO remain reasonably stable. Eh and temperature show a slight increase/decrease within the range of expected natural variability (Figure 5-11).



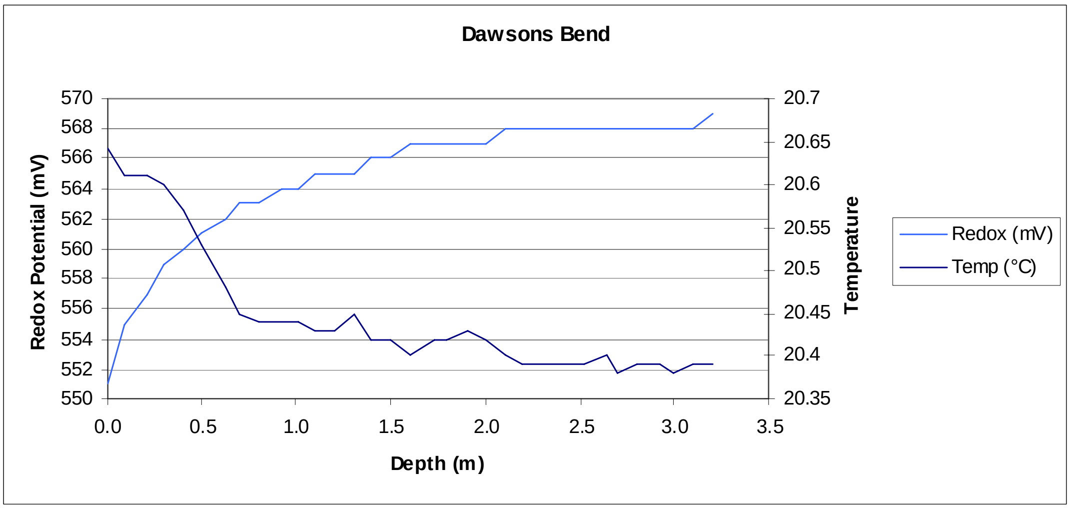


Figure 5-11 Dawson River at Dawsons Bend vertical profile

6.1 River Health of Major Streams

River health sampling has been undertaken from pool and edgewater habitats at a range of sites across the Fairview area since 2003 (EnviroTest various, Simmonds and Bristow 2007 & 2008). Sites sampled include control sites upstream of impacts, and sites down the Dawson River in an attempt to assess any longitudinal changes in river health (Figure 6-1).

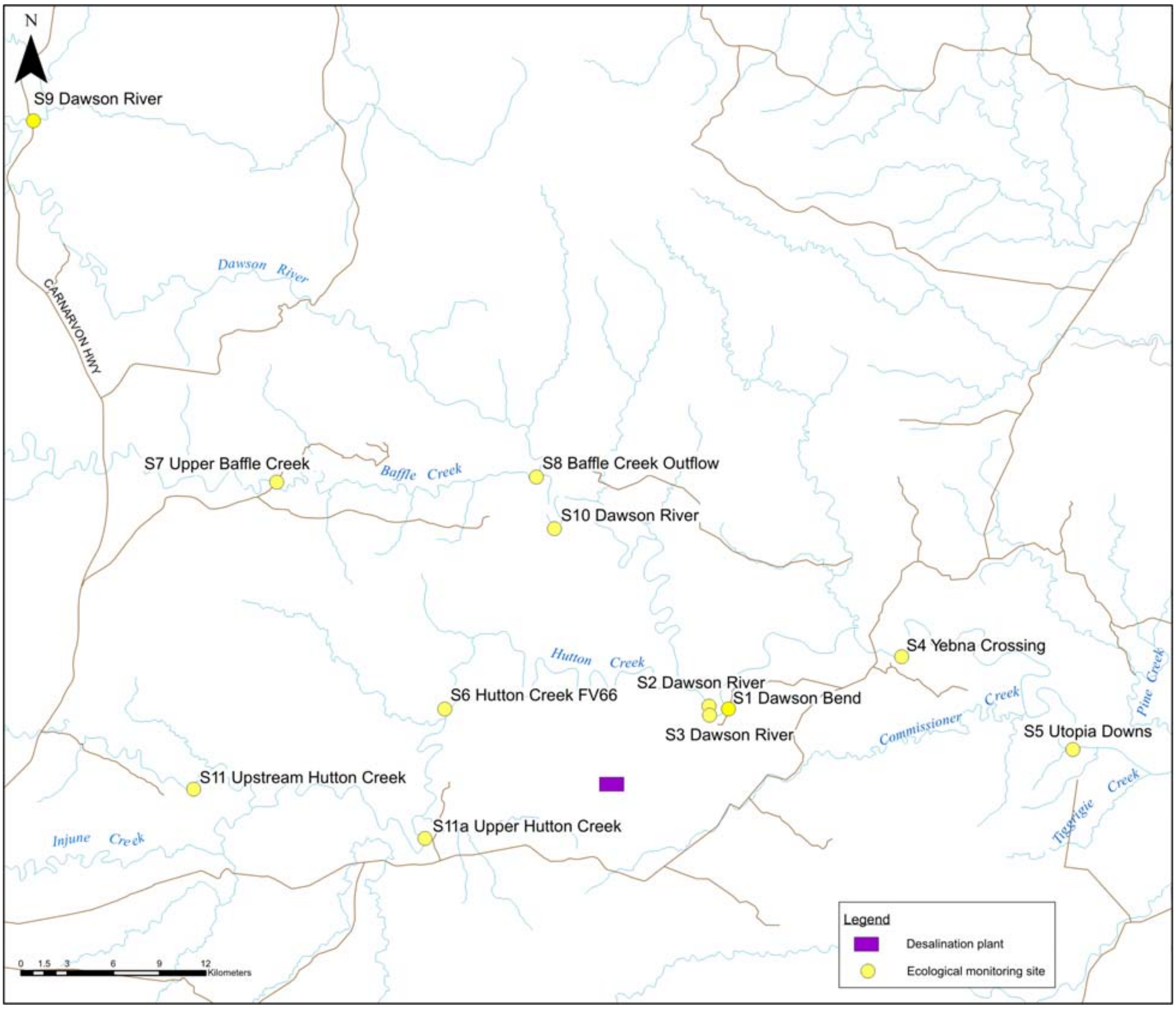


Figure 6-1 River health sampling sites at Fairview

The AusRivas macroinvertebrate and habitat sampling methodology and models developed under the National River Health Program are used. These models assign samples to various river health "bands" based on the fauna observed at a site compared with fauna predicted to be at that site based on habitat and other physical characteristics. Predictions of fauna are made on the basis of an analysis of fauna observed at "reference condition" sites. Thus predicted fauna represent the fauna that would be expected to be at the sampling site if it were in reference condition. Models are seasonal and sampling habitat based (e.g. pools, edgewaters).

Existing Environment - River Health

River health bands are defined in relation to reference condition as shown in Table 6-1. Calculated AusRivas bands are shown in Table 6-2.

Table 6-1 AusRivas river health bands

Band	Condition class	Description
X	Richer than reference	O/E greater than 90^{th} percentile of reference sites
A	Equivalent to reference site	O/E within range of central 80% of reference sites
B	Below reference	O/E below 10^{th} percentile of reference sites (same width as Band A)
C	Well below reference	O/E below Band B (same width as Band A)
D	Impoverished	O/E below Band C down to zero

Table 6-2 AusRivas model bands for spring and autumn samples Sep 03–Apr 07

Edge Habitats Site	Season	Spring 03	Autumn 04	Spring 04	Autumn 05	Spring 06	Autumn 07
	Date	Sep-03	Apr-04	Nov-04	May-05	May-06	Apr-07
Upstream petroleum activities							
Upper Baffle Creek		-	-	-	C	B	C
Dawson River Waterhole		-	-	-	-	-	-
Dawson River Road Crossing		-	-	-	-	B	B
Upper Hutton Creek		-	-	-	-	-	B
Downstream petroleum activities							
Baffle Creel		-	-	-	-	-	-
Baffle Creek outflow		-	C	C	C	C	B
Hutton Creek 500m upstream Dawson confluence		-	-	-	B	-	-
Hutton Creek		-	-	-	-	-	-
Hutton Creek FV66		-	C	-	C	C	C
Dawson River Hutton Creek outflow		-	-	-	-	-	C
Dawson River downstream Hutton Creek 1		-	C	B	B	C	B
Dawson River downstream Hutton Creek 2		-	-	C	B	C	B
Dawsons Bend		-	-	B	B	B	C
Yebna Crossing		-	C	C	C	B	B
Utopia Downs		-	-	-	C	C	B

Pool habitats Site	Season	Spring 03	Autumn 04	Spring 04	Autumn 05	Spring 06	Autumn 07
	Date	Sep-03	Apr-04	Nov-04	May-05	May-06	Apr-07
Upstream petroleum activities							
Upper Baffle Creek		C	D	B	-	C	C
Dawson River Waterhole		C	C	D	-	-	-
Dawson River Road Crossing #2		-	-	-	-	B	C
Upper Hutton Creek		C	-	-	-	-	B
Downstream petroleum activities							
Baffle Creek		C	-	-	-	-	-
Baffle Creek outflow		C	C	D	C	B	C
Hutton Creek 500m upstream Dawson confluence		-	-	-	-	-	-
Hutton Creek		C	-	-	-	-	-
Hutton Creek FV66		-	C	C	C	C	C
Dawson River Hutton Creek outflow		-	-	B	-	-	C
Dawson River downstream Hutton Creek 1		-	C	C	-	C	C
Dawson River downstream Hutton Creek 2		-	C	-	C		D
Dawsons Bend		C	C	C	C	C	B
Yebna Crossing		C	C	C	C	C	C
Utopia Downs		-	-	-	C	C	A

Single season models were used to assign sites to AusRivas bands in Table 6-2.

Band assignment varies significantly from year to year for sites both upstream and downstream of associated water discharges. Macroinvertebrate fauna are sensitive to a range of factors including changes in habitat, baseline and event based water quality, and flow conditions.

Recent advice from DNRW is that the AusRivas models for Central Queensland should not be used at this time since they have been found to be inaccurate. Additional work is being completed to update models over the next few years. Despite this warning, data was analysed using AusRivas models for comparative purposes as discussed below.

Since combined season models are usually considered more robust that individual season models the observed to expected (O/E50) ratios from each site were compared to identify any statistically significant changes in median O/E50 scores using Mann-Whitney U Tests at the 95% significance level. O/E50 scores were calculated for Spring/Autumn models for both edgewater and pool habitats.

Table 6-3 Significant O/E ratio shifts between sites

Combined Seasonal Model	Upstream Site	Downstream Site	Direction of Change
Edgewater	Baffle Creek Outflow	Dawsons Bend	▲
Pool	Hutton at FV66	Dawson at Utopia	▲
Pool	Dawson at Yebna	Dawson at Utopia	▲
Edgewater	Hutton at FV66[1]	Dawson u/s Hutton	▲
Edgewater	Hutton at FV66	Dawson at Yebna	▲

Note: 1) Hutton at FV66 is not upstream of Dawson u/s Hutton.

These results suggest that Hutton Creek at FV66 has a significantly lower river health than downstream and upstream sites on the Dawson River. There is some evidence to indicate that river health in Baffle Creek is lower than in the Dawson River, at least at Dawsons Bend. Furthermore, there is evidence to support improvement in river health between Dawson River at Yebna Crossing and Dawson River at Utopia.

Despite the limitations of the AusRivas models, and taking into account the characteristics of associated water discharges and the comparison of water quality parameters between sites in Section **Error! Reference source not found.**, it appears that there is some evidence for river health impacts arising from associated water discharges in Baffle Creek and Hutton Creek. These changes are subtle and are not reflected in general AusRivas bands. In general the data sets are minimal and the differences may simply arise from sampling variability.

Changes in O/E50 between Yebna Crossing and Utopia Downs are more likely to be associated with habitat change between the sites, or from sampling variability due to the low sample numbers.

6.2 River Health of Minor Streamlines Receiving Discharge

A number of minor streamlines exist on the escarpment amongst the existing CSG operations. These streams typically only contain water during significant rainfall events and have few refugia. They are significantly degraded due to extensive land clearing, removal of riparian vegetation and stock access. The area is highly erosive, and unlimited stock access has denuded riparian vegetation, created erosion points, and provides direct nutrient inputs (Simmons and Bristow, 2007). Streamlines generally exhibit significant bank erosion and are incised in the landscape down to bedrock with slopes significantly greater than surrounding land contours. Some small depositional areas exist, but in general terms once rock has been reached the erosion toe moves upstream.

Due to the intermittent flows, widespread removal of riparian vegetation and active erosion in these streamlines it is highly probable that the ecosystems are under significant stress. In addition to this degradation, some streamlines have received associated water discharge to grade for the last 10 – 15 years. Associated water discharges contribute continuous releases of low dissolved oxygen, high temperature and moderate salinity water. The status of these streamlines is therefore considered heavily disturbed and this has been supported by a rapid and qualitative ecological survey (URS unpub. data 2008). Further work is planned to assess whether there is a marginal decline in streamline condition between cleared streamlines and cleared streamlines receiving associated water discharges.

The nature of associated water discharges is preferential to algal or slime growth. A number of streamlines currently receiving associated water discharges contain filamentous algae and slime mats in channel. Limited impacts are evident on riparian vegetation except in some limited cases where some tree roots appear to have been drowned.

There is some evidence to suggest that the ecological impacts of associated water discharges are temporary. Where discharge has been halted, riparian vegetation and streamlines superficially appear no different to surrounding areas. Additional work is required to confirm this.

6.3 River Health of Other Minor Streamlines

General observation of other minor streamlines in agricultural areas supports the view that widespread clearing of vegetation and unrestricted stock access places the streams under significant stress. Together with the intermittent flows experienced in the area the streamlines can be categorised as heavily impacted.

Streams that maintain their riparian vegetation exhibit less erosion and a greater diversity of fauna and flora (URS unpub. qualitative data, 2008) than agricultural streams. Few water refugia are evident.

As part of an investigation into Pony Hills Water Treatment Plant permeate discharges near FV77, Simmonds and Bristow (2007b) completed a rapid ecological assessment of a minor streamline discharging to Hutton Creek. This survey was undertaken shortly after significant rainfall in the area.

The tributary rises approximately 130m above its confluence with Hutton Creek as shown in the elevation vs distance graph in Figure 6-2.

The tributary is certainly ephemeral and probably intermittent. It flows predominantly northeast and northwest before discharging into Hutton Creek approximately 8km from the proposed discharge point. Riparian vegetation is relatively intact in the vicinity of the proposed permeate discharge point near FV77, though dominated by weed species. Despite the good vegetation coverage and the presence of boulders local erosion of stream banks is evident.

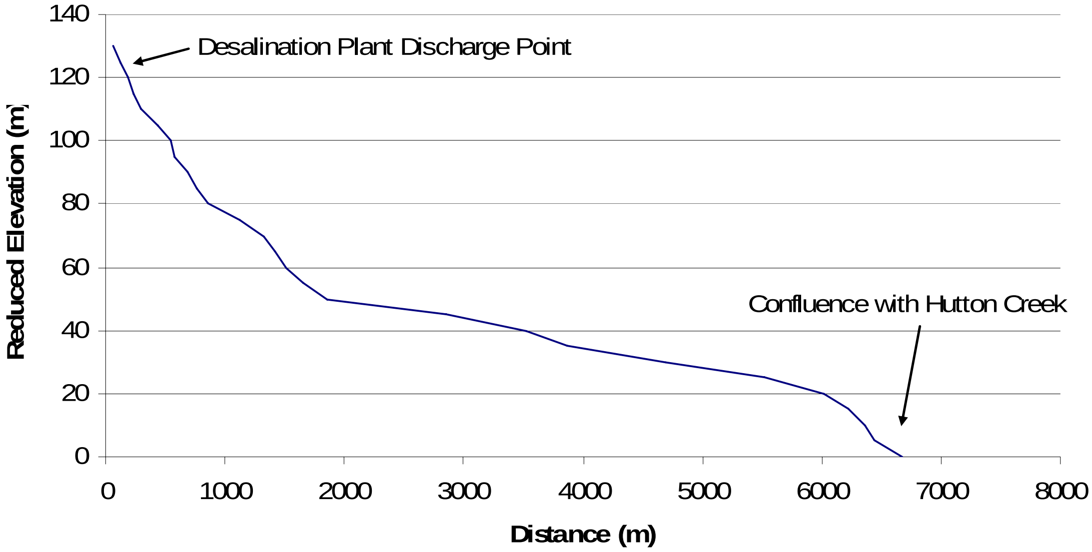


Figure 6-2 Elevation profile unnamed tributary of Hutton Creek near FV77

From the discharge point the tributary follows an incised valley to the mid-stream sections approximately 1.5 km downstream. From this point riparian and catchment vegetation has largely been cleared and the stream is subject to stock access. There is also evidence of channel works with a number of straight sections identified (S. Anderson *pers. comm.*). The reach extending from the discharge point is generally narrow (1 – 3 m), with occasional pools. The substrate ranges from silty clay, sand with cobbles, boulders and bedrock, tending to sandy cobbles and sandstone towards the Hutton Creek outflow. Stream banks are undercut and show evidence of scouring and sand deposition.

Riparian vegetation along the tributary is predominantly comprised of native and exotic grasses and other weed species, which provide some shading of the waterway. The highest density of weed species occurs in the upper reaches of the tributary. Adjacent to Hutton Creek the riparian zone broadens and the tributary feeds into a spring or billabong system dominated by wetland species.

Habitat types along the northern reaches of the tributary are limited to flat water or shallow pools, with refuges provided by fallen trees and trailing vegetation. A diverse macroinvertebrate population was observed along the northern reaches of the tributary. The spring/billabong system near the Hutton Creek outflow provides significant habitat for wetland flora and fauna. A rapid flora and fauna survey of the tributary did not identify any endangered species, though potential supporting habitats were observed (BooBook, 2007).

No rare or threatened fauna or flora were encountered, and no endangered regional ecosystems or ecological communities occur within or in close proximity to the watercourse.

Fifty-eight vertebrate species were recorded including 45 birds, 4 mammals, 4 reptiles, 4 amphibians and one fish. One scheduled threatened species was detected – the squatter pigeon listed as vulnerable under the Nature Conservation Act 1992 and Environment Protection and Biodiversity Conservation Act 1999. A small flock of white squatter pigeons was flushed from the ground in white cypress pine/eucalypt woodland beside a temporary pool at One site. Another pair of squatter pigeons was flushed from the bank of the watercourse.

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Habitats within and adjoining the watercourse are suitable for populations of other rare and threatened fauna including brigalow scaly-foot, golden trailed gecko, little pied bat and large-eared bat. Targeted field surveys would be required to detect these species.

A single Herbert's rock wallaby (a locally significant species) was disturbed on a rocky slope approximately 1 km downstream of the permeate discharge point.

Two hundred and three species of plants were identified along the watercourse, of which about 30 are introduced species.

Frogs, turtles and fish were found in the spring/billabong pond adjacent to Hutton Creek. However, the steepness of the stream, and likelihood of few water refugia under dry conditions suggests the stream provides little habitat for turtles and fish.

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Two desalination plants are under consideration for the Fairview Project Area:

- Pony Hills Water Treatment Plant (PHWTP) near FV77 is planned to be constructed in 2008.
- Central Desalination Plant (CDP) is proposed for 2009.

Investigations for the Pony Hills permeate discharge are complete and detailed plans have been developed for its implementation in 2008.

Investigations for Central Desalination Plant are currently being initiated.

7.1 Pony Hills Water Treatment Plant

This Section outlines the proposed discharge of treated (desalinated) associated water to grade in an unnamed tributary of Hutton Creek (Hutton Tributary) adjacent to FV77 and the potential downstream effects of this discharge on Hutton Creek and the Dawson River.

7.1.1 Hutton Tributary

The Hutton Tributary is intermittent/ephemeral, and has a small catchment area extending approximately 3.5km upstream of the permeate discharge point. Field observations made in December 2007 following significant flooding found a pool and channel system with significant water storage capacity (Simmons & Bristow, 2007b). Adjacent and well connected to Hutton Creek is a billabong or spring system.

The general environment of the tributary is described in Section 6.3.

Limited water quality data (EC, pH, temperature and DO) was also collected in December 2007 from the unnamed Hutton Tributary both at the proposed discharge point (FV77) and downstream near the confluence with Hutton Creek (Simmonds & Bristow, 2007b). The data indicates background EC in the range 354 to 533 µS/cm and pH in the range 6.8 to 7.7. This is similar to median observed levels of these parameters in Hutton Creek. Further measurements of EC in early February 2008 suggest an EC range of 450 – 510 µS/cm.

Temperatures recorded by Simmonds & Bristow (2007b) ranged from circa 22 - 31 C, and was generally lower towards the confluence with Hutton Creek. DO concentrations varied substantially (0.8 - 8.2mg/L) along the tributary.

7.1.2 Permeate Discharge

The operation of the PHWTP will involve the use of a number of chemicals including biocides and antiscalants for backwash and cleaning purposes. All water will be captured from these operations and treated. No discharge of this water is planned and it is estimated that any residual amounts of chemicals used in this process will be undetectable in permeate due to dilution and the reverse osmosis process.

Permeate is therefore likely to be clean. The predicted permeate water quality range is shown in Table 7-1 where it is compared with relevant MTV for the area. Only those water quality parameters of relevance to permeate are shown. The temperature of permeate is likely to be less than the temperature of associated water at the wells but above ambient temperatures particularly in the dry season.

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The salinity, pH and temperature of permeate are likely to be higher than the MTVs. The ecological risks associated with these likely exceedances are considered in the context of the existing catchment and receiving water environments in the following sections.

Table 7-1 Predicted permeate discharge quality PHWTP

Water Quality Parameter Type	Water Quality Parameter Name	Units	Min.	90th percentile	MTV	
					Value	Source
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	150	500	340	
	pH	Stand	6.5	8.76	6.5-8.0	
	Temperature	C	NA	NA		
	Total dissolved solids	mg/L	100	325	1000	
	TSS	mg/L	0	0	10	
	TOC	mg/L as C	0	0		
	DOC	mg/L as C	0	0		
Inorganic Non-Metallic Parameters	Total Alkalinity	mg/L as CaCO3	40	125	20–400	QWQG
	Bicarbonate Alkalinity	mg/L as CaCO3	40	115		
	Carbonate Alkalinity	mg/L as CaCO3	0	10		
	Chloride	mg/L	30	72	175	
	Fluoride	mg/L	0	0.5	1	
	Sulphate	mg/L	0.2	0.3	400	
	Silica	mg/L as SiO_2	0.2	1.0		
Cations	Calcium	mg/L	0	0.5	1000	
	Magnesium	mg/L	0	0		
	Potassium	mg/L	0	0.6		
	Sodium	mg/L	35	107	115	
Nutrients	Ammonia-Nitrogen	mg/L	0	0.05	20#	
	Nitrate-Nitrogen	mg/L	0	0.02	0.4	
	Phosphorus/Phosphate	mg/L as P	ND	0.0004	0.05	
Trace elements	Aluminium	mg/L	0	0.05		
	Barium	mg/L	0	0.03		
	Boron	mg/L	0.1	3	370	
	Iron	µg/L	0.3	0.7	200	
	Lead	µg/L	0.3	1.7	3.4	
	Manganese	ug/L	0.05	0.1	<10 1900	QWQG* AWQG
	Zinc	µg/L	0.05	0.75	8	
	Strontium	mg/L	0.004	0.037		

NOTES:
* Guideline for aquatic aquaculture
# WQO is for Ammonia

7.1.3 Potential Impacts on Typical flows

The full flow record from Hutton Creek is compared with permeate discharges in Figure 7-1. The bankfull flood (6620 ML/day) in Hutton Creek is also shown. The bankfull flood is generally accepted as the flow that maintains channel geometry and has an Average Recurrence Interval of ~2.33 years.

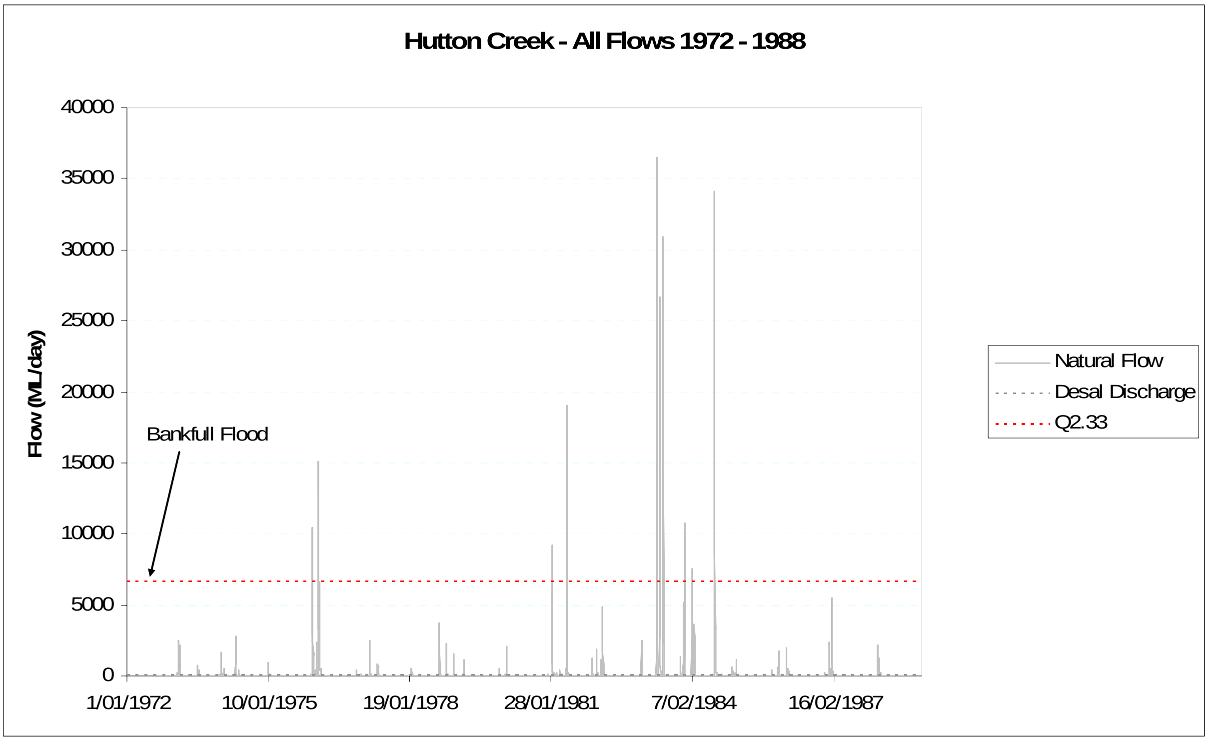

Figure 7-1 All Hutton Creek flows compared with PHWTP permeate discharge

The permeate discharge is not visible in Figure 7-1 since it is a very small percentage of the channel forming flood discharge.

To provide an improved view of the relative size of the permeate discharge to natural flows in Hutton Creek, the below figure has been split into two covering the periods 1972 – 1981 and 1982 – 1988. Furthermore any flows greater than 50 ML/day are removed from Figure 7-2 a) and b).

When flows do occur in Hutton Creek, it is likely that the permeate will be significantly diluted by the large flow volumes that occur. However, there are long periods during which the instream water quality will be significantly affected by permeate discharge. The degree of impact will be dependent upon the level of mixing that occurs instream since Hutton Creek maintains long deep pools.

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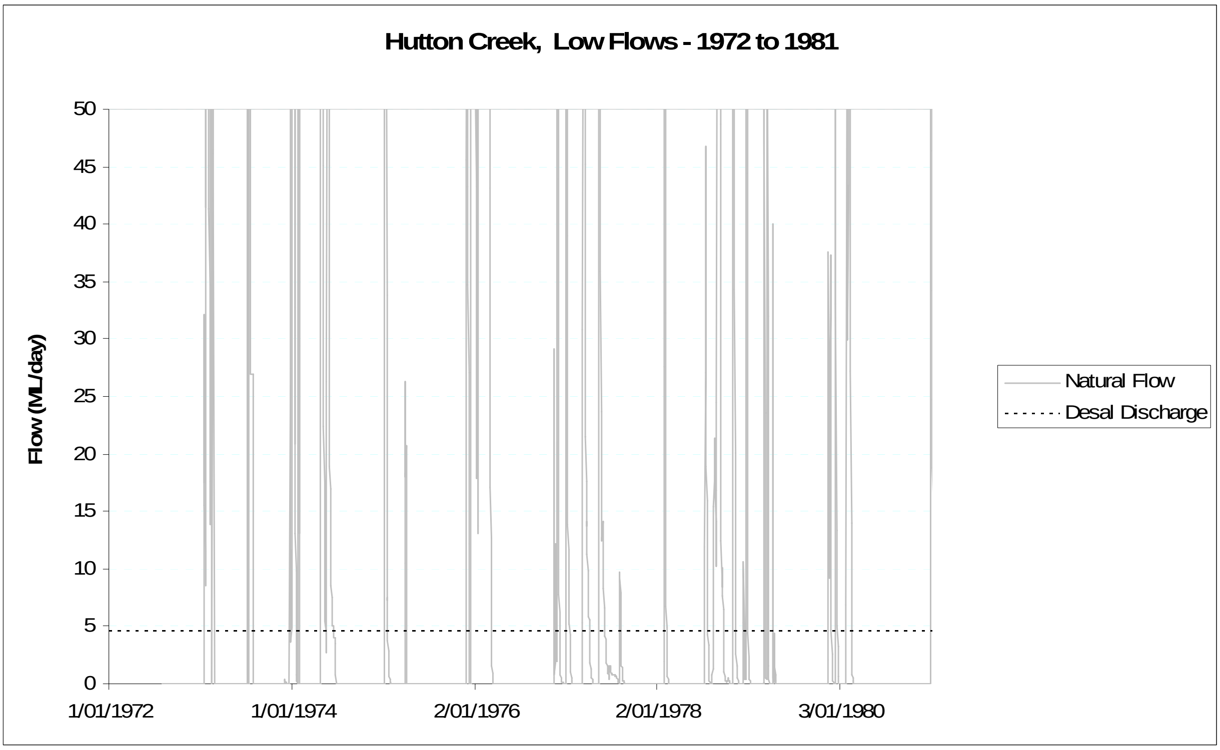

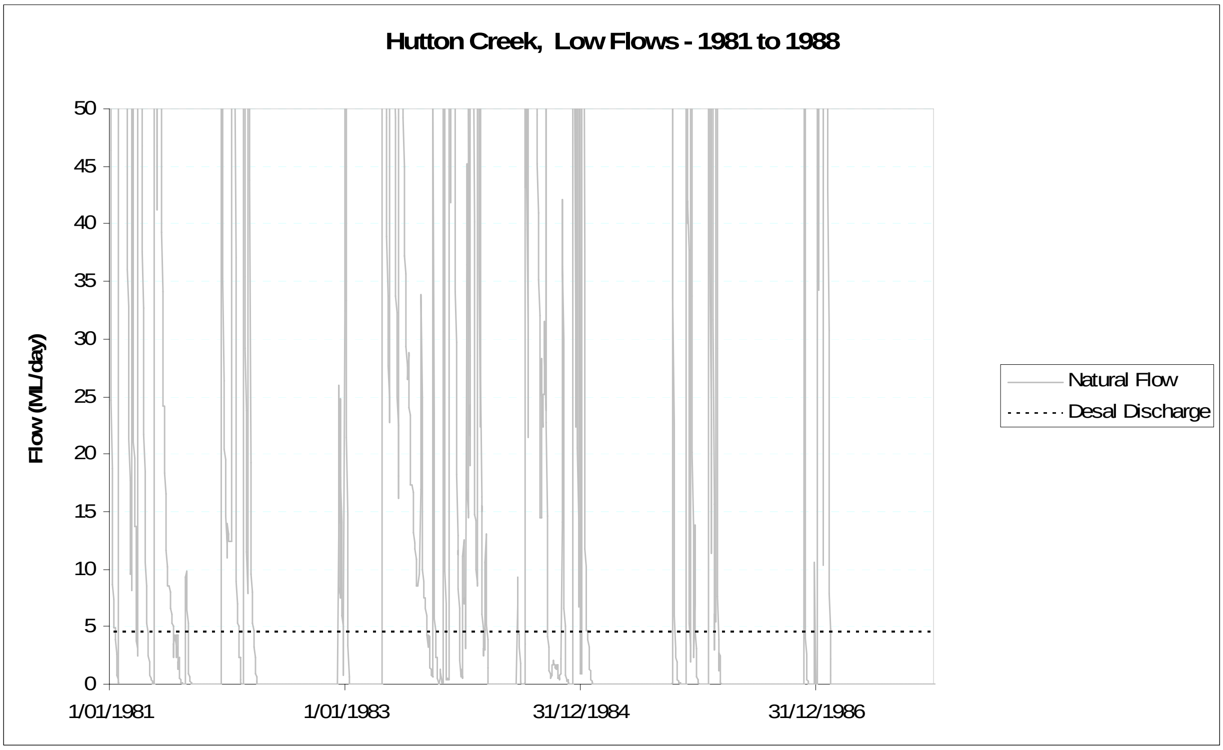

Figure 7-2 Low Hutton Creek flows compared with PHWTP permeate discharge

7.1.4 Potential Impacts on Channel Erosion

At the point of the proposed permeate discharge the unnamed Hutton Tributary has a width of approximately 20 m and a depth of approximately 1.4 m. This is more than sufficient to carry 4.5 ML/day permeate discharge within a small proportion of the stream bed. Local engineering works are planned to minimise erosion at this point.

Downstream of this point the tributary narrows but significant water storage capacity is available in scour pools and the channel system. Heavy rains lead to local flooding prior to the December 2007 field visit (Simmonds and Bristow, 2007b). There was no evidence of overbank flow even in the narrowest sections of the stream. Erosion and scour arising from the planned volumes of permeate water discharge are expected to be minimal.

Rating tables from the Hutton Creek gauging station suggest a rise in water level of approximately 100 – 150mm associated with the permeate discharge in Hutton Creek. This will simply maintain flows within the bottom of the channel since the dominant features of Hutton Creek are long wide ponds with short riffle sections between. Increased erosion is therefore considered unlikely during low flows in Hutton Creek.

At Utopia Downs on the Dawson River, DNRW rating tables suggests a rise of water level of circa 20 mm during normal flows. Once again this rise in water level will be well contained within the existing channel and no significant increase in erosion or scouring is likely.

7.1.5 Potential Impacts on Downstream Flooding

Discharges from the desalination plant will result in small rises in Hutton Creek and Dawson River as discussed in the previous section. Frequency analysis of floods in the Hutton Creek, Dawson River at Utopia and Dawson River at Taroom suggest that permeate discharge will be 0.07% and 0.03% of bankfull discharges respectively. Consideration of the cross-sections at these sites (see Figure 7-3 a and b) suggests little if any rise in natural bankfull flood levels.

7.1.6 Potential Salinity Impacts from Permeate Discharge

The predicted EC of the permeate discharge is comparable with existing EC levels in the unnamed Hutton Tributary and significantly lower than the elevated EC levels observed in Hutton Creek under low flow conditions. The proposed permeate discharge will therefore dilute salinity levels in Hutton Creek.

Estimated EC in Dawson River

The impacts of permeate discharges on the Dawson River EC have been estimated using a simple model that assumes complete mixing and conservation of mass. Two conservative flow conditions were considered:

- The “very low flows” condition is the minimum observed discharge during the dry season, and
- The “median November flows” condition was adopted as representative of small to medium flows.

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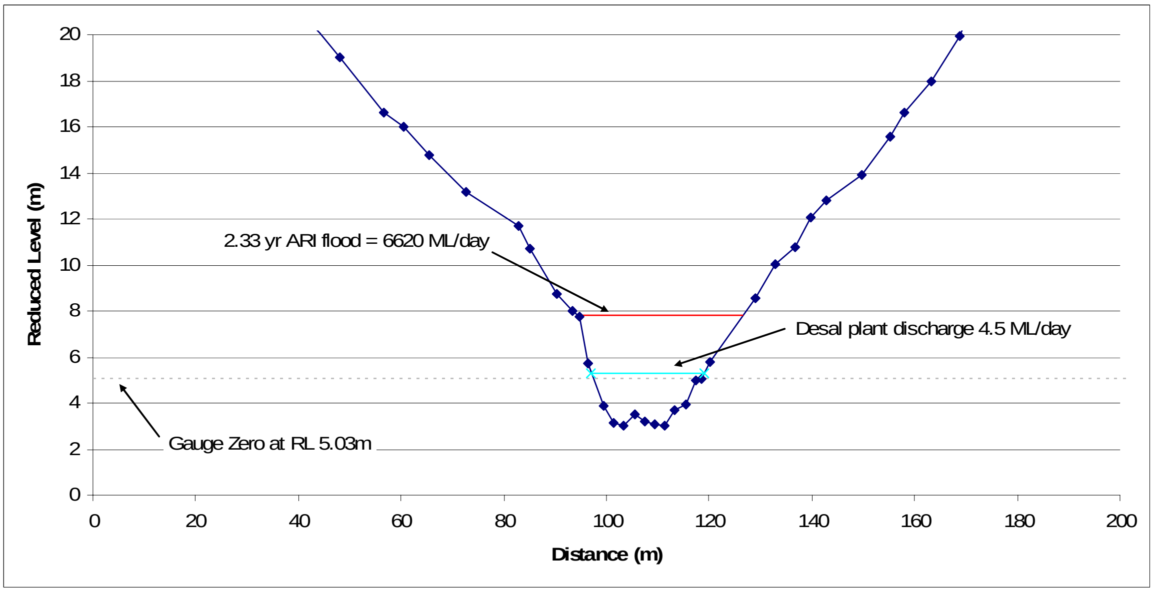
a) Hutton Creek



b) Utopia Downs

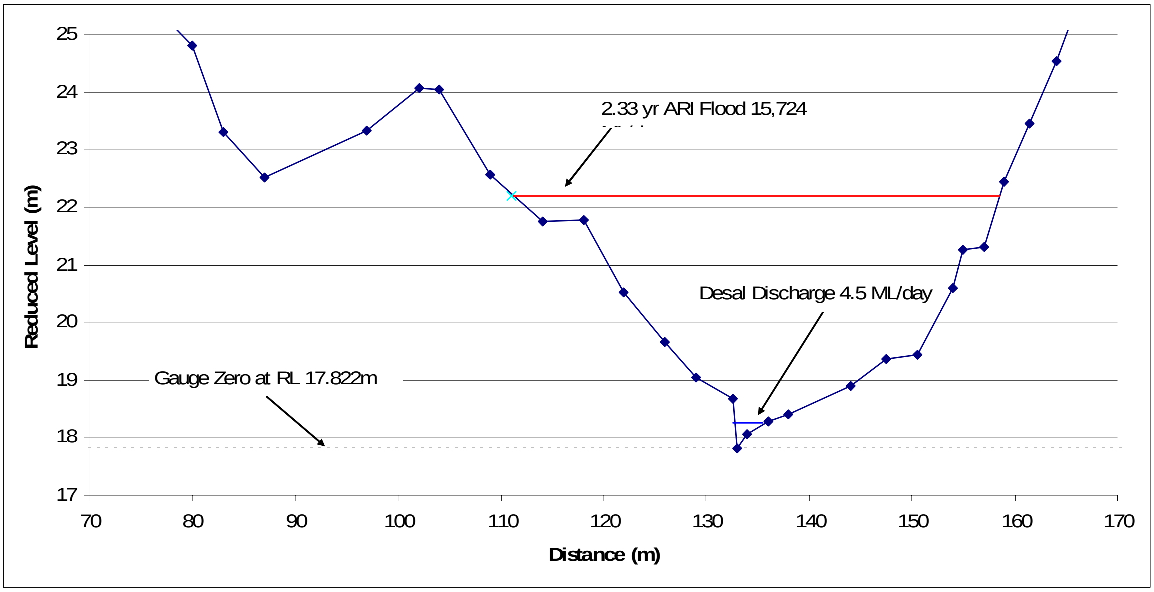


Figure 7-3 River cross-sections in Hutton Creek and Dawson River

Figure 7-4 shows the results of this modelling using various EC targets for a 4.5 ML/day permeate discharge. Under the very low flow condition, permeate discharges will potentially have a more significant effect on Dawson River EC compared with moderate flow conditions (as represented by median November flows) when little impact on Dawson River EC is likely.

To minimise EC impacts from the permeate it is intended to operate the plant to deliver 4.5 ML/day at 500 µS/cm which is within the observed range of EC at the discharge point in the unnamed Hutton Tributary, and below the current range of EC in Hutton Creek. A discharge with 500 µS/cm will also mean that the relevant WQO (340 µS/cm) is met within the Dawson River even under very low flows. This represents a very conservative operating scenario and very low risk of impacting on the riverine environment.

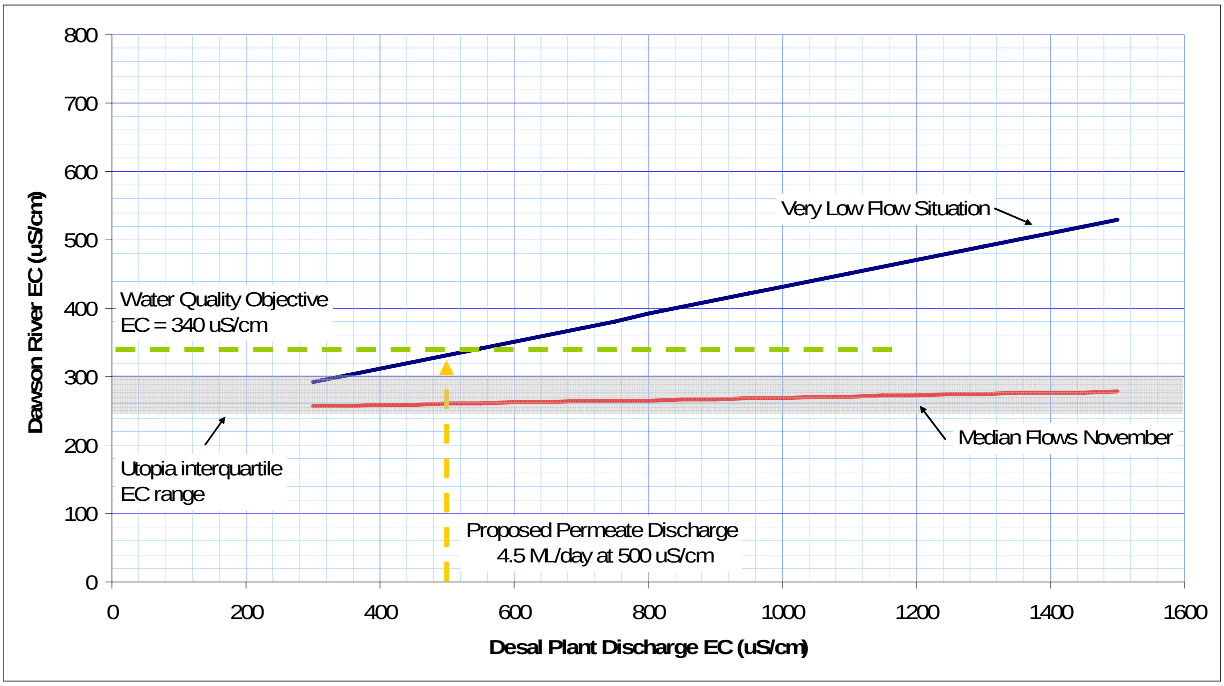


Figure 7-4 Modelled Impacts of Pony Hills Permeate Discharges

7.1.7 Potential Impacts from Permeate Discharge on Salt Loads

Annual salt loads from the Dawson River at Utopia Downs were calculated for the period 1997 - 2006 using the full length of the EC record at that site. In some years, insufficient information was available to provide a reliable estimate of annual load. Since discharge data and EC records are concurrent, a simple sum of hourly flow x salinity was used to calculate annual loads. Time weighted scaling was used to account for missing record where possible. Calculated average annual salt load is 4477 +/- 1267 tonne.

Permeate discharge of 4.5 ML/day at 500 µS/cm from Pony Hills Water Treatment plant is equivalent to an annual salt load of 558.8 tonne. This load is well within the natural variation in the catchment.

The dominant mechanism for natural salt load movement in the Dawson River is via flood events in the wet season. The increase in catchment salt load arising from the desalination plant discharge arises from a constant input in both wet and dry seasons.

During the dry season the dominant issue with permeate discharge is likely to be the concentration rather than the load.

During wet season the relative size of existing storages along the Dawson River (Glebe Weir 17,700 ML, Neville Hewitt Weir 11,300 ML) is small compared with even the median flow volume at Taroom (195,000 ML). Regular flushing of water in these storages is expected with no long term aggregation of salt in the weir pools.

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Given the predicted increase in salt loads is within the natural annual variability, the low level of concentration of salt discharged, and the high flow rates in the catchment it is unlikely that the increased salt load will cause any significant issues in the Dawson or Fitzroy river systems.

Table 7-2, below provides a comparison of predicted permeate water quality outputs and existing water quality observed instream. Minima, medians and maxima are shown for Hutton Creek, Dawson Bend and Yebna Crossing.

7.1.8 Other Potential Water Quality Impacts

Fluoride

Due to the proposed low concentration of fluoride in the desalination water, the discharge is predicted to dilute existing fluoride levels downstream.

Nutrients

Median ammonia concentrations in the permeate are approximately five times lower than median concentrations in Hutton Creek. The differences between maxima are within the error of measurement. Nitrate concentrations are approximately half that found in Hutton Creek, and the maximum concentration in permeate discharges is a one hundredth of that found in Hutton Creek. Consequently, nutrient concentrations are expected to improve in sites downstream of the discharge point.

Sodium

Median concentrations of Sodium in permeate water discharges will increase median concentrations in Hutton Creek but remain below guideline values. Maximum concentrations of Sodium in the permeate are well below existing observed maxima in Hutton Creek.

pH

Associated water pH is alkaline with a predicted median pH of 8.5 entering the desalination plant. Dosing with acid and other processes within the plant is expected to largely neutralise the pH of the discharge water with the expected range of pH discharged being 6.5 to 8.5 units, similar to background levels in the area. pH is expected to rapidly adjust towards local conditions on contact with soils in the balancing pond, through the proposed cooling tower, and on discharge to the unnamed Hutton Tributary. It is noted the predicted pH of the discharge water is lower than currently recorded in the unnamed Hutton Tributary, and therefore water quality within the tributary could potentially become more neutral.

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Table 7-2 Predicted permeate quality versus existing stream water quality.

MTV	Units	Permeate		Hutton Creek				Dawson Bend				Dawson R @ Yebna Crossing			
		Min	90th%ile	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n
Physico-Chemical Parameters															
Electrical Conductivity	µS/cm at 25C	150	500	131	233	1294	16	136	251	273	6	110	247	435	46
pH	Stand	6.5	8.76	6.60	7.85	8.30	16	6.4	6.9	7.3	6	7.20	7.75	8.00	6
Temperature	C	NA	NA	84	150	1010	16	92	129	220	6	75	168	296	46
Total dissolved solids	mg/L	100	325	5	28	630	16	4	12	366	4	2	8	142	5
TSS	mg/L	0	0	–	–	–	–	–	–	–	–	–	–	–	–
TOC	mg/L - C	0	0	–	–	–	–	–	–	–	–	–	–	–	–
DOC	mg/L - C	0	0	6.60	7.85	8.30	16	6.4	6.9	7.3	6	7.20	7.75	8.00	6
Inorganic Non-Metallic Parameters															
Total Alkalinity	mg/L - CaCO3	40	125	–	–	–	–	–	–	–	–	–	–	–	–
Bicarbonate Alkalinity	mg/L - CaCO3	40	115	65	100	820	16	55	118	157	6	87	114	130	6
Carbonate Alkalinity	mg/L - CaCO3	0	10	–	–	–	–	–	–	–	–	–	–	–	–
Chloride	mg/L	30	72	4	18	355	16	9	14	15	6	19	21	22	6
Fluoride	mg/L	0	0.5	<0.1	0.1	1.4	12	<0.1	0.2	0.2	6	<0.1	0.2	0.2	6
Sulphate	mg/L	0.2	0.3	<1	5.0	170	12	<1	<10	<5	6	<1	<5	<10	6
Silica	mg/L - SiO2	0.2	1.0	–	–	–	–	–	–	–	–	–	–	–	–
Cations															
Calcium	mg/L	0	0.5	5	16	85	16	1	14	19	6	7	11	17	6
Magnesium	mg/L	0	0	2	5	67	16	<1	8	9	6	4	6	6	6
Potassium	mg/L	0	0.6	2	5	10	16	2	3	5	6	3	3	6	6
Sodium	mg/L	35	107	9	21	280	16	15	21	27	6	27	28	33	6
Nutrients															
Ammonia-Nitrogen	mg/L	0	0.05	<.01	0.16	0.24	3	<0.006	<0.01	<0.01	3	<0.01	<0.01	0.014	3
Nitrate-Nitrogen	mg/L	0	0.02	1	1	69	9	–	<10	–	1	<10	–	–	1
Phosphorus/ Phosphate	mg/L - P	ND	0.0004	<10	95	230	5	20	53	750	5	<10	40	280	5
Trace elements															
Aluminium	mg/L	0	0.05	–	–	–	–	–	–	–	–	–	–	–	–
Barium 2	mg/L	0	0.03	–	–	–	–	–	–	–	–	–	–	–	–
Boron 2	mg/L	0.1	3	<0.1	0.06	800	12	<0.1	257	500	6	–	–	–	–
Iron	µg/L	0.3	0.7	62	1700	2358	3	66	97	950	3	76	156	390	3
Lead	µg/L	0.3	1.7	<1		2	2	<1	–	<1	2	<1	–	<1	2
Manganese	µg/L	0.05	0.1	–	–	–	–	–	–	–	–	–	–	–	–
Zinc	µg/L	0.05	0.75	<10	–	1.5	2	<1	–	<10	2.00	<1	–	<10	2
Strontium	mg/L	0.004	0.037	–	–	–	–	–	–	–	–	–	–	–	–

Aluminium

Aluminium has not been measured in the waterways of the Upper Dawson River catchment. Modelled Aluminium 90th percentile concentrations in permeate may reach as high as 0.05 mg/L just under the AWQG trigger value for 95% protection of aquatic ecosystems (0.055 mg/L).

Strontium

Strontium has not been detected in the Upper Dawson River waterways to date.

Strontium will not be discharged in the permeate under normal conditions. However, from time to time Strontium may be sourced from associated water with a maximum predicted concentration in permeate of 0.05 mg/L. No guideline values for Strontium 2+ are available in Australia.

Natural concentrations of Strontium in the worlds groundwaters typically lie in the range 0.0001 – 0.1 mg/L (Chapman, 1998); although natural concentrations as high as 15 mg/L have been identified in drinking water extracted from some German aquifers (Behrens et al, 2001). The world average concentration for unpolluted rivers is 0.1 mg/L. This suggests that occasional Strontium discharges will not cause significant environmental harm. A working group of the German Federal Environmental Agency considered the use of Strontium salts as a tracer in groundwater investigation and recommend an upper limit of 15 mg/L is not significantly exceeded in drinking water (*ibid.*).

Temperature

Associated water has a temperature range of circa 30 – 45C. Without further treatment, permeate temperatures are likely to be close to ambient water temperatures during summer and significantly higher than ambient during winter.

High temperature discharges could pose ecological risk due to the relative constant temperature of associated water in contrast to the seasonal temperature fluctuations in streams in the area. The relative volumes of flow and almost complete mixing expected within stream means that the temperature regime in Hutton Creek may be expected to be significantly affected, while the temperatures in the Dawson River may be expected to have minimal change from current conditions due to the dominance of spring flows (the minimum 90th percentile monthly observed flow at Utopia is 211 ML/day nearly 50 times the permeate discharge).

Due to the uncertainties surrounding the rate of movement of permeate temperature back to ambient stream temperature, Santos will install cooling towers downstream of the RO plant. Cooling towers will ensure the maintenance of diurnal and seasonal temperature variations in the discharge tributary, Hutton Creek and downstream. Cooling towers will normally deliver water within 5C of wet bulb temperature.

Installation and operation of the cooling towers will be monitored. Discharge water temperatures will be monitored and compared with conditions in Hutton Creek (upstream and downstream of the tributary) and Dawson River (upstream and downstream of Hutton Creek).

7.1.9 Potential River Health Impacts from Permeate Discharge

Discharges from the proposed desalination plant may improve habitat for rock wallabies and pigeons. Changes to the billabong adjacent to Hutton Creek are likely to be minimal due to the relative size of the pond compared with flows and existing connection with Hutton Creek, The main potential ecological change is a shift in macroinvertebrate species evident in the lower reaches of the tributary due to the increased flow regime. This shift is likely to be minor.

Water quality in the tributary post permeate discharge is expected to be significantly better than at present with higher dissolved oxygen, salinity closer to background levels.

Permeate water discharge is likely to lead to a general improvement in water quality through dilution of a range of parameters. The volumes of discharge are significant under low flow conditions, but are mainly expected to lead to an improvement in available habitat as pools will remain full for longer periods and riffles between pools will contain flow. There is unlikely to be a major shift in aquatic species.

The surface waters of the Upper Dawson River are of economic, environmental and social importance. Small, low order streamlines within the Santos Production Licences are often intermittent and certainly ephemeral; and they are subject to significant erosion due to clearing and stock access. These streams do not offer significant refugia during the dry season and are considered of less value that lower order streams such as Hutton Creek, Baffle Creek and Dawson River which maintain large pools even during dry season.

7.2 Central Desalination Plant

Investigations for the potential installation and use of the Central Desalination Plant are currently underway and will be presented in detail in the 2009 EMP for the Fairview Project Area.

Using the same model for salinity as for the PHWTP and taking into account planned discharges from PHWTP and spring flows in the Dawson River it is estimated (Figure 7-5) that the permeate from the Central Desalination Plant must be no higher than 340 µS/cm in order to maintain the salinity in the Dawson River at Dawson Bend at or below the relevant WQO.

Discharges are assumed to be 15 ML/day from the CDP in this preliminary scenario.

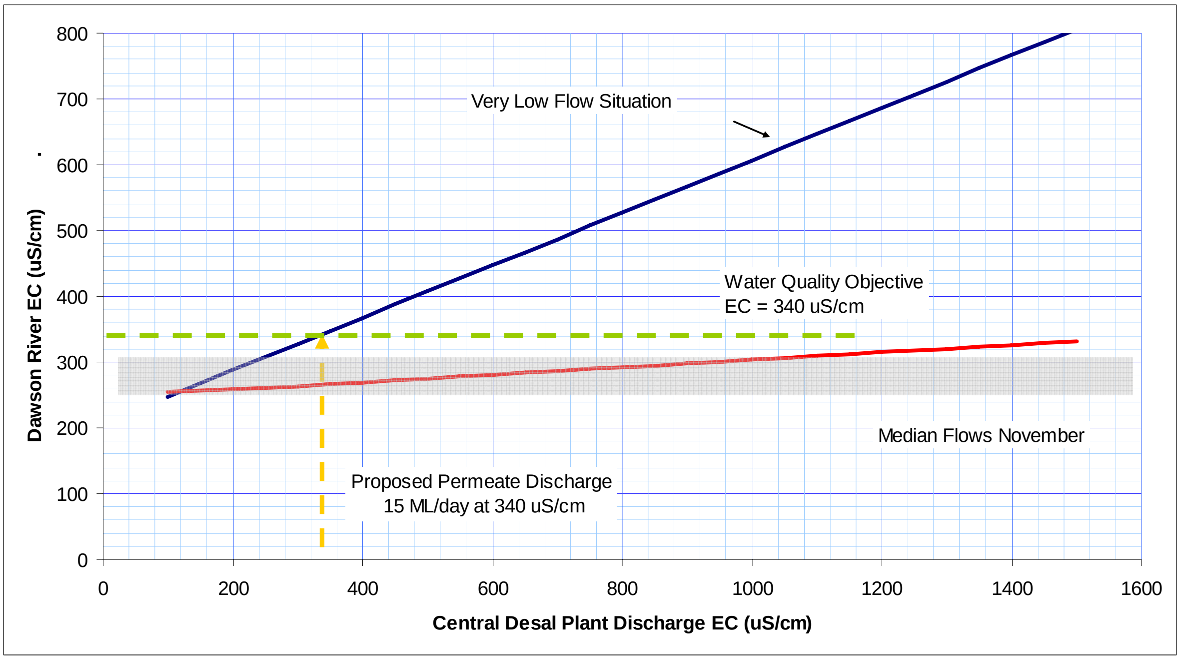

Figure 7-5 Modelled Impacts of Central Desalination Plant Permeate Discharges

Section 8 Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos Pty Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between November 2007 and January 2009 and is based on the information reviewed and conditions encountered at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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Water Quality Data Tables

Appendix A

Table A10
Upper Dawson River Spring Analytical Results
GLNG CSG Surface Water

Location	Sample ID	Date Sampled	Metals (Total)									Major Ions										Alkalinity			
			Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulfate as SO4 2-	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity
		LOR	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*1*	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
		Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
		MTV	*0.024/ 0.013*	*0.37*	*0.0002*	*0.05*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*	*1000*	*175*	*1*	*na*	*na*	*115*	*400*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
SP01	SP01_30/04/08	30/04/2008	0.002	<0.1	**0.0003**	0.001	**0.002**	**9.39**	0.002	0.002	0.01	37	46	**1.2**	10	4	43	4	4.71	4.67	0.53	<1	<1	167	167
SP01	SP01_30/04/08CHK	30/04/2008	0.002	<0.1	**0.0002**	<0.001	**0.002**	**9.42**	0.002	0.002	**0.008**	-	51	**1.2**	-	-	-	-	-	-	-	<1	<1	191	191
SP02	SP02_30/04/08	30/04/2008	0.001	<0.1	**0.0002**	0.001	**0.003**	**3.68**	0.002	0.003	**0.015**	91	166	**1.2**	28	9	63	57	10.6	9.82	3.67	<1	<1	235	235
SP02	QC01_30/04/08	30/04/2008	0.001	<0.1	**0.0002**	<0.001	**0.002**	**1.48**	0.001	0.002	**0.009**	83	52	**1.2**	24	6	55	64	8.39	8.68	1.67	<1	<1	280	280
SP03	SP03_30/04/08	30/04/2008	0.006	<0.1	**0.0002**	0.002	**0.004**	**14.9**	**0.004**	0.01	**0.017**	36	13	**1.3**	13	4	33	7	4.54	4.38	1.81	<1	<1	201	201
SP04	SP04_01/05/08	1/05/2008	0.002	<0.1	**0.0002**	<0.001	**0.002**	**4.4**	<0.001	0.001	0.01	20	28	<0.1	6	2	28	8	2.91	2.82	-	<1	<1	98	98
SP04	SP04_01/05/08CHK	1/05/2008	-	-	-	-	-	-	-	-	-	19	-	-	6	2	26	8	-	-	-	-	-	-	-
SP05	SP05_01/05/08	1/05/2008	<0.001	<0.1	0.0001	<0.001	<0.001	**0.73**	<0.001	<0.001	<0.005	4	13	**1.2**	1	2	25	<1	1.6	1.4	-	<1	<1	62	62
SP06	SP06_01/05/08	1/05/2008	<0.001	<0.1	**0.0005**	<0.001	0.001	**1.15**	<0.001	<0.001	**0.008**	4	19	**1.1**	2	2	24	<1	1.63	1.45	-	<1	<1	55	55
SP07	SP07_01/05/08	1/05/2008	<0.001	<0.1	**0.0004**	<0.001	0.011	**0.72**	<0.001	<0.001	**0.021**	4	21	**1.1**	2	2	25	<1	1.71	1.54	-	<1	<1	56	56
SP08	SP08_01/05/08	1/05/2008	<0.001	<0.1	**0.0002**	<0.001	<0.001	**0.82**	<0.001	0.006	0.007	28	46	**1.3**	8	4	45	14	4.1	4.06	0.47	<1	<1	125	125
SP09	SP09_01/05/08	1/05/2008	<0.001	<0.1	**0.0006**	<0.001	0.001	**1.09**	<0.001	<0.001	<0.005	7	23	**1.1**	3	2	28	<1	1.97	1.85	-	<1	<1	66	66
SP10	SP10_01/05/08	1/05/2008	<0.001	<0.1	0.0001	<0.001	0.001	**1.25**	<0.001	<0.001	<0.005	6	23	**1.2**	3	2	45	<1	2.73	2.54	-	<1	<1	104	104
SP10	SP10_01/05/08CHK	1/05/2008	<0.001	<0.1	**0.0002**	<0.001	0.001	**1.26**	<0.001	<0.001	<0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SP11	SP11_01/05/08	1/05/2008	<0.001	<0.1	**0.0002**	<0.001	<0.001	**0.41**	<0.001	<0.001	<0.005	6	24	**1.2**	3	2	44	<1	2.79	2.59	-	<1	<1	106	106
SP11	SP11_01/05/08CHK	1/05/2008	-	-	-	-	-	-	-	-	-	-	24	**1.2**	-	-	-	-	-	-	-	<1	<1	102	102
SP12	SP12_01/05/08	1/05/2008	<0.001	<0.1	**0.0002**	<0.001	<0.001	**0.45**	<0.001	<0.001	<0.005	8	26	**1.2**	3	2	39	<1	2.65	2.46	-	<1	<1	96	96
SP13	SP13_02/05/08	2/05/2008	<0.001	<0.1	**0.0002**	<0.001	<0.001	**0.8**	<0.001	<0.001	<0.005	22	21	**1.2**	12	2	27	<1	3.39	3.26	2	<1	<1	140	140
SP14	SP14_02/05/08	2/05/2008	<0.001	<0.1	**0.0003**	<0.001	<0.001	**0.78**	<0.001	<0.001	<0.005	22	21	**1.2**	12	2	27	<1	3.43	3.3	1.9	<1	<1	142	142
SP14	QC02_02/05/08	2/05/2008	<0.001	<0.1	**0.0005**	<0.001	<0.001	**0.78**	<0.001	<0.001	<0.005	22	20	**1.3**	11	2	30	<1	3.42	3.41	0.17	<1	<1	143	143
SP15	SP15_02/05/08	2/05/2008	0.001	<0.1	**0.0005**	<0.001	0.001	**1.08**	<0.001	<0.001	0.005	21	19	**1.3**	11	2	26	1	3.14	3.15	0.16	<1	<1	129	129
SP15	SP15_02/05/08CHK	2/05/2008	-	-	-	-	-	-	-	-	-	21	-	-	11	2	28	1	-	-	-	-	-	-	-

NOTES
MTV - minimum guideline trigger value
"CHK" - lab duplicate sample
"QC" - field duplicate sample
BOLD Greater than relevant MTV

Table A1
URS Water Quality Parameters Upper Dawson Catchment
GLNG CSG Surface Water

Site ID		**Date/Time**	**Water Quality Parameters**					
Number	**Name**	**Date**	**Time (EST)**	**EC (µS/cm)**	**DO (mg/L)**	**pH**	**Turbidity (NTU)**	**Temp (oC)**
			MTV	*340*		*6.5-8*	*50*	
D002	Dawson River @ Yebna Crossing	05-Mar-08	12:00	107	6.2	7.1	**270**	23.9
D002	Dawson River @ Yebna Crossing	02-Feb-08	10:35	264	5.47	6.76	**166**	25.4
D002	Dawson River @ Yebna Crossing	14-May-08	16:20	265	11.3	7.5	9	17.3
D003	Pine Creek @ Phelps Rd	05-Mar-08	-	-	-	-	-	-
D003	Pine Creek @ Phelps Rd	02-Feb-08	12:20	227.2	4	6.59	**266**	29.2
D003	Pine Creek @ Phelps Rd	13-May-08	15:45	-	-	-	-	-
D004	Dawson River @ Taroom-Roma Rd	05-Mar-08	16:40	150	6.01	7.73	**555**	23.3
D004	Dawson River @ Taroom-Roma Rd	02-Feb-08	13:36	270	5.23	6.82	**215**	27.3
D004	Dawson River @ Taroom-Roma Rd	13-May-08	10:55	**368**	9.84	7.78	14	14.6
D005	Eurombah @ Hornet Bank Rd	05-Mar-08	17:10	118	6.15	7.5	**492**	24.4
D005	Eurombah @ Hornet Bank Rd	02-Feb-08	14:15	317	5.95	7.16	**191**	28.8
D005	Eurombah @ Hornet Bank Rd	13-May-08	10:00	**340**	6.22	7.3	13	16.1
D006	Bridge/Ram Creek @ Roma Rd	05-Mar-08	16:30	192	7.43	**8.41**	**111**	28.1
D006	Bridge/Ram Creek @ Roma Rd	02-Feb-08	14:43	271	6.18	7.51	32	30.9
D006	Bridge/Ram Creek @ Roma Rd	13-May-08	11:30	-	-	-	-	-
D007	Paddys Creek @ Roma Rd	05-Mar-08	16:05	65.3	8.62	**8.41**	2	31.2
D007	Paddys Creek @ Roma Rd	02-Feb-08	14:56	232	4.57	**8.05**	**408**	30.8
D007	Paddys Creek @ Roma Rd	13-May-08	11:45	265	7.9	7.4	**240**	17.4
D008	Middle Creek @ Roma Rd	05-Mar-08	15:40	186	6.4	**8.5**	**152**	28.6
D008	Middle Creek @ Roma Rd	02-Feb-08	15:30	234	8.58	**8.34**	**54**	33.7
D008	Middle Creek @ Roma Rd	13-May-08	12:15	**488**	11.3	**8.5**	**160**	20.7
D009	Juandah Creek @ Roma Rd	05-Mar-08	15:20	120.2	2.26	7.14	**473**	28.5
D009	Juandah Creek @ Roma Rd	02-Feb-08	15:46	244	6.04	**8.06**	**163**	30.4
D009	Juandah Creek @ Roma Rd	13-May-08	12:30	218	6.36	6.8	**410**	20.5
D010	Dawson River @ Old Taroom Bridge	05-Mar-08	14:50	157.2	5.39	7.42	**427**	24.2
D010	Dawson River @ Old Taroom Bridge	02-Feb-08	16:23	225.1	4.15	6.98	**243**	27.8
D010	Dawson River @ Old Taroom Bridge	13-May-08	13:35	**420**	8.22	7.77		18.9
D011	Kinnoul Creek @ Taroom Rd	05-Mar-08	10:50	104	4.3	7.2	30	25.1
D011	Kinnoul Creek @ Taroom Rd	02-Feb-08	17:00	245	6.48	7.49	28	28.8
D011	Kinnoul Creek @ Taroom Rd	13-May-08	14:10	205	9.5	7.43	28	20.2
D012	Hutton Creek @ Carnarvon Hwy	05-Mar-08	-	-	-	-	-	-
D012	Hutton Creek @ Carnarvon Hwy	03-Feb-08	9:00	**485**	4.5	7.2	5	26.8
D012	Hutton Creek @ Carnarvon Hwy	13-May-08	9:15	260	6.7	6.98	22	14.9
D013	Dawson River @ Arcadia Valley Rd	06-Mar-08	10:00	136	-	7.1	-	-
D013	Dawson River @ Arcadia Valley Rd	03-Feb-08		222.9	6.33	7	31	25.5
D014	Dawson River @ Hornet Bank Rd	02-Feb-08	14:00	-	-	-	-	-
D015	Dawson River @ Baralaba	04-Feb-08	12:45	132	7.88	6.58	**180**	27.6
D016	Dawson River @ Carnavon Hwy	03-Feb-08		-	-	-	-	-

Notes:

MTV	minimum trigger value
BOLD	Greater than MTV
"-"	Creek dry

Table A3
Upper Dawson Catchment - Upstream Dawson River Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date		Physical									Cations				Anions				Nutrients & Biological					Trace Elements										Flow		Physical Appearance	Data Source
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-*a* (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity		
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*		
Dawson River - Arcadia Valley	4/05/2002																																				No Flow	S
Dawson River - Arcadia Valley	1/01/2002																																				No Flow	S
Dawson River - Arcadia Valley	1/01/2002																																				No Flow	S
Dawson River - Arcadia Valley	22/06/2001																																				No Flow	S
Dawson River - Arcadia Valley	25/05/2001																																				No Flow	S
Dawson River - Arcadia Valley	20/04/2001																																				No Flow	S
Dawson River - Arcadia Valley	8/03/2001			26		199			135																												Clear	S
Dawson River - Arcadia Valley	8/02/2001	11:00		26		285			194																												Clear	S
Dawson River - Arcadia Valley	5/01/2001	13:00		27		279			190																												Clear	S
Dawson River - Arcadia Valley	17/12/2000	14:00		25		231			157																												Clear	S
Dawson River - Arcadia Valley	18/11/2000	15:30		25		231			157																												Clear	S
Dawson River - Arcadia Valley	5/10/2000																																					S
Dawson River - Arcadia Valley	5/09/2000																																				No Water	S
Dawson River - Arcadia Valley	3/08/2000																																				No Water	S
Dawson River - Arcadia Valley	13/07/2000																																				No Flow	S
Dawson River - Arcadia Valley	15/06/2000																																				No Sample	S
Dawson River - Arcadia Valley	2/06/2000																																					S
Dawson River - Arcadia Valley	29/04/2000																																					S
Dawson River - Arcadia Valley	1/04/2000																																				Not Flowing	S
Dawson River - Arcadia Valley	2/03/2000																																				No Flow	S
Dawson River - Arcadia Valley	30/01/2000																																					S
Dawson River - Arcadia Valley	30/12/1999																																					S
Dawson River - Arcadia Valley	29/11/1999																																					S
Dawson River - Arcadia Valley	30/10/1999																																					S
Dawson River - Arcadia Valley	30/09/1999																																				Not Flowing	S
Dawson River - Arcadia Valley	29/08/1999																																				No Water	S
Dawson River - Arcadia Valley	29/07/1999																																				No Water	S
Dawson River - Arcadia Valley	1/06/1999																																				No Water	S
Dawson River - Arcadia Valley	7/05/1999																																				No Water	S
Dawson River - Arcadia Valley	5/04/1999			28		135			92																												No flow, mud hole	S
Dawson River - Arcadia Valley	6/03/1999	15:00		27		176			120																												slight flow, murky	S
Dawson River - Arcadia Valley	26/02/1999																																				No Water	S
Dawson River - Arcadia Valley	1/01/1999																																				No Flow	S
Dawson River - Arcadia Valley	21/12/1998																																				No Flow	S
Dawson River - Arcadia Valley	29/11/1998																																				No Flow	S
Upstream Dawson Waterhole	9/10/2003			26.5	7.1	170	6.80	86	109			17	11	3	3	98	8	0.1	<5							**<100**									Isolated	No flow		RH
Upstream Dawson Waterhole	22/04/04			24.9	7	273	7.90	96	156	**52**		22	6	14	5	151	12	0.1	<10	**7780**	**140**					**500**									Isolated	Low		RH
Upstream Dawson Waterhole	17/11/04			24.5	6.6	**1702**	5.70	**69**	108	**82**		3	<1	6	6	70	8	0.24	<10		**1900**	**380**				**<100**									Low-Mod	Mod		RH
Dawson Road Crossing	5/09/2006			15.4	7	50	8.61	**84**	46	**125**	**101**	3	4	1	1	28	3	0.1	4	**570**	<10	10			4	<100	<0.1	16	2	**4407**	3	<0.1	4	**14**				RH
Dawson Road Crossing	26/04/2007		19.5	18.9	6.6	159	0.81	**9**	160	**68**		11	10	18	6	95	6	0.24	<1	**3300**	**110**	**590**	128*	**8.8**	2.8	23	<1	<1	**<2**	**5100**	<1	<0.5	<3	<1				RH

NOTES

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

All samples collected upstream of existing associated water discharge

S - Santos

Water Quality Data Summary

			Physical									Cations				Anions				Nutrients				Trace Elements										Biologica	Flow			
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-a (µg/L)	Level	Velocity	Physical Appearance	Data source
		MTV	na	0-80 %il	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1.2	400	500	50	20		24/13	370	0.2	50	1.4	200	3.4	0.6	11	8	5	na	na		
Upper Baffle Creek	4/05/2002	15:40		21		**1585**			1078																												Clear	S
Upper Baffle Creek	1/01/2002	10:30		24		**1570**			1068																												Slight cloudy brown	S
Upper Baffle Creek	1/01/2002	10:30		24		**1570**			1068																												Slight cloudy brown	S
Upper Baffle Creek	1/01/2002	14:35		25		147			100																												Not Flowing - Yellow Brown	S
Upper Baffle Creek	1/01/2002	13:35		27		128			87																												Slight flow, muddy	S
Upper Baffle Creek	1/01/2002					97			66																												Slow Flow - Yellow Brown	S
Upper Baffle Creek	1/01/2002	13:10		29		115			78																												Slight flow, muddy	S
Upper Baffle Creek	1/01/2002	9:00		27		144			98																												Mod flow, muddy	S
Upper Baffle Creek	22/06/2001								0																												No Flow	S
Upper Baffle Creek	25/05/2001								0																												No Flow	S
Upper Baffle Creek	20/04/2001								0																												No Flow	S
Upper Baffle Creek	8/03/2001								0																												No Flow	S
Upper Baffle Creek	5/10/2000								0																													S
Upper Baffle Creek	5/09/2000								0																												No Flow	S
Upper Baffle Creek	3/08/2000								0																												No Flow	S
Upper Baffle Creek	13/07/2000	14:29		24		142			97																												Cloudy, some sediment	S
Upper Baffle Creek	15/06/2000	14:22		24		**1296**			881																												Cloudy, some sediment	S
Upper Baffle Creek	2/06/2000	10:30		19		**1901**			1293																												Slight cloudy brown	S
Upper Baffle Creek	29/04/2000	10:30		21		**1490**			1013																												Slight cloudy brown	S
Upper Baffle Creek	1/04/2000	10:30		24		**1456**			990																												Slight cloudy brown	S
Upper Baffle Creek	2/03/2000			24		**1467**			998																												Slight cloudy brown	S
Upper Baffle Creek	30/01/2000	10:30		24		**1856**			1262																												Slight cloudy brown	S
Upper Baffle Creek	30/12/1999	16:00		25		200			136																												Not Flowing	S
Upper Baffle Creek	29/11/1999	11:17		24		280			190																												Not Flowing	S
Upper Baffle Creek	30/10/1999	15:42		25		**460**			313																												Not Flowing	S
Upper Baffle Creek	30/09/1999			21		211			143																												Not Flowing	S
Upper Baffle Creek	29/07/1999			15		185			126																												No Flow	S
Upper Baffle Creek	29/07/1999			19		191			130																												Not Flowing	S
Upper Baffle Creek	1/06/1999	14:00		14		162			110																												Not Flowing	S
Upper Baffle Creek	7/05/1999	16:00		18		86			58																												Not Flowing	S
Upper Baffle Creek	5/04/1999			27		98			67																												slight flow, murky	S
Upper Baffle Creek	9/09/2003			17.5	6.8	67	8.90	94	43			6	5	1	2	54	<0.5	0.1	<5						**<100**										Mod	Low		RH
Upper Baffle Creek	21/04/2004			26.5	6.6	152	12.30	155	64	6		8	6	6	4	77	7	<.1	<10	**1350**	**60**				**500**										Low	Low		RH
Upper Baffle Creek	16/11/2004			32.7	7.8	134	8.60	119	84	**49**		<1	7	4	3	67	7	0.32	<10		**1000**	**100**			**<100**										Low	Low		RH
Upper Baffle Creek	23/05/2005				7.4	108			114	**30**		5	5	4	4	47	6	0.43	<10	**810**	**50**	**30**			**<100**				**1800**						Mod	Low		RH
Upper Baffle Creek	5/08/2006			15.8	7.1	212	9.87	99	126	**48**	**105**	17	6	11	7	99	9	0.4	3	480	**<10**	**<10**		<1	**<100**	<0.1	<1	<1	81	<1	<0.1	<1	**<10**		Mod	Low		RH
Upper Baffle Creek	22/04/2007		27.5	22.9	7.6	138	7.23	**85**	160	**49**		17	12	15	7	93	5	0.32	<1	**1100**	**<20**	**77**	318*	<1	25	<1	<1	**<2**	**750**	<1	<0.5	<3	**8.3**	**6.5**				RH
Baffle Creek	7/01/2002					**1520**			1034																												Clear	S
Baffle Creek	5/11/2001			22		**1384**			941																												Brown tinge	S
Baffle Creek	12/10/2001			22		**1484**			1009																												Brown tinge	S
Baffle Creek	29/08/2001			23		**1484**			1009																												Brown tinge	S
Baffle Creek	1/07/2001			22		**1530**			1040																												Clear, slight brown tinge	S
Baffle Creek Outflow	5/04/1999	11:50		23		**775**			527																												Slow flow - murky	S
Baffle Creek Outflow	4/05/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002					188			128																												Slow flow - murky	S
Baffle Creek Outflow	1/01/2002	11:30		27		328			223																												Mod flow, muddy	S
Baffle Creek Outflow	22/06/2001			19		**1260**			857																												Slightly cloudy Brown	S
Baffle Creek Outflow	25/05/2001			23		**1340**			911																												Slightly cloudy Brown	S
Baffle Creek Outflow	20/04/2001			25		**1350**			918																												Slightly cloudy Brown	S
Baffle Creek Outflow	8/03/2001			26		**1459**			992																												Clear, slight brown tinge	S
Baffle Creek Outflow	5/09/2000								0																												No Sample	S
Baffle Creek Outflow	3/08/2000								0																												No Sample	S
Baffle Creek Outflow	23/07/2000								0																												No Sample	S
Baffle Creek Outflow	15/06/2000								0																												No Sample	S
Baffle Creek Outflow	1/04/2000								0																												Not Flowing	S
Baffle Creek Outflow	1/04/2000	13:00		21		**1150**			782																												Slight cloudy brown	S
Baffle Creek Outflow	1/04/2000	13:00		19		**1348**			917																												Slight cloudy brown	S
Baffle Creek Outflow	2/03/2000								0																												No Tested	S
Baffle Creek Outflow	30/01/2000	13:00		24		**1252**			851																												Slight cloudy brown	S
Baffle Creek Outflow	30/12/1999								0																												Not Flowing	S
Baffle Creek Outflow	29/11/1999	14:22		22		**860**			585																												Not Flowing	S
Baffle Creek Outflow	29/10/1999	9:24		21		**880**			598																												Not Flowing	S
Baffle Creek Outflow	30/09/1999			18		**1281**			871																												Slow Flow	S
Baffle Creek Outflow	29/07/1999			16		**867**			590																												Slow flow - murky	S
Baffle Creek Outflow	29/07/1999			13		**1233**			838																												Slow - Med. Flow	S
Baffle Creek Outflow	1/06/1999	12:13		14		**553**			376																												Slow flow - murky	S
Baffle Creek Outflow	7/05/1999	11:00		19		**621**			422																												Slow - Med. Flow	S
Baffle Creek Outflow	5/04/1999			26		**649**			441																												Slow- med flow	S
Baffle Creek Outflow	9/10/2003			19		**1444**	7.30	**79**	925			**347**	4	1	1	726	55	**2**	<5						200										Low	Low		RH
Baffle Creek Outflow	22/04/2004			20		**870**	5.10	**56**	612	**37**		**162**	5	5	3	916	36	0	<10	**3970**	**220**				**700**										Low	Low		RH
Baffle Creek Outflow	17/11/2004			23		**1403**	0.40	**5**	852	**76**		**232**	8	<1	2	623	56	1	<10	**1800**	**350**				**400**										Mod	Low		RH
Baffle Creek Outflow	21/05/2005			14		**1373**	10.10	98	1030	**10**		**349**	6	<1	2	664	68	**2**	<10	**720**	**150**	**120**			**500**				**6013**						Low	Low		RH
Baffle Creek Outflow	5/09/2006			12		**1864**	7.90	**73**	1168	**39**	**154**	**437**	6	1	2	723	93	**2**	24	**770**	**<10**	**<10**		9	**600**	<0.1	16	3	**6362**	**8**	<0.1	3	**14**		Mod	Low		RH
Baffle Creek Outflow	22/04/2007		31	19	7.8	**832**	3.01	**33**	640	**16**		**200**	6	7	3	570	40	1	<1	**1100**	**66**	16	<44*	2	360	<1	<1	<2	**1300**	<1	<0.5	<3	3	**5**				RH

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

Upper Baffle Creek samples upstream of existing associated water discharge

Baffle Creek & Baffle Creek Outflow samples downstream of existing associated water discharge

S - Santos

Table A5
Upper Dawson Catchment - Baffle Creek Water Quality Data
GLNG CSG Surface Water

			Physical								Cations				Anions				Nutrients				Trace Elements										Biologica		
Sample Collection Point	**Sample Date**	**Time**	**Air Temp (°C)**	**Water Temp (°C)**	**pH**	**EC (µS/cm)**	**DO (mg/L)**	**DO % sat**	**TDS (mg/L)**	**TSS (mg/L)**	**Sodium (mg/L)**	**Potassium (mg/L)**	**Calcium (mg/L)**	**Magnesium (mg/L)**	**Bicarbonate as HCO3 (mg/L)**	**Chloride (mg/L)**	**Fluoride (mg/L)**	**Sulphate (mg/L)**	**TN (µg/L)**	**TP (µg/L)**	**Ammonia (µg/L)**	**Nitrate as NO_3 (µg/L)**	**Arsenic (µg/L)**	**Boron (µg/L)**	**Cadmium (µg/L)**	**Chromium (µg/L)**	**Copper (µg/L)**	**Iron (µg/L)**	**Lead (µg/L)**	**Mercury (µg/L)**	**Nickel (µg/L)**	**Zinc (µg/L)**	**Chl-*a* (µg/L)**	**Physical Appearance**	**Data source**
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*		
Dawson Downstream Baffle	4/05/2002																																	Not tested	S
Dawson Downstream Baffle	1/01/2002																																	Not tested	S
Dawson Downstream Baffle	1/01/2002																																	Not tested	S
Dawson Downstream Baffle	22/06/2001			19		**1130**			768																									Silty cloudy Brown	S
Dawson Downstream Baffle	25/05/2001			23		**980**			666																									Silty cloudy Brown	S
Dawson Downstream Baffle	22/06/2001	11:00		24		**844**			574																									Slow flow, lt Brown	S
Dawson Downstream Baffle	22/06/2001	12:15		26		**853**			580																									Slow flow, muddy	S
Dawson Downstream Baffle	22/06/2001					182			124																									Slow flow - lt Brown	S
Dawson Downstream Baffle	22/06/2001	11:05		26		**783**			532																									Slt flow, muddy	S
Dawson Downstream Baffle	22/06/2001	11:45		27		**353**			240																									Mod flow, muddy	S
Dawson Downstream Baffle	22/06/2001			28		**673**			458																									Slow - med flow	S
Dawson Downstream Baffle	20/04/2001			24		**800**			544																									Silty cloudy Brown	S
Dawson Downstream Baffle	8/03/2001			25		288			196																									Clear, slt brown tinge	S
Dawson Downstream Baffle	5/10/2000	10:30		24		**1367**			930																									Clear, slt sediment	S
Dawson Downstream Baffle	5/09/2000	10:00		24		**1498**			1019																									Clear, slt sediment	S
Dawson Downstream Baffle	3/08/2000	10:00		20		**1358**			923																									Clear, slt sediment	S
Dawson Downstream Baffle	23/07/2000																																	No Sample	S
Dawson Downstream Baffle	15/06/2000																																	No Sample	S
Dawson Downstream Baffle	2/06/2000																																		S
Dawson Downstream Baffle	29/04/2000																																		S
Dawson Downstream Baffle	1/04/2000	1.00PM		24		**1060**			721																									Silty cloudy brown	S
Dawson Downstream Baffle	2/03/2000			24		**1152**			783																									Silty cloudy brown	S
Dawson Downstream Baffle	30/01/2000																																		S
Dawson Downstream Baffle	31/12/1999	2:30		21		**1050**			714																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	29/11/1999	15:00		22		**880**			598																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	29/10/1999	10:52		21		**910**			619																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	30/09/1999			18		**1402**			953																									Slow Flow	S
Dawson Downstream Baffle	29/07/1999			15		**872**			593																									Slow flow - murcky	S
Dawson Downstream Baffle	29/07/1999			15		**1319**			897																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	1/06/1999	11:30		13		**556**			378																									Slow flow - murcky	S
Dawson Downstream Baffle	7/05/1999	11:15		19		**664**			452																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	25/4/07		24.6	19.5	**8.3**	**1296**	6.05	**67.0**	990	**99.0**	**280.0**	10	10	5.5	820	120	**1.4**	<1	**1600.0**	**90.0**	**82.0**	305*	3.4	**480.0**	<1	8.3	**<2**	**1700**	<1	<0.5	4.2	1.5	**15**		RH

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources
*by calcuation from Nitrate as N

Table A6
Upper Dawson Catchment - Hutton Creek Water Quality Data
GLNG CSG Surface Water

			Physical									Cations				Anions
Sample Collection Point	**Sample Date**	**Time**	**Air Temp (°C)**	**Water Temp (°C)**	**pH**	**EC (µS/cm)**	**DO (mg/L)**	**DO % sat**	**TDS (mg/L)**	**TSS (mg/L)**	**Turbidity (NTU)**	**Sodium (mg/L)**	**Potassium (mg/L)**	**Calcium (mg/L)**	**Magnesium (mg/L)**	**Bicarbonate as HCO3 (mg/L)**
		MTV	*na*	*0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*
Upper Hutton Creek	9/10/2003			18.8	7.9	**1478**	9.10	98	1139			**133**	9.4	91	16	314
Upper Hutton Creek	25/04/2007		27.7	22.5	6.6	156	4.31	**49**	190	**570**		14		20		
Hutton Creek	19/04/2004			24.4	7.2	**358**	3.60	**41**	292	**10**		27	7.0	27	7	171
Hutton Creek	16/11/2004			23.2	7.6	**461**	5.60	**66**	284	**36**		39	10.0	30	9	190
Hutton Creek	26/05/2005			9.7	7	195	9.90	88	195	**170**		18	7.0	9	4	87
Hutton Creek	5/08/2006			14.9	6.6	183	8.00	**78**	116	**123**	**116**	24	6.0	5	2	83
Hutton Creek	21/04/2007		34.3	21.3	7.1	273	3.49	**39**	220	**32**		59	7.4	12	4	130
Hutton Creek	8/08/1973	1450		19	**8.1**	155			96	**116**		14	5.4	11	3	65
Hutton Creek	15/12/1976	1317		31	7.9	**390**			198	7		30	6.8	36	7	145
Hutton Creek	8/09/1980	1405			**8.2**	215			122	**10**	**75**	17	4.1	16	4	88
Hutton Creek	25/03/1982	1405		27	8	160			97	**200**	**100**	12	4.2	12	3	77
Hutton Creek	16/12/1983	930		24	**8.2**	195			130	**20**	25	17	4.6	16	4	90
Hutton Creek	20/03/1984	1400		27	7.8	250			150	**10**	12	20	4.9	20	5	110
Hutton Creek	24/06/1984	1405		14	7.5	270			150	5		22	4.8	22	5	135
Hutton Creek	19/10/1984	1500		20	7.9	**570**			320	5		70	1.6	34	11	185
Hutton Creek	15/01/1985	920		24	7.8	200			120	**445**	**100**	17	5.2	15	4	88
Hutton Creek	20/10/1985	1025		20	**8.2**	**390**			1010	**10**	1	**175**	4.5	85	67	275
Hutton Creek	14/02/1988	1109		25	7.2	131			84	**630**	**100**	9	4.3	12	3	65

		Anions			Nutrients				Trace Elements										Biologica	Flow		
Sample Collection Point	**Sample Date**	**Chloride (mg/L)**	**Fluoride (mg/L)**	**Sulphate (mg/L)**	**Total nitrogen (µg/L)**	**Total phosphorous (µg/L)**	**Ammonia (µg/L)**	**Nitrate as NO_3 (µg/L)**	**Arsenic (µg/L)**	**Boron (µg/L)**	**Cadmium (µg/L)**	**Chromium (µg/L)**	**Copper (µg/L)**	**Iron (µg/L)**	**Lead (µg/L)**	**Mercury (µg/L)**	**Nickel (µg/L)**	**Zinc (µg/L)**	**Chl-*a* (µg/L)**	**Level**	**Velocity**	**Data source**
		175	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*	
Upper Hutton Creek	9/10/2003	**267**	0.1	120						<100										Isolated	No flow	RH
Upper Hutton Creek	25/04/2007	6	0.31	<1	**1800**	**170**	**51**	**168***	<1	32	**<1**	<1	**2**	**1900**	**4.8**	<0.5	6.3	1.5	**13**	-	-	RH
Hutton Creek	19/04/2004	28	<.1	<10	**2340**	**70**				**800**										Moderate	Low	RH
Hutton Creek	16/11/2004	39	0.36	<10	**1300**	**100**				<100										Low	Low	RH
Hutton Creek	26/05/2005	12	0.43	<10	**1330**	**230**	**240**			<100				**2358**						Low	Low	RH
Hutton Creek	5/08/2006	12	0.2	5	**680**	**<10**	**<10**		2	<100	<0.1	5	**<1**	62	2	<0.1	<1	**<10**		Mod	Low	RH
Hutton Creek	21/04/2007	20	0.31	<1	**1200**	**76**	**93**	**101***	1.6	79	**<1**	<1	**<2**	**2300**	<1	<0.5	<3	**20**	**6.6**			RH
Hutton Creek	8/08/1973	10	0.14																			DNRW
Hutton Creek	15/12/1976	37	0.5	4				**1200**														DNRW
Hutton Creek	8/09/1980	15	0.1	5				**4000**														DNRW
Hutton Creek	25/03/1982	8		5.4				**2100**														DNRW
Hutton Creek	16/12/1983	15		2.7				**1200**		20												DNRW
Hutton Creek	20/03/1984	25	0.1	6.3						20												DNRW
Hutton Creek	24/06/1984	19	0.1	3.3						20												DNRW
Hutton Creek	19/10/1984	81	0.1	12				**1100**		10												DNRW
Hutton Creek	15/01/1985	16	0.1	2				**1100**		20												DNRW
Hutton Creek	20/10/1985	**355**	0.3	170				**500**		100												DNRW
Hutton Creek	14/02/1988	4	0.1	2.1				**3800**		10												DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources

Table A7
Upper Dawson Catchment - Dawson Downstream Hutton Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date		Physical									Cations				Anions				Nutrients				Trace Elements										Biological	Flow			
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-a (µg/L)	Level	Velocity	Physical Appearance	Data source
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*		
Dawson d/s Hutton-1	23/04/2004			22.2	6.8	264	4.90	**56**	108	**66**		20	3	15	6	138	14	<.1	<10	**1050**	**190**				**400**										Moderate	Moderate		RH
Dawson d/s Hutton-1	19/11/2004			22.1	7	129	7.90	91	88	**316**		15	5	1	2	54	8	0.1	<10	**4100**	**580**				<100										Moderate	Moderate		RH
Dawson d/s Hutton-1	22/05/2005			9.3	7.4	266	13.40	116	160	3		21	3	15	8	111	14	0.21	<10	120	**<50**	<10			<100										No flow			RH
Dawson d/s Hutton-1	24/05/2005			12.4	**6**	265	8.10	**75**	143	3		21	3	16	9	113	16	0.2	<10	170	**<50**	**40**			<100										Low-Mod	Low		RH
Dawson d/s Hutton-1	5/10/2006			14.6	7.3	226	7.20	**70**	108	**15**	6	18	3	14	7	104	10	0.2	<1	60	**<10**	<10		<1	<100	<0.1	<1	<1	60	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawson d/s Hutton-1	23/04/2007		31.9	22.5	6.9	265	4.16	**49**	160	9		23	3	21	9	150	11	0.21	<1	**550**	**<20**	**30**	<44*	<1	16	<1	<1	<2		<1	<0.5	<3	**17**	<1				RH
Dawson d/s Hutton-2	23/04/2004			25.1	7.6	260	5.40	**66**	132	**20**		20	3	14	6	138	14	<.1	<10	280	**110**				**400**										Low	Moderate		RH
Dawson d/s Hutton-2	19/11/2004			22.7	7.2	134	8.00	93	922	**292**		15	6	1	2	56	8	0.08	<10	**3100**	**680**				<100										Moderate	Moderate		RH
Dawson d/s Hutton-2	24/05/2005			13.8	7	249	9.50	93	172	3		21	3	16	9	111	14	0.17	<10	190	**<50**	<10			<100				66						Low-Mod	Low		RH
Dawson d/s Hutton-2	5/10/2006			15.4	7.6	228	7.20	**71**	124	**11**	4	19	3	14	7	106	12	0.2	<1	60	**<10**	<10		<1	<100	<0.1	<1	<1	97	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawson d/s Hutton-2	23/04/2007		31.5	21.8	7	282	5.93	**68**	160	3		28	4	26	11	150	12	0.21	<1	**560**	**<20**	<6	<44*	<1	15	<1	<1	<2		<1	<0.5	<3	<1	<1				RH
Dawsons Bend	9/11/2003			19.2	6.7	258	5.10	**55**	95			27	2	14	7	157	12	0.1	<5						<100										Low	Low		RH
Dawsons Bend	20/04/2004			24.6	**6**	270	4.50	**54**	92			21	3	14	7	131	15	<.1	<10	270	**60**				**500**										Low	Low		RH
Dawsons Bend	19/11/2004			21.2	6.9	136	7.40	**84**	136	**366**		15	5	1	<1	55	9	0.17	<10	**3400**	**750**				<100										Moderate	Moderate		RH
Dawsons Bend	24/05/2005			17.9	7.1	244	8.40	89	148	4		21	3	14	9	106	15	0.21	<10	40	**<50**	<10			<100				62						Low	Mod		RH
Dawsons Bend	5/10/2006			16.7	7.3	228	7.00	**72**	122	**10**	2	21	3	13	8	102	13	0.2	<1	90	20	<10		<1	<100	<0.1	<1	<1	23	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawsons Bend	23/04/2007		23.1	24.1	6.9	273	5.03	**60**	220	**14**		22	3	19	9	130	14	0.28	<1	**540**	46	<6	<44*	<1	14	<1	<1	<2		<1	<0.5	<3	<1	<1				RH
Yebna Crossing	31/09/1999			19		**430**			292																												Slow Flow	S
Yebna Crossing	1/04/2002	15:00		22		182			124																												Slightly cloudy brown	S
Yebna Crossing	7/01/2002					244			166																												Muddy	S
Yebna Crossing	1/01/2002	15:00		25		318			216																												Very slight cloudy brown	S
Yebna Crossing	1/01/2002	15:00		25		318			216																												Very slight cloudy brown	S
Yebna Crossing	9/11/2001			21		234			159																												Clear	S
Yebna Crossing	10/10/2001					234			159																												Clear	S
Yebna Crossing	29/08/2001			22		241			164																												Clear	S
Yebna Crossing	1/07/2001			21		250			170																												Clear	S
Yebna Crossing	22/06/2001			18		215			146																												Slightly Murky	S
Yebna Crossing	25/05/2001			24		165			112																												Slightly Murky	S
Yebna Crossing	20/04/2001			24		160			109																												Slightly Murky	S
Yebna Crossing	8/03/2001			25		176			120																												Clear	S
Yebna Crossing	4/02/2001	15:00		26		186			126																												Slightly cloudy	S
Yebna Crossing	23/01/2001	14:00		25		151			103																												Slightly cloudy	S
Yebna Crossing	19/12/2000	16:00		25		249			169																												Slightly cloudy	S
Yebna Crossing	21/11/2000	13:00		26		266			181																												Clear	S
Yebna Crossing	10/10/2000	11:30		25		290			197																												Clear	S
Yebna Crossing	2/09/2000	11:00		25		297			202																												Clear	S
Yebna Crossing	3/08/2000	14:37		25		257			175																												Clear	S
Yebna Crossing	23/07/2000	14:32		25		266			181																												Clear	S
Yebna Crossing	21/06/2000	14:24		25		275			187																												Clear	S
Yebna Crossing	14/04/2000	15:00		25		241			164																												Very slight cloudy brown	S
Yebna Crossing	21/06/2000	12:30		22		305			207																												Faint Cloudy brown	S
Yebna Crossing	14/04/2000	12:30		21		279			190																												Faint Cloudy brown	S
Yebna Crossing	6/03/2000			24		**344**			234																												Very slight cloudy brown	S
Yebna Crossing	30/01/2000	12:30		25		282			192																												Very slight cloudy brown	S
Yebna Crossing	30/12/1999	10:45		20		260			177																												Flow	S
Yebna Crossing	29/11/1999	16:35		22		**380**			258																												Flow	S
Yebna Crossing	29/10/1999	16:00		23		**430**			292																												Flow	S
Yebna Crossing	29/07/1999			15		**348**			237																												Slow flow - murky	S
Yebna Crossing	29/07/1999			17		**435**			296																												Slow Flow - Clear to Yellow	S
Yebna Crossing	1/06/1999	8:00		12		245			167																												Slow flow - murky	S
Yebna Crossing	8/05/1999	9:30		18		194	4.00		132																												Mod flow - murky	S
Yebna Crossing	23/02/1999	9:50		25		110			75																												Mod flow, murky	S
Yebna Crossing	23/02/1999	10:00		28		187			127																												Mod flow, muddy	S
Yebna Crossing	23/02/1999			26		231			157																												Mod flow, muddy	S
Yebna Crossing	28/11/1998	11:30		17		286			194																												Med Flow - Brown	S
Yebna Crossing	28/11/1998	14:30		28		200			136																												Mod flow, murky	S
Yebna Crossing	28/11/1998	15:00				176			120																												Med Flow - Brown	S
Yebna Crossing	9/08/2003			19.1	7.8	214	9.50	103	89			31	3	11	5	127	19	0.1	<5						<100										Moderate	Moderate		RH
Yebna Crossing	20/04/2004			20.8	7.2	292	7.20	**81**	92	4		27	3	14	6	124	22	<.1	<10	**500**	40				**600**										Moderate	Low		RH
Yebna Crossing	18/11/2004			24.6	7.3	273	5.00	**60**	172	**142**		29	6	7	5	103	19	0.23	<10	**1100**	**280**				<100										Mod-High	Mod		RH
Yebna Crossing	25/05/2005			13	7.7	226	13.00	124	127	2		27	3	11	6	88	22	0.16	<10	50	<50	<10			<100				156						Low	Mod		RH
Yebna Crossing	5/11/2006			13.4	7.8	228	14.30	135	134	8	4	27	3	9	4	87	21	0.1	<1	30	<10	<10		<1	<100	<0.1	<1	<1	76	<1	<0.1	<1	**<10**		Mod	Mod		RH
Yebna Crossing	24/04/2007		27.4	21.6	**8**	242	9.28	107	180	**11**		33	4	17	6	130	20	0.22	<1	**500**	22	14	<44*	<1	16	<1	<1	<2	**390**	<1	<0.5	<3	<1	<1				RH

BOLD Exceeds adopted guideline value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources
*by calcuation from Nitrate as N

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-*a* (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*		*20*	*700*	*5*		*371*	*1.4*	*200*			*8*							
Dawson Taroom	31/09/1999						19		**445**			303																													Med Flow	S
Dawson Taroom	1/04/2002	14:00					24		96			65																													Cloudy brown	S
Dawson Taroom	1/04/2002	12:45					19		257			175																													Rapid Flow - Flood level 4.35 m, Brown	S
Dawson Taroom	1/04/2002	16:00					28		300			204																													Mod flow, muddy	S
Dawson Taroom	1/04/2002	17:00							193			131																													Rapid Flow - Brown	S
Dawson Taroom	1/04/2002	11:10					25		117			80																													Mod flow, muddy	S
Dawson Taroom	1/04/2002	11:30					27		140			95																													Mod flow, murky	S
Dawson Taroom	1/04/2002						27		258			175																													Mod flow, murky	S
Dawson Taroom	7/01/2002								216			147																													Muddy	S
Dawson Taroom	1/01/2002	16:00					24		247			168																													Clear	S
Dawson Taroom	1/01/2002	16:00					24		247			168																													Clear	S
Dawson Taroom	9/11/2001						21		242			165																													Clear	S
Dawson Taroom	10/10/2001								242			165																													Clear	S
Dawson Taroom	10/08/2001						22		214			146																													Brown tinge	S
Dawson Taroom	1/07/2001						20		234			159																													Clear	S
Dawson Taroom	22/06/2001						19		220			150																													Slightly Murky	S
Dawson Taroom	25/05/2001						24		155			105																													Slightly Murky	S
Dawson Taroom	20/04/2001						24		145			99																													Slightly Murky	S
Dawson Taroom	8/03/2001						25		118			80																													Clear	S
Dawson Taroom	5/02/2001	13:00					27		**364**			248																													Clear	S
Dawson Taroom	18/01/2001	10:30					26		**381**			259																													Clear	S
Dawson Taroom	20/12/2000	13:20					25		213			145																													Clear	S
Dawson Taroom	20/11/2000	14:00					26		268			182																													Clear	S
Dawson Taroom	2/10/2000	13:30					24		321			218																													Clear	S
Dawson Taroom	2/09/2000	13:00					24		324			220																													Clear	S
Dawson Taroom	3/08/2000	14:35					24		301			205																													Clear	S
Dawson Taroom	22/07/2000	14:33					24		297			202																													Slight cloudy, brown sediment	S
Dawson Taroom	20/06/2000	14:18					24		284			193																													Slight cloudy, brown sediment	S
Dawson Taroom	14/04/2000	16:00					24																																		Clear	S
Dawson Taroom	14/04/2000	11:45					22		**410**			279																													Clear	S
Dawson Taroom	14/04/2000	11:45					21		**410**			279																													Clear	S
Dawson Taroom	6/03/2000						23		314			214																													Clear	S
Dawson Taroom	30/01/2000	11:45					24		**377**			256																													Clear	S
Dawson Taroom	30/12/1999	11:30					22		**340**			231																													Flow	S
Dawson Taroom	29/11/1999	15:04					24		310			211																													Flow	S
Dawson Taroom	29/10/1999	14:28					24		**410**			279																													Flow	S
Dawson Taroom	29/07/1999						16		**367**			250																													Slow flow - murcky	S
Dawson Taroom	29/07/1999						17		**450**			306																													Slow Flow - Murky	S
Dawson Taroom	1/06/1999	9:10					14		319			217																													Mod. Flow - clear/murcky	S
Dawson Taroom	8/05/1999	11:00					19		209			142																													Moderate flow-murky	S
130302A	1/12/1963	1630	0.81	0.60	0.10			**8.10**	290			200			33		21.0	11.0	143	36	0.20	2.0														117.00	0.00		98	246.2		DNRW
130302A	28/05/1964	2359	0.71	0.20	0.10			**8.00**	244			148			36		22.0	8.0	146	32	0.60	1.0														120.00			88	245.6		DNRW
130302A	30/11/1964	1520	0.65	0.07	0.10			7.30	287			148			41		16.0	7.0	138	33	0.40															113.00	0.00		69	235.4		DNRW
130302A	7/09/1965	950	0.69	0.13	0.10			7.40	290			164			36		18.0	8.0	132	32	0.20	1.0														108.00	0.00		78	227.2		DNRW
130302A	3/02/1966	830	0.71	0.20	0.10			**8.20**	310						42		35.0	8.0	195	32	0.30	7.0														160.00			120	319.3		DNRW
130302A	3/02/1966	830					29																																			DNRW
130302A	14/04/1966	1430	0.84	0.23	0.10			7.80	172						22		14.0	5.0	93	12	0.15	11.0														76.00			56	157.2		DNRW
130302A	14/04/1966	1430					24																																			DNRW
130302A	11/05/1966	1645	0.69	0.18	0.10			7.60	196						22		19.0	5.0	112	14	0.10	4.0														92.00			68	176.1		DNRW
130302A	11/05/1966	1645					17																																			DNRW
130302A	25/04/1971	830	0.74	0.34	0.10			7.90	**435**						34		44.0	11.0	220	35	0.15															180.00	0.00		155	344.2		DNRW
130302A	25/04/1971	830	0.73	0.34			18																																			DNRW
130302A	26/08/1971	1500	0.72	0.22	0.10			7.90	**390**						35		32.0	10.0	189	30	0.15															155.00	0.00		121	296.2		DNRW
130302A	26/08/1971	1500	0.72	0.22			17																																			DNRW
130302A	16/09/1972	845	0.64	0.05			20																																			DNRW
130302A	14/12/1972	1615	0.65	0.02	0.10			7.70	282						30		23.0	6.0	142	24	0.20															116.00	0.00		82	225.2		DNRW
130302A	14/12/1972	1615					31																																			DNRW
130302A	13/04/1973	835	0.66	0.14	0.10			7.60	165			113	**197**		15	6.7	14.5	3.5	93	10	0.19						**10000**			90		**400**		7.00		76.00			51	153.2		DNRW
130302A	13/04/1973	835					21																																			DNRW
130302A	10/08/1973	1630	0.86	1.56	0.10			7.80	180			115	2		18	5.2	13.7	3.5	73	18		7.0										**2100**		13.00		60.00		0.2	49	141.1		DNRW
130302A	10/08/1973	1630					18																																			DNRW
130302A	5/12/1973	1630	0.70	0.22	0.10			7.80	230			134	**70**		18	6.1	22.0	4.7	116	16	0.17											**300**		10.00		96.00	0.00	0.4	74	183.8		DNRW
130302A	5/12/1973	1630					29																																			DNRW
130302A	27/03/1974	755	0.70	0.24	0.10			7.70	**360**			204	**20**		36	6.8	27.0	8.5	170	28	0.13													14.00		140.00	0.00	0.5	102	276.9		DNRW
130302A	27/03/1974	755					25																																			DNRW
130302A	24/06/1974	1700	0.78	0.52	0.10			7.60	265			152	**85**		28	5.5	20.0	5.3	122	24	0.15													9.00		100.00	0.00	0	72	205		DNRW
130302A	24/06/1974	1700					15																																			DNRW
130302A	19/09/1974	1710	0.69	0.21	0.10			7.80	315			175			37	3.7	18.0	7.0	146	34	0.27													3.00		120.00	0.00	0	74	246		DNRW
130302A	19/09/1974	1710					19																																			DNRW
130302A	16/10/1974	1038	0.69	0.25	0.10			7.70	290			158			31	3.3	17.0	6.0	129	30	0.17													7.00		106.00	0.00	0	67	216.5		DNRW
130302A	16/10/1974	1038	0.69	0.25			22																																			DNRW
130302A	16/12/1974	1405	0.58	0.02	0.10			7.50	310			192	**31**		32	6.3	19.5	6.8	136	30	0.22													30.00		112.00	0.00	0	77	230.8		DNRW
130302A	16/12/1974	1405					30																																			DNRW
130302A	7/04/1975	1610	0.85	1.60			23																																			DNRW
130302A	2/07/1975	1615	0.71	0.15			18																																			DNRW
130302A	27/08/1975	1645	0.62	0.08	0.10			7.70	267			140	**14**		28	3.5	14.0	5.9	125	24														2.00		103.00	0.00	0	59	200.4		DNRW
130302A	27/08/1975	1645					16																																			DNRW
130302A	14/10/1975	1630	0.59	0.03	0.10			7.90	261			140	**20**		31	3.3	12.0	5.7	115	26	0.10													2.00		94.00	0.00	0	53	193.1		DNRW
130302A	14/10/1975	1630					23																																			DNRW
130302A	15/10/1975	1640	0.58	0.03			24																																			DNRW
130302A	12/01/1976	1606	0.85	1.85	0.20			**8.15**	258			158	**72**		23	6.4	21.0	6.1	115	22	0.20	3.0					**2400**									96.00		0.8	78			DNRW
130302A	12/01/1976	1606	0.86	1.85			27																																			DNRW
130302A	13/09/1976	1542	0.64	0.16	0.10			**8.50**	**370**			201			43	3.4	24.0	7.8	165	38							200									141.00	0.00	3.2	92	284.7		DNRW
130302A	13/12/1976	1642	0.72	0.54	0.10			7.30	230			128	**159**		18	5.2	20.0	4.3	102	14	0.70	2.0					**1700**							12.00		84.00	0.00	0.1	68	168		DNRW
130302A	13/12/1976	1642					31																																			DNRW
130302A	18/04/1977	1637	0.69	0.40	0.10			**8.00**	310			172	**27**		28	5.7	24.0	7.2	120	26	0.10	5.0					**700**							16.00		100.00		0.7	90	217.4		DNRW
130302A	18/04/1977	1637					24																																			DNRW
130302A	28/10/1977	1210	0.60	0.12	0.10			**8.20**	335			174			41	3.4	13.0	7.8	142	33	0.20						200							4.00		118.00		1.1	65	241.7		DNRW
130302A	28/10/1977	1210					26																																			DNRW
130302A	12/04/1978	1428	0.62	0.21	0.10			7.90	250			149	**19**		21	5.0	21.0	5.8	128	18	0.20	2.5					900							11.00		106.00		0.6	76	203		DNRW
130302A	12/04/1978	1428					24																																			DNRW
130302A	28/07/1978	1124	0.69	0.48			14																																			DNRW
130302A	25/10/1978	1605	0.61	0.18			23																																			DNRW
130302A	5/01/1981	1045	1.25	2.73	0.10			7.50	200			122	**1270**		16	7.4	17.0	4.5	95	7	0.10	5.0					5000							13.00		78.00		0.2	61	156.8		DNRW
130302A	5/01/1981	1045					25																																			DNRW
130302A	25/03/1981	1425	0.66	0.26			26																																			DNRW
130302A	24/07/1981	1630	0.71	0.43	0.10			7.70	**370**			189	**10**	13	34	4.2	25.0	7.6	160	30	0.10	1.0					2000							6.00		132.00		0.5	94	264.4		DNRW
130302A	24/07/1981	1630					16																																			DNRW
130302A	9/09/1981	1410	1.19	1.47	0.10			7.90	160			101	**50**	**100**	13	5.3	12.0	3.1	65	11	0.10	8.0					4000							12.00		54.00		0.3	43	121.8		DNRW
130302A	9/09/1981	1410					17																																			DNRW
130302A	9/09/1981	1410	0.61	0.25	0.10			**8.00**	**400**			212	**10**	5	40	3.7	27.0	8.6	183	34	0.10	5.0												3.00		152.00		1.1	103	302.5		DNRW
130302A	9/10/1981	800	0.57	0.09	0.10			7.80	**390**			207	**10**	5	41	3.6	23.0	8.2	177	34	0.10	5.0					1000							3.00		146.00		0.6	91	293.5		DNRW
130302A	9/10/1981	800					21																																			DNRW
130302A	20/04/1982	1620	0.81	0.22			23																																			DNRW
130302A	9/08/1982	1645	0.79	0.14	0.10			**8.50**	320			170	9	2	36	3.7	21.0	6.4	140	29	0.10	3.0					400			20		20		1.00		119.00		2.7	79	242.4		DNRW
130302A	9/08/1982	1645					15																																			DNRW
130302A	2/11/1982	1105	0.70	0.02	0.10			**8.10**	310			170	**10**	8	39	3.8	15.5	6.6	140	34	0.20	1.0					600									116.00		1	66	241.2		DNRW
130302A	2/11/1982	1105					25																																			DNRW
130302A	23/03/1984	1625	0.98	0.80	0.10			7.40	**355**			200	**20**	17	33	4.9	27.0	7.3	170	25	0.10	8.3					500			20		100		14.00		140.00		0.3	98	276.5		DNRW
130302A	23/03/1984	1625					26		330																																	DNRW
130302A	20/06/1984	1600	0.85	0.25	0.10			7.40	**450**			250	5		51	3.9	32.0	9.7	195	42	0.10	3.7								10				7.00		161.00		0.4	120	337.8		DNRW
130302A	20/06/1984	1600					15		**425**																																	DNRW
130302A	29/07/1984	715	6.56	976.38	0.10			7.00	165			160	**1000**	**100**	22	6.4	9.5	3.0	95	8		4.1								40		**4600**	0.03	56.00		78.00		0.1	36	152.6		DNRW
130302A	29/07/1984	715					13																																			DNRW
130302A	29/07/1984	1350	6.52	1050.59	0.10			6.90	175			120	**800**	**100**	21	6.4	10.0	2.3	85	9		5.0					2300			**1000**		**1200**	1.00	19.00		70.00			34	144		DNRW
130302A	30/07/1984	855	6.43	602.20	0.10			**6.50**	120			120	**80**	**100**	12	6.0	8.1	2.7	60	6		3.3								20		**4800**	0.02	52.00		49.00			31	102.5		DNRW
130302A	31/07/1984	835	6.13	605.58	0.10			6.80	115			110	**80**	**100**	11	5.1	7.7	2.6	67	6		3.1								20		**4000**	0.01	44.00		55.00			30	106.1		DNRW
130302A	16/10/1984	945	0.87	0.40	0.10			**8.00**	**425**			240	5		55	2.4	26.0	8.9	185	40	0.10	9.0								10		**200**		6.00		154.00		1.2	102	327.8		DNRW
130302A	16/10/1984	945					24																																			DNRW
130302A	10/04/1985	840	0.81	0.16	0.10			7.80	270			160	**60**	**63**	25	5.5	22.0	5.0	140	20	0.20	2.1					600			30		**390**		12.00		116.00		0.5	76	221.3		DNRW
130302A	10/04/1985	840					23		250																																	DNRW
130302A	2/07/1985	1635	0.81	0.15	0.10			**8.10**	**450**			180	**10**	24	38	3.8	22.0	6.4	145	33	0.10						600			20		**240**		5.00		121.00		1	81	250.1		DNRW
130302A	2/07/1985	1635					13		284																																	DNRW

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological						Total Metals/Trace Elements							Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400	500	50		20	700	5		371	1.4	200			8							
130302A	17/10/1985	1500	1.07	1.07	0.10			7.90	330			170	20	20	36	3.6	19.0	6.4	145	35	0.20	2.0					500			20		10	0.01	1.00		120.00		0.7	74	248.4		DNRW
130302A	17/10/1985	1500					23		315																																	DNRW
130302A	7/11/1985	845	0.92	0.38			23		170																																	DNRW
130302A	21/01/1986	1100	0.82	0.12	0.10			7.90	255			140	**80**	**89**	22	5.7	17.0	5.0	110	18	0.20	2.0					500			30		**500**	0.01	15.00		91.00		0.5	63	181.4		DNRW
130302A	21/01/1986	1100					29		134																																	DNRW
130302A	15/04/1986	1427	0.78	0.05	0.10			**8.20**	275			150	**105**	2	24	5.0	23.0	6.0	130	17	0.20	2.1								30		80		8.00		109.00		1.2	82	208.6		DNRW
130302A	15/04/1986	1427					23		275																																	DNRW
130302A	16/07/1986	1055	0.81	0.11	0.10			**8.10**	**345**			180	**20**	8	36	5.0	24.0	7.0	155	30	0.10									20		30		1.00		129.00		1.3	89	258.4		DNRW
130302A	16/07/1986	1055					15		**363**																																	DNRW
130302A	14/10/1986	1642	0.95	0.07	0.10			**8.00**	310			160	5	7	33	3.7	20.5	6.4	140	27	0.10									10		30		1.00		116.00		0.9	78	231.1		DNRW
130302A	14/10/1986	1642					25		300																																	DNRW
130302A	31/03/1987	1544	0.80	0.03	0.10			7.80	260			140	**28**		22	5.4	21.0	5.0	125	16	0.20									20		30		12.00		103.00		0.4	73	195		DNRW
130302A	31/03/1987	1544					25		246																																	DNRW
130302A	14/07/1987	1616	0.85	0.09	0.10			7.80	305			160	5	3	33	4.6	20.0	6.0	140	27	0.10									10		20		1.00		116.00		0.5	75	231.2		DNRW
130302A	14/07/1987	1616					13		**361**																																	DNRW
130302A	4/11/1987	1405	0.77	0.23	0.10			7.20	205			120	**142**	**100**	25	5.8	15.0	3.3	95	14	0.10						**700**					**350**		12.00		78.00		0.1	51	159.4		DNRW
130302A	4/11/1987	1405					26		208																																	DNRW
130302A	10/02/1988	833	3.29	43.20	0.10			7.10	195			110	**4900**	**100**	12	5.6	20.0	3.3	105	5	0.20	2.6					**3400**			20		110		11.00		86.00		0.1	64	157.1		DNRW
130302A	10/02/1988	833					23		181																																	DNRW
130302A	19/05/1988	1240	0.85	0.13	0.10			7.70	210			120	**302**	**100**	21	3.9	14.0	3.0	93	14	0.10	2.2					**1400**					**360**		14.00		77.00		0.2	47	153.2		DNRW
130302A	19/05/1988	1240					18																																			DNRW
130302A	24/09/1988	1145	0.80	0.06	0.10			7.90	250			150	**60**	38	29	3.2	20.0	5.2	125	23	0.10											40		3.00		104.00		0.6	71	206.1		DNRW
130302A	24/09/1988	1145					21		295																																	DNRW
130302A	12/01/1989	800	1.46	4.43	0.10			7.00	125			83	**280**	**100**	10	5.3	8.9	2.4	56	10	0.10						**800**					**1300**		19.00		46.00			32	94.2		DNRW
130302A	12/01/1989	800					26		138																																	DNRW
130302A	6/05/1989	1150	1.95	11.78	0.10			7.80	190			130	**124**	**100**	19	7.4	15.5	4.1	87	19		2.2					**4700**					190		12.00		72.00		0.3	56	159.4		DNRW
130302A	6/05/1989	1150							230																																	DNRW
130302A	3/09/1989	1100	0.97	0.58	0.10			7.70	325			190	**100**	**100**	35	3.5	23.0	7.3	140	38	0.10	4.4					500			40		40		8.00		115.00		0.4	88	252.2		DNRW
130302A	3/09/1989	1100							**347**																																	DNRW
130302A	3/12/1989	1720	1.05	1.07			29		96																																	DNRW
130302A	25/03/1990	1310	0.94	0.45	0.10			7.80	211			124	**74**	**200**	22	5.5	14.3	4.5	87	17	0.14	3.6					**1900**			20		70		12.20		72.00	0.01	0.3	54	156.5		DNRW
130302A	25/03/1990	1310					23		282																																	DNRW
130302A	13/07/1990	1415	1.03	0.83	0.10			**8.20**	**394**			233	**36**	**58**	44	4.5	28.1	9.2	169	38	0.13	6.0					**1100**			10		**350**		17.70		141.00	0.03	1.5	107	301.2		DNRW
130302A	13/07/1990	1415					10	**8.20**	**423**																																	DNRW
130302A	15/11/1990	805	0.84	0.13	0.10			7.90	**525**			295	**11**	8	66	5.2	33.0	11.8	221	60	0.19	3.3							0.05	30	40			6.50		182.00	0.01	1	131	401		DNRW
130302A	15/11/1990	805					25	**8.30**	**522**																																	DNRW
130302A	3/12/1990	1720	0.83	1.07				7.80	280			180	**103**	**100**	30	4.6	24.0	5.8	130	27	0.20	4.8					**1700**		0.15	10	20	80	0.01	16.00	**10**	110.00		0.5	83	230		DNRW
130302A	25/03/1991	920	0.78	0.07	0.10			7.30	241			140	**57**	3	22	6.4	17.9	5.4	115	16	0.17	1.9					500		0.04	40	40	20		13.20	**10**	94.00	0.00	0.1	66	186.3		DNRW
130302A	25/03/1991	920					24	7.90	230																																	DNRW
130302A	3/08/1991	1630	0.83	0.13	0.10			7.90	**350**			191	**10**	5	42	5.0	21.9	7.5	155	37	0.15								0.04	10				1.30		128.00	0.02	0.8	85	269.1		DNRW
130302A	3/08/1991	1630					9	**8.40**	303																																	DNRW
130302A	1/12/1991	1815	0.45	0.47	0.10			7.60	**470**			251	**13**	5	52	6.3	30.1	10.4	206	44	0.18						**3300**		0.06		20	20		2.70	**10**	170.00	0.01	0.5	117	353.8		DNRW
130302A	10/04/1992	853	0.83	0.12	0.10			7.60	204			123	**158**	**200**	19	4.7	17.5	4.1	102	9	0.16	1.9					**1700**		0.33		10	190		14.60		84.00	0.01	0.2	60	160.7		DNRW
130302A	10/04/1992	853					19		201																																	DNRW
130302A	13/08/1992	745	0.79	0.09	0.10			**8.10**	304			159	9		34	3.0	19.5	6.5	135	26	0.13	0.4					**1000**		0.01					0.50		113.00	0.03	1.1	75	227.6		DNRW
130302A	13/08/1992	745					14	7.70	310																																	DNRW
130302A	23/11/1992	1625	1.48	5.88			27	7.52	249																																	DNRW
130302A	2/07/1993	1205	0.73	0.07			14	7.40	320																																	DNRW
130302A	22/07/1993	827	0.77	0.13	0.10			7.60	335			183	**12**	3	37	5.6	21.5	8.2	154	28	0.14	1.8					200				10	10		4.90	**10**	126.00	0.01	0.4	87	256.7		DNRW
130302A	22/07/1993	827					15	7.60	325																																	DNRW
130302A	23/11/1993	1625	1.48	5.88	0.10			7.60	259			151	**71**	36	22	6.7	21.0	5.3	126	19	0.14	1.5					**3200**				20	60		11.00		103.00	0.01	0.2	74	204		DNRW
130302A	16/12/1993	1400	1.70	9.30	0.10			7.40	165			100	**515**	**200**	14	5.4	12.7	3.2	78	8	0.11	2.3					**5400**				40			11.00		63.00	0.01	0.1	44	128.8		DNRW
130302A	13/04/1994	1723	0.78	0.19	0.10			7.70	263			160	**46**	43	27	6.0	20.5	5.4	132	19	0.11	1.4					**1100**		0.17		30	130		15.30		109.00	0.01	0.4	73	212.7		DNRW
130302A	13/04/1994	1723					21	7.50	269																																	DNRW
130302A	31/08/1994	1535					20	**8.10**	313																																	DNRW
130302A	31/08/1994	1600	0.72	0.03	0.10			7.80	314			164	3	1	37	4.4	19.5	6.3	139	27	0.11	0.4					300				10			0.30		115.00	0.01	0.5	74	234.8		DNRW
130302A	31/08/1994	1600																						22.0																		DNRW
130302A	31/08/1994	1600																							0.00	**33.0**																DNRW
130302A	25/10/1994	845	7.20		0.10			7.20	263			154	**120**	**200**	35	4.8	15.0	4.6	113	31	0.14	1.1					**1000**		0.37		40	**210**	0.01	5.90	**10**	93.00		0.1	56	206.2		DNRW
130302A	25/10/1994	845																						**330.0**																		DNRW
130302A	25/10/1994	845																							0.18	5.0																DNRW
130302A	25/10/1994	845																										2.00														DNRW
130302A	25/10/1994	900	0.64	0.00	0.20	25	20	7.29	270	3.21																																DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30			7.65	331			179	7	2	38	6.0	20.2	6.5	151	29	0.15	0.0					560		0.00			10	0.00	4.30		124.60	0.01	0.39	77.13	251.83		DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30																			**65.7**																		DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30		27	7.40	**342**																																	DNRW
130302A	16/02/1995	1253	6.00	540.00	0.20			7.14	146			88	**461**	**200**	14	5.5	10.1	2.1	62	8	0.11	2.1					**4070**		0.27			170	0.00	11.40		51.30	0.00	0.05	33.83	108.85		DNRW
130302A	16/02/1995	1253																						**509.4**																		DNRW
130302A	16/02/1995	1253																							0.16	6.7																DNRW
130302A	16/02/1995	1253																										2.00														DNRW
130302A	16/02/1995	1253	6.00	540.00	0.20		23	6.71	135																																	DNRW
130302A	28/03/1995	1730	0.78	0.26	0.30			**8.04**	213			133	**46**	**78**	22	5.1	17.4	5.0	110	14	0.13	1.3					**1010**		0.03		50	80	0.02	12.60		91.00	0.02	0.67	63.97	176.15		DNRW
130302A	28/03/1995	1730																						**113.4**																		DNRW
130302A	28/03/1995	1730																							0.02	**35.0**																DNRW
130302A	28/03/1995	1730	0.78		0.30		27	6.88	228	3.78																																DNRW
130302A	29/03/1995	1530	0.78	0.26			27	6.88	228	3.78																																DNRW
130302A	4/05/1995	1545	0.74		0.30			7.77	317			189	**15**	12	35	5.6	24.3	7.2	156	28	0.13	1.5					160		0.00		10		0.0	9.20	**10**	129.00	0.01	0.51	90.23	259.2		DNRW
130302A	4/05/1995	1545																						24.5																		DNRW
130302A	4/05/1995	1545																							0.01	7.1																DNRW
130302A	4/05/1995	1545	0.74	0.06	0.20		21	7.80	**342**	4.40				15																												DNRW
130302A	27/07/1995	1035	0.76	0.13	0.20		11	7.50	312	10.55				6																												DNRW
130302A	27/07/1995	1050	0.76	0.13	0.20			7.78	303			166	**11**	6	38	3.7	18.8	5.9	138	29	0.14	0.5							0.01		30		0.00	1.20	**10**	113.60	0.01	0.46	71.17	234.33		DNRW
130302A	27/07/1995	1050																						4.0																		DNRW
130302A	27/07/1995	1050																							0.00	**27.4**																DNRW
130302A	31/08/1995	1500	0.73	0.46	0.20			7.71	298			167	**17**	11	37	3.7	20.3	6.4	141	29	0.12	0.0					270		0.00		30	120	0.01	0.70		116.50	0.01	0.42	76.96	238.1		DNRW
130302A	31/08/1995	1500																						12.6																		DNRW
130302A	31/08/1995	1500																							0.00	**30.3**																DNRW
130302A	31/08/1995	1500	0.73	0.46	0.20	25	20	7.80	317	6.20				11																												DNRW
130302A	29/11/1995	1734	1.42	5.11	0.10			7.47	169			92	**320**	**450**	14	5.0	12.0	3.1	70	9	0.11	1.1					**970**		0.00		40		0.00	12.40		57.20	0.01	0.11	42.69	115.37		DNRW
130302A	29/11/1995	1734																						**312.9**																		DNRW
130302A	29/11/1995	1734																							0.05	**67.1**																DNRW
130302A	29/11/1995	1734	1.42	5.11	0.10		27	7.30	156	5.12				**589**																												DNRW
130302A	27/03/1996	1722	0.76	0.11	0.20			7.84	**396**			224	**17**	11	42	6.2	28.6	8.3	190	32	0.15	1.0							0.02		10	40	0.01	12.40		157.10	0.01	0.8	105.49	308.6		DNRW
130302A	27/03/1996	1722																						45.6																		DNRW
130302A	27/03/1996	1722																							0.01	**43.6**																DNRW
130302A	27/03/1996	1722	0.75	0.11	0.20		24	7.68	**410**	4.11				16																												DNRW
130302A	24/05/1996	1100	0.72		0.20			7.41	214			129	**50**	**205**	28	4.7	12.8	3.5	104	14	0.16	1.8					**1300**		0.00		20		0.00	10.90	**10**	85.60	0.00	0.14	46.33	170.84		DNRW
130302A	24/05/1996	1100																						**138.2**																		DNRW
130302A	24/05/1996	1100																							0.04	**42.2**																DNRW
130302A	24/05/1996	1100	0.82	0.31	0.20	21	15	7.30	217	6.80				**216**																						80.00						DNRW
130302A	19/07/1996	1130	0.76	0.14			10	7.80	317																																	DNRW
130302A	30/07/1996	1455	0.77	0.19	0.10			7.95	309			167	**14**	9	37	4.0	19.6	6.3	141	28	0.11	0.5							0.00			10	0.00	1.70	**10**	116.90	0.01	0.69	74.81	236.89		DNRW
130302A	30/07/1996	1455																						16.6																		DNRW
130302A	30/07/1996	1455																							0.00	10.2																DNRW
130302A	30/07/1996	1455	0.07	0.19	0.10		14	7.94	318	8.71				12																												DNRW
130302A	12/03/1997	700	4.06	97.00	0.10			7.01	172			111	**197**	**327**	19	7.2	10.7	2.5	84	10	0.08	2.5					**1100**		0.00		10	10	0.00	16.90	**50**	68.89	0.00	0.05	36.98	137.19		DNRW
130302A	12/03/1997	700																						**696.4**																		DNRW
130302A	12/03/1997	700																							0.30	**163.0**																DNRW
130302A	12/03/1997	700	4.06	97.00	0.10		24	6.85	172					**367**																												DNRW
130302A	26/03/1997	1345	0.95	1.38	0.20			7.53	304			183	**57**	**60**	30	6.6	24.9	6.5	154	20	0.13	2.0					**1320**		0.00		10		0.00	15.30		126.50	0.00	0.29	88.85	245.93		DNRW
130302A	26/03/1997	1345																						**136.1**																		DNRW
130302A	26/03/1997	1345																							0.04	**61.6**																DNRW
130302A	26/03/1997	1345	0.95	1.38	0.20		24	7.80	309	5.00				**91**																												DNRW
130302A	12/08/1997	1700	0.74	0.11	0.20		16	7.90	319	8.10																																DNRW
130302A	12/08/1997	1720	0.74	0.11	0.20			7.76	315			168	**13**	1	37	4.2	20.1	6.0	146	28	0.08	0.0							0.00		10		0.00	0.80		120.30	0.01	0.49	74.82	241.38		DNRW
130302A	12/08/1997	1720																						9.2																		DNRW
130302A	12/08/1997	1720																							0.01	**31.8**																DNRW
130302A	19/11/1997	1330	2.22	14.19	0.20	19	23	6.90	157	5.00				**2800**																												DNRW
130302A	19/11/1997	1340	2.22	14.19	0.20			7.16	164			102	**1944**	**2761**	23	4.6	7.8	1.7	61	14	0.11	4.8					**3270**		0.00		10		0.00	12.70	**60**	50.10	0.00	0.05	26.45	120.23		DNRW
130302A	19/11/1997	1340																						**1033.3**																		DNRW
130302A	19/11/1997	1340																							0.19	**56.7**																DNRW
130302A	27/03/1998	830	0.74	0.07	0.10			7.30	200			120	**100**	**410**	11	7.5	19.5	4.7	100	10	0.20	2.0					**2300**		0.05	100	50	20	0.02	9.00	**20**	84.00	0.00	0.1	68	160		DNRW
130302A	27/03/1998	830																						**370.0**																		DNRW
130302A	27/03/1998	830																							0.09	**84.0**																DNRW
130302A	27/03/1998	830	0.74	0.07	0.10	23	24	7.26	199	2.15				**463**																												DNRW
130302A	5/08/1998	730	0.76	0.15	0.20			**8.10**	265			140	**10**	10	29	4.1	16.5	5.1	120	22	0.10	2.0					500		0.05	100	50	20	0.02	1.00	**20**	100.00	0.00	0.9	62	200		DNRW
130302A	5/08/1998	730																						22.0																		DNRW
130302A	5/08/1998	730																							0.00	6.0																DNRW
130302A	5/08/1998	730	0.76	0.15	0.20	16	14	7.70	262	8.20				18																												DNRW
130302A	20/08/1998	1415	0.78	0.14	0.30			7.52	265			141	**14**	20	30	4.2	16.4	5.1	122	23	0.13	0.4					210		0.02		10	20	0.00	1.60		100.60	0.01	0.22	61.89	201.86		DNRW
130302A	20/08/1998	1415																					224.9	42.8																		DNRW
130302A	20/08/1998	1415	0.77	0.14	0.30	28	18	7.85	265	7.55				24																						105.60						DNRW
130302A	8/10/1998	1525	0.96	1.36	0.20			7.39	232			142	**93**	**160**	25	6.3	16.4	3.7	103	20	0.10	2.8					**1070**		0.00		20		0.00	16.50		84.34	0.00	0.14	56.13	178.1		DNRW
130302A	8/10/1998	1525																					**1036.7**	**255.5**																		DNRW
130302A	8/10/1998	1525																							0.10	10.4																DNRW
130302A	8/10/1998	1525	0.96	1.36	0.20	22	22	7.23	221	5.10				**194**																												DNRW

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-*a* (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400	500	50		20	700	5		371	1.4	200			8							
130302A	18/11/1998	950	0.76	0.16	0.20			7.95	**350**			200	**40**	29	41	7.2	24.0	6.2	160	30	0.20	2.0					**900**		0.05	100	50	20	0.02	11.00	**20**	135.00	0.00	0.8	85	270		DNRW
130302A	18/11/1998	950																						**120.0**																		DNRW
130302A	18/11/1998	950																							0.04	11.0																DNRW
130302A	18/11/1998	950	0.76	0.16	0.20		25	7.15	**401**	3.30				39																												DNRW
130302A	9/02/1999	720	2.08	18.30	0.10			7.55	145			96	**300**	**375**	14	6.2	10.0	2.6	80	6	0.10	2.0					**1500**		0.21	100	50	**290**	0.02	15.00	**20**	66.00	0.00	0.1	35.5	120		DNRW
130302A	9/02/1999	720																						**420.0**																		DNRW
130302A	9/02/1999	720																							0.12	**32.0**																DNRW
130302A	9/02/1999	720	2.08	18.30	0.10	24	26	7.24	157	5.47				**567**																												DNRW
130302A	23/02/1999	1710	0.91	0.98	0.20			**8.05**	200			120	**80**	**170**	21	5.9	14.0	3.9	98	13	0.10	2.0					**1200**		0.05	100	50	70	0.02	14.00	**20**	82.00	0.00	0.6	51	160		DNRW
130302A	23/02/1999	1710																						**230.0**																		DNRW
130302A	23/02/1999	1710																							0.09	**26.0**																DNRW
130302A	23/02/1999	1740	0.91	0.98	0.20	32	28	7.30	232	4.40				**181**																												DNRW
130302A	23/02/1999	1740	0.78	0.20	0.20		13	7.40	313					32																												DNRW
130302A	9/03/1999	750	4.36	132.14	0.10			7.45	145			90	**160**	**235**	16	6.0	7.9	2.2	64	7	0.10	2.0					**1500**		0.23	100	50	**200**	0.02	17.00	**20**	53.00	0.00	0.1	29	110		DNRW
130302A	9/03/1999	750																						**450.0**																		DNRW
130302A	9/03/1999	750																							0.18	**26.0**																DNRW
130302A	9/03/1999	750	4.36	132.14	0.10	24	25	7.05	161	3.80				**302**																												DNRW
130302A	7/06/1999	1510	0.75	0.08	0.30			**8.05**	320			200	**10**	12	42	5.1	23.0	7.2	165	31	0.10	2.0					500		0.05	100	50	20	0.02	6.00	**20**	135.00	0.00	1.1	87	270		DNRW
130302A	7/06/1999	1510																						48.0																		DNRW
130302A	7/06/1999	1510	0.75	0.08	0.30	25	17	7.90	**345**	6.70				13																						116.00						DNRW
130302A	7/07/1999	1715	0.78		0.10																		336.4	33.5																		DNRW
130302A	7/07/1999	1715																							0.01	11.1																DNRW
130302A	7/07/1999	1715	0.78	0.22	0.10		14	7.50	325	8.20				32																												DNRW
130302A	13/09/1999	1350	0.74	0.11	0.30			7.93	282			161	**11**	5	34	4.1	18.8	6.6	142	25	0.12	0.4					340		0.00				0.00	1.10	**10**	117.65	0.01	0.63	74.04	232.13		DNRW
130302A	13/09/1999	1350																					286.7	42.0																		DNRW
130302A	13/09/1999	1350	0.74	0.11	0.30	27	19	7.50	293	7.80				9																						193.20						DNRW
130302A	8/12/1999	1650	0.71	0.03	0.20			7.79	321			190	9	9	41	5.5	21.0	7.8	162	31	0.16	0.0					530		0.01				0.00	3.10	**30**	133.44	0.01	0.58	84.47	269.09		DNRW
130302A	8/12/1999	1650																					348.8	39.4																		DNRW
130302A	8/12/1999	1650																							0.01	**33.4**																DNRW
130302A	8/12/1999	1650	0.71	0.03	0.20		27	7.60	337	6.92				10																												DNRW
130302A	18/02/2000	927	3.66	68.53	0.20			7.02	145			92	**149**	**197**	12	7.5	10.5	2.6	61	12	0.11	2.6					**1640**		0.00				0.00	13.10		50.16	0.00	0.03	36.89	110.14		DNRW
130302A	18/02/2000	927																					**1221.0**	**562.0**																		DNRW
130302A	18/02/2000	927																							0.34	14.1																DNRW
130302A	18/02/2000	927	3.66	68.53	0.20		22	7.20	133	4.10																																DNRW
130302A	22/03/2000	1520	0.89	0.84	0.20			**8.16**	**410**			221	**39**	37	57	6.7	18.1	6.2	185	30	0.21	1.0					**1030**		0.00			**250**	0.00	9.00	**30**	150.00	0.02	1.52	70.65	304.73		DNRW
130302A	22/03/2000	1520																					497.0	**109.1**																		DNRW
130302A	22/03/2000	1520																							0.04	**21.7**																DNRW
130302A	22/03/2000	1520	0.89	0.84	0.20		26	7.60	**376**	4.40				**52**																												DNRW
130302A	15/08/2000	1702	0.76		0.30			**8.04**	290			151	**13**	7	36	4.2	15.4	5.3	134	23	0.14	0.0					190		0.00				0.00	0.60		111.20	0.02	0.85	60.22	218.55		DNRW
130302A	15/08/2000	1702	0.76		0.30																		181.1	25.0																		DNRW
130302A	15/08/2000	1702	0.76		0.30																				0.01	4.3																DNRW
130302A	15/08/2000	1702	0.76	0.16	0.30		15	7.90	281	8.20				8																												DNRW
130302A	1/11/2000	815	2.00	2.09	0.20			6.96	135			88	**1050**	**1250**	15	5.3	7.6	2.0	55	8	0.10	2.8					**5000**		1.23			**510**	0.00	15.20		45.00	0.00	0.03	27.19	100.55		DNRW
130302A	1/11/2000	815	2.00		0.20																		**3220.0**	**664.0**																		DNRW
130302A	1/11/2000	815	2.00		0.20																				0.16	**32.6**																DNRW
130302A	1/11/2000	815	2.00	2.09	0.20		19	6.70	126	6.60																																DNRW
130302A	15/11/2000	1510	1.09	2.45	0.30			7.60	140			91	**220**	**345**	13	4.3	9.3	2.7	72	6	0.10	2.0					**1400**		0.05	100	50	**490**	0.02	18.00	**700**	59.00	0.00	1	35	110		DNRW
130302A	15/11/2000	1510	1.09		0.30																		**1300.0**	**320.0**																		DNRW
130302A	15/11/2000	1510	1.09		0.30																				0.09	**66.0**																DNRW
130302A	15/11/2000	1510	1.09	2.45	0.30		23	7.00	140	5.50				**365**																												DNRW
130302A	27/02/2001	1657	0.74	0.10	0.20		29	6.60	160	3.30				**120**																												DNRW
130302A	27/02/2001	1715	0.74	0.09	0.20			7.40	160			98	**30**	**115**	13	5.1	12.0	3.5	86	7	0.10	2.0					**800**		0.17	100	50	**320**	0.02	14.00	**20**	71.00	0.00	1	44	130		DNRW
130302A	27/02/2001	1715	0.74		0.20																		**740.0**	**190.0**																		DNRW
130302A	27/02/2001	1715	0.74		0.20																				0.07	**37.0**																DNRW
130302A	27/02/2001	1715	0.74		0.20		29	6.60	160	3.30				**120**																												DNRW
130302A	7/06/2001	1340	0.69	0.02	0.30			7.95	220			120	**10**	11	18	5.3	17.0	5.1	115	11	0.10	2.0					500		0.05	100	50	20	0.02	9.00	**20**	94.00	0.00	0.5	63	170		DNRW
130302A	7/06/2001	1340																					**510.0**	**50.0**																		DNRW
130302A	7/06/2001	1340	0.69	0.02	0.30	29	18	7.50	220	6.30				12																						99.00						DNRW
130302A	17/07/2001	1555	0.71	0.04	0.20			7.80	290			150	**10**	6	28	5.8	18.5	6.3	135	23	0.10	2.0					500		0.05	100	50	20	0.02	3.00	**20**	110.00	0.00	0.5	72	220		DNRW
130302A	17/07/2001	1555																					370.0	30.0																		DNRW
130302A	17/07/2001	1555																							0.01	10.0																DNRW
130302A	17/07/2001	1555																										**7**														DNRW
130302A	17/07/2001	1555	0.71	0.04	0.20		14	7.70	289	7.30				**84**																												DNRW
130302A	9/10/2001	1335	0.62	0.30	0.30			7.76	310			161	**11**	4	34	4.3	18.9	6.2	140	27	0.14	0.0							0.00	30			0.00	1.50	**10**	115.70	0.01	0.46	72.65	230.84		DNRW
130302A	9/10/2001	1335																					339.6	31.1																		DNRW
130302A	9/10/2001	1335	0.62	0.30	0.30		19	7.70	311	6.10				7																						112.40						DNRW
130302A	5/12/2001	1610	0.86	0.49			29	7.30	193	4.10																																DNRW
130302A	5/12/2001	1620	0.86	0.49	0.20			7.45	195			120	**650**	**890**	24	4.9	11.0	2.8	85	11	0.10	4.0					**2500**		0.24	200	30	170	0.03	15.00	**30**	70.00	0.00	0.1	39	150		DNRW
130302A	5/12/2001	1620																					**1700.0**	**370.0**																		DNRW
130302A	5/12/2001	1620																							0.15	**59.0**																DNRW
130302A	5/12/2001	1620	0.71	0.49	0.20		29	7.30	193	4.10				**914**																												DNRW
130302A	18/02/2002	1750	2.77	47.37	0.30			7.10	135			84	**1100**	**1750**	12	4.4	9.9	2.5	68	5	0.10	3.0					**3600**		0.05	100	30	10	0.03	10.00	**40**	56.00	0.00	0.1	35	110		DNRW
130302A	18/02/2002	1750																					**2100.0**	**640.0**																		DNRW
130302A	18/02/2002	1750																							0.05	**29.0**																DNRW
130302A	18/02/2002	1750	2.77	47.37	0.30		27	7.20	148	3.50				**1170**																												DNRW
130302A	19/02/2002	748	3.45	47.73	0.30		27	7.10	89	3.00				**882**																												DNRW
130302A	19/02/2002	1210	3.45	47.73	0.30			6.95	110			76	**550**	**860**	11	4.7	7.0	2.1	55	5	0.10	4.0					**2700**		0.05	**800**	30	10	0.03	13.00	**40**	45.00	0.00	0	26	92		DNRW
130302A	19/02/2002	1210																					**1700.0**	**690.0**																		DNRW
130302A	19/02/2002	1210																							0.11	**24.0**																DNRW
130302A	20/02/2002	910	2.92	29.43	0.30			6.95	87			60	**340**	**580**	8	4.1	5.3	1.7	45	4	0.10	2.0					**1500**		0.05	**700**	30	10	0.03	11.00	**40**	37.00	0.00	0	20	71		DNRW
130302A	20/02/2002	910																					**1200.0**	**420.0**																		DNRW
130302A	20/02/2002	910																							0.08	**34.0**																DNRW
130302A	20/02/2002	910	2.92	29.43	0.30		26	7.00	90	3.60				**513**																												DNRW
130302A	12/03/2002	1545	0.95	1.66	0.20			7.55	190			110	**90**	**225**	19	4.3	12.5	3.7	90	9	0.10	2.0					**1600**		0.13	100	30	140	0.03	12.00	**10**	74.00	0.00	0.2	46	140		DNRW
130302A	12/03/2002	1545																					**700.0**	**140.0**																		DNRW
130302A	12/03/2002	1545																							0.05	**33.0**																DNRW
130302A	12/03/2002	1545	0.95	1.66	0.20		26	7.30	185	8.00				**214**																												DNRW
130302A	12/03/2002	1620	0.95	1.63	0.20		26	7.30	185	8.00																																DNRW
130302A	7/05/2002	1455	0.68	0.91	0.10			7.73	268			152	**35**	**114**	36	4.6	15.2	4.3	137	13	0.16	1.1					**1090**		0.01	50		40	0.01	9.90		112.60	0.01	0.4	55.61	211.69		DNRW
130302A	7/05/2002	1455																					**614.8**	**152.3**																		DNRW
130302A	7/05/2002	1455	0.67	0.91	0.10	28	20	7.30	265	3.60				**113**																												DNRW
130302A	8/07/2002	1600	0.75	0.12	0.40			7.85	250			130	**10**	30	28	4.1	14.5	4.5	110	21	0.10	2.0					500		0.05	100	30	70	0.03	5.00	**10**	91.00	0.00	0.4	55	180		DNRW
130302A	8/07/2002	1600																					300.0	44.0																		DNRW
130302A	8/07/2002	1600																							0.01	11.0																DNRW
130302A	8/07/2002	1600	0.75		0.40		11	7.90	241	9.90				28																												DNRW
130302A	8/10/2002	745	0.69		0.10			7.40	245			130	**50**	**140**	28	5.3	14.5	3.9	110	17	0.20	2.0					**900**		0.07	100	30	110	0.03	7.00	**40**	92.00	0.00	0.2	52	180		DNRW
130302A	8/10/2002	745																					**830.0**	**220.0**																		DNRW
130302A	19/11/2002	1545	0.74	0.56	0.20			7.60	**345**			190	**220**	**250**	53	6.4	14.0	4.0	165	24	0.20	2.0					**1600**		0.05	200	30	110	0.03	7.00	**10**	135.00	0.00	0.4	52	270		DNRW
130302A	19/11/2002	1545																					280.0	**1200.0**																		DNRW
130302A	19/11/2002	1545																							0.09	**56.0**																DNRW
130302A	19/11/2002	1545	0.84	0.56	0.20	33	25	7.40	**342**	2.90				**373**																												DNRW
130302A	18/03/2003	1630	0.77		0.20			7.60	200			120	**150**	**260**	23	5.2	12.0	3.6	105	7	0.20	2.0					**1500**		0.05	100	30	10	0.03	11.00	**10**	87.00	0.00	0.2	45.5	160		DNRW
130302A	18/03/2003	1630																					**900.0**	**290.0**																		DNRW
130302A	18/03/2003	1630																							0.03	**36.0**																DNRW
130302A	18/03/2003	1630	0.77		0.20		30	7.20	171	3.60				**261**																												DNRW
130302A	15/05/2003	1500	0.78		0.20			7.57	210			122	**78**	**255**	24	4.2	13.0	3.6	104	11	0.12	0.8					**1310**		0.05		10	100	0.01	12.81		85.77	0.01	0.21	47.33	162.41		DNRW
130302A	15/05/2003	1500																					**789.5**	**189.0**																		DNRW
130302A	15/05/2003	1500	0.78		0.20	24	20	7.40	221	4.80																										228.00						DNRW
130302A	18/06/2003	1723	0.75		0.20			7.85	248			144	**20**	45	29	4.5	16.5	4.8	122	18	0.12	1.0					260		0.04	100	10	60	0.03	9.99	**10**	101.17	0.01	0.47	60.98	196.71		DNRW
130302A	18/06/2003	1723	0.75		0.20																		371.6	44.7																		DNRW
130302A	18/06/2003	1723	0.75		0.20																				0.01	10.2																DNRW
130302A	18/06/2003	1723	0.75		0.20		14	7.30	255	6.50				45																												DNRW
130302A	9/09/2003	1635	0.75	0.12	0.10			**8.10**	280			150	**10**	14	32	3.9	16.0	5.2	130	22	0.10	2.0					500		0.05	200	30	10	0.03	1.00	**10**	110.00	0.00	0.9	61	210		DNRW
130302A	9/09/2003	1635	0.75		0.10																		200.0	20.0																		DNRW
130302A	9/09/2003	1635	0.75		0.10																				0.01	8.0																DNRW
130302A	9/09/2003	1650	0.75	0.12	0.20		19	**8.10**	279	7.50				16																												DNRW
130302A	28/10/2003	810	0.70		0.20			7.60	305			160	**20**	12	34	4.8	19.0	6.1	150	24	0.20	2.0					500		0.05	100	30	10	0.03	1.00	**10**	125.00	0.00	0.3	72	240		DNRW
130302A	28/10/2003	810	0.70		0.20																		330.0	42.0																		DNRW
130302A	28/10/2003	810	0.70		0.20	27	23	7.70	313	3.10				12																						135.00						DNRW
130302A	13/01/2004	1530	0.83		0.10			7.20	155			98	**1300**	**2000**	17	5.0	10.0	2.0	78	6	0.20	4.0					**2600**		0.05	100	30	20	0.03	14.00	**50**	64.00	0.00	0.1	33	120		DNRW
130302A	13/01/2004	1530	0.83		0.10																		**2300.0**	**850.0**																		DNRW
130302A	13/01/2004	1530	0.83		0.10																				0.23	**73.0**																DNRW
130302A	13/01/2004	1530	0.83		0.10		27	6.90	154	2.20				**2000**																												DNRW
130302A	13/01/2004	1535	0.83	0.59			27	6.90	154	2.10				**2000**																												DNRW
130302A	11/05/2004	1545	0.76		0.10			7.80	**385**			210	**10**	22	49	5.6	21.5	6.7	185	30	0.20	2.0					500		0.05	100	30	20	0.03	10.00	**10**	150.00	0.00	0.7	81	300		DNRW
130302A	11/05/2004	1545	0.76		0.10																		350.0	41.0																		DNRW
130302A	11/05/2004	1545	0.76		0.10																				0.01	9.0																DNRW
130302A	11/05/2004	1545	0.76		0.10		19	7.60	**382**	5.60				22																												DNRW
130302A	22/05/2004	1050	999.99		0.20			7.85	**380**			210	**20**	13	46	5.0	21.0	7.0	180	31	0.20	2.0					500		0.05	100	30	10	0.03	6.00	**10**	150.00	0.00	0.8	82	290		DNRW
130302A	22/05/2004	1050	999.99		0.20																		210.0	29.0																		DNRW
130302A	22/05/2004	1050	999.99		0.20	24	16	7.90	**378**	7.20				16																						157.60						DNRW
130302A	25/10/2004	1515	0.77		0.10			7.78	**342**			180	**19**	14	41	5.0	19.0	6.5	157	28	0.10	1.0					500		0.05	30	30	10	0.03	2.00	**10**	130.00	0.00	0.7	74	258		DNRW
130302A	25/10/2004	1515	0.77		0.10																		380.0	40.0																		DNRW
130302A	25/10/2004	1515	0.77		0.10																				0.01	4.7																DNRW
130302A	25/10/2004	1515	0.77		0.10		27	7.50	**346**	5.00				14																												DNRW
130302A	28/10/2004	730	1.48		0.30			7.18	218			127	**1760**	**2790**	24	6.9	13.0	3.3	101	11	0.10	3.9					**2200**		0.05	60	30	10	0.03	13.00	**30**	83.00	0.00	0.1	45	165		DNRW

Water Quality Data Summary

Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Physical: Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Cations/Anions: Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)
					MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*
130302A	28/10/2004	730	1.48		0.30																	
130302A	28/10/2004	730	1.48		0.30																	
130302A	28/10/2004	730	1.48		0.30		20	7.20	215	3.20				**2000**								
130302A	16/11/2004	1200	1.62		0.30			7.48	201			123	**766**	**976**	20	5.7	15.0	3.6	99	12	0.10	1.7
130302A	16/11/2004	1200	1.62		0.30																	
130302A	16/11/2004	1200	1.62		0.30	33	26	7.60	145	4.00				**800**								
130302A	16/03/2005	820	0.69		0.10			7.74	**388**			227	**40**	**59**	59	6.8	18.0	5.1	213	22	0.20	1.0
130302A	16/03/2005	820	0.70		0.10																	
130302A	16/03/2005	820	0.70		0.10																	
130302A	16/03/2005	820	0.70		0.10		25	7.60	**386**	2.10				**62**								
130302A	7/07/2005	1730	0.89		0.00			7.57	204			120	**310**	**389**	26	4.3	9.3	3.0	92	15	0.10	2.3
130302A	7/07/2005	1730	0.90		0.00																	
130302A	7/07/2005	1730	0.90		0.00																	
130302A	7/07/2005	1730					15	7.50	205	8.10				**380**								
130302A	24/10/2005	1700	3.20		0.10			7.10	118			77	**1340**	**1830**	17	4.2	4.3	1.4	58	6	0.20	1.5
130302A	24/10/2005	1700	3.20		0.10																	
130302A	24/10/2005	1700			0.10		24	7.00	92	7.00				**999**								
130302A	15/11/2005	1520	0.89		0.20			7.48	193			115	**149**	**262**	19	5.0	13.0	3.9	97	12	0.10	1.2
130302A	15/11/2005	1520	0.00		0.00																	
130302A	15/11/2005	1520	0.00		0.00																	
130302A	15/11/2005	1520					27	7.20	194	5.30												
130302A	12/12/2005	1730			0.30			7.39	161			99	**716**	**759**	14	6.0	12.0	2.7	82	6	0.10	1.9
130302A	12/12/2005	1730			0.30																	
130302A	14/12/2005	1730			0.30	34	30	7.40	136	6.40				**660**								
130302A	7/02/2006	1505	0.00		0.10			7.40	234			136	**44**	**86**	22	6.9	17.0	4.1	120	10	0.10	1.0
130302A	7/02/2006	1505	0.72		0.10																	
130302A	7/02/2006	1505	0.72		0.10																	
130302A	7/02/2006	1505			0.10		29	7.40	246	2.00				**87**								
130302A	5/05/2006	810	0.68		0.10			7.37	199			118	**32**	**52**	18	5.6	15.0	3.9	110	8	0.20	1.0
130302A	5/05/2006	810			0.10																	
130302A	5/05/2006	810			0.10																	
130302A	5/05/2006	810			0.10		16	7.30	182	2.10				**54**								
130302A	23/08/2006	705	0.68		0.20			7.77	292			154	9	6	33	5.7	18.0	5.2	134	25	0.10	1.0
130302A	23/08/2006	705	0.68		0.20		15	7.60	297					8								
130302A	10/11/2006	1640			0.10			7.37	179			105	**916**	**1480**	17	5.6	13.0	2.8	85	10	0.13	3.0
130302A	10/11/2006	1640			0.10																	
130302A	10/11/2006	1640			0.10	26	25	7.30	166	8.20				**905**								
130302A	14/11/2006	810	1.72		0.10	22	26	7.50	259	7.50				**230**								
130302A	30/11/2006	945						7.52	**358**			200	**78**	**106**	40	6.3	23.0	6.2	172	23	0.20	2.3
130302A	30/11/2006	945																				
130302A	30/11/2006	945																				
130302A	30/11/2006	945	0.72		0.10		26	7.50	**361**					**121**								
130302A	20/03/2007	1600			0.10			7.38	131			89	**700**	**1090**	17	4.8	9.5	2.0	70	5	0.12	3.2
130302A	20/03/2007	1600																				
130302A	20/03/2007	1600			0.10	31	26	7.30	122	9.60				**999**								
130302A	21/03/2007	1220	0.94		0.20			7.35	137			86	**648**	**1010**	13	5.7	9.7	2.1	70	5	0.12	2.4
130302A	21/03/2007	1220																				
130302A	21/03/2007	1220																				
130302A	21/03/2007	1220	0.95		0.20		26	7.00	137	4.50				**900**								
130302A	6/05/2007	830		0.00	0.60			7.40	220			127	**86**	**106**	17	6.7	18.0	4.2	117	7	0.15	1.4
130302A	6/05/2007	830																				
130302A	8/05/2007	1130			0.10			7.46	195			120	**119**	**255**	16	6.3	16.0	3.7	108	8	0.14	2.4
130302A	8/05/2007	1130																				
130302A	8/05/2007	1130			0.10		20	7.20	182	8.00												
130302A	3/07/2007	1645			0.20			7.63	216			121	**131**	**275**	21	4.6	15.0	4.3	102	15	0.12	1.4
130302A	3/07/2007	1645			0.20																	
130302A	3/07/2007	1645																				
130302A	3/07/2007	1645	0.93		0.20		12	7.60	215	10.20				**290**								
130302A	25/09/2007	1500																				1.0
130302A	25/09/2007	1500			0.20	34	20	7.70	320	8.30				28								

Sample Collection Point	Sample Date	Time	Nutrients & Biological: Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-*a* (µg/L)	Aluminium as Al soluble (mg/L)	Total Metals/Trace Elements: Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Alkalinity: Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
			500	*50*		*20*	*700*	*5*		*371*	*1.4*	*200*			*8*							
130302A	28/10/2004	730	**3807.5**	**1387.1**																		DNRW
130302A	28/10/2004	730			0.16	**41.4**																DNRW
130302A	28/10/2004	730																				DNRW
130302A	16/11/2004	1200					**3100**		0.10	40	30	80	0.03	12.00	**20**	82.00	0.00	0.2	53	161		DNRW
130302A	16/11/2004	1200	**1549.4**	**417.9**																		DNRW
130302A	16/11/2004	1200														87.00						DNRW
130302A	16/03/2005	820					**1000**		0.05	80	30	10	0.03	9.00	**10**	176.00	0.00	0.6	65	326		DNRW
130302A	16/03/2005	820	**639.0**	**157.0**																		DNRW
130302A	16/03/2005	820			0.05	**35.0**																DNRW
130302A	16/03/2005	820																				DNRW
130302A	7/07/2005	1730					**2000**		0.05	50	30	10	0.03	12.00	**60**	76.00	0.00	0.2	35	154		DNRW
130302A	7/07/2005	1730	**1037.0**	**197.0**																		DNRW
130302A	7/07/2005	1730			0.09	**49.0**																DNRW
130302A	7/07/2005	1730																				DNRW
130302A	24/10/2005	1700					**3800**		0.05	70	30	10	0.03	10.00	**80**	48.00	0.00	0	17	97		DNRW
130302A	24/10/2005	1700	**2052.0**	**411.0**																		DNRW
130302A	24/10/2005	1700																				DNRW
130302A	15/11/2005	1520					**1200**		0.05	30	30	10	0.03	12.00	**10**	80.00	0.00	0.1	49	152		DNRW
130302A	15/11/2005	1520	**880.0**	**168.0**																		DNRW
130302A	15/11/2005	1520			0.03	**27.1**																DNRW
130302A	15/11/2005	1520																				DNRW
130302A	12/12/2005	1730					**2300**		0.05	50	30	50	0.03	14.00	**80**	68.00	0.00	0.1	41	127		DNRW
130302A	12/12/2005	1730	**1328.2**	**449.5**																		DNRW
130302A	14/12/2005	1730																				DNRW
130302A	7/02/2006	1505					**1000**		0.05	40	30	140	0.03	17.00	**10**	98.00	0.00	0.2	58	180		DNRW
130302A	7/02/2006	1505	**757.7**	**233.6**																		DNRW
130302A	7/02/2006	1505			0.10	**20.9**																DNRW
130302A	7/02/2006	1505																				DNRW
130302A	5/05/2006	810					500		0.05	30	30	60	0.03	12.00	**20**	90.00	0.00	0.1	54	162		DNRW
130302A	5/05/2006	810	**540.0**	**130.0**																		DNRW
130302A	5/05/2006	810			0.03	**41.7**																DNRW
130302A	5/05/2006	810																				DNRW
130302A	23/08/2006	705					500		0.05	60	30	10	0.03	1.00	**20**	111.00	0.00	0.4	67	222		DNRW
130302A	23/08/2006	705																				DNRW
130302A	10/11/2006	1640					**3000**		0.05	70	30	60	0.03	9.00	**60**	70.00	0.00	0.1	44	139		DNRW
130302A	10/11/2006	1640	**2370.0**	**519.0**																		DNRW
130302A	10/11/2006	1640																				DNRW
130302A	14/11/2006	810																				DNRW
130302A	30/11/2006	945					**1300**		0.05	40	30	10	0.01	12.00	**10**	142.00	0.00	0.3	82	275		DNRW
130302A	30/11/2006	945	**731.7**	**110.3**																		DNRW
130302A	30/11/2006	945			0.01	**22.6**																DNRW
130302A	30/11/2006	945																				DNRW
130302A	20/03/2007	1600					**1900**		0.11	140	30	100	0.01	11.00	**100**	58.00	0.00	0.1	32	114		DNRW
130302A	20/03/2007	1600	**1870.0**	**605.0**																		DNRW
130302A	20/03/2007	1600																				DNRW
130302A	21/03/2007	1220					**2700**		0.08	50	30	70	0.01	11.00	**30**	58.00	0.00	0.1	33	111		DNRW
130302A	21/03/2007	1220	**1445.1**	**356.3**																		DNRW
130302A	21/03/2007	1220			0.13	**51.7**																DNRW
130302A	21/03/2007	1220																				DNRW
130302A	6/05/2007	830					**900**		0.05	30	30	40	0.01	13.00	**10**	96.00	0.00	0.2	63	173		DNRW
130302A	6/05/2007	830	**583.6**	**184.5**																		DNRW
130302A	8/05/2007	1130					**700**		0.07	50	30	110	0.01	13.00	**30**	89.00	0.00	0.2	56	162		DNRW
130302A	8/05/2007	1130	**777.7**	**187.6**																		DNRW
130302A	8/05/2007	1130																				DNRW
130302A	3/07/2007	1645					**1400**		0.06	30	30	90	0.01	8.00	**20**	84.00	0.00	0.2	54	164		DNRW
130302A	3/07/2007	1645	**587.5**	**127.4**																		DNRW
130302A	3/07/2007	1645			0.04	**34.7**																DNRW
130302A	3/07/2007	1645																				DNRW
130302A	25/09/2007	1500								40	30	10	0.01		**10**		0.00					DNRW
130302A	25/09/2007	1500																				DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNRW - Department of Natural Resources and Water

Table A9
Upper Dawson Catchment - Dawson River at Utopia Downs
GLNG CSG Surface Water

Sample Collection Point	Sample Date	Time	Physical									Cations				Anions				Nutrients & Biological					Trace Elements										Flow		Data source
			Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-*a* (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity	
		MTV	*na*	*'0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1.2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*	
Utopia	25/05/2005			12	7.2	233	11.30	103	154	9		28	3	12	6	91	22	0.15	<10	70	**<50**	**<10**				<100	-	-	-	165					Low-mod	Mod	RH
Utopia	5/11/2006			12.3	7.9	223	14.20	132	136	**10**	4	29	4	11	4	91	21	0.1	1	100	**<10**	**<10**			<1	<100	<0.1	<1	<1	1	<1	<0.1	<1	**<10**	Mod	Mod	RH
Utopia	24/04/2007		29.8	19.8	7.6	286	8.08	89	200	**12**		37	6	22	7	150	23	0.22	<1	**680**	34	18	<44*	<1	<1	20	<1	<1	<2	**460**	<1	<0.5	<3	**<1**			RH
Utopia	20/11/1964	2359			7.7	310			174			47		19	9	156	40	0.2	2				55														DNRW
Utopia	2/02/1966	2359			7.4	288			161			35		20	7	140	30	0.1																			DNRW
Utopia	6/10/1966	2359			**8**	270			162			39		14	9	136	32	0.15	1																		DNRW
Utopia	11/08/1968	1510			7.6	273			170			40		20	6	137	28		9																		DNRW
Utopia	8/06/1970	1307			7.7	290			173			38		24	5	154	30	0.15																			DNRW
Utopia	24/04/1971	1310		19	**8**	**390**			212			32		40	9	195	35	0.1																			DNRW
Utopia	25/08/1971	1445		17	7.8	320			180			32		20	15	159	35	0.1																			DNRW
Utopia	25/11/1971	1000		24	**8**	**360**			102			44		34	4	178	36	0.2																			DNRW
Utopia	10/05/1972	800		18	**8**	270			167			40		17	8	146	30	0.25																			DNRW
Utopia	15/09/1972	1330		18																																	DNRW
Utopia	14/04/1973	1730		23	**8.2**	310			187	**13**		32	5	27	8	163	70	0.2								20											DNRW
Utopia	11/08/1973	1200		17	**8.1**	200			122			21	5	15	5	87	20																				DNRW
Utopia	5/12/1973	1100		27	**8.3**	270			161	**20**		24	5	23	7	131	26	0.16																			DNRW
Utopia	27/03/1974	1030		27	7.8	**355**			203			40	5	25	8	164	32	0.13																			DNRW
Utopia	26/06/1974	1215		15	7.7	300			178	**42**		34	4	21	7	139	31	0.13																			DNRW
Utopia	18/09/1974	1530		17	7.6	335			199	**54**		36	4	21	9	149	34	0.27																			DNRW
Utopia	16/12/1974	1730		27	7.5	330			171	9		35	5	20	8	158	14	0.16																			DNRW
Utopia	8/04/1975	1000		21.5																																	DNRW
Utopia	5/07/1975	1055		16	**8**	262			145	**33**		27	3	16	6	115	22	0.1																			DNRW
Utopia	17/10/1975	1300		26	7.6	311			165	**11**		32	4	16	7	140	26	0.2																			DNRW
Utopia	3/06/1976	1350		16	**8.1**	**430**			239			42	4	35	9	186	40	0.2	5				55														DNRW
Utopia	14/09/1976	1231		16	**8.3**	**375**			211	5		43	4	28	8	167	37	0.2					55														DNRW
Utopia	14/12/1976	1632		29	**8.2**	**360**			198	**11**		28	6	34	8	165	26	0.4	2				331														DNRW
Utopia	20/04/1977	1347		22	**8.2**	**385**			212	7		39	5	28	9	153	36		5				193														DNRW
Utopia	25/10/1977	937		24	**8.2**	325			181			35	4	21	8	150	28	0.1					166														DNRW
Utopia	11/04/1978	1305		77	**8**	280			164	**15**		30	4	19	7	142	26	0.1	2				83														DNRW
Utopia	24/10/1978	1154		21																																	DNRW
Utopia	11/11/1980	1505		29	7.8	330			172			34	4	18	8	150	24	0.1	1				138														DNRW
Utopia	18/12/1980	1200		29	7.6	320			170			31	4	19	9	148	25	0.1	1				55														DNRW
Utopia	4/02/1981	1440		18	7.6	78			77	**500**		8	4	5	2	24	3	0.1	6				**7724**														DNRW
Utopia	4/02/1981	1440			7.4	90			62	**500**		8	4	6	2	38	4	0.1	4				**1379**														DNRW
Utopia	5/02/1981	945		18	7.5	117			75	**500**		10	5	8	2	47	6	0.1	4				**1931**														DNRW
Utopia	8/02/1981	725			7.3	116			83	**100**		9	4	8	2	44	6	0.1	13				**1931**														DNRW
Utopia	24/03/1981	1755			**8.1**	285			144	**10**	16	24	5	21	7	133	20	0.1	1																		DNRW
Utopia	24/03/1981	1755		27																																	DNRW
Utopia	4/06/1981	1010		16	7.3	86			58	**200**	680	8	3	5	2	26	6	0.1	7				**1103**														DNRW
Utopia	23/07/1981	1640			**8.2**	**370**			195	**10**	10	37	4	25	8	155	31	0.1	2																		DNRW
Utopia	10/11/1981	915		24	**8.5**	**360**			200	**10**		33	4	24	8	150	27	0.2	13				276														DNRW
Utopia	25/03/1982	850		22	**8**	290			160	**50**	100	24	4	20	6	135	20	0.1	4				276														DNRW
Utopia	12/08/1982	1130		14	**8.1**	300			170	9	2	35	3	19	7	140	27	0.1	3				110														DNRW
Utopia	3/11/1982	1545		25	7.8	330			190	**10**	13	37	5	21	8	165	30	0.2	1				110														DNRW
Utopia	16/02/1983	1730		28																																	DNRW
Utopia	15/12/1983	800		24	**8.1**	320			190	**25**	72	31	4	24	7	145	28	0.1	3.3				138														DNRW
Utopia	24/03/1984	1045		26	7.3	290			220	5	3	37	4	28	9	175	33	0.1	7							30											DNRW
Utopia	23/06/1984	1210		12	7.8	330			200	5		41	3	25	8	150	36	0.1	2.5																		DNRW
Utopia	18/10/1984	1140		20	**8.3**	**480**			280	5		56	5	31	10	200	55	0.1	4.5				138			10											DNRW
Utopia	13/04/1985	1345		23	7.5	**350**			200	**10**	3	41	3	23	7	165	36	0.1								20											DNRW
Utopia	5/07/1985	1425			**8.1**	**340**			180	5	6	37	3	20	7	150	33	0.1																			DNRW
Utopia	18/10/1985	1330		22	7	90			77	**330**	100	9	3	8	2	50	8	0.1	2				138			10											DNRW
Utopia	22/01/1986	1714		30	**8**	292			160	5	5	33	5	19	7	140	26	0.2					331			20											DNRW
Utopia	18/07/1986	1440		16	**8.4**	238			160	**25**	9	32	3	19	7	130	26	0.1																			DNRW
Utopia	17/10/1986	1643		25	**8**	301			160	**10**	13	32	3	19	7	140	27	0.1					690														DNRW
Utopia	9/01/1987	1807		28	7.7	152			95	**2460**	100	11	5	13	3	72	7	0.1	2.6				**1324**														DNRW
Utopia	3/04/1987	930		23	7.9	288			160	**10**	7	32	4	20	6	140	26	0.1								20											DNRW
Utopia	17/07/1987	1530		11	**8.1**	314			150	**19**	9	31	3	17	6	125	22	0.1																			DNRW
Utopia	6/11/1987	1720		21	7.3	273			150	**44**	34	29	5	17	6	120	22	0.2																			DNRW
Utopia	12/02/1988	1645		28	7.3	142			97	**730**	100	12	5	11	4	69	9	0.1					524			10											DNRW
Utopia	17/05/1988	1452		18	7.5	250			130	**48**	38	26	3	16	5	115	21	0.1																			DNRW
Utopia	26/09/1988	1430		24	**8.1**	274			150	**12**	6	29	4	18	7	125	25	0.1																			DNRW
Utopia	12/01/1989	1437		27	7.1	175			89	**125**	100	10	5	13	3	73	9	0.1																			DNRW
Utopia	7/05/1989	852			7.8	308			150	**81**	80	24	6	19	6	105	27		3.2				**2152**														DNRW
Utopia	2/09/1989	1613			7.9	**434**			250	**10**	11	46	3	31	10	180	54	0.1	5							50											DNRW
Utopia	3/12/1989	1440		30	**8.5**	**405**			230	**76**	59	43	4	28	8	155	48	0.2	4				331			100			0.02								DNRW
Utopia	24/03/1990	1115		22	**8.1**	320			179	**47**	45	33	4	20	7	133	32	0.16	2.8				166			30											DNRW
Utopia	13/07/1990	1145		11	**8.2**	**475**			260		32	51	4	31	11	182	46	0.16	7				386			20											DNRW
Utopia	15/11/1990	1330		26	7.6	**498**			270	2		58	4	31	11	200	52	0.16	3.4							40			0.03								DNRW
Utopia	23/03/1991	915		22	7.8	**380**			217	4	5	47	5	24	8	167	44	0.19								30			0.03								DNRW
Utopia	3/08/1991	1405		8	**8**	303			176	**16**	4	37	3	19	7	141	33	0.13	2.8							20			0.04								DNRW
Utopia	29/11/1991	1340		27	7.5	294			182	4	3	41	4	17	8	143	32	0.16	0.6										0.03								DNRW
Utopia	12/04/1992	1003		17	7.6	302			158	**11**	3	33	3	19	7	135	26	0.14																			DNRW
Utopia	12/08/1992	1120		12	**8.3**	240			151	**11**	1	33	2	16	7	124	25	0.13	0.7				55														DNRW
Utopia	2/12/1992	1405		26	**8.1**	310			167	9	5	34	4	17	8	136	25	0.12	0.3				221						0.01								DNRW
Utopia	24/03/1993	1015		21.1	7.7	284			153	**11**	7	37	4	14	7	121	26	0.14					55						0.02								DNRW
Utopia	21/07/1993	915		14.2	7.9	249			137	**23**	15	30	3	15	6	115	20	0.12	0.6				28														DNRW
Utopia	24/11/1993	1455			7.6	190			110	**230**	100	15	4	13	4	79	19	0.1	2				**938**			100			0.05								DNRW
Utopia	24/11/1993	1455		24.6	7.75	163																															DNRW
Utopia	16/12/1993	1300			7.65	165			99	**290**	100	15	4	11	4	76	12	0.1	2				**1048**			100			0.05								DNRW
Utopia	13/04/1994	940		15.7	7.9	294			168	8	4	33	4	19	6	134	28	0.1	0.6				110						0.01								DNRW
Utopia	31/08/1994	1330		17.4	**8**	278			147	4	3	33	3	15	7	126	23	0.11	0.7		20	17															DNRW
Utopia	23/09/1994	1420		16.2	7.8	294			155	3		34	4	16	7	134	26	0.12			27	**20**							0.02								DNRW
Utopia	30/11/1994	920		24.3	7.79	312			170	**19**	9.8	31	4	20	9	150	22	0.14	0		**73**		149			0			0								DNRW
Utopia	11/01/1995	1250		27.4	7.25	182			110	**400**	100	18	5	12	4	76	14	0.2	2		**260**	**150**	**1434**			100			0.05								DNRW
Utopia	10/02/1995	919		25.1	7.18	95	6.21		65	**1220**	200	9	4	7	2	42	7	0.11	1.29		**487**	**30**	**1131**			0			0								DNRW
Utopia	9/03/1995	1539			7.58	185			114	**124**	200	18	4	13	4	85	17	0.1	1.8		**191**	**49**	414			0			0.01								DNRW

Water Quality Data Summary

Sample Collection Point	Sample Date	Time	Physical: Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Cations: Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*
Utopia	29/03/1995	900		22.6	**8.31**	321	6.75		180	8	8.9	37	4	21	7
Utopia	4/05/1995	1000			7.56	303			163	4	4.5	35	4	18	6
Utopia	7/06/1995	1100			7.91	296			158	**10**	3.3	32	4	17	6
Utopia	5/07/1995	845		9	7.95	292	10.85		159	**11**	7.9	33	3	16	7
Utopia	26/07/1995	1530		10.4	7.81	292	11.48		163	0	9.74	37	3	17	6
Utopia	31/08/1995	900		15.7	7.84	297	7.96		159	9	7.11	34	3	18	7
Utopia	5/10/1995	1330		20.9	7.92	289	8.24		153	9	7.24	31	4	16	7
Utopia	2/11/1995	1300			7.24	192			113	**196**		21	4	11	4
Utopia	28/11/1995	1315		27	7.57	195	6.13		113	**208**	340	19	4	13	4
Utopia	8/01/1996	750		25.4	7.94	262	6.53		117	**92**	143	20	3	15	5
Utopia	1/02/1996	1120		28.1	7.35	218	5.82		132	**235**	371	22	5	15	5
Utopia	4/03/1996	1432		24.1	7.81	**403**	9.66		224	**14**	17.1	45	5	27	8
Utopia	27/03/1996	1021		21.9	7.96	**391**	6.64		211	**11**	12.8	44	4	24	8
Utopia	9/05/1996	1540			7.48	203			123	**124**		29	4	10	3
Utopia	4/06/1996	1450		15.9	7.78	303	9.90		169	8	22.2	35	5	18	6
Utopia	3/07/1996	1530		10.9	7.98	307	11.38		166	9	11	35	3	18	7
Utopia	30/07/1996	950		12.3	7.86	289	9.20		156	**20**	14	34	3	17	6
Utopia	4/12/1996	925		26.1	7.98	338	3.50		189	**20**	18	43	5	18	8
Utopia	25/03/1997	925		20.8	7.56	312	6.76		179	**30**	54	33	5	21	7
Utopia	13/08/1997	1230		12.2	7.75	299			160	**10**		35	3	17	6
Utopia	21/11/1997	1030	28.6	22.6	7.8	260	6.20		150	**800**	1120	45	5	8	2
Utopia	25/03/1998	1230	31.9	25.9	7.75	285	7.90		160	**10**	16.1	28	6	21	6
Utopia	25/03/1998	1250		25.9	7.8	285	7.90				16				
Utopia	23/07/1998	1315	16.3	12.9	7.59	258	10.30		140	**15**	26	30	3	15	6
Utopia	8/10/1998	800	14.7	18.4	7.96	240	7.40		155	**34**	79	28	5	18	5
Utopia	24/02/1999	1330			**8.1**	230			140	**40**	60	25	5	16	5
Utopia	24/02/1999	1400	22.5	23.2	7.8	272	7.00				72.3				
Utopia	8/03/1999	1500		26.7	7.45	129	6.20		79	**160**	294	11	6	8	2
Utopia	6/07/1999	1232		11.6	7.3	261	9.80				12				
Utopia	6/07/1999	1500		11.8	**8.28**	262	9.80		152	4	12	32	3	16	7
Utopia	8/12/1999	1215		24.5	**8.16**	**396**	7.40		234	6	8	63	5	16	7
Utopia	28/02/2000	805													
Utopia	22/03/2000	1025		24	**8.1**	248	6.90		146	**37**	86	32	5	13	5
Utopia	16/08/2000	1620		13.3	**8.26**	284	11.20		142	**14**	10	31	3	14	6
Utopia	15/11/2000	859		22.4	7.75	164	6.90		100	**150**	257	20	4	9	3
Utopia	28/02/2001	1205		26.3	7.85	249	6.60		140	**10**	13	26	4	15	5
Utopia	18/07/2001	1138		10.3	**8.1**	259	10.40		140	**10**	6	28	3	14	6
Utopia	5/12/2001	1330		28.2	**8.1**	335	7.20		190	**20**	27	39	4	19	10
Utopia	20/02/2002	1105		26.5	7.3	130	6.50		82	**240**	308	14	4	7	3
Utopia	9/07/2002	1255		8.3	**8.1**	273	11.00		150	**20**	12	36	3	14	6
Utopia	20/11/2002	825		21.9	7.95	291	4.60		160	**20**	16	36	4	15	7
Utopia	18/03/2003	1115		23.4	**8.1**	261	7.40		150	**30**	47	31	5	16	5
Utopia	18/06/2003	1455		11	7.97	266	9.50		149	**10**	11	32	3	16	6
Utopia	9/09/2003	1440			**8.25**	275			150	**10**	11	33	3	15	6
Utopia	9/09/2003	1448		17.1		278	9.60				13				
Utopia	13/01/2004	1245		29.3	7.7	304	5.50		170	**40**	28	43	5	13	6
Utopia	12/05/2004	1250		14.4	**8.1**	291	9.60		160	**10**	9	35	3	16	6
Utopia	26/10/2004	1215		25.3	7.76	302	4.70		160	**12**	8	36	4	15	7
Utopia	15/03/2005	1130		24.2	7.83	270	6.10		147	**14**	17	33	5	14	5
Utopia	6/07/2005	1415		13.5	**8.14**	**551**	9.50		317	**136**	311	112	4	6	3
Utopia	16/11/2005	1008		23.3	7.57	167	8.60		109	**345**	444	19	4	11	3
Utopia	7/02/2006	1030			7.09	161			91	**207**	344	14	8	9	3
Utopia	8/02/2006	1030		26.1	7.1	158					350				
Utopia	4/05/2006	1540		15.5	7.99	222	9.40		131	**16**	19	27	4	13	5
Utopia	22/08/2006	1230		14.6	7.98	297			141	**27**	8	32	3	14	6
Utopia	29/11/2006	1025		26.1	7.8	**350**					87				
Utopia	20/03/2007	1040		22.2	7.4	196	4.30				195				
Utopia	3/07/2007	1426		11.3	7.4	**427**	10.00				364				

Sample Collection Point	Sample Date	Anions: Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Nutrients & Biological: TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-*a* (µg/L)	Trace Elements: Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Flow: Level	Velocity	Data source
		na	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*	
Utopia	29/03/1995	142	28	0.13	1.08		34	**20**	121			0			0.05								DNRW
Utopia	4/05/1995	131	28	0.12	1.02		40	7				0			0.02								DNRW
Utopia	7/06/1995	125	28	0.12	0.78		28	**27**	408			0			0.01								DNRW
Utopia	5/07/1995	132	27	0.11	0.47		21	9				0			0.02								DNRW
Utopia	26/07/1995	133	28	0.14	0.63		3	**38**				0			0.02								DNRW
Utopia	31/08/1995	132	27	0.12	0.56		17	**21**	36			0			0.05								DNRW
Utopia	5/10/1995	127	25	0.14	0		15	**26**				0			0.02								DNRW
Utopia	2/11/1995	89	17	0.13	1.64		**158**	**25**	519			0			0.07								DNRW
Utopia	28/11/1995	82	18	0.11	2.04		**184**	**58**	433			0			0.01								DNRW
Utopia	8/01/1996	117	5	0.11	0.9		**114**	**41**	339			0			0.04								DNRW
Utopia	1/02/1996	99	18	0.11	1.9		**193**	**20**	**772**			0			0								DNRW
Utopia	4/03/1996	182	35	0.13	0.9		**59**	**30**				0			0.02								DNRW
Utopia	27/03/1996	174	35	0.14	0.54		42	**27**				0			0.01								DNRW
Utopia	9/05/1996	97	16	0.15	1.9		**138**	**24**	359			0			0.02								DNRW
Utopia	4/06/1996	135	27	0.1	0.79		32	**25**	251			0			0.01								DNRW
Utopia	3/07/1996	135	27	0.1	0		20	14				0			0.05								DNRW
Utopia	30/07/1996	127	26	0.06	0.38		29	20				0			0								DNRW
Utopia	4/12/1996	153	28	0.15	0		**59**	**57**	193			0			0								DNRW
Utopia	25/03/1997	145	23	0.12	1.33		**92**	**37**	276			0			0.01								DNRW
Utopia	13/08/1997	135	26	0.1	2		10	0	138			100			0.05								DNRW
Utopia	21/11/1997	130	11	0.2	2		**550**	**31**	662			100			0.05								DNRW
Utopia	25/03/1998	140	21	0.1	2		**70**	**87**	138			100			0.05								DNRW
Utopia	25/03/1998																						DNRW
Utopia	23/07/1998	119	22	0.12	0.37		30	12	66			0			0								DNRW
Utopia	8/10/1998	115	24	0.1	1.56	**573**	**118**	6	190			0			0.01								DNRW
Utopia	24/02/1999	115	16	0.1	2		**130**	5	193			100			0.05								DNRW
Utopia	24/02/1999																						DNRW
Utopia	8/03/1999	58	4	0.1	2		**330**	**20**	414			100			0.05								DNRW
Utopia	6/07/1999																						DNRW
Utopia	6/07/1999	127	24	0.11	0.38	105	22	4				0			0								DNRW
Utopia	8/12/1999	207	29	0.21	0	301	**79**	**55**	138			100			0								DNRW
Utopia	28/02/2000					**873**	**126**																DNRW
Utopia	22/03/2000	117	20	0.15	1.04	434	**98**	**21**	406			0			0								DNRW
Utopia	16/08/2000	124	22	0.13	0	147	27	10	47			0			0								DNRW
Utopia	15/11/2000	84	11	0.1	2	**990**	**250**	**23**	524			100			0.05								DNRW
Utopia	28/02/2001	120	18	0.1	2	320	**80**	8	138			100			0.05								DNRW
Utopia	18/07/2001	120	23	0.1	2	110	20		138			100			0.05								DNRW
Utopia	5/12/2001	160	24	0.2	2	320	**55**	14	138			20			0.03								DNRW
Utopia	20/02/2002	62	7	0.1	3	**1200**	**340**	**24**	497			100			0.03								DNRW
Utopia	9/07/2002	125	24	0.1	2	100	19	4	138			100			0.03								DNRW
Utopia	20/11/2002	135	25	0.2	2	290	**59**	17	138			20			0.03								DNRW
Utopia	18/03/2003	130	18	0.2	2	330	48	14	138			100			0.03								DNRW
Utopia	18/06/2003	122	23	0.11	0.65	104	13	3	138			100			0.03								DNRW
Utopia	9/09/2003	130	23	0.1	2	150	21	3	138			100			0.03								DNRW
Utopia	9/09/2003																						DNRW
Utopia	13/01/2004	145	25	0.2	2	310	**64**	**26**	138			100			0.03								DNRW
Utopia	12/05/2004	135	25	0.1	2	130	23	6	138			100			0.03								DNRW
Utopia	26/10/2004	139	24	0.1	1	244	43	7	138			30			0.03								DNRW
Utopia	15/03/2005	129	24	0.1	1	312	41	11	138			40			0.03								DNRW
Utopia	6/07/2005	289	32	0.3	1	**929**	**118**	**51**	524			170			0.03								DNRW
Utopia	16/11/2005	85	14	0.1	2	**1030**	**230**	**25**	441			80			0.03								DNRW
Utopia	7/02/2006	68	9	0.1	1				**745**			30			0.03								DNRW
Utopia	8/02/2006					**1637**	**265**	**48**															DNRW
Utopia	4/05/2006	114	21	0.1	1	164	34	6	138			20			0.03								DNRW
Utopia	22/08/2006	120	23	0.1	1				138			70			0.03								DNRW
Utopia	29/11/2006					**596**	**109**	**55**															DNRW
Utopia	20/03/2007																						DNRW
Utopia	3/07/2007																						DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources

Table A2

Upper Dawson Catchment - URS Surface Water Analytical Results

GLNG CSG Surface Water

Location	Sample ID	Date Sampled	Analyte	Physico-Chemical Parameters				Metals (Total)								
			Sample Type	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Suspended Solids (SS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc
			Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
			LOR	*2*	*5*	*1*	*1*	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*
			MTV	*na*	*na*	*na*	*10*	*0.024/0.013*	*0.37*	*0.0002*	*0.05*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*
D002	D002_05/03/08	5/03/2008	PS	-	31	8	**152**	0.002	<0.1	**0.0002**	0.004	**0.005**	-	**0.004**	0.004	**0.016**
D002	D002_05/03/08CHK	5/03/2008	LD	-	-	-	**146**	-	-	-	-	-	-	-	-	-
D002	D002_13/05/08	13/05/2008	PS	<5	1	-	3	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.67**	<0.001	<0.001	<0.005
D004	D004_05/03/08	5/03/2008	PS	-	47	10	**152**	0.002	<0.1	0.0001	0.006	**0.008**	-	**0.007**	0.008	**0.031**
D004	D004_05/03/08CHK	5/03/2008	LD	-	-	10	-	-	-	-	-	-	-	-	-	-
D004	QC02_05/3/08	5/03/2008	FD	-	49	<1	**290**	0.003	<0.1	0.0018	0.009	**0.008**	-	**0.007**	0.008	**0.04**
D004	D004_13/05/08	13/05/2008	PS	49	2	-	8	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.4**	<0.001	<0.001	<0.005
D004	D004_13/05/08CHK	13/05/2008	LD	-	2	-	-	-	-	-	-	-	-	-	-	-
D005	D005_05/03/08	5/03/2008	PS	-	44	<1	**270**	0.002	0.1	**0.0007**	0.003	**0.009**	-	**0.005**	0.005	**0.028**
D005	D005_13/05/08	13/05/2008	PS	<5	7	-	5	<0.001	0.08	<0.0001	<0.001	<0.001	**0.23**	<0.001	0.001	<0.005
D007	D007_05/03/08	5/03/2008	PS	-	54	<1	**74**	0.002	<0.1	<0.0001	0.003	**0.007**	-	0.003	0.004	**0.02**
D007	D007_13/05/08	13/05/2008	PS	28	9	-	**119**	0.002	0.05	<0.0001	0.002	**0.002**	**2.91**	0.001	0.002	<0.005
D007	D007_13/05/08CHK	13/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-
D009	D009_05/03/08	5/03/2008	PS	-	49	<1	**214**	0.004	<0.1	**0.0002**	0.005	**0.01**	-	**0.006**	0.007	**0.034**
D009	D009_13/05/08	13/05/2008	PS	16	7	-	**122**	0.002	<0.05	<0.0001	0.005	**0.007**	**9.62**	**0.005**	0.006	**0.025**
D009	D009_13/05/08CHK	13/05/2008	LD	14	-	-	-	-	-	-	-	-	-	-	-	-
D010	D010_05/03/08	5/03/2008	PS	-	42	<1	**260**	0.002	<0.1	**0.0002**	0.005	**0.007**	-	**0.006**	0.005	**0.025**
D010	D010_05/03/08CHK	5/03/2008	LD	-	42	-	-	-	-	-	-	-	-	-	-	-
D010	D010_13/05/08	13/05/2008	PS	<5	3	-	6	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.28**	<0.001	<0.001	<0.005
D011	D011_05/03/08	5/03/2008	PS	-	82	<1	**26**	0.002	<0.1	<0.0001	<0.001	**0.003**		<0.001	0.002	<0.005
D011	D011_13/05/08	13/05/2008	PS	8	7	-	**21**	0.001	0.05	**0.0005**	<0.001	**0.003**	**0.81**	<0.001	0.001	<0.005
D012	D012_14/05/08	14/05/2008	PS	45	10	-	**13**	<0.001	<0.05	0.0001	<0.001	**0.003**	**0.21**	<0.001	0.002	<0.005
D012	D012_14/05/08CHK	14/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-

Sample ID	Nutrients				Major Ions											Alkalinity			
	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
LOR	*0.01*	*0.1*	*0.01*	*0.1*	*1*	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
MTV	*na*	*na*	*0.05*	*0.5*	*1000*	*175*	*1*	*na*	*na*	*115*	*400*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
D002_05/03/08	**0.141**	1	**0.2**	**1.1**	12	8	0.1	4	6	20	2	1.74	1.9	-	<1	<1	73	73
D002_05/03/08CHK	-	-	-	-	12	-	-	4	5	22	2	-	-	-	-	-	-	-
D002_13/05/08	<0.01	0.4	0.02	0.4	19	25	0.1	7	3		31	2.93	2.97	-	-	-	-	-
D004_05/03/08	**0.174**	0.9	**0.19**	**1.1**	18	16	0.1	5	6	28	2	2.54	2.68	-	<1	<1	102	102
D004_05/03/08CHK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QC02_05/3/08	**0.149**	1.4	**0.19**	**1.6**	16	15	0.1	4	5	28	2	2.51	2.52	-	-	-	102	102
D004_13/05/08	<0.01	0.1	0.03	0.1	27	35	<0.1	9	4		43	3.94	4.02	1.05	-	-	-	-
D004_13/05/08CHK	**0.012**	-	-	-	28	-	-	9	4		49	-	-	-	-	-	-	-
D005_05/03/08	**0.28**	0.8	**0.21**	**1.1**	16	9	0.1	3	6	20	2	1.93	2.05	-	<1	<1	82	82
D005_13/05/08	<0.01	0.8	**0.05**	**0.8**	35	19	0.2	6	6		33	3.69	3.83	1.82	-	-	-	-
D007_05/03/08	<0.01	1.8	**0.56**	**1.8**	13	8	0.1	2	9	20	2	1.84	1.95	-	<1	<1	78	78
D007_13/05/08	**0.012**	1.2	**0.22**	**1.2**	24	14	0.4	5	9		25	2.88	2.92	-	-	-	-	-
D007_13/05/08CHK	-	-	**0.2**	-	-	14	0.3	-	-		-	-	-	-	-	-	-	-
D009_05/03/08	**0.353**	1.7	**0.42**	**2.1**	12	6	0.1	2	8	23	3	1.89	2	-	<1	<1	83	83
D009_13/05/08	**0.177**	1.4	**0.37**	**1.6**	17	9	0.2	4	7		26	2.23	2.41	-	-	-	-	-
D009_13/05/08CHK	-	-	-	-			-								-	-	-	-
D010_05/03/08	**0.182**	1.3	**0.17**	**1.5**	13	16	0.2	3	6	35	2	2.53	2.63	-	<1	<1	102	102
D010_05/03/08CHK	-	-	-	-	-	15	0.2	-	-	-	-	-	-	-	<1	<1	102	102
D010_13/05/08	<0.01	0.3	<0.01	0.3	28	39	0.2	10	5		49	4.34	4.45	1.18	-	-	-	-
D011_05/03/08	**0.015**	1	**0.3**	**1**	14	1	<0.1	3	8	17	1	1.74	1.91	-	<1	<1	84	84
D011_13/05/08	<0.01	0.7	**0.09**	**0.7**	21	<1	0.1	4	7		16	2.02	2.22	-	-	-	-	-
D012_14/05/08	<0.01	0.9	**0.07**	**0.9**	26	12	0.2	7	8		26	3.09	3.2	1.69	-	-	-	-
D012_14/05/08CHK	<0.01	-	-	-	25	-	0.1	7	7		25	-	-	-	-	-	-	-

NOTES

MTV - minimum trigger value

BOLD greater than MTV

PS - Primary Sample

LD - Lab Duplicate

FD - Field Duplicate Sample

Review of Salinity Impacts on Australian Biota

Appendix B

Review of salinity impacts on stream biota with particular focus on temporary and/or arid streams

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25 April 2008

1. Salinity units and terminology

1.1 *Salinity units and measurement*

Salinity is a measure of the concentration of salts in solution (Close 1990). In inland aquatic systems salinity is most directly expressed as Total Dissolved Solids (TDS), i.e. the total mass of salts per unit volume of water. The TDS of seawater is about 35,000 mg L^{-1}, whereas that of 'fresh' water is usually < 300 mg L^{-1} (see Table 1 below).

Electrical conductivity (EC) can be used as a surrogate for TDS-based salinity measurements because there is a consistent and linear relationship between EC and TDS over a wide range of ecologically relevant salinities. For NaCl-dominated systems in inland Australia, the following relationship is often used to infer TDS from EC:

$$\text{TDS (mg L}^{-1}) = 0.6 * \text{EC } (\mu\text{S cm}^{-1} \text{ @ } 25^{\circ}\text{C}) \qquad (1)$$

Thus a 'typical' inland water sample with an EC of 1500 μS cm^{-1} would have a TDS of about 900 mg L^{-1}. This value is often rounded up to 1000 mg L^{-1}.

The relationship between EC and TDS, however, varies with ionic composition, temperature, and salinity itself. The relationship shown in Equation (1) applies only for waters with an ionic composition that approximates that of seawater. The assumption of NaCL-dominance holds for most, but not all, inland waters in Australia (Williams 1967) and most terrestrial soils (Rengasamy 2006). It does not hold, for example, for waters draining karst systems, which are often dominated by other ions such as Ca^{2+}, Mg^{2+} and carbonates. Thus EC cannot be used accurately to infer salinity, at least using most commonly available field instruments, in aquatic systems that have an ionic composition that differs significantly from that of seawater. The EC:TDS relationship is affected also by temperature; most field instruments automatically apply a temperature correction and results for EC are often standardised to 25°C.

A main source of potential error in using EC to infer salinity in TDS units occurs when EC is measured in highly saline systems. The TDS:EC relationship is linear only for salinities around, and preferably less than, those of seawater. It becomes progressively less accurate as salinity increases greatly above seawater values. It is completely inappropriate to use EC to measure TDS with very highly saline samples, such as often occur in inland salt lakes (Williams & Sherwood 1994).

Where it has been necessary to convert between units of TDS and EC, formula (1) has been used in this report to allow direct comparisons across different studies. In general, though, the units used in the original report have been used, except where a direct comparison across studies is paramount.

1.2 *Meaning of the term 'saline'*

There is little agreement about meaning of the terms 'fresh', 'saline' and 'slightly saline' among different practitioners. Williams (1987) outlined the difference between limnologists and water managers in their perceptions of what constitutes fresh, saline and highly saline water (Table 1). Note that *hypersaline* merely means that the salinity is higher than that of seawater, although it is often implied to mean water with a very high salinity, as in the case of a 'hypersaline lake'. *Brackish* is often used to mean slightly salty water, but strictly speaking refers only to a mixture of fresh water and marine water (Bayly 1967)

Table 1: Comparison of limits used by water managers and limnologists for various water salinities. Source: Williams (1987).

	Salinity (mg L^{-1})			
	Fresh	**Slightly saline**	**Saline**	**Highly saline**
Water managers	< 300	300 - 1,000	1,000 – 3,000	> 3000
Limnologists	< 300	3,000 – 10,000	10,000 – 100,000	> 100,000

2. Salinity as an ecological perturbation

The following summary provides a background to the impacts of increased salinity on aquatic biota and has been taken largely from our recent book chapter on salinity impacts in arid and semi-arid streams (Bailey *et al.* 2006).

An ecological perturbation is a distinct change in the properties of an ecological system that has been created by a disturbance (Downes *et al.* 2002). Perturbations consist of two elements: a *disturbance* and a *response*. The conceptual separation of disturbance and response within the concept of perturbation allows comparisons of how different taxa, populations or ecosystems respond to a similar disturbance. It also allows the analysis of disturbance and response at contrasting temporal scales, which is valuable attribute since disturbances may be acute but their ecological impacts (i.e. responses) are often chronic.

2.1 *Disturbances*

Salinity-induced disturbances can take place over a wide range of spatial and temporal scales. A *pulse* disturbance is short-lived with a sharp peak in salinity whereas *press* disturbance is a sustained, long-term increase that builds at a constant rate. A long-term disturbance that increases in intensity with time is often called a *ramp* disturbance (Downes *et al.* 2002). These are important distinctions because the response of aquatic systems to increased salinity may depend strongly on the rate of salinisation. Although pulse and ramp disturbances are not often differentiated in the literature on salinity impacts, they are an important consideration because the mode of delivery of salt can have a large effect on the magnitude and type of response exhibited by the aquatic biota.

2.2 Responses and impacts

There are three components of ecological responses to an environmental disturbance such as salinisation: *inertia, resilience* and *stability* (Underwood 1996). *Inertia* refers to the ability of a population to withstand disturbance; abundance of a population with high inertia does not change with disturbance. *Resilience* is the ability of a population to recover from the disturbance; abundance of a poorly resilient population will be permanently reduced by the disturbance. *Stability* is the rate at which the abundance of a population recovers from the disturbance; a population with high stability will rapidly return to pre-disturbance abundances.

The literature on salinity impacts has not yet developed to the stage whether it differentiates among these different aspects of responses to salinity-induced disturbances. The different types of responses, however, are an important aspect to introduce because they have a strong bearing on how aquatic ecosystems respond to increased salinity. For example, repeated disturbances to a stable population will have little impact if the disturbances are spaced at intervals that allow the population to recover (i.e., it will show excellent resilience but possibly poor inertia). In an unstable population, however, disturbances could repeatedly occur before the population has recovered and the ecological impact could be much greater as inertia, resilience and stability are all compromised.

Since inertia, resilience and stability are rarely invoked in studies of salinity impacts, it is more profitable to examine ecological responses by looking at effects on the *structure* of the ecosystem (i.e., effects on individual species), *ecological processes* (i.e., interactions among species) and *landscape-level* changes (i.e., whole-of-ecosystem effects). Impacts can be manifest as changes in any or all of these components and this tripartite system is used to organise the subsequent review of salinity impacts.

3. How does salinity affect aquatic biota?

Salinity exerts impacts on aquatic systems via three mechanisms (Kozlowski 1997, Bailey *et al.* 2006):

- Direct toxic impacts arising from the accumulation of Na^+ and Cl^- in cells, and to a lesser extent by the disruption of the uptake of other essential ions (e.g., Ca^{++} and Mg^{++}) by the presence of high external NaCl concentrations;
- Direct osmotic impacts caused by the effect of dissolved salts on the availability of water to plant and animal cells; and
- Indirect impacts arising from the effects of salinity on physio-chemical characteristics of water and/or aquatic systems.

Most studies address only the two direct impacts of increased salinity (e.g., see Kefford 1998, Kefford *et al.* 2004 a, Zalizniak *et al.* 2006). Nevertheless, indirect impacts may exert significant effects, especially through effects on dissolved oxygen (DO) concentrations, pH and altered availability of other dissolved material, especially sulfate. In the case of soils, they may exert an indirect effect via modification of soil structure.

Indirect impacts arising from DO changes

The concentration of DO in water at air-saturation is strongly dependent upon salinity (Table 2).

Table 2: Predicted air-equilibrium oxygen concentrations (mg O_2 L^{-1}) at three temperatures and six NaCl concentrations. Derived from Williams (1998 a).

NaCl concentration (mg L^{-1})	**Water temperature (°C)**		
	10	**20**	**30**
0	11.3	9.1	7.5
5,000	11.0	8.9	7.3
10,000	10.7	8.6	7.1
50,000	8.3	6.8	5.8
100,000	6.0	5.0	4.3

Oxygen deficiencies in waters in arid and semi-arid regions could be exacerbated by high salinity, especially if combined with high water temperature. The combination of very salty water sometimes found in hypersaline lakes (e.g., 260,000 mg L^{-1}) and warm (e.g., 30°C) water, for example, produces an air-equilibrium oxygen concentration of only 1,600 mg L^{-1}, considerably below tolerances of almost all invertebrates and fish.

Indirect impacts arising from pH shifts

Increases in salinity in aquatic systems may be associated with changes in water-column pH. Bailey *et al.* (2006), for example, reported that, in a large temporary wetland in central Victoria, water-column pH decreased by 1.4 units (to 5.5) in low-salt treatments (initially 600 mg L^{-1}) but in high salt treatments (initially 1,800 mg L^{-1}) the pH fell to 3.8. In contrast, water-column pH in controls and the general wetland decreased by only 0.5 pH units over the period of water-level drawdown.

Indirect impacts arising from other solutes

Saline disposal waters and saline groundwater often contains salts other than the NaCl that is most commonly responsible for toxic-ion and osmotic effects. Ecological impacts may arise from elevated concentrations of these other ions (see Section 4.4 of this report). Loads and/or concentrations of sulphate (SO_4^{2-}), for example, are often elevated in salinizised systems and the increased availability of SO_4^{2-} has serious ramifications for decomposition pathways in wetland sediments; sulphate-reduction can these result in the production of phytotoxins such as H_2S and the generation of acid-sulfate soils.

4. Salinity impacts on aquatic systems – responses at the species level

4.1 *Pre-adaptation of the extant biota in Australian fresh waters*

It has long been thought that the Australia aquatic biota is well adapted to the periodically highly saline environments that have existed over the last 6 million years in the Murray-Darling Basin (Bailey *et al.* 2006. The consequence of this assumption is that it is often assumed also that the biota is 'pre-adapted' to high salinities resulting from secondary salinisation (e.g., Close 1990). Although it is well known that freshwater organisms exhibit a range of tolerances to salinity (Hart *et al.* 1991, Bailey *et al.* 2002), extreme care must be taken when extrapolating such an argument to the case of secondary salinisation. Secondary salinisation is almost always associated with other hydrological changes to which the biota may not be well adapted. For example, taxa that are well adapted to high salinities and falling water levels in temporary wetlands may not be well adapted to the evolutionary rare combination of high salinity and permanent water logging (e.g., see Salter *et al.* 2006 for the example of Swamp Paperbark, *Melaleuca ericifolia*).

4.2 *Salt-sensitivity of the Australian freshwater biota*

Knowledge of the salt-sensitivity of the Australian freshwater biota comes primarily from biological presence-absence data that have been later correlated with field measurements of EC (Hart *et al.* 1991, Bailey *et al.* 2002). A reliance on presence-absence data means that critical salinity thresholds may be overestimated for the recorded taxa. In other words, a given species may have been lost from a given habit long before the observed (high) salinity was measured. Moreover, the mere existence of a species at a given salinity does not mean that it can reproduce at that salinity: many plants, for example, require falls in salinity for seeds to germinate and young seedlings to establish even though adults may continue to survive Finally, single measurements of EC give no indication of whether high salinity has resulted from acute (pulse) increases or a more gradual press-type disturbance over longer time frames.

The data that are available on the salt sensitivity of the Australian freshwater biota come from relatively few primary sources. The reviews by Hart *et al.* (1990, 1991) provide primary meta-data sources but are now dated. These reviews were updated by Bailey *et al.* (2002) in a report that is available on the website of Land & Water Australia (see references). More recently, the *Australian Journal of Botany* devoted an entire issue to the topic of salinisation (e.g., see James *et al.* 2003, Nielsen *et al.* 2003) and a book chapter has been published recently on the impacts of secondary salinisation on arid and semi-arid zone systems in Australia (Bailey *et al.* 2006).

As part of the review for the current project, I undertook a literature search to identify the literature published on the ecological impacts of salinity on the Australian aquatic biota since 2000 (roughly when the Bailey *et al.* (2002) review ceased its inspection of the literature). An interrogation of the ISI Web of Science database for the key words *salinity* + *Australia** returned 1093 reports: the first 300 of these were checked for this report. A refinement of this initial search, using the terms *salinity* + *Australia** + *freshwater* returned 127 reports; all 127 were examined. Because of the limited time available to complete this report, it was not possible to include details from all the relevant studies.

<u>Microbes</u>

I could find no reports on the salt sensitivity of aquatic bacteria or fungi in Australian freshwaters. This result suggests there has been little or no advance in this field since Hart *et al.* (1991) reported the same state of knowledge over 15 years ago. It is likely, however, that salinisation does affect microbial populations in temporary wetlands, as Boon *et al.* (1996) reported changes in key biomarkers (e.g., sterols, fatty acids etc) for different groups of benthic microbes during the wet and dry phases of a large temporary wetland in central Victoria.

Algae

There seems to be little information on the salinity tolerance of freshwater phytoplankton. This group of plants was not examined at all by Bailey *et al*. (2002). Hart *et al*. (1991) reported that cyanobacteria were present in waters with salinities exceeding 200,000 mg L^{-1} but no information was provided on the salinity tolerance of individual taxa. More recently, Tonk *et al*. (2007) reported that the nuisance blue-green alga *Microcystis aeruginos*a was largely unaffected by salinity up to about 10,000 mg L^{-1} and it could temporarily endure salinities of up to 17,500 mg L^{-1}.

Data on the salt sensitivity of aquatic algae are dominated by reports on macroscopic charophytes such as *Chara* and *Lamprothamnium*. *Chara* and *Nitella* seem to be restricted to salinities of < 10,000 mg L^{-1} whereas *Lamprothamnium papulosum* can be found in hypersaline waters with salinities >100,000 mg L^{-1}.

Aquatic vascular plants

Hart *et al*. (1990) concluded that the majority of macrophyte species in fresh waters were salt sensitive and that changes in plant performance and decreased botanical diversity commenced at salinities of about 1,000 mg L^{-1}. A salinity of about 4,000 mg L^{-1} was proposed in Hart *et al*. (1990) as the upper limit tolerated by most species of freshwater macrophytes, such as *Myriophyllum propinquum*, *Triglochin procera*, *Crassula helmsii* and *Isoetes muelleri*. It was noted, however that sub-lethal effects, such as reduced vigour, were likely to operate at salinities less than the maximum that were tolerated by the adults of a given species. Sub-lethal effects are discussed later in the report.

The species richness – but not necessarily the productivity – of aquatic vascular plant communities decreases with increasing salinity (Hart *et al*. 1991). Bailey *et al*. (2002) provided 49 entries for emergent, submerged and floating aquatic plants from 12 reports which identified 26 plant genera. Unfortunately, 40 % of the entries were from two reports on saline wetlands. About 40 % of the plant genera were restricted to salinities < 5,000 mg L^{-1}. This result is consistent with the conclusion reached by Brock & Lane (1983) that macrophytes with freshwater affinities occur at salinities < 4,000 – 5,000 mg L^{-1}. Even so, ~ 40 % of the reported plant genera were found in waters with a salinity >8,000 mg L^{-1}. The most salt tolerant aquatic vascular plant species were *Ruppia tuberosa* and *Lepilaena preissii* , which could be found at 230,000 mg L^{-1} and 150,000 mg L^{-1}, respectively. Both taxa are known also to be able to tolerate large fluctuations in salinities (Brock & Lane 1983). Other genera present at high salinities were *Bolboschoenus caldwelli, Cyperus gymnocaulus, Pachycornia* and *Suaeda* (25,000 mg L^{-1}) and *Phragmites australis*

Zooplankton

Given they are such a diverse group, spanning a range of faunal orders, it is not possible to generalize about the impacts of increasing salinity on zooplankton. The key groups of zooplankton in Australian fresh waters are rotifers and microcrustaceans (cladocerans, copepods and ostracods).

Rotifers are critical zooplankton in Australian fresh waters because they have a dominant role in structuring planktonic food webs. Rotifers as a group seem to have a wide salinity tolerance, as species have been collected during field surveys from waters ranging from < 1,000 to >15,000 mg L^{-1} (Hart *et al*. 1991). It is unlikely that such a wide salinity tolerance is possessed by individual species of rotifer, given the well-known niche separation that occurs among different rotifer taxa. Bailey *et al.* (2002) suggested that there was a bimodal response to salinity by rotifers, with one group showing a peak of abundance at salinities of < 500 mg L^{-1} and the other group having an optimum at a salinity of 7,000 – 8,000 mg L^{-1}.

In contrast to rotifers, cladocerans (i.e., water fleas) seem, as a group, salt sensitive and are thus often restricted to fresh waters with salinities of < 1,000 mgL^{-1} (Hart *et al.* 1991). Bailey *et al.* (2002) concluded that 30 % of reported genera of cladocerans were found at salinities of < 3,000 mg L^{-1} and a number of genera were restricted to waters < 500 mgL^{-1}. An exception is *Daphniopsis pusilla,* which has been found in the field at salinities of up to 50,000 mgL^{-1} (Hart *et al.* 1991). Field studies in temporary ponds in central Victoria have shown that cladoceran abundances decreased by more than 90 % when salinities increased from 200 to 2,500 mgL^{-1} (Bailey *et al.* 2006).

The salt sensitivity of copepods, like that of rotifers, seems to be bimodal. Hart *et al.* (1991) concluded that most copepods were restricted to fresh waters, usually < 1,000 mg L^{-1}, but a number of copepod genera had secondarily colonised saline waters. An example is *Calamoecia salina*, which can be found in waters with salinities that exceed 175,000 mg L^{-1} (Hart *et al.* 1991). Bailey *et al.* (2002) reported a broadly similar pattern, with ~ 70 % of genera having a salinity maximum of > 8,000 mg L^{-1} and the remaining 30 % having a tolerance of < 2,000 mg L^{-1}.

Many ostracods are found in highly saline waters (i.e. > 35,000 mg L^{-1}) but those species that are restricted to fresh waters are rarely found at salinities of > 1,000 mg L^{-1} (Hart *et al.* 1991). Consistent with this conclusion, Bailey *et al.* (2002) reported that the abundance of ostracod genera peaked at salinities of < 500 mg L^{-1} but a smaller peak occurred at very high salinities of > 70,000 mg L^{-1}. Some ostracod genera, e.g., *Cypretta* and *Limnocythere*, were seemingly insensitive to salinity differences and could be found at salinities ranging from < 1,000 to > 15,000 mg L^{-1}.

Macroinvertebrates

Aquatic macroinvertebrates are the best studied group of the Australian freshwater biota in terms of salt tolerance. The depth of knowledge has allowed some generalisations to be made about responses to increased salinities by different groups. Bailey *et al.* (2002), for example, identified 57 entries for molluscs, from 13 reports. Twenty one genera were examined, mostly gastropods, but there were only eight entries for bivalves. Molluscs could be divided into two groups in terms of salt sensitivity; one group was limited to salinities of less than 3,000 mg L^{-1}, representing 48 % of reported genera, and another was found it waters > 8,000 mg L^{-1}, and represented 28 % of the reported genera. *Pettancyclus* sp. and *Helicorbis australiansis* were the only taxa limited to salinities of < 1,000 mg L^{-1}. The most salt tolerant genus was *Coxiella*, which could be found in salinities as high as 124,000 mg L^{-1}.

Aquatic cnidaria (e.g., *Hydra*) seem to be largely limited to low-salinity waters (< 2,000 mg L^{-1}). This group may be among the most salt-sensitive of all aquatic animals (Hart *et al.* 1991). Among the worms, there is little information for platyhelminths and what information is available does not permit of broad generalisations (Hart *et al.* 1991). Similarly, little is known about osmoregulation in annelid worms; most species, however, seem to be restricted to waters with salinities of < 1,000 mg L^{-1} according to Hart *et al.* (1991).

Mayflies (Ephemeroptera) and stoneflies (Plectoptera) are generally restricted to well oxygenated, fast flowing streams of low salinity (Hart *et al.* 1991). For mayflies, Bailey *et al.* (2002) identified 33 entries from 11 reports that examined 11 genera. Mayflies seem a salt-sensitive group as they were not reported at salinities > 6,000 mg L^{-1}, and 45 % percent of genera were only found at salinities < 500 mg L^{-1}. *Cloeon* and *Tasmanocoenis* were the most salt-tolerant genera, and could be found in systems with a salinity of ~ 5,000 mg L^{-1}. Kefford *et al.* (2003) reported a 72-h LC_{50} of >9,000 mgL^{-1} for *Tasmanocoenis* spp. collected from the Barwon River, Victoria. Similarly, most caddisflies (Trichoptera) are found in low-salinity environments and Hart *et al.* (1991) concluded that long-term increases in salinity would likely have a deleterious impact on the trichopteran fauna of streams.

Most dragonflies and damselflies (Odonata) are found in waters with salinities of < 1,000 mg L^{-1} and a number of species are restricted to dystrophic waters with salinities of < 50 mg L^{-1} (Hart *et al.* 1991). A few dragonfly species, however, are found in saline and hypersaline waters; *Ischnura aurora* survives over the salinity range of 100 to 21,000 mg L^{-1}. Bailey *et al.* (2002) reported that the most salt-tolerant odonate was *Austrolestes annulosus*, which could be found at salinities of > 35,000 mg L^{-1}.

Bailey *et al.* (2002) analysed 14 reports on 18 genera of water bugs (Hemiptera). They found that 72 % of genera had a salinity maximum of < 6,000 mg L^{-1}. Hart *et al.* (1991) concluded that hemipterans, as a group, seemed largely insensitive to increased salinity, even if some genera were clearly restricted to low-salinity waters (e.g., *Anisops*, *Notonecta*: < 1,000 mg L^{-1}). Hart *et al.* (1991) postulated that increased salinity would merely replace these salt-tolerant taxa with more salt-tolerant species.

True flies (Diptera) seem to be the only order of aquatic insects that has successfully colonized highly saline waters (Hart *et al.* 1991). Two major families (Tipulidae and Simuliidae) seem to be restricted to salinities of < 1,000 mg L^{-1} but both families of biting or nuisance flies (Empididae and Ceratopogonidae) have been found in saline or even hypersaline waters with salinities of > 70,000 mg L^{-1}. Bailey *et al.* (2002) identified 86 entries from ten reports (covering 35 genera) of chironomids and other aquatic diptera. Fifty percent of the reported dipteran genera were limited to salinities < 2,000 mg L^{-1}, and the majority of genera (68 %) occurred at salinities < 4,000 mg L^{-1}. Four genera had salinity maxima 7,000-8,000 mg L^{-1}, and six genera (17 %) were found at salinities in excess of seawater (i.e. >35,000 mg L^{-1}). Thus it seems that chironomids and other aquatic diptera could be divided into two groups, one restricted to low salinities and another small group tolerant of hypersaline conditions. Among the more salt sensitive genera were *Microspectra*, *Pseudochironomus*, *Rheocricotopus*, *Tvenetia* and *Cordites*. The most salt tolerant genus was *Tanytarsus barbitarsis*, which was found in field samples from waters of 100,000 mg L^{-1}.

Fish

The response of fish to salinity is complicated by the range of life histories shown by different fish species. Some species are restricted totally to fresh waters and have no marine ancestry. In Australia it seems that there are only three species (in two families) in this group. In contrast, Rainbowfish (family Melanotaeniidae) are somewhat tolerant of salt, which is likely to be a function of their recent evolution from a marine hardyhead ancestor (Hart *et al.* 1991). Most other Australia fish fall into what is called the 'peripheral division', which have a high salinity tolerance and only those species that have been long isolated in freshwaters are likely to have lost this tolerance. At least 20 species of Australia 'freshwater' fish are diadromous, meaning they move between fresh water and sea water to complete their life stages.

In general, the Australian freshwater fish fauna seems quite salt tolerant. Bailey *et al.* (2002) analysed 34 entries from 14 reports of 19 genera of freshwater fish and concluded that over 80 % of reported genera had a salinity maximum of > 8,000 mg L^{-1} and none had a salinity maximum of < 4,000 mg L^{-1}. Hart *et al.* (1991, page 128) presented summary data for salt-sensitivity of a range of Australia fish species but emphasised that "care should be taken in interpreting [this information], since both laboratory and field results may not truly reflect actual halotolerance".

Galaxids (Galaxiidae) probably have considerable salt tolerance. Grayling (Prototroctidae) are anadromous: they live in rivers but spawns in coastal streams and the larvae drift downstream to the ocean, then migrate up rivers from about 6 months of age. Smelts (Petropinnidae) have been reported in a wide range of inland waters and in seawater, although it seems that breeding is limited to fresh water. Hardyheads (Atherinidae) are, as group, highly salt tolerant and one species, *Craterocephalus cuneiceps* has been found in waters at ~ 70,000 mg L^{-1}. The limited amount of information available suggests that gudgeons (Eleotridae) can survive in waters > 10,000 mg L^{-1} and some taxa can survive > 30,000 mg L^{-1}. In contrast, carp (Cyprinidae) seem to be restricted to salinities of < ~ 7,000-10,000 mg L^{-1}. The noxious pest *Gambusia* (Poeciliidae) is highly salt tolerant and can survive up to 59,000 mg L^{-1} for 30 days.

Amphibians

Hart *et al.* (1991) could find no studies of the salt tolerance of tadpoles or adults of any species of Australian frog. Bailey *et al.* (2002) reported a similar lack of data. Overseas studies, however, indicate strongly that amphibians are rarely able to osmoregulate well and from this it can be concluded that most adult frogs are probably intolerant of salinity. There is some information on salinity tolerance of the introduced cane toad (*Bufo marinus*); adults can survive in salinities of up to 14,000 mg L^{-1} and gradual acclimatization to higher salinities increases the number of toads that survive exposure to salt. More recently, Smith *et al.* (2007) reported that the numbers of tadpoles in wetlands in aquatic systems of south-eastern Australia should not be affected by salinities of up to about 3000 EC (~1,800 mg L^{-1}) but almost all tadpoles would be excluded should be salinity increase to 6000 EC (~3,600 mg L^{-1}).

4.3 *Conclusions*

Many aquatic vascular plants are salt sensitive and salinities of 1,000-2,000 mg L^{-1} could be lethal to these salt-sensitive taxa. Of the animal taxa, invertebrates seem the most sensitive to increases in salinity and some species would show adverse effects from salinities as low as 1,000 mg L^{-1} (Hart *et al.* 1991). The most sensitive insects seem to be stoneflies, some mayflies, caddisflies, dragonflies and damselflies, and some species of water bugs. The Australian freshwater fish fauna seems salt tolerant up to or greater than about 10,000 mg L^{-1}, within the caveats noted below for the sensitivity of larval stages and eggs, and for non-lethal impacts.

4.4 *Caveats*

Considerable caution is required when interpreting data on the salt sensitivity of aquatic plants, since data have been obtained with a variety of approaches (e.g., glass house versus field observations), over different life stages (e.g., juveniles, small seedlings, and occasionally adult plants) and with a range of 'end points' (e.g., presence/absence, LD_{50}, etc). Hart *et al*. (1990, 1991) described in greater detail the implications of these procedural limitations for obtaining impact 'thresholds'. The most critical of these caveats are discussed in turn next.

Method used to infer salinity tolerance

Data on salinity-induced effects are often sparse and generally limited to mere presence-absence information from field samples which are then correlated with observed salinities (measured as EC) at the time of collection. As noted earlier in this report, estimates of *in situ* salinity may be in error if TDS is inferred from EC values from very hypersaline waters or from waters that do not have an ionic composition similar to that of seawater. Where laboratory, mesocosm or glass house experiments have been used to generate data (admittedly a small subset of the available data), there is an inevitable trade -of between precision and realism. Horrigan *et al*. (2007) discussed the strengths and weaknesses of laboratory versus field-based observations of salinity tolerances of aquatic macro-invertebrates and concluded that acute mortality data (e.g., 96-hour LC_{50}) were significantly correlated with maximum salinities for streams in south-east Queensland.

Salinity is not just NaCl

Secondary salinisation is a complex process that often involves various ions and synergistic effects on dissolved oxygen, pH, water density, nutrients and bioavailability of heavy metals. NaCl is one salt that contributes to the salinity of aquatic systems but it is not the only one. Other ions make up source materials for a wide range of chemicals, fertilizers and other commodities, including evaporates based on sulphates (e.g. gypsum), halides (e.g. halite and carnallite), carbonates (e.g. natron), borax and nitrates (e.g. nitre). Kefford *et al*. (2004 a) reported on the importance of salts other than NaCl in affecting the salt sensitivity of the aquatic biota.

Differences across life-history stages

Almost all the available data refer only to adult life-history stages, and it is possible that juveniles may be more sensitive to salt for some or even many taxa. Kefford *et al*. (2004 b) examined the salinity tolerance of eggs and hatchlings of ten taxa of macroinvertebrates from south-eastern Australia and two from South Africa, and concluded that young life-history stages may be less tolerant of salt than the adult or visually dominant stages. In a later report, Kefford *et al*. (2007 b) examined this issue further and noted that there was a range of responses among different macroinvertebrate taxa, with the younger life stages of some freshwater macroinvertebrates (e.g., eggs or hatchlings) having salinity tolerances 4-88 % of their older life stages.

The situation is clearer with aquatic plants, where it was been demonstrated repeatedly that seedling establishment is the most salt-sensitive stage of their life history. In his expansive review, Kozlowski (1997) concluded that woody plants are usually relatively salt tolerant during seed germination, much more sensitive during emergence and seedling establishment, and progressively more salt tolerant with maturation. Warwick & Bailey (1996) showed that *Triglochin procera* was more tolerant to salt as adult plants than as juveniles. Moreover, field and greenhouse trials indicated that salinities of ~ 6,000 mgL^{-1} could prevent the development of reproductive structures in *Triglochin procera*, yet adult plants continued to survive.

The issue of timing of salinity increased is also important for predicting salinity impacts, and has some links to the issue of exposure of adults versus juveniles. Bailey & Warwick (1996), for example, demonstrated that new turion development was completely prevented in *Potamogeton tricarinatus* plants that were exposed, from emergence, to a salinity of 6,000 mgL^{-1}, and that significant reductions in tuber dry weight were evident at salinities as low as 2,000 mgL^{-1}. In contrast, plants exposed to 6,000 mgL^{-1} after 30 days of vegetative growth were unaffected by this level of salinity.

<u>Differences within a single species across sites</u>

It is not valid to assume that the same species from different sites will respond in the same way to increased salinity. There is also good evidence that salt tolerance within a single species can vary from region to region. Sands (1981), for example, reported that differences in germination of River red gum (*Eucalyptus camaldulensis*) seeds from three different sites in Australia were due to variations in tissue tolerances to Na^+ and/or Cl^-. Similarly, Brock *et al.* (2005) showed that the effect of increased salinity on the germination of aquatic plants and emergence of zooplankton from sediments was not consistent across all the seven wetlands sites they examined in south-eastern Australia. Nevertheless, as salinity increased above about 1,000 mgL^{-1}, there was a general decrease in species richness and abundance of plants and zooplankton emerging from benthic resting stages.

It is possible that the biota of temporary wetlands and arid-zone regions could respond differently to that of perennial streams in the better-watered south-east of the continent: Porter *et al.* (2007) showed that saline temporary wetlands and permanent freshwater wetlands were the most variable in terms of their sediment-based seedbanks. Unfortunately, little research has been undertaken on the biota of streams in arid or semi-arid regions of Australia (e.g., see Sheil *et al.* 2006) despite temporary wetlands being ubiquitous and of global significance (Deil 2005).

<u>Sub-lethal effects</u>

Data on structural aspects of aquatic systems often relate only to acute and lethal impacts. A range of sub-acute and non-lethal impacts, for example behavioural changes, may be manifest at much lower salinities. Hassell *et al.* (2006) showed that increased salinity extended by 15-88 % the time-to-emergence for a chironomid species found in Victorian streams; moreover, growth rates were reduced with increasing salinity, especially once EC climbed over 10,000 $\mu S\ cm^{-1}$ (equivalent to TDS of ~ 6,000 mgL^{-1}). Sub-lethal effects may be induced also by changes in the ionic composition of aquatic systems subjected to secondary salinisation: Zalzniak *et al.* (2006) reported that Ca^{2+} availability was particularly important in explaining different sub-lethal responses in aquatic macro-invertebrates that had been induced by altered stream-water salinity.

Sub-lethal effects occur also with aquatic plants. As an example, Bailey *et al.* (2006) reported that the total combined biomass of all aquatic plant species in a temporary wetland in central Victoria was not affected by salinities of up to 5,800 mg L^{-1}, but there were differences among species in salinity tolerances. All the freshwater species present under non-saline conditions (*Amphibromus fluitans*, *Potamogeton tricarinatus*, *Triglochin procera* and *Myriophyllum crispatum*) persisted at salinities of 5,800 mg L^{-1}. Although *A. fluitans* was unaffected by salt, the biomass of *P. tricarinatus* and *M. crispatum* were both significantly reduced with increasing salinity. *Triglochin procera* was unaffected by increased salinity, probably because this species had completed most of its growth before the salinity had increased. (Note: this is another example of the difference between pulse and press salinity increases.) Increasing salinity can prompt other non-lethal changes in aquatic plants. Morris & Ganf (2001), for example, reported that the emergent wetland plants *Bolboschoenus medianus* and *Baumea arthrophylla* shifted biomass allocation from above-ground culms to below-ground tubers with increasing salinity.

Sub-lethal effects may be apparent in fish also. Whiterod & Walker (2006) reported that although carp were moderately tolerant of salinity (LC50 ~ 12,000 mgL^{-1}), osmoregulation and behaviour were affected at 7,500 mg L^{-1}, and sperm motility at 8,300 mg L^{-1}.

Non-linear responses to salinisation

The responses to increasing salinity may not always be linear and increases in salt concentrations may not always have adverse ecological impacts. Hassell *et al*. (2006), for example, reported that the emergence of a chironomid species from Victoria showed a U-shaped response to salinity, with greatest emergence in intermediate ECs of 650-5,000 $\mu S\ cm^{-1}$ (equivalent to TDS of ~ 400 - 3,000 mg L^{-1}). Similarly, growth and development of the damselfly *Ischnura heterosticta* were better at intermediate salinities than at very low or very high salinities (Kefford *et al*. 2006). Similar results have been reported for the freshwater snail *Physa acuta* (Kefford & Nugegoda 2005). Such responses are not limited to macro-invertebrates. Robinson *et al*. (2006), for example, showed that seed germination in Swamp Paperbark (*Melaleuca ericifolia*) was greater at slightly elevated salinity (2,000 mgL^{-1}) than in fresh water. Hyporheic invertebrates may also show highest biodiversity and total abundance at intermediate salt levels (see Boulton *et al*. 2007).

Press versus pulse disturbances

The way that salt is introduced to aquatic systems is a critical – but often neglected – aspect of secondary salinisation. Nielsen *et al*. (2007) grouped aquatic plants and zooplankton into five groups according to how they responded to salinity increases that were delivered as pulse increases or as press increases. The emergence of aquatic plants and zooplankton from resting stages in sediments did not seem to be affected by short pulses of high salinity; indeed such pulses could prompt some taxa of zooplankton to hatch. Marshall & Bailey (2004) compared the effect of press and pulse salinisation on macroinvertebrates in the ephemeral Hughes Creek of central Victoria. The abundance of the gastropod *Ferrissia tasmanica*, the mayfly *Baetis* spp. and scraper and predator functional groups were significantly reduced at a salinity of 1,500 mg L^{-1}, and the effect was strongest in the pulse treatment. The abundance of 49 other macroinvertebrate taxa, composition of collector-gatherer functional groups, and species diversity were, however, unaffected by the way salt was increased in the creek system. Marshall & Bailey (2004) concluded that delivering multiple, short pulses of salt was more detrimental than delivering the same salt load at a low concentration over a longer duration.

5 Salinity impacts on aquatic systems – responses at the level of ecological processes

A complementary approach for examining to impacts of increased salinity on freshwater systems is to explore the effects on fundamental ecological processes such as primary production, nutrient cycling and decomposition rates and pathways. The difficulty is there is far less information available on salinity impacts on ecological processes than there is on impacts on relatively simple structural analysis based on species composition (James *et al.* 2003, Nielsen *et al.* 2003). Nevertheless, it is possible to infer some likely impacts from fundamental understanding of how aquatic systems function in arid and semi-arid systems. The following list is not exhaustive, but meant to give an overview of the types of ecosystem-wide impacts that could accrue from increased salinity.

5.1 *Biogeochemical processes, plant decay and nutrient release*

Decomposition pathways

Decomposition proceeds by a biogeochemical sequence in aquatic systems, based on the relative availability of alternative electron acceptors (Boon 2006). It begins with aerobic decay (O_2 as the oxidant) and progresses through nitrification (NO_3^- as the oxidant), metal reduction (Fe^{3-} to Fe^{2-} and Mn^{4-} to Mn^{2-}), sulfate reduction (SO_4^{2-} to H_2S) and, finally methanogenesis (production of CH_4 from acetate, or the reduction of CO_2 by H_2). Methanogenesis is the dominant anaerobic pathway in freshwater aquatic systems (Boon & Mitchell 1995, Boon 2000), but is replaced by sulphate-reduction as salinity increases, due to the abundance of SO_4^{2-} in most saline waters, especially those of a marine origin. Bartlett *et al.* (1987) showed a strong negative correlation between methane fluxes and long-term average salinity in a Virginia (USA) salt marsh. It is not the NaCl that shifts biogeochemical pathways away from methanogenesis towards sulphate-reduction under salinized conditions, but the presence of SO_4^{2-}; methanogenic bacteria are largely unaffected by NaCl up to quite high salt concentrations (Liu & Boone 1991) but are easily outcompeted by sulphate-reducing bacteria once SO_4^{2-} is present (Boon 2000).

This biogeochemical shift has major implications for ecosystem-scale processes in aquatic systems because the end product of sulphate-reduction is hydrogen sulphide gas; H_2S is highly toxic to most aquatic organisms and its production has been invoked to explain the sudden death of plant communities in many salinized systems. The liberation of H_2S also has broader biogeochemical significance, as S^{2-} quickly reacts with reduced iron to produce ferrous sulfide (FeS) and pyrite (FeS_2), making metals such as iron unavailable to aquatic biota. Iron is a critical trace element because it is used in many biochemical reactions in cells. Mercury may also be precipitated by H_2S but, if the SO_4^{2-} concentration is low, may be methylated by sulfate-reducing bacteria, greatly increasing its biological availability and toxicity (Lewis *et al.* 1999).

Leaf breakdown

Increasing salinity also reduced rates at which leaves breakdown. In one of the few Australian studies on this topic, Roache *et al.* (2004) reported that breakdown of the aquatic plants *Triglochin procera* and *Phragmites australis* was affected by relatively low salinity (~ 1,200 mg L^{-1}) in field experiments undertaken in an ephemeral wetland in southern Victoria. The inhibitory effect was more pronounced in the laboratory at higher concentration (~ 5,400 mg L^{-1}).

Nutrient release

It is likely also that secondary salinisation will affect the rate of nutrient release from aquatic sediments. In part this change will be a function of shifts in bacterial groups with the increased availability of SO_4^{2-}. Baldwin *et al.* (2006) have recently shown that increased NaCl concentrations in overlaying water prompted an immediate release of NH_4^+ and Fe^{2+} from sediments collected from a wetland on the River Murray floodplain. The release of inorganic phosphorus, however, was inhibited by increasing salinity.

5.2 *Trophic structure*

Secondary salinisation would be expected to have ecosystem-scale impacts on trophic dynamics and food-web structure. One of the greatest sources of impact on higher trophic levels is likely to be through the effect of salinity on food availability for higher consumer. Kefford *et al.* (2007 a), for example, showed that the most salt-tolerant zooplankton in waters from the southern Murray-Darling Basin were much more sensitive to salt than were the most tolerant macroinvertebates and most freshwater fish. Thus salinisation would be expected to affect zooplankton diversity and abundance and then to have implications for food supply for carnivorous macro-invertebrates and fish further up the food web.

Although impacts of salinity on trophic interactions and food web dynamics have been rarely studied, it is well known that disturbance to natural landscapes, including salinisation, tends to diminish biodiversity (Biswas 1997, Williams 1999). A large number of studies have shown that the number of taxa within different trophic levels of aquatic food webs is reduced dramatically as salinity increases (e.g., Hammer 1986, Hart *et al.* 1991, Blinn 1993, Williams 1998 b, Blinn & Bailey 2001, Herbst 2001). This effect may, in turn, reduce the number of linkages in food webs and carbon transfer within these ecosystems (Martinez 1994). Reduced biodiversity within primary and intermediate trophic levels would be expected to reduce the resilience of food webs in the affected ecosystems, because of a reduction in the number of alternative pathways available for carbon and energy flow.

There is some evidence from field studies in central Victoria to support these theoretical discussions. An increase in salinity from ~ 140 mg L^{-1} to 1,500 mg L^{-1}) significantly reduced the abundance of scraper and predator functional groups in Hughes Creek in central Victoria (Marshall & Bailey 2004). Whereas the abundance of predators increased during the recovery period (5 days), the scrapers remained either rare or absent. The loss of scrapers could represent a significant change to community composition and trophic relationships because scrapers (dominated by gastropods and baetid mayflies) can represent over 15% of all macroinvertebrates present in this system (Bailey *et al.* 2006).

5.3 *Plant performance*

Sexual reproduction and allocation of biomass to underground, vegetative storage organs, such as tubers or rhizomes, can be reduced by increased salinity, a process which would compromise the survival of macrophytes over periods of dormancy (Bailey *et al.* 2002). At Raftery Swamp, a temporary wetland in central Victoria, *Potamogeton tricarinatus* did not flower when salinities increased to 2,000-3,000 mgL^{-1}; laboratory studies showed that the germination rate of *Triglochin procera* seeds was halved at 6,000 mgL^{-1}, and almost entirely ceased at 12,000 mgL^{-1}. The biomass and number of tubers of *P. tricarinatus* were reduced 50 % and 70 %, respectively, at salinities of up to 6,000 mgL^{-1}. Tubers are not only a mechanism by which many plants survive adverse conditions (e.g., drought) but are also a source of food for many aquatic birds (e.g., swans and *Ruppia* tubers). It is clear that there are a range of sub-lethal effects of increased salinity on plants and many of these could have ecosystem-wide ramifications.

6 Salinity impacts on aquatic systems – landscape-scale analyses

There is considerable overlap between ecosystem-scale and landscape-scale impacts of salinity, but it is possible to conceptually limit the latter to largely physical considerations and the former to biogeochemical processes. Secondary salinisation could have significant impacts at the landscape level, primarily via impacts on the availability of refugia in arid and semi-arid zones.

Opportunistic resources for biota are a key feature of the ecology of these regions after rainfall (see Kingsford & Norman 2002 for waterbirds). Critical refugia 'tie over' the biota during dry periods, especially in arid and semi-arid regions. As many species of bird require fresh water for drinking (but can feed in saline waters), the loss of freshwater environments could have serious impacts on avian diversity and abundance.

Secondary salinisation could have impacts also on food supplies to animals at an ecosystem-wide scale. Recent research has demonstrated that shallow aquatic systems often exist in one of a limited number of stable states (e.g. see Boon & Bailey 1998, Morris *et al*. 2004). Although the concept of alternative stable states was developed originally with reference to submerged plants and nutrient enrichment, it is now becoming clear that secondary salinisation also can drive a shallow aquatic system from one stable state into another (Jin 2007). Extreme salinisation, foe example, can drive a wetland that was previously densely vegetated with submerged aquatic plants into a different, but equally stable state, now dominated by benthic algae (Strehlow *et al*. 2005, Sim *et al*. 2006 a, b). Benthic algae provide different – and likely poorer – food sources than dense beds of submerged aquatic plants.

7 Synthesis of guidelines for salinity increases in aquatic systems

7.1 *ANZECC guidelines*

The range of default trigger values for salinity set in the *Australian and New Zealand guidelines for fresh and marine water quality 2000* (ANZECC-ARMCANZ 2000) to protect aquatic systems in various regions of Australia is shown in Table 3. Note that there are currently no trigger values for wetlands in south-eastern Australia and that salinities in tropical and arid-zone regions are expected to vary markedly with hydrological conditions.

Table 3: Range of default trigger values for salinity for various ecosystem types and different regions of Australia. Source: ANZECC-ARMCANZ (2000, Section 3.3.2). Note that salinities have been converted from EC units in the original report to approximate TDS units to facilitate comparison with Section 4.2 of this report.

Region and ecosystem type	Approximate salinity range ($mg\ L^{-1}$)
South-east Australia (slightly disturbed)	
Upland rivers	20 – 200
Lowland rivers	80 – 1,300
Lakes and reservoirs	10 – 20
Tropical Australia (slightly disturbed)	
Upland and lowland rivers	10 – 150 [a]
Lakes, reservoirs and wetlands	50 – 540 [b]
Low-rainfall central Australia (slightly disturbed)	
Lowland rivers	60 – 3,000 [a]
Lakes, reservoirs and wetlands	180 – 600 [b]

[a] Expected to vary markedly with flow
[b] May be higher during water-level drawdown

Default trigger values for protecting ecosystems against the adverse impacts of increased salinity were given in EC units in the ANZECC-ARMCANZ report. They have been converted to TDS values in Table 3 in order to allow a direct comparison with the critical values outlined in Section 4.2 of this report. For aquatic systems in arid and semi-arid zones, the trigger salinities for rivers and wetlands are about 3,000 and 600 mg L^{-1}, respectively.

7.2 *Other reports*

Hart *et al.* (1991, page 105) concluded that "… direct adverse biological effects are likely to occur in Australian river, stream and wetland ecosystems if salinity is increased to around 1000 mg L^{-1}". Similarly, Neilson *et al.* (2003), in their review of the impacts of secondary salinisation on Australian freshwater ecosystems, concluded that 1500 EC (equated with a TDS of 1,000 mgL^{-1} in their review) was the limit at which aquatic biota would be adversely affected by increasing salinity. Muschal (2006) suggested a guideline trigger value of 1,100 mg L^{-1} for the Hunter River in central New South Wales.

8 Conclusions

Most reports indicate that substantial changes can be expected to aquatic ecosystems in south-eastern Australia should salinity increase to over about 1,000 mgL^{-1}. Impacts on sensitive groups, especially some taxa of macro-invertebrates, would be expected at lower salinities. Higher salinities may be experienced in arid and semi-arid regions, but there is too little empirical evidence to give a more definitive threshold. On the basis of ANZECC-ARMCANZ guidelines, the salinity of arid-zone wetlands should not exceed about 600 mg L^{-1} and arid-zone rivers about 3,000 mgL^{-1}. Such inland environments, however, are characterised by highly variable ecological systems it is likely that salinities could well vary greatly outside these ranges.

Almost all the information on salinity impacts refers to effects on structural elements. There is less information available to infer impacts on ecosystem-scale ecological processes and on landscape-scale phenomena. Even so, there are good theoretical reasons for predicting that there will be impacts on ecological processes by salinities in the grams-per-litre range.

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Macroinvertebrate Drift and Salinity Tolerances

Appendix C

WATER MANAGEMENT OPTIONS FOR ASSOCIATED WATER AT THE FAIRVIEW CSG FIELD, QUEENSLAND

A LITERATURE REVIEW OF MACROINVERTEBRATE DRIFT AND AN ANALYSIS OF MACROINVERTEBRATE DISTRIBUTION DATA IN THE FITZROY & CONDAMINE-BALONNE RIVER SYSTEMS

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1. INTRODUCTION

This report was prepared in response to a request from URS Australia Pty Ltd (URS) to undertake a review of literature and data in relation to water management options being examined by Santos Ltd (Santos). Santos requires a qualitative investigation into possible environmental impacts of production water from drilling activities at its gas fields near Roma, Queensland.

This report forms a small part of the larger investigation and focuses on ecological behaviour and requirements of stream macroinvertebrate fauna that are likely to be encountered in the region of the gas fields. Specific deliverables of the work include:

1. Undertake a literature review of macroinvertebrate drift due to salinity, temperature, turbidity and flow (i.e. low flows versus moderate flows). The focus of the review where possible should be key triggers for drift and catastrophic drift in ephemeral streams during non event times (i.e. dry season). As part of this review a tabularised summary of information reviewed should be provided;

2. Undertake analysis of existing river health monitoring data (DNRW data, provided in an electronic format) to identify whether different macroinvertebrate species are found at different sites and whether this is related to salinity, temperature, turbidity and flow;

3. Examine the approach undertaken by Webb and Hart (2004) for assessing environmental risks from salinity increases in the Goulburn-Broken catchment with particular focus on how the consequence data was built and employed. Using the approach of Webb and Hart (2004), undertake a review of the Bailey and Boon (2002) salinity sensitivity database to construct macroinvertebrate sensitivity distributions using data from relevant DNRW databases. The information compiled needs to be relevant to the area under investigation (i.e. ephemeral streams in Queensland). The output needs to be formatted for use as consequence data in an ecological risk assessment. Where possible, construct sensitivity distributions of

    a. Relevant macroinvertebrate salinity tolerances (to be predominantly informed by the Bailey and Boon database)
    b. Relevant macroinvertebrate temperature tolerances (to be predominantly informed by the Bailey and Boon database) and
    c. Macroinvertebrate species likely to be present in ephemeral streams and non ephemeral streams. This may be informed by a multivariate analysis of macroinvertebrates in ephemeral versus non ephemeral streams to determine if there are any differences in assemblages between the two stream types.

2. APPROACH

Each of the three deliverables outlined above were approached separately with results synthesised in the Discussion and Summary section.

Each deliverable was approached with an understanding of the environmental setting that led to the investigation. In particular, the following possibilities were considered:

- potential influences of long-term discharges to streams that are naturally episodic (i.e. naturally the streams only flow after rainfall events);
- potential influences of differing salinity concentrations at an individual discharge point; and
- potential influences of elevated temperatures across the individual discharges.

During the course of the project, further exploration of some deliverables was identified as not being worthwhile due to a lack of literature, relevant information, or data. In particular, the multivariate analysis (MVA) that was suggested as part of deliverable 3c was not undertaken because:

a. the literature review identified that the taxa in ephemeral streams will typically be derived from the fauna of nearby refugia or other sources of colonists; and

b. we did not have access to data sets from the region that delineated ephemeral streams from non-ephemeral streams.

Some investigations were identified as not being ecologically meaningful and these are identified within the findings for each of the individual deliverables. In contrast, MVA was identified as being a useful tool for Deliverable 2: assessing differences in macroinvertebrate species assemblages across sites and identifying the role of salinity, turbidity, temperature and flow in species distributions. Therefore, a MVA of the DNRW data sets was included in the assessment of these potential influences.

3. DELIVERABLES

3.1. DELIVERABLE 1: LITERATURE REVIEW OF MACROINVERTEBRATE DRIFT

The three intersecting foci of the literature review were:

I. identify key triggers for drift (and catastrophic drift)

II. identify and characterise drift in ephemeral stream systems; and

III. Identify and characterise drift during non-event times in ephemeral streams.

A tabulated summary of the most relevant documents is provided in Appendix 1. The information presented below has been gleaned from these documents.

Definitions of Drift

Aquatic macroinvertebrate drift is a phenomenon in which the invertebrate fauna (referred to as the 'drift fauna') of a flowing stream enters the water column from the benthic zone (stream bed) and drifts with the water current. For an individual, any single drift is typically in the order of a few centimetres to 10s (tens) of metres (Brittain and Eikeland 1988). Several drifting episodes can accumulate to result in substantial distances being covered by individuals or parts of populations. Drifting can be voluntary or accidental (Brittain and Eikeland 1988).

Several different types of drift have been described (Brittain and Eikeland 1988, Ramirez and Pringle 1998). These include:

- **active** drift (whereby the fauna actively enters the flowing water column, usually to avoid predation or to seek more abundant resources);
- **passive** drift (where the fauna are going about their activities, are picked up by the current and transported downstream). Passive drift can be exacerbated by changes in environmental conditions. For example, low dissolved oxygen concentrations may encourage some species to seek locations with higher current velocities (which are typically more aerated);
- **catastrophic** drift, in which large numbers of invertebrates enter the drift in a short period of time. Catastrophic drift is usually flood related but can occur due to a range of triggers such as pesticide inputs, temperature changes and increased suspended sediment concentrations. Catastrophic drift can be active (e.g. avoidance of toxic conditions), or passive (e.g. fauna are picked up by high flow events).

Drift has also been described in terms of its ecological function, with **distributional** drift being described as a method of dispersal within a population or community. Many species have been observed to have a greater probability of drifting during specific stages of their life-cycle, especially very young stages (O'Hop and Wallace 1983; Svendsen et al. 2004).

Drift in the Context of CSG Discharges to Intermittent Streams

There is little information on the drift fauna of subtropical, ephemeral, Australian streams. There is even less information (possibly none) on the influences of salinity, temperature and sediment inputs to drift in these streams. The vast majority of the ecological information provided in the discussion below was derived from international literature on drift (refer Appendix 1) rather than literature focused on Australian, subtropical, ephemeral/episodic stream systems.

Within the context of this project, the source of the drift fauna is an important issue. The invertebrate fauna of a stream system includes the bottom-dwelling fauna ('benthic fauna'). Stream systems also contain a fauna that inhabits the subsurface waters below rivers and their banks ('hyporheic fauna') (Clinton et al. 1996; del Rosario and Resh 2000). The drift community within a stream is not a separate community. Rather, it is a part of the benthic community that enters the drift. The hyporheic fauna do not typically form part of the drift (Clinton et al. 1996).

During prolonged dry spells (that is, periods of ***no*** surface water, rather than cease-to-flow periods with isolated pools), a hyporheic fauna may be supported at, or near, the water table, whereas stream systems without any surface water typically do not support a benthic fauna (del Rosario and Resh 2000). Since the drift fauna is a component of the benthic fauna, a lack of surface water inhibiting existence of a benthic fauna also inhibits a drift fauna.

Therefore, during prolonged dry spells, key triggers for drift and catastrophic drift in ephemeral streams are unlikely to exist as there is as there is unlikely to be a benthic community and to provide any drift fauna. The benthic community in an ephemeral stream during a wet period most likely originates through colonisation from nearby habitats (including refuges), rather than from dormant stages of the fauna (Miller and Golliday 1996; Stanley et al. 1994), although a small percentage of the fauna (primarily zooplankton) may survive dry periods in the egg stage of the life cycle (e.g. URS 2006). The likely absence of a benthic community in dry drainage lines means that an artificial discharge into this habitat is unlikely to have a significant effect on either the benthic community or the drift community.

Many of the streams currently receiving discharges of production water from drilling activities are more episodic (event-driven) rather than ephemeral (seasonal). The study area experiences semi-regular wet seasons. However, the uncertainty of whether any given year will experience a wet season probably means that the area will be somewhere between episodic and ephemeral. Under current conditions, many of the drainage lines have been observed to flow for less than 2 days after rain events. There is unlikely to be substantial colonisation of fauna under these conditions.

Drift in the Context of CSG Discharges to Larger Streams and Refuges

Beyond the episodic systems discussed above, discharges of water with elevated temperature or salinity to larger ephemeral stream systems (generally flowing for a whole season or longer) may also occur, including systems that may normally contain refuge habitat (e.g. pools, wetlands) or even low flows, during dry periods.

<u>*Effects of Flow Changes*</u> The influence of flow changes on invertebrate drift has long been recognised with a substantial number of studies showing that an increase in flow volumes or velocity leads to increased drift (Brittain and Eikeland 1988). Studies of stream flow

influences on macroinvertebrate drift include those that assess effects of reduced flows (e.g. Corrarino and Brusven 1983; Clinton et al. 1996; del Rosario and Resh 2000), increased flows (e.g. Brooker and Hemsworth 1978; O'Hop and Wallace 1983; Matthei et al. 1997) and both increased and decreased flows (e.g. Perry and Perry 1986; Miller and Golladay 1996). Many studies have reported an increase in drift during spates, with some taxa drifting in the initial phases of the spate whereas other taxa drift following the flow peak (Brittain and Eikeland 1988).

In a study examining the effects of flow reduction on invertebrate drift, Corrarino and Brusven (1983) demonstrated that catastrophic drift was created by substantial reductions in stream flows, although the drift response was influenced by season, channel shape and time of day. The effects of the drying phase of an intermittent prairie stream in Oklahoma, USA indicated that the drying phase led to a lower diversity of taxa due to the dry phase preventing flow dependent taxa from completing their life-cycle (Miller and Golladay 1996). The study did not test for drift migration of invertebrates from riffles to pools during the drying period, but noted that this phenomenon has been reported in several studies, including one study in Australia (Boulton and Lake 1992). In contrast, a study of intermittent streams in northern California, USA showed that the invertebrates did not migrate to either pools or the hyporheos to avoid stream drying (del Rosario and Resh 2000).

Results of several studies have been mixed, with authors reporting that the importance of streamflow versus suspended sediment loads are difficult to separate as drift triggers. Some researchers suggest that suspended sediment cannot be separated from flow as the cause of drift (O'Hop and Wallace 1983), while others have used elevated suspended sediment concentrations to mimic high flow events and found drift increased significantly in number of individuals and number of taxa (Doeg and Milledge 1991). One study of an artificial discharge downstream of an impoundment reported a dramatic increase in drift with the increased flow and noted that although this was accompanied by a large increase in the total *load* of suspended sediment, the actual concentration never increased above 6 mgL^{-1} (Brooker and Hemsworth 1978).

A study of drift in an Australian tropical stream (Benson and Pearson 1987) noted that there was a distinctly seasonal drift pattern, with greater drift during the wet (summer) season and that this was related to life-cycles rather than disturbance. The authors suggest that this drift pattern was therefore dispersive, distributing young nymphs to new habitats while conditions were favourable. No flood events occurred during the study or in the few months prior to sampling. Therefore, impacts of event flows could not be assessed.

Svendsen et al. (2000) note: "Unfortunately, it is not possible to conduct meaningful comparisons of drift rates between studies due to lack of detail provided on total discharge <u>patterns</u> and how drift rates are actually quantified and reported" (underline mine). Within the context of this study, the increase in drift associated with increased discharge that is often reported (Brittain and Eikeland 1988) cannot be readily transferred to the stream systems in the study area or to the potential discharge regime of associated water. Assessments of increased flows on invertebrate drift are typically associated with spates and floods, rather than longer-term additions to base flows. An understanding of the influence of potential discharges to stream systems of the study area is more likely to be achieved through a carefully designed experiment than through a literature review. However, fluctuations in flows of large streams in the study area caused by discharges of associated water are likely to be substantially less than the fluctuations that occur naturally.

Effects of Temperature Changes Similar to the effects of flow changes, results of studies on the influence of temperature on the drift of macroinvertebrates are not readily transferred to the specific situation for this study. Temperature is typically discussed in terms of night/day ranges or seasonal differences. Brittain and Eikeland (1988) note that one author had suggested that rising temperatures may be a trigger for species that drift during the daytime, whereas another author had found a negative correlation between rising temperatures and drift. Similarly, Svendsen et al. (2000) state that in general, stream temperature has not been shown to have a primary influence on stream drift and that instead it has been inferred that increases in temperature increase insect activity, which may then increase the risk of accidental drift (see for e.g. Williams 1990, Winterbottom et al. 1997, in Svendsen et al. 2000).

A complicating factor in considering effects of temperature on drift is the multiple confounding with season, photoperiod and flow rates. No studies were found that isolated temperature as an influence on drift. Any further examination of the potential effects of temperature on streams that may receive discharges of associated water from the Fairview gas field, consideration should be given to the extent to which water temperature will decrease after it leaves the discharge pipe, as a function of time, distance, dilution and weather conditions.

Effects of Salinity Changes Salinity has long been known to influence the community structure of stream macroinvertebrates. Metzeling (1993) showed community variation in species compositions at salinities ranging from 51 to 1100 mg/L (approximately 80 to 1800 µS/cm). These ranges have been supported by a study in Queensland (Horrigan et al. 2005) that demonstrated changes in macroinvertebrate communities at similar salinities, with a salinity-based index decreasing rapidly as salinities increased to approximately 800–1000 µS cm^{-1} and thereafter decreasing at a slower rate as salinities further increased.

A study measuring macroinvertebrate drift in relation to salinity recorded increases in drift as a result of adding saline solutions independent of discharge (Wood and Dykes 2002), whereas another study recorded difficulty in distinguishing between the effect of a salinity "spike" on drift and the effects of a specific "trigger" salinity concentration (Silva and Davies

1999). In many ecosystems elevated salinities are likely to occur over long periods, making it difficult to assess the effects of salinity on drift events.

Possible Effects of the Discharges on Refuges The term 'refuge' is used here to describe remnant waterbodies (wetlands, deep pools) associated with intermittent streams. Refuges provide a source of biota for colonisation of more ephemeral waterbodies following the return of wet conditions. The relationships between refuges and macroinvertebrate drift are not clear nor consistent. Some studies have indicated that macroinvertebrates may drift from riffle zones into refuges during the drying phase of a stream (e.g. del Rosario and Resh 2000), whereas others have recorded catastrophic drift in response to flow reductions (Corrarino and Brusven 1983), indicating that the macroinvertebrates were seeking refuge from drying conditions.

A potential impact of the discharge of associated water from the Fairview gas field on refuges would be the possible concentration of salts as water flows into the refuges and subsequently evaporates. The extent to which this occurs naturally is unknown, as is the expected load of salts from the discharges to any refuges and the potential for dilution. Each of these would be worthy of investigation. A report by Simmonds and Bristow (2008) records clear increases in salt concentrations at sites downstream of the associated water discharges. All sites upstream of the discharges meet salinity guidelines whereas nearly all sites downstream fail the salinity guidelines. These results suggest that salinity from the discharges has the potential impact the ecology of the larger flowing streams and refugia that remain during drier periods.

3.2. DELIVERABLE 2: VARIATIONS IN MACROINVERTEBRATE DISTRIBUTIONS

The two primary questions for this deliverable were:

I. Do macroinvertebrate distributions in the region near the Santos gas field operations vary across sampled sites; and
II. if macroinvertebrate distributions do vary across sampled sites, can the distributions be related to salinity, flow (discharge), temperature and/or turbidity?

The Data

River health monitoring data for the region, incorporating aquatic macroinvertebrate fauna and water quality measures, were obtained from data sets supplied by URS and compiled by Queensland DNRW. These data were from the Condamine-Balonne (8 sites) and the Fitzroy River (6 sites) Catchments, which occur in the region of Santos' gas field operations. The data set contained 130 samples from the 14 sites, taken between 1994 and 2004, using Edge (E), Rocky Pool (K), Riffle (R), Sandy Pool (S) and Macrophyte (M) sampling methods (Table 3.1).

As well as presence of the biota, the DNRW data set contained macroinvertebrate indices, derived from the species assemblages and used to provide indications on the ecological condition of streams. The indices used included Invertebrate Richness, PET Richness, SIGNAL Score, and AusRivAS O/E. Invertebrate Richness is a simply the number of invertebrate families found at a site (with a higher number of families indicating a 'healthier' stream), while PET Richness sums the number of families belonging the ecologically sensitive orders of Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies). The SIGNAL Score is an index that assigns a score based on the tolerance/sensitivity to pollution of the aquatic invertebrate families present and AusRivAS O/E is the Observed (O) number of families at a site, divided by the Expected (E) number of families at the site. The number of Expected families is calculated using a model with measured environmental conditions as the input, whereas the number of Observed families is simply the tally of families collected during sampling. For all of the indices, a higher score indicates a higher standard of stream condition.

Table 3.1: Number of samples by Sample Type used in the MVA

Habitat Code	Habitat Type	Number of Samples
E	Edge	60
K	Rocky pool	13
R	Riffle	17
S	Sandy pool	34
M	Macrophyte	6

Environmental data that were collected with the biological sampling and subsequently used in the numerical analyses were:

- stream discharge;
- electrical conductivity (an indicator of salinity), using the mean of field and laboratory readings for each sampling;
- turbidity ('muddiness'), using laboratory data from each sampling; and
- water temperature, using field data from each sampling.

Methods for Numerical Analyses I: Univariate Analysis

The biological indices (SIGNAL, Richness, PET Richness and AusRivAS) were all subjected to univariate analyses (Generalized Linear Model). The model was formulated as an additive model, without any interaction terms. The dependent variables were normally distributed sufficiently for them to be analysed in their raw form. The independent variables had to be transformed as follows:

1. EC – used Log(EC) to normalise the distribution
2. Discharge – changed to bivariate (YES/NO) data, as there were a large proportion of zero flows (so no transform could help these). Included as a categorical variable.
3. Turbidity – used Log(Turbidity) to normalise the distribution
4. Temperature – not transformed.

To be included in the analysis, all environmental data had to be present for a record. If one or more of the four variables (EC, Discharge, Turbidity, Temperature) was missing, then the record was excluded.

Methods for Numerical Analyses II: Multivariate Analysis

Multivariate analyses were undertaken on the biological and environmental data using the PRIMER computer package (Clarke and Warwick 1994). Site ordinations were undertaken using the multidimensional scaling (MDS) program in PRIMER. Relationships between the sites' community composition and environmental variables were subsequently analysed using PRIMER's BIOENV procedure (Clarke and Ainsworth 1993), which exhaustively searches for the combination of environmental variables that that produces a similarity matrix most correlated to the similarity matrix of sites based on the biota. In effect, this procedure carries out tests of the relationship between community composition and environmental variables - comparable to multiple regressions. BIOENV examines all possible combinations of variables, from each environmental variable separately through to all at the same time. The output provides combinations of the environmental variables that are effective in explaining the distributions of the macroinvertebrate biota.

Multivariate analyses were undertaken with habitats with sufficient sample sizes (E and S, refer Table 3.1). The BIOENV procedure requires the environmental data to be normally distributed. Turbidity and EC data were log-transformed to normality. Temperature data were normally distributed. Discharge data were fourth root transformed; this resulted in a bimodal distribution with a one peak at zero and then a normal 'sub-distribution' away from zero.

Two BIOENV analyses were carried out for each of the E and S habitats (Table 3.1). One used all four environmental variables, and the other excluded discharge. This was done for two reasons.

1. Discharge data are missing for more records than the other environmental variables, leading to a larger proportion of the biological data being excluded from the analysis (as a missing data point leads to elimination of the sample within the analysis); and
2. The discharge data was not normally distributed and so there may be some effect on the environmental data matrix.

Results and Findings of the Numerical Analyses

The results of the numerical analyses indicate that:

I. The macroinvertebrate assemblages do vary between sites, although the differences are quite small; and

II. There are no major correlations of assemblages with the environmental variables. The greatest correlation appears to be with EC, although this is weak and is not reflected in the results of the univariate analyses.

Univariate Analyses: The p values associated with the effects for each habitat and independent variable are displayed in Table 3.2. Sample sizes are also shown. Note that the sample size in Table 3.2 differs from the numbers of samples per habitat type in Table 3.1 as some samples were removed from the analysis due to missing data (generally discharge data).

Table 3.2: Number of samples by Sample Type used in the MVA.

Significance at p= 0.01 (with rounding) are indicated in bold

Index	**Habitat Code**	**N**	**p values for test of Independent Variables**			
			log EC	**Flow (Y/N?)**	**log Turb**	**Temp**
SIGNAL	E	45	0.145	0.374	0.226	0.042
	K	11	0.827	0.922	0.73	0.829
	R	16	0.872	0.122	0.174	0.107
	S	22	0.178	0.525	0.837	0.72
Richness	E	45	0.287	0.49	0.075	0.05
	K	11	0.175	**0.012**	**0.014**	0.031
	R	16	0.225	0.95	0.058	0.422
	S	22	0.824	0.463	0.631	0.301
PET	E	45	0.65	0.474	0.018	0.053
	K	11	0.027	**0.001**	**0.004**	0.038
	R	16	0.11	0.347	0.015	0.123
	S	22	0.558	0.692	0.499	0.918
AusRivAS	E	45	0.637	0.043	0.704	0.031
	K	11	0.459	0.035	0.369	0.149
	R	16	0.87	0.596	0.507	0.085
	S	22	0.73	0.703	0.471	0.755

Habitat "M" had also been sampled (N=5), but with 4 independent variables in the model, this results in 0 degrees of freedom for the error term, and no ability to test any hypotheses.

Although the analysis resulted in a few significant results, there was not a particularly consistent output among the different indices. Habitat K (Kick) was the only habitat type that gave significant result, these being for the PET and Richness indices, in relation to Flow and Turbidity influences. This habitat type had the smallest number of samples, which reduces confidence in the outputs.

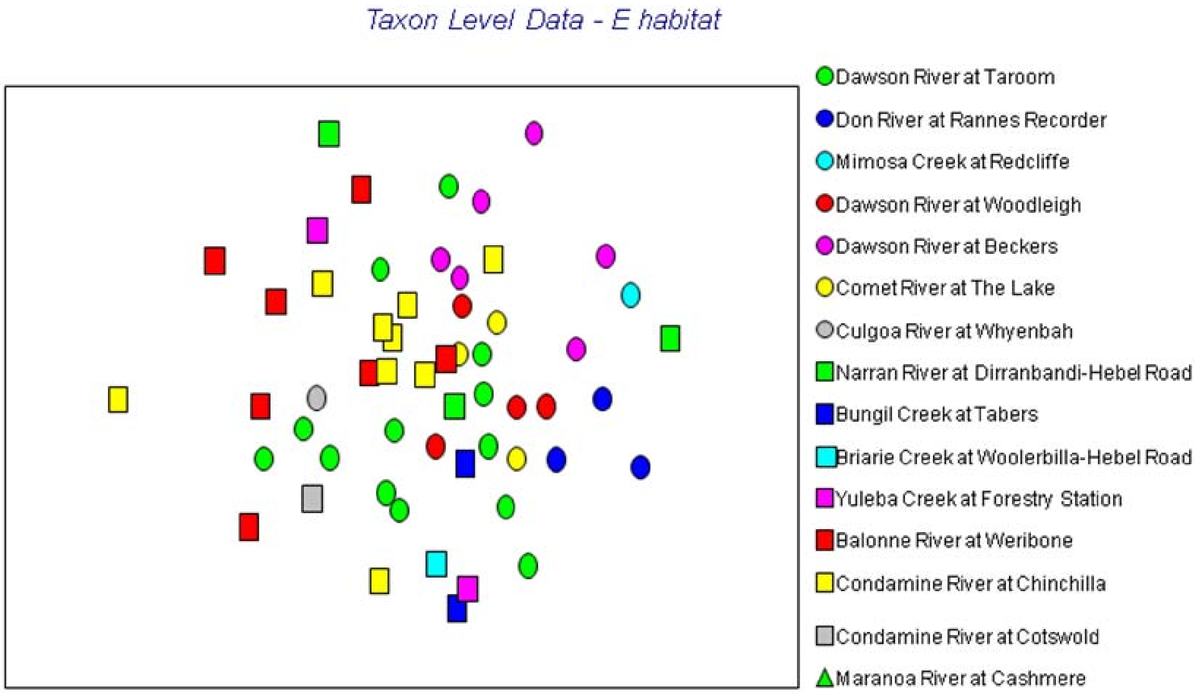
Multivariate Analyses: The MDS plots (Figure 1) show some slight grouping of sites (based on macroinvertebrate assemblages), although the grouping is weak. The plots are 2-dimensional representations of distributions in multidimensional space. Fitting the distributions into 2 dimensions results in distortions to the display that are measured as 'stress'. Generally speaking, a stress value of > 0.20 means that 'caution' should be used in interpreting the plots. Values of 0.3 to 0.4 mean that the plot is not meaningful. Stress for the plots in Figure 1 was quite high (0.26 and 0.21), which means that the 2-dimensional representation of the multivariate data is acceptable but should be used for general interpretations only.

"Bubble plots" were also produced for each of the environmental variables (Appendix 2). A bubble plot scales the symbol by the value of the environmental variable. A gradient of increasing symbol size from one side of the plot to the other would indicate a correlation of the macroinvertebrate assemblage with that environmental variable. The title for each plot shows what variable was used to scale the bubbles. The largest bubble corresponds to the highest value in the data set, and the smallest – the smallest. The bubble plots indicate no effects for any of the environmental variables, except a possible slight effect of EC in the Edge habitat data, but not EC for Sweep habitat.

The results of the BIOENV analyses are displayed below (Tables 3.3 and 3.4). The results are displayed as combinations of environmental variables that provide the best explanation of the patterns produced by the multivariate analyses of macroinvertebrate assemblages.

Table 3.3: Best results for Edge habitat from the BIOENV analyses

Number of Variables used	Correlations (Spearmans rho)	Variables used
3	0.125	LogEC; Fourth Root Discharge; LogTurbidity
4	0.106	All
2	0.103	Fourth Root Discharge; LogTurbidity
2	0.101	LogEC; Fourth Root Discharge



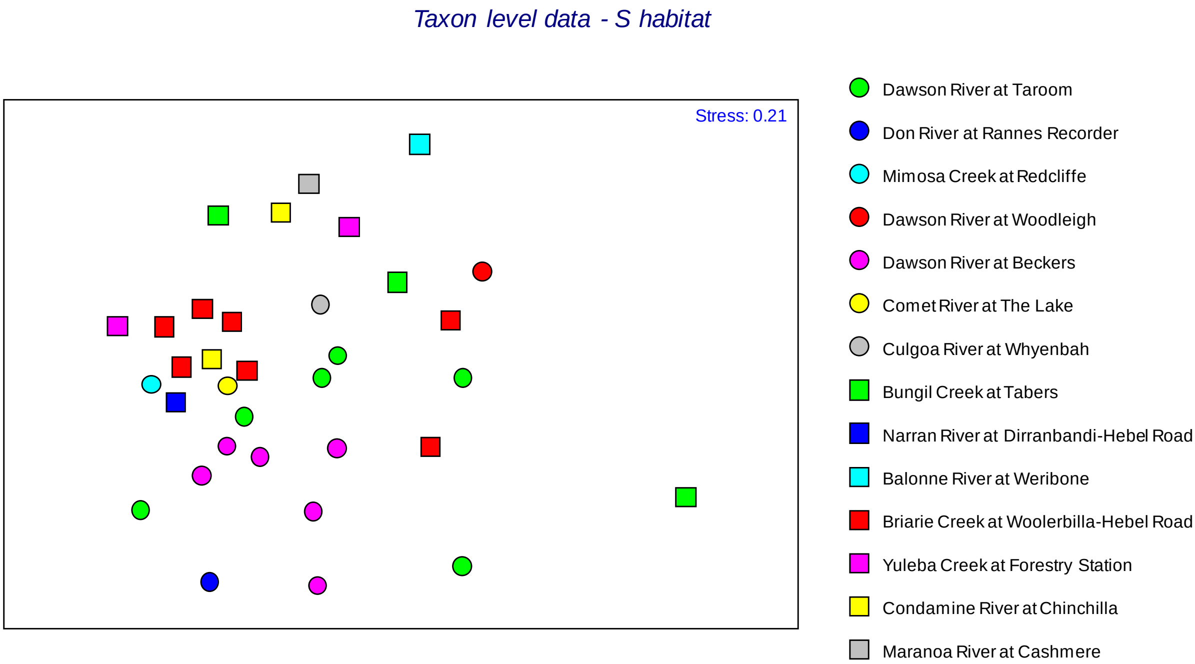


Figure 1: Species-based site ordination for Edge (E) and Sandy Pool (S) habitats

Table 3.4: Sweep habitat *Best results*

Number of Variables used	Correlations (Spearmans rho)	Variables used
1	0.194	LogEC
2	0.110	LogEC; Fourth Root Discharge

The results reveal poor correlations between the macroinvertebrate data and the environmental variables, with no correlation reaching even 0.2. As many of the discharge data points were missing, this led to several samples being omitted from the analyses. Therefore, the analyses were run a second time, without the discharge data included. The results were very similar, with slightly lower correlations being obtained and are therefore not displayed. In summary, the BIOENV analyses did not produce any strong correlations between the environmental variables and the biological data. Of the variables, logEC appears to be the one that appears near the top of the best solutions most of the time, albeit weakly.

3.3. DELIVERABLE 3: COMPILATION OF SALINITY AND TEMPERATURE TOLERANCES OF REGIONAL INVERTEBRATE FAUNA

Salinity Tolerances

Lists of representative aquatic macroinvertebrate fauna for the region were obtained from the data sets supplied by URS and compiled by Queensland DNRW. These data were from the Condamine-Balonne and the Fitzroy River Catchments, which occur in the region of Santos' gas field operations. The data were gathered by DNRW in accordance with the AUSRIVAS sampling and processing methods (e.g. DNRM 2001), which requires identification of most taxa to family level. Higher level (i.e. less detailed) identifications are accepted for groups that are difficult to identify.

The combined Fitzroy and Condamine-Balonne data sets contained a total of 83 families. One of these families – Chironomidae – was divided into three subfamilies (Table 3.5).

The families recorded in the DNRW data sets were compared against aquatic salinity tolerances derived by Webb and Hart (2004), using records from a salinity tolerance database produced by Bailey and Boon (2002). The approach undertaken in the allocation of salinity tolerances to aquatic fauna by Webb and Hart (2004) involved the following steps:

1. Use of field-based data only (i.e. exclusion of laboratory-derived tolerance data)
2. Entries in the database that had not been identified at least to family level were discarded

3. Family was added to entries that had been identified to genus or species level but had not had family allocated

4. Family-level estimates of EC tolerance were derived using the geometric mean of the maximum EC estimates for all species genus and family entries that fell within that particular family

A more detailed description of the process for obtaining species-level and genus-level maxima can be found in Webb and Hart (2004). The individual family-level salinity tolerances used by Webb and Hart (2004) were not presented in their report, and were provided for this project by Webb (unpublished data). The majority of the families identified in the DNRW data set had been assigned family-level salinity tolerances in the Webb salinity tolerances data set. These are presented in Table 3.5, along with the highest EC measures at which each family was recorded in the Queensland DNRW data sets. Table 3.5 shows that many of the families were found at ECs that exceeded their assigned EC tolerance levels. In their report, Webb and Hart (2004) identified several uncertainties that arise from using salinity tolerance data derived by examining unrelated studies of biota and compiling associated salinity measures. One particularly pertinent to this study is that using these outputs to determine salinity/EC maxima for selected taxa does not mean that all stages of the taxa are able to tolerate the salinity/EC maxima. For example, finding an adult of an insect family at a site with an EC of 2000 µS cm^{-1} does not guarantee that eggs or larvae from that family would be able to withstand 2000 µS cm^{-1}. Another issue raised by Webb and Hart is duration, whereby spot measures of salinity/EC associated with the presence of a particular taxon, does not provide evidence that the taxon can withstand the same measures for a prolonged period. The use of geometric means by Webb and Hart was an environmentally conservative approach, designed to account for these uncertainties. This conservative approach may also result in some of the families being allocated tolerances within the boundaries of their natural salinity ranges.

A further issue with the use of the data in this study is the use of family data. The macroinvertebrates sampled for the DNRW program were identified to family level, which is the standard approach for Australia-wide for the AusRivAS program. However, this level of identification misses detailed information that may be obtained from genus and species-level identifications, particularly in the examination of individual taxon responses to single issues/impacts (i.e. salinity). Within many of the families identified in the DNRW data, there may be a large number of species with varying tolerances to salinity concentrations. Again the use of geometric means by Webb and Hart (and in this study) provides an environmentally conservative approach to the issues arising from this uncertainty.

Table 3.5: EC tolerance levels for families found in the DNRW data sets from Condamine-Balonne and Fitzroy River data sets, with accompanying highest EC measure recorded against each family in the data sets (ND = No data)

Family	EC Tolerance Levels	Highest EC (Qld data)
Aeshnidae	1288	1249
Ancylidae	978	345
Atriplectidae	ND	265
Atyidae	8100	1848
Baetidae	1148	1848
Belostomatidae	5916	340
Bithyniidae	1455	206
Caenidae	1368	1848
Calamoceratidae	3900	1848
Carabidae	ND	342
Chaoboridae	876	230
Ceratopogonidae	5954	1848
Chironomidae (Tanypodinae)	1850	1848
Chironomidae (Orthocladiinae)	1081	378
Chironomidae (Chironominae)	3716	1848
Chrysomelidae	ND	616
Clavidae	8568	337
Coenagrionidae	4631	1848
Conoesucidae	1085	273
Corallanidae	ND	378
Corbiculidae	13800	1848
Corduliidae	163	1848
Corixidae	7017	1848
Culicidae	2805	1516
Curculionidae	5916	1848
Dolichopodidae	3428	700
Dugesiidae	ND	1848
Dytiscidae	5424	1848
Ecnomidae	3049	1516
Elmidae	700	700
Empididae	2024	727
Ephydridae	10729	337
Erpobdellidae	ND	273
Gerridae	3200	700
Glossiphoniidae	683	1848
Glossosomatidae	1809	265
Gomphidae	720	1848
Gyrinidae	2738	1516
Haliplidae	381	1848
Hebridae	1108	378

Heteroceridae	ND	145
Hydraenidae	4215	1848
Hydridae	947	265
Hydrobiidae	6809	335
Hydrobiosidae	1046	345
Hydrometridae	85	378
Hydrophilidae	5287	1848
Hydropsychidae	1387	700
Hydroptilidae	1818	345
Hygrobiidae	3502	238
Hyriidae	ND	296
Isostictidae	ND	1848
Leptoceridae	3153	1848
Leptophlebiidae	678	700
Libellulidae	10199	1848
Lymnaeidae	1152	1516
Mesoveliidae	1901	1516
Naucoridae	5916	1516
Nepidae	1288	1516
Noteridae	ND	1516
Notonectidae	3018	1848
Ochteridae	ND	378
Ornithobdellidae	ND	265
Palaemonidae	24216	1848
Parastacidae	4348	1516
Physidae	5800	1848
Planorbidae	1248	1848
Pleidae	2940	1848
Protoneuridae	163	1516
Psephenidae	887	273
Ptilodactylidae	ND	145
Pyralidae	13550	317
Sciomyzidae	3339	160
Scirtidae	1623	1516
Simuliidae	2688	700
Sisyridae	ND	1848
Sphaeriidae	5243	1516
Staphlinidae	2999	700
Stratiomyidae	3136	313
Tabanidae	ND	700
Temnocephalidae	ND	378
Thiaridae	2940	1848
Tipulidae	1241	700
Veliidae	9039	1516
Viviparidae	1139	1848

Temperature Tolerances

A review of the Bailey and Boon (2002) database revealed that it was solely focused on salinity tolerances – there were no temperature data for tolerance-setting. As noted in the drift review, further examination of the potential effects of temperature on streams that may receive discharges of associated water from the Fairview gas field, should consider the extent to which water temperature will decrease after it leaves the discharge pipe, as a function of time, distance, dilution and weather conditions. This may not require elaborate monitoring: a simple survey of temperature changes with distance from discharge from pipes selected to cover a range of scenarios may be sufficient.

4. DISCUSSION AND SUMMARY

The findings of this study suggest that long-term discharges to the drainage lines are unlikely to impact the 'natural' drift fauna within the drainage lines as there are unlikely to be drift communities without the discharges. Further review may be best to consider the possible effects of elevated salinity discharges on the overall stream system (ephemeral and otherwise), rather than a focus on the drift fauna. Further downstream, in larger stream lines and dry season refugia, the discharges have the potential to impact the stream ecosystems through elevated salinities. This could be particularly problematic if saline discharges lead to concentration of salts in refuge pools and wetlands, through evaporation during dry seasons. The potential extent of this problem could only be evaluated with information on discharge quantities, salt concentrations and natural flow volumes in the receiving streams.

The numerical analyses of four selected variables – discharge, salinity, turbidity and temperature – against the macroinvertebrate fauna distributions did not yield any marked influences, although the data did indicate that salinity (EC) may be influencing distributions to some extent. This suggests that within the ranges measured, there was no measurable influence of the other three variables upon invertebrate distributions. However, Simmonds and Bristow (2008) reported on sampling undertaken in the region subsequent to heavy rainfall event, and recorded very high turbidities at many sites, typically associated with light grazing and extensive bank and local catchment erosion. Although beyond the scope of this report, the findings of Simmonds and Bristow (2008) highlight the importance of significant rainfall events on streams and suggest that land management (in the form of restricting stock access to streams and improve management of riparian zones) could be an important stream management consideration within the region generally.

The weak associations between salinity measures and biota suggest that increases to the range in salinity may yield changes in the faunal assemblages at stream sites downstream of the drainage lines receiving saline discharges. This is supported by the salinity tolerance data derived from Bailey and Boon (2002) by Webb and Hart (2004), indicating that many of the families recorded in the DNRW data sets were close to, or exceeding, their salinity tolerance estimates.

Within the context of the greater study, the potential impacts can be divided into two distinct receiving environments: ***minor drainage lines*** with episodic flows, and ***larger streams*** with longer-lasting seasonal flows and potential refugia. The findings of this study suggest that aquatic macroinvertebrates are more likely to be useful in the assessment of ***larger streams*** impacts, rather than the minor drainage lines, because:

- the discharge of production water into the minor drainage lines creates an aquatic invertebrate fauna where none previously existed. It is therefore unsound to assess impacts of the discharges on a fauna that has been created by those discharges;

- although some of the episodic streams receiving the discharges may occasionally build up an invertebrate fauna during a prolonged wet period, the literature suggests the fauna will be opportunistic colonists that will disappear upon stream drying;
- the DNRW data from ***larger streams*** lower in the catchment indicates that the macroinvertebrate fauna in these streams may be influenced by salinity concentrations. A recent report by Simmonds and Bristow (2008) has recorded salinity concentrations above State guidelines at most sites downstream of the discharges. It is therefore important to monitor the potential cumulative effects of the saline discharges in the larger streams and associated refugia. This is aided by the existence of current and recent data from several sites that are potentially affected.
- assessment of impacts from the discharges to the ***minor drainage lines*** should logically be undertaken through monitoring the biota and habitat conditions that were present ***prior*** to the discharges. This would include the vegetation cover within and abutting the drainage lines, as well as the soil/substrate conditions under the vegetation, including soil salinity and water-logging.

5. REFERENCES CITED

This references list contains general documents referred to in this study, as well as references cited in the review of the drift literature. Appendix 1 contains only the references used in the literature review, accompanied by their most salient points for this report.

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This report has been prepared with due diligence and care and is based on the best information reasonably available at the time of publication. Although due care has been taken in the preparation, the author holds no responsibility for any errors or omissions within this report. Any decisions made by other parties based on the information in this report are solely the responsibility of those parties.

APPENDIX 1: TABULATED SUMMARY OF ARTICLES REVIEWED FOR LITERATURE REVIEW ON IMPACTS OF DISCHARGES ON MACROINVERTEBRATE DRIFT IN EPHEMERAL STREAMS DURING NON-EVENT PERIODS

Reference	**Notes**
1. Brittain J.E. & Eikeland T.J. (1988). Invertebrate Drift – A Review, *Hydrobiologia* **166** : 77 -93	General: This paper reviewed the literature on drift, with focus on the 15 years prior to publication. General findings include: • Drift can occur for many reasons (simultaneously), making it difficult to ascribe it to one or a few factors in isolation • Some factors include dispersal, predator avoidance, habitat needs, foraging, accidental uptake while foraging; pollution, high flows, life-cycle triggers • There have been many descriptive papers, adding little to theory of drift • There have been many conflicting findings as to whether or not the invertebrates drift under specific scenarios, making theory-development difficult Project Specific: • Low DO concentrations can result in some fauna moving to areas of greater current exposure, increasing their susceptibility to accidental drift • Reduced seasonal influence in tropics/subtropics – although 'end of rainy season' can have increased drift • One study found peak in winter in subtropics • One study found less drift in a temporary stream than in an adjacent permanent stream

2. Svendsen, C.R., Quinn, T. and Kolbe, D. (2004). *Review of Macroinvertebrate Drift in Lotic Ecosystems.* Final Report, Wildlife Research Program Environmental and Safety Division Seattle City Light, WA, USA	General: This report reviewed the drift literature, providing a more recent account of studies and findings than Brittain and Eikeland (1988). These included: • drift is not a distinct faunal group. It is derived from the benthic community and is that subset that participates in drifting (whether voluntarily or otherwise) • abiotic influences on drift include light (generally a peak in dusk/evening drift density), current (positive association with drift), oxygen (lower oxygen leads to some spp. seeking areas with higher velocity and accidentally entering the drift), season (season with greatest biomass production of benthos = season with greatest drift) • biotic factors influencing drift include predation (invertebrate predators tend to increase drift, especially at night, when they are most active. Fish predators that feed from the water column tend to reduce drift, especially during the day, when they are most effective) • sediment movement and pollution can cause catastrophic drift Project Specific: • for there to be a drift fauna there has to be a benthic fauna (as distinct from a hyporheic fauna). So, in an episodic stream, there will not be a drift fauna. • very little info on the impacts of landscape-scale influences on drift, but it could be important (e.g. land clearance, agricultural activities)
3. Sheldon, F and Thoms, M. (2006). Relationships between Flow Variability and Macroinvertebrate Assemblage Composition: Data from Four Australian Dryland Rivers, *River Research and. Applications* **22**: 219–238.	General: This paper examined spp assemblages in Dryland rivers in relation to flow variability. Generally not relevant to a study on drift, although a couple of observation may translate into the current study. Project Specific: • flow variability may be a strong determinant of species assemblage composition in dryland rivers • with time and in the absence of floods that connect waterbodies and instigate a homogenising effect, selective pressures may lead to a depauperate assemblage of tolerant generalists, many of which are vagile and show little habitat specificity

4. Anholt, B. (1995). Density Dependence Resolves the Stream Drift Paradox, *Ecology* **76:**2235-2239	General: This paper explores the concept of density dependence (i.e. that drift occurs as a result of excess production). Uses modelling to explore influence of density versus 'upstream flight for ovipositing + downstream drift = population maintenance'. Not really relevant to this study, more an exploration of the ecological theories of drift in terms of population dynamics Project Specific: • concept of drift as a function of invertebrate production (i.e. reduced drift if populations are low?)
5. Matthei, C., Uehlinger, U. and Frutiger, A. (1997). Response of benthic invertebrates to natural versus experimental disturbance in a Swiss prealpine river. *Freshwater Biology* **37**:61-77.	General: This paper compared the impacts of a natural flood versus an experimental disturbance on the invertebrate fauna (including drift). Not overly relevant to this study – focus was more on invert population in general, rather than causes of drift. Project Specific: • drift was most important form of recolonisation after flood and artificial disturbance • drift rates did not necessarily increase post flood, but remained proportional to benthic densities. This was still enough for rapid recolonisation • probable that egg "seed bank" provided an important source for colonisation, through entering the drift after hatching (i.e. part of seasonal cycle rather than 'waiting' in storage for any flood cues) •
6. Brooker, M. and Hemsworth R. (1978). The effect of the release of an artificial discharge of water on invertebrate drift in the R. Wye, Wales, *Hydrobiologia* **59**:155-163.	General: This paper used a BACI approach, with one control and one impact site, during a release of water from a reservoir. The authors found a substantial increase in invertebrate drift (total numbers and density) as a result of the increased flows, noting that Temp., D.O. and TSS concentrations did not change significantly during the discharge. Project Specific: • substantial increase in drift even though stage height only increased from approx 70 to 80 cm • increased flow $\Rightarrow$ increased drift

7. Brewin, P. and Ormerod, S. (1994). Macroinvertebrate drift in streams of the Nepalese Himalaya, *Freshwater Biology* **32**:573-583	General: This paper compared drift in two stream systems, at different altitudes. Taxa in drift was significantly correlated with benthic composition. Drift aperiodic in streams without fish, nocturnal peak in streams with fish. Project Specific: • notes that tropical and subtropical systems poorly studied regarding drift • terrestrial macroinvertebrate drift lowest in treeless catchments • notes positive relationship between drift and temperature (taken from other studies)
8. Ramirez, A. and Pringle, C. (1998). Invertebrate drift and benthic community dynamics in a lowland neotropical stream, Costa Rica, *Hydrobiologia* **386:**19–26.	General: This paper looked at factors influencing drift in a neotropical stream. Noted that much of the drift was larval shrimp, which could be in other tropical/subtropical streams. No seasonal patterns, strongly nocturnal due to predatory fish and omnivorous adult shrimp. Similar to many other papers reviewed here, not directly relevant to current study Project Specific: • lack of studies of drift in tropical regions • no seasonal fluctuation in drift (common in tropics) • drift can be function of resource (eg algal standing crop)
9. Benson, L and Pearson, R. (1987). Drift and upstream movement in Yuccabine Creek, an Australian tropical stream, *Hydrobiologia* **153:**225-239.	General: This paper studied drift in a tropical stream over a 14 month period. Findings include no correlation between drift density and benthic density, or between drift density and water discharge. A strong diel pattern was observed, peaking just after sunset and indicating a strong behavioural component of drift. No catastrophic drift observed (as there were no high flow events during, or just prior to, any sampling). Sampling of upstream movement indicated an average of 8% of drift was compensated by fauna crawling back upstream. Distinct seasonal drift (higher in wet season), suggesting peak drafts associated with life cycles rather than disturbance (i.e. young nymphs drifting to new habitats, just created by rising stream levels) Project Specific: • The authors only 8 studies found that looked at drift in tropical areas • distinctly seasonal tropical stream with wet & dry seasons ⇒ distinct seasonality of drift. Less seasonal tropical streams showed little if any seasonality

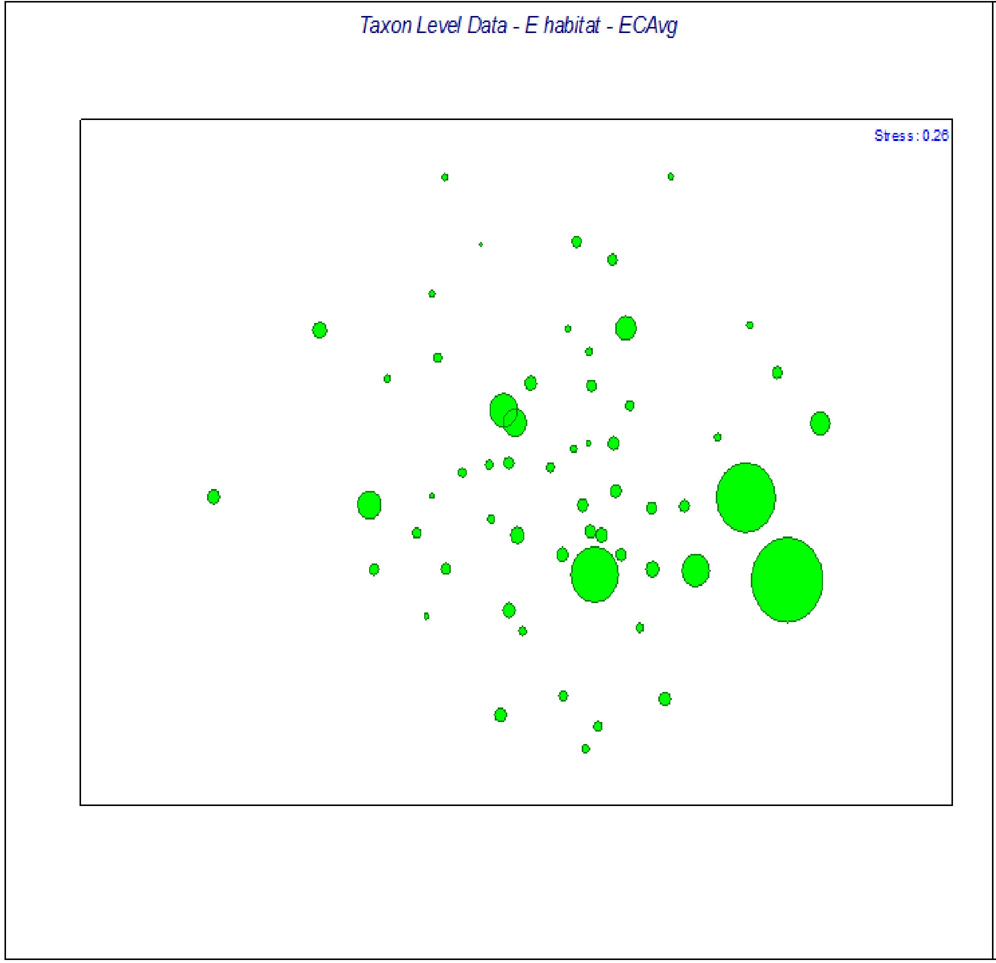
10. Borchardt, D. (1993). Effects of flow and refugia on drift loss of benthic macroinvertebrates: implications for habitat restoration in lowland streams, *Freshwater Biology* **29:**221-227.	General: This paper examined concurrent changes in flow velocity and volumes of woody debris in influencing drift of invertebrates. The major finding was that increased shelter offered by woody debris mitigates against impacts of increased flow velocities (albeit differently for different species). So more woody debris results in less catastrophic drift Project Specific: • If concerned about 'catastrophic drift', need to consider the effect of habitat refugia (coarse woody debris) in mitigating impacts of high flows.
11. Corrarino, C. and Brusven, M. (1983). The Effects of Reduced Stream Discharge on Insect Drift and Stranding of near Shore Insects, *Freshwater Invertebrate Biology*. **2**:88-98.	General: Experimentally reduced stream flows were shown to cause catastrophic drift of invertebrates. Magnitude of drift varied by time of day (greater drift at night), season, channel shape. Mayfly spp drift more at night, Blackfly drifted immediately after flow reductions regardless of time of day Project Specific: • Flow fluctuations may be important in drift.
12. Doeg, T. and Milledge, G. (1991). Effect of experimentally increasing concentrations of suspended sediment on macroinvertebrate drift, *Australian Journal of Marine and Freshwater Research* **42:**519-26.	General: Experimentally increased suspended sediment concentrations to an artificial channel within a stream in Victorian foothills. Substantial increase in drift recorded. Rates of increase varied between taxa but almost all taxa recorded an increase in drift. The increased drift did not deplete the benthic fauna, measured by kick sampling. Species that drifted the most were those known to be sensitive to agricultural disturbances in catchments Project Specific: • increased input of TSS increases drift, even without increased flows

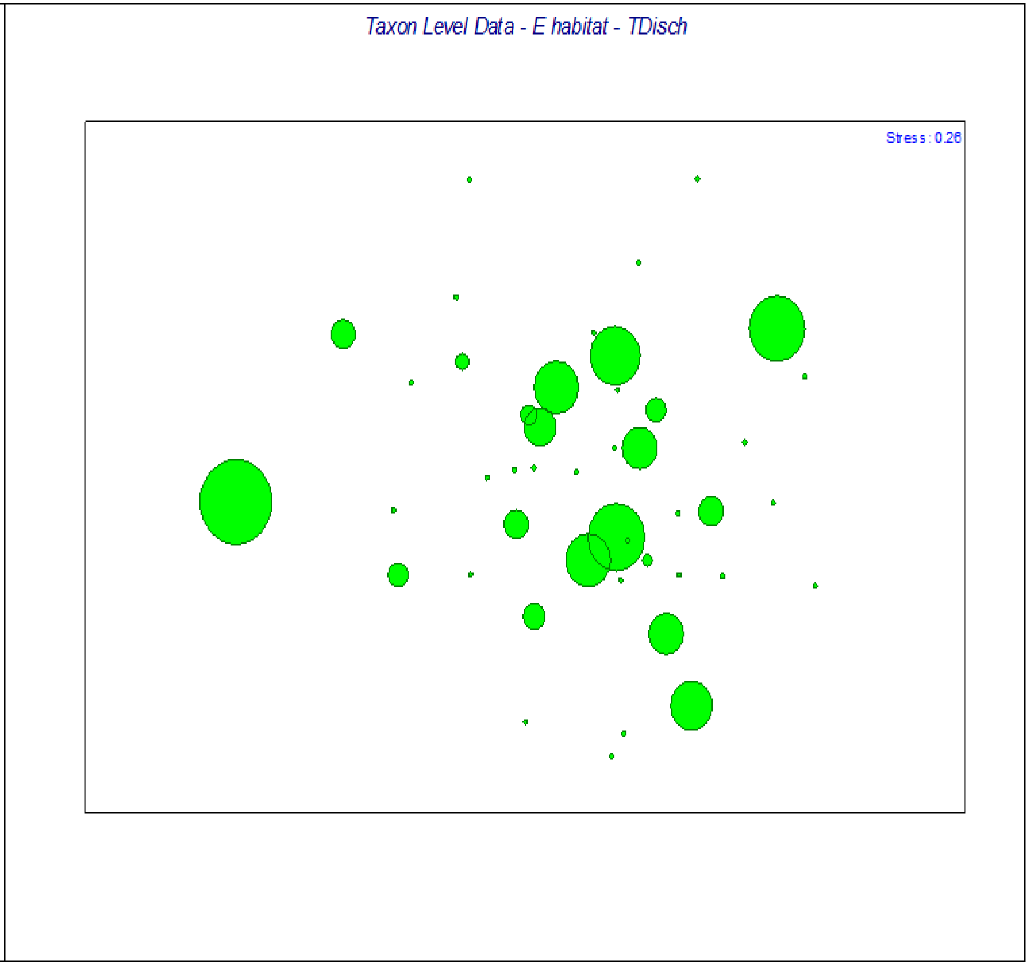
13. Clinton, S., Grimm, N. and Fisher, S. (1996). Response of a hyporheic invertebrate assemblage to drying disturbance in a desert stream, *Journal of the North American Benthological Society* **15:**700-712.	General: Study of a drying ephemeral creek system. Examined biota and water quality in wells as the stream dried. The study found that invertebrate abundances decreased at the near surface and increased in the deeper sediments, indicating that the biota actively migrate down the sediment profile, pursuing the wet areas. Project Specific: • hyporheic fauna is distinct and different from the benthic fauna • benthic fauna did not move into the hyporheic zone • there do not seem to be desiccation-resistant forms in the life-cycles of the hyporheos • seems that the system has benthic biota that get decimated by floods and drought, and a hyporheic biota that survives by migrating up and down with the water table.
14. Miller, A.M. and Golladay, S. (1996). Effects of spates and drying on macroinvertebrate assemblages of an intermittent and a perennial prairie stream, *Journal of the North American Benthological Society* **15:**670-689.	General: Compared two adjacent streams – one intermittent and one perennial. Examined effects of spates and drying periods on biota. Study appeared to be a little confounded by differences in habitat (perennial stream had forested streamside and better substrate for invertebrates). Project Specific: • intermittent stream had lower density and taxa richness, probably due to summer drying reduces recruitment potential • summer drying also prevents flow-dependent taxa from completing life-cycle • data suggested that pool refugia in the intermittent stream were key sources for recolonisation of riffles after dry season
15. Del Rosario, R. and Resh, V. (2000). Invertebrates in intermittent and perennial streams: is the hyporheic zone a refuge from drying? *Journal of the North American Benthological Society* **19:**680-696.	General: This study compared two streams – one intermittent and one perennial (similar to Miller and Golladay 1996, but this time the study had less confounding influences). Benthic and hyporheic faunas were similar between streams, although the intermittent stream had lower densities of animals. The hypothesis being tested was that the hyporheic zone acts as a refuge for benthic fauna during drying of the intermittent stream. Project Specific: • benthic fauna did not migrate to hyporheic zone during drying • benthic invertebrates also did not seem to move to pools as refuges during drying, either

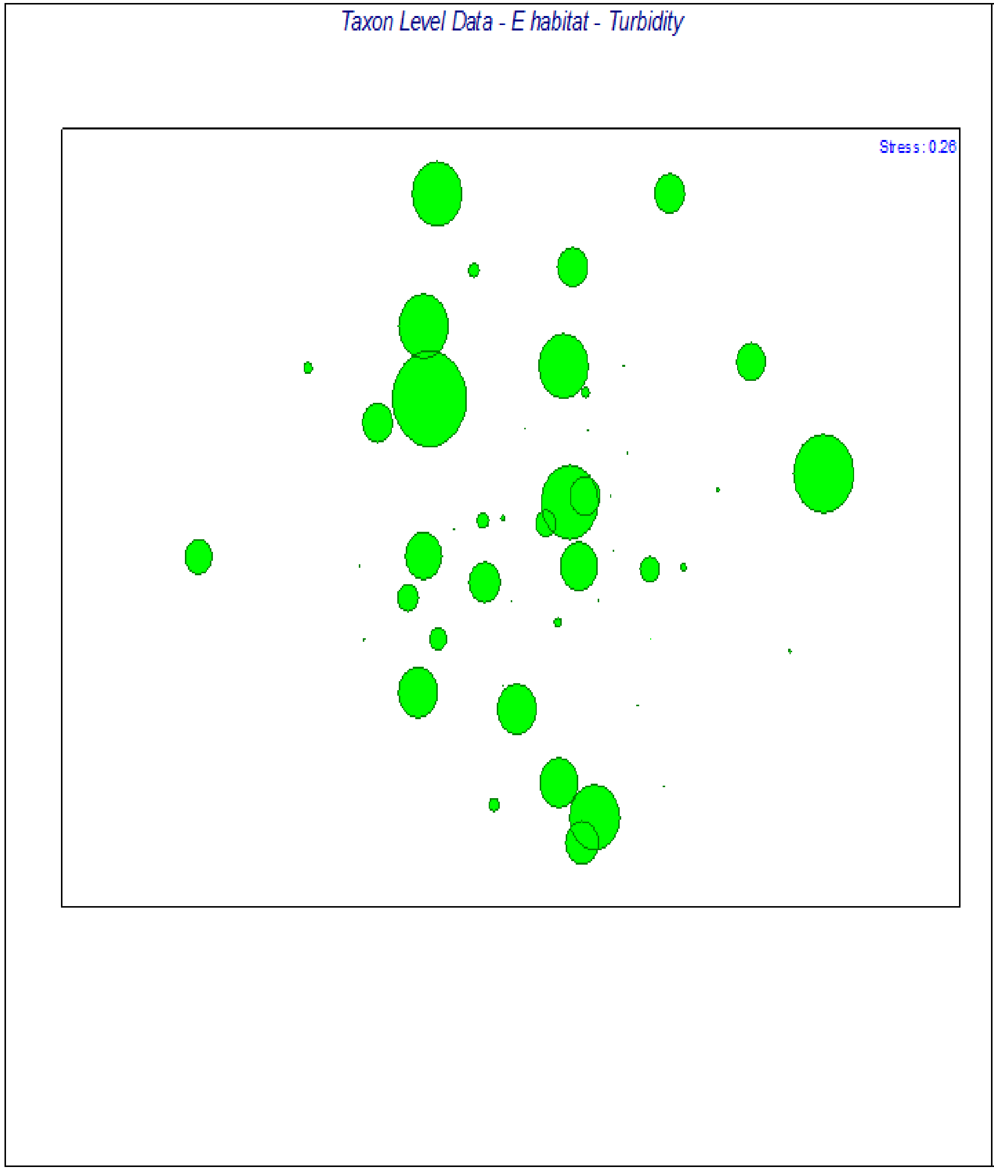
16. O'Hop, J. and Wallace, J.B. (1983). Invertebrate drift, discharge, and sediment relations in a southern Appalachian headwater stream, *Hydrobiologia* **98:**71-84.	General: This study sampled drift, suspended sediments (organic and inorganic) and discharge relations in a headwater stream in SE USA. Some of the daily drift data occasionally correlated with one of the environmental variables, but there didn't appear to be any consistent patterns with any taxa. Project Specific: • noted that storm events increase sediment transport and drift density, with drift density corresponding with organic sediment transport more than inorganic • drift was seasonally influenced and related to growth stages of the community
17. Moser, D. and Minshall, G.W. (1996). Effects of localised disturbance on macroinvertebrate community structure in relation to mode of colonisation and season, *American Midland Naturalist* **135:**92-101.	General: Compared drift versus crawling in terms of importance for colonising benthic areas under different influences (seasons, after disturbance). Sampled by placing tiles on stream bed (for crawling) and at 2 – 5 cm above stream bed (for drift fauna). In spring, greater density but lower diversity of invertebrates on elevated tiles. Colonisation through drift was more important in spring, when temperature was low, discharge was high and algal resources were low. In summer and autumn, when temperature was low, discharge was high and algal resources were abundant, drift and crawlers colonised equally rapidly.
18. Williams, D. (1996). Environmental constraints in temporary fresh waters and their consequences for the insect fauna, *Journal of the North American Benthological Society* **15:**634-650.	General: Intermittent = cyclically refilled; Episodic = unpredictably refilled water body. Length of time between filling seems to be a key determinant of diversity, with longer dry period leading to decreasing diversity of invertebrate fauna. Project Specific: • in some temporary waters, some taxa are derived entirely from recolonisation from nearby waterbodies • when drying occurs, some spp move to where the water is

19. Stanley, E., Buschman, D., Boulton, A., Grimm, N. and Fisher, S. (1994). Invertebrate Resistance and Resilience to Intermittency in a Desert Stream, *American Midland Naturalist* **131:**288-300.	General: Discharge in desert streams is characterised by flash-floods, followed by drying. This study examined two stream reaches in Sonoran desert – one which dries completely and one which typically recedes upstream and only dries partially. After complete drying, few individuals persisted at any site beyond 10 days and only 5 individuals were found two weeks post-drying. Project Specific: • invertebrate persistence chiefly due to recolonisation • "Although numerous surface taxa were collected from the hyporheic zone in a South Australian arid-zone stream, Cooling and Boulton (1993) felt that these individuals were probably passive colonists and unlikely to be an important source of recolonists after rewetting" • "There is virtually no survival after water loss; resilience, rather than resistance, has been favored among Sycamore Creek and other arid land stream benthos"
20. Wallace, J.B., Vegel, D.S. and Cuffney, T.F. (1986). Recovery of a headwater stream from an insecticide-induced community disturbance, *Journal of the North American Benthological Society* **5:**115-126.	General: Examined two streams – one impacted by insecticide, one not impacted. After 2 years, the impacted stream had recovered in terms of trophic structure, but with a different taxonomic structure (i.e. species list). As well as trophic structure, ecological functions (e.g. processing of leaf litter) also returned to pre-impact levels. This shows that although some impacts may cause lasting changes to the species list of a stream, the stream may be resilient in terms of its ecological function and trophic structure. Project Specific: • application of insecticide caused "massive" invertebrate drift • recolonisation could not be caused by drift, as the stream was impacted right up to source, therefore most likely recolonised from adult flight

APPENDIX 2: Bubble Plots of Environmental variables overlain on sites



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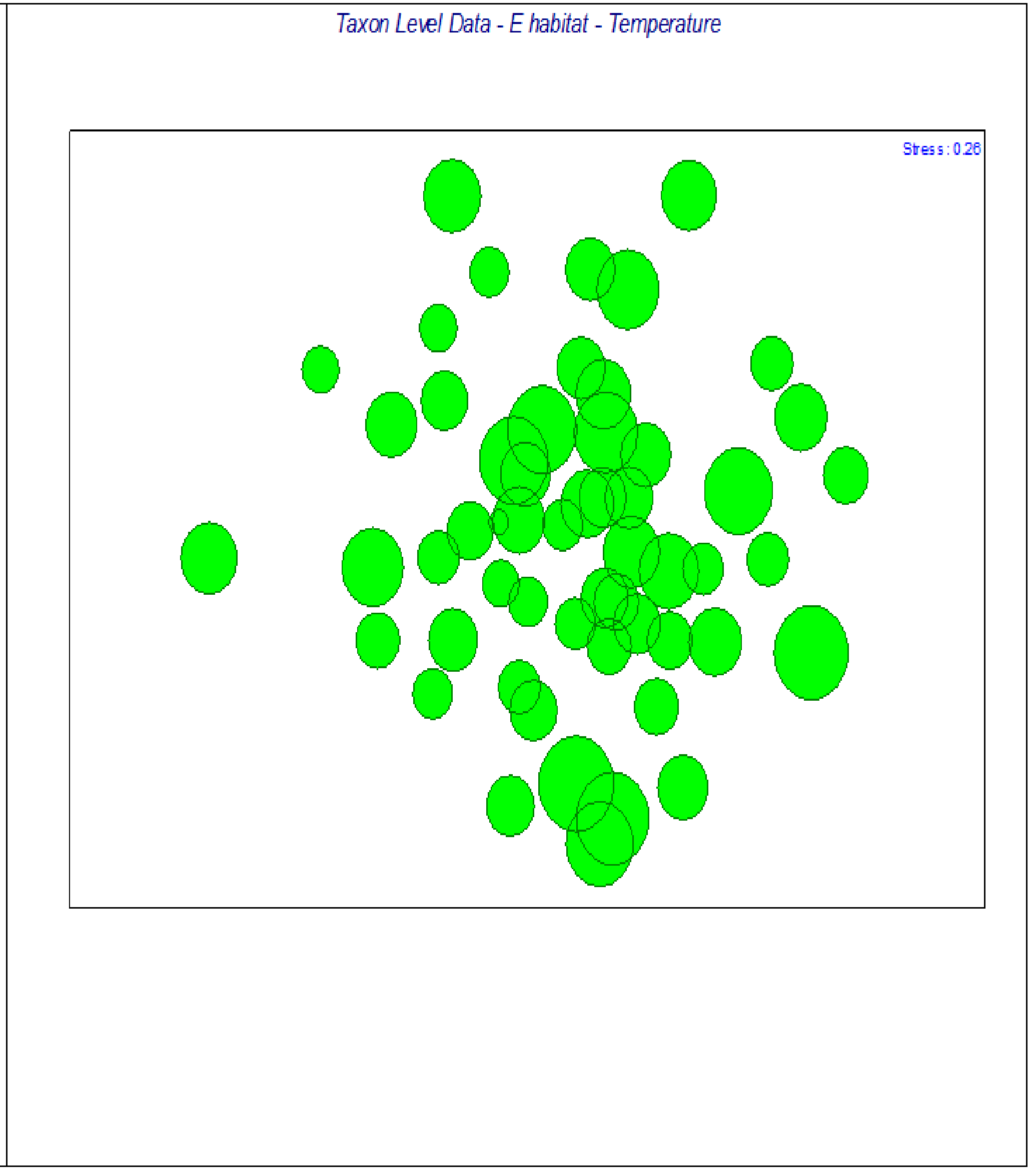
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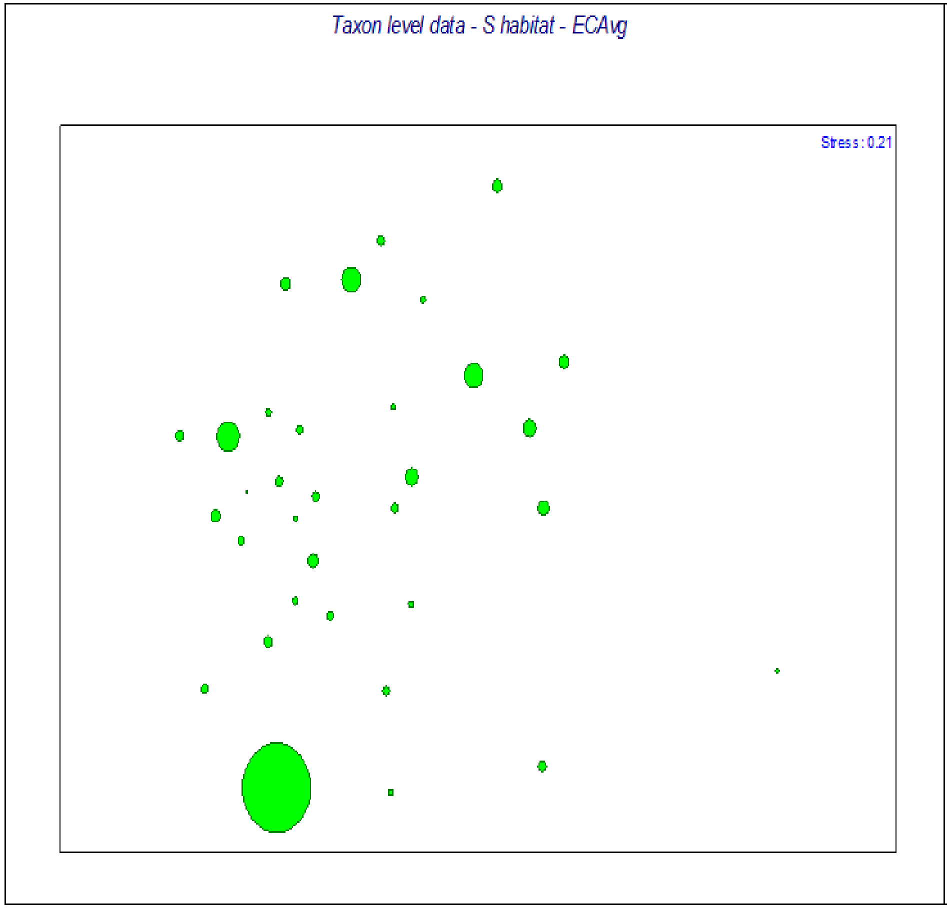

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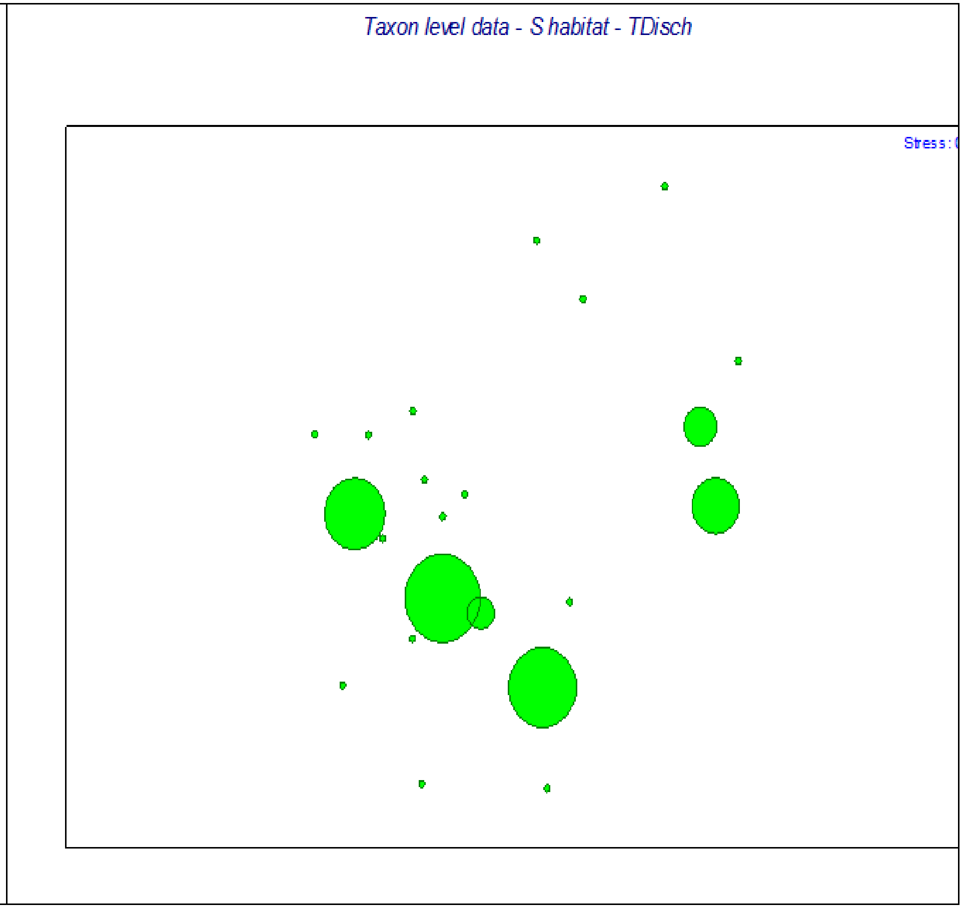
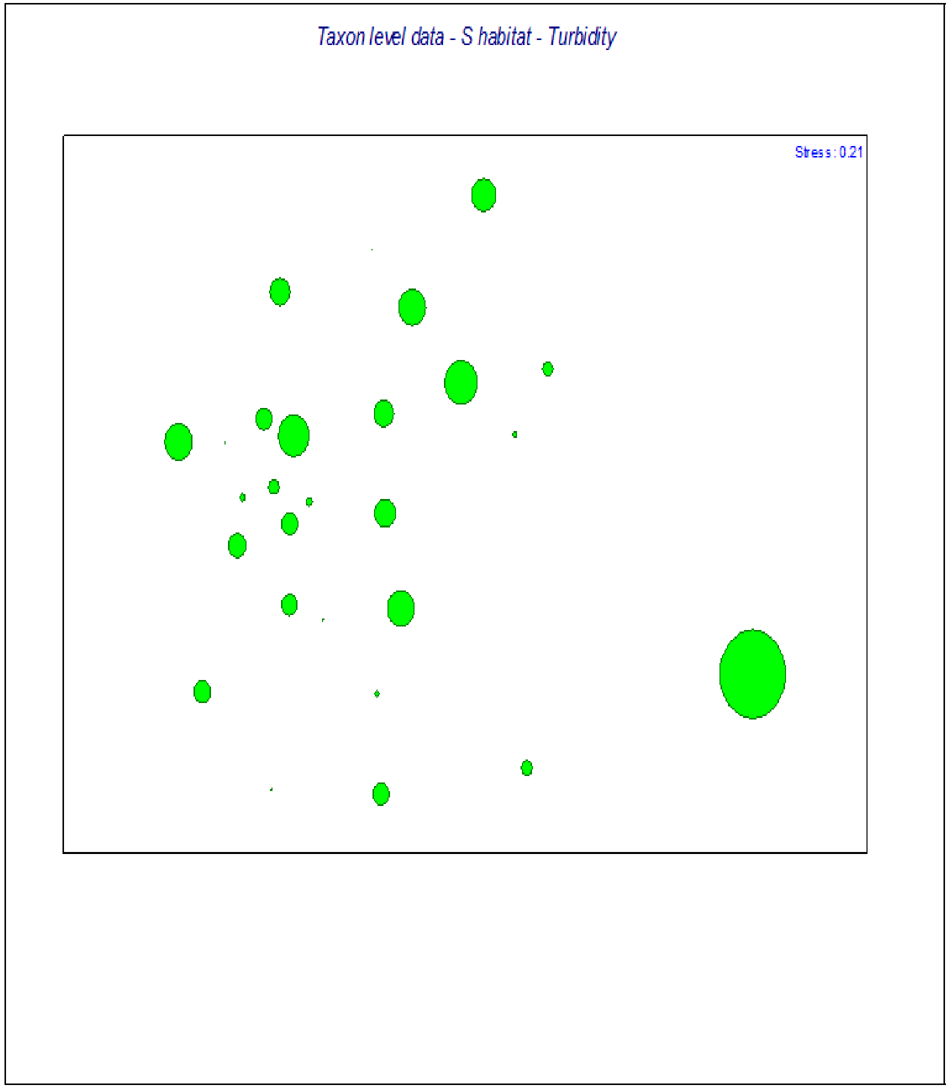
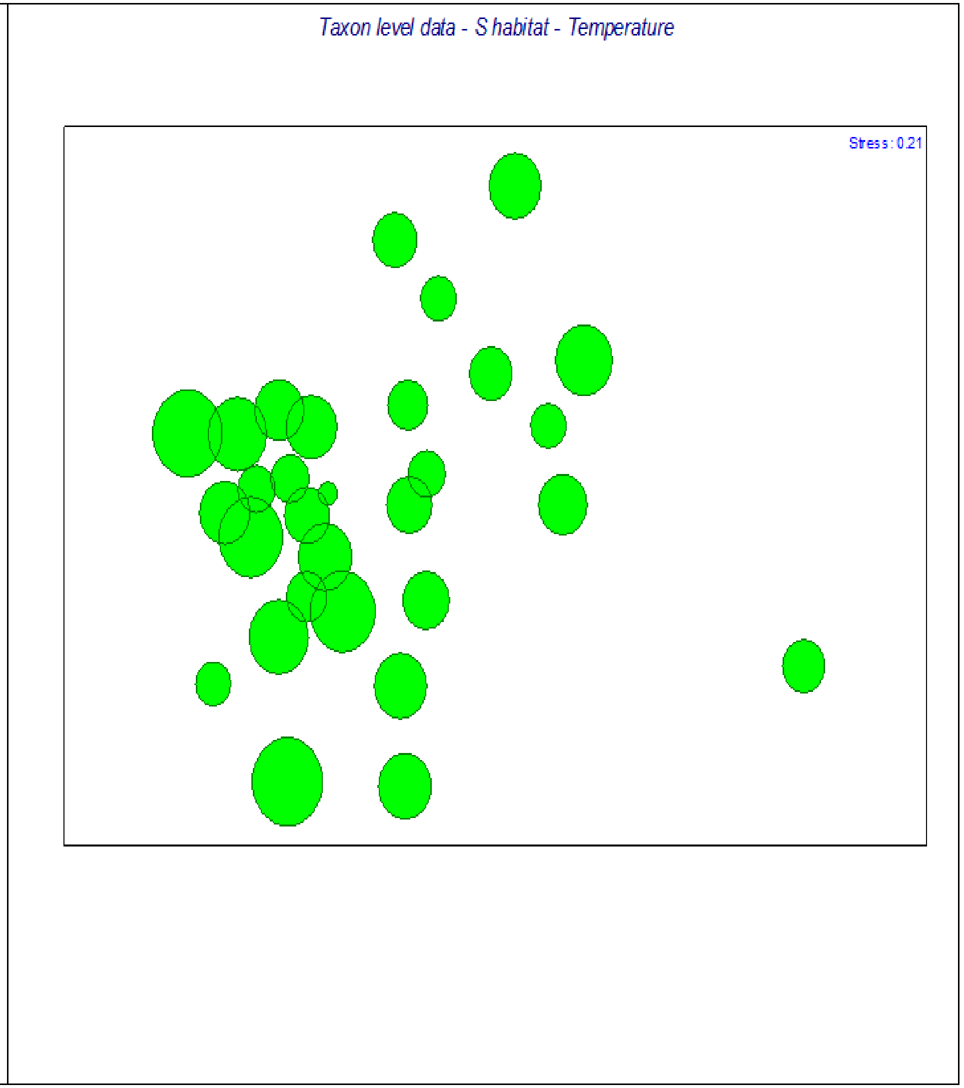


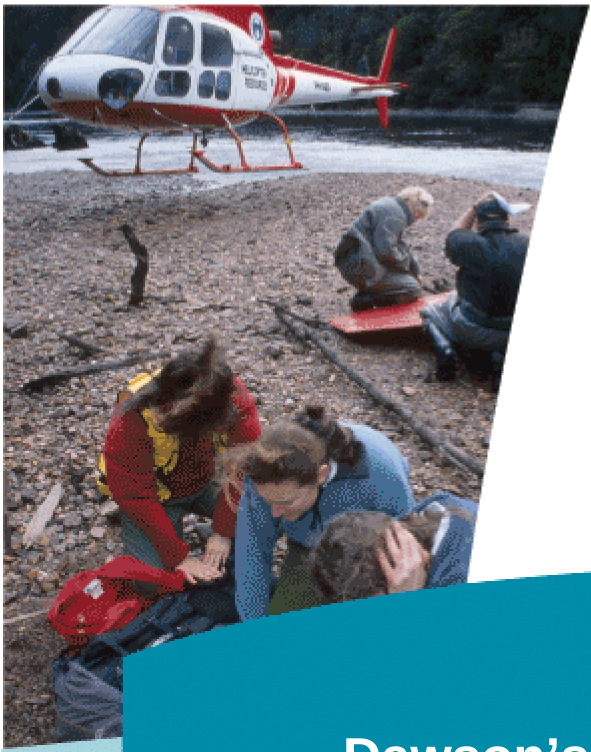
Taxon level data - S habitat - TDisch

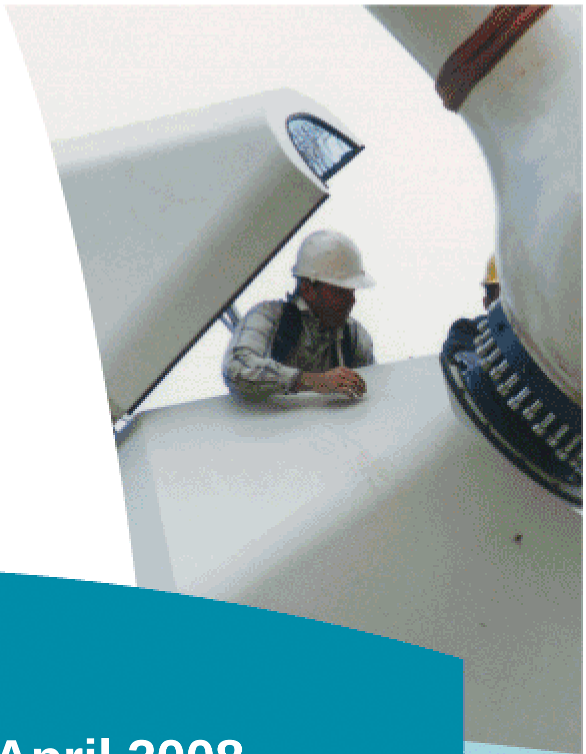

Taxon level data - S habitat - Turbidity
Stress: 0.21


Taxon level data - S habitat - Temperature
Stress: 0.21

Survey of Dawson River Springs

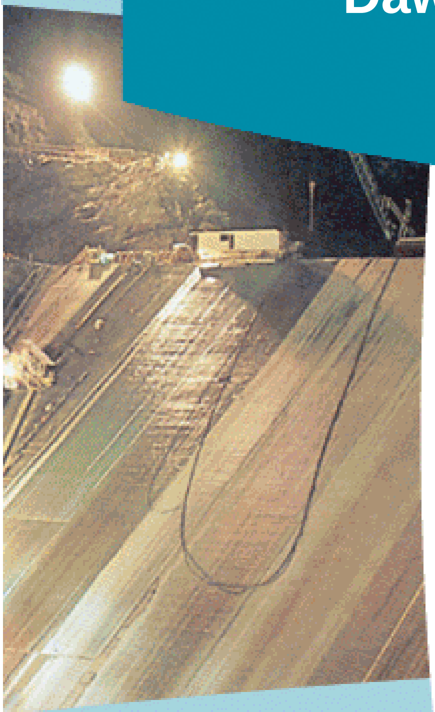
Appendix D

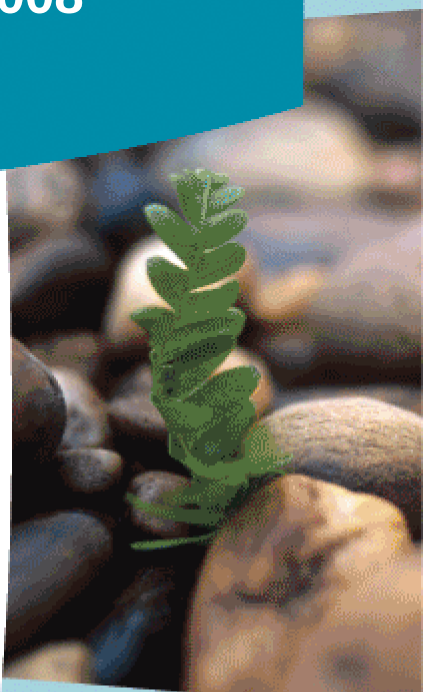




Hydro Tasmania Consulting

Dawson's Creek Survey April 2008





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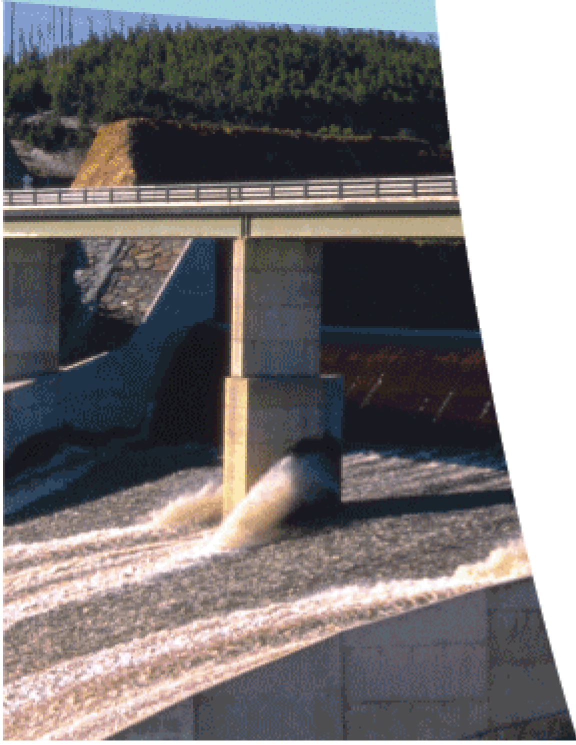

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	Anthony Buckland	Date	4-6-08
Approved for submission	**Approved**	Sign	
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Table of Contents

Introduction

This report summaries work carried out by the Hydro Tasmania Consulting's (HTC) Resource Monitoring & Information personnel in the measurement of flow and water quality within an eighteen kilometre reach of Dawson Creek near Roma Queensland. The River survey was conducted on foot over a three day period from 29th April to 2nd May 2008.

The river survey was requested by URS representative Penny Flukes and was undertaken by Anthony Buckland and Craig Tybell.

Scope & Background

HTC was engaged to conduct flow and water quality measurements on an eighteen kilometre reach of Dawson's Creek beginning at the Yebna Crossing and was terminated at the junction of the Hutton River. Particular reference was made in sampling of springs entering Dawson's Creek.

The scope of the monitoring being:

1. To conduct discharge (flow) measurements on the reach of Dawson's Creek and at the springs encountered;
2. Measure physical water quality parameters of springs and Dawson Creek waters;
3. Sample fifteen springs for further analysis and duplicates for quality assurance testing.
4. Photos taken both upstream and downstream of each site.

Instrumentation and Methodology

Listed below are the Hydrographic field instrumentation used in the determination of flow and physical chemical properties onsite.

- Hydrological Services flow current meter (model Os-B1) meter 40 fan 4 and 30m cloth measurement tape. Volumetric gaugings = 1litre bottle/time
- Hydrolab MS-5 water quality meter (Temperature, pH, Conductivity, Salinity, Turbidity, Dissolved Oxygen (mg/l) & (% saturation).
- GPS - Magellan eXplorist XL`

Field discharge measurements (gaugings)

Flow measurements (Gaugings) were carried out at each site by physically wading the stream with a current meter to determine the velocities, and the corresponding the width and depth at numerous points of the x-section to determine the flow. Velocity measurements were untaken for a 40 second period. Dawson's Creek had long distances between the riffle and runs zones and as is expected in low gradients streams large pondage zones where present. These large zones of pondage however meant that locations for gaugings were limited and therefore were undertaken where possible.

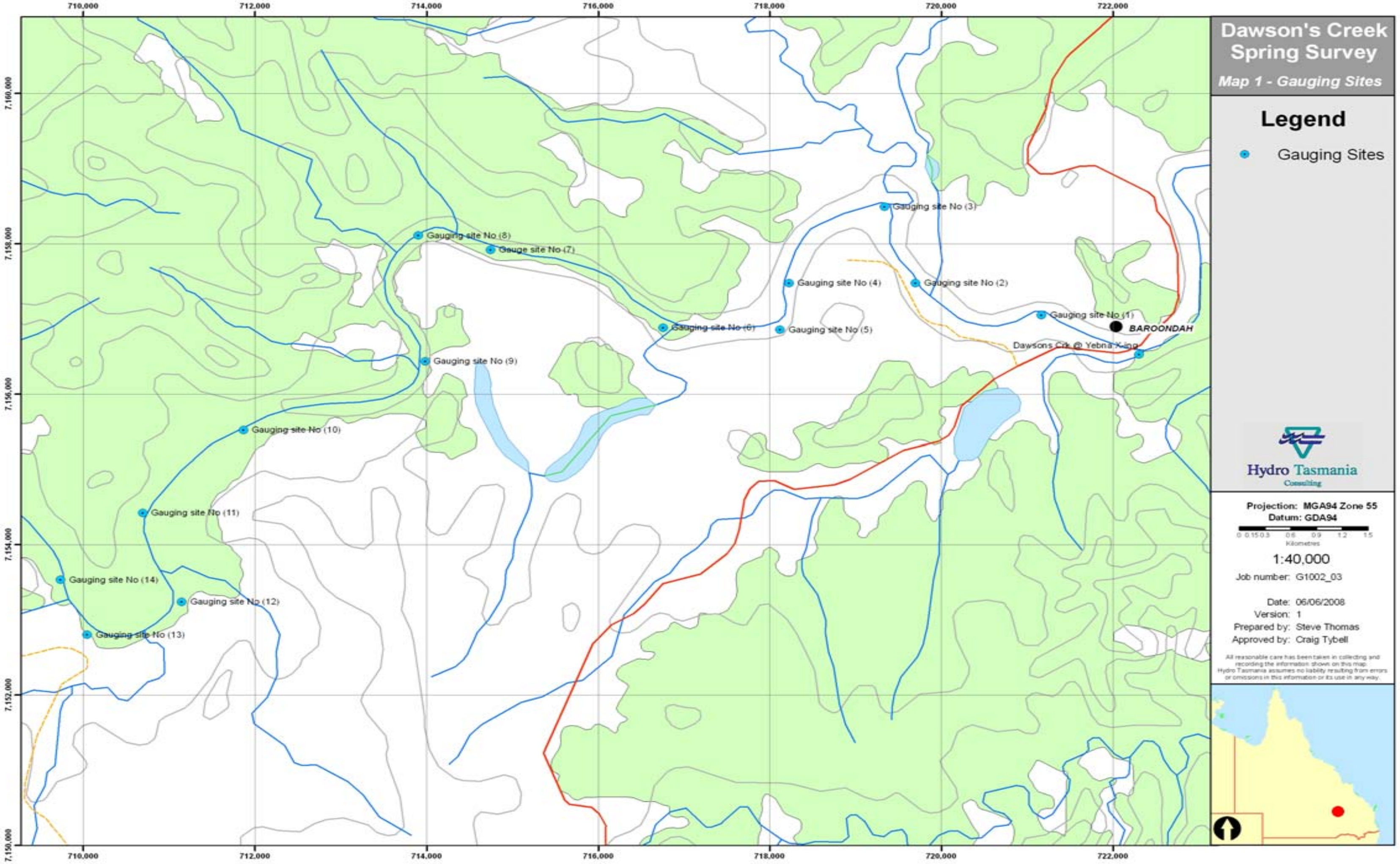
Gauging's were conducted to Australian standards (flow measurements in open channels).

Field water quality measurements

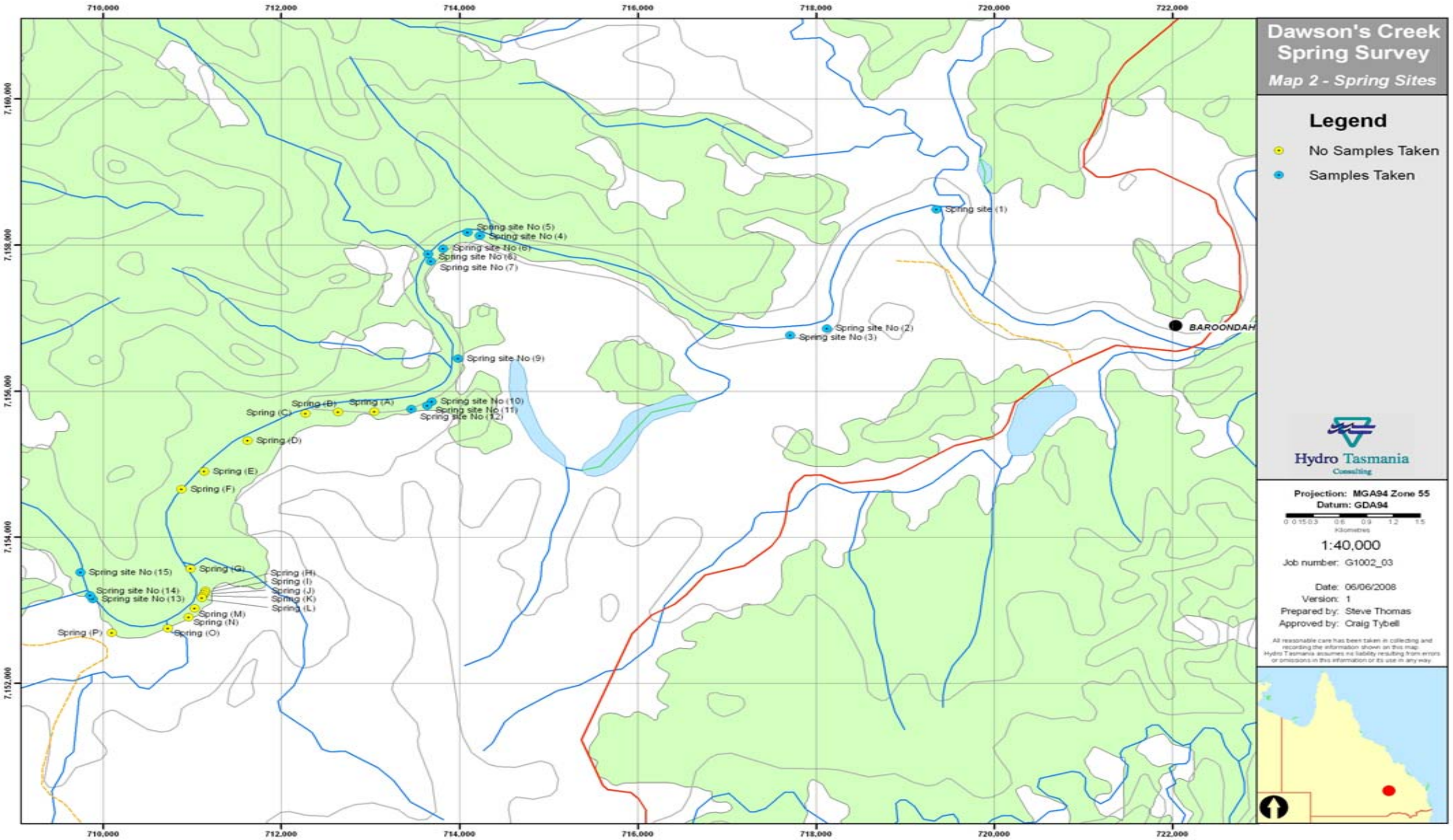
Field water quality measurements were undertaken with a Hydrolab MS-5 multiprobe measuring pH, Temperature, conductivity, turbidity and dissolved oxygen at each flow measurement (gauging) location and at each spring sites (refer to map and spreadsheet 1), Photos were taken and the locations GPS coordinates noted at each site which is included in the accompanying disk (appendix B).

Calibration of the water quality meter was conducted using Manufacturers laboratory specified solutions and procedures.

Site map (Gaugings)



Site Map (Springs)



Summary of results

Dawson's Creek Flow and Water Quality Summary

As shown in the tabulated results (appendix A) the discharge measurements within Dawson's creek ranged from 0.068 cumecs (68 litres per second) at the upper most flow measurement site (gauging 14) to 0.273 cumecs (273 litres per second) at gauging 4. There were losses in the lower reaches of Dawson's Creek near the homestead (Gaugings 1-6) which may have been the extraction of water for domestic or agricultural purposes or merely increased losses from geological anomalies (cast) or sub surface movement through course sand beds. There was evidence of extraction (polypipe) that had been used for drilling operations. Although no permanent pumping sites were located in the reach in question the extraction pipe/s may have been submerged at the time of this survey.

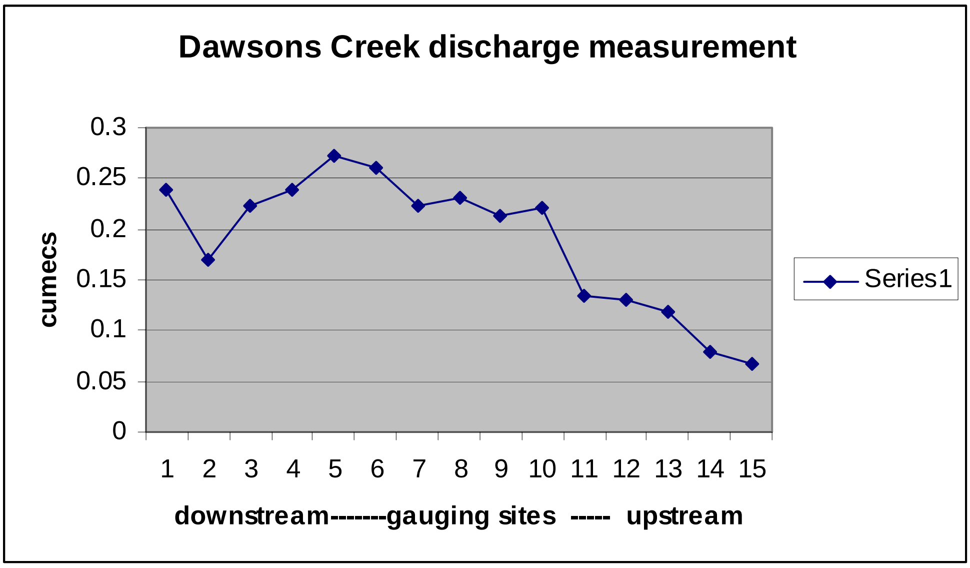


Figure 1: ***Flow versus gauging locations on Dawson's Creek***

	TEMP	SAL(PPT)	pH	TURB (NTU)	LDO (%)	LDO (Mg/l)	SCOND (uS/cm)
Max	19.5	0.15	7.83	18	102.7	10.05	314.8
Min	14.31	0.14	6.95	7.2	43.8	4.27	284.7
Average	16.2	0.1	7.3	11.4	72.0	7.1	303.2
Stdev	1.3	0.0	0.3	3.1	17.6	1.8	8.7

Table 1 ***Dawson's Creek water quality results at gauged sites***

Water temperature's within Dawson's creek ranged from a maximum of 19.5°C to a minimum of 14.31°C (average = 15.1°C) but is highly dependent on the ambient air temperatures at the time of the field measurement.

Measurements of Ph found variations from a minimum 6.95 to a maximum of 7.83 with an increasing trend toward the lower reaches of Dawson's Creek with the maximum value recorded at the Yebna crossing. This was likewise the case for conductivity readings to which the maximum was recorded at Yebna crossing – 314uS/cm and the minimum at gauging site 12 being 284.7uS/cm.

The dissolved oxygen readings likewise increased with the distance downstream with the minimum recorded at gauging site 9 (43%saturation/ 4.27mg/l) and the maximum being at gauging site 2 (maximum102% or 10.05mg/L).

Dawson's Creek Turbidity ranged only 11ntu with a maximum of 18ntu (gauging site 9) to 7.2ntu (gauging site 13).

Spring inflow and Water Quality Summary

A total of thirty springs were discovered in the survey area. The majority of springs were discovered on the right bank of Dawson's Creek, notably in aggregations over a small geographical area (refer to map2). Cattle disturbance of the river bed and banks was evident throughout the survey area. The weather was stable during the survey period with no rainfall occurring. Fifteen water samples were taken for further analysis at sites

There was much variation in the water quality results from the numerous springs discovered in this survey, as shown in table 2 below.

	TEMP	SAL(PPT)	pH	TURB (NTU)	LDO (%)	LDO (Mg/l)	SCOND (uS/cm)
Max	26.16	0.46	7.62	18	92.8	8.63	890.1
Min	12.85	0.06	5.8	0	0.45	0.21	131.7
AVG	22.1	0.1	6.6	7.1	42.2	4.1	283.4
Stdev	3.3	0.1	0.5	7.1	33.6	3.1	162.9

Table 2 *Spring water quality results*

Temperature and conductivity readings from the springs varied greatly. The highest conductivity recorded at spring 2 being 890 uS/cm but its discharge was minimal (15ml/s). The highest temperature was recorded at spring 11 at 26.16°C surrounding springs 9 through C all being above 20°C. Waters from Spring 6 had very low dissolved oxygen readings at 0.21mg/l and also had the lowest Ph 5.8. The springs flow ranged from 2mls/sec to 3 litres/sec.

CD contents

Please find enclosed in Appendix B a disk containing the following

- Site digital photos
- Maps (gauging and springs)
- Interactive sample map file
- Raw data worksheet

Attachment A Dawson's Creek Spring survey results spreadsheet.

SITE NAME	EASTING	NORTHING	ELEVATION	TIME/DATE	TEMP	SAL(PPT)	pH	TURB (NTU)	LDO (%)	LDO (Mg/l)	SCOND (uS)	GAUGING	FLOW M/Sec	ISCHARGE (CUMEC	FLOW +/- READ FROM BOTTOM (
Dawsons Crk @ Yebna X-ing	55722310E	7156528N	244m	29.04.08@12:00	16.2	0.15	7.83	10.7	83.2	8.22	314.4	Yes	0.518m/s	0.239cumecs	0.0703cumecs +70.3lt
Gauging site No (1)	55721172E	7157051N		29.04.08@12:55	16.4	0.15	7.66	10.1	85.7	8.42	314.8	Yes	0.2038m/s	0.169cumecs	0.0552 Minus 55.2lts
Gauging site No (2)	55719703E	7157478N		29.04.08@15:25	16.68	0.15	7.78	8.8	102.7	10.05	309.9	Yes	0.3350m/s	0.224cumecs	0.0139 Minus 13.9lt
Spring site (1) (wq done at entry t	55719356E	7158490N		30.04.08@07:30	12.85	0.15	7.62	14.4	81.5	8.63	306.7	No		Approx 2-3ml/s	
Gauging site No (3) 10m u/s of S	55719338E	7158494N		30.04.08@09:00								Yes	0.3112m/s	0.238cumecs	0.0354 Minus 35.4lt
Gauging site No (4)	55718227E	7157478N		30.04.08@10:00	14.31	0.15	7.44	8.4	88.5	9.09	302.5	Yes	0.3242m/s	0.273cumecs	0.0117cumecs +11.7lt
Spring site No (2) TRB (QC01)	55718123E	7156857N		30.04.08@10:25	21.9	0.46	6.09	2.1	0.45	5.3	890.1	No		Approx 15ml/s	
Gauging site No (5) 10m u/s of S	55718123E	7156856N		30.04.08@10:45	15.07	0.15	7.31	10.9	87.9	8.88	309	Yes	0.4258m/s	0.261cumecs	0.037cumecs +37lt
Spring site No (3) (wq done at en	55717713E	7156764N		30.04.08@11:20	19.66	0.15	7.28	18	83.7	7.64	322	No		Approx 2-3ml/s	
Gauging site No (6)	55716759E	7156882N		30.04.08@12:20	16.23	0.14	7.38	10.4	86.8	8.55	297.5	Yes	0.3126m/s	0.224cumecs	0.0070 Minus 7.0lt
Gauge site No (7)	55714749E	7157919N		01.05.08@07:00	15.33	0.15	7.25	15.2	64.7	6.51	299.2	Yes	0.3402m/s	0.231cumecs	0.0178cumecs +17.8lt
Spring site No (4) TRB	55714229E	7158129N		01.05.08@07:45	20.5	0.15	6.23	N/A	17	1.5	306	No		Approx 20-30ml/s	
Spring site No (5) TLB	55714092E	7158172N		01.05.08@08:30	17.3	0.06	7.14	N/A	88	8.48	131.7	No		Approx 2-3lt/s	
Gauging site No (8)	55713904E	7158110N		01.05.08@09:00	15.25	0.15	7.11	13.8	61.5	6.19	307.9	Yes	0.3438m/s	0.214cumecs	0.0085 Minus 8.5lt
Spring site No (6) TRB	55713813E	7157951N		01.05.08@09:35	24.12	0.06	5.8	1.6	2.5	0.21	145.2	No		Approx 20-30ml/s	
Spring site No (7) TRB	55713678E	7157776N		01.05.08@10:05	23.69	0.07	5.93	0.2	9.3	0.78	154.3	No		Approx 1-2lt/s	
Spring site No (8) TLB	55713649E	7157880N		01.05.08@10:35	19.32	0.19	7	6.3	92.8	8.6	389.5	No		Approx 2-3lt/s	
Gauging site No (9) 10m d/s Spri	55713982E	7156437N		01.05.08@11:00	16.76	0.15	7	18	43.8	4.27	306.2	Yes	0.3796m/s	0.222cumecs	0.0867cumecs +86.7lt
Spring Site No (9) TLB	55713983E	7156447N		01.05.08@11:20	20.54	0.08	6.9	18	70.8	6.4	182.9	No		Approx 1lt/s	
Spring site No (10) TLB	55713689E	7155857N		01.05.08@12:00	25.6	0.12	6.5	N/A	49.5	4.08	250.6	No		Approx 500ml/s	
Spring site No (11) TLB	55713636E	7155800N		01.05.08@12:45	26.16	0.12	6.26	N/A	10.1	0.82	245.3	No		Approx 1lt/s	
Spring site No (12) TRB	55713459E	7155753N		01.05.08@13:25	25.53	0.11	6.47	N/A	35.2	2.89	239	No		Approx 1lt/s	
Spring (A) no grab samples	55713041E	7155721N		01.05.08	24.92	0.08	6.26	N/A	8.2	0.67	191	No		Approx 1-2lt/s	
Spring (B) no grab samples	55712634E	7155711N		01.05.08	24.27	0.11	6.64	N/A	56.4	4.37	242	No		Approx 1-2lt/s	
Spring (C no grab samples)	55712269E	7155691N		01.05.08	23.1	0.12	6.84	6.9	55.2	4.75	251.1	No		Approx 200-300ml/s	
Gauging site No (10)	55711863E	7155522N		01.05.08@14:00	16.21	0.15	7.28	14.6	70.3	6.94	310	Yes	0.2205m/s	0.135cumecs	0.0050cumecs +5.0lt
Springs (D,E,F) no grab samples	55711622E 55711133E 55710880E	7155323N 7154900N 7154659N		01.05.08 01.05.08 01.05.08											
Gauging site No (11)	55710694E	7154423N		01.05.08@15:15	18.19	0.14	7.25	11.8	72.5	6.86	293.1	Yes	0.3312m/s	0.130cumecs	0.0112cumecs +11.2lt
Spring (G) no grab samples	55710980E	7153567N		01.05.08	22.5	0.09	6.88	10.5	71.4	6.21	195	No		Approx 2-3lt/s	
Springs (H,I) no grab samples	55711149E 55711142E	7153262N 7153240N		01.05.08 01.05.08											
Gauging site No (12) u/s spring (I	55711144E	7153240N		01.05.08@16:20	19.5	0.14	6.95	11.9	52.4	4.84	284.7	Yes	0.2488m/s	0.119cumecs	0.0401cumecs +40.1lt
Springs (J,K,L,M,N,O,P) no grab	55711128E 55711113E 55711109E 55711026E 55710959E 55710723E 55710093E	7153214N 7153187N 7153168N 7153027N 7152901N 7152753N 7152689N		01.05.08 01.05.08 01.05.08 01.05.08 01.05.08 01.05.08 02.05.08@07:30											
Gauging site No (13)	55710041E	7152801N		02.05.08@06:30	15.78	0.15	7.16	7.2	55.7	5.53	301.2	Yes	0.2011m/s	0.079cumecs	0.0116cumecs +11.6lt
Spring site No (13) TRB (QC03)	55709884E	7153154N		02.05.08@07:20	23.82	0.15	6.34	0	2.8	0.24	317.1	No		Approx 500ml/s	
Spring site No (14) TRB (QC02)	55709850E	7153201N		02.05.08@07:50	19.85	0.16	6.81	0.3	59.3	5.43	322.6	No		Approx 1lt/s	
Gauging site No (14) 5m u/s Spri	55709731E	7153532N	264m	02.05.08@08:25	15.28	0.14	7.08	7.8	52.1	5.18	294.7	Yes	0.1778m/s	0.068cumecs	
Spring site No (15) TRB	55709743E	7153519N		02.05.08@08:50	23.79	0.15	6.37	N/A	7.8	0.65	301.7	No		Approx .1-.2lt/s	

Environmental Values and Associated Water Quality

Appendix E

REPORT

GLNG Project

Environmental Values and Associated Water Quality

Prepared for

Santos

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Brisbane QLD

21st January 2009

43270896

URS

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Reference:	GLNG Project Environmental Values and Associated Water Quality
Status:	Final

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Executive Summary

This brief report reviews the water quality of streams and associated water in the catchments and well fields of the Gladstone Liquid Natural Gas (GLNG) project. The GLNG field is situated within the Condamine-Balonne, Upper Dawson and Comet-Brown catchments.

Environmental Values

The report identifies the environmental values and water quality objectives of the Condamine-Balonne, Upper Dawson and Comet-Brown rivers. Similar environmental values exist for all catchments as follows:

- Protection of slightly to moderately disturbed aquatic ecosystems.
- Primary Industries: irrigation, water for farm use (other than drinking water, such as in fruit packing or milking sheds), stock watering, and human consumption of wild or stocked fish or crustaceans.
- Recreation & aesthetics: primary recreation (direct contact), secondary recreation (indirect contact), and visual appreciation (no contact).
- Industrial uses.
- Cultural and spiritual values: indigenous and non-indigenous cultural heritage.

In addition, the environmental value of raw drinking water supply for human consumption applies for the Condamine-Balonne (in the Balonne River only) and Comet-Brown catchments.

Regulatory Framework

The National Water Quality Management Strategy (ARMCANZ & ANZECC, 1994) is implemented in Queensland through the EPP(Water). Scientific guidelines are available that provide trigger values for the protection of the above environmental values. The preferred order of application in Queensland, as outlined in the EEP(Water) are local guidelines, the Queensland Water Quality Guidelines, and the Australian Water Quality Guidelines ANZECC & ARMCANZ (2000).

The EPP(Water) encourages the development of water quality objectives for a waterbody; that is the set of water quality guidelines that will protect all the identified environmental values. But water quality objectives must also take into account social, economic and current environmental condition factors, and involve a process of community consultation. Often the technical guideline trigger value may prove to be too conservative and economically unacceptable.

There are no officially endorsed water quality objectives developed for the catchments influenced by the GLNG field. Therefore in order to make a meaningful evaluation of the quality of associated water compared with the existing surface water quality across the GLNG field area, the available data is reviewed against the available technical guidelines for protection of each environmental value. Where several guidelines trigger values are available for one parameter, the minimum trigger value (MTV) has been adopted for comparison purposes.

Existing Surface Water Quality

The pre-CSG development surface water quality of the three catchments is evaluated using data from DNRW, supplemented by targeted and spatially dense samples taken during this study. Unverified QMDC catchment water quality data is used to assess the representativeness of project data. The data is compared with the MVT for each indicator, that is, the most conservative guideline value that protects all identified environmental values.

The review shows that:

Executive Summary

- The majority of waters sampled fall in the 6.5 – 8.5 pH range, consistent with the protection of all environmental values. However, some pH readings around 9.0 were observed. These readings are slightly higher than recommended for recreation and drinking water supply, but are still consistent the protection of irrigation use.
- All systems are subject to significant dissolved oxygen sags which correspond with the high levels of chemical and biological oxygen demand measured. The observed DO levels are well below those recommended for recreation, drinking water supply or the maintenance of aquatic ecosystems.
- All catchments are subjected to a wide range of electrical conductivity (EC - a surrogate for salinity) over time and space. However, most streams typically have EC consistent with the recommended WQO (340 [1]µS/cm).
- Sodium is normally found in the range 30 – 40 mg/L which is well below the trigger values for irrigation, recreation or drinking water supply. There is no trigger value for the protection of aquatic ecosystems.
- Chloride has a wider range in the Condamine–Balonne system (1 – 40 mg/L) compared with the Upper Dawson and Comet-Brown catchments (10 – 20 mg/L). All chloride concentrations are below the recommended trigger values for irrigation, recreation and raw water drinking water supply. There are no trigger values for stock watering or the protection of aquatic ecosystems.
- Fluoride concentrations are usually below the recommended trigger levels for stock, irrigation and drinking water supply. There are no trigger values for the protection of aquatic ecosystems or for recreation.
- Boron concentrations are predominantly below the recommended trigger levels for the protection of all environmental values (aquatic ecosystems, stock, irrigation, recreation and drinking water supply).
- Surface waters across all catchments are nutrient enriched (eutrophic) with concentrations of nitrogen, phosphorus and ammonia frequently higher than the guideline trigger values for protection of aquatic ecosystems.
- Turbidity and suspended solids concentration are frequently orders of magnitude above the recommended trigger values for the protection of aquatic ecosystems.
- At least 25% of all samples have copper concentrations higher than the relevant trigger value for the protection of aquatic ecosystems, but substantially lower than the trigger values for stock watering, irrigation, recreation and the taking of raw water for drinking water supply.
- Iron concentrations are often well above the recommended trigger levels for irrigation, recreation and the taking of raw water for drinking water supply.
- Zinc concentrations regularly exceed the trigger level for the protection of aquatic ecosystems across all catchments. The observed maximum concentration is below the trigger levels for stock watering, irrigation, recreational use and the taking of raw water for water supply.

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[1] Note there is no guideline value for EC available for the Condamine-Balonne. The QWQG (2006) provides the 75th percentile of EC (325µS/cm) in the Maranoa-Balonne-Border Rivers salinity zone which provides a suitable reference point.

- Lead concentrations are above the trigger level for the protection of aquatic ecosystems in approximately 50% of samples. The maximum recorded lead concentration is well below the relevant trigger levels for stock watering, irrigation, recreational use and the taking of raw water for water supply.

In summary, the existing water quality of surface streams across the GLNG catchments is variable. Surface waters frequently do not meet the quality specified for the protection of aquatic ecosystems for a number of indicators such as salinity, DO, nutrients, copper, iron, zinc and lead. This suggests the published water quality guideline trigger values are overly conservative in these ephemeral stream networks.

Associated Water Quality

The quality of associated water from the Fairview and Roma well fields is similar at the two fields, but Roma water quality is typically more saline and contains higher chloride levels than Fairview water. Given the ephemeral nature of the streams the potential exists for flow to be comprised entirely of associated water. Therefore a comparison of associated water quality with the guideline trigger values is appropriate as a conservative measure.

Examination of associated water indicates that the existing fields have water with:

- High pH, low dissolved oxygen, low to moderate salinity.
- Moderately high temperature
- Elevated sodium, fluoride and boron concentrations.
- No hydrocarbons
- No coliforms.
- Low chloride concentrations at Fairview.
- Elevated chloride concentrations at Roma.
- Elevated ammonia concentrations (compared with Queensland guidelines but well below national guidelines).
- Elevated copper or zinc concentrations from some wells.
- Low phosphorus and iron concentrations from most wells.
- Low nutrients (with the exception of ammonia and phosphorus).

Comparison of Surface and Associated Water Quality

Surface water quality and associated water quality are contrasted in Section 9. It is concluded that the following key water quality parameters need to be addressed in assessing the risk of discharge to grade:

- Salinity (electrical conductivity)
- Sodium
- Chloride
- Fluoride

Executive Summary

- Boron

In addition, due care needs to be taken to manage pH, dissolved oxygen, suspended solids and temperature.

Existing surface water is of variable quality. Once potential discharge points are identified detailed water quality information of the existing environment will need to be captured in order to evaluate the impacts of associated water discharge. Discharging associated water will cause increased concentrations of some indicators such as EC, but may result in dilution of others such as iron and copper if there is water remaining in stream.

A wide variation in the quality of associated water from individual wells is identified and plotted within the report. It is concluded that it will be necessary to capture water quality data to establish the characteristics of the water from each well field before decisions can be made on discharge to grade or other means of water management. Water quality data is also of importance in deciding whether individual poor quality wells are separated from or mixed with discharges from other wells in a field.

1.1 Background

Santos Ltd (Santos) is proposing to expand and commercialise its existing coal seam gas (CSG) operations in central Queensland. The development will include expansion of the field areas in the Arcadia, Comet Ridge, Fairview and Roma region. Liquefied Natural Gas (LNG) will be transported to an export facility at Gladstone via a 425 km gas transmission corridor. The export facility will initially be constructed to produce three to four million tonnes per annum (Mtpa) of LNG, with the potential for future expansion to a nominal 10 Mtpa. An Environmental Impact Statement (EIS) is being undertaken to assess the feasibility of the LNG project from an environmental, social and economic perspective

In order to extract CSG it is necessary to extract significant amounts of groundwater from each production bore. Production of groundwater, termed associated water, increases during the initial stages of extraction. As the amount of water held within the coal seam fractures decreases, the production of gas increases and associated water production declines over time. The volume of associated water produce varies between wells and across the different regions.

Appropriate management of the associated water is paramount for the GLNG Project. . Santos is considering a variety of water management options including discharge to grade, evaporation, stock watering, treatment, injection, irrigation and beneficial use. This report focuses on the discharge of associated water to grade, providing an overview of the existing surface water quality within the catchments and the quality of associated water.

1.1 Study Area

The proposed field development area consists of a number of regions in central Queensland: Roma, Fairview, Arcadia Valley, Denison, Comet and Mahalo. These areas are defined by either Production Licences (PL) or Authorities to Prospect (ATPs) and are situated within three different surface water catchments. In order to provide an assessment of surface water environments it is necessary to consider catchments as a whole. This report therefore makes reference to three catchments; the Condamine-Balonne Catchment, Upper Dawson Catchment, and Comet-Brown Catchment.

The following provides an overview of each catchment. Figure 1 (attached) shows the extent of each catchment and the proposed LNG field development area.

1.2 Catchment Overview

1.2.1 Condamine-Balonne

The Roma field area is situated within the Condamine-Balonne catchment (Figure 2, attached). Roma is the main township in the area, situated on Bungil Creek. The catchment contains extensive, meandering streams that are largely ephemeral or intermittent. The topography is primarily flat with wide alluvial floodplains. Streams have long periods of low to zero flows, forming a series of disconnected waterholes.

Major streams within the subcatchment include Bungil Creek, Wallumbilla Creek, Yuleba Creek and minor tributaries. Bungil Creek flows roughly north to south. Wallumbilla and Yuleba Creeks flow to the south-southwest. Another principal stream, Bungeworgorai Creek, is located in the western portion of proposed Roma field and flows in a south-westerly direction discharging into Bungil Creek. The three main creeks discharge to the Balonne River which in turn flows to the Murray Darling Basin, hence all creeks fall within the MDB and are subject to inter-governmental agreements and actions such as the Basin Salinity Management Strategy.

Waters within the catchment generally exhibit high turbidity levels, likely associated with the nature of local soils but exacerbated by increased removal of native vegetation and cattle grazing in the central reaches. Total phosphorous (TP) has been found to be extremely high in the middle catchment. Salinity levels are generally low, though they increase in the upper catchment where soils have a naturally high salt content (Australian Natural Resources Atlas, November 2007).

During a field visit in January 2008 extensive evidence of flooding was observed, with debris noted well above the bank-full level in the major streamlines. The major streams were flowing in January 2008, however smaller tributaries to the northeast of Roma (e.g. Coxon Creek) were essentially dry. All streams had ceased to flow when subsequent field trips (March and May 2008) were undertaken. Pond habitats of varying size were present in many of the larger streamlines, though some sites on Bungil Creek were dry.

Evidence of cattle access is widespread cross the catchment, with banks frequently showing signs of erosion. Streambed substrate varied from sandstone/mudstone bedrock in Coxon Creek and surrounding streams, to predominantly sand in the lower reaches and larger streams. The major streams are deep and wide in sections, with many of the tributaries incised.

There are limited CSG pilot and producing wells currently operating in the Roma field area. Associated water is captured in holding dams, with no releases to grade.

1.2.2 Upper Dawson River

The Fairview project area lies within the Upper Dawson River catchment that extends upstream and westwards from Taroom, encompassing the townships of Injune and Wandoan (Figure 3, attached). The catchment contains extensive but largely ephemeral or intermittent stream networks. Major streams in the area are the Dawson River, Hutton Creek, Baffle Creek, Juandah Creek, Eurombah Creek, Commissioner Creek and Broken Creek. The Dawson River is spring fed along a reach from the outflow of Hutton Creek to Yebna Crossing.

During field visits undertaken in January through April 2008 the Dawson River was observed to be flowing at several locations upstream from Taroom. Major tributaries had generally ceased to flow by March 2008 and were either dry or contained minor ponds. In January 2008 extensive evidence of flooding was observed, with debris noted well above the bank-full level in the major streamlines and extensive erosion of roadways.

Coal Seam Gas (CSG) production at Fairview has occurred since at least 1993 initially under the control of the Tri-Star Petroleum Company (1993 to 2002), then Tipperary Oil and Gas (Australia) Pty Ltd. (TOGA, 2002 to 2005). In September (June) 2005 TOGA was purchased by Santos Ltd.

Discharge of associated water to grade has occurred throughout this period into small, often intermittent, streamlines or gullies that then discharge to Baffle Creek, the Dawson River or Hutton Creek. Santos captures associated water with salinity greater than 3,500 µS/cm and this is used for plant works or disposes via injection into the basement Timbury Hills Formation.

1.2.3 Comet-Brown River

The Arcadia Valley, Denison, Comet and Mahalo field areas lie within the Comet-Brown Catchment (Figure 4, attached), extending from east of the Carnarvon Ranges northwards to Emerald. The Comet-Brown catchment is part of the larger Fitzroy Basin, which comprises almost 10% of the agriculturally productive land in Queensland. The primary river within the basin, the Fitzroy River, discharges into the marine environment at the southern end of the Great Barrier Reef, near the major urban centre of Rockhampton.

The primary land uses in the catchment include grazing and cropping. The catchment contains extensive but largely ephemeral or intermittent stream networks with summer rainfall dominant. The major stream in the GLNG field area is the Brown River, which becomes Comet River in the vicinity of Rolleston, flowing north and discharging to the McKenzie River. Major tributaries enter the Comet-Brown River from the east and west. The only township in the Arcadia Valley, Rolleston, is situated on the Comet River.

With the exception of Carnarvon Creek all streams had ceased to flow by March 2008, with minimal ponding observed at some locations and vegetation present in many of the dry streambeds. Carnarvon Creek continued to flow in April 2008.

Comet and Brown Rivers and their tributaries have a catchment area of approximately 17,295 km^2, with stream lengths totally approximately 4,821km (Henderson, 2000). Basin flow is mostly from south to north and is largely ephemeral.

Environmental Values Section 2

2.1 Overview

Environmental values are broadly defined in the Environment Protection (Water) Policy 1997 (EPP(Water)) as maintaining water quality suitable for the biological integrity of an aquatic ecosystem (modified or pristine); recreational use; minimal treatment before supply as drinking water; agricultural use; and industrial use. Queensland EPA (2005) provides further clarity on the definition of environmental values based on the EPP (Water) and National Water Quality Management Strategy (NWQMS) to include:

- Protection of aquatic ecosystems: ranging from high conservation value aquatic ecosystems, slightly to moderately disturbed aquatic ecosystems, and highly disturbed aquatic ecosystems systems.
- Primary Industries: irrigation, water for farm use (other than drinking water, such as in fruit packing or milking sheds), stock watering, and human consumption of wild or stocked fish or crustaceans.
- Recreation & aesthetics: primary recreation (direct contact), secondary recreation (indirect contact), and visual appreciation (no contact).
- Drinking Water: raw drinking water supply.
- Industrial uses: includes power generation, manufacturing plants.
- Cultural and spiritual values: indigenous and non-indigenous cultural heritage.

The EPP(Water) Schedule 1 prescribes environmental values for specific water bodies in Queensland, however none of the catchments in the vicinity of the GLNG project are listed. Since similar land uses exist within each catchment it is expected that the same environmental values will apply to all streams within a catchment. The relevance of each of the above environmental values to these streams is therefore considered at the catchment scale.

Table 2-1 summarises the environmental values applicable in each catchment, discussed further in Sections 2.2 to 2.4.

Table 2-1 Catchment Environmental Values

Environmental Value	Catchment		
	Condamine-Balonne	Upper Dawson	Comet-Brown
Protection of aquatic ecosystems (slightly to moderately disturbed)	✓	✓	✓
Primary Industries	✓	✓	✓
Recreation & aesthetics	✓	✓[1]	✓
Raw drinking water supply			✓
Industrial uses	✓	✓	✓
Cultural and spiritual values	✓	✓	✓

NOTE: [1] not including secondary contact

2.2 Condamine-Balonne

Protection of aquatic ecosystems is applicable to all stream lengths within the proposed development area. The waterways of the Condamine-Balonne River catchment are considered predominantly to consist of slightly to moderately disturbed ecosystems, as “systems that have undergone some changes, with aquatic biological diversity affected to some degree but the natural communities are still largely intact and functioning” (EPA, 2005).

Weirs and dams along the Balonne River are used for primary and secondary recreation purposes such as swimming and fishing. It is possible that water holes along the Bungil Creek are also utilised for local recreational purposes. The use of the waterways for ‘visual recreation’ purposes must also be considered, particularly in the less disturbed regions of the upper Bungil Creek.

The towns of Roma and Mitchell draw drinking water from the artesian groundwater basin. However Surat takes drinking water from the Balonne River, as do towns situated further downstream. On this basis the environmental value of drinking water must be protected at and downstream of Surat, but is not considered relevant to upstream Bungil Creek, Wallumbilla Creek and Yuleba Creek.

The Roma area is extensively used for cattle grazing, and across the catchment there is evidence of stock access to streams. It is likely that water is taken from the waterways for stock and farming purposes, evident by observation of a dam on the Bungil Creek downstream of Roma.

The Roma field area falls within the Condamine Balonne Tributaries Zone 2 Water Management Area. Water allocations in the Tributaries Water Management Area including from Bungil Creek, Bungeworgorai Creek and Yuleba Creek are listed for the purposes of any’ (DNRW, 2007). This includes agriculture, irrigation and industrial water use.

2.3 Upper Dawson River

Protection of aquatic ecosystems is applicable to all stream lengths within the proposed development area. The waterways of the upper Dawson River catchment are considered predominantly to consist of “slightly to moderately disturbed ecosystems” based on the State of the River Report for the region (Telfer, 2005). These are “systems that have undergone some changes, with aquatic biological diversity affected to some degree but the natural communities are still largely intact and functioning”.

Water allocations under the Dawson Valley Water Supply Scheme are primarily for the purposes of ‘agriculture’ or ‘any’ (DNRM, 2006). Significant allocations are made along the Dawson River from approximately 20 km downstream of Taroom to the Fitzroy River junction, though some licences are used upstream particularly on Juandah Creek. Taroom is approximately 90 km downstream from Fairview. Allocations are for stock watering, irrigation and industrial water use. Between the Hutton Creek Junction and Fairview it is evident from river health surveys (EnviroTest various, Simmonds and Bristow, 2007 & 2008) that stock access waterways in this area from time to time. However, stock access to the Dawson River is generally limited due to steep banks.

Fishing is a widespread recreational activity along the Dawson River including upstream of Yebna Crossing only 12 km downstream of Fairview (Mr Radel pers. comm.). Other recreational activities such as swimming are possible but realistically only along the Dawson River downstream of Yebna Station. Access along the Dawson River is restricted due to steep banks and limited road crossings. Swimming is probably occasional and intermittent. At Taroom, treated groundwater supplies are used to maintain the local swimming pool. Without specific evidence of swimming, primary contact recreation has not been identified as an environmental value.

Along the Dawson River downstream of Taroom, the Glebe Weir is utilised for primary recreation (such as swimming) and secondary recreation purposes (such as canoeing and fishing) (Taroom Shire Council pers. comm.). It is possible that other waterholes upstream and downstream along the Dawson River are also used for local recreational purposes. The aesthetics of the waterways are of relevance with parts of the region considered to be of “inherent natural beauty” (Telfer, 1995).

The towns of Taroom and Injune draw drinking water from an artesian groundwater supply. Water from the Dawson River is used in the urban setting for irrigation of schools and sports fields only. It is understood that residential properties within the catchment but outside of the townships utilise rainwater or borewater for drinking purposes (Taroom Shire Council pers. comm.). On this basis the environmental value of drinking water is not considered to apply to the upper Dawson catchment. Whilst the possibility exists that local properties not connected to water supply will draw water from the river under riparian rights for personal use this is considered unlikely.

2.4 Comet-Brown Catchment

Along the Comet River a number of dams and the Comet Weir provide water primarily for irrigation purposes. Water allocations from the Nogoa-McKenzie Supply Scheme downstream of the Comet River are predominantly for ‘agricultural’ or ‘other’ purposes (Fitzroy Basin Resource Operations Plan, April 2006).

The town of Rolleston utilises water from the Comet River for drinking purposes. Water is harvested approximately once per year based on rainfall events, stored in ring tanks and treated. Groundwater is also used to supplement the drinking water supply (Bauhinia Shire Council pers. comm.).

Regions of the Brown and Comet River catchment, particularly in the western portion have been identified as ‘scenic rural settings’, with the potential for activities such as swimming and fishing to be realised (Henderson, 2002).

Based on the above identified uses of the rivers and tributaries all environmental values are considered applicable in the Comet and Brown River catchment area.

3.1 Regulatory Framework

The National Water Quality Management Strategy (ARMCANZ & ANZECC, 1994) is implemented in Queensland through the EPP(Water). The EPP(Water) outlines the relevant water quality guidelines for Queensland in order of preference:

- Locally derived guideline values;
- Queensland Water Quality Guidelines (QWQG) which provide guideline values tailored to Queensland regions and water types and were published in 2006 (updated March 2007); or
- Where the QWQG or local guidelines are not available, the default guidelines are the Australian Water Quality Guidelines (AWQG) published by ANZECC & ARMCANZ (2000).

Under the EPP(Water), Water Quality Objectives (WQOs) are the set of water quality guidelines that will protect all of the identified environmental values for an area. The EPP(Water) specifies WQOs for some water bodies throughout Queensland (Schedule 1). The water bodies within the proposed GLNG field development area are not listed therefore the WQOs are the minimum set of water quality parameter guideline values that will ensure each of the identified environmental values is maintained. However, the derivation of WQOs must also take into account social, economic and current condition factors. In many instances the technical guideline value may prove to be technically and economically unacceptable. Queensland EPA provides guidance on establishing draft WQOs for a waterway (QLD, 2005).

There have been no officially endorsed WQOs developed for the catchments influenced by the GLNG field development. For the purposes of evaluating and comparing the existing surface water quality and the predicted quality of associated water the appropriate guideline trigger values have been used as a point of comparison. Where several trigger values are available to protect different environmental values the most conservative, or minimum trigger value (MTV), has been adopted.

3.2 Water Regions and Types

The QWQG specifies guideline values for a range of indicators for the Central Coast region, which encompasses the Upper Dawson and Comet-Brown catchments. The Condamine-Balonne catchment falls within the Murray Darling region. There is considered to be insufficient data available in the Murray-Darling region for appropriate reference values to be derived, therefore the QWQG default to the AWQG for all parameters.

The QWQG defines fresh waterways as either:

- Upland stream: small (first, second and third order) upland streams (surrogate = altitude >250m): moderate-to-fast flowing due to steep gradients, substrate usually cobbles and bedrock, sometimes gravel, rarely sand or mud; or
- Lowland stream: larger (third, fourth and fifth order), slow-flowing and meandering streams and rivers, gradient very slight, substrates sometimes cobble and gravel but more often sand, silt or mud.

The AWQG defines all waters >150m elevation as upland waters. However, the predominant characteristics of streams across all catchments are in line with the definition of lowland freshwater waterways. On this basis the guideline values applicable to lowland streams have been adopted for the region.

3.3 Relevant Water Quality Guidelines

QWQG provides guideline trigger values for the protection of aquatic ecosystems for the Central Queensland Region. The AWQG provide trigger values for water used for stock watering, primary and secondary contact recreation, and irrigation, It is noted that while the QWQG and AWQG refer to drinking water as an environmental value, the specified guidelines are the Australian Drinking Water Guidelines 2004 (ADWG). The ADWG applies at the point of water consumption, and does not provide guidelines for untreated catchment surface water quality. These guidelines are therefore extremely conservative and should be applied with caution.

Based on the environmental values identified in Section 2, and an examination of the QWQG and AWQG the relevant set of water quality guideline trigger values has been identified for the waters of each catchment. These are shown in Table 3-2 (Condamine-Balonne), Table 3-4 (Upper Dawson), and Table 3-6 (Comet-Brown) below.

The QWQG also establish a framework for deriving and applying local guidelines for Queensland waters. Development of local guideline values is important as they reflect existing local conditions which may vary substantially from broader guidelines developed at the regional scale. Local guidelines can therefore take into account natural and anthropogenic influences on water quality and flow that would not otherwise be recognised.

The preferred means of establishing local water quality guidelines is to establish reference condition (. background condition, most commonly subject to minimal disturbance, but may be modified from natural condition) immediately upstream of an activity, or in the immediate region. Guidelines for reference condition must be derived from a minimum of at least 18 samples from one or more reference sites (QWQG, 2006).

Given the large extent of the GLNG field area and variability in water quality across the catchments, local water quality guidelines have not been developed for this report. Once the location of proposed associated water discharges have been clarified suitable reference sites can be identified and local guidelines derived for relevant indicators where sufficient data is available.

The following outlines for each catchment the identified guideline trigger values based on the environmental values identified for each catchment.

3.3.1 Condamine-Balonne

There is minimal local water quality information across the Condamine-Balonne Catchment. However, sufficient spot water quality data is available to establish local guideline values at two sites within the study area, as shown in Table 3-1. Twentieth and 80th percentile values of water quality data from Bungil Creek at Tabers are shown in Table 3-4 for comparison with the WQOs and guidelines. Cells are shaded where local data exceeds WQOs and guidelines.

Table 3-1 Spot water quality data sufficient to establish local guidelines

Sampling Site	Water Quality Parameter
Bungil Ck at Tabers[1]	EC, DO, pH, Turbidity, Temperature, TSS, TN, TP, calcium, chloride, fluoride, sodium, sulphate, boron, copper, iron
Yuleba Creek at Forestry[2]	Temperature, boron, TP, calcium, chloride, fluoride, magnesium, potassium, sodium, sulphate, alkalinity

Note: 1 URS and DNR data
2 DNR data

Only temperature falls within the range of the MTV. The local data suggests that WQOs should be relaxed for the rest of the parameters.

Table 3-2 MTVs for major streams in the Balonne-Condamine catchment

WQ PARAMETER	Units	QWQG 2006	ANZECC 2000					Drinking Water[c]	MTV[d]	Local Data[#]	
			Aquatic Ecosystems[a]		Stockwater	Irrigation[b]	Recreation				
			Lowland	Upland						20%ile	80%ile
Electrical Conductivity (at 25^{o}C)	µS/cm	325[e]	125-2200	30-350	-	<650[f]	-	-	325	**120.8**	**659.2**
Dissolved Oxygen	% sat	-	85-110	90-110	-	-	>80	> 85%	85-110	**55**	110
pH	Stand.	-	6.5-8.0	6.5-7.5	-	6-9	6.5-8.5	6.5-8.5	6.5-8.0	7.5	**8.2**
Temperature	^{o}C	-	20%ile-80%ile		-	-	15-35	-	20%ile-80%ile[l]	17	25.24
Turbidity	NTU	-	6-50	2-25	-	-	-	5	50	19.1	**323.8**
Total dissolved solids	mg/L	-		-	4000g	-	1000	500[h]	500		
Total suspended solids	mg/L	-	-	-	-	-	1000	-	10	17.6	466.4
Ammonia (as N)	ug/L	-	900				10	500	10		
Ammonium (NH^{4+})	µg/L	-	20	10	-	-	-	-	20		
Chlorophyll-a	µg/L	-	5	na	-	-	-	-	5		
Nitrate	ug/L	-	700		400	-	-	50[j]	50		
Oxidised nitrogen (NOx)	µg/L	-	40	15					40		
Total nitrogen	µg/L	-	500	250	-	5000	-	-	500	**620**	**1723**
Total phosphorous	µg/L	-	50	30	-	50	-	-	50	45	**422**
Calcium	mg/L	-			1000	-	-		1000	8.9	55
Chloride	mg/L	-	-		-	175[f]	400	250[i]	175	5	43
Fluoride	mg/L	-	-		2	1	-	1.5	1	0.05	0.2
Sodium	mg/L	-	-			115	300	180	115[i]	10.4	64.7
Sulphate	mg/L	-	-		1000		400	500	400	2.0	82.1
Aluminium	ug/L	-	55		5000	5000	200	200	55[i]		
Arsenic	µg/L	-	24/13[k]		500	100	50	7	7		
Boron	µg/L	-	370		5000	500	1000	4000	370	24	100

WQ PARAMETER	Units	QWQG 2006	ANZECC 2000					Drinking Water[c]	MTV[d]	Local Data[#]	
			Aquatic Ecosystems[a]		Stockwater	Irrigation[b]	Recreation				
			Lowland	Upland						20%ile	80%ile
Cadmium	µg/L	-	0.2		10	10	5	2	0.2		
Chromium (VI)	µg/L	-	1		1000	100	50	50 (CrVI)	1		
Copper	µg/L	-	1.4		1000	200	1000	2000	1.4	**2**	**10**
Iron	µg/L	-	-			200	300	300	200	**152**	**932**
Lead	µg/L	-	3.4		100	2000	50	10	3.4		
Mercury	µg/L	-	0.6		2	2	1	1	0.6		
Nickel	µg/L	-	11		1000	200	100	20	11		
Zinc	µg/L	-	8		20000	2000	5000	3000	8[i]		

NOTES

a Trigger values for protection of 95% of freshwater aquatic ecosystems

b Values for long term irrigation trigger chosen at most conservative

c National Water Quality Management Strategy, Australian Drinking Water Guidelines 6, 2004

d MTV – minimum trigger value

e No guideline specified in QWQG, but Appendix G identifies the 75th percentile of EC in relevant salinity zone (Maranoa–Balonne–Border rivers) as a suitable point of comparison..

f Sensitive crops

g Suitable for beef cattle and horses

n/a Not available

h Drinking water aesthetics: <500mg/L regarded as good drinking water based on taste, 500-1000mg/L acceptable based on taste, >1000mg/L may be associated with excessive scaling, corrosion and unsatisfactory taste.

i Aesthetic value

j Drinking water guideline value will protect bottle-fed infants under 3 months from methaemoglobinaemia. Adults and children over 3 months can safely drink water with up to 100 mg/L nitrate.

k AsIII/AsV respectively

l The QWQG recommend temperature guidelines for protection of aquatic ecosystems such that median discharge temperature lies within the 20th and 80th percentiles of observed temperature variation. Significant diel and seasonal variation in temperature are evident within river systems. Ensuring an appropriate data set from which to identify these percentiles is problematic since samples are often collected in particular seasons and during daylight hours. Continuous records of temperature are available from Bungil creek at Tabers.

(yellow) Most conservative guideline trigger values to satisfy all environmental values

(green) Relevant water quality objectives for streams in the Condamine-Balonne River Catchment

Based on analysis of data from Bungil Creek at Tabers. DO in mg/L converted to % saturation assuming observed temperatures for samples with DO similar to percentiles. It is also assumed that the stream is at sea level.

3.3.2 Upper Dawson River

Sufficient spot water quality data is available from the Upper Dawson catchment to establish local guideline values at the sites shown in Table 3-1. Twentieth and 80th percentile values of water quality data from Dawson River at Utopia Downs are shown in Table 3-4 for comparison with the published guidelines. Cells are shaded where local data exceeds the published guidelines.

Table 3-3 Spot water quality data sufficient to establish local guidelines

Sampling Site	Water Quality Parameter
Upper Baffle Creek[1]	Temp, EC, TDS
Lower Baffle Creek[2]	Temp, EC, TDS
Dawson R d/s Baffle Ck[2]	Temp, EC, TDS
Dawson R at Yebna Crossing[2]	Temp, EC, TDS
Dawson R at Utopia Downs[2]	Temp, pH, DO, EC, TDS, TSS, Na, K, Mg, Ca, HCO_3, Cl, F, SO_4, TN, TP, NH_4, NO_3, B, Cu
Dawson R at Taroom[2]	Temp, EC, TDS

Note: [1] upstream of associated water discharges
[2] downstream of associated water discharges

It should be noted that while the site Dawson River at Utopia Downs (1964 – 2007) has the most significant set of spot sample water quality data, it also lies downstream of existing associated water discharges. The data from this site were therefore examined for differences in median water quality parameter values before and after associated water discharges commenced using two sided Mann-Whitney U tests at 95% significance. The only water quality parameter with a significant increase in median concentration was Boron. Other parameters with significant shifts in median values were EC, TDS, Ca, Mg, Alkalinity, Cl and SO_4. All these parameters exhibit a reduction in concentration pre to post associated water discharges.

The data from Dawson River at Utopia Downs was therefore used to derive 20th and 80th percentile water quality values for comparison with the guideline based water quality objectives (Table 3-4). The local data suggests that WQOs should be relaxed for nutrients, turbidity and suspended solids.

Table 3-4 MTVs for major streams in the Upper Dawson River catchment

WQ PARAMETER	UNITS	QWQG 2006[a]		ANZECC GUIDELINES 2000				MTV	Local Data[#]	
		Lowland	Upland	Aquatic Ecosystems[b]	StockWater	Irrigation[c]	Recreation		20%ile	80%ile
Temperature*	°C	20%ile-80%ile	20%ile-80%ile	NA	NA	NA	15-35	**	14.7	26.1
pH	units	6.5-8.0	6.5-7.5	NA	NA	6-9	6.5-8.5	6.5-8.0	7.56	8.1
Electrical Conductivity (at 25°C)	µS/cm	340[d]	340[d]	NA	NA	<650[e]	NA	340[a]	223	330
Dissolved Oxygen	% Sat.	85-110	90-110	NA	NA	NA	>80	85-110	**72**	86
Total dissolved solids	mg/L	-	-	-	4000[f]	-	1000	1000	131	189
Total suspended solids	mg/L	10	-	NA	NA	NA	1000	10	9	**124**
Turbidity	NTU	50	25	NA	NA	NA	NA	50	7.0	**100**
Sodium	mg/L	-	-			<115[e]	300	<115	24	38.1
Potassium	mg/L							-	3.3	4.7
Calcium	mg/L	-	-		1000	-	-	1000	13.0	21.0
Magnesium	mg/L							-	4.48	8
Alkalinity HCO_3	mg/L							-	104	153
Chloride	mg/L	-	-	-	-	<175[e]	400	<175	18.0	32
Fluoride	mg/L	-	-		2[g]	1		1	0.1	0.16
Sulphate	mg/L	-	-		<1000		400	400	1	3.2
Total nitrogen	µg/L	500	250	NA	NA	5000	NA	500	118	**795.8**
Total phosphorous	µg/L	50	30	NA	NA	50	NA	50	21.7	**146**
Ammonia	µg/L	20[2]	10	900	NA	NA	NA	20	8	**37.3**
Oxidised nitrogen (NOx)	µg/L	60	15	NA	400,000[k]	NA	NA	60	**138**	**524**

[2] It is noted that the Queensland guideline table suggests that trigger values for ammonia-N are equivalent to ANZECC (2000) guidelines. This is incorrect and possibly indicates that EPA has misinterpreted the national guideline triggers for ammonia- N and ammonium ion concentrations.

WQ PARAMETER	UNITS	QWQG 2006[a]		ANZECC GUIDELINES 2000				MTV	Local Data[#]	
		Lowland	Upland	Aquatic Ecosystems[b]	StockWater	Irrigation[c]	Recreation		20%ile	80%ile
Boron	µg/L	-	-	370	5000[i]	500	1000	370	20	100
Copper	µg/L	-	-	1.4	1000[g]	200	1000	1.4	0.02	0.05
Chlorophyll-a	µg/L	5	n/a	NA	NA	NA	NA	5		
Arsenic	µg/L	-	-	24/13[j]	500[g]	100	50	24/13	-	-
Cadmium	µg/L	-	-	0.2	10[g]	10	5	0.2	-	-
Chromium	µg/L	-	-	1.0 (CrVI)	1000[g]	100	50	50	-	-
Iron	µg/L	-	-	300 (interim)	-	200	300	200	-	-
Lead	µg/L	-	-	3.4	100[g]	2000	50	3.4	-	-
Mercury	µg/L	-	-	0.6	2[h]	2	1	0.6	-	-
Nickel	µg/L	-	-	11	1000[g]	200	100	11	-	-
Zinc	µg/L	-	-	8	<20000	2000	5000	8	-	-

NOTES

a Guideline trigger values for protection of aquatic ecosystems (Central Coast Region)

b Values for 95% protection of aquatic ecosystems

c Values for long term irrigation trigger chosen as most conservative

d 75th percentile of EC in relevant salinity zone (Fitzroy Central). Source QWQG (2006)

e For sensitive crops

f Suitable for beef cattle and horses

g May be hazardous to animal health if exceeded

h Mercury may accumulate in edible animal tissues >2 µg/L and may therefore pose a human health risk

i Higher concentrations of Boron (>5000µg/L) may be tolerated for short periods of time.

j AsIII/AsV respectively

k For nitrate

NA indicates not applicable as QWQG take precedence

\- indicates no applicable guideline value

(yellow) These cells are the most conservative parameter values to satisfy all environmental values

(green) These cells are the relevant water quality objectives for streams in the Upper Dawson River catchment.

n/a Not available

^ MTV – minimum trigger value

Based on analysis of data from Dawson R at Utopia (1964 – 2007) DO in mg/L converted to % saturation assuming observed temperatures for samples with DO similar to percentiles

* The QWQG recommends setting temperature guidelines for protection of aquatic ecosystems so that median discharge temperature lies within the 20th and 80th percentiles of observed temperature variations. Significant diel and seasonal variation in temperature are evident within river systems. Ensuring an appropriate data set from which to identify these percentiles is problematic since samples are often collected in particular seasons and during daylight hours.

3.3.3 Comet-Brown Catchment

Sufficient spot water quality data is available in the Comet-Brown Catchment to establish local guideline values at the sites shown in Table 3-5. Twentieth and eightieth percentile values of water quality data from Comet River at Comet Weir are shown in Table 3-6 for comparison with the WQOs and guidelines. Cells are shaded where local data exceeds WQOs and guidelines (see footnote on page 12 regarding adopted Ammonia – N trigger values).

Table 3-5 Spot water quality data sufficient to establish local guidelines

Sampling Site	Water Quality Parameter
Comet River at Comet Weir*	EC, DO, pH, Turbidity, Temp
Comet River d/s Rolleston	EC, DO, pH, Turbidity, Temp
Meteor Creek	Temp
Planet Creek	Temp
Brown Creek	EC, Temp
Carnarvon Creek at Ingelara	EC, pH, Temp

Note: * URS and DNR Data

EC, temperature and pH levels are all within the MTVs. The local data suggests that WQOs should be relaxed for dissolved oxygen and turbidity.

Table 3-6 MTVs for major streams in the Brown & Comet River catchment

WQ Parameter	Units	QWQG 2006[a]		ANZECC GUIDELINES 2000				Drinking Water[l]	MTV	Local Data[#]	
		Lowland	Upland	Aquatic Ecosystems[b]	Stockwater	Irrigation[c]	Recreation			20%ile	80%ile
Electrical conductivity (at 25°C)	µg/L	340[d]	340[d]	NA	NA	<650[e]	NA	NA	340	121	253
Dissolved Oxygen	% Sat	85-110	90-110	NA	NA	NA	>80	>85[o]	85-110	**55**	100
pH	units.	6.5-8.0	6.5-7.5	NA	NA	6-9	6.5-8.5	6.5-8.5[o]	6.5-8.0	6.96	7.8
Temperature	°C	20%ile-80%ile	20%ile-80%ile	NA	NA	NA	15-35	NA	**	20.12	28.78
Turbidity	NTU	50	25	NA	NA	NA	NA	5[o]	50	**75.8**	**1618**
Total dissolved solids	mg/L	-	-	-	4000[f]	-	1000	<500[m/o]	<500		
Total suspended solids	mg/L	10	-	NA	NA	NA	1000	NA	10		
Ammonia (as N)	µg/L	20	10	900	NA	NA	NA	500	20		
Chlorophyll-a	µg/L	5	n/a	NA	NA	NA	NA	NA	5		
Nitrate	mg/L	-	-	-	400	-	-	50[n/o]	50		
Oxidised nitrogen (NOx)	µg/L	60	15	NA	400,000[k]	NA	NA	NA	60		
Total nitrogen	µg/L	500	250	NA	NA	5000	NA	NA	500		
Total phosphorous	µg/L	50	30	NA	NA	50	NA	NA	50		
Calcium	mg/L	-	-	-	1000	-	-	-	1000		
Chloride	mg/L	-	-	-	-	<175[e]	400	250[o]	<175		
Fluoride	mg/L	-	-	-	2[g]	1	-	1.5	1		
Sodium	mg/L	-	-	-	-	<115[e]	300	180[o]	<115		
Sulphate	mg/L	-	-	-	<1000		400	500	400		
Arsenic	µg/L	-	-	24/13[j]	500[g]	100	50	7	7		
Boron	µg/L	-	-	370	5000[i]	500	1000	4000	370		
Cadmium	µg/L	-	-	0.2	10[g]	10	5	2	0.2		
Chromium	µg/L	-	-	1.0 (CrVI)	1000[g]	100	50	50 (CrVI)	1		

WQ Parameter	Units	QWQG 2006[a]		ANZECC GUIDELINES 2000				Drinking Water[l]	MTV	Local Data[#]	
		Lowland	Upland	Aquatic Ecosystems[b]	Stockwater	Irrigation[c]	Recreation			20%ile	80%ile
Copper	µg/L	-	-	1.4	1000[g]	200	1000	2000	1.4		
Iron	µg/L	-	-	300 (interim)	-	200	300	300[o]	200		
Lead	µg/L	-	-	3.4	100[g]	2000	50	10	3.4		
Mercury	µg/L	-	-	0.6	2[h]	2	1	1	0.6		
Nickel	µg/L	-	-	11	1000[g]	200	100	20	11		
Zinc	µg/L	-	-	8	<20000	2000	5000	3000[o]	8		

NOTES

a Guideline physico-chemical indicator values for Central Coast Region
b Values for 95% protection of aquatic ecosystems
c Values for long term irrigation trigger chosen at most conservative
d 75th percentile of EC in relevant salinity zone (Fitzroy Central). Source EPA (2006)
e For sensitive crops
f Suitable for beef cattle and horses
g May be hazardous to animal health if exceeded
h Mercury may accumulate in edible animal tissues >2 µg/L and may therefore pose a human health risk
i Higher concentrations of Boron (>5000µg/L) may be tolerated for short periods of time.
j AsIII/AsV respectively

l For nitrate
m Drinking water aesthetics: <500mg/L regarded as good drinking water based on taste, 500-1000mg/L acceptable based on taste, >1000mg/L may be associated with excessive scaling, corrosion and unsatisfactory taste.
n Drinking water guideline value will protect bottle-fed infants under 3 months from methaemoglobinaemia. Adults and children over 3 months can safely drink water with up to 100 mg/L nitrate.
o Aesthetic Value
NA indicates not applicable as QWQG take precedence
(yellow) Most conservative parameter values to satisfy all environmental values
(green) Relevant water quality objectives for streams in the Comet Ridge Catchment
n/a Not available
^ MTV – minimum trigger value
\# Based on analysis of data from Comet River at Comet Weir DO in mg/L converted to % saturation assuming observed temperatures for samples with DO similar to percentiles. It is also assumed that the stream is at sea level.

k For nitrate
*The QWQG recommend temperature guidelines for protection of aquatic ecosystems such that median discharge temperature lies within the 20th and 80th percentiles of observed temperature variation. Significant diel and seasonal variation in temperature are evident within river systems. Ensuring an appropriate data set from which to identify these percentiles is problematic since samples are often collected in particular seasons and during daylight hours. Continuous records of temperature are available from Dawson R at Utopia and Dawson R at Taroom stream gauging stations.

3.4 Application of Water Quality Guideline Trigger Values

The guideline trigger values can be used as a benchmark against which potential developments or discharges can be assessed. In assessing the impacts of any discharge to the environment the guidelines should not be used on a pass or fail basis, but rather as trigger values for further investigation within a risk assessment framework (s3.1.1.3, ANZECC & ARMCANZ, 2000).

The in-stream dynamics of water flow and quality, as well as the interactions between contaminants, make it difficult to make definitive statements regarding the environmental effects of particular levels of water quality. QWQG and AWQG suggest the use of aquatic health measures in preference to physico-chemical measures since ecological systems reflect the full range of conditions encountered including droughts, floods, and episodic changes in water quality.

Setting water quality guideline values for ephemeral streams is problematic and is not dealt with definitively by either by the QWQG or the AWQG. Notes within the QWQG recognise that ephemeral streams and residual pools will have poorer water quality (particularly dissolved oxygen and nutrients) than flowing streams. Due to evaporative concentration of salts within pools, it can be expected that salinity would also be marginally poorer in such systems when compared with flowing waters.

Associated water quality can also be compared against the MTV. Consideration then must be given to cumulative affects when occur once discharged to the environment. In some instances dilution of water quality parameters present at high levels in the existing environment may occur, while for other parameters an increase is likely. Furthermore from international studies undertaken for CSG operations around the world there is evidence to suggest that the chemistry of associated water changes upon exposure to the surface water environment. Therefore care must be taken in interpreting the guideline trigger values as a benchmark.

Data Sources and Water Quality Monitoring Events

Prior to commencement or expansion of CSG operations it is important to gain an understanding of the existing environment with respect to surface water quality. This provides a benchmark by which the effects of any future potential discharges to grade can be assessed.

A detailed review of existing water quality information was undertaken and data gaps identified. The quantity and quality of existing information available varies substantially between each catchment. Very little information is available for the Condamine-Balonne in the vicinity of the Roma field area. More extensive records exist for the Upper Dawson River and Comet-Brown River, though spatial replication is poor. To supplement existing data URS undertook a series of water quality monitoring rounds over a short period of time (January – May 2008) to provide greater coverage of the catchments encompassing the GLNG field area.

In addition to the broad sampling program, targeted data collection was undertaken in the Fairview area where associated water from CSG operations has historically and is currently being discharged, and around the Roma field area where limited flow or water quality information is available.

4.1 Data Sources

Water quality data sets are available from a range of sources, as outlined below.

Condamine-Balonne

- Historical data (1972 – 2006 varying on a site to site basis) provided by DNRW.
- Stream gauging sites installed on behalf of URS during August 2008 to collect continuous water quality and height/flow data in Bungil Creek and Wallumbilla Creek.
- URS water quality monitoring undertaken January 2008 through May 2008
- Unpublished data collected through the QMDC community monitoring program. This data has not been included in this report but has been used as verification for URS data.

Figure 2 (attached) shows the locations of URS and DNRW water quality sites, and stream gauging sites in the Condamine-Balonne Catchment.

Upper Dawson

- Monitoring data provided by Santos (from 1998 to 2002);
- River Health Assessments undertaken for Santos (from 2003 to 2007);
- Department of Natural Resources and Water (DNRW);
- URS water quality monitoring undertaken January 2008 through August 2008;
- URS water quality depth profiling September 2008;
- Data loggers installed by URS in Upper Dawson Catchment June through September 2008; and
- Spring flow assessment undertaken on behalf of URS, March 2008.

Figure 3 (attached) shows the locations of URS and DNRW water quality sites in the Upper Dawson catchment.

Comet-Brown

- DNRW (1967 – 2007 varying on a site to site basis).

- URS water quality monitoring undertaken January 2008 through May 2008

The location of URS and DNRW spot and continuous water quality sites are shown in Figure 4 (attached).

4.2 URS Water Quality Monitoring Events

From January through May 2008 URS conducted three water quality monitoring rounds from select sites across all catchments. Beyond this period insufficient water was available in the catchment to justify additional sampling. Data was collected to validate and supplement the limited existing information and to provide greater spatial replication across the region.

Sample locations are provided in Figures 1 through 4 (attached). Findings are discussed in Sections 5, 6 and 7.

4.2.1 Site Selection

Sample sites were selected to provide maximum spatial coverage across the region. An initial reconnaissance to identify sites was undertaken from 29 January through 5 February 2008, with a further two monitoring rounds conducted 4-6 March 2008 and 13-16 May 2008.

As the location of future potential associated water discharge is not currently known, an attempt was made to provide coverage of the entire field area to ensure suitable reference sites for future monitoring programs. However, sampling was predominantly restricted to public road crossings due to difficulties in obtaining access to private property. This limited the number of samples that could be collected particularly during the drier months, as many of the road crossings were dry and it was not possible to access pools up or downstream on private property. Where access was possible, samples were also collected from DNRW monitoring sites in order to validate existing data sets.

Access to streamlines within the Comet-Brown Catchment in particular was very limited due to restrictions on entering private property. The single arterial road running through the basin provided the only publically available access point, and sampling was confined predominantly to Arcadia Creek. Across the northern portion of the basin encompassing Arcadia Valley there are many streamlines that could not be characterised. Furthermore due to the ephemeral nature of the streams, many sites were dry during March through May 08.

Details of surface water sample locations[3] are provided in Table 4-1, Table 4-2 and Table 4-3 below.

Table 4-1 Condamine-Balonne Water Quality Monitoring Sites

Site No.	Site Name	Easting	Northing
R001	Bungil Ck @ Warrego Hwy	680890	7059369
R002	Bungil Creek @ Burton Rd	680577	7066480
R003	Mooga Mooga Creek @ Roma-Taroom Rd	679597	7077707
R004	Bungil Creek @ Carnarvon Hwy	678771	7075239
R005	Eumamurrin Creek @ Carnarvon Hwy	671135	7100103
R006	Bungil Creek @ Euminah Rd	671080	7092693
R007	Spring Creek @ Orallo Rd	650329	7096779
R008	Bungeworgorai Creek @ Orallo Rd	657682	7085288

[3] All locations as eastings/northings GDA94 unless otherwise specified

Site No.	Site Name	Easting	Northing
R009	Bungeworgorai Creek @ Dargal Rd	669360	7062575
R010	Dargal Creek @ Hodgsons Lane North	661372	7064490
R011	Blyth Creek @ Carnarvon Hwy	689156	7042122
R012	Bungil Creek @ Dunkeld Rd	696803	7023509
R013	Bungil Creek @ Maranoa Rd	701026	6998157
R014	Wallumbilla Creek @ Roma Condamine Rd	720885	7020424
R015	Blyth Creek @ Warrego Hwy	662430	7058811
R016	Wallumbilla Creek @ Yarrawonga Rd	721290	7051707
R017	Wallumbilla Creek @ Donnabar	718048	7040403
R018	Pickanjinnie Creek @ Wallumbilla to Roma Condamine Rd	715152	7039284
R019	Yuleba Creek @ Roma Condamine Rd	743164	7023590
R020	Yuleba Creek @ Forestry Rd	745136	7029642
R021	Yuleba Creek @ Warrego Hwy	737891	7054339
R021	Yuleba Creek @ Warrego Hwy	737890	7054335
R022	Kangaroo Creek @ Wallumbilla North Rd	723601	7067184
R023	Cattle Creek @ Cattle Creek Rd	728837	7086154
R024	Bungeworgorai Creek @ Six Mile Rd	681841	7043181
R025	Blyth Creek @ Nth Pickanjinee Rd	666942	7444952
R026	Blyth Creek @ Coxon Creek Rd #1	710336	7082560
R027	Coxon Creek @ Coxon Creek Rd	711305	7081102
R028	Bungil Creek @ Tabers	677439	7077965

Table 4-2 Upper Dawson Catchment Water Monitoring Sites

Site No.	Site Name	Easting	Northing
D001	Dawsons Bend	710193	7152667
D002	Dawson River @ Yebna Crossing	722278	7156525
D003	Pine Creek @ Phelps Rd	736832	7157232
D004	Dawson River @ Taroom-Roma Rd	756620	7144264
D005	Eurombah @ Hornet Bank Rd	753202	7142854
D006	Bridge/Ram Creek @ Roma Rd	760434	7143811
D007	Paddys Creek @ Roma Rd	768265	7145045
D008	Middle Creek @ Roma Rd	775918	7150415
D009	Juandah Creek @ Roma Rd	781471	7156690
D010	Dawson River @ Old Taroom Bridge	780296	7160820
D011	Kinnoul Creek @ Taroom Rd	764200	7158700
D012	Hutton Creek @ Carnarvon Hwy	666569	7151826
D013	Dawson River @ Arcadia Valley Rd	684020	7179844
D016	Dawson River @ Carnavon Hwy	664406	7187427

Table 4-3 Comet-Brown Catchment Water Quality Monitoring Sites

Site No.	Site Name	Easting	Northing
C001	Arcadia Creek @ Arcadia Valley Rd #1	686766	7186920
C002	Basin Creek @ Arcadia Valley Rd	685789	7191402
C003	Arcadia Creek @ Arcadia Valley Rd #2	683500	7205300
C004	Arcadia Creek @ Arcadia Valley Rd #3	678335	7230900
C005	Spring Creek @ Arcadia Rd	675360.5	7213353.7
C006	Moolayember Creek @ Carnarvon Hwy	659023	7228350
C007	Carnarvon Creek @ Carnarvon Hwy	675337	7213367
C008	Carnavon Creek @ Rewan (Plane Crash)	640225	7236901
C009	Comet River @ Rolleston	664205	7293319
C010	Comet River @ Comet Weir	-	-
C011	Triumph Creek @ Rolleston Rd	-	-
C012	Arcadia Ck @ Castle Hill	687425	7194820
C013	Arcadia Ck @ Towrie	684495	7197953
C014	Arcadia Ck @ Sunny Holt	685916	7199345

4.2.2 Analytical Program

Water quality indicators were selected based on parameters of potential concern known to be present in associated water (discussed further in Section 8). In addition analysis was undertaken for parameters for which levels are likely to be altered through the introduction of associated water, such as turbidity, major ions and nutrients.

Where sufficient water was present the following was undertaken:

- In-situ measurements of physical parameters including electrical conductivity (EC), dissolved oxygen (DO), pH, Turbidity and temperature.
- Grab samples were collected during the latter two sampling events and submitted for laboratory analysis of:
  - Total metals (arsenic, boron, cadmium, chromium, copper, iron, lead, nickel, zinc).
  - Total nitrogen (TN) and total phosphorous (TP).
  - Major cations/anions (calcium, chloride, fluoride, magnesium, potassium, sodium, sulphate, alkalinity).
  - Biochemical demand (BOD)[4], chemical oxygen demand (COD), total organic carbon (TOC).
  - Total suspended solids (TSS).

[4] Due to the difficulty in meeting the required holding times of two days for BOD analysis, limited samples were analysed.

4.2.3 Methodology and QAQC

Water quality measurements and samples were collected in general accordance with the *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC & ARMCANZ, 2000), and the *Queensland EPA Water Quality Sampling Manual* (1999).

In-situ measurements of physico-chemical parameters were taken using a calibrated multiprobe TPS90FLT water quality meter or Hydrolab™ DS5X. Calibration certificates are presented in Appendix D.

Grab samples were collected in laboratory prepared sample bottles containing appropriate preservative as required. Disposable gloves were used during sample collection. Samples were stored in eskies on ice, and transported to ALS Brisbane[5] under Chain of Custody (COC) documentation.

Field duplicate quality control samples were collected at an approximate frequency of 1 in 20 samples. A review of the analytical data, methodologies and laboratory QAQC was undertaken. Overall the data is considered representative of field conditions and is suitable for interpretive use. However, the following should be noted:

- Samples collected from the Roma field area on 4 March 2008 exceeded the recommended storage temperature. However, samples were preserved which acts to limit biological activity that may otherwise affect results. Furthermore the temperature of samples upon delivery to the lab did not exceed the temperature of the water body. Therefore the results are considered representative of conditions encountered.
- Samples collected between 4 through 6 March 2008 and submitted for analysis of one or more of TSS and pH were extracted after the recommended holding time due to laboratory error. Discussion with the laboratory indicates the results for TSS are unlikely to be compromised due to the relatively low TSS and BOD concentrations present in the surface waters. pH results obtained are comparable to previous results and therefore considered representative.

4.3 Targeted Data Collection - Condamine - Balonne Continuous Stream Gauging Sites

To enable collection of future continuous flow and water quality information, three permanent stream gauging sites were installed during the dry season (July 2008) across the Roma field (Table 4-4).

Table 4-4 Stream gauging site details

Site	Coordinates (Easting Northing, GDA 94)	Parameters Monitored
Bungil Creek @ Burtons Road	680577 7066480	Height, EC, temperature
Bungil Creek @ Dunkeld Road	696803 7023509	Height, flow, EC, temperature
Wallumbilla Creek @ Roma-Condamine Road	720885 7020424	Height, flow, EC, temperature

[5] ALS is accredited by the National Association of Testing Authorities (NATA) for all analyses undertaken.

Data is measured continually at each site and transmitted via a telemetry system to a central database maintained by Hydro Tasmania Consulting (HTC). On a weekly basis data is verified for quality control purposes and transferred to a secure web-based portal for viewing.

The information collected from these sites will provide an indication of existing conditions prior to discharge of associated water. Should associated water then be discharged into either creek these sites will provide an indication of any resultant changes in water quality and flow. Note at the time of writing there was no water at any of the sites.

Condamine-Balonne Water Quality

5.1 Review of Water Quality Data

Overall there is limited water quality data available for the Condamine-Balonne catchment. URS data provides a reasonable degree of spatial replication albeit over a short time frame, whilst DNRW data provides temporal replication.

QMDC manages an ongoing community monitoring program whereby measures of river health and physical parameters are collected at sites across the catchment. This data is in draft form and has not been subjected to any form of quality control review. However, it does provide a useful point of comparison for other data sets. Generally results obtained are comparable across all data sets.

Bungil, Yuleba and Wallumbilla Creeks and tributaries are generally characterised by levels of EC, turbidity, TSS, various metals (cadmium, chromium, copper, zinc) and nutrients (total N and P) above the guideline trigger values for protection of aquatic ecosystems. When considering the potential affects of discharging associated water to grade, parameters of concern also include temperature, pH and major ions (including sodium, magnesium, potassium and alkalinity).

Summaries of all available water quality data from the Condamine-Balonne River Catchment are provided in Appendix A. Water quality data collected by URS is presented in full in Tables A1 through A3 (attached). DNRW data is presented Tables A4 through A7 (attached). Sites in these tables are ordered from upstream to downstream along the major streams. Results collected by URS and DNRW from the same location and similar time are generally comparable unless otherwise noted. Table 5-1 and Table 5-2 below summarise water quality indicators of interest, discussed further in the following sections.

Table 5-1 Condamine-Balonne Physico-chemical Results Summary

Stream	Parameter	EC (µS/cm)	DO (mg/L)	pH	Turbidity (NTU)	Temp (°C)
	MTV	***325***	***na***	***6.5-8.0***	***50***	***na***
Bungil Creek & Tributaries	n	55	46	49	45	65
	Min	65	2.2	**6.35**	5	9
	Med	238	6.1	7	**112**	23
	Max	**1647**	14.2	**9**	**1645**	28
Bungeworgorai Creek & Tributaries	n	12	12	12	13	12
	Min	3	2.3	**6.48**	27	17
	Med	318	6.1	7	**98**	26
	Max	**535**	11.8	8	**>1000**	29
Wallumbilla Creek & Tributaries	n	10	10	10	10	10
	Min	123	1.9	**5.99**	**71**	16
	Med	204	6.2	7	**142**	23
	Max	**376**	7.0	7	**700**	177
Yuleba Creek & Tributaries	n	10	10	10	10	10
	Min	92	1.9	**6.12**	78	16
	Med	128	3.7	7	**181**	21
	Max	**989**	7.7	7	**471**	28
Blyth Creek & Tributaries	n	6	6	6	5	6
	Min	156	5.3	**6.17**	**72**	18
	Med	263	6.6	7	**83**	27
	Max	**397**	8.5	**9**	**3268**	33

NOTES

Bold Greater than adopted MTV

Includes URS and DNRW data for Bungil Creek and Yuleba Creek.

For consistency DNRW field data has been used in preference to laboratory data where available

Table 5-2 Condamine-Balonne surface water chemistry

Water Quality Indicator		Units	MTV	Bungil Creek & Tributaries				Bungeworgorai Creek & Tributaries				Wallumbilla Creek & Tributaries				Yuleba Creek & Tributaries			
				n	Min	Med	Max	n	Med	Median	Max	n	Min	Med	Max	n	Min	Med	Max
Physico-Chemical	BOD	mg/L	*na*	8	<2	37	41	7	<2	33	41	10	<2	31	49	6	<2	27	69
	COD	mg/L	*na*	11	<5	18.5	95	8	6	9	81	10	<5	8	18	9	7	17	109
	TOC	mg/L	*na*	6	<1	7	12	4	6	6	7	4	7	10.5	12	5	<1	9	50
	TSS	mg/L	*10*	53	5	**86**	**1500**	8	**16**	**50**	**178**	9	**37**	**60**	**131**	17	**10**	**84**	**360**
Metals (Total)	Arsenic	mg/L	*0.007*	11	0.001	0.002	0.003	6	<0.001	0.00125	0.005	8	<0.001	0.00075	0.004	11	0.001	0.003	0.005
	Boron	mg/L	*0.37*	45	0.01	0.05	0.14	6	0.05	0.05	<0.1	8	0.05	0.05	<0.1	18	<0.1	0.05	**0.82**
	Cadmium	mg/L	*0.0002*	11	<0.0001	**0.0002**	0.0014	6	<0.0001	<0.0001	<0.0001	8	<0.0001	0.0001	**0.0003**	11	<0.0001	<0.0001	**0.0003**
	Chromium	mg/L	*0.001*	11	<0.001	**0.002**	**0.006**	6	<0.001	**0.002**	**0.012**	8	<0.001	**0.001**	**0.008**	11	<0.001	**0.003**	**0.007**
	Copper	mg/L	*0.0014*	38	0.001	0.006	0.07	5	<0.002	**0.0025**	**0.008**	8	**0.002**	**0.002**	**0.004**	15	**<0.001**	**0.003**	**0.01**
	Iron	mg/L	*0.2*	4	0.14	**0.53**	**0.98**	3	**0.13**	**0.5**	**17.1**	5	**0.31**	**1.02**	**3.01**	14	**0.2**	**3.35**	**5.7**
	Lead	mg/L	*0.0034*	7	0.002	0.002	0.003	3	<0.001	0.0013	**0.006**	8	<0.001	0.0015	**0.004**	11	0.002	0.002	**0.004**
	Nickel	mg/L	*0.011*	11	0.002	0.004	0.006	6	<0.001	0.003	0.006	8	0.002	0.004	0.007	11	0.002	0.004	0.006
	Zinc	mg/L	*0.008*	11	0.006	**0.017**	**0.022**	6	<0.005	**0.013**	**0.034**	8	0.006	**0.012**	**0.021**	16	0.006	**0.015**	**0.05**
Nutrients	Nitrate and Nitrite (as N)	mg/L	*na*	11	<0.01	0.027	0.057	7	<0.01	0.041	0.132	9	0.01	0.03	0.058	10	0.01	0.058	0.109
	Total Phosphorus as P	mg/L	*0.05*	37	0.01	**0.13**	**1.36**	6	**0.05**	**0.07**	**0.28**	9	<0.01	**0.08**	**0.17**	19	0.05	**0.26**	**0.55**
	Total Nitrogen as N	mg/L	*0.5*	27	0.4	**1.00**	**2.51**	6	**0.7**	**0.85**	**2**	8	**0.6**	**0.7**	**1.2**	15	**0.5**	**1.5**	**3**
Major Ions	Calcium	mg/L	*1000*	51	4.3	19.2	130	7	18	34	49	9	4	16	29	22	4	9	25
	Chloride	mg/L	*175*	48	2.6	11.2	**350**	6	2	22.5	34	8	7	12.5	28	22	<1	11	77
	Fluoride	mg/L	*1*	47	0.02	0.1	0.5	6	<0.1	0.2	0.3	9	<0.1	0.1	0.4	19	<0.1	0.1	0.8
	Magnesium	mg/L	*na*	50	1.1	4	22	7	4	8	13	9	2	6	9	22	1.8	4	11
	Potassium	mg/L	*na*	50	2.2	5.3	11	7	5	6	9	9	6	7	8	22	3.4	6	8.1

Water Quality Indicator	Units	MTV	Bungil Creek & Tributaries				Bungeworgorai Creek & Tributaries				Wallumbilla Creek & Tributaries				Yuleba Creek & Tributaries			
			n	Min	Med	Max	n	Med	Median	Max	n	Min	Med	Max	n	Min	Med	Max
Sodium	mg/L	*115*	48	5.6	22.6	**320.1**	4	18	23.5	33	4	20	23	38	18	9	18	8.1
Sulphate	mg/L	*400*	47	1	8	**558**	7	5	31	50	9	3	22	29	23	1	7.52	230
Total Alkalinity (as $CaCO_3$)	mg/L	*na*	47	25	90.85	422.2	3	65	159	165	4	70	72.5	75	20	20	55	124

NOTES Includes URS and DNRW data for Bungil Creek and Yuleba Creek.
For consistency DNRW field data has been used in preference to laboratory data where available
Where result is less than the laboratory limit of reporting (LOR) a value of half the LOR has been adopted for the purposes of calculating the median
BOLD Greater than adopted MTV

5.1.1 Physico-Chemical Parameters

Dissolved Oxygen (DO)

DO concentrations vary within each stream and across the field area, with many of the reported DO values lower than the typical range of 6-10 mg/L (QLD EPA, 1999). Concentrations less than 5 mg/L may adversely affect biological functioning of a water body and below 2mg/L may cause fish deaths (Chapman, 1998). DO levels vary in response to fluctuating organic matter, water temperature, nutrients, hydrodynamics, pH and biological processes, and are subject to daily and seasonal variation. DO generally decreases with increasing temperature and salinity. Biological respiration also decreases DO concentrations (Chapman, 1998). Intermittent or ephemeral streams with slow flowing or pooled water may demonstrate naturally low and variable DO concentrations due to thermal stratification and organic loading (ANZECC 2000). This may be a factor in the larger pools in Bungil Creek, with DNRW recording a range of 3.7-14.2 mg/L at the Tabers site. URS data tended to be slightly lower for Bungil Creek, in the range of 2-7 mg/L.

Similar variability was observed across the catchment with concentrations as low as 1.9 mg/L detected in Wallumbilla Creek, ranging to a maximum of 11.8 mg/L at Bungeworgorai Ck @ Orallo Road.

Based on observations made during sampling events, the URS data does not appear to show any trends in DO associated with flowing/non-flowing water.

Electrical Conductivity (EC)

Measurements of EC[6] vary markedly across the catchment, within streamlines, and temporally at some locations. EC levels in Bungil Creek fluctuate greatly over time, ranging from 65 µS/cm to a maximum of 1,890 µS/cm at the DNRW Tabers site. During the May 08 sampling event URS found similarly elevated concentrations downstream Bungil Creek at Carnarvon Highway (1,418 µS/cm). QMDC has reported increasing EC concentrations from February through May 08 at Mooga Mooga Creek, which discharges to Bungil Creek downstream of the Tabers site.

EC fluctuates across the remainder of the catchment. Concentrations in Bungil Creek north of Carnarvon Highway and Bungeworgorai Creek are often higher than the MTV of 325 µS/cm. Large fluctuations have also been observed by QMDC in Yuleba Creek (<100 µS/cm to approximately 1900 µS/cm).

EC levels in Wallumbilla, Blythe and Wallumbilla Creeks were predominantly found to be below the MTV at all URS and DNRW sites.

While the higher salinity levels might be attributed to ponding and evaporation of ephemeral streams, this is not observed in all streamlines across the rest of the catchment. High EC levels have been recorded during both wet and dry seasons. Furthermore all URS samples collected in March 2008 and May 2008 were from pools as none of the streamlines were flowing, yet EC results are not necessarily higher during these sampling events. This suggests the possibility of local groundwater - surface water interactions, or point source inputs across the catchment.

Relative EC concentrations across the catchment are presented in Figure 5 (attached).

[6] EC refers to specific electrical conductivity standardised to 25°C. The water quality instruments used automatically correct for temperature.

pH

Surface waters of the Condamine-Balonne Catchment are typically neutral to slightly alkaline, with pH generally falling within the MTV range. DNRW results from Bungil Creek at Tabers range from 6.5 to 8.5, levels supported by URS data (6.4-8). Similar variability was noted in DRNW data from Yuleba Creek and Balonne River, with slightly lower maximum values (<8). URS data showed similar variability, with the exception of a low pH (6) observed in Wallumbilla Creek at Donnabar and a maximum at Blythe Creek at Coxon Creek Road (8.5).

Suspended Solids (TSS) and Turbidity

Turbidity is the reduction of clarity in water due to the presence of suspended or colloidal particles, measured by the amount of light reflected by the particles. Total suspended solids (TSS) is a measure of suspended solids in water which will not settle out by gravity. It is closely related to turbidity; however turbidity also includes plankton and other organisms. Turbidity is affected by a number of factors such as high flow rates and heavy rain, soil erosion, decaying plants/animals and algal blooms, and does not always correlate directly with TSS concentrations as the properties of suspended soils in different water samples may vary causing different effects on light transmission.

Turbidity levels vary considerably across the catchment and between sampling events, influenced by rainfall events and stock access. Frequently higher levels were detected in January/February following heavy rainfall and flooding. Elevated levels were also detected in pools showing evidence of recent stock access (such as Blyth Creek at Coxon Creek Road). Results obtained by DNRW ranged across several orders of magnitude, tending to be higher in the Balonne River (583-3620 NTU) than Bungil and Yuleba Creeks (1.1 to 700 NTU and 80 to 802 NTU respectively[7]). URS found similar variability in results across the catchment, as expected in regions of variable flow. Turbidity in the catchment is naturally high and generally increases with distance downstream (QMDC, 2003; CBWC, 1999).

The majority of turbidity results are greater than the MTV, suggesting a less conservative trigger value would be more appropriate for these ephemeral streamlines.

TSS concentrations were similarly variable across all sites, with concentrations greater than the MTV (10 mg/L) at the majority of sites.

5.1.2 Metals

Results reported are for total metals (unfiltered)[8].

Aluminium

Limited information is available for aluminium concentrations across the catchment. DNRW data indicates intermittent marginal exceedances of the MTV at DNRW Bungil Creek at Tabers and Balonne River at Surat (maximum 0.24 mg/L and 0.8 mg/L respectively). A slightly higher concentration was detected at Yuleba (1.8 mg/L), however there is only one result available.

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[7] Extremely low turbidity measurements in Bungil Creek may be anomalous

[8] Queensland Government Natural Resources and Water, *Water Monitoring Data Collection Standards,* Version 2.1, March 2007

Aluminium is the most abundant metallic element in the lithosphere, but has little or no known biological function. Toxicity to fish and invertebrates is increased at low and high pH (< 5.5 and > 9.0), which is outside of the current pH range observed at all sites. Increased temperature may increase aluminium toxicity. Toxicity is reduced with increases in humic substances (ANZECC & ARMCANZ 2000).

Copper

Copper concentrations are consistently greater than the MTV across all streamlines and tributaries, up to a maximum concentration of 0.07 mg/L recorded by DNRW at Bungil Creek at Tabers. It should be noted that toxicity decreases with increasing hardness and alkalinity of water and therefore trigger values should be altered accordingly. In accordance with the AWQG (Vol 1, Table 3.4.4), based on the hardness of the water in Bungil Creek a factor of up to x5.2 (hardness as $CaCO_3$ of 150 mg/L) can be applied in many instances to results, which gives a less conservative trigger value of 0.007 mg/L.

Copper is found at low concentrations in river systems and is an essential trace element for aquatic organisms. Toxicity decreases with increasing hardness and alkalinity. Levels of dissolved organic matter in most river waters are sufficient to remove copper toxicity. Copper is also strongly adsorbed by suspended material (ANZECC & ARMCANZ 2000).

Cadmium

Cadmium concentrations were found to be marginally higher than the MTV throughout the catchment. With the exception of one high result from Bungil Creek at Dunkeld Road (0.0014 mg/L) concentrations were within the expected error margin of laboratory reporting, and are not considered significant. Furthermore, the toxicity of cadmium reduces with increasing hardness thereby increasing the guideline trigger value. There is no DNRW information available for cadmium.

Chromium

Concentrations of chromium in URS samples were higher than the MTV (0.0002 mg/L) across the catchment, though generally within the same order of magnitude. A maximum concentration of 0.012 mg/L was recorded at Dargal Creek at Hodgsons Lane North. There is no DRNW data for chromium.

Lead

Concentrations of lead were generally below the MTV with the exception of marginally elevated concentrations in samples collected from Dargal Creek at Hodgsons Lane North, Wallumbilla Creek at Donnabar and Cattle Creek at Cattle Creek Road. These results are within the expected range of laboratory error and are not considered to represent a significant water quality issue.

Zinc

Concentrations of zinc were consistently higher than the MTV (0.008 mg/L) across the catchment. Limited DNRW data from Yuleba Creek at Forestry is similar to levels detected in URS samples.

Zinc is an essential trace element that adsorbs to suspended material. Toxicity of zinc can increase with low dissolved oxygen (ANZECC & ARMCANZ, 2000). However, levels of organic matter found in most freshwater streams are generally sufficient to remove zinc toxicity. Given the amount of suspended sediment and relatively low zinc concentrations found in these streams it is unlikely that zinc would present a significant water quality issue.

Iron

Limited information is available regarding iron concentrations across the catchment. Generally concentrations in URS samples were higher than the MTV (0.2 mg/L) in all streamlines, with a maximum of 17.1mg/L recorded at Dargal Creek at Hodgsons Creek Lane North. Slightly lower concentrations of iron were noted in the Yuleba Creek and tributaries (3.2 – 5.38 mg/L) and in Wallumbilla Creek and tributaries (0.31 – 3.01 mg/L). DNRW data is only available for Yuleba Creek, where detected concentrations are of a similar magnitude to URS data (0.6 - 5 mg/L).

Boron

Concentrations of boron across the catchment are generally below the MTV (0.37 mg/L) with the exception of one URS result from Yuleba Creek @ Roma Condamine Road (0.87 mg/L). Boron is not considered to be a water quality issue; however it is potentially a contaminant of concern in associated water.

5.1.3 Nutrients

Concentrations of Total N (TN), nitrate as NO_3 and total P (TP) were consistently above MTV at all DNRW sites: Bungil Creek at Tabers, Balonne River at Surat and Yuleba Creek at Forestry. Similarly URS data indicated TP and TN above the MTV at all sites. Maximum TP concentrations were observed in Bungil Creek (1.36 mg/L), whereas maximum TN was recorded in Yuleba Creek (3 mg/L at Warrego Hwy).

Land uses such as grazing and cropping which are extensive in the vicinity of the monitoring sites are likely to contribute substantially to nutrient and sediment concentrations in the waterways. Run-off from urban sewage and homestead septic systems also contribute to nutrient loads.

5.1.4 Major Ions

Concentrations of chloride were detected above the MTV in DNRW data from Bungil Creek at Tabers. The elevated results occurred concurrently with a period of high salinity, suggesting chloride salts are significant contributors to EC levels. All other concentrations reported for chloride and other major ions are well below the MTVMTV.

5.1.5 Organic Indicators

Levels of total organic carbon (TOC) are generally less than 10 mg/L, which is within the expected range for unpolluted surface waters (Chapman, 1998), with the exception of Kangaroo Creek (50 mg/L). Levels of chemical oxygen demand COD) and biochemical oxygen demand (BOD) are variable. COD in unpolluted surface waters is generally less than 20 mg/L (Chapman, 1998). Results obtained from Yuleba Creek are of a magnitude that suggests effluent impacts. Levels of BOD for unpolluted surface water are generally less than 2 mg/L (Chapman, 1998). However, median concentrations of BOD were approximately 30 mg/L across the catchment. The elevated results suggest point source influences possible relating to cattle access, homestead septic systems and surface runoff. The elevated levels of organic indicators are likely also attributed to the stagnant ponding at many of the sample locations.

5.2 Summary

Streams in the Condamine-Balonne catchment relevant to the development of the Roma Field are generally characterised by the following:

- pH in the range 6.5 to 9.0 which is wider than the recommended MTV pH range (6.5 – 8.0).
- Very low dissolved oxygen levels have been identified (as low as 1.9 mg/L) and correlate with relatively high chemical and biological oxygen demand results. For Yuleba Creek the levels of BOD suggest point source impacts.
- Wide fluctuations in electrical conductivity are evident in the streams with Bungil Creek range 65 – 1647 µS/cm, Wallumbilla 123 – 376 µS/cm, Yuleba 92 – 989 µS/cm and Blyth 156 – 397 µS/cm. Bungil Creek is near the west of the Roma Field, and Yuleba lies to the East.
- Sodium concentrations below the MTV, with a maximum observed concentration of 38 mg/L.
- Chloride concentrations predominantly below the MTV.
- Fluoride concentrations below the MTV (1 mg/L).
- Boron concentrations below the MTV, with the exception of a single result in Yuleba Creek.
- Waters are often nutrient enriched with total phosphorus often well above the MTV (maximum observed concentration 1.36 mg/L) and total nitrogen often exceeding the MTV by a factor of two. Ammonia-N (by calculation) is around 0.02 - 0.04 mg/L compared with trigger values of 0.02 mg/L (QWQG) and 0.9 mg/L (ANZECC & AMRCANZ (2000)).
- Turbidity and total suspended solids samples are extremely high in comparison with relevant MTV.
- Copper concentrations are consistently higher than the MTV (0.0014 mg/L) for all streamlines. Application of the AWQG suggests a revised WQO should be 0.007 mg/L when the hardness of the water is accounted for.
- Iron is elevated with widespread exceedance of the recommended WQO (0.2 mg/L). The maximum observed concentration is 17.1 mg/L.
- Zinc regularly exceeds the MTV (0.008 mg/L). The maximum observed concentration is 0.034 mg/L.
- In approximately 50% of samples, lead concentrations exceed the MTV. The maximum observed concentration is 0.006 mg/L.

Upper Dawson Catchment Existing Environment

6.1 Review of Water Quality Data

Tributaries of the Dawson River, Baffle Creek and Hutton Creek, currently receive associated water discharge from CSG operations at Fairview. This section provides an outline of water quality in streams upstream of any associated water discharge.

The Upper Baffle Creek, Upper Hutton Creek and Upper Dawson River water quality monitoring sites lie above any influence from associated water discharge. Tributaries flowing into Dawson River are similarly unaffected. A comparison of water quality results within waters not receiving associated water discharge with the MTVs (Table 6-1) is provided below.

Summaries of all available water quality data from the Upper Dawson River Catchment are provided in Appendix B. Water quality data collected by URS is presented in full in Tables B1 through B2 (attached). DNRW data is presented Tables B3 through B9 (attached). Results collected by URS and DNRW from the same location and similar time are generally comparable unless otherwise noted.

Table 6-1 Water quality in the Upper Dawson Catchment

Water Quality Indicator		Units	MTV	Upper Dawson River				Dawson R at Yebna Crossing				Dawson R at Utopia				Dawson R at Taroom			
				Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	340	50	215	1702	12	110	247	435	46	78	289	551	139	87	260	525	288
	pH	Stand	6.5-8.0	6.6	7	7.1	5	7.2	7.75	8	6	7	7.81	8.5	138	6.5	7.6	8.5	228
	Temperature	C		15.4	25.5	28	12	12	24	28	43	8	22	77	122	9	23.1	31	182
	Total dissolved solids	mg/L	1000	46	146	194	12	75	168	296	46	58	160	317	130	60	152	306	173
	TSS	mg/L	10	52	75	125	4	2	8	142	5	0	14.5	2460	114	2	50	4900	126
Inorganic Non-Metallic Parameters	Bicarbonate Alkalinity	mg/L - CaCO3	-	28	95	151	5	87	113.5	130	6	24	134	289	130				
	Chloride	mg/L	175	3	8	12	5	19	20.5	22	6	3	25	70	130	4	20.6	59.9	140
	Fluoride	mg/L	1	0.1	0.1	0.24	5	<0.1	0.13	0.23	6	0.06	0.11	0.4	126	0.08	0.13	0.7	132
	Sulphate	mg/L	400	<1	5	<10	5	<1	7.5	<10	6	0	2	13	97	0	2	11	116
Cations	Calcium	mg/L	1000	1	6	18	5	7	10.8	17	6	5.2	17	40	130	4.3	18	44	140
	Magnesium	mg/L		1	5	6.1	5	4	5.5	6.2	6	1.5	6.5	15	130	1.4	5.2	11.8	140
	Potassium	mg/L		<1	6	10.7	5	3	3.2	6	6	2.2	4	7.7	121	2.4	5.1	7.5	130
	Sodium	mg/L	115	3	11	22	5	27	28	33	6	7.5	32.7	112	130	7.7	28	65.8	140
Nutrients	Ammonia-Nitrogen	µg/L	20	10		590	3	<10	10	14	3	0	20.1	150	56	4.3	31.8	163	53
	Nitrate as (NO_3^-)	mg/L			128		1		<44		1	2	192	7724	81	160	1080	10000	102
	Total Phosphorous	mg/L - P	50	<10	125	1900	4	<10	40	280	5	3	55	550	59	4	157	1387	71
Metals	Boron	µg/L	370	<0.1	23	500	5	<0.1	8	600	6	0	0.02	100	73	10	50	1000	73
	Iron	µg/L	200	4407		5100	2	76		390	3	1	165	460	3	10	60	4800	93
	Lead	µg/L	3.4	<1		3	2		<1		2		<1		3				
	Zinc	µg/L	8	<1		14	2	<1		<10	2	<1		<10	2	10	20	700	60

NOTES: **BOLD** Greater than MTV

Refer Section 3.3.2 regarding use of data for Dawson River downstream of associated water discharges

6.1.1 Physico-Chemical Parameters

Dissolved Oxygen (DO)

Many of the reported DO values are lower than the typical range for surface waters of 6-10mg/L (QLD EPA, 1999). Intermittent or ephemeral streams with slow flowing or pooled water may demonstrate naturally low and variable DO concentrations due to thermal stratification and organic loading (ANZECC 2000). This may be a factor in a large pool monitored in Upper Baffle Creek, where DO measurements range from approximately 2 mg/L to 11 mg/L. Less variability was observed in continuous data obtained from a smaller pool in Upper Hutton Creek (approximately 4-10 mg/L).

Electrical Conductivity

Electrical conductivity measurements from streams that do not receive associated water discharge range from less than 100 µS/cm to approximately 1,800 µS/cm in sites in Upper Baffle Creek (Santos, various). The results at the upper end of the range are higher than would be reasonable expected based on EC levels across the catchment. It is noted the range of EC reported in Upper Baffle Creek is substantial, with results either well above 1000 µS/cm or less than 200 µS/cm. There is insufficient information to ascertain the likely cause of the elevated results.

EC in upstream waters fluctuates as expected likely in response to rainfall events, erosion caused by cattle access and agricultural practices. Figure 6-1 below shows continuous EC levels at Upper Hutton Creek over a period of approximately six weeks.

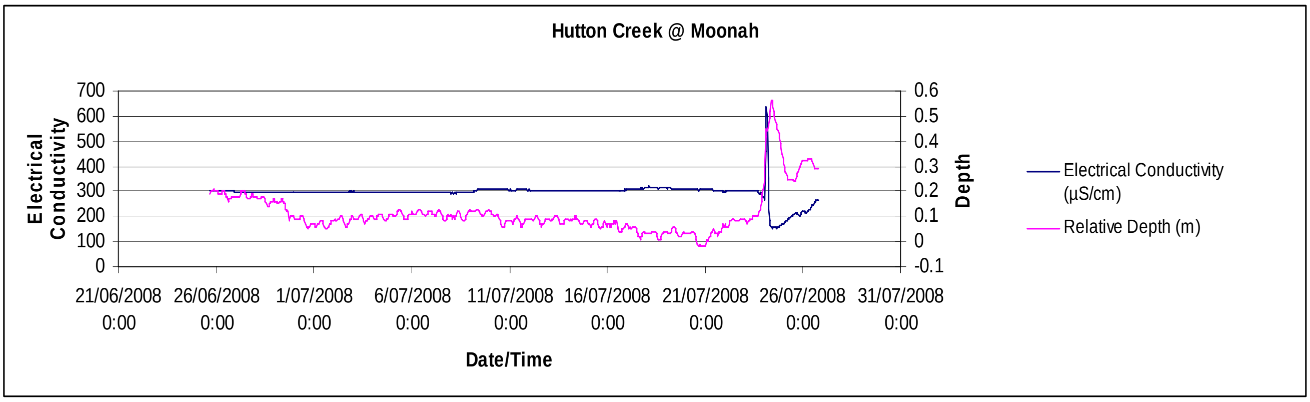


Figure 6-1 Hutton Creek at Moonah continuous EC and relative depth

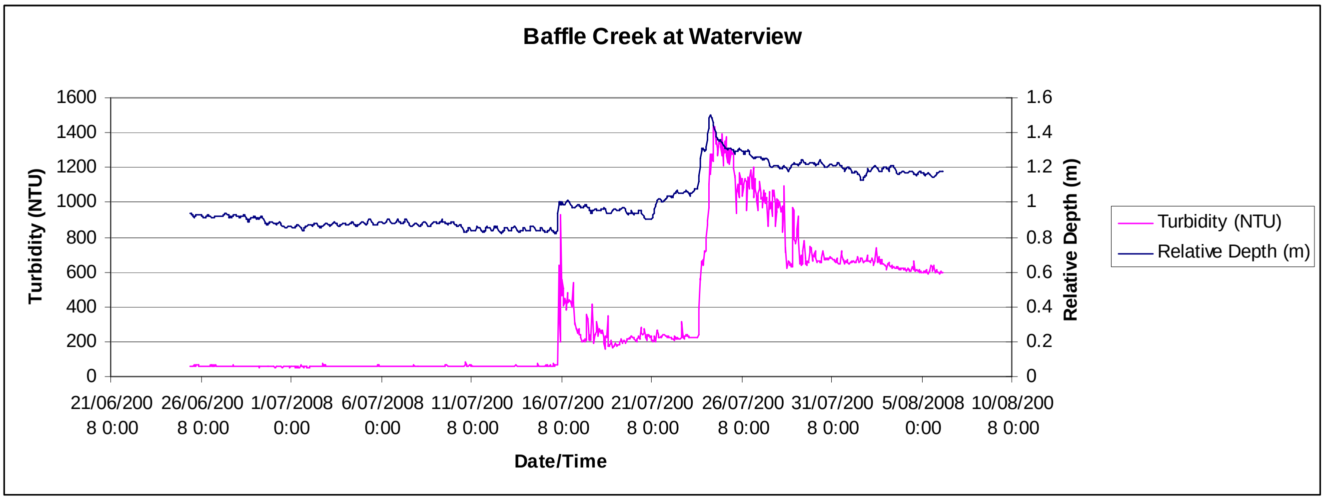
pH

Waters in the Upper Dawson catchment are typically neutral to slightly alkaline (pH~8). Recent field sampling shows some of the smaller tributaries of the Dawson River naturally have pH circa 8.5. Continuous monitoring at Upper Hutton Creek during May through September 2008 indicated typically neutral conditions (pH~6.8-7.8), whereas waters at Upper Baffle Creek are slightly more alkaline (pH~7-8.2).

High Suspended Solids (TSS) and High Turbidity

Turbidity levels vary considerably across the catchment and between sampling events, influenced by rainfall events and stock access. Levels are frequently above the MTV. The soils and slopes in the area are susceptible to erosion, which has been exacerbated by the removal of vegetation in agricultural areas, and unrestricted stock access to streams. The nature of flooding in the area is a major factor driving suspended solids transport and erosion processes.

Figure 6-2 shows a typical increase in turbidity levels at Upper Baffle Creek (Waterview) following a rainfall event.



NOTE: relative depth measurement for comparison purposes does not represent true depth

Figure 6-2 Baffle Creek at Waterview – turbidity

6.1.2 Metals

Boron

Concentrations of Boron were predominantly below the MTV upstream of associated discharges with the exception of two slightly elevated concentrations in Dawson waterhole and Upper Baffle Creek.

Cadmium

Cadmium concentrations were found to be intermittently marginally higher than the MTV throughout the catchment. However, concentrations were within the expected error margin of laboratory reporting, and are not considered to present a significant water quality issue.

Copper

There are limited results for copper from upstream tributaries. However samples collected from other tributaries across the catchment indicate copper concentrations greater than the MTV.

Iron

There are a number of iron concentrations above the MTV observed at sites in Baffle and Hutton Creeks and Dawson River upstream of associated water discharges. Iron does not present a risk to livestock or ecosystem health at the concentrations detected.

Lead

Concentrations of lead marginally higher than the MTV were detected at the majority of locations sampled by URS. It is noted there is limited data available. Lead is generally present in very low concentrations in natural waters and is readily adsorbed to suspended matter.

Zinc

Several concentrations of zinc marginally greater than the MTV were detected at sites upstream of associated water discharges in both DNRW and URS data. Toxicity of zinc can increase with low dissolved oxygen (ANZECC & ARMCANZ, 2000). However, levels of organic matter found in most freshwater streams are generally sufficient to remove zinc toxicity. Given the amount of suspended sediment and relatively low zinc concentrations found in these streams it is unlikely that zinc would present a significant water quality issue.

6.1.3 Nutrients

Limited results for total nitrogen (TN), total phosphorous (TP) and ammonia from streams that do not receive associated water discharges indicate that nutrients are generally higher than the MTV. Elevated nutrient levels are associated with high turbidity, high TSS and high Chlorophyll. The levels exhibited are possibly due to the general erosive nature of soils and the extensive land clearing and grazing activities in the catchment.

6.1.4 Organic Indicators

Levels of total organic carbon (TOC) are less than 10 mg/L, which is within the expected range for unpolluted surface waters (Chapman, 1998). Levels of chemical oxygen demand (COD) and biochemical oxygen demand (BOD) are variable. COD in unpolluted surface waters is generally less than 20 mg/L, however results of up to circa 80mg/L were obtained in some tributaries of the Dawson River. Levels of BOD for unpolluted surface water are generally less than 2 mg/L (Chapman, 1998). However, median concentrations of BOD were approximately 14 mg/L across the catchment. The elevated results suggest point source influences possibly relating to cattle access, homestead septic systems and surface runoff. The elevated levels of organic indicators are likely also attributed to the stagnant ponding at many of the sample locations.

6.2 Summary

Streams in the Upper Dawson River catchment unaffected by associated water discharges and relevant to the development of the Fairview Field are typically characterised by the following:

- pH in the range 6.5 to 8.5 which is slightly wider than the recommended pH range (MTV range 6.5 – 8.0).
- Very low dissolved oxygen levels have been identified (as low as 2 mg/L) and support records of relatively high chemical and biological oxygen demands.
- Wide fluctuations in electrical conductivity are evident in the streams with Baffle Creek (100 – 1800 µS/cm), in Upper Hutton Creek EC range of 150 – 650 µS/cm has been observed in one small rainfall event, and in

Dawson River at Utopia EC has been recorded as high as 800 µS/cm. Typical EC under low flow conditions is circa 300 µS/cm.

- Sodium concentrations are all well below the MTV with typical range 20 – 30 mg/L.
- Most chloride concentrations are below the MTV with observed range 1 – 39 mg/L.
- Fluoride concentrations are all below the MTV with a range of 0.1 – 0.4 mg/L.
- Boron concentrations are below the recommended WQO with a range of 0.05 – <0.1 mg/L.
- There is evidence of eutrophication in-stream with elevated nutrients, turbidity, suspended solids and chlorophyll-a. Ammonia (by calculation from nutrient data) lies in the range 0.02 – 0.05 mg/L compared to QWQG trigger for protection of aquatic ecosystems (0.02 mg/L) and ANZECC & ARMCANZ (2000) 0.9 mg/L. Turbidity and total suspended solids samples exhibit a large range of readings with typical turbidity circa 50 NTU (well above recommended the MTV).
- Phosphorus concentrations are higher than the MTV (0.05 mg/L) and is found in the range <0.01 – 0.56 mg/L.
- Copper concentrations are consistently higher than the MTV (0.0014 mg/L) for most streamlines.
- Iron concentrations are elevated and are often above the recommended MTV (0.2 mg/L).
- Zinc is often found to exceed the MTV (0.008 mg/L) with a maximum observed concentration of 0.034 mg/L.
- Lead is often found to be higher than recommended MTV (0.0034 mg/L), with maximum concentration 0.007 mg/L.

Comet-Brown Catchment Water Quality

7.1 Review of Water Quality Data

Limited information is available regarding water quality across the Comet-Brown catchment, particularly in southern Arcadia. DNRW sites provide spot water quality data from major tributaries and the Comet-Brown river, primarily north of Rolleston. DNRW also maintain continuous flow and water quality monitoring sites on Carnarvon Creek and the Comet-Brown River (Figure 7-1). URS collected limited data from Arcadia Creek though this is limited due to access restrictions.

The following provides a discussion of parameters exhibiting concentrations great than the MTVs (Table 3-4), as well as parameters of concern identified in associated water. Water quality data collected by URS is presented in Tables C1 and C2 (attached). DNRW data is summarised in Table C3, and presented in full in Tables C3 through C11 (attached).

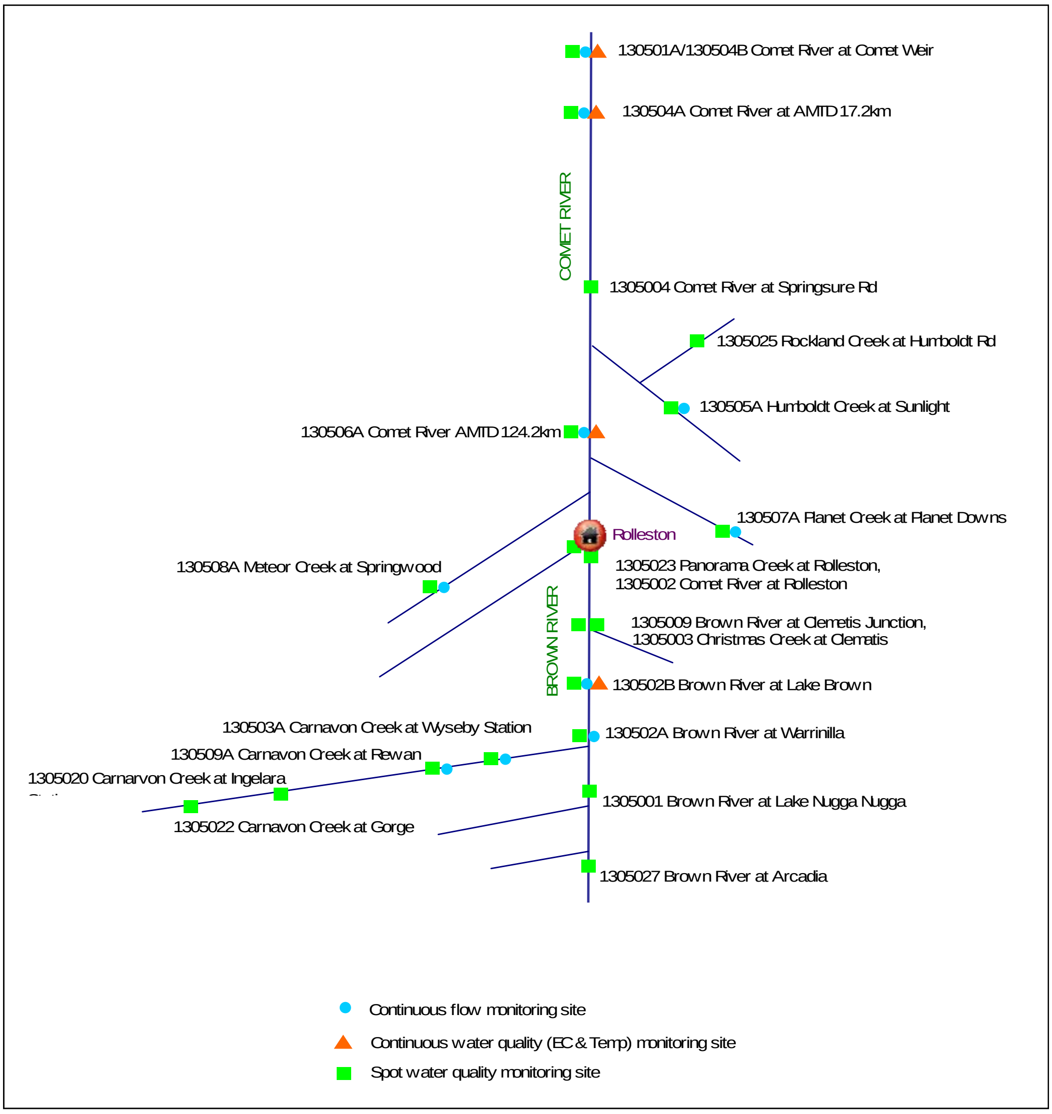


Figure 7-1 Water quality and flow sites Comet-Brown River catchment

7.1.1 Physico-Chemical Parameters

pH

pH is observed in the range 5.5 – 9.0 which is wider than the recommended WQO. Streams in the Arcadia Creek area tend to be acidic to circumneutral (pH 5.5 – 7.5) while streams lower down the catchment are circumneutral to alkaline (pH 6.5 – 9.0).

Dissolved Oxygen (DO)

DO levels vary considerably across all sites as expected, influenced by fluctuating organic matter, water temperature, nutrients, hydrodynamics, pH and biological processes. DO levels are also subject to daily and seasonal variation. Intermittent or ephemeral streams with slow flowing or pooled water may demonstrate naturally low and variable DO concentrations due to thermal stratification and organic loading (ANZECC 2000).

Fairly low DO levels (as low as 2 mg/L) have been observed across the catchment, likely resulting from the ephemeral nature of the streams. The highest level recorded (17.5 mg/L at Brown River u/s Rolleston) is unlikely to be representative of actual conditions. It is noted there is limited data available for water bodies other than Brown/Comet River and Carnarvon Creek.

Electrical Conductivity (EC)

Continuous data is available for electrical conductivity and temperature as shown in Figure 7-2. Graphs presented in this figure also depict flow (discharge) conditions to aid interpretation. Significant issues with the data are apparent at each site. For example high EC variability from the Brown River at Lake Brown suggests no correction for temperature. Most sites have substantial periods of missing data. Missing data may be associated with drying of waterways as instruments are left high and dry, but detailed further investigation is needed to validate the data prior to use. There are also a number of significant shifts in EC without apparent reason.

It is also notable that excursions to high EC level appear to be event based (they peak quickly and show a slower recovery to normal conditions) but seem to be unrelated to flow conditions. This may suggest low flow point source discharges of some kind.

A review of spot EC measurements collected by DNRW and URS from upstream to downstream indicates:

- Brown River upstream of Rolleston and Comet River at Rolleston EC levels are generally less than the MTV.
- Levels at Carnarvon Creek, flowing into the Comet River from the west tended to be marginally higher than the MTV (median 434 µS/cm).
- Creeks entering Comet River from the east, downstream of Rolleston including Meteor Creek and Planet Creek exhibit consistently elevated EC levels above the MTV (medians 615 µS/cm and 690 µS/cm, maximums 810 µS/cm and 1080 µS/cm respectively). It is noted these this is based on historical data collected between 1973 and 1993. It is not known whether the methodology used at this time has any implications on the higher ECs recorded.
- Comet River downstream of Rolleston and Meteor/Planet Creeks exhibits levels intermittently above the WQO, though median concentrations are circa 240 µS/cm. Similar readings are recorded downstream at Comet Weir. The highest results were generally recorded from 1972 to 1991, in keeping with elevated

readings noted in upstream Meteor/Planet Creeks. It was not possible to access these creeks and collect validation measurements during the field programs.

- EC levels within Humboldt Creek are historically less than the MTV. However, there are a limited number of measurements available.

Relative EC levels (from spot water quality monitoring) across the catchment are shown in Figure 7 (attached).

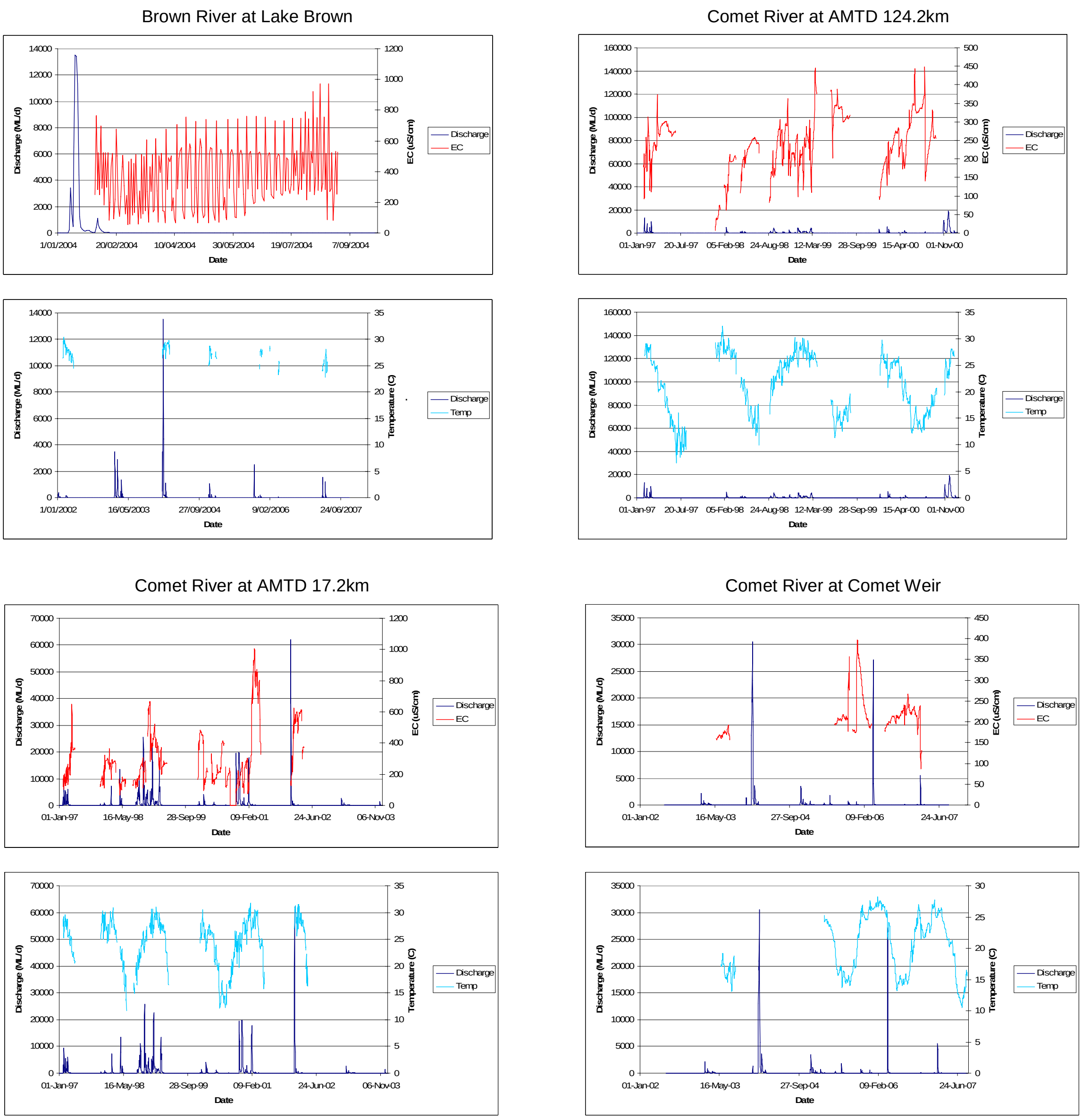


Figure 7-2 DNRW continuous water quality data Comet-Brown river catchment

Total Suspended Solids (TSS) and High Turbidity

The soils and slopes in the area are susceptible to erosion. This has been exacerbated by the removal of vegetation in agricultural areas, and unrestricted stock access to streams. The nature of flooding in the area is a major factor driving suspended solids transport and erosion processes.

Observations relating to turbidity and TSS measurements from upstream to downstream in the catchment are as follows:

- Turbidity in Arcadia Creek, Basin Creek and Brown Creek is variable, at times greater than the MTV but generally less than 300 NTU.
- Tributaries Carnarvon Creek, Meteor Creek and Planet Creek exhibit low turbidity with occasional spikes to above the MTV.
- Turbidity in the Comet River at Rolleston is moderate (median circa 150 NTU), but increases substantially downstream to a median turbidity around 800 NTU. The two available data points from Humboldt and Rockand Creeks are of similar magnitude (median 650 NTU).
- Downstream Comet River towards the outflow turbidity is extremely variable, with a median of 690 NTU, reaching a maximum of approximately 9000 NTU.
- There are inconsistencies between field and lab measurements of turbidity in DNRW data, with at times an order of magnitude difference between results. Storage of samples for turbidity analysis can lead to settling and precipitation due to pH changes, resulting in altered turbidity results.
- TSS concentrations are greater than the MTV across much of the catchment. Generally TSS results mirror the turbidity results. It is noted the MTV for TSS appears to provide a more sensitive measure of water quality than the MTV for turbidity, with a great number of samples exceeding the TSS MTV.

7.1.2 Metals

Samples collected by URS were submitted for analysis of total metals (unfiltered). Similarly DNRW samples were unfiltered for total metal analysis[9].

Aluminium

Based on the limited aluminium concentration data recorded, it is difficult to draw conclusions about the elevated levels compared with MTVs measured at various sites. Reported concentrations of aluminium were intermittently higher than the MTVs across the catchment. Results were reasonably consistent, with minimum and maximum concentrations within one order of magnitude.

Copper

Copper concentrations were greater than the MTV at all sampling sites and during the majority of sampling events, across the Comet Catchment. There are limited data points available for all tributaries; the most samples were taken from Brown and Comet Rivers. It appears the laboratory limit of reporting for copper

[9] Queensland Government Natural Resources and Water, *Water Monitoring Data Collection Standards,* Version 2.1, March 2007

analysis in the DNRW is an order of magnitude higher than the MTV, therefore making comparisons unreliable. However the limited URS results indicate concentrations in Arcadia and Carnarvon Creeks are marginally but consistently above the MTV.

Cadmium, Chromium and Lead

There is limited data for cadmium, chromium and lead concentrations in the catchment. Two DNRW samples from Comet Weir returned concentrations of cadmium and chromium above the MTV. Samples collected by URS from southern Arcadia contained concentrations of cadmium and/or chromium marginally above the MTV at Basin Creek, Arcadia Creek and Carnarvon Creek. There is no information for the central portion of the catchment.

Nickel, Zinc and Lead

URS samples from Arcadia Creek (Arcadia Valley Rd #2) and Basin Creek contained concentrations of nickel, zinc and lead above the MTVs. Other samples from southern Arcadia (including Arcadia Creek and Carnarvon Creek) were below the MTVs. There is no DNRW data available for these metals.

Iron Content

Of the five samples from southern Arcadia analysed for iron, four returned concentrations great the MTV (Basin Creek and Arcadia Creek). There is insufficient data to draw any conclusions. Iron does not present a risk to livestock or ecosystem health at the concentrations detected (ANZECC & ARMCANZ, 2000).

Boron

Concentrations of Boron are below the MTV across the catchment, with a maximum concentration of circa 0.1 mg/L. Boron is a potential contaminant of concern in associated water.

7.1.3 Nutrients

Nutrient enrichment, high ammonia, total nitrogen (TN) and total phosphorus (TP) levels at sites in the Comet/Brown Catchment suggest that these water quality issues are likely to be due to the general erosive nature of soils and existing grazing activities in the catchment. Concentrations of TN/TP increase in the Comet River at, and downstream of Rolleston, with all results greater than the MTV. Concentrations of ammonia are also intermittently above the QWQG trigger for protection of aquatic ecosystems. There is limited or no information is available for tributaries. Limited data points from Carnarvon Creek are at or below the MTVs.

The recorded phosphorus levels of up to 2.8 mg/L in the lower Comet River are similar to levels present in raw sewage. It is noted that Rolleston is un-sewered and relies on an ageing septic system. Elevated phosphorous, nitrate and ammonia concentrations may also be attributed to runoff from agricultural practices and stock access.

7.1.4 Organic Indicators

Limited data is available for the Comet-Brown Catchment. Levels of TOC in Carnarvon and Arcadia Creeks are all less then 1 mg/L, which is within the expected range for unpolluted surface waters (Chapman, 1998). Levels of chemical oxygen demand COD) and biochemical oxygen demand (BOD) are variable. COD in unpolluted surface waters is generally less than 20 mg/L, however results obtained from Arcadic Creek reach a maximum of 85 mg/L. Similarly whilst levels of BOD for unpolluted surface water are generally less than 2 mg/L

(Chapman, 1998), however median concentrations of BOD were approximately 40 mg/L across the catchment. The elevated results suggest point source influences possible relating to cattle access, homestead septic systems and surface runoff. The elevated levels of organic indicators are likely also attributed to the stagnant ponding at many of the sample locations.

7.2 Summary

Streams in the Comet-Brown River catchment are relevant to the development of the Arcadia Field. They typically have:

- pH in the range 6.5 to 9.0 which is outside the recommended MTV pH range (6.5 – 8.0).
- Very low dissolved oxygen levels have been identified (as low as 2 mg/L) with high BOD across the catchment and elevated COD circa Arcadia Creek.
- Wide fluctuations in electrical conductivity are evident instream regardless of location in the catchment. Low EC is recorded in the upper catchment (Arcadia Creek is typically 200 – 250 µS/cm), and similar median EC readings are observed on the main river at Rolleston and Comet Weir. Median EC is higher in streams on the eastern side of the catchment and elevated in Carnarvon Creek to the west.
- Sodium is almost always below the MTV with a typical concentration of ~40 mg/L.
- Most chloride concentrations are below the MTV. However, there appears to be some input from Planet Creek lower in the catchment.
- Fluoride concentrations are all below the MTV (1 mg/L).
- Boron concentrations are all below the recommended MTV.
- Waters are often eutrophic with ammonia and phosphorus regularly recorded above the recommended MTVs. Total nitrogen often exceeds the MTV by a factor of at least two. Turbidity and total suspended solids samples are extremely high in comparison with recommended MTVs.
- Copper concentrations are consistently higher than the MTV (0.0014 mg/L) for all streamlines and often appear to be approximately three times higher.
- Iron concentrations are greater than the MTV (0.2 mg/L), with a maximum observed concentration of 0.98 mg/L. A limited number (5) samples are available.
- Very few records of zinc concentrations are available. In some cases concentrations exceed the MTV (0.008 mg/L) by a factor of 4.
- Lead exceedances of MTV are evident in approximately 50% of limited samples taken for this project.

8.1 Water Quality of Associated Water at Fairview and Roma

There is currently no information available regarding the chemistry of associated water likely to be produced in the Arcadia Field (Comet-Brown catchment). However, there are a significant number of samples at Fairview Field and just over 100 samples from Roma Field. Fairview samples cover a much wider range of parameters than is available at Roma.

Table 8-2 and Table 8-3 show the quartiles[10] of water quality parameters for the Fairview and Roma samples and their relationship to water quality guidelines. Shaded quartiles with bold text indicate exceedance of the MTV. Bold text only indicates equivalence to the MTV. Only those water quality parameters of general interest or exceedance are shown. Full descriptive statistics are provided in Appendix E.

It should be noted that these tables utilise the limit of reporting in the calculation of statistics rather than adopting a zero concentration or ½ the limit of reporting. Thus they are inherently conservative. For example, some parameters such as cadmium and silver are unlikely to be a problem since the range of values is effectively always below the limit of reporting although these limits are higher than the corresponding MTV.

A number of water quality parameters exceed guidelines in 75% of wells, some exceed guidelines in 50% of wells and some exceed guidelines at the majority of wells.

The following parameters were identified as exceeding trigger values and warrant further investigation:

Table 8-1 Associated water quality parameters for further review

- Dissolved oxygen
- Temperature*
- pH
- Electrical conductivity (and TDS)
- Chloride
- Sodium
- Ammonia
- Aluminium
- Boron
- Cadmium
- Cobalt
- Copper
- Cyanide
- Fluoride
- Iron
- Lead
- Silver
- Sodium
- Zinc

[10] The first quartile (Q1) is the value below which 25% of observations lie, the second quartile (Q2) is equivalent to the median, and the third quartile (Q3) is the value below which 75% of observations lie.

Table 8-2 Fairview field wellhead water quality –parameters for further investigation

					QWQG 2006		ANZECC GUIDELINES 2000					
Variable	Units	Q1	Median	Q3	Lowland	Upland	Aquatic Ecosystems	Stockwater	Irrigation	Recreation	Drinking Water	MTV
pH		**8.3**	**8.6**	**8.76**	6.5-8.0	6.5-7.5	n/a	n/a	6-9	6.5-8.5	n/a	6.5-8.0
Conductivity	uS/cm	**1419**	**1840**	**2458**	340[d]	340[d]	n/a	n/a	650[e]	n/a	n/a	340[a]
Total Dissolved Solids	mg/L	**1420**	**2000**	**2985**	-	-	-	4000[f]	-	1000	n/a	1000
Dissolved O2	mg/L (%)	**3.4 (55)**	**4.1 (66)**	**5 (80)**	(85-110)	(90-110)	n/a	n/a	n/a	>80	n/a	(85-110)
Turbidity	NTU	0.225	0.8	2.05	50	25	n/a	n/a	n/a	n/a	n/a	50
Chemical Oxygen Demand	mg/L	23	72	546							n/a	
Suspended Solids	mg/L	5	**10**	**209**	10	-	n/a	n/a	n/a	1000	n/a	10
Tot Alkalinity	mg/L	750.8	861.5	1040							n/a	
Bicarbonate Alkalinity	mg/L	691	788	958.8							n/a	-
Ammonia N	mg/L	**0.32**	**0.4125**	**0.5845**	0.02	0.01	0.9	n/a	n/a	n/a	n/a	0.02
Total Organic Carbon	mg/L	7.6	21	61							n/a	
Aluminium	mg/L	0.02	**0.09**	**0.22**			0.055	5	5		n/a	0.055
Boron as B	mg/L	**0.516**	**0.711**	**1.019**	-	-	0.37	5[i]	0.5	1	n/a	0.37
Cadmium	mg/L	**0.001**	**0.001**	**0.005**	-	-	0.0002	0.01[g]	0.01	0.005	n/a	0.0002
Calcium	mg/L	1	1.2	2.46	-	-		1000	-	-	n/a	1000
Chloride	mg/L	20	55	125	-	-	-	-	175[e]	400	n/a	175
Chromium	mg/L	**0.001**	**0.001**	**0.01**	-	-	0.001 (CrVI)	1[g]	0.1	0.05	n/a	0.001
Cobalt	mg/L	**0.002**	**0.002**	**0.01**			0.001	1	0.05	1	n/a	0.001
Copper	mg/L	**0.002**	**0.005**	**0.02**	-	-	0.0014	1[g]	0.2	1	n/a	0.0014
Fluoride by ISE	mg/L	**1.4**	**1.9**	**2.71**	-	-		2[g]	1		n/a	1
Iron	mg/L	0.1	**0.27**	**0.81**	-	-			0.2	0.3	n/a	0.2
Iron (Soluble)	mg/L	0.091	**0.226**	**0.647**					0.2	0.3	n/a	0.2
Lead	mg/L	**0.005**	**0.009**	**0.04**	-	-	0.0034	0.1[g]	0.2	0.05	n/a	0.0034
Mercury	mg/L	0.0001	**0.0006**	**0.1**	-	-	0.0006	0.002	0.002	0.001	n/a	0.0006
Molybdenum	mg/L	0.005	0.005	**0.01**	-	-	-	0.15	0.01	-	n/a	0.01
Phosphorous	mg/L	0.02	0.04	**0.06**	0.05	0.03	n/a	n/a	0.05	n/a	n/a	0.05

					QWQG 2006		ANZECC GUIDELINES 2000					
Variable	Units	Q1	Median	Q3	Lowland	Upland	Aquatic Ecosystems	Stockwater	Irrigation	Recreation	Drinking Water	MTV
Potassium	mg/L	2	2.4	4.6	-	-	-	-	-	-	n/a	-
Silica	mg/L	23.64	37.67	80.73							n/a	
Silver	mg/L	**0.001**	**0.001**	**0.001**			0.00005				n/a	0.00005
Sodium	mg/L	**366**	**466**	**657**	-	-	-	-	115[e]	300	n/a	115
Sodium Adsorption Ratio	mg/L	84.6	106	122							n/a	
Sulphate	mg/L	1	1	2.5	-	-		<1000		400	n/a	400
Cyanide	mg/L	**0.01**	**0.01**	**0.01**			0.007				n/a	0.007
Zinc	mg/L	0.006	**0.018**	**0.06**	-	-	0.008	20	2	5	n/a	0.008

Table 8-3 Roma field wellhead water quality –parameters for further investigation

					QWQG 2006		ANZECC GUIDELINES 2000					
Variable	Units	Q1	Median	Q3	Lowland	Upland	Aquatic Ecosystems	Stockwater	Irrigation	Recreation	Drinking Water	MTV
Barium	mg/L	0.223	0.246	0.309	-	-	-	-	-	-	0.7	0.7
Bicarbonate (HCO3)	mg/L	651	821	991	-	-	-	-	-	-	-	-
Calcium	mg/L	3	10.1	73.4	-	-	-	1000	-	-	-	1000
Chloride	mg/L	**555**	**701**	**1130**	-	-	-	-	175	400	250	175
Conductivity	uS/cm @25 C	**3200**	**3610**	**6200**	340	340	n/a	n/a	650	n/a	n/a	340
Fluoride	mg/L	**1.2**	**2**	**2.8**	-	-	-	2	1	-	1.5	1
Iron	mg/L	0.1	**3**	**117.5**	-	-	0.3 (interim)	-	0.2	0.3	0.3	0.2
Potassium	mg/L	4	47	769	-	-	-	-	-	-	-	-
pH	pH units	**8.4**	**8.7**	**8.9**	6.5-8.0	6.5-7.5	n/a	n/a	6.0-9.0	6.5-8.5	6.5-8.5	6.5-8.0
Sodium	mg/L	**630**	**792**	**950**	-	-	-	-	115	300	180	115
Sulphate	mg/L	1.66	4	18	-	-	-	<1000		400	250	250
TDS(EC)	mg/L	**1918**	**2300**	**4040**	-	-	-	4000	-	1000	500	500

8.2 Investigation of Associated Water Quality - Roma and Fairview Fields

The water quality data for individual parameters is often significantly skewed with a few large outliers, though parameters such as pH, bicarbonate, total alkalinity and dissolved oxygen are symmetrically distributed. Distributions of relevant water quality parameters are shown in Figure 8-1 and Figure 8-2 for the Roma Field, and in Figure 8-3 to Figure 8-5 for the Fairview Field. Histograms have been truncated to highlight the majority of samples and to allow cross-comparison between CSG fields.

8.2.1 pH

pH ranges are similar between the two fields with median pH ~8.5. It is likely to be buffered by the level of bicarbonate in the water and will tend to remain in the observed range as acids or bases are added to aqueous solution. The range of pH encountered can exceed 9 which would limit the direct use of the water for all uses (ANZECC & ARMCANZ, 2000).

8.2.2 Conductivity

Roma Field associated water is typically more saline and hence has a higher EC than Fairview Field data. A significant proportion of Fairview data lies below 1500 µS/cm though very low readings (below 340 µS/cm) are possibly due to incorrect readings such as the use of deciSiemens/cm instead of microSiemens/cm. However, there is a known strong gradient in EC at Fairview from fresher in the northwest of the field to more saline in the southeast. ARMCANZ & ANZECC (2000) recommend guideline values for lowland aquatic ecosystems in the range 125 – 2200 µS/cm but defer to local data. The trigger value for long term irrigation use is 650 µS/cm.

8.2.3 Sodium

Sodium ion concentrations have a similar range and distribution at both fields. However, typical concentrations appear to be 2-300 mg/L more at Roma than at Fairview. The majority of wells discharge water with sodium concentrations greater than the relevant trigger levels for irrigation (115 mg/L), recreation (300 mg/L) and drinking water supply (180 mg/L). There are no trigger values for sodium for the protection of aquatic ecosystems.

8.2.4 Chloride

The distributions of chloride ion concentrations are quite different at the two fields. Roma Field associated water contains much more chloride with almost all readings well above the trigger levels for irrigation (175 mg/L), drinking water supply (250 mg/L) and recreation (400 mg/L). No trigger levels exist for aquatic ecosystems or stock water.

At Fairview, almost all samples demonstrate chloride at levels below the trigger level for irrigation, drinking water supply and recreation.

8.2.5 Bicarbonate

Bicarbonate ion concentrations are similarly distributed with similar range at both well fields. However, the most frequent concentrations at Roma lie approximately 100 -200 mg/L above those at Fairview.

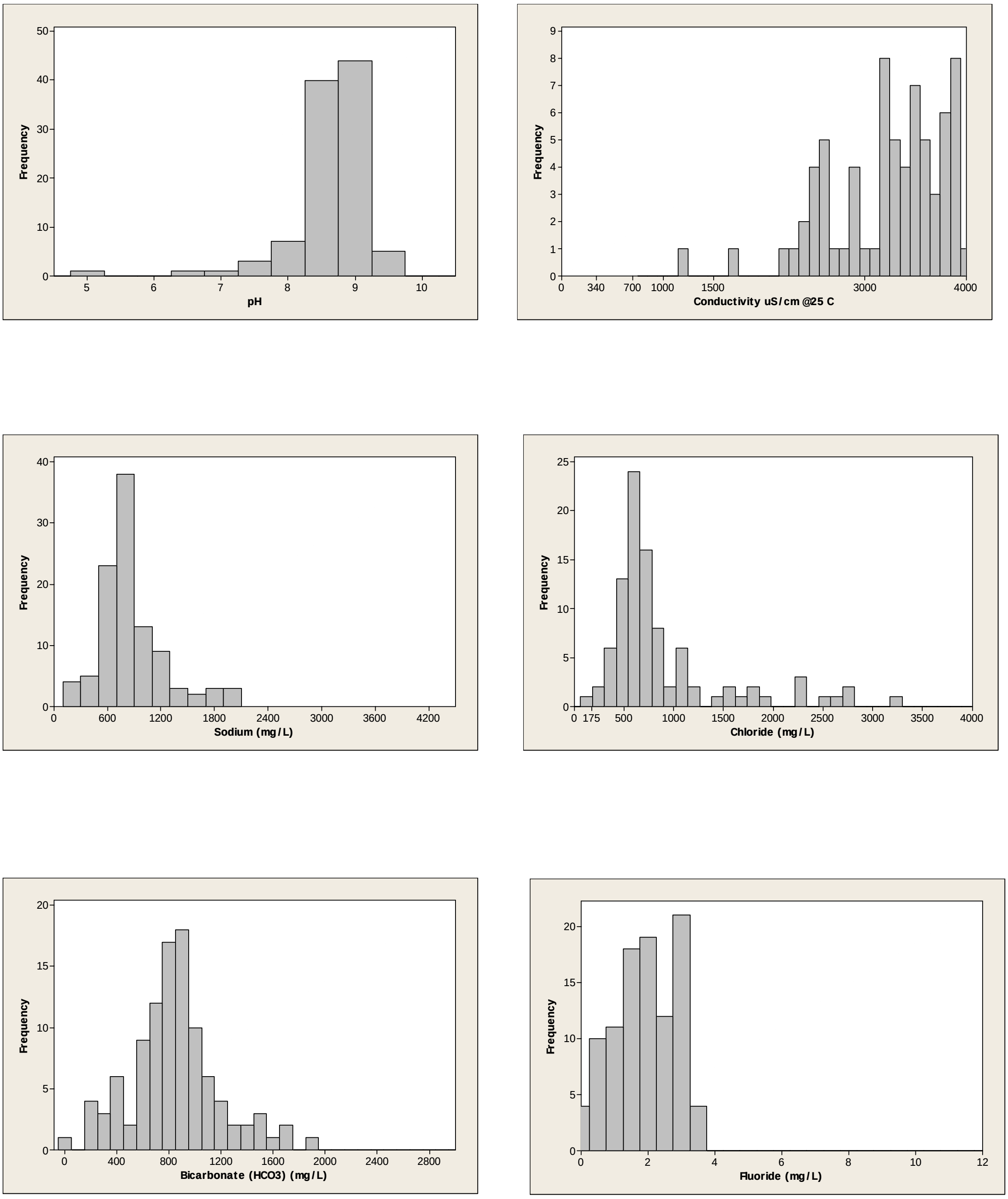


Figure 8-1 Roma field - associated water quality distributions

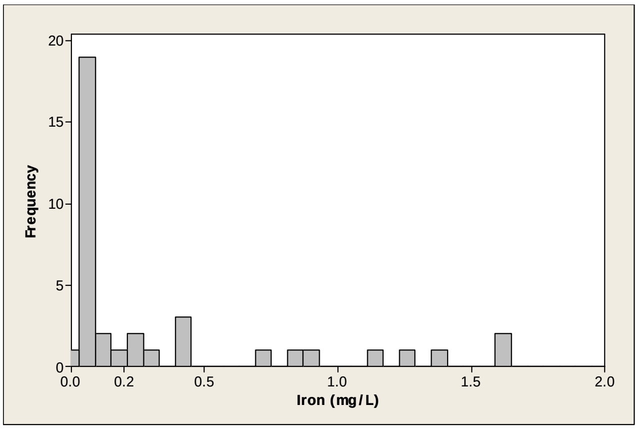


Figure 8-2 Roma field - associated water quality distributions (continued)

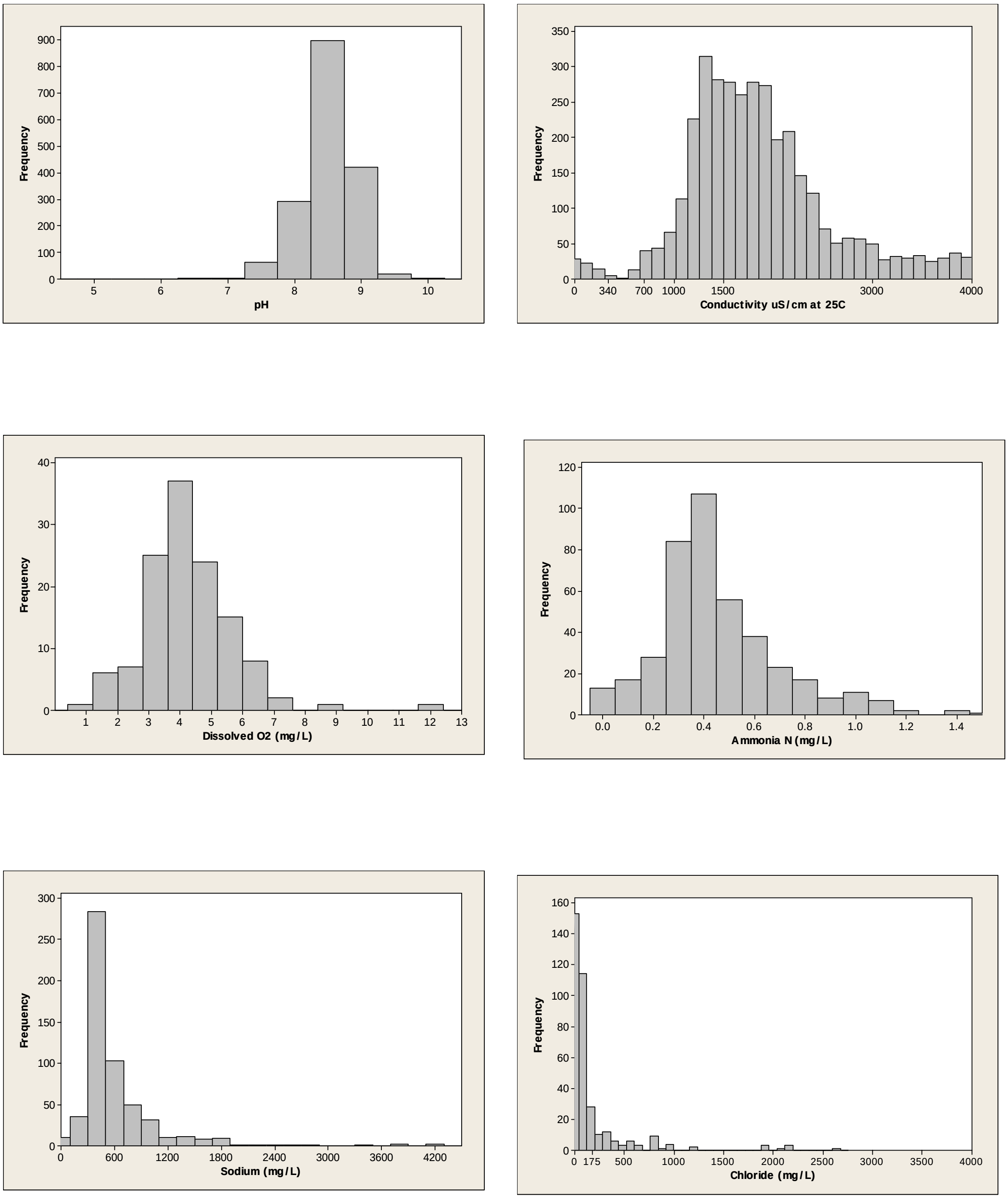


Figure 8-3 Fairview field - associated water quality distributions

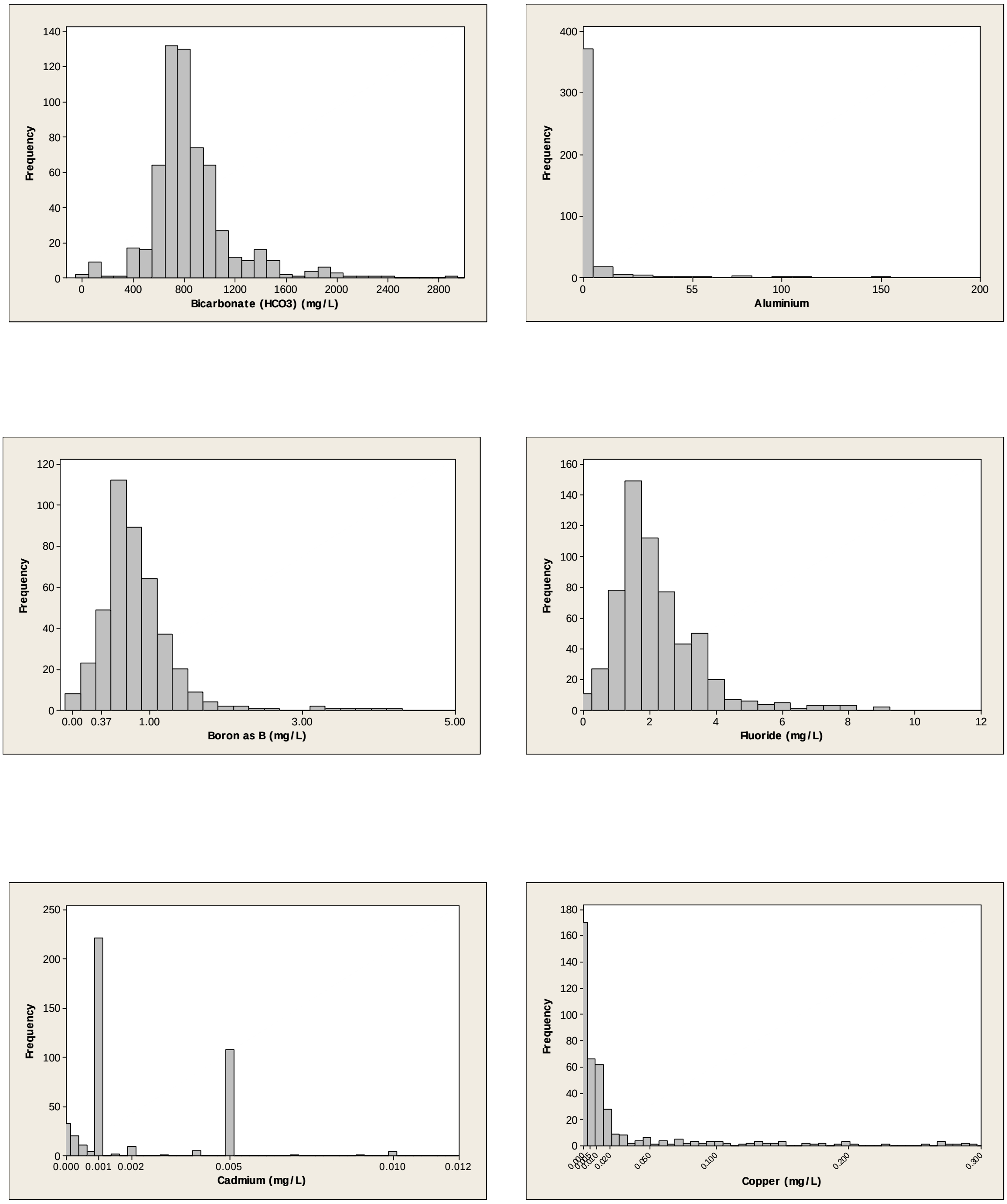
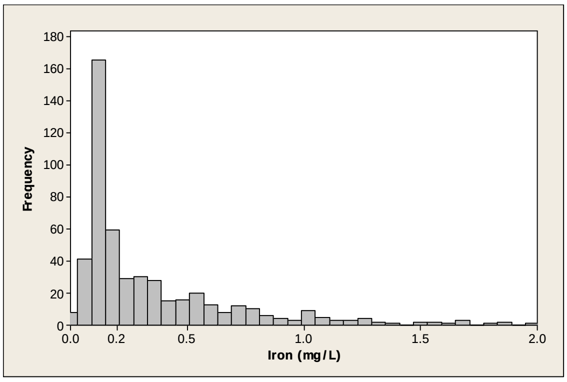


Figure 8-4 Fairview field - associated water quality distributions (ctd)



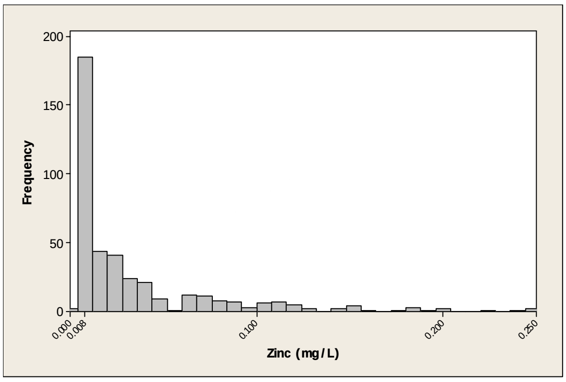


Figure 8-5 Fairview field - associated water quality distributions (ctd)

8.2.6 Fluoride

Fluoride concentrations are distributed differently at each field with an asymmetric bell curve at Fairview and a relatively uniform distribution at Roma. The range of observations is similar at both sites. At both fields, approximately 75% of all samples lie above the trigger level for irrigation use (1 mg/L). Approximately 50% of samples lie above the trigger level for stock watering (2 mg/L) and regular exceedances of the trigger level for drinking water supply (1.5 mg/L) are also experienced. There are no trigger levels for the protection of aquatic ecosystems or for recreation.

8.2.7 Iron

Observations of iron concentrations at both fields indicate that associated water is typically below the relevant trigger level for irrigation (0.2 mg/L) and therefore suitable for other less sensitive uses including recreation and drinking water supply. There are significant spikes in each of the two histograms thought to be consistent with the limit of reporting of the tests undertaken. However, the range of iron concentration observations is quite large often exceeding trigger values for irrigation, recreation (0.3 mg/L) and drinking water supply (0.3 mg/L). This indicates that instead of discharge to grade, alternative water management options are required for some wells.

Dissolved iron in the ferrous state in CSG environments oxidizes with atmospheric air upon contact and precipitates iron oxides readily, creating TSS issues that can lead to fouling of re-injection formations and scaling of pipeline and vessel surfaces. Total Iron is not present in CSG associated water in Queensland at concentrations of environmental concern, but is of concern to operating practices at CSG petroleum facilities.

8.3 Investigation of Other Water Quality Parameters – Fairview Field

Other water quality parameters available for Fairview Field but not the Roma Field are discussed below:

8.3.1 Dissolved Oxygen

Dissolved oxygen demonstrates a symmetric distribution of sample values with the range from near zero to approximately 8 mg/L possibly explained by the range of conditions (including exposure to air) under which samples of associated water are taken. Approximately 75% of samples have less than 5 mg/L DO which is considered low for the maintenance of aquatic biota and below recommended ranges for recreation or drinking water supply.

8.3.2 Boron

Boron concentrations in associated water at Fairview Field are often well above the trigger value for aquatic ecosystems (0.37 mg/L) but almost always below 2 mg/L. Direct use of associated water for stock watering is appropriate (trigger value 5 mg/L), and for raw drinking water supply (<4 mg/L trigger), but concentrations of Boron above 0.5 mg/L would not be recommended for irrigation. Concentrations above 1 mg/L are not recommended for (primary) recreation.

8.3.3 Ammonia

Almost all samples of associated water exceed the Central Queensland trigger value for the protection of aquatic ecosystems, but are all well below the national trigger value – of 0.9 mg/L (ANZECC & ARMCANZ, 2000 - see the footnote on page 12) Ammonia levels almost always exceed the trigger level for recreation and exceed the trigger level for raw drinking water supply approximately 50% of the time. No trigger values exist for stock watering or irrigation.

8.3.4 Aluminium

Aluminium concentrations are predominantly below the laboratory limits of reporting (0.1 mg/L).However it should be noted the LOR is well above the WQO (0.055 mg/L). It is concluded that there is no evidence of elevated aluminium in the water samples. Aluminium concentrations in associated water are unlikely to affect stock watering, irrigation, recreation or drinking water supply for the vast majority of wells.

8.3.5 Cadmium

Cadmium level distribution shows two clear peaks representing the limits of reporting adopted for the tests (0.001 and 0.005 mg/L). Unfortunately both of these limits are well above the WQO for protection of aquatic ecosystems (0.0002 mg/L). Provided there is no confusion in units of reporting, it is concluded that there is insufficient information to decide whether there is elevated cadmium in the water samples.

8.3.6 Copper

Approximately 25% of copper concentration readings are at the limits of reporting (0.001 mg/L or 0.01 mg/L). Of the remainder, most exceed the trigger value for the protection of aquatic ecosystems (0.0014 mg/L). However, ANZECC & ARMCANZ (2000) suggest that the trigger level should be modified upwards to ~0.0126 mg/L due to the high alkalinity and hardness of associated water. Almost all samples have concentrations of copper below this modified trigger value. Comparison with stock irrigation, recreation and drinking water triggers suggest that most wells produce water with copper concentrations suitable for these uses.

8.3.7 Zinc

The majority of samples have zinc levels at or above the MTV (0.008 mg/L). However, the toxicity of zinc degreases with increasing hardness, therefore in accordance with ANZECC & ARMCANZ (2000) the trigger value may be modified to approximately 0.07 mg/L. The majority of samples have zinc concentrations below this level. Comparison with trigger values for stock watering, irrigation, recreation and drinking water supply indicate most associated water could be used for these purposes.

8.3.8 Lead

The majority of associated water samples have lead concentrations above the MTV (0.0034 mg/L). However, ANZECC & ARMCANZ (2000) suggest this trigger level be modified due to the hardness of the water (to approximately 0.08 mg/L). Lead concentrations are generally below this modified value. Comparison with stockwatering, irrigation and recreation triggers suggest that most wells produce water with lead concentrations suitable for these uses.

8.3.9 Additional Ungraphed Parameters

Other parameters of interest that have not been graphed include mercury, molybdenum, chromium, cobalt, cyanide and phosphorus.

Mercury, Molybdenum, Chromium, Cobalt, and Cyanide

Further investigation of data for these parameters indicates that all samples (cyanide) or the vast majority of samples (Mo, Hg, Cr, Co) are reported at the limit of reporting which is variously at, above or below the MTV. No significant variance from the relevant MTVs is identified.

Phosphorus

Phosphorus data also suffers from the various limits of reporting used. However, there appears to be some evidence that about 25% of phosphorus samples exceed the trigger value for aquatic ecosystems and irrigation (0.05 mg/L). No trigger values are available for other uses.

8.3.10 Notes on Other Parameters

Coliforms

Microbiological sampling indicates that associated water is very low in coliforms (1 count per 100 mL).

Nitrogen

Results for nitrate and nitrite have not been included in the above discussion and have been separated from the remainder of the statistics in Appendix E due to concerns regarding units, limits of reporting, analysis types and database entry. The statistics (nitrate and nitrite only) indicate that associated water is always well below guideline values with the exception of one very large reading (thought to be an error) for nitrate. Apart from ammonia and phosphorus (discussed above) associated waters are very low in nutrients.

Petroleum Hydrocarbons

Characterization of Queensland CSG associated water indicates that volatile hydrocarbons are not present, and a narrow band of hydrocarbon compounds in the C10 to C36 range are the only detected hydrocarbons in one or two samples (Appendix E). These may represent native hydrocarbons in the coal seams, or more likely they represent residual hydrocarbons used in the manufacture of drilling pipe, drilling fluids, or a number of related petroleum well field activities that become dissolved in associated water.

Release of hydrocarbons dissolved in associated water to the environment may cause nuisance oil sheens or aquatic toxicity. Hydrocarbons at low concentrations in associated water may also present operational difficulties, requiring oil/water separation.

8.4 Summary

Associated water produced at the Fairview and Roma CSG fields is characterised by:

- Relatively high pH, low dissolved oxygen, and low to moderate salinity.
- Elevated sodium, fluoride and boron concentrations.
- No hydrocarbons
- No coliforms.
- Low chloride concentrations at Fairview.
- Elevated chloride concentrations at Roma.
- Elevated ammonia concentrations (compared with Queensland guidelines but well below national guidelines).
- Elevated copper or zinc concentrations for some wells.
- Low phosphorus and iron concentrations for most wells.
- Low nutrients (with the exception of ammonia and phosphorus).

In addition, data from the Fairview field indicates that typically associated water has a temperature in the order of 40 degrees Celsius.

The relevance of these findings is discussed in terms of surface water environments in the next Section.

9.1 Comparison of Surface and Associated Water Quality

9.1.1 Surface Water Quality

In Sections 5, 6 and 7 the water quality of existing pre-development surface waters was investigated and it was found that these waters are:

- Subject to a greater range of pH than MTVs.
- Subject to significant depletions of dissolved oxygen corresponding to elevated chemical oxygen demand and very high biological oxygen demand. The DO sags are below the levels where fish mortality is likely.
- Subject to a wide range of variability in EC with some areas experiencing ~1500 µS/cm regularly, but most streams have EC circa 300 µS/cm consistent with the guideline trigger value for protection of aquatic ecosystems of 340 µS/cm.
- Sodium is normally well below the MTV (115 mg/L) with observed concentrations typically in the range 30 - 40 mg/L.
- Most chloride concentrations are below the MTV (175 mg/L) with observed concentrations typically in the range 1 – 40 mg/L circa Roma, and typically 10 – 20 mg/L in the Upper Dawson and Comet-Brown catchments.
- Fluoride concentrations are all below the MTV (1 mg/L).
- Boron is generally below the recommended MTV, and always below this level for the Upper Dawson and Comet-Brown catchments. However, the maximum recorded concentration in Yuleba Creek (Roma Field) is 2.5 times the MTV.
- Waters are typically nutrient enriched with elevated ammonia, phosphorus, turbidity, suspended solids and nitrogen levels.
- Copper concentrations are consistently higher than the guideline trigger value for protection of aquatic ecosystems (0.0014 mg/L) for almost all streamlines. Application of the AWQG suggests a revised WQO should be 0.007 mg/L.
- Iron is elevated with widespread exceedance of the recommended MTV (0.2 mg/L).
- Zinc regularly exceeds the MTV (0.008 mg/L) across all catchments with maximum observed concentration 0.034 mg/L.
- Lead exceedances of MTV are evident in approximately 50% of all sites across all catchment. Maximum observed concentration is 0.007 mg/L.

9.1.2 Associated Water Quality and Likely Impacts of Discharge

Table 9-1 contrasts the median quality of associated water from Fairview and Roma with surface waters.

Table 9-1 Associated water quality compared with existing environments

Water Quality Parameter	Units	Median WQ Fairview Assoc Water	Median WQ Roma Assoc Water	Condamine-Balonne Median WQ[1]	Upper Dawson Median WQ	Comet-Brown Median WQ[2]
pH	units	8.6	8.7	7	7	7.8
Temperature	°C	38	-	23	25.5	23.0
Dissolved Oxygen	mg/L	4.1	-	6.1	-	7.9
Electrical Conductivity (EC)	µS/cm	1840	3610	238	215	164.3
Total Dissolved Solids (TDS)	mg/L	975	2300	152	146	167
Total Suspended Solids (TSS)	mg/L	10	-	86	75	612
Sodium	mg/L	466	792	22.6	11	16.8
Chloride	mg/L	55	701	11.2	8	13.6
Fluoride	mg/L	1.9	2.0	0.1	0.1	0.1
Boron (total)	mg/L	0.7	-	0.05	0.023	0.032
Ammonia as N	mg/L	0.41	-	0.002	0.380	0.018
Iron (total)	mg/L	0.27	-	0.53	-	-
Bicarbonate Alkalinity	mg/L	788	821	101.5	70	140
Sodium Absorption Ratio (SAR)[3]	-	438	600 (75)[4]	<2	1.2	<1

NOTES
1 Bungil Creek
2 Comet River d/s Rolleston
3 By calculation
4 Roma water quality data has two SAR peaks one near 600 and the other near 75

pH

The pH of associated water is typically more alkaline than surface waters but well within the range of natural variability. No significant impacts are expected.

Dissolved Oxygen

Median dissolved oxygen levels of associated water are lower than surface waters but will equilibrate quickly upon exposure to the atmosphere and land surface. Investigations at Fairview (URS, 2008) indicate that waters equilibrate within approximately 500 m of discharge point.

Temperature

The temperature of associated water is significantly higher than surface waters particularly during the dry season. Investigations of small discharges at Fairview suggest that temperatures equilibrate within approximately 500 m of the discharge point (URS, 2008).

Electrical Conductivity

The electrical conductivity of associated water is typically well above the background levels instream and significant dilution or treatment will be required to maintain a low risk of discharge to grade.

Sodium

Sodium concentrations are much higher in associated water and since there is little calcium or magnesium the Sodium Adsorption Ratios (SARs) are much higher than in surface waters. High SAR has the potential to degrade soil structure by breaking down clay aggregates, making soils more erodible, reducing water infiltration, and affecting plant growth (ARMCANZ & ANZECC, 2000).

Chloride

Chloride levels from Fairview are well within the recommended water quality objective and the range of observed concentrations in natural streams. No dilution of associated water is required at Fairview Field.

At Roma, chloride concentrations in associated water are much higher than the MTV and the surrounding streams. While no particular toxic effects are associated directly with chloride, its contributions to salinity and ionic balance in water can produce indirect effects including increasing the toxicity of some parameters. High chloride concentrations (25-40 mg/L) can lead to foliar damage on irrigated tobacco, but most crops appear to be less sensitive and can entertain concentrations between 0 and 350 mg/L with a low risk of damage (ARMCANZ & ANZECC, 2000). Only ~25% of Roma associated water samples fit into this category.

Significant dilution or treatment of associated water is required at Roma Field.

Fluoride

Fluoride occurs naturally usually in the form of the mineral fluorspar. The main environmental impacts related to fluoride compounds are in respect of hydrogen fluoride, which immediately converts to hydrofluoric acid on contact with moisture. Under normal ranges of pH in surface waters reaction to hydrofluoric acid is very unlikely to occur.

Elevated levels of fluoride (> 2 mg/L) can cause mottling of tooth enamel in humans and animals (Chapman, 1996).

Approximately 50% of associated water samples contain much higher concentrations of fluoride compared with guidelines or surrounding streams. The vast majority of samples lie below 5 mg/L but this is substantially higher than national trigger values for irrigation (1 mg/L), stock watering (2 mg/L) and recreation (1.5 mg/L). As a result dilution or mixing of at least 50% of associated waters will be necessary to meet guideline values.

Boron

Boron is a widespread naturally occurring trace element of igneous rocks and is commonly found in sedimentary rocks of marine origin (ANZECC & ARMCANZ, 2000). Associated water is typically high in boron compared with background and guideline concentrations. Almost all samples of associated water contain boron at less than 2 mg/L but this is an order of magnitude higher than guidelines (0.37 mg/L). Guideline values are based on examination of toxicity tests on fish, crustacean, macrophytes and algae. Some fish and algae may be subject to lethal effects below around 1 mg/L. Some macrophytes experience toxic effects at around 1 mg/L.

The main forms of boron in freshwater are borates and the main mechanism for removal is adsorption onto suspended sediments and clays. Due to the turbidity of surface waters in the project area it is likely that toxicity will be reduced, but significant dilution of this parameter is required for conservative management.

Nutrients

Ammonia levels in associated water are above guideline values but certainly within the range of observed concentrations in the surface waters. Free ammonia is of concern due to aquatic toxicity. However, since the oxidized forms of nitrogen (nitrite and nitrate) are not present at significant concentrations it is clear that a low redox environment is likely to exist in coal seams at the source of CSG associated water. Free ammonia in CSG associated water, if present due to the typically alkaline pH of associated water, is readily removed by air stripping upon atmospheric contact or by shifts in pH towards neutral conditions which shift the free ammonia equilibrium to the dissolved ammonium ion. Johnson (2007) investigated the toxicity of ammonia in associated waters and found that increased pH reduced ammonia toxicity.

Copper

Approximately 75% of associated water contains copper at levels higher than trigger values. Similarly, surface waters regularly exhibit concentrations well in excess of the MTV. The laboratory limit of reporting for copper (0.01 mg/L) is greater than the guideline trigger value.

ANZECC & ARMCANZ (2000) indicates that the toxicity of copper is significantly reduced by hardness and for the hardness evident in associated water an adjusted MTV of 0.126 mg/L is appropriate. Almost all associated water samples lie under this concentration suggesting there is a small risk of toxic effects from the observed copper concentrations.

Iron

Iron concentrations in associated water are similar in range to those observed at the surface. Both of these sets of data exceed recommended water quality guidelines. Most observations of iron in associated water are less than 1 mg/L. Iron does not present a risk to livestock or ecosystem health at the concentrations detected. The main issues associated with high levels of iron are precipitation and biofouling resulting in blockages of irrigation equipment (ANZECC & ARMCANZ, 2000).

Zinc

The water quality objective for zinc is regularly exceeded across all surface waters and catchments. Most concentrations in associated water are well below this level. No significant increased in toxic effects from zinc are expected with associated water discharge, especially with the increased hardness (ANZECC & ARMCANZ, 2000 suggest raising the trigger value from 0.008 mg/L to around 0.07 mg/L for the high level of alkalinity observed in associated water).

Zinc is an essential trace element that adsorbs to suspended material. Toxicity of zinc can increase with low dissolved oxygen (ANZECC & ARMCANZ, 2000). However, levels of organic matter found in most freshwater streams are generally sufficient to remove zinc toxicity. Given the amount of suspended sediment and relatively low zinc concentrations found in these streams it is unlikely that zinc would present a significant water quality issue.

Lead

The majority of associated water contains lead concentrations at or below those observed at surface and below 0.01 mg/L, although some exceptions are evident up to 1 mg/L (and these need to be checked for units). ANZECC(2000) suggests modification of lead toxicity by a factor of approximately 23 for very hard water consistent with the alkalinity observed in associated water. This would bring the relevant guideline value up from 0.034 mg/L to approximately 0.08 mg/L. It is concluded that there is unlikely to be lead toxicity arising from associated water discharges.

9.2 Conclusions

There is a wide degree of variation in the quality of associated water across fields and between wells. It is necessary to undertake water quality “finger printing” in order to understand the characteristics of the water that is proposed to be discharged in the context of the local surface water environments. Where necessary alternative forms of management will be required possibly including dilution and treatment.

Adequate management of water quality variability is required to ensure appropriate management of discharge to grade. In the USA, many wells discharge to ponds where water is mixed and held for an undefined period of time. Discharges to grade are made from these holding ponds.

The key parameters of concern in associated water in the GLNG are:

- Salinity (electrical conductivity)
- Sodium
- Chloride
- Fluoride
- Boron

In addition, due care needs to be taken to manage pH, dissolved oxygen, suspended solids and temperature.

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 12 October 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between October 2007 and January 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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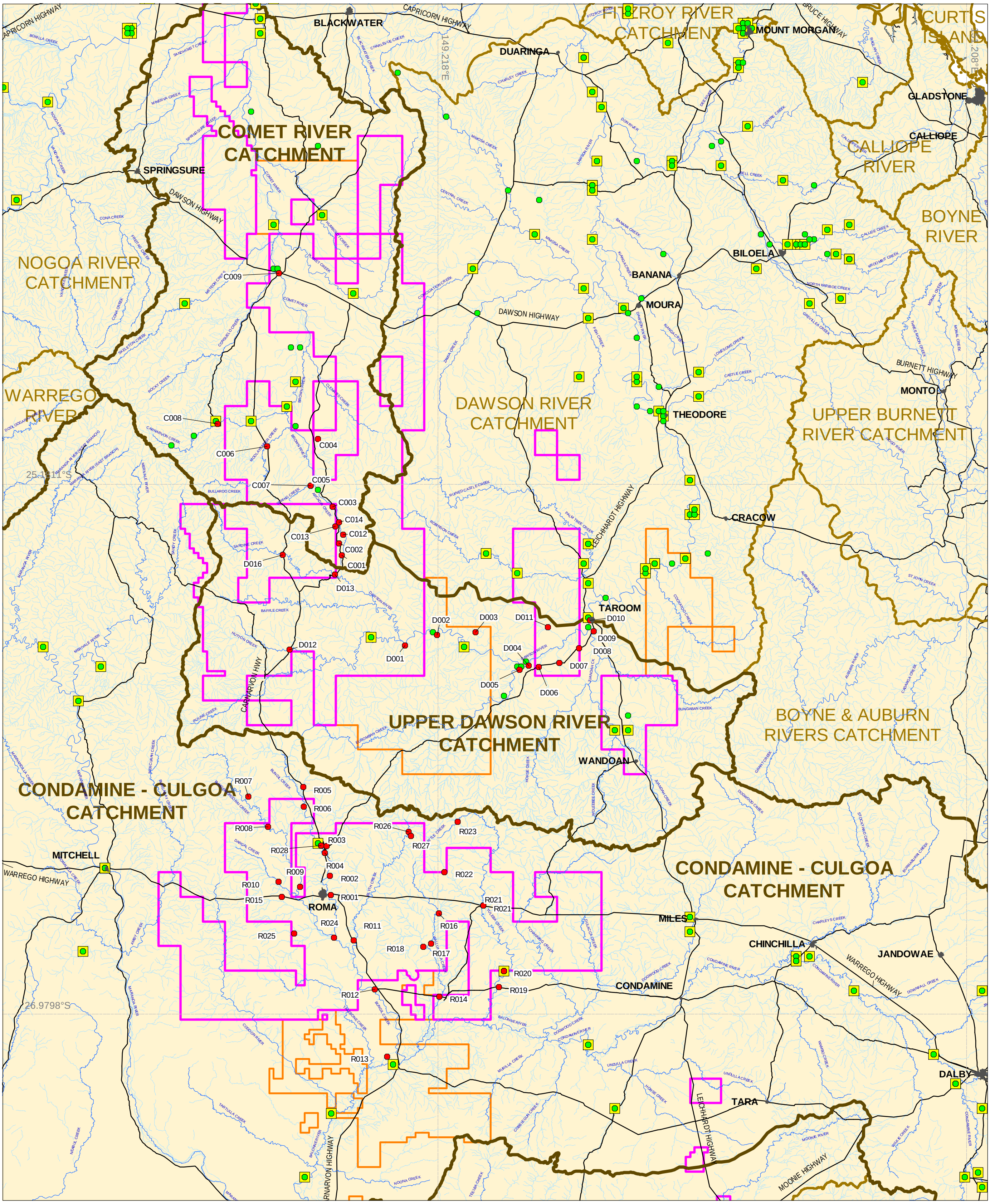
Figures



- URS Water Quality Site Locations
- DNR Monitoring Points
- DNR Continuous Monitoring Stations
- Catchment Boundary
- Major Roads
- Major Drainage
- Santos Operated ATP / PLs
- Non-Santos Operated ATP / PLs

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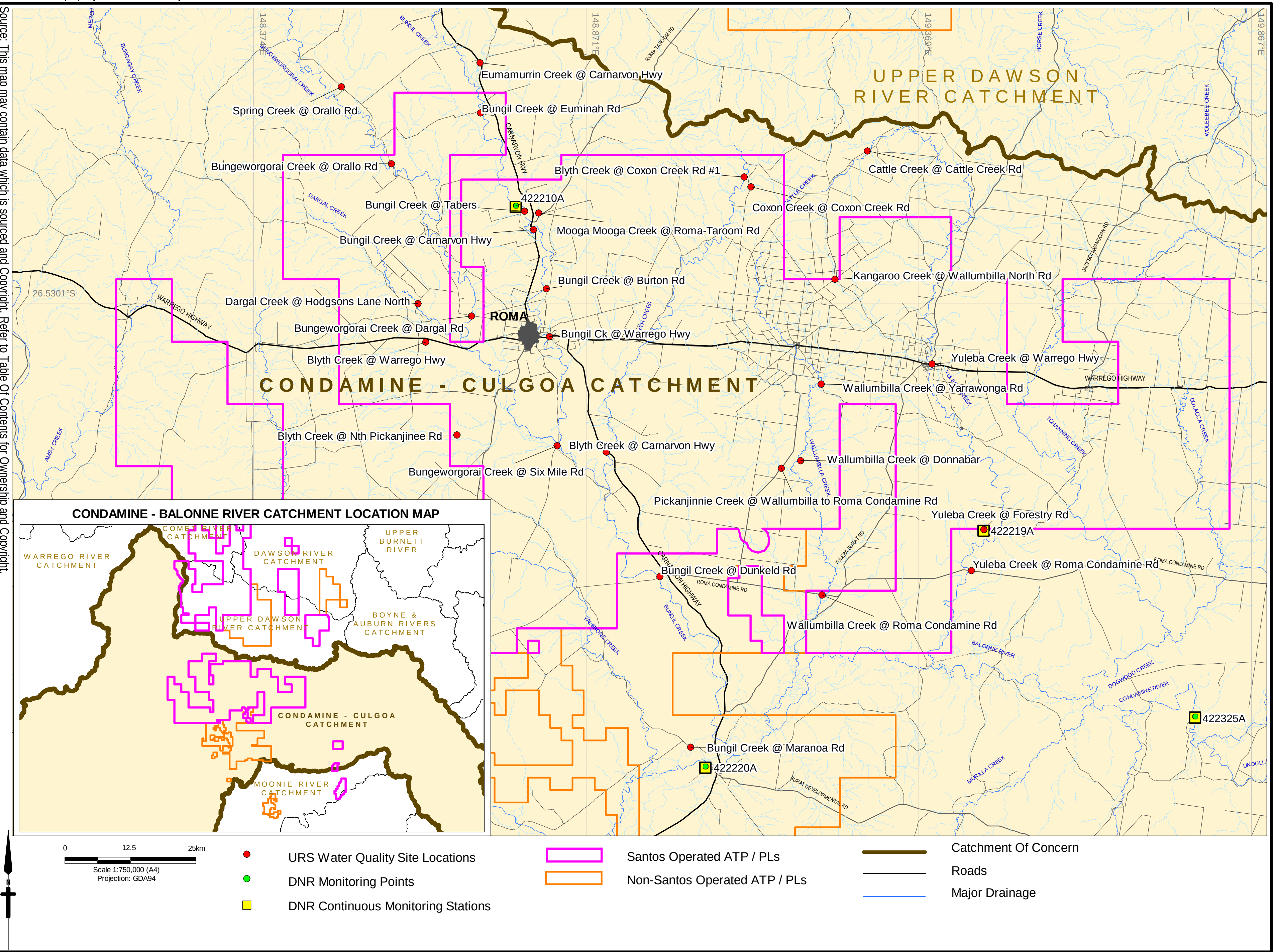
Client	Project	Title
Santos / URS	GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT	SURFACE WATER CATCHMENT AREAS AND WATER QUALITY SITE LOCATIONS
	Drawn: CA · Approved: JB · Date: 17-10-2008	Figure: 1 · Rev:A
	Job No: **4262 6220** · File No: 42626220-g-527.wor	A4

Draft



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URS

Client: Santos LNG

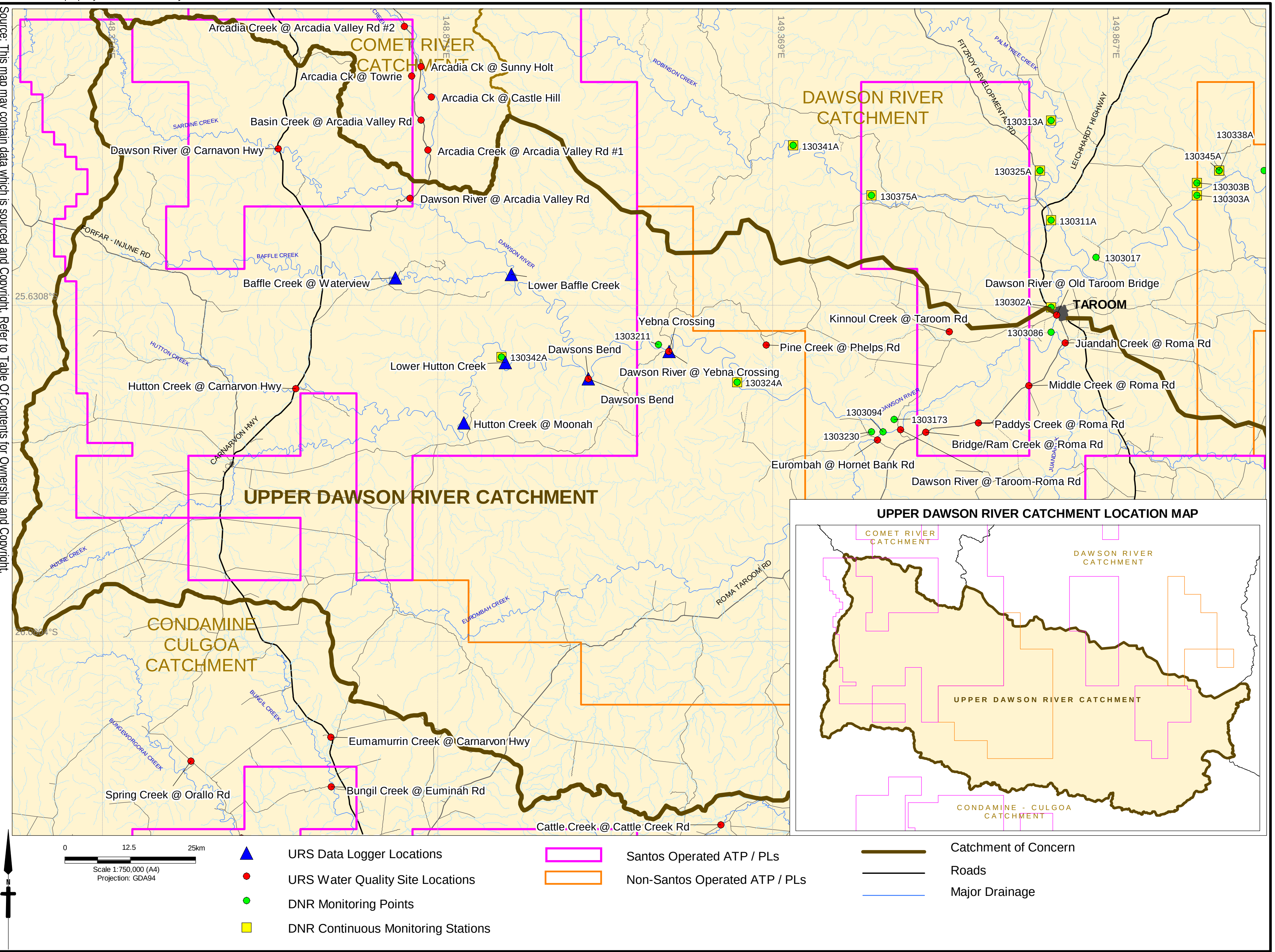
Project: GLADSTONE LNG PROJECT
CSG FIELD SURFACE WATER REPORT

Title: CONDAMINE - BALONNE RIVER CATCHMENT WATER QUALITY SITES AND DNR MONITORING SITES

Drawn: CA | Approved: JB | Date: 17-10-2008

Job No: 4262 6220 | File No: 42626220-g-530.wor

Figure: 2 | Rev: A | A4



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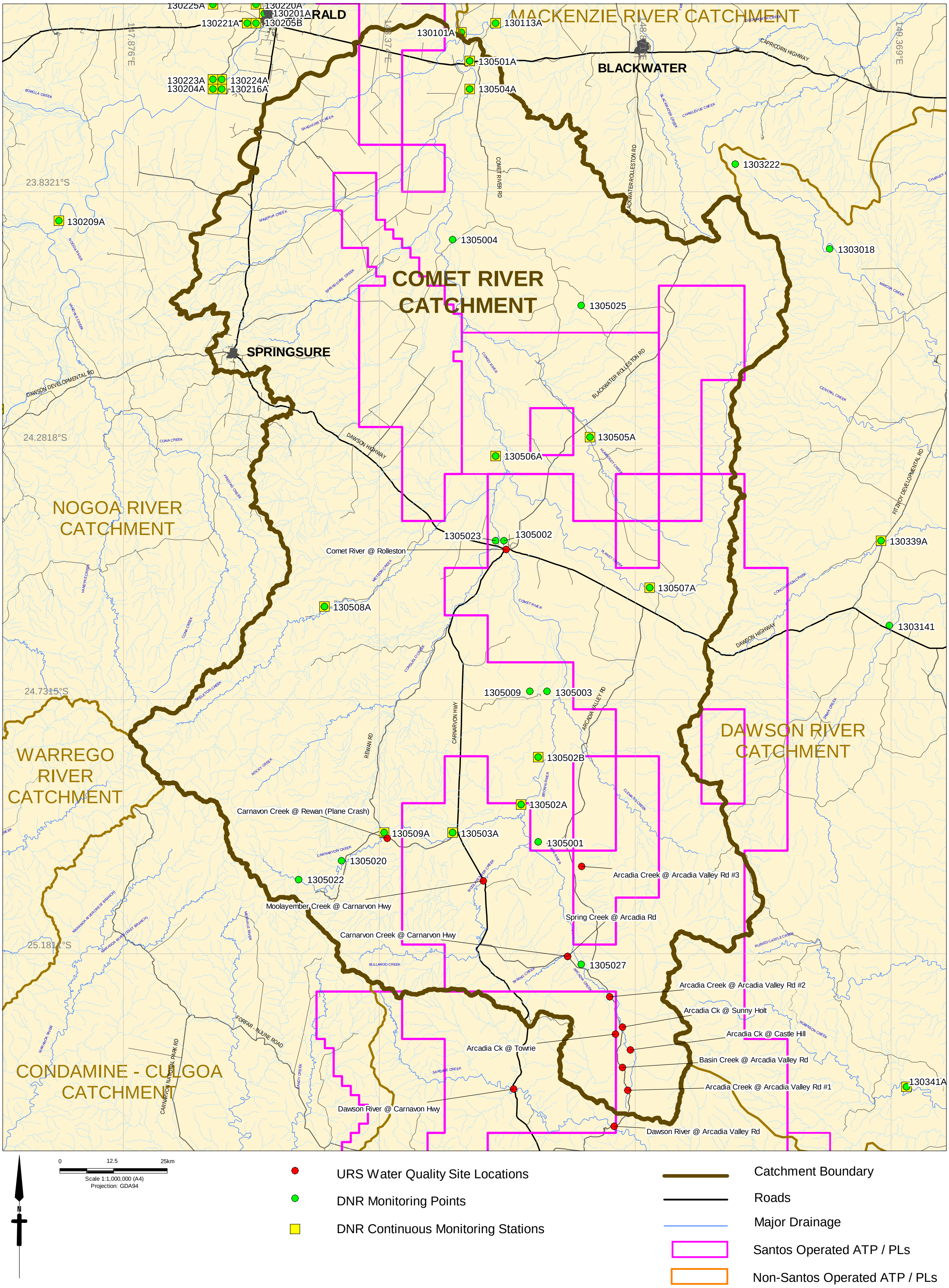
Client: URS / Santos

Project: GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT

Title: UPPER DAWSON RIVER CATCHMENT WATER QUALITY SITES AND DNR MONITORING SITES

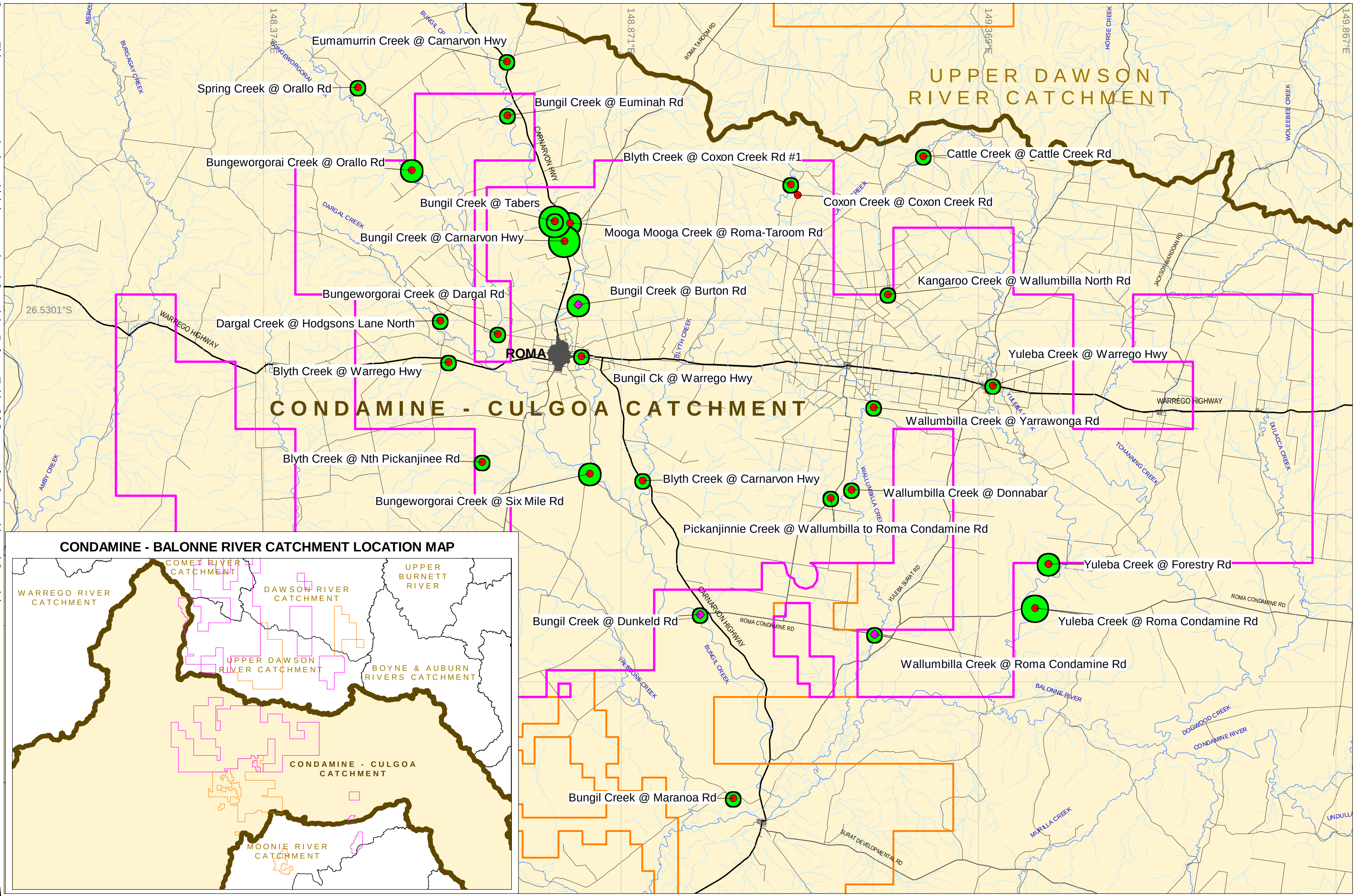
Drawn: CA	Approved: JB
Date: 17-10-2008	
Job No: 4262 6220	File No: 42626220-g-529.wor
Figure: 3	Rev: A
	A4



- URS Water Quality Site Locations
- DNR Monitoring Points
- DNR Continuous Monitoring Stations
- Catchment Boundary
- Roads
- Major Drainage
- Santos Operated ATP / PLs
- Non-Santos Operated ATP / PLs

Source: This map may contain data which is sourced and Copyright. Refer to Table Of Contents for Ownership and Copyright.

Client	Project	Title
Santos / URS	GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT	**COMET RIVER CATCHMENT WATER QUALITY SITES AND DNR MONITORING SITES** (Draft)
	Drawn: CA | Approved: JB | Date: 17-10-2008	Figure: **4** | Rev:A
	Job No: **4262 6220** | File No: 42626220-g-528.wor	A4



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0 12.5 25km
Scale 1:750,000 (A4)
Projection: GDA94

N

◆	Stream Gauging Site (URS, Installed July 2008)
●	URS Water Quality Site Locations
L → H	Relative maximum EC Concentration (µS/cm) (From lowest to highest concentration)
Magenta outline	Santos Operated ATP / PLs
Orange outline	Non-Santos Operated ATP / PLs
Brown line	Catchment Of Concern
Black line	Roads
Blue line	Major Drainage

Results compiled from DNRW data, URS monitoring (February - August 2008) and information provided by Santos.

URS

Client: Santos LNG

Project: GLADSTONE LNG PROJECT
CSG FIELD SURFACE WATER REPORT

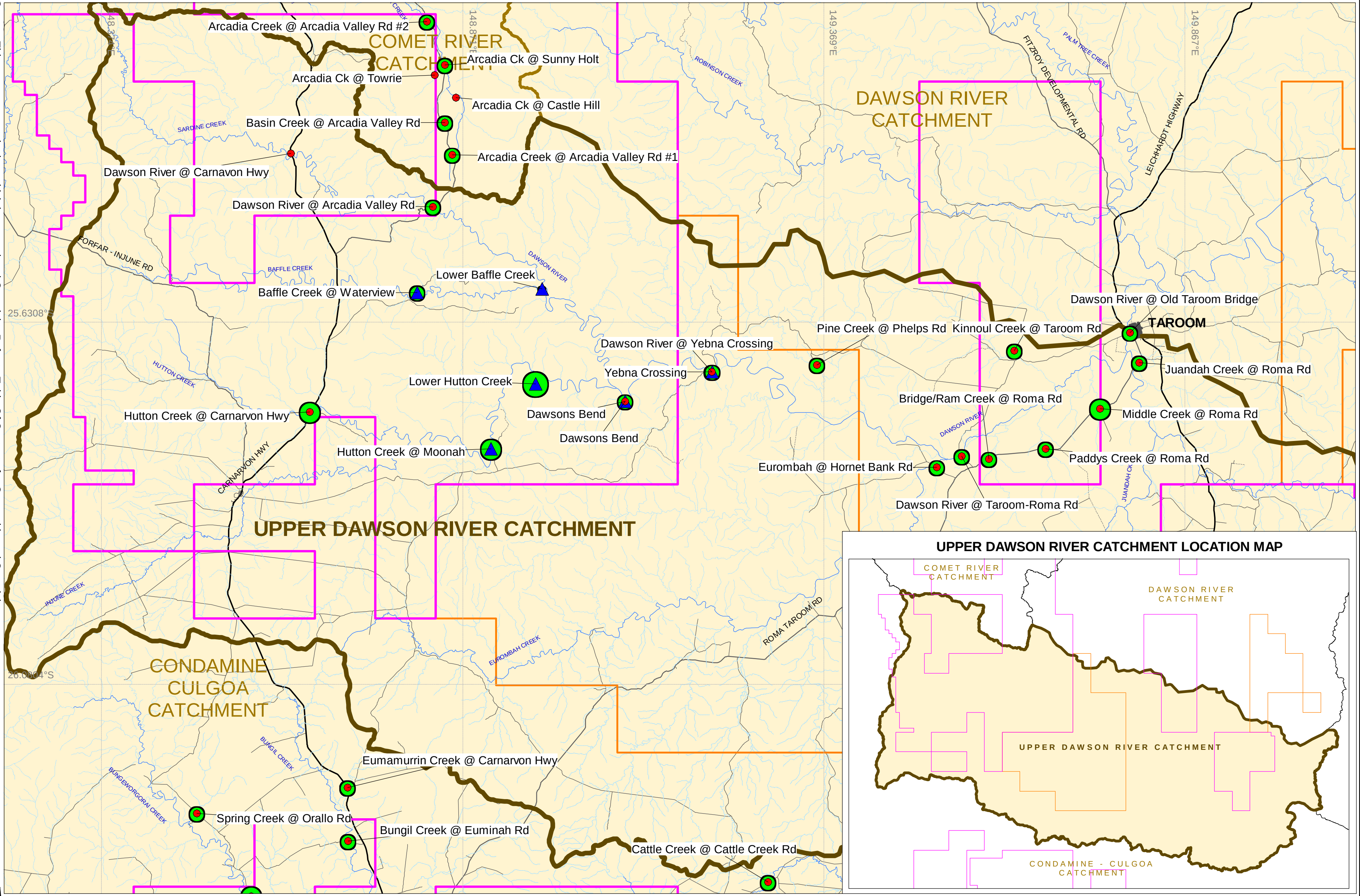
Title: **CONDAMINE - BALONNE RIVER CATCHMENT EC CONCENTRATIONS**

DRAFT

Drawn: CA | Approved: JB | Date: 17-10-2008

Job No: **4262 6220** | File No: 42626220-g-535.wor

Figure: **5** | Rev: A | A4



URS Data Logger Locations

URS Water Quality Site Locations

L → H Relative maximum EC Concentration (µS/cm)
(From lowest to highest concentration)

Santos Operated ATP / PLs

Non-Santos Operated ATP / PLs

Catchment Of Concern

Roads

Major Drainage

Results compiled from DNRW data, URS monitoring (February - August 2008) and information provided by Santos.

Source: This map may contain data which is sourced and Copyright. Refer to Table Of Contents for Ownership and Copyright.

Client: URS / Santos

Project: GLADSTONE LNG PROJECT
CSG FIELD SURFACE WATER REPORT

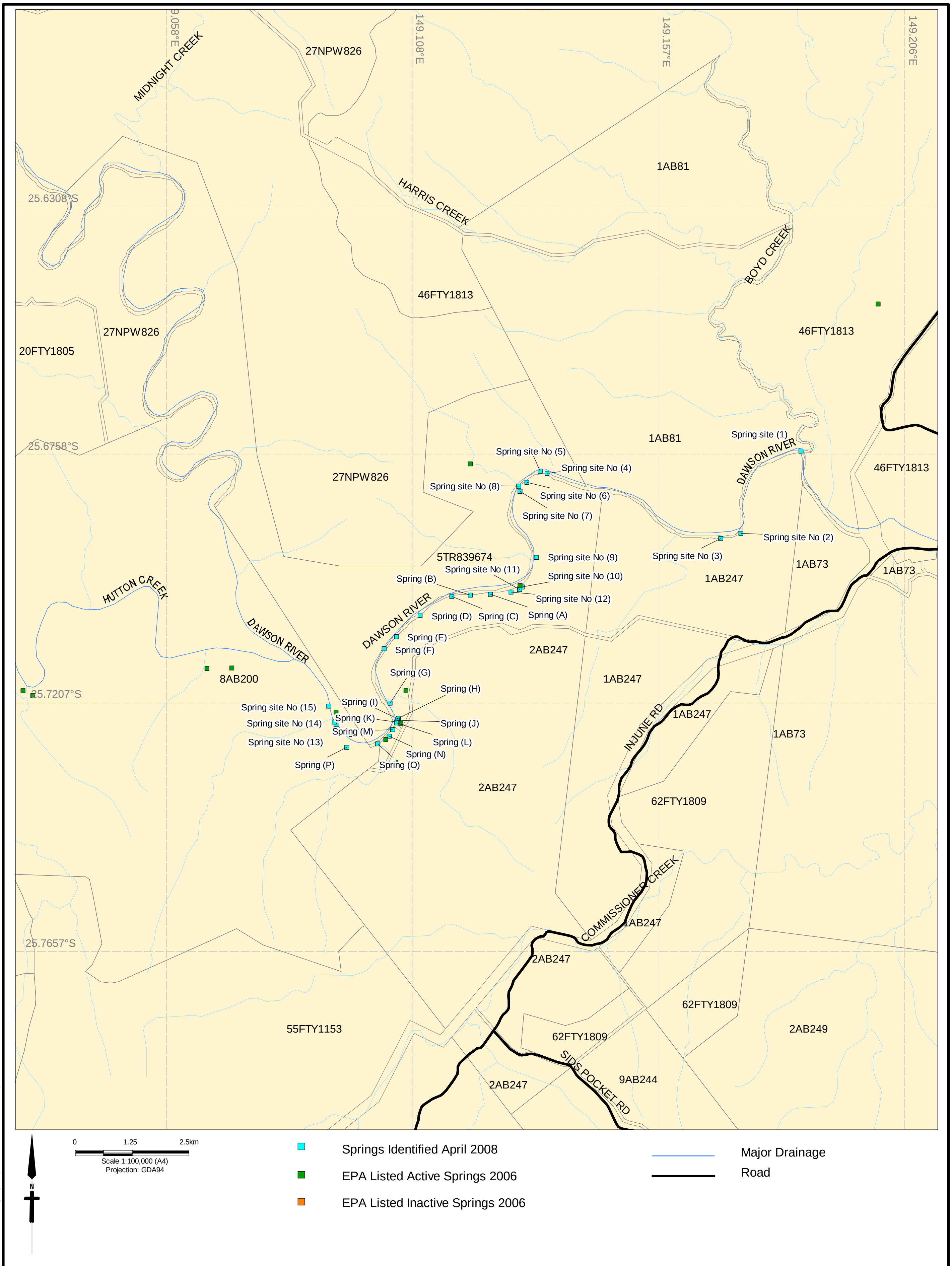
Title: UPPER DAWSON RIVER CATCHMENT
EC CONCENTRATIONS

Draft

Drawn: CA | Approved: JB | Date: 17-10-2008

Job No: **4262 6220** | File No: 42626220-g-533.wor

Figure: 6 | Rev: A | A4



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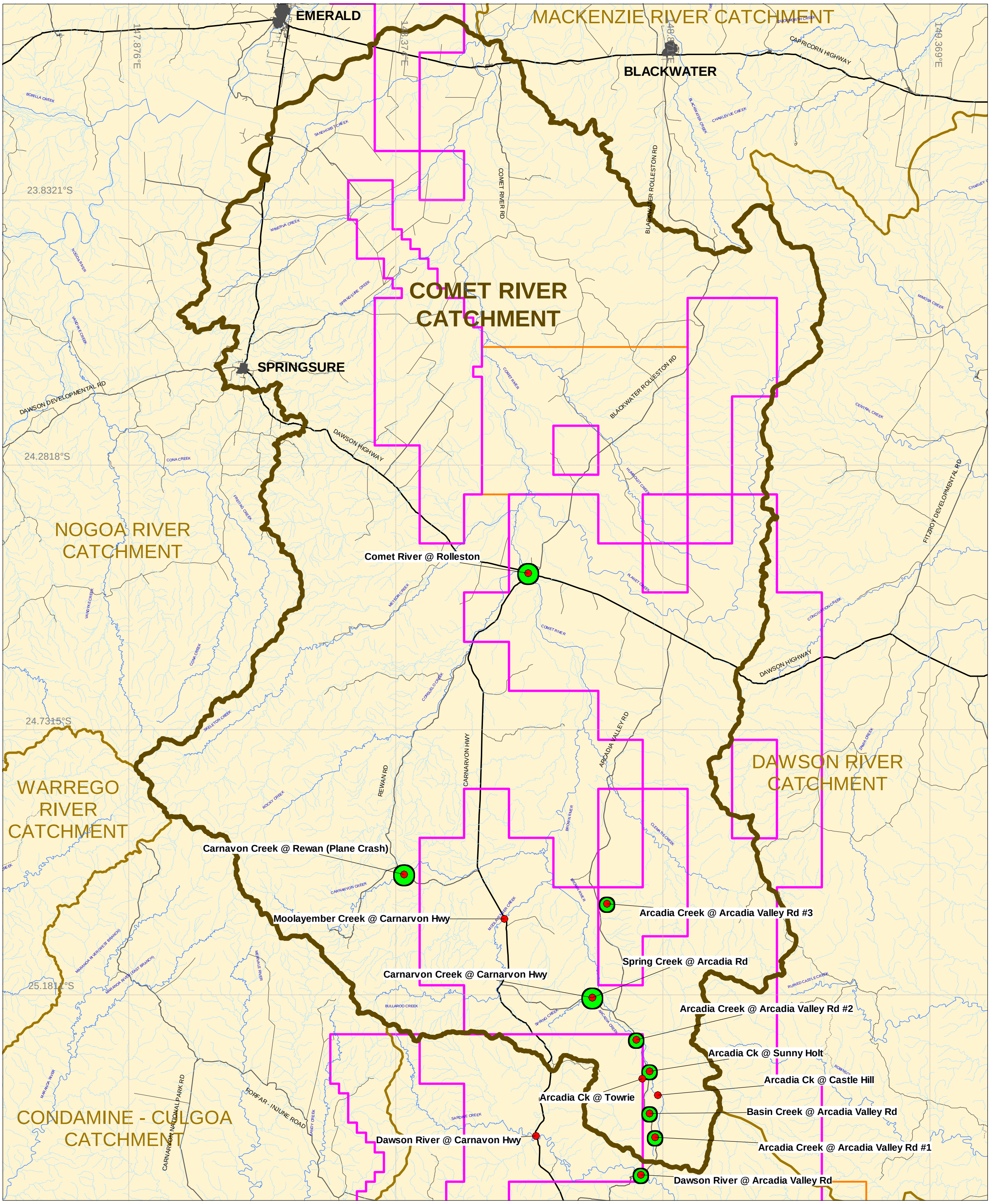
Client	Project	Title
LNG Santos / URS	GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT	SPRINGS ON DAWSON RIVER
	Drawn: CA / Approved: JB / Date: 17-10-2008	Figure: 7 / Rev:A
	Job No: 4262 6220 / File No: 42626220-g-538.wor	A4



0 12.5 25km

Scale 1:1,000,000 (A4)
Projection: GDA94

N

URS Water Quality Site Locations

L H Relative maximum EC Concentration (µS/cm)
(From lowest to highest concentration)

Results compiled from DNRW data, URS monitoring (February - August 2008), and information provided by Santos.

Santos Operated ATP / PLs

Non-Santos Operated ATP / PLs

Catchment Of Concern

Roads

Major Drainage

Source: This map may contain data which is sourced and Copyright. Refer to Table Of Contents for Ownership and Copyright.

Client	Project	Title	
Santos	GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT	**COMET RIVER CATCHMENT EC CONCENTRATIONS** (Draft)	
URS	Drawn: CA · Approved: JB · Date: 17-10-2008	Figure: **8**	Rev:A
	Job No: **4262 6220** · File No: 42626220-g-531.wor		A4

Condamine-Balonne Catchment Water Quality Data

Appendix A

Table A1
Upper Balonne Catchment - URS Water Quality Parameters
GLNG CSG Surface Water

Site ID		Date/Time	Water Quality Parameters					
Number	**Name**	**Date**	**Time (EST)**	**EC (µS/cm)**	**DO (mg/L)**	**pH**	**Turbidity (NTU)**	**Temp (°C)**
			WQO	*325*	*na*	*6.5-8.0*	*50*	*na*
Bungil Creek & Tributaries								
R005	Eumamurrin Ck @ Carnarvon Hwy	31-Jan-08	10:00	244	4.35	6.97	24	24.3
R005	Eumamurrin Ck @ Carnarvon Hwy	04-Mar-08	11:00	135	3.8	6.8	**145**	23.6
R005	Eumamurrin Ck @ Carnarvon Hwy	14-May-08	11:26	198	4.64	7.58	**150**	16.9
R006	Bungil Ck @ Euminah Rd	31-Jan-08	10:25	225	4.22	6.8	38	25.7
R006	Bungil Ck @ Euminah Rd	04-Mar-08	10:00	105	2.64	6.7	**212**	22.8
R006	Bungil Ck @ Euminah Rd	14-May-08	10:52	-	-	-	-	-
R028	Bungil Ck @ Tabers	04-Mar-08	17:40	232	6.93	6.93	**307**	24.1
R028	Bungil Ck @ Tabers	14-May-08	10:01	**1287**	6.37	**8.19**	27	15.7
R003	Mooga Mooga Ck @ Roma-Taroom Rd	31-Jan-08	9:00	285	2.3	6.64	**66**	26.3
R003	Mooga Mooga Ck @ Roma-Taroom Rd	04-Mar-08	9:30	**500**	2.24	6.6	47	23.4
R003	Mooga Mooga Ck @ Roma-Taroom Rd	14-May-08	9:34	-	-	-	-	-
R002	Bungil Ck @ Burton Rd	31-Jan-08	8:30	**744**	6.12	7.35	10	24
R002	Bungil Ck @ Burton Rd	04-Mar-08	8:10	275	5.2	7.2	**280**	20.5
R004	Bungil Ck @ Carnarvon Hwy	31-Jan-08	-	**568**	6.65	7.25	10	24.9
R004	Bungil Ck @ Carnarvon Hwy	04-Mar-08	15:00	148	6.3	7.8	**223**	24.5
R004	Bungil Ck @ Carnarvon Hwy	14-May-08	9:22	**1418**	3.05	7.32		14.9
R001	Bungil Ck @ Warrego Hwy	31-Jan-08	7:29	**367**	2.4	6.9	**116**	24
R001	Bungil Ck @ Warrego Hwy	04-Mar-08	-	193	4.32	7.39	**151**	23.9
R001	Bungil Ck @ Warrego Hwy	15-May-08	8:45	**350**	3.37	6.72	**58**	15.9
R012	Bungil Ck @ Dunkeld Rd	31-Jan-08	15:05	201	5.73	7.35	**1122**	27
R012	Bungil Ck @ Dunkeld Rd	05-Mar-08	12:00	288	6.31	7.12	**218**	21.5
R012	Bungil Ck @ Dunkeld Rd	14-May-08	16:17	305	2.9	6.35	**108**	18.7
R013	Bungil Ck @ Maranoa Rd	31-Jan-08	16:00	172	5.42	6.97	**1645**	27.7
R013	Bungil Ck @ Maranoa Rd	05-Mar-08	12:40	201	6.65	7.32	**429**	22.6
R013	Bungil Ck @ Maranoa Rd	15-May-08	14:03	**327**	7.44	6.96	**117**	19.2
Bungeworgorai Creek & Tributaries								
R007	Spring Ck @ Orallo Rd	31-Jan-08	11:20	199	5.14	7.2	**278**	27.5
R007	Spring Ck @ Orallo Rd	04-Mar-08	12:00	**301**	5.8	7.9	**98**	28.7
R007	Spring Ck @ Orallo Rd	14-May-08	12:05	-	-	-	-	-
R008	Bungeworgorai Ck @ Orallo Rd	04-Mar-08	12:20	**446**	5.7	**8**	**76**	26.8
R008	Bungeworgorai Ck @ Orallo Rd	31-Jan-08	11:45	283	6.74	7.2	**62**	27.5
R008	Bungeworgorai Ck @ Orallo Rd	00-Jan-00	12:25	**467**	11.84	**8.03**	30	20.5
R024	Bungeworgorai Ck @ Six Mile Rd	01-Feb-08	18:43	**363**	6.2	7.21	**228**	28.2
R024	Bungeworgorai Ck @ Six Mile Rd	05-Mar-08	10:20	**348**	7.9	7.48	**119**	20.6
R024	Bungeworgorai Ck @ Six Mile Rd	14-May-08	15:12	**535**	7.22	6.7	27	21.2
R010	Dargal Ck @ Hodgsons Lane North	31-Jan-08		205	3.12	**6.48**	**671**	26.8
R010	Dargal Ck @ Hodgsons Lane North	04-Mar-08	13:15	3	2.6	6.9	**535**	24.3
R010	Dargal Ck @ Hodgsons Lane North	14-May-08	13:30	292	2.32	6.5	**>1000**	16.5
R009	Bungeworgorai Ck @ Dargal Rd	31-Jan-08	12:33	**334**	6.15	7.2	**98**	26.8
R009	Bungeworgorai Ck @ Dargal Rd	04-Mar-08	14:15	251	6.02	7.76	**51**	24
R009	Bungeworgorai Ck @ Dargal Rd	14-May-08	14:05	-	-	-	-	-
Wallumbilla Creek & Tributaries								
R014	Wallumbilla Ck @ Roma Condamine Rd	31-Jan-08	17:30	178	4.73	6.85	**282**	27.7
R014	Wallumbilla Ck @ Roma Condamine Rd	04-Mar-08	12:40	202	1.92	7.13	**282**	19.8
R014	Wallumbilla Ck @ Roma Condamine Rd	15-May-08	12:00	**321**	3.53	6.6	**187**	16.3
R016	Wallumbilla Ck @ Yarrawonga Rd	01-Feb-08	10:00	206	6.22	6.91	**164**	28.3
R016	Wallumbilla Ck @ Yarrawonga Rd	04-Mar-08	11:30	261	6.64	7.23	**71**	22.6
R016	Wallumbilla Ck @ Yarrawonga Rd	15-May-08	9:45	**376**	6.63	**6.25**	**277**	177
R017	Wallumbilla Ck @ Donnabar	04-Mar-08	15:05	156	3.58	6.66	**86**	23
R017	Wallumbilla Ck @ Donnabar	01-Feb-08		-	-	-	-	-
R017	Wallumbilla Ck @ Donnabar	15-May-08	10:40	188	6.51	5.99	**119**	18.8
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	01-Feb-08	10:41	123	2.98	**6.39**	**700**	25.3
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	04-Mar-08	11:50	192	6.2	7.27	**102**	24.4
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	15-May-08	11:15	308	7.03	6.67	**77**	18.6
Yuleba Creek & Tributaries								
R023	Cattle Ck @ Cattle Ck Rd	01-Feb-08	15:25	112	5.09	6.51	**84**	29
R023	Cattle Ck @ Cattle Ck Rd	05-Mar-08	15:45	112	7.7	7.29	**78**	25.7
R023	Cattle Ck @ Cattle Ck Rd	15-May-08	11:50	92	6.95	6.61	**250**	18.7
R022	Kangaroo Ck @ Wallumbilla North Rd	01-Feb-08	15:00	130	2.8	6.58	**160**	28.2
R022	Kangaroo Ck @ Wallumbilla North Rd	05-Mar-08	15:00	114	1.92	6.98	**124**	22.5
R022	Kangaroo Ck @ Wallumbilla North Rd	15-May-08	11:20	162	7.04	7	**92**	18.8
R021	Yuleba Ck @ Warrego Hwy	01-Feb-08		-	-	-	-	-
R021	Yuleba Ck @ Warrego Hwy	06-Mar-08	9:20	126	3.77	**6.3**	**202**	19.2
R021	Yuleba Ck @ Warrego Hwy	13-May-08		178	2.66	**6.12**	**108**	15.8
R019	Yuleba Ck @ Roma Condamine Rd	01-Feb-08	11:32	124	3.61	6.5	**434**	25.1
R019	Yuleba Ck @ Roma Condamine Rd	04-Mar-08	13:20	213	4	7.22	**366**	23.6
R019	Yuleba Ck @ Roma Condamine Rd	15-May-08	12:45	**989**	2.53	7.2	**471**	18.4
Blyth Creek & Tributaries								
R026	Blyth Ck @ Coxon Ck Rd #1	05-Feb-08	17:15	**333**	10.58	**8.55**	**88**	31
R026	Blyth Ck @ Coxon Ck Rd #1	05-Mar-08	17:15	**397**	7.03	7.83	**3268**	26.8
R026	Blyth Ck @ Coxon Ck Rd #2	05-Feb-08	17:15	259	8.35	**8.55**	**83**	32.1
R026	Blyth Ck @ Coxon Ck Rd #1-2	15-May-08	10:40	-	-	-	-	-
R027	Coxon Ck @ Coxon Ck Rd	05-Feb-08		-	-	-	-	-
R027	Coxon Ck @ Coxon Ck Rd	15-May-08	10:05	-	-	-	-	-
R025	Blyth Ck @ Nth Pickanjinee Rd	05-Feb-08	9:30	267	5.29	7.83	-	32.5
R025	Blyth Ck @ Nth Pickanjinee Rd	05-Mar-08	16:50	-	-	-	-	-
R025	Blyth Ck @ Nth Pickanjinee Rd	15-May-08	10:20	-	-	-	-	-
R015	Blyth Ck @ Warrego Hwy	01-Feb-08	9:00					
R015	Blyth Ck @ Warrego Hwy	04-Mar-08	10:00	193	6.65	6.78	**72**	21.4
R015	Blyth Ck @ Warrego Hwy	15-May-08	9:15	-	-	-	-	-
R011	Blyth Ck @ Carnarvon Hwy	31-Jan-08	14:36	156	5.45	6.76	**227**	28.1
R011	Blyth Ck @ Carnarvon Hwy	14-May-08	16:50	280	8.47	**6.17**	**78**	18.2

Notes:

- \- Parameters not taken, creek dry or no access possible
- **Bold** Greater than relevant WQO (refer table xx)

Table A2
Roma - URS Surface Water Analytical Results Summary
GLNG CSG Surface Water

Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				Major Ions										Alkalinity			
	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Suspended Solids (TSS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
LOR	*2*	*5*	*1*	*1*	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*0.01*	*0.1*	*0.01*	*0.1*	*1*	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
MTV	*na*	*na*	*na*	*10*	*0.007*	*0.37*	*0.0002*	*0.001*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*	*na*	*na*	*0.05*	*0.5*	*1000*	*175*	*1*	*na*	*na*	*115*	*400*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
Bungil Creek & Tributaries																															
Number	8	11	6	11	11	11	11	11	11	4	7	10	11	11	10	10	10	10	9	11	10	10	7	10	9	9	5	6	6	6	6
Min	<2	<5	<1	15	0.001	<0.05	<0.0001	<0.001	0.001	**0.14**	0.002	0.002	<0.005	<0.01	0.4	0.01	0.4	12	5	<0.1	2	5	14	1	1.8	2	1.47	<1	<1	80	80
Median	37	18.5	7	61	0.002	0.05	**0.0002**	**0.002**	**0.004**	**0.53**	0.002	0.004	**0.015**	0.027	0.85	**0.12**	**0.9**	22	14	0.2	6	7	30	11.5	2.7	3	1.57	<1	<1	101.5	101.5
Max	41	95	12	187	0.003	<0.1	**0.0014**	**0.006**	**0.006**	**0.98**	0.003	0.006	**0.022**	0.057	1.2	**1.36**	**1.2**	33	22	0.3	7	11	32	33	3.7	4	4.06	<1	<1	120	120
Bungeworgorai Creek & Tributaries																															
Number	7	8	4	8	6	6	6	6	5	3	3	6	6	7	6	6	6	7	6	6	7	7	4	7	6	6	5	3	3	3	3
Min	<2	6	6	16	<0.001	0.05	<0.0001	<0.001	<0.002	**0.13**	0.13	<0.001	<0.005	<0.01	0.7	**0.05**	**0.7**	18	2	<0.1	4	5	18	5	2.1	2.2	<0.01	<1	<1	65	65
Median	33	9	6	50	0.00125	0.05	<0.0001	**0.002**	**0.0025**	**0.5**	0.00125	0.003	**0.013**	0.041	0.8	**0.07**	**0.85**	34	22.5	0.2	8	6	23.5	31	4.075	4.23	1.96	<1	<1	159	159
Max	41	81	7	178	0.005	<0.1	<0.0001	**0.012**	**0.008**	**17.1**	**0.006**	0.006	**0.034**	0.132	1.8	**0.28**	**2**	49	34	0.3	13	9	33	50	5.28	5.25	3.52	<1	<1	165	165
Wallumbilla Creek & Tributaries																															
Number	10	10	4	9	8	8	8	8	8	5	8	8	8	9	9	9	8	9	8	9	9	9	4	9	7	7	6	4	4	4	4
Min	<2	<5	7	37	<0.001	0.05	<0.0001	<0.001	**0.002**	**0.31**	<0.001	0.002	0.006	0.01	0.6	<0.01	**0.6**	4	7	<0.1	2	6	20	3	1.73	1.87	0.44	<1	<1	70	70
Median	31	8	10.5	60	0.00075	0.05	0.0001	0.00125	**0.002**	**1.02**	0.0015	0.004	**0.0115**	0.03	0.7	**0.08**	**0.7**	16	12.5	0.1	6	7	23	22	2.56	2.69	2.12	<1	<1	72.5	72.5
Max	49	18	12	131	0.004	<0.1	**0.0003**	**0.008**	**0.004**	**3.01**	**0.004**	0.007	**0.021**	0.058	1.2	**0.17**	**1.2**	29	28	0.4	9	8	38	29	3.53	3.66	6.09	<1	<1	75	75
Yuleba Creek & Tributaries																															
Number	6	9	5	10	11	10	11	11	11	4	11	11	11	10	11	11	9	9	9	9	9	9	5	9	9	9	3	5	5	5	5
Min	<2	7	<1	25	0.001	0.05	0.0001	<0.001	0.001	**3.2**	0.002	0.002	0.006	0.01	0.5	**0.05**	**0.6**	4	<1	<0.1	2	4	13	2	1.22	1.32	1.05	<1	<1	55	55
Median	27	17	9	50.5	0.003	0.05	<0.0001	0.003	**0.003**	**4.475**	0.002	0.004	**0.015**	0.058	1.2	**0.21**	**1.3**	9	7	0.1	4	7	15	7	1.5	1.66	2.38	<1	<1	58	58
Max	69	109	50	148	0.005	**0.82**	**0.0003**	**0.007**	**0.004**	**5.38**	**0.004**	0.006	**0.032**	0.109	2.9	**0.28**	**3**	14	77	0.8	6	8	38	230	10	10.5	5.52	<1	<1	85	85

NOTES

For the purposes of calculating the median where results are less than the LOR, a value of half the LOR has been adopted.

MTV - minimum trigger value

Table A3
Roma - URS Surface Water Analytical Results
GLNG CSG Surface Water

Location		Sample ID	Date Sampled	Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				Major Ions										Alkalinity			
					Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Suspended Solids (TSS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
				Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/l	meq/l	%	mg/L	mg/L	mg/L	mg/L
				LOR	2	5	1	1	0.001	0.1	0.0001	0.001	0.001	0.05	0.001	0.001	0.005	0.01	0.1	0.01	0.1	1	1	0.1	1	1	1	1	0.01	0.01	0.01	1	1	1	1
				MTV	na	na	na	10	0.007	0.37	0.0002	0.001	0.0014	0.2	0.0034	0.011	0.008	na	na	0.05	0.5	1000	<175	1	na	na	115	400	na	na	na	na	na	na	na
Bungil Creek & Tributaries																																			
R006	Bungil Ck @ Euminah Rd	R006_04/03/08	4/03/2008		<2	23	6	48	0.002	<0.1	<0.0001	0.003	0.005		0.003	0.004	0.014	0.057	0.6	1.36	0.7	12	5	<0.1	2	9	19	1	2.07	1.91	4.06	<1	<1	95	95
R006	Bungil Ck @ Euminah Rd	R006_04/03/08CHK	4/03/2008					48																											
R028	Bungil Ck @ Tabers	R028_04/03/08	4/03/2008			80	<1	142	0.002	<0.1	0.0002	0.006	0.006		0.003	0.006	0.022	0.027	1	0.16	1	21	14	0.1	4	6	31	13	2.83	2.92		<1	<1	108	108
R028	Bungil Ck @ Tabers	QC03_14/05/08	14/05/2008		32	8		20	0.001	0.08	<0.0001	<0.001	0.001	0.14	<0.001	<0.001	0.017	<0.01	0.5	0.05	0.5			0.2											
R028	Bungil Ck @ Tabers	R028_14/05/08	14/05/2008		37	8		15	0.002	0.08	<0.0001	<0.001	0.002	0.16	<0.001	0.002	<0.005	<0.01	0.6	0.04	0.6	21	5	0.2	7	11		10	2.17	2.34					
R028	Bungil Ck @ Tabers	R028_14/05/08CHK	14/05/2008		37																														
R028	Bungil Ck @ Tabers	QC03_14/05/08CHK	14/05/2008																					0.2											
R002	Bungil Ck @ Burton Rd	R002_04/03/08	4/03/2008		<2	14	7	187	0.002	<0.1	<0.0001	0.006	0.006		0.003	0.005	0.02	0.039	0.4	0.01	0.4	19	21	<0.1	4	6	30	8	2.65	2.74	1.62	<1	<1	95	95
R001	Bungil Ck @ Warrego Hwy	R001_04/03/08	4/03/2008		<2	<5	7	109	0.002	<0.1	0.0002	0.002	0.004		0.003	0.004	0.019	0.05	1.2	0.13	1.2	25	22	<0.1	6	7	32	9	3.19	3.29	1.57	<1	<1	120	120
R001	Bungil Ck @ Warrego Hwy	R001_04/03/08CHK	4/03/2008						0.002	<0.1	0.0002	0.003	0.004		0.003	0.004	0.018																		
R001	Bungil Ck @ Warrego Hwy	R001_15/05/08	15/05/2008		38	8		61	0.001	<0.05	<0.0001	<0.001	0.002	0.9	0.002	0.002	<0.005	<0.01	0.9	0.13	0.9	33	20	0.2	7	6		33	3.74	3.85	1.5				
R011	Blyth Ck @ Carnarvon Hwy	R011_06/03/08	7/03/2008			95	12	16	0.003	<0.1	0.0003	<0.001	0.002		<0.001	0.003	0.006	0.047	0.8	0.07	0.9	14	6	<0.1	4	8	14	2	1.82	1.86		<1	<1	80	80
R011	Blyth Ck @ Carnarvon Hwy	R011_06/03/08CHK	7/03/2008			95																													
R012	Bungil Ck @ Dunkeld Rd	R012_05/03/08	5/03/2008			89	8	106	0.002	<0.1	0.0014	0.004	0.004		0.002	0.004	0.015	0.03	0.9	0.13	0.9	23	16	0.2	5	7	28	17	3.1	3.01	1.47	<1	<1	114	114
R012	Bungil Ck @ Dunkeld Rd	R012_05/03/08CHK	5/03/2008																			26			6	8	31	17							
R012	Bungil Ck @ Dunkeld Rd	R012_14/05/08	14/05/2008		41	7		67	<0.001	0.06	0.0002	<0.001	0.001	0.98	<0.001	0.002	0.011	<0.01	1.2	0.1	1.2	23	13	0.3	6	5		23	2.65	2.77					
R012	Bungil Ck @ Dunkeld Rd	R012_14/05/08CHK	14/05/2008															<0.01																	
Bungeworgorai Creek																																			
R008	Bungeworgorai Ck @ Orallo Rd	R008_14/05/08	14/05/2008		40	6		25	<0.001	0.06	<0.0001	<0.001	0.002	0.13	<0.001	0.002	0.009	<0.01	0.7	0.05	0.7	34	34	0.2	8	6		50	4.49	4.68	1.96				
R008	Bungeworgorai Ck @ Orallo Rd	R008_14/05/08CHK	14/05/2008					24																											
R010	Dargal Ck @ Hodgsons Lane North	R010_04/03/08	4/03/2008		<2	26	7	75	0.005	<0.1	<0.0001	0.012	0.008		0.006	0.008	0.034	0.105	0.8	0.24	0.9	18	5	<0.1	4	5	18	31	2.1	2.2	2.13	<1	<1	65	65
R010	Dargal Ck @ Hodgsons Lane North	R010_04/03/08CHK	4/03/2008		<2	24	6											0.107				18			4	6	18	32							
R010	Dargal Ck @ Hodgsons Lane North	R010_14/05/08	14/05/2008		41	9		178	0.003	0.05	<0.0001	0.009	0.005	17.1	0.005	0.007	0.028	0.033	1.3	0.28	1.4	29	2	0.3	6	5		19	2.77	2.9					
R010	Dargal Ck @ Hodgsons Lane North	R010_14/05/08CHK	14/05/2008		41	8																													
R009	Bungeworgorai Ck @ Dargal Rd	R009_04/03/08	4/03/2008		<2	9	6	16	<0.001	<0.1	<0.0001	<0.001*	0.002		<0.001	0.002	<0.005	0.041	0.8	0.06	0.8	43	30	<0.1	9	9	33	5	4.25	4.56	3.52	<1	<1	165	165
R024	Bungeworgorai Ck @ Six Mile Rd	R024_05/03/08	5/03/2008			81	6	101	0.002	<0.1	0.0001	0.002	0.003		0.002	0.004	0.017	0.132	1.8	0.08	2	36	15	0.2	8	8	29	15	3.9	3.9	<0.01	<1	<1	159	159
R024	Bungeworgorai Ck @ Six Mile Rd	R024_05/03/08CHK	5/03/2008					100																											
R024	Bungeworgorai Ck @ Six Mile Rd	R024_14/05/08	14/05/2008		33	9		17	<0.001	<0.05	<0.0001	<0.001	<0.001	0.5	<0.001	<0.001	<0.005	<0.01	0.7	0.06	0.7	49	30	0.3	13	9		35	5.28	5.25	0.36				
Wallumbilla Creek & Tributaries																																			
R016	Wallumbilla Ck @ Yarrawonga Rd	R016_04/03/08	4/03/2008		5	18	11	95	0.004	<0.1	0.0002	0.008	0.004		0.003	0.007	0.021	0.052	0.7	0.12	0.7	13	14	<0.1	6	8	20	4	1.99	2.19	4.94	<1	<1	75	75
R016	Wallumbilla Ck @ Yarrawonga Rd	R016_04/03/08CHK	4/03/2008		5	17	12	95										0.058				13		<0.1	6	8	20	4				<1	<1	75	75
R016	Wallumbilla Ck @ Yarrawonga Rd	R016_15/05/08	15/05/2008		33	7		131	<0.001	0.06	<0.0001	0.002	0.004	3.01	0.002	0.005	0.011	<0.01	1.2	0.15	1.2	29	28	0.4	9	7		29	3.53	3.66	1.66				
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	R018_15/05/08	15/05/2008		40	8		38	<0.001	0.05	0.0001	<0.001	0.002	0.31	<0.001	0.002	0.013	<0.01	0.8	0.08	0.8	27	10	0.3	8	7		23	3.12	3.16	0.57				
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	R018_15/05/08CHK	15/05/2008																				10												
R017	Wallumbilla Ck @ Donnabar	R017_04/03/08	4/03/2008		<2	<5	7	60	0.004	0.1	<0.0001	0.008	0.004		0.004	0.006	0.016	0.033	0.6	<0.01	0.7	4	18	<0.1	2	6	38	3	1.98	2.24	6.09	<1	<1	70	70
R017	Wallumbilla Ck @ Donnabar	QC04_15/05/08	15/05/2008		32	7		42	0.001	<0.05	0.0003	<0.001	0.002	1.02	0.001	0.002	0.006	0.03	0.6	0.09	0.6			0.1											
R017	Wallumbilla Ck @ Donnabar	R017_15/05/08	15/05/2008		43	6		39	<0.001	<0.05	0.0002	<0.001	0.002	0.97	0.001	0.002	0.01	0.029	0.6	0.08	0.6	13	7	0.1	5	6		15	1.73	1.87					
R017	Wallumbilla Ck @ Donnabar	QC04_15/05/08CHK	15/05/2008		30																														
R014	Wallumbilla Ck @ Roma Condamine Rd	R014_04/03/08	4/03/2008		2	15	10	37	0.001	<0.1	0.0001	0.002	0.002		<0.001	0.004	0.007	0.037	0.6	0.05	0.7	16	24	<0.1	6	8	26	23	2.56	2.69	2.58	<1	<1	70	70
R014	Wallumbilla Ck @ Roma Condamine Rd	R014_04/03/08CHK	4/03/2008																0.7	0.05															
R014	Wallumbilla Ck @ Roma Condamine Rd	R014_15/05/08	15/05/2008		49	9		92	<0.001	<0.05	<0.0001	<0.001	0.002	2.02	0.002	0.004	0.012	<0.01	1.2	0.17	1.2	23	11	0.2	9	7		22	3.04	3.07	0.44				
R014	Wallumbilla Ck @ Roma Condamine Rd	R014_15/05/08CHK	15/05/2008			8																26			9	8		24							
Yuleba Creek																																			
R023	Cattle Ck @ Cattle Ck Rd	R023_05/03/08	5/03/2008			96	16	30	0.003	<0.1	0.0001	0.003	0.002		0.002	0.004	0.016	0.062	2.2	0.09	2.3	7	2	<0.1	2	6	14	3	1.22	1.32		<1	<1	55	55
R023	Cattle Ck @ Cattle Ck Rd	R023_05/03/08CHK	5/03/2008						0.002	<0.1	<0.0001	0.003	0.002		0.002	0.004	0.015																		
R023	Cattle Ck @ Cattle Ck Rd	R023_15/05/08	15/05/2008		68	18		147	0.003	0.05	0.0002	0.002	0.003	4.47	0.004	0.004	0.01	0.014	1.9	0.26	1.9	10	<1	<0.1	3	6		15	1.37	1.55					
R023	Cattle Ck @ Cattle Ck Rd	R023_15/05/08CHK	15/05/2008					148																											
R022	Kangaroo Ck @ Wallumbilla North Rd	R022_05/03/08	5/03/2008			94	50	30	0.005	<0.1	<0.0001	0.003	0.002		0.002	0.005	0.032	0.109	1.1	0.21	1.2	9	2	0.1	4	7	13	2	1.28	1.47		<1	<1	58	58
R022	Kangaroo Ck @ Wallumbilla North Rd	R022_05/03/08CHK	5/03/2008															0.104	1.1	0.23															
R022	Kangaroo Ck @ Wallumbilla North Rd	R022_15/05/08	15/05/2008		69	14		54	0.001	0.06	<0.0001	0.002	0.003	4.48	0.002	0.003	0.014	<0.01	1.5	0.2	1.5	14	7	0.2	6	7		15	2.02	2					
R022	Kangaroo Ck @ Wallumbilla North Rd	R022_15/05/08CHK	15/05/2008						0.002		<0.0001	0.002	0.003		0.002	0.004	0.016																		
R021	Yuleba Ck @ Warrego Hwy	R021_06/03/08	6/03/2008			109	<1	71	0.005	<0.1	0.0001	0.004	0.003		0.002	0.006	0.015	0.096	2.9	0.28	3	9	3	0.1	4	8	15	3	1.46	1.62		<1	<1	66	66
R021	Yuleba Ck @ Warrego Hwy	R021_13/05/08	13/05/2008		8	8		25	0.003	<0.05	<0.0001	<0.001	0.001	5.38	0.002	0.002	0.018	0.044	1	0.14	1	11	8	0.2	5	7		12	1.5	1.66					
R019	Yuleba Ck @ Roma Condamine Rd	QC01_04/03/08	4/03/2008		<2	17	7	66	0.004	0.1	<0.0001	0.007	0.004		0.003	0.006	0.016	0.041	0.7	0.08	0.7	4	18	<0.1	2	6	38	3	2.28	2.24	1.05	<1	<1	85	85
R019	Yuleba Ck @ Roma Condamine Rd	R019_04/03/08	4/03/2008		<2	12	9	37	0.003	<0.1	0.0002	0.003	0.003		0.002	0.004	0.015	0.099	0.5	0.05	0.6	9	11	<0.1	4	8	18	7	1.56	1.75	5.52	<1	<1	55	55
R019	Yuleba Ck @ Roma Condamine Rd	R019_15/05/08	15/05/2008		46	7		47	<0.001	0.82	0.0003	<0.001	0.002	3.2	0.002	0.002	0.006	0.054	1.2	0.28	1.3	5	77	0.8	2	4		230	10	10.5	2.38				
R019	Yuleba Ck @ Roma Condamine Rd	R019_15/05/08CHK	15/05/2008																1.2	0.28															

NOTES

CHK - Lab Duplicate sample
LOR - Limit of reporting
MTV - minimum trigger value

Table A4
GLNG CSG Surface Water
Roma - DNRW Surface Water Analytical Results Summary

Parameter	**Physico-Chemical Parameters**												**Nutrients**									
	Colour True	Conductivity @ 25C	Conductivity @ 25C FLD	Dissolved Oxygen FLD	pH	pH FLD	Air Temp	Water Temp	Turbidity	Turbidity FLD	Total Diss. Solids	Total Suspended Solids	Chlorophyll-a	Nitrate as NO3	Nitrate + nitrite as N - total	Ammonia as N - soluble	Faecal Coliform	Kjeldahl Nitrogen	Total Nitrogen	Nitrate + nitrite as N - soluble	Total React P sol	Total Phosphorus as P
Units	*Hazen units*	*uS/cm*	*uS/cm*	*mg/L*	*pH units*	*pH units*	*° C*	*° C*	*NTU*	*NTU*	*mg/L*	*mg/L*	*ug/L*	*mg/L*	*mg/L*	*mg/L*	*CFU/100 ml*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
WQO	*325*	*325*	*325*		*6.5-8.0*	*6.5-8.0*		*20%ile-80%ile*	*50*	*50*	*500*	*10*	*5*	*0.05*		*0.01*			*0.5*			*0.05*
Bungil Creek Tabers																						
Number	31	41	30	21	40	24	21	40	34	21	41	42	0	30	1	2	0	10	17	2	2	27
Minimum	4.00	66.30	65	3.70	6.80	6.60	8.50	8.70	1.10	4.70	41	5	0	**0.27**	0.34	0.002	0	0.39	0.43	0.002	0.06	0.01
Median	30	160.3	227	6.9	7.5	7.8	23.8	22.15	**100**	**58.05**	110	**96.5**		**1.9**	0.3356	0.002		0.83	**1.212**	0.002	0.0615	**0.2**
Maximum	200	**1890**	**1647**	14.20	**8.50**	**8.70**	34.50	28.40	**700**	**>1000**	**1306**	**1500**	0	**4.20**	0.34	0.002	0	2.93	**2.51**	0.002	0.06	**0.68**
Balonne River Surat																						
Number	6	6	0	0	6	0	0	0	6	0	6	6	0	6	0	1	0	0	9	1	1	9
Minimum	2	74	#REF!	#REF!	6.81	#REF!	#REF!	0	**583**		53	**148**		**1.40**		0.01			**0.92**	0.39	0.04	**0.32**
Median	9	95			6.88				**1295**		67	**857.5**		**2.35**		0.009			**1.7**	0.39	0.0355	**0.62**
Maximum	14	154	#REF!	#REF!	7.24	#REF!	#REF!	0	**3620**		97	**2810**		**3.80**		**0.01**			**3.60**	0.39	0.04	**1.60**
Yuleba Creek Forestry																						
Number	5	21	1	1	17	1	5	20	15	1	11	14	2	10	1	3	3	2	3	3	3	5
Minimum	16	72	#REF!	#REF!	6.6	#REF!	22.1	12	**80**		54	10	**9**	**0.5**		**0.018**	18	1.255	**1.6**	0.037	0.008	**0.27**
Median	70	164			7.4		29.4	24.95	**245**		107	**107**	**18.5**	**1.475**		**0.02**	70	1.4915	**1.9**	0.07	0.014	**0.39**
Maximum	92	**455**	#REF!	#REF!	7.9	#REF!	38.9	29.5	**802**		250	**360**	**28**	**4**		**0.037**	110	1.728	**2.1**	0.25	0.03	**0.55**

Table A4
GLNG CSG
Roma - DN

Parameter	Major Ions								Metals								Alkalinity					
	Calcium as Ca soluble	Chloride as Cl	Hydrogen as H	Magnesium as Mg soluble	Potassium as K	Sodium as Na	Sulphate as SO4	Total Diss. Ions	Aluminium as Al soluble	Boron as B	Copper as Cu soluble	Flouride as F	Iron as Fe soluble	Manganese as Mn soluble (mg/L)	Silica as SiO_2 soluble	Zinc as Zn soluble	Total Alkalinity as CaCO3	Total Alkalinity as CaCO3 FLD	Hydroxide as OH	Carbonate as CO3	Bicarbonate as HCO3	Hardness as CaCO3
Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
WQO	*1000*	*175*				*115*	*400*		*0.055*	*0.37*	*0.0014*	*1*	*0.2*			*0.008*						
Bungil Creek																						
Number	41	38	2	40	40	41	37	41	22	23	16	34	0	0	0	0	41	2	11	32	41	40
Minimum	4.30	2.55	0.10	1.10	2.2	5.6	1	50.16	0.01	<0.02	**<0.01**	<0.02	0	0	0	0	25.00	70.80	0.01	0.02	21.50	15.50
Median	14.6	10.65	1.35	3.25	5	19	6.3	132.7	0.05	0.05	**0.01**	0.1					71.4	134.4	0.01	0.39	86.9	53.2
Maximum	130.2	**350**	2.60	22	11	320	558	1458.3	**0.24**	0.14	**0.07**	0.50	0	0	0	0	422.2	198.0	0.03	15.5	502.9	402.2
Balonne Rive																						
Number	6	6	0	6	6	6	6	6	6	6	6	6	0	0	0	0	6	0	0	1	6	6
Minimum	2.60	<4	0	1.30	3.6	8	4	58	0.05	0.05	**<0.03**	<0.1					24.00		0	0.10	29	12
Median	2.95	11		1.65	4	12.5	5	72.5	0.05	0.05		0.1					30			0.1	36.5	14.5
Maximum	7.70	11	0	3.70	4.2	15	6	112	**0.08**	<0.1	<0.03	0.10					52.00		0	0.10	64	35
Yuleba Creek																						
Number	11	11	1	11	11	11	11	11	2	6	2	8	8	5	11	2	13	1	1	7	11	1
Minimum	4	4.2		1.8	3.4	9	1	57	0	0	0	0.09	0	0	10	0.01	20			0.06	24	
Median	8.2	16.17		4	5.3	18.7	7.52	122.51	**0.91**	0.03	**0.005**	0.1	**1.95**	0.01	20	0.03	52.41			0.1	55	
Maximum	25	64		11	8.1	45	14	318.2	**1.81**	0.1	**0.01**	0.13	**5.7**	0.03	63	0.05	124			0.4	150	

Table A5
GLNG CSG Surface Water
Roma - DNRW Surface Water Analytical Results Summary
422210A Bungil Creek Tabers

DATE	TIME	Stream Water Level	Stream Discharge	Depth	Physico-Chemical Parameters: Colour True	Conductivity @ 25C	Conductivity @ 25C FLD	Dissolved Oxygen FLD	pH	pH FLD	Air Temp	Water Temp	Turbidity	Turbidity FLD	Total Diss. Solids	Total Suspended Solids
	Units	m	Cumecs	m	Hazen units	uS/cm	uS/cm	mg/L	pH units	pH units	°C	°C	NTU	NTU	mg/L	mg/L
	WQO					325	325		6.5-8.0	6.5-8.0		20%ile-80%ile	50	50	<500	10
18/01/1972	1400	1.08	4.276	0.1		137			7			21			77	
27/05/1974	1633	0.75	0.099	0.1		1540			7.8			14			988	100
12/01/1976	1620	0.73	0.048	0.1								25				
18/01/1976	0925	0.78	0.196	0.1								27				
14/02/1980	1300	0.74	0.131	0.1		125			7.2			24			85	10
9/12/1980	1700	0.77	0.249	0.1								26				
24/05/1983	0910	6.67	427	0.1		87			7.5						55	710
28/05/1983	1555	4.93	115	0.1		110			7.5						63	215
23/06/1983	1530	1.46	13.5	0.1		145			7.5				100		100	285
30/07/1983	1415	0.74	0.038	0.1		930			7.5			16			550	10
6/02/1984	1000	0.83	0.409	0.1	40	520			8.5			24	20		310	15
1/09/1984	1620	0.74	0.024	0.1	5	1300			7.8				19		800	20
2/12/1984	1100	0.58	0	0.1	10	1050			7.9			28			650	5
9/03/1985	1145	0.79	0.132	0.1		140			6.9			18	100		110	1177
19/02/1986	1035	0.73	0.019	0.1			180					28				
2/09/1986	0900	0.09	0	0.1		155							100		84	510
13/11/1986	1010	1.13	4.806	0.1	70	74	65		7.1			17	100		61	1500
15/02/1987	1215	0.75	0.054	0.1	15	730	710		8			27	18		460	23
28/05/1989	1630	0.82	0.358	0.1			560					17				
31/05/1990	1115	0.74	0.0787	0.1			250					16				
8/12/1993	1115	1.148		0.1			99.3			7.5		24.1				
3/02/1994	1440	0.77	0.129	0.1		144	128.5		7	8.5		21.6	200		98	735
10/03/1994	0900	3.24	54.13	0.1	70	129	120		7.6			22.9	182		81	340
29/11/1994	1600	0.58	0	0.3	200	160.3	151		7.31	7.3		22	200		95.61	86
12/04/1995	1500	NA	0	0.2	40	307.3	315	14.2	7.58	7.3	24.7	19.6	7.1	19.5	179.71	22
21/02/1996	1700	0.67		0.3	16	688	684	6.7	7.97	7.5	34.5	27	14.2	19	420.39	22
21/06/1996	1615	0.578	0	0.3	59	340	343	11.1	8.1	8.5	23.8	16.2	11	14.7	200	20
9/10/1996	0850	0.22	0	0.3	30	445	462	6	7.75	8	16.9	17.7	16	21	260	30
19/02/1997	0800	0.96	2.177	0.2	37	159	160	6.9	7.36	8	24.9	25	230	328	106.43	180
12/05/1997	1420	0.7	0.007	0.2	13	1174	1249	5.4	7.9	7.6	23.4	18.1	5.7	9	767.09	10
18/06/1997	0900	0.66	0.002	0.1	12	1600	1647	9.3	8.18	7.8	8.5	9.2	3.4	4.7	1056.64	8
7/10/1997	1420	0.67	0	0.1	28	1440	1343	6.5	7.73	8.5	20	22.3	100	93.6	930.59	93
24/11/1997	1615	0.66	0.003	0.1	40	204	203	6.3	7.5	7.6	32.8	27.2	218	190	123.76	188
12/08/1998	0830	0.59	0	0.1	6	144	141	5	6.88	7.9	9.1	8.7	287	306	100.13	123
12/01/1999	1115															
29/01/1999	1100	0.48	0	0.1	58	241	238	3.7	7.77	7.5	27.5	28.4	37.7	69.1	146.66	39
12/04/1999	1115															65
21/04/1999	0930															
21/04/1999	1340	0.41		0.1	59	269	288	7.2	7.47	7.8	21.3	23.1	24.2	38	177.21	24
21/05/1999	0930															81
9/07/1999	1200	0.3	0	0.1	20	257	237	8.6	8.05	8.4	16.7	14.5	12.6	21	152.8	5
13/04/2000	1250	0.3	0	0.1	49	221	217	7.9	7.52	8.7	21.5	22.8	131	192	128.67	128
30/10/2000	1830	2.41		0.1	72	72	65	8.1	6.8	8.1	19.2	17	700	>1000	49	750
31/10/2000	1020	1.34		0.1	95	97.1	93	11.2	6.87	7.9	17.4	17.8	441	726	66.26	458
1/11/2000	1420	1.2		0.1	79	98.6	92	7.6	7.03	7.7	28	20.2	612	913	62.15	594
27/02/2002	1510	5.85		0.1	13	66.3	67	5.3	7.03	6.6	29.2	24.5	662	936	40.64	664
28/02/2002	1025	1.18		0.1	33	124.9	124	5.2	7.33	7.2	28.5	25.3	475	656	76.91	509
9/04/2002	1038	0.66		0.1	24	1401	430	5.5	8.04	7.6	27.8	22.8	7.1	47	947.71	12
12/08/2002	1355	0.55		0.1	11	1890	1644	10.2	8.18	8.2	26.5	18.8	1.1	5	1305.76	7
30/06/2005	1120	0.68		0.1	4	116			7.21				474		87	248
25/10/2005	1300	0.71		0.1	7	111			7.17				624		72	472
6/12/2005	1445	0.78		0.2												
3/11/2006	1208	0.79		0.1	16	91			7.07				160		55	826

DATE	Nutrients: Chlorophyll-a	Nitrate as NO3	Nitrate + nitrite as N - total	Ammonia as N - soluble	Faecal Coliform	Kjeldahl Nitrogen	Total Nitrogen	Nitrate + nitrite as N - soluble	Total React P sol	Total Phosphorus as P	Major Ions: Calcium as Ca soluble	Chloride as Cl	Hydrogen as H	Magnesium as Mg soluble	Potassium as K	Sodium as Na	Sulphate as SO4	Total Diss. Ions
Units	ug/L	mg/L	mg/L	mg/L	CFU/100 ml	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WQO	5	0.05		0.01			0.5			0.05	1000	<175				115	400	
18/01/1972											12	8		5		12		118.5
27/05/1974											85	350		22	11	240	100	1146.7
12/01/1976																		
18/01/1976																		
14/02/1980		2									10	10		2.2	4	11	5	105.3
9/12/1980																		
24/05/1983		2.4									6.3			1.7	3.9	9.6		66.9
28/05/1983		1.4									8.4			1.9	3.9	8		72.7
23/06/1983		2.5									11.5	4		2.5	4.1	15	2.7	121.3
30/07/1983											77	91		13	4.7	100	96	662.4
6/02/1984											50	32	0.1	8.1	5.3	49	32	401.1
1/09/1984											97	115		16	5	160	180	985.1
2/12/1984											62	105		12	7.4	155	135	803.7
9/03/1985		3.8									12	5.6		2.6	4.6	11	12	123
19/02/1986																		
2/09/1986											12	11	2.6		5	15		82.8
13/11/1986		0.9									5.6	4		1.7	3.7	6.8	2	58.6
15/02/1987		1.8									74	46		11	6.1	70	84	590.3
28/05/1989																		
31/05/1990																		
8/12/1993																		
3/02/1994		4.2								0.59	7.9	7.5	ND	1.7	2.6	22.2	12.4	121.4
10/03/1994		2.3									8.9	5.4	ND	2.1	5.3	12.9	1.8	98.8
29/11/1994		3.77									10	8.33	ND	2.3	5.5	15.5	3.71	119.73
12/04/1995		1.41				0.8761				0.1324	24.8	12.28	ND	5.9	9.7	34.5	6.3	266.05
21/02/1996		0.27				0.606				0.0397	77.2	25.59	ND	11.3	6.3	56.8	74.59	554.83
21/06/1996		0.5				0.658				0.0408	29	13.5	ND	5	6.7	35.5	24.5	270
9/10/1996		0.5				1.033				0.0522	32	22	ND	6.9	7.4	56	23	370
19/02/1997		0.8				1.308				0.2765	14.6	5.1	ND	3	7.1	13.8	1.2	132.7
12/05/1997		0.44				0.517				0.033	108.2	103.23	ND	17.3	7	148.3	127.5	979.92
18/06/1997		ND				0.391				0.0137	130.2	81.32	ND	18.8	5.2	222.4	320.04	1286.94
7/10/1997		ND				0.827				0.0866	54.5	98.06	ND	15.5	6.1	252	354.06	1068.99
24/11/1997		0.63				0.833				0.2269	19.2	10.29	ND	3.2	5	19	6.52	161.19
12/08/1998		2.29					2.37			0.4347	11.6	13.62	ND	2.1	3.6	16.7	7.03	119.1
12/01/1999				0.002			0.94	0.002	0.06	0.2								
29/01/1999		1.51					0.66			0.1342	20.7	9.5	ND	3.8	7.3	22.9	2.35	194.02
12/04/1999																		
21/04/1999				0.002				0.002	0.063									
21/04/1999		3.16					1.94			0.3688	25.6	11.58	ND	4.7	8.9	26.2	3.52	237.74
21/05/1999							0.61			0.06								
9/07/1999		ND					0.74			0.0802	23	11.22	ND	4.6	6.8	29.1	2.2	229.55
13/04/2000		2.4					1.12			0.1821	16.8	8.18	ND	3.3	6	23.7	2.95	174
30/10/2000		2.5					2.10			0.46	4.3	<4	ND	1.1	3.3	7.9	2	57
31/10/2000		2.89					1.79			0.44	6.2	5.03	ND	1.5	4.5	9.1	1.43	77.21
1/11/2000		1.47					1.47			0.435	7	3.62	ND	1.4	4.3	9	1.05	73.38
27/02/2002		1.07					1.29			0.3286	4.9	2.55	ND	1.1	2.2	5.6	1	50.16
28/02/2002		1.28					1.21			0.3079	11.3	3.52	ND	2.2	3.2	9.6	2.68	100.25
9/04/2002		ND					0.43			0.0433	130	72.1	ND	15.2	4.7	178.5	316.96	1134.44
12/08/2002		1.23					0.61			0.0156	100	116.76	ND	20.6	5.1	320.1	558	1458.29
30/06/2005		2.6					1.20			0.21	4.3	5.3	ND	1.2	2.7	17	5.6	89
25/10/2005		2.3									9.1	3.1	ND	1.9	3.8	10	1.6	94
6/12/2005			0.3356			2.93	2.16			0.576								
3/11/2006		2.5					2.51			0.6782	5.5	4.8	ND	1.3	3.6	8	2.3	68

DATE	Metals: Aluminium as Al soluble	Boron as B	Copper as Cu soluble	Flouride as F	Iron as Fe soluble	Manganese as Mn soluble (mg/L)	Silica as SiO_2 soluble	Zinc as Zn soluble	Alkalinity: Total Alkalinity as CaCO3	Total Alkalinity as CaCO3 FLD	Hydroxide as OH	Carbonate as CO3	Bicarbonate as HCO3	Hardness as CaCO3
Units	mg/L	mg/L	mg/L	mg/L					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WQO	0.055	0.37	0.0014	1	0.2			0.008						
18/01/1972				0.5					66				81	51
27/05/1974				0.14					279			1.6	337	303
12/01/1976														
18/01/1976														
14/02/1980				0.1					50				61	34
9/12/1980														
24/05/1983		0.01							35			0.1	42.5	23
28/05/1983		0.01							40			0.1	48.5	29
23/06/1983									64			0.1	78	39
30/07/1983		0.04		0.1					222			0.1	270	246
6/02/1984		0.03							188			4.6	220	158
1/09/1984		0.04							340			2.1	410	308
2/12/1984		0.05		0.2					270			2	325	204
9/03/1985		0.01		0.1					57				69	41
19/02/1986														
2/09/1986				0.2					44			15.5	21.5	
13/11/1986		0.01		0.1					25				30.5	21
15/02/1987		0.05		0.1					245			2.1	295	230
28/05/1989														
31/05/1990														
8/12/1993														
3/02/1994			0.07	0.02					51		ND	ND	62.7	26
10/03/1994	0.24		0.06	0.02					49		0.01	0.1	59.8	30
29/11/1994	0.16	ND	ND	0.07					57.9		ND	0.08	70.47	34
12/04/1995	0.05	ND	0.05	0.14					140.5		0.01	0.37	170.64	86
21/02/1996	ND	0.1	ND	ND					249.8		0.02	1.87	300.89	239
21/06/1996	0.05	<0.1	<0.05	<0.1					130		ND	1.1	160	93
9/10/1996	0.05	<0.1	<0.05	0.1					185		ND	0.8	225	110
19/02/1997	0.01	ND	0.01	0.1					71.4		ND	0.1	86.89	49
12/05/1997	ND	0.1	0.01	0.22					385.6	198	0.01	2.58	465.13	341
18/06/1997	ND	0.1	0.01	0.13					422.2		0.03	5.96	502.87	402
7/10/1997	0.1	0.1	ND	0.15					237.6		0.01	1.18	287.43	200
24/11/1997	0.01	ND	ND	0.12					79.85	70.8	0.01	0.17	97.05	61
12/08/1998	ND	ND	0.01	0.02					50.95		ND	0.02	62.11	38
12/01/1999														
29/01/1999	0.07	ND	ND	0.12					103.5		0.01	0.4	125.44	67
12/04/1999														
21/04/1999														
21/04/1999	0.01	ND	ND	0.12					126.42		ND	0.25	153.7	83
21/05/1999														
9/07/1999	0.01	ND	ND	0.1					125.84		0.02	0.93	151.58	76
13/04/2000	0.03	ND	ND	0.04					90.85		ND	0.19	110.44	55
30/10/2000	0.06	0.1	<0.05	<0.1					27		ND	ND	33	16
31/10/2000	0.07	ND	ND	0.02					38.16		ND	0.02	46.52	22
1/11/2000	0.04	ND	ND	0.02					37.33		ND	0.03	45.49	23
27/02/2002	0.01	0.03	0.01	0.02					26.01		ND	0.02	31.7	17
28/02/2002	0.02	0.02	0.01	0.03					54.52		ND	0.07	66.36	37
9/04/2002	0.02	0.12	0.01	0.17					344.57		0.02	3.4	413.39	387
12/08/2002	0.01	0.14	ND	ND					279.2		0.03	3.92	332.56	334
30/06/2005	0.05	0.05	<0.03	<0.1					42		ND	ND	51	16
25/10/2005	0.05	0.05	<0.03	0.1					51		ND	ND	62	30
6/12/2005														
3/11/2006	0.05	<0.02	<0.03	0.1					33		ND	ND	40	19

Notes
123 Greater than WQO
Various data collected prior to 1994 considered to be of poor quality

Table A6
GLNG CSG Surface Water
Roma - DNRW Surface Water Analytical Results Summary
422220A Balonne River @ Surat

				Physico-Chemical Parameters							Nutrients						Major Ions								Metals				Alkalinity				
DATE	**TIME**	Stream Water Level	Depth	Colour True	Conductivity @ 25C	pH	Water Temp	Turbidity	Total Diss. Solids	Total Suspended Solids	Nitrate as NO3	Ammonia as N - soluble	Total Nitrogen	Nitrate + nitrite as N - soluble	Total React P sol	Total Phosphorus as P	Calcium as Ca soluble	Chloride as Cl	Hydrogen as H	Magnesium as Mg soluble	Potassium as K	Sodium as Na	Sulphate as SO4	Total Diss. Ions	Aluminium as Al soluble	Boron as B	Copper as Cu soluble	Flouride as F	Total Alkalinity as CaCO3	Hydroxide as OH	Carbonate as CO3	Bicarbonate as HCO3	Hardness as CaCO3
	Units	*m*	*m*	*Hazen units*	*uS/cm*	*pH units*	*°C*	*NTU*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
	WQO				*325*	*6.5-8.0*	*20%ile-80%ile*	*50*	*<500*	*10*	*0.05*	*0.01*	*0.5*			*0.05*	*1000*	*<175*				*115*	*400*		*0.055*	*0.37*	*0.0014*	*1*					
9/12/2004	0922	5.15	0.1	3	80	6.82		**3620**	54	**2810**	**2.9**		**3.6**			**1.6**	2.8	<5	-	1.4	3.6	9	6	58	**0.08**	<0.1	**<0.03**	0.1	24	-	-	29	13
9/12/2004	1227	5.53	0.1	8	74	6.81		**2880**	53	**2100**	**2.7**		**2.8**			**1.2**	2.6	<4	-	1.3	3.7	8	5	58	0.05	<0.1	**<0.03**	<0.1	26	-	-	31	12
13/12/2004	1716	5.15	0.1	14	102	6.84		**1480**	71	**1030**	**3.8**		**2.1**			**0.62**	3.1	<8	-	1.7	4.2	14	6	76	0.05	<0.1	**<0.03**	<0.1	30	-	-	36	15
14/12/2004	0812	4.8	0.1	13	92	6.91		**1110**	65	**685**	**2**		**2**			**0.59**	2.8	<7	-	1.6	3.8	12	5	71	0.05	<0.1	**<0.03**	<0.1	30	-	-	37	14
16/12/2004	1043	3.59	0.1	10	98	6.94		**826**	69	**522**	**1.7**		**1.7**			**0.42**	3.1	<7	-	1.8	4.2	13	4	74	0.05	<0.1	**<0.03**	0.1	33	-	-	40	15
6/12/2005	1350	5.11	0.2									0.0091		0.39	0.0355																		
22/12/2005	1900	3.17	0.2										**1.58**			**0.4**																	
21/01/2006	0700	3.35	0.2										**1.647**			**0.69**																	
21/01/2006	1830	3.24	0.2										**1.646**			**0.68**																	
21/02/2006	1730	3.1	0.2										**0.92**			**0.32**																	
6/05/2006	1600	0	0.2	2	154	7.24		**583**	97	**148**	**1.4**						7.7	11	-	3.7	4.2	15	4.3	112	0.05	0.05	**<0.03**	0.1	52	-	0.1	64	35

123	Greater than WQO

Table A7
GLNG CSG Surface Water
Roma - DNRW Surface Water Analytical Results Summary
422219A Yuleba Creek @ Forestry

					Physico-Chemical Parameters								Nutrients									Major Ions							Metals								Alkalinity		
DATE	TIME	Stream Water Level	Stream Discharge	Depth	Colour True	Conductivity @ 25C	pH	Air Temp	Water Temp	Turbidity	Total Diss. Solids	Total Suspended Solids	Chlorophyll-a	Nitrate as NO3	Ammonia as N - soluble	Faecal Coliform	Kjeldahl Nitrogen	Total Nitrogen	Nitrate + nitrite as N - soluble	Total React P sol	Total Phosphorus as P	Calcium as Ca soluble	Chloride as Cl	Magnesium as Mg soluble	Potassium as K	Sodium as Na	Sulphate as SO4	Total Diss. Ions	Aluminium as Al soluble	Boron as B	Copper as Cu soluble	Flouride as F	Iron as Fe soluble	Manganese as Mn soluble (mg/L)	Silica as SiO_2 soluble	Zinc as Zn soluble	Total Alkalinity as CaCO3	Carbonate as CO3	Bicarbonate as HCO3
	Units	*m*	*Cumecs*	*m*	*Hazen units*	*uS/cm*	*pH units*	*°C*	*°C*	*NTU*	*mg/L*	*mg/L*	*ug/L*	*mg/L*	*mg/L*	*CFU/100 ml*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
	WQO					*325*	*6.5-8.0*		*20%ile-80%ile*	*50*	*<500*	*10*	*5*	*0.05*	*0.01*			*0.5*			*0.05*	*1000*	*<175*			*115*	*400*		*0.055*	*0.37*	*0.0014*	*1*	*0.2*			*0.008*			
2/10/1973	1705	1.17	0.089	0.1		164	7				107	**252**										10	30	5.5	3.4	18.7	1	127.7				0.11	**5**		12		44		54
2/10/1973	1705								20																														
3/03/1974	1145	1.103	0.007						27																														
18/01/1975	1200	1.245	0.309						27																														
18/01/1976	1240	1.55	1.276						26																														
13/09/1978	1145	1.48	1.131	0.1		105	6.6				70	**175**		**0.7**								5.5	11	2.3	4.5	12	7	67							15		20		24
13/09/1978	1145								14																														
5/02/1982	1420	1.14	0.006	0.1		150	7.7			**100**	110	**50**		**4**								8	13	4.3	5.3	17	10	116.8				0.09			23		45	0.1	55
5/02/1982	1420								29																														
29/05/1983	1430	7.65	125	0.1		72	7.9			**100**	54	**360**		**4**								4	4.2	1.8	4	9	3.7	57				0.1	**0.6**	0.01	11		21	0.1	25.5
27/07/1983	1550	1.28	0.223	0.1		250	7.5				200	**58**		**3.3**								13	31	6.3	4.9	28	11	182.4		0.06			**5.7**	0.01	63		65	0.1	79
27/07/1983	1550								12																														
9/11/1983	1515	1.31	0.213	0.1	20	**455**	7.6				250	**10**		**0.6**								25	64	11	8.1	45	14	318.2		0.03		0.1			10		124	0.4	150
9/11/1983	1515								27																														
3/02/1984	1440	2.5	6.529						27																														
31/08/1984	1600	1.35	0.286	0.1	70	205	7.2			**80**	140	**10**		**2.2**								9	28	4	5.5	26	12	161.8		0.02			**2**		20		60	0.1	73
30/11/1984	1700	1.04	0						27																														
17/11/1986	1230	1.31	0.379	0.1	70	115	7.2			**100**	93	**300**		**0.5**								5.7	7.1	2.7	5.5	10	7.7	82.8		0.03		0.1	**3.5**	0.03	34		33		40
17/11/1986	1230					106			22																														
21/05/1988	1040	1.13	0.008	0.1		115	6.9			**100**	85	**154**		**1.6**								5.8	7.3	2.7	4.3	13	6.1	84.3				0.1	**1.9**		24		34		41.5
21/05/1988	1040					88			13																														
29/05/1989	1147	1.165	0.061			132			15																														
9/01/1992	1115	1.25	0.39			94			25																														
19/12/1995	1145	1.24	0.202			209	7.4	29.4	24.9	**597**																													
20/02/1996	1635	1.288	0.142			202	7.8	36.3	26.2	**180**																													
8/10/1996	1415	1.18	0.021			190	7.4		19	**213**																													
11/03/1997	1445	1.61	1.329			112	7.4	28.2	24.4	**802**																													
27/05/1997	1645	0.77	0	0.2	16	166	7.25			**323**	105.67	**51**		**1.35**								8.2	16.17	3.6	6.2	19	3.98	122.51	0	0.00	**0.01**	0.13	0.00	0.00	15.60	**0.01**	52.41	0.06	63.82
27/05/1997	1645																1.255				**0.268**																		
27/05/1997	1645	0.77	0			173	7.25	22.1	15.5	**322**																											53.6		
27/11/1997	1405	1.17	0	0.1	92	238	7.21			**327**	148.05	**84**		**1.19**								11.9	26.26	5.5	7.7	29.4	7.52	167.74	**1.81**	0.1	0	0.12	**1.06**	0	20	**0.05**	64.12	0.07	78.07
27/11/1997	1405																1.728				**0.39**																		
27/11/1997	1405					245	7.4	38.9	29.5	**245**																											72		
12/01/1999	930											**200**																											
12/01/1999	930																	**2.1**			**0.36**																		
12/01/1999	930														**0.02**				0.25	0.03																			
12/01/1999	930															70																							
12/04/1999	1300									**680**		**130**																											
12/04/1999	1300																	**1.9**			**0.55**																		
12/04/1999	1300														**0.037**				0.037	0.014																			
12/04/1999	1300												**28**																										
12/04/1999	1300															110																							
1/07/1999	0									**500**		**75**																											
1/07/1999	0																	**1.6**			**0.48**																		
1/07/1999	0														**0.018**				0.07	0.008																			
1/07/1999	0												**9**																										
1/07/1999	0															18																							

Notes
Bold Greater than WQO

Upper Dawson Catchment Water Quality Data

Appendix B

Table B1
URS Water Quality Parameters Upper Dawson Catchment
GLNG CSG Surface Water

Site ID		Date/Time	Water Quality Parameters					
Number	**Name**	**Date**	**Time (EST)**	**EC (µS/cm)**	**DO (mg/L)**	**pH**	**Turbidity (NTU)**	**Temp (oC)**
			MTV	*340*		*6.5-8*	*50*	
D002	Dawson River @ Yebna Crossing	05-Mar-08	12:00	107	6.2	7.1	**270**	23.9
D002	Dawson River @ Yebna Crossing	02-Feb-08	10:35	264	5.47	6.76	**166**	25.4
D002	Dawson River @ Yebna Crossing	14-May-08	16:20	265	11.3	7.5	9	17.3
D003	Pine Creek @ Phelps Rd	05-Mar-08	-	-	-	-	-	-
D003	Pine Creek @ Phelps Rd	02-Feb-08	12:20	227.2	4	6.59	**266**	29.2
D003	Pine Creek @ Phelps Rd	13-May-08	15:45	-	-	-	-	-
D004	Dawson River @ Taroom-Roma Rd	05-Mar-08	16:40	150	6.01	7.73	**555**	23.3
D004	Dawson River @ Taroom-Roma Rd	02-Feb-08	13:36	270	5.23	6.82	**215**	27.3
D004	Dawson River @ Taroom-Roma Rd	13-May-08	10:55	**368**	9.84	7.78	14	14.6
D005	Eurombah @ Hornet Bank Rd	05-Mar-08	17:10	118	6.15	7.5	**492**	24.4
D005	Eurombah @ Hornet Bank Rd	02-Feb-08	14:15	317	5.95	7.16	**191**	28.8
D005	Eurombah @ Hornet Bank Rd	13-May-08	10:00	**340**	6.22	7.3	13	16.1
D006	Bridge/Ram Creek @ Roma Rd	05-Mar-08	16:30	192	7.43	**8.41**	**111**	28.1
D006	Bridge/Ram Creek @ Roma Rd	02-Feb-08	14:43	271	6.18	7.51	32	30.9
D006	Bridge/Ram Creek @ Roma Rd	13-May-08	11:30	-	-	-	-	-
D007	Paddys Creek @ Roma Rd	05-Mar-08	16:05	65.3	8.62	**8.41**	2	31.2
D007	Paddys Creek @ Roma Rd	02-Feb-08	14:56	232	4.57	**8.05**	**408**	30.8
D007	Paddys Creek @ Roma Rd	13-May-08	11:45	265	7.9	7.4	**240**	17.4
D008	Middle Creek @ Roma Rd	05-Mar-08	15:40	186	6.4	**8.5**	**152**	28.6
D008	Middle Creek @ Roma Rd	02-Feb-08	15:30	234	8.58	**8.34**	**54**	33.7
D008	Middle Creek @ Roma Rd	13-May-08	12:15	**488**	11.3	**8.5**	**160**	20.7
D009	Juandah Creek @ Roma Rd	05-Mar-08	15:20	120.2	2.26	7.14	**473**	28.5
D009	Juandah Creek @ Roma Rd	02-Feb-08	15:46	244	6.04	**8.06**	**163**	30.4
D009	Juandah Creek @ Roma Rd	13-May-08	12:30	218	6.36	6.8	**410**	20.5
D010	Dawson River @ Old Taroom Bridge	05-Mar-08	14:50	157.2	5.39	7.42	**427**	24.2
D010	Dawson River @ Old Taroom Bridge	02-Feb-08	16:23	225.1	4.15	6.98	**243**	27.8
D010	Dawson River @ Old Taroom Bridge	13-May-08	13:35	**420**	8.22	7.77		18.9
D011	Kinnoul Creek @ Taroom Rd	05-Mar-08	10:50	104	4.3	7.2	30	25.1
D011	Kinnoul Creek @ Taroom Rd	02-Feb-08	17:00	245	6.48	7.49	28	28.8
D011	Kinnoul Creek @ Taroom Rd	13-May-08	14:10	205	9.5	7.43	28	20.2
D012	Hutton Creek @ Carnarvon Hwy	05-Mar-08	-	-	-	-	-	-
D012	Hutton Creek @ Carnarvon Hwy	03-Feb-08	9:00	**485**	4.5	7.2	5	26.8
D012	Hutton Creek @ Carnarvon Hwy	13-May-08	9:15	260	6.7	6.98	22	14.9
D013	Dawson River @ Arcadia Valley Rd	06-Mar-08	10:00	136	-	7.1	-	-
D013	Dawson River @ Arcadia Valley Rd	03-Feb-08		222.9	6.33	7	31	25.5
D014	Dawson River @ Hornet Bank Rd	02-Feb-08	14:00	-	-	-	-	-
D015	Dawson River @ Baralaba	04-Feb-08	12:45	132	7.88	6.58	**180**	27.6
D016	Dawson River @ Carnavon Hwy	03-Feb-08		-	-	-	-	-

Notes:

MTV	minimum trigger value
BOLD	Greater than MTV
"-"	Creek dry

Table B2
Upper Dawson Catchment - URS Surface Water Analytical Results
GLNG CSG Surface Water

			Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				Major Ions										Alkalinity			
Location	Sample ID	Date Sampled	Sample Type	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Suspended Solids (SS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
			Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
			LOR	*2*	*5*	*1*	*1*	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*0.01*	*0.1*	*0.01*	*0.1*	*1*	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
			MTV	*na*	*na*	*na*	*10*	*0.024/0.013*	*0.37*	*0.0002*	*0.05*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*	*na*	*na*	*0.05*	*0.5*	*1000*	*175*	*1*	*na*	*na*	*115*	*400*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
D002	D002_05/03/08	5/03/2008	PS	-	31	8	**152**	0.002	<0.1	**0.0002**	0.004	**0.005**	-	**0.004**	0.004	**0.016**	**0.141**	1	**0.2**	**1.1**	12	8	0.1	4	6	20	2	1.74	1.9	-	<1	<1	73	73
D002	D002_05/03/08CHK	5/03/2008	LD	-	-	-	**146**	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	4	5	22	2	-	-	-	-	-	-	-
D002	D002_13/05/08	13/05/2008	PS	<5	1	-	3	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.67**	<0.001	<0.001	<0.005	<0.01	0.4	0.02	0.4	19	25	0.1	7	3		31	2.93	2.97	-	-	-	-	-
D004	D004_05/03/08	5/03/2008	PS	-	47	10	**152**	0.002	<0.1	0.0001	0.006	**0.008**	-	**0.007**	0.008	**0.031**	**0.174**	0.9	**0.19**	**1.1**	18	16	0.1	5	6	28	2	2.54	2.68	-	<1	<1	102	102
D004	D004_05/03/08CHK	5/03/2008	LD	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D004	QC02_05/3/08	5/03/2008	FD	-	49	<1	**290**	0.003	<0.1	0.0018	0.009	**0.008**	-	**0.007**	0.008	**0.04**	**0.149**	1.4	**0.19**	**1.6**	16	15	0.1	4	5	28	2	2.51	2.52	-	-	-	102	102
D004	D004_13/05/08	13/05/2008	PS	49	2	-	8	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.4**	<0.001	<0.001	<0.005	<0.01	0.1	0.03	0.1	27	35	<0.1	9	4		43	3.94	4.02	1.05	-	-	-	-
D004	D004_13/05/08CHK	13/05/2008	LD	-	2	-	-	-	-	-	-	-	-	-	-	-	**0.012**	-	-	-	28	-	-	9	4		49	-	-	-	-	-	-	-
D005	D005_05/03/08	5/03/2008	PS	-	44	<1	**270**	0.002	0.1	**0.0007**	0.003	**0.009**	-	**0.005**	0.005	**0.028**	**0.28**	0.8	**0.21**	**1.1**	16	9	0.1	3	6	20	2	1.93	2.05	-	<1	<1	82	82
D005	D005_13/05/08	13/05/2008	PS	<5	7	-	5	<0.001	0.08	<0.0001	<0.001	<0.001	**0.23**	<0.001	0.001	<0.005	<0.01	0.8	**0.05**	**0.8**	35	19	0.2	6	6		33	3.69	3.83	1.82	-	-	-	-
D007	D007_05/03/08	5/03/2008	PS	-	54	<1	**74**	0.002	<0.1	<0.0001	0.003	**0.007**	-	0.003	0.004	**0.02**	<0.01	1.8	**0.56**	**1.8**	13	8	0.1	2	9	20	2	1.84	1.95	-	<1	<1	78	78
D007	D007_13/05/08	13/05/2008	PS	28	9	-	**119**	0.002	0.05	<0.0001	0.002	**0.002**	**2.91**	0.001	0.002	<0.005	**0.012**	1.2	**0.22**	**1.2**	24	14	0.4	5	9		25	2.88	2.92	-	-	-	-	-
D007	D007_13/05/08CHK	13/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.2**	-	-	14	0.3	-	-		-	-	-	-	-	-	-	-
D009	D009_05/03/08	5/03/2008	PS	-	49	<1	**214**	0.004	<0.1	**0.0002**	0.005	**0.01**	-	**0.006**	0.007	**0.034**	**0.353**	1.7	**0.42**	**2.1**	12	6	0.1	2	8	23	3	1.89	2	-	<1	<1	83	83
D009	D009_13/05/08	13/05/2008	PS	16	7	-	**122**	0.002	<0.05	<0.0001	0.005	**0.007**	**9.62**	**0.005**	0.006	**0.025**	**0.177**	1.4	**0.37**	**1.6**	17	9	0.2	4	7		26	2.23	2.41	-	-	-	-	-
D009	D009_13/05/08CHK	13/05/2008	LD	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-								-	-	-	-
D010	D010_05/03/08	5/03/2008	PS	-	42	<1	**260**	0.002	<0.1	**0.0002**	0.005	**0.007**	-	**0.006**	0.005	**0.025**	**0.182**	1.3	**0.17**	**1.5**	13	16	0.2	3	6	35	2	2.53	2.63	-	<1	<1	102	102
D010	D010_05/03/08CHK	5/03/2008	LD	-	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	0.2	-	-	-	-	-	-	-	<1	<1	102	102
D010	D010_13/05/08	13/05/2008	PS	<5	3	-	6	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.28**	<0.001	<0.001	<0.005	<0.01	0.3	<0.01	0.3	28	39	0.2	10	5		49	4.34	4.45	1.18	-	-	-	-
D011	D011_05/03/08	5/03/2008	PS	-	82	<1	**26**	0.002	<0.1	<0.0001	<0.001	**0.003**		<0.001	0.002	<0.005	**0.015**	1	**0.3**	**1**	14	1	<0.1	3	8	17	1	1.74	1.91	-	<1	<1	84	84
D011	D011_13/05/08	13/05/2008	PS	8	7	-	**21**	0.001	0.05	**0.0005**	<0.001	**0.003**	**0.81**	<0.001	0.001	<0.005	<0.01	0.7	**0.09**	**0.7**	21	<1	0.1	4	7		16	2.02	2.22	-	-	-	-	-
D012	D012_14/05/08	14/05/2008	PS	45	10	-	**13**	<0.001	<0.05	0.0001	<0.001	**0.003**	**0.21**	<0.001	0.002	<0.005	<0.01	0.9	**0.07**	**0.9**	26	12	0.2	7	8		26	3.09	3.2	1.69	-	-	-	-
D012	D012_14/05/08CHK	14/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	-	-	-	25	-	0.1	7	7		25	-	-	-	-	-	-	-

NOTES

MTV - minimum trigger value

BOLD greater than MTV

PS - Primary Sample

LD - Lab Duplicate

FD - Field Duplicate Sample

Table B3
Upper Dawson Catchment - Upstream Dawson River Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date		Physical										Cations				Anions				Nutrients & Biological					Trace Elements										Flow		Physical Appearance	Data Source
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-a (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity		
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*		
Dawson River - Arcadia Valley	4/05/2002																																				No Flow	S
Dawson River - Arcadia Valley	1/01/2002																																				No Flow	S
Dawson River - Arcadia Valley	1/01/2002																																				No Flow	S
Dawson River - Arcadia Valley	22/06/2001																																				No Flow	S
Dawson River - Arcadia Valley	25/05/2001																																				No Flow	S
Dawson River - Arcadia Valley	20/04/2001																																				No Flow	S
Dawson River - Arcadia Valley	8/03/2001			26		199			135																												Clear	S
Dawson River - Arcadia Valley	8/02/2001	11:00		26		285			194																												Clear	S
Dawson River - Arcadia Valley	5/01/2001	13:00		27		279			190																												Clear	S
Dawson River - Arcadia Valley	17/12/2000	14:00		25		231			157																												Clear	S
Dawson River - Arcadia Valley	18/11/2000	15:30		25		231			157																												Clear	S
Dawson River - Arcadia Valley	5/10/2000																																					S
Dawson River - Arcadia Valley	5/09/2000																																				No Water	S
Dawson River - Arcadia Valley	3/08/2000																																				No Water	S
Dawson River - Arcadia Valley	13/07/2000																																				No Flow	S
Dawson River - Arcadia Valley	15/06/2000																																				No Sample	S
Dawson River - Arcadia Valley	2/06/2000																																					S
Dawson River - Arcadia Valley	29/04/2000																																					S
Dawson River - Arcadia Valley	1/04/2000																																				Not Flowing	S
Dawson River - Arcadia Valley	2/03/2000																																				No Flow	S
Dawson River - Arcadia Valley	30/01/2000																																					S
Dawson River - Arcadia Valley	30/12/1999																																					S
Dawson River - Arcadia Valley	29/11/1999																																					S
Dawson River - Arcadia Valley	30/10/1999																																					S
Dawson River - Arcadia Valley	30/09/1999																																				Not Flowing	S
Dawson River - Arcadia Valley	29/08/1999																																				No Water	S
Dawson River - Arcadia Valley	29/07/1999																																				No Water	S
Dawson River - Arcadia Valley	1/06/1999																																				No Water	S
Dawson River - Arcadia Valley	7/05/1999																																				No Water	S
Dawson River - Arcadia Valley	5/04/1999			28		135			92																												No flow, mud hole	S
Dawson River - Arcadia Valley	6/03/1999	15:00		27		176			120																												slight flow, murky	S
Dawson River - Arcadia Valley	26/02/1999																																				No Water	S
Dawson River - Arcadia Valley	1/01/1999																																				No Flow	S
Dawson River - Arcadia Valley	21/12/1998																																				No Flow	S
Dawson River - Arcadia Valley	29/11/1998																																				No Flow	S
Upstream Dawson Waterhole	9/10/2003			26.5	7.1	170	6.80	86	109			17	11	3	3	98	8	0.1	<5							**<100**									Isolated	No flow		RH
Upstream Dawson Waterhole	22/04/04			24.9	7	273	7.90	96	156	**52**		22	6	14	5	151	12	0.1	<10	**7780**	**140**					**500**									Isolated	Low		RH
Upstream Dawson Waterhole	17/11/04			24.5	6.6	**1702**	5.70	**69**	108	**82**		3	<1	6	6	70	8	0.24	<10		**1900**	**380**				**<100**									Low-Mod	Mod		RH
Dawson Road Crossing	5/09/2006			15.4	7	50	8.61	**84**	46	**125**	**101**	3	4	1	1	28	3	0.1	4	**570**	<10	10			4	<100	<0.1	16	2	**4407**	3	<0.1	4	**14**				RH
Dawson Road Crossing	26/04/2007		19.5	18.9	6.6	159	0.81	**9**	160	**68**		11	10	18	6	95	6	0.24	<1	**3300**	**110**	**590**	128*	**8.8**	2.8	23	<1	<1	**<2**	**5100**	<1	<0.5	<3	<1				RH

NOTES

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

All samples collected upstream of existing associated water discharge

S - Santos

Water Quality Data Summary

			Physical									Cations				Anions				Nutrients				Trace Elements										Biological	Flow			
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-a (µg/L)	Level	Velocity	Physical Appearance	Data source
		MTV	*na*	*0-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1.2*	*400*	*500*	*50*	*20*		*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*		
Upper Baffle Creek	4/05/2002	15:40		21		**1585**			1078																												Clear	S
Upper Baffle Creek	1/01/2002	10:30		24		**1570**			1068																												Slight cloudy brown	S
Upper Baffle Creek	1/01/2002	10:30		24		**1570**			1068																												Slight cloudy brown	S
Upper Baffle Creek	1/01/2002	14:35		25		147			100																												Not Flowing - Yellow Brown	S
Upper Baffle Creek	1/01/2002	13:35		27		128			87																												Slight flow, muddy	S
Upper Baffle Creek	1/01/2002					97			66																												Slow Flow - Yellow Brown	S
Upper Baffle Creek	1/01/2002	13:10		29		115			78																												Slight flow, muddy	S
Upper Baffle Creek	1/01/2002	9:00		27		144			98																												Mod flow, muddy	S
Upper Baffle Creek	22/06/2001								0																												No Flow	S
Upper Baffle Creek	25/05/2001								0																												No Flow	S
Upper Baffle Creek	20/04/2001								0																												No Flow	S
Upper Baffle Creek	8/03/2001								0																												No Flow	S
Upper Baffle Creek	5/10/2000								0																													S
Upper Baffle Creek	5/09/2000								0																												No Flow	S
Upper Baffle Creek	3/08/2000								0																												No Flow	S
Upper Baffle Creek	13/07/2000	14:29		24		142			97																												Cloudy, some sediment	S
Upper Baffle Creek	15/06/2000	14:22		24		**1296**			881																												Cloudy, some sediment	S
Upper Baffle Creek	2/06/2000	10:30		19		**1901**			1293																												Slight cloudy brown	S
Upper Baffle Creek	29/04/2000	10:30		21		**1490**			1013																												Slight cloudy brown	S
Upper Baffle Creek	1/04/2000	10:30		24		**1456**			990																												Slight cloudy brown	S
Upper Baffle Creek	2/03/2000			24		**1467**			998																												Slight cloudy brown	S
Upper Baffle Creek	30/01/2000	10:30		24		**1856**			1262																												Slight cloudy brown	S
Upper Baffle Creek	30/12/1999	16:00		25		200			136																												Not Flowing	S
Upper Baffle Creek	29/11/1999	11:17		24		280			190																												Not Flowing	S
Upper Baffle Creek	30/10/1999	15:42		25		**460**			313																												Not Flowing	S
Upper Baffle Creek	30/09/1999			21		211			143																												Not Flowing	S
Upper Baffle Creek	29/07/1999			15		185			126																												No Flow	S
Upper Baffle Creek	29/07/1999			19		191			130																												Not Flowing	S
Upper Baffle Creek	1/06/1999	14:00		14		162			110																												Not Flowing	S
Upper Baffle Creek	7/05/1999	16:00		18		86			58																												Not Flowing	S
Upper Baffle Creek	5/04/1999			27		98			67																												slight flow, murky	S
Upper Baffle Creek	9/09/2003			17.5	6.8	67	8.90	94	43			6	5	1	2	54	<0.5	0.1	<5						**<100**										Mod	Low		RH
Upper Baffle Creek	21/04/2004			26.5	6.6	152	12.30	155	64	6		8	6	6	4	77	7	<.1	<10	**1350**	**60**				**500**										Low	Low		RH
Upper Baffle Creek	16/11/2004			32.7	7.8	134	8.60	119	84	**49**		<1	7	4	3	67	7	0.32	<10		**1000**	**100**			**<100**										Low	Low		RH
Upper Baffle Creek	23/05/2005				7.4	108			114	**30**		5	5	4	4	47	6	0.43	<10	**810**	**50**	**30**			**<100**				**1800**						Mod	Low		RH
Upper Baffle Creek	5/08/2006			15.8	7.1	212	9.87	99	126	**48**	**105**	17	6	11	7	99	9	0.4	3	480	**<10**	**<10**		<1	**<100**	<0.1	<1	<1	81	<1	<0.1	<1	**<10**		Mod	Low		RH
Upper Baffle Creek	22/04/2007		27.5	22.9	7.6	138	7.23	**85**	160	**49**		17	12	15	7	93	5	0.32	<1	**1100**	**<20**	**77**	318*	<1	25	<1	<1	**<2**	**750**	<1	<0.5	<3	**8.3**	**6.5**				RH
Baffle Creek	7/01/2002					**1520**			1034																												Clear	S
Baffle Creek	5/11/2001			22		**1384**			941																												Brown tinge	S
Baffle Creek	12/10/2001			22		**1484**			1009																												Brown tinge	S
Baffle Creek	29/08/2001			23		**1484**			1009																												Brown tinge	S
Baffle Creek	1/07/2001			22		**1530**			1040																												Clear, slight brown tinge	S
Baffle Creek Outflow	5/04/1999	11:50		23		**775**			527																												Slow flow - murky	S
Baffle Creek Outflow	4/05/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002					188			128																												Slow flow - murky	S
Baffle Creek Outflow	1/01/2002	11:30		27		328			223																												Mod flow, muddy	S
Baffle Creek Outflow	22/06/2001			19		**1260**			857																												Slightly cloudy Brown	S
Baffle Creek Outflow	25/05/2001			23		**1340**			911																												Slightly cloudy Brown	S
Baffle Creek Outflow	20/04/2001			25		**1350**			918																												Slightly cloudy Brown	S
Baffle Creek Outflow	8/03/2001			26		**1459**			992																												Clear, slight brown tinge	S
Baffle Creek Outflow	5/09/2000								0																												No Sample	S
Baffle Creek Outflow	3/08/2000								0																												No Sample	S
Baffle Creek Outflow	23/07/2000								0																												No Sample	S
Baffle Creek Outflow	15/06/2000								0																												No Sample	S
Baffle Creek Outflow	1/04/2000								0																												Not Flowing	S
Baffle Creek Outflow	1/04/2000	13:00		21		**1150**			782																												Slight cloudy brown	S
Baffle Creek Outflow	1/04/2000	13:00		19		**1348**			917																												Slight cloudy brown	S
Baffle Creek Outflow	2/03/2000								0																												No Tested	S
Baffle Creek Outflow	30/01/2000	13:00		24		**1252**			851																												Slight cloudy brown	S
Baffle Creek Outflow	30/12/1999								0																												Not Flowing	S
Baffle Creek Outflow	29/11/1999	14:22		22		**860**			585																												Not Flowing	S
Baffle Creek Outflow	29/10/1999	9:24		21		**880**			598																												Not Flowing	S
Baffle Creek Outflow	30/09/1999			18		**1281**			871																												Slow Flow	S
Baffle Creek Outflow	29/07/1999			16		**867**			590																												Slow flow - murky	S
Baffle Creek Outflow	29/07/1999			13		**1233**			838																												Slow - Med. Flow	S
Baffle Creek Outflow	1/06/1999	12:13		14		**553**			376																												Slow flow - murky	S
Baffle Creek Outflow	7/05/1999	11:00		19		**621**			422																												Slow - Med. Flow	S
Baffle Creek Outflow	5/04/1999			26		**649**			441																												Slow- med flow	S
Baffle Creek Outflow	9/10/2003			19		**1444**	7.30	**79**	925			**347**	4	1	1	726	55	**2**	<5						200										Low	Low		RH
Baffle Creek Outflow	22/04/2004			20		**870**	5.10	**56**	612	**37**		**162**	5	5	3	916	36	0	<10	**3970**	**220**				**700**										Low	Low		RH
Baffle Creek Outflow	17/11/2004			23		**1403**	0.40	**5**	852	**76**		**232**	8	<1	2	623	56	1	<10	**1800**	**350**				**400**										Mod	Low		RH
Baffle Creek Outflow	21/05/2005			14		**1373**	10.10	98	1030	**10**		**349**	6	<1	2	664	68	**2**	<10	**720**	**150**	**120**			**500**				**6013**						Low	Low		RH
Baffle Creek Outflow	5/09/2006			12		**1864**	7.90	**73**	1168	**39**	**154**	**437**	6	1	2	723	93	**2**	24	**770**	**<10**	**<10**		9	**600**	<0.1	16	3	**6362**	**8**	<0.1	3	**14**		Mod	Low		RH
Baffle Creek Outflow	22/04/2007		31	19	7.8	**832**	3.01	**33**	640	**16**		**200**	6	7	3	570	40	1	<1	**1100**	**66**	16	<44*	2	360	<1	<1	<2	**1300**	<1	<0.5	<3	3	**5**				RH

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

Upper Baffle Creek samples upstream of existing associated water discharge

Baffle Creek & Baffle Creek Outflow samples downstream of existing associated water discharge

S - Santos

Table B5
Upper Dawson Catchment - Baffle Creek Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date		Physical								Cations				Anions				Nutrients				Trace Elements										Biologica	Physical Appearance	Data source
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-*a* (µg/L)		
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*		
Dawson Downstream Baffle	4/05/2002																																	Not tested	S
Dawson Downstream Baffle	1/01/2002																																	Not tested	S
Dawson Downstream Baffle	1/01/2002																																	Not tested	S
Dawson Downstream Baffle	22/06/2001			19		**1130**			768																									Silty cloudy Brown	S
Dawson Downstream Baffle	25/05/2001			23		**980**			666																									Silty cloudy Brown	S
Dawson Downstream Baffle	22/06/2001	11:00		24		**844**			574																									Slow flow, lt Brown	S
Dawson Downstream Baffle	22/06/2001	12:15		26		**853**			580																									Slow flow, muddy	S
Dawson Downstream Baffle	22/06/2001					182			124																									Slow flow - lt Brown	S
Dawson Downstream Baffle	22/06/2001	11:05		26		**783**			532																									Slt flow, muddy	S
Dawson Downstream Baffle	22/06/2001	11:45		27		**353**			240																									Mod flow, muddy	S
Dawson Downstream Baffle	22/06/2001			28		**673**			458																									Slow - med flow	S
Dawson Downstream Baffle	20/04/2001			24		**800**			544																									Silty cloudy Brown	S
Dawson Downstream Baffle	8/03/2001			25		288			196																									Clear, slt brown tinge	S
Dawson Downstream Baffle	5/10/2000	10:30		24		**1367**			930																									Clear, slt sediment	S
Dawson Downstream Baffle	5/09/2000	10:00		24		**1498**			1019																									Clear, slt sediment	S
Dawson Downstream Baffle	3/08/2000	10:00		20		**1358**			923																									Clear, slt sediment	S
Dawson Downstream Baffle	23/07/2000																																	No Sample	S
Dawson Downstream Baffle	15/06/2000																																	No Sample	S
Dawson Downstream Baffle	2/06/2000																																		S
Dawson Downstream Baffle	29/04/2000																																		S
Dawson Downstream Baffle	1/04/2000	1.00PM		24		**1060**			721																									Silty cloudy brown	S
Dawson Downstream Baffle	2/03/2000			24		**1152**			783																									Silty cloudy brown	S
Dawson Downstream Baffle	30/01/2000																																		S
Dawson Downstream Baffle	31/12/1999	2:30		21		**1050**			714																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	29/11/1999	15:00		22		**880**			598																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	29/10/1999	10:52		21		**910**			619																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	30/09/1999			18		**1402**			953																									Slow Flow	S
Dawson Downstream Baffle	29/07/1999			15		**872**			593																									Slow flow - murcky	S
Dawson Downstream Baffle	29/07/1999			15		**1319**			897																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	1/06/1999	11:30		13		**556**			378																									Slow flow - murcky	S
Dawson Downstream Baffle	7/05/1999	11:15		19		**664**			452																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	25/4/07		24.6	19.5	**8.3**	**1296**	6.05	**67.0**	990	**99.0**	**280.0**	10	10	5.5	820	120	**1.4**	<1	**1600.0**	**90.0**	**82.0**	305*	3.4	**480.0**	<1	8.3	**<2**	**1700**	<1	<0.5	4.2	1.5	**15**		RH

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources
*by calcuation from Nitrate as N

Table B6
Upper Dawson Catchment - Hutton Creek Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date	Time	Physical: Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Cations: Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)
		MTV	*na*	*0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*
Upper Hutton Creek	9/10/2003			18.8	7.9	**1478**	9.10	98	1139			**133**	9.4	91	16
Upper Hutton Creek	25/04/2007		27.7	22.5	6.6	156	4.31	**49**	190	**570**		14		20	
Hutton Creek	19/04/2004			24.4	7.2	**358**	3.60	**41**	292	**10**		27	7.0	27	7
Hutton Creek	16/11/2004			23.2	7.6	**461**	5.60	**66**	284	**36**		39	10.0	30	9
Hutton Creek	26/05/2005			9.7	7	195	9.90	88	195	**170**		18	7.0	9	4
Hutton Creek	5/08/2006			14.9	6.6	183	8.00	**78**	116	**123**	**116**	24	6.0	5	2
Hutton Creek	21/04/2007		34.3	21.3	7.1	273	3.49	**39**	220	**32**		59	7.4	12	4
Hutton Creek	8/08/1973	1450		19	**8.1**	155			96	**116**		14	5.4	11	3
Hutton Creek	15/12/1976	1317		31	7.9	**390**			198	7		30	6.8	36	7
Hutton Creek	8/09/1980	1405			**8.2**	215			122	**10**	**75**	17	4.1	16	4
Hutton Creek	25/03/1982	1405		27	8	160			97	**200**	**100**	12	4.2	12	3
Hutton Creek	16/12/1983	930		24	**8.2**	195			130	**20**	25	17	4.6	16	4
Hutton Creek	20/03/1984	1400		27	7.8	250			150	**10**	12	20	4.9	20	5
Hutton Creek	24/06/1984	1405		14	7.5	270			150	5		22	4.8	22	5
Hutton Creek	19/10/1984	1500		20	7.9	**570**			320	5		70	1.6	34	11
Hutton Creek	15/01/1985	920		24	7.8	200			120	**445**	**100**	17	5.2	15	4
Hutton Creek	20/10/1985	1025		20	**8.2**	**390**			1010	**10**	1	**175**	4.5	85	67
Hutton Creek	14/02/1988	1109		25	7.2	131			84	**630**	**100**	9	4.3	12	3

Sample Collection Point	Sample Date	Anions: Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Nutrients: Total nitrogen (µg/L)	Total phosphorous (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Trace Elements: Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Biologica: Chl-*a* (µg/L)	Flow: Level	Velocity	Data source
		na	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*	
Upper Hutton Creek	9/10/2003	314	**267**	0.1	120						<100										Isolated	No flow	RH
Upper Hutton Creek	25/04/2007		6	0.31	<1	**1800**	**170**	**51**	**168***	<1	32	**<1**	<1	**2**	**1900**	**4.8**	<0.5	6.3	1.5	**13**	-	-	RH
Hutton Creek	19/04/2004	171	28	<.1	<10	**2340**	**70**				**800**										Moderate	Low	RH
Hutton Creek	16/11/2004	190	39	0.36	<10	**1300**	**100**				<100										Low	Low	RH
Hutton Creek	26/05/2005	87	12	0.43	<10	**1330**	**230**	**240**			<100				**2358**						Low	Low	RH
Hutton Creek	5/08/2006	83	12	0.2	5	**680**	**<10**	**<10**		2	<100	<0.1	5	**<1**	62	2	<0.1	<1	**<10**		Mod	Low	RH
Hutton Creek	21/04/2007	130	20	0.31	<1	**1200**	**76**	**93**	**101***	1.6	79	**<1**	<1	**<2**	**2300**	<1	<0.5	<3	**20**	**6.6**			RH
Hutton Creek	8/08/1973	65	10	0.14																			DNRW
Hutton Creek	15/12/1976	145	37	0.5	4				**1200**														DNRW
Hutton Creek	8/09/1980	88	15	0.1	5				**4000**														DNRW
Hutton Creek	25/03/1982	77	8		5.4				**2100**														DNRW
Hutton Creek	16/12/1983	90	15		2.7				**1200**		20												DNRW
Hutton Creek	20/03/1984	110	25	0.1	6.3						20												DNRW
Hutton Creek	24/06/1984	135	19	0.1	3.3						20												DNRW
Hutton Creek	19/10/1984	185	81	0.1	12				**1100**		10												DNRW
Hutton Creek	15/01/1985	88	16	0.1	2				**1100**		20												DNRW
Hutton Creek	20/10/1985	275	**355**	0.3	170				**500**		100												DNRW
Hutton Creek	14/02/1988	65	4	0.1	2.1				**3800**		10												DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources

Table B7
Upper Dawson Catchment - Dawson Downstream Hutton Water Quality Data
GLNG CSG Surface Water

			Physical									Cations				Anions				Nutrients				Trace Elements										Biological	Flow			
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-*a* (µg/L)	Level	Velocity	Physical Appearance	Data source
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*		
Dawson d/s Hutton-1	23/04/2004			22.2	6.8	264	4.90	**56**	108	**66**		20	3	15	6	138	14	<.1	<10	**1050**	**190**				**400**										Moderate	Moderate		RH
Dawson d/s Hutton-1	19/11/2004			22.1	7	129	7.90	91	88	**316**		15	5	1	2	54	8	0.1	<10	**4100**	**580**				<100										Moderate	Moderate		RH
Dawson d/s Hutton-1	22/05/2005			9.3	7.4	266	13.40	116	160	3		21	3	15	8	111	14	0.21	<10	120	**<50**	<10			<100										No flow			RH
Dawson d/s Hutton-1	24/05/2005			12.4	**6**	265	8.10	**75**	143	3		21	3	16	9	113	16	0.2	<10	170	**<50**	**40**			<100										Low-Mod	Low		RH
Dawson d/s Hutton-1	5/10/2006			14.6	7.3	226	7.20	**70**	108	**15**	6	18	3	14	7	104	10	0.2	<1	60	**<10**	<10		<1	<100	<0.1	<1	<1	60	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawson d/s Hutton-1	23/04/2007		31.9	22.5	6.9	265	4.16	**49**	160	9		23	3	21	9	150	11	0.21	<1	**550**	**<20**	**30**	<44*	<1	16	<1	<1	<2		<1	<0.5	<3	**17**	<1				RH
Dawson d/s Hutton-2	23/04/2004			25.1	7.6	260	5.40	**66**	132	**20**		20	3	14	6	138	14	<.1	<10	280	**110**				**400**										Low	Moderate		RH
Dawson d/s Hutton-2	19/11/2004			22.7	7.2	134	8.00	93	922	**292**		15	6	1	2	56	8	0.08	<10	**3100**	**680**				<100										Moderate	Moderate		RH
Dawson d/s Hutton-2	24/05/2005			13.8	7	249	9.50	93	172	3		21	3	16	9	111	14	0.17	<10	190	**<50**	<10			<100				66						Low-Mod	Low		RH
Dawson d/s Hutton-2	5/10/2006			15.4	7.6	228	7.20	**71**	124	**11**	4	19	3	14	7	106	12	0.2	<1	60	**<10**	<10		<1	<100	<0.1	<1	<1	97	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawson d/s Hutton-2	23/04/2007		31.5	21.8	7	282	5.93	**68**	160	3		28	4	26	11	150	12	0.21	<1	**560**	**<20**	<6	<44*	<1	15	<1	<1	<2		<1	<0.5	<3	<1	<1				RH
Dawsons Bend	9/11/2003			19.2	6.7	258	5.10	**55**	95			27	2	14	7	157	12	0.1	<5						<100										Low	Low		RH
Dawsons Bend	20/04/2004			24.6	**6**	270	4.50	**54**	92			21	3	14	7	131	15	<.1	<10	270	**60**				**500**										Low	Low		RH
Dawsons Bend	19/11/2004			21.2	6.9	136	7.40	**84**	136	**366**		15	5	1	<1	55	9	0.17	<10	**3400**	**750**				<100										Moderate	Moderate		RH
Dawsons Bend	24/05/2005			17.9	7.1	244	8.40	89	148	4		21	3	14	9	106	15	0.21	<10	40	**<50**	<10			<100				62						Low	Mod		RH
Dawsons Bend	5/10/2006			16.7	7.3	228	7.00	**72**	122	**10**	2	21	3	13	8	102	13	0.2	<1	90	20	<10		<1	<100	<0.1	<1	<1	23	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawsons Bend	23/04/2007		23.1	24.1	6.9	273	5.03	**60**	220	**14**		22	3	19	9	130	14	0.28	<1	**540**	46	<6	<44*	<1	14	<1	<1	<2		<1	<0.5	<3	<1	<1				RH
Yebna Crossing	31/09/1999			19		**430**			292																												Slow Flow	S
Yebna Crossing	1/04/2002	15:00		22		182			124																												Slightly cloudy brown	S
Yebna Crossing	7/01/2002					244			166																												Muddy	S
Yebna Crossing	1/01/2002	15:00		25		318			216																												Very slight cloudy brown	S
Yebna Crossing	1/01/2002	15:00		25		318			216																												Very slight cloudy brown	S
Yebna Crossing	9/11/2001			21		234			159																												Clear	S
Yebna Crossing	10/10/2001					234			159																												Clear	S
Yebna Crossing	29/08/2001			22		241			164																												Clear	S
Yebna Crossing	1/07/2001			21		250			170																												Clear	S
Yebna Crossing	22/06/2001			18		215			146																												Slightly Murky	S
Yebna Crossing	25/05/2001			24		165			112																												Slightly Murky	S
Yebna Crossing	20/04/2001			24		160			109																												Slightly Murky	S
Yebna Crossing	8/03/2001			25		176			120																												Clear	S
Yebna Crossing	4/02/2001	15:00		26		186			126																												Slightly cloudy	S
Yebna Crossing	23/01/2001	14:00		25		151			103																												Slightly cloudy	S
Yebna Crossing	19/12/2000	16:00		25		249			169																												Slightly cloudy	S
Yebna Crossing	21/11/2000	13:00		26		266			181																												Clear	S
Yebna Crossing	10/10/2000	11:30		25		290			197																												Clear	S
Yebna Crossing	2/09/2000	11:00		25		297			202																												Clear	S
Yebna Crossing	3/08/2000	14:37		25		257			175																												Clear	S
Yebna Crossing	23/07/2000	14:32		25		266			181																												Clear	S
Yebna Crossing	21/06/2000	14:24		25		275			187																												Clear	S
Yebna Crossing	14/04/2000	15:00		25		241			164																												Very slight cloudy brown	S
Yebna Crossing	21/06/2000	12:30		22		305			207																												Faint Cloudy brown	S
Yebna Crossing	14/04/2000	12:30		21		279			190																												Faint Cloudy brown	S
Yebna Crossing	6/03/2000			24		**344**			234																												Very slight cloudy brown	S
Yebna Crossing	30/01/2000	12:30		25		282			192																												Very slight cloudy brown	S
Yebna Crossing	30/12/1999	10:45		20		260			177																												Flow	S
Yebna Crossing	29/11/1999	16:35		22		**380**			258																												Flow	S
Yebna Crossing	29/10/1999	16:00		23		**430**			292																												Flow	S
Yebna Crossing	29/07/1999			15		**348**			237																												Slow flow - murky	S
Yebna Crossing	29/07/1999			17		**435**			296																												Slow Flow - Clear to Yellow	S
Yebna Crossing	1/06/1999	8:00		12		245			167																												Slow flow - murky	S
Yebna Crossing	8/05/1999	9:30		18		194	4.00		132																												Mod flow - murky	S
Yebna Crossing	23/02/1999	9:50		25		110			75																												Mod flow, murky	S
Yebna Crossing	23/02/1999	10:00		28		187			127																												Mod flow, muddy	S
Yebna Crossing	23/02/1999			26		231			157																												Mod flow, muddy	S
Yebna Crossing	28/11/1998	11:30		17		286			194																												Med Flow - Brown	S
Yebna Crossing	28/11/1998	14:30		28		200			136																												Mod flow, murky	S
Yebna Crossing	28/11/1998	15:00				176			120																												Med Flow - Brown	S
Yebna Crossing	9/08/2003			19.1	7.8	214	9.50	103	89			31	3	11	5	127	19	0.1	<5						<100										Moderate	Moderate		RH
Yebna Crossing	20/04/2004			20.8	7.2	292	7.20	**81**	92	4		27	3	14	6	124	22	<.1	<10	**500**	40				**600**										Moderate	Low		RH
Yebna Crossing	18/11/2004			24.6	7.3	273	5.00	**60**	172	**142**		29	6	7	5	103	19	0.23	<10	**1100**	**280**				<100										Mod-High	Mod		RH
Yebna Crossing	25/05/2005			13	7.7	226	13.00	124	127	2		27	3	11	6	88	22	0.16	<10	50	<50	<10			<100				156						Low	Mod		RH
Yebna Crossing	5/11/2006			13.4	7.8	228	14.30	135	134	8	4	27	3	9	4	87	21	0.1	<1	30	<10	<10		<1	<100	<0.1	<1	<1	76	<1	<0.1	<1	**<10**		Mod	Mod		RH
Yebna Crossing	24/04/2007		27.4	21.6	**8**	242	9.28	107	180	**11**		33	4	17	6	130	20	0.22	<1	**500**	22	14	<44*	<1	16	<1	<1	<2	**390**	<1	<0.5	<3	<1	<1				RH

BOLD Exceeds adopted guideline value (refer Environmental Values Table)

MTV - minimum trigger value

Samples collected downstream of existing associated water discharge points

S - Santos

RH - River Health Report

DNR - Department of Natural Resources

*by calcuation from Nitrate as N

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400	500	50		20	700	5		371	1.4	200			8							
Dawson Taroom	31/09/1999						19		445			303																													Med Flow	S
Dawson Taroom	1/04/2002	14:00					24		96			65																													Cloudy brown	S
Dawson Taroom	1/04/2002	12:45					19		257			175																													Rapid Flow - Flood level 4.35 m, Brown	S
Dawson Taroom	1/04/2002	16:00					28		300			204																													Mod flow, muddy	S
Dawson Taroom	1/04/2002	17:00							193			131																													Rapid Flow - Brown	S
Dawson Taroom	1/04/2002	11:10					25		117			80																													Mod flow, muddy	S
Dawson Taroom	1/04/2002	11:30					27		140			95																													Mod flow, murky	S
Dawson Taroom	1/04/2002						27		258			175																													Mod flow, murky	S
Dawson Taroom	7/01/2002								216			147																													Muddy	S
Dawson Taroom	1/01/2002	16:00					24		247			168																													Clear	S
Dawson Taroom	1/01/2002	16:00					24		247			168																													Clear	S
Dawson Taroom	9/11/2001						21		242			165																													Clear	S
Dawson Taroom	10/10/2001								242			165																													Clear	S
Dawson Taroom	10/08/2001						22		214			146																													Brown tinge	S
Dawson Taroom	1/07/2001						20		234			159																													Clear	S
Dawson Taroom	22/06/2001						19		220			150																													Slightly Murky	S
Dawson Taroom	25/05/2001						24		155			105																													Slightly Murky	S
Dawson Taroom	20/04/2001						24		145			99																													Slightly Murky	S
Dawson Taroom	8/03/2001						25		118			80																													Clear	S
Dawson Taroom	5/02/2001	13:00					27		364			248																													Clear	S
Dawson Taroom	18/01/2001	10:30					26		381			259																													Clear	S
Dawson Taroom	20/12/2000	13:20					25		213			145																													Clear	S
Dawson Taroom	20/11/2000	14:00					26		268			182																													Clear	S
Dawson Taroom	2/10/2000	13:30					24		321			218																													Clear	S
Dawson Taroom	2/09/2000	13:00					24		324			220																													Clear	S
Dawson Taroom	3/08/2000	14:35					24		301			205																													Clear	S
Dawson Taroom	22/07/2000	14:33					24		297			202																													Slight cloudy, brown sediment	S
Dawson Taroom	20/06/2000	14:18					24		284			193																													Slight cloudy, brown sediment	S
Dawson Taroom	14/04/2000	16:00					24																																		Clear	S
Dawson Taroom	14/04/2000	11:45					22		410			279																													Clear	S
Dawson Taroom	14/04/2000	11:45					21		410			279																													Clear	S
Dawson Taroom	6/03/2000						23		314			214																													Clear	S
Dawson Taroom	30/01/2000	11:45					24		377			256																													Clear	S
Dawson Taroom	30/12/1999	11:30					22		340			231																													Flow	S
Dawson Taroom	29/11/1999	15:04					24		310			211																													Flow	S
Dawson Taroom	29/10/1999	14:28					24		410			279																													Flow	S
Dawson Taroom	29/07/1999						16		367			250																													Slow flow - murcky	S
Dawson Taroom	29/07/1999						17		450			306																													Slow Flow - Murky	S
Dawson Taroom	1/06/1999	9:10					14		319			217																													Mod. Flow - clear/murcky	S
Dawson Taroom	8/05/1999	11:00					19		209			142																													Moderate flow- murky	S
130302A	1/12/1963	1630	0.81	0.60	0.10			8.10	290			200			33		21.0	11.0	143	36	0.20	2.0														117.00	0.00		98	246.2		DNRW
130302A	28/05/1964	2359	0.71	0.20	0.10			8.00	244			148			36		22.0	8.0	146	32	0.60	1.0														120.00			88	245.6		DNRW
130302A	30/11/1964	1520	0.65	0.07	0.10			7.30	287			148			41		16.0	7.0	138	33	0.40															113.00	0.00		69	235.4		DNRW
130302A	7/09/1965	950	0.69	0.13	0.10			7.40	290			164			36		18.0	8.0	132	32	0.20	1.0														108.00	0.00		78	227.2		DNRW
130302A	3/02/1966	830	0.71	0.20	0.10			8.20	310						42		35.0	8.0	195	32	0.30	7.0														160.00			120	319.3		DNRW
130302A	3/02/1966	830					29																																			DNRW
130302A	14/04/1966	1430	0.84	0.23	0.10			7.80	172						22		14.0	5.0	93	12	0.15	11.0														76.00			56	157.2		DNRW
130302A	14/04/1966	1430					24																																			DNRW
130302A	11/05/1966	1645	0.69	0.18	0.10			7.60	196						22		19.0	5.0	112	14	0.10	4.0														92.00			68	176.1		DNRW
130302A	11/05/1966	1645					17																																			DNRW
130302A	25/04/1971	830	0.74	0.34	0.10			7.90	435						34		44.0	11.0	220	35	0.15															180.00	0.00		155	344.2		DNRW
130302A	25/04/1971	830	0.73	0.34			18																																			DNRW
130302A	26/08/1971	1500	0.72	0.22	0.10			7.90	390						35		32.0	10.0	189	30	0.15															155.00	0.00		121	296.2		DNRW
130302A	26/08/1971	1500	0.72	0.22			17																																			DNRW
130302A	16/09/1972	845	0.64	0.05			20																																			DNRW
130302A	14/12/1972	1615	0.65	0.02	0.10			7.70	282						30		23.0	6.0	142	24	0.20															116.00	0.00		82	225.2		DNRW
130302A	14/12/1972	1615					31																																			DNRW
130302A	13/04/1973	835	0.66	0.14	0.10			7.60	165			113	197		15	6.7	14.5	3.5	93	10	0.19						10000			90		400		7.00		76.00			51	153.2		DNRW
130302A	13/04/1973	835					21																																			DNRW
130302A	10/08/1973	1630	0.86	1.56	0.10			7.80	180			115	2		18	5.2	13.7	3.5	73	18		7.0										2100		13.00		60.00		0.2	49	141.1		DNRW
130302A	10/08/1973	1630					18																																			DNRW
130302A	5/12/1973	1630	0.70	0.22	0.10			7.80	230			134	70		18	6.1	22.0	4.7	116	16	0.17											300		10.00		96.00	0.00	0.4	74	183.8		DNRW
130302A	5/12/1973	1630					29																																			DNRW
130302A	27/03/1974	755	0.70	0.24	0.10			7.70	360			204	20		36	6.8	27.0	8.5	170	28	0.13													14.00		140.00	0.00	0.5	102	276.9		DNRW
130302A	27/03/1974	755					25																																			DNRW
130302A	24/06/1974	1700	0.78	0.52	0.10			7.60	265			152	85		28	5.5	20.0	5.3	122	24	0.15													9.00		100.00	0.00	0	72	205		DNRW
130302A	24/06/1974	1700					15																																			DNRW
130302A	19/09/1974	1710	0.69	0.21	0.10			7.80	315			175			37	3.7	18.0	7.0	146	34	0.27													3.00		120.00	0.00	0	74	246		DNRW
130302A	19/09/1974	1710					19																																			DNRW
130302A	16/10/1974	1038	0.69	0.25	0.10			7.70	290			158			31	3.3	17.0	6.0	129	30	0.17													7.00		106.00	0.00	0	67	216.5		DNRW
130302A	16/10/1974	1038	0.69	0.25			22																																			DNRW
130302A	16/12/1974	1405	0.58	0.02	0.10			7.50	310			192	31		32	6.3	19.5	6.8	136	30	0.22													30.00		112.00	0.00	0	77	230.8		DNRW
130302A	16/12/1974	1405					30																																			DNRW
130302A	7/04/1975	1610	0.85	1.60			23																																			DNRW
130302A	2/07/1975	1615	0.71	0.15			18																																			DNRW
130302A	27/08/1975	1645	0.62	0.08	0.10			7.70	267			140	14		28	3.5	14.0	5.9	125	24														2.00		103.00	0.00	0	59	200.4		DNRW
130302A	27/08/1975	1645					16																																			DNRW
130302A	14/10/1975	1630	0.59	0.03	0.10			7.90	261			140	20		31	3.3	12.0	5.7	115	26	0.10													2.00		94.00	0.00	0	53	193.1		DNRW
130302A	14/10/1975	1630					23																																			DNRW
130302A	15/10/1975	1640	0.58	0.03			24																																			DNRW
130302A	12/01/1976	1606	0.85	1.85	0.20			8.15	258			158	72		23	6.4	21.0	6.1	115	22	0.20	3.0					2400									96.00		0.8	78			DNRW
130302A	12/01/1976	1606	0.86	1.85			27																																			DNRW
130302A	13/09/1976	1542	0.64	0.16	0.10			8.50	370			201			43	3.4	24.0	7.8	165	38							200									141.00	0.00	3.2	92	284.7		DNRW
130302A	13/12/1976	1642	0.72	0.54	0.10			7.30	230			128	159		18	5.2	20.0	4.3	102	14	0.70	2.0					1700							12.00		84.00	0.00	0.1	68	168		DNRW
130302A	13/12/1976	1642					31																																			DNRW
130302A	18/04/1977	1637	0.69	0.40	0.10			8.00	310			172	27		28	5.7	24.0	7.2	120	26	0.10	5.0					700							16.00		100.00		0.7	90	217.4		DNRW
130302A	18/04/1977	1637					24																																			DNRW
130302A	28/10/1977	1210	0.60	0.12	0.10			8.20	335			174			41	3.4	13.0	7.8	142	33	0.20						200							4.00		118.00		1.1	65	241.7		DNRW
130302A	28/10/1977	1210					26																																			DNRW
130302A	12/04/1978	1428	0.62	0.21	0.10			7.90	250			149	19		21	5.0	21.0	5.8	128	18	0.20	2.5					900							11.00		106.00		0.6	76	203		DNRW
130302A	12/04/1978	1428					24																																			DNRW
130302A	28/07/1978	1124	0.69	0.48			14																																			DNRW
130302A	25/10/1978	1605	0.61	0.18			23																																			DNRW
130302A	5/01/1981	1045	1.25	2.73	0.10			7.50	200			122	1270		16	7.4	17.0	4.5	95	7	0.10	5.0					5000							13.00		78.00		0.2	61	156.8		DNRW
130302A	5/01/1981	1045					25																																			DNRW
130302A	25/03/1981	1425	0.66	0.26			26																																			DNRW
130302A	24/07/1981	1630	0.71	0.43	0.10			7.70	370			189	10	13	34	4.2	25.0	7.6	160	30	0.10	1.0					2000							6.00		132.00		0.5	94	264.4		DNRW
130302A	24/07/1981	1630					16																																			DNRW
130302A	9/09/1981	1410	1.19	1.47	0.10			7.90	160			101	50	100	13	5.3	12.0	3.1	65	11	0.10	8.0					4000							12.00		54.00		0.3	43	121.8		DNRW
130302A	9/09/1981	1410					17																																			DNRW
130302A	9/09/1981	1410	0.61	0.25	0.10			8.00	400			212	10	5	40	3.7	27.0	8.6	183	34	0.10	5.0												3.00		152.00		1.1	103	302.5		DNRW
130302A	9/10/1981	800	0.57	0.09	0.10			7.80	390			207	10	5	41	3.6	23.0	8.2	177	34	0.10	5.0					1000							3.00		146.00		0.6	91	293.5		DNRW
130302A	9/10/1981	800					21																																			DNRW
130302A	20/04/1982	1620	0.81	0.22			23																																			DNRW
130302A	9/08/1982	1645	0.79	0.14	0.10			8.50	320			170	9	2	36	3.7	21.0	6.4	140	29	0.10	3.0					400			20		20		1.00		119.00		2.7	79	242.4		DNRW
130302A	9/08/1982	1645					15																																			DNRW
130302A	2/11/1982	1105	0.70	0.02	0.10			8.10	310			170	10	8	39	3.8	15.5	6.6	140	34	0.20	1.0					600									116.00		1	66	241.2		DNRW
130302A	2/11/1982	1105					25																																			DNRW
130302A	23/03/1984	1625	0.98	0.80	0.10			7.40	355			200	20	17	33	4.9	27.0	7.3	170	25	0.10	8.3					500			20		100		14.00		140.00		0.3	98	276.5		DNRW
130302A	23/03/1984	1625					26		330																																	DNRW
130302A	20/06/1984	1600	0.85	0.25	0.10			7.40	450			250	5		51	3.9	32.0	9.7	195	42	0.10	3.7								10				7.00		161.00		0.4	120	337.8		DNRW
130302A	20/06/1984	1600					15		425																																	DNRW
130302A	29/07/1984	715	6.56	976.38	0.10			7.00	165			160	1000	100	22	6.4	9.5	3.0	95	8		4.1								40		4600	0.03	56.00		78.00		0.1	36	152.6		DNRW
130302A	29/07/1984	715					13																																			DNRW
130302A	29/07/1984	1350	6.52	1050.59	0.10			6.90	175			120	800	100	21	6.4	10.0	2.3	85	9		5.0					2300			1000		1200	1.00	19.00		70.00			34	144		DNRW
130302A	30/07/1984	855	6.43	602.20	0.10			6.50	120			120	80	100	12	6.0	8.1	2.7	60	6		3.3								20		4800	0.02	52.00		49.00			31	102.5		DNRW
130302A	31/07/1984	835	6.13	605.58	0.10			6.80	115			110	80	100	11	5.1	7.7	2.6	67	6		3.1								20		4000	0.01	44.00		55.00			30	106.1		DNRW
130302A	16/10/1984	945	0.87	0.40	0.10			8.00	425			240	5		55	2.4	26.0	8.9	185	40	0.10	9.0								10		200		6.00		154.00		1.2	102	327.8		DNRW
130302A	16/10/1984	945					24																																			DNRW
130302A	10/04/1985	840	0.81	0.16	0.10			7.80	270			160	60	63	25	5.5	22.0	5.0	140	20	0.20	2.1					600			30		390		12.00		116.00		0.5	76	221.3		DNRW
130302A	10/04/1985	840					23		250																																	DNRW
130302A	2/07/1985	1635	0.81	0.15	0.10			8.10	450			180	10	24	38	3.8	22.0	6.4	145	33	0.10						600			20		240		5.00		121.00		1	81	250.1		DNRW
130302A	2/07/1985	1635					13		284																																	DNRW

Water Quality Data Summary

Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Physical									Cations/Anions							
						Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400
130302A	17/10/1985	1500	1.07	1.07	0.10			7.90	330			170	20	20	36	3.6	19.0	6.4	145	35	0.20	2.0
130302A	17/10/1985	1500					23		315													
130302A	7/11/1985	845	0.92	0.38			23		170													
130302A	21/01/1986	1100	0.82	0.12	0.10			7.90	255			140	80	89	22	5.7	17.0	5.0	110	18	0.20	2.0
130302A	21/01/1986	1100					29		134													
130302A	15/04/1986	1427	0.78	0.05	0.10			8.20	275			150	105	2	24	5.0	23.0	6.0	130	17	0.20	2.1
130302A	15/04/1986	1427					23		275													
130302A	16/07/1986	1055	0.81	0.11	0.10			8.10	345			180	20	8	36	5.0	24.0	7.0	155	30	0.10	
130302A	16/07/1986	1055					15		363													
130302A	14/10/1986	1642	0.95	0.07	0.10			8.00	310			160	5	7	33	3.7	20.5	6.4	140	27	0.10	
130302A	14/10/1986	1642					25		300													
130302A	31/03/1987	1544	0.80	0.03	0.10			7.80	260			140	28		22	5.4	21.0	5.0	125	16	0.20	
130302A	31/03/1987	1544					25		246													
130302A	14/07/1987	1616	0.85	0.09	0.10			7.80	305			160	5	3	33	4.6	20.0	6.0	140	27	0.10	
130302A	14/07/1987	1616					13		361													
130302A	4/11/1987	1405	0.77	0.23	0.10			7.20	205			120	142	100	25	5.8	15.0	3.3	95	14	0.10	
130302A	4/11/1987	1405					26		208													
130302A	10/02/1988	833	3.29	43.20	0.10			7.10	195			110	4900	100	12	5.6	20.0	3.3	105	5	0.20	2.6
130302A	10/02/1988	833					23		181													
130302A	19/05/1988	1240	0.85	0.13	0.10			7.70	210			120	302	100	21	3.9	14.0	3.0	93	14	0.10	2.2
130302A	19/05/1988	1240					18															
130302A	24/09/1988	1145	0.80	0.06	0.10			7.90	250			150	60	38	29	3.2	20.0	5.2	125	23	0.10	
130302A	24/09/1988	1145					21		295													
130302A	12/01/1989	800	1.46	4.43	0.10			7.00	125			83	280	100	10	5.3	8.9	2.4	56	10	0.10	
130302A	12/01/1989	800					26		138													
130302A	6/05/1989	1150	1.95	11.78	0.10			7.80	190			130	124	100	19	7.4	15.5	4.1	87	19		2.2
130302A	6/05/1989	1150							230													
130302A	3/09/1989	1100	0.97	0.58	0.10			7.70	325			190	100	100	35	3.5	23.0	7.3	140	38	0.10	4.4
130302A	3/09/1989	1100							347													
130302A	3/12/1989	1720	1.05	1.07			29		96													
130302A	25/03/1990	1310	0.94	0.45	0.10			7.80	211			124	74	200	22	5.5	14.3	4.5	87	17	0.14	3.6
130302A	25/03/1990	1310					23		282													
130302A	13/07/1990	1415	1.03	0.83	0.10			8.20	394			233	36	58	44	4.5	28.1	9.2	169	38	0.13	6.0
130302A	13/07/1990	1415					10	8.20	423													
130302A	15/11/1990	805	0.84	0.13	0.10			7.90	525			295	11	8	66	5.2	33.0	11.8	221	60	0.19	3.3
130302A	15/11/1990	805					25	8.30	522													
130302A	3/12/1990	1720	0.83	1.07				7.80	280			180	103	100	30	4.6	24.0	5.8	130	27	0.20	4.8
130302A	25/03/1991	920	0.78	0.07	0.10			7.30	241			140	57	3	22	6.4	17.9	5.4	115	16	0.17	1.9
130302A	25/03/1991	920					24	7.90	230													
130302A	3/08/1991	1630	0.83	0.13	0.10			7.90	350			191	10	5	42	5.0	21.9	7.5	155	37	0.15	
130302A	3/08/1991	1630					9	8.40	303													
130302A	1/12/1991	1815	0.45	0.47	0.10			7.60	470			251	13	5	52	6.3	30.1	10.4	206	44	0.18	
130302A	10/04/1992	853	0.83	0.12	0.10			7.60	204			123	158	200	19	4.7	17.5	4.1	102	9	0.16	1.9
130302A	10/04/1992	853					19		201													
130302A	13/08/1992	745	0.79	0.09	0.10			8.10	304			159	9		34	3.0	19.5	6.5	135	26	0.13	0.4
130302A	13/08/1992	745					14	7.70	310													
130302A	23/11/1992	1625	1.48	5.88			27	7.52	249													
130302A	2/07/1993	1205	0.73	0.07			14	7.40	320													
130302A	22/07/1993	827	0.77	0.13	0.10			7.60	335			183	12	3	37	5.6	21.5	8.2	154	28	0.14	1.8
130302A	22/07/1993	827					15	7.60	325													
130302A	23/11/1993	1625	1.48	5.88	0.10			7.60	259			151	71	36	22	6.7	21.0	5.3	126	19	0.14	1.5
130302A	16/12/1993	1400	1.70	9.30	0.10			7.40	165			100	515	200	14	5.4	12.7	3.2	78	8	0.11	2.3
130302A	13/04/1994	1723	0.78	0.19	0.10			7.70	263			160	46	43	27	6.0	20.5	5.4	132	19	0.11	1.4
130302A	13/04/1994	1723					21	7.50	269													
130302A	31/08/1994	1535					20	8.10	313													
130302A	31/08/1994	1600	0.72	0.03	0.10			7.80	314			164	3	1	37	4.4	19.5	6.3	139	27	0.11	0.4
130302A	31/08/1994	1600																				
130302A	31/08/1994	1600																				
130302A	25/10/1994	845	7.20		0.10			7.20	263			154	120	200	35	4.8	15.0	4.6	113	31	0.14	1.1
130302A	25/10/1994	845																				
130302A	25/10/1994	845																				
130302A	25/10/1994	845																				
130302A	25/10/1994	900	0.64	0.00	0.20	25	20	7.29	270	3.21												
130302A	30/11/1994	1215	0.83	0.39	0.30			7.65	331			179	7	2	38	6.0	20.2	6.5	151	29	0.15	0.0
130302A	30/11/1994	1215	0.83	0.39	0.30																	
130302A	30/11/1994	1215	0.83	0.39	0.30		27	7.40	342													
130302A	16/02/1995	1253	6.00	540.00	0.20			7.14	146			88	461	200	14	5.5	10.1	2.1	62	8	0.11	2.1
130302A	16/02/1995	1253																				
130302A	16/02/1995	1253																				
130302A	16/02/1995	1253																				
130302A	16/02/1995	1253	6.00	540.00	0.20		23	6.71	135													
130302A	28/03/1995	1730	0.78	0.26	0.30			8.04	213			133	46	78	22	5.1	17.4	5.0	110	14	0.13	1.3
130302A	28/03/1995	1730																				
130302A	28/03/1995	1730																				
130302A	28/03/1995	1730	0.78		0.30		27	6.88	228	3.78												
130302A	29/03/1995	1530	0.78	0.26			27	6.88	228	3.78												
130302A	4/05/1995	1545	0.74		0.30			7.77	317			189	15	12	35	5.6	24.3	7.2	156	28	0.13	1.5
130302A	4/05/1995	1545																				
130302A	4/05/1995	1545																				
130302A	4/05/1995	1545	0.74	0.06	0.20		21	7.80	342	4.40				15								
130302A	27/07/1995	1035	0.76	0.13	0.20		11	7.50	312	10.55				6								
130302A	27/07/1995	1050	0.76	0.13	0.20			7.78	303			166	11	6	38	3.7	18.8	5.9	138	29	0.14	0.5
130302A	27/07/1995	1050																				
130302A	27/07/1995	1050																				
130302A	31/08/1995	1500	0.73	0.46	0.20			7.71	298			167	17	11	37	3.7	20.3	6.4	141	29	0.12	0.0
130302A	31/08/1995	1500																				
130302A	31/08/1995	1500																				
130302A	31/08/1995	1500	0.73	0.46	0.20	25	20	7.80	317	6.20				11								
130302A	29/11/1995	1734	1.42	5.11	0.10			7.47	169			92	320	450	14	5.0	12.0	3.1	70	9	0.11	1.1
130302A	29/11/1995	1734																				
130302A	29/11/1995	1734																				
130302A	29/11/1995	1734	1.42	5.11	0.10		27	7.30	156	5.12				589								
130302A	27/03/1996	1722	0.76	0.11	0.20			7.84	396			224	17	11	42	6.2	28.6	8.3	190	32	0.15	1.0
130302A	27/03/1996	1722																				
130302A	27/03/1996	1722																				
130302A	27/03/1996	1722	0.75	0.11	0.20		24	7.68	410	4.11				16								
130302A	24/05/1996	1100	0.72		0.20			7.41	214			129	50	205	28	4.7	12.8	3.5	104	14	0.16	1.8
130302A	24/05/1996	1100																				
130302A	24/05/1996	1100																				
130302A	24/05/1996	1100	0.82	0.31	0.20	21	15	7.30	217	6.80				216								
130302A	19/07/1996	1130	0.76	0.14			10	7.80	317													
130302A	30/07/1996	1455	0.77	0.19	0.10			7.95	309			167	14	9	37	4.0	19.6	6.3	141	28	0.11	0.5
130302A	30/07/1996	1455																				
130302A	30/07/1996	1455																				
130302A	30/07/1996	1455	0.07	0.19	0.10		14	7.94	318	8.71				12								
130302A	12/03/1997	700	4.06	97.00	0.10			7.01	172			111	197	327	19	7.2	10.7	2.5	84	10	0.08	2.5
130302A	12/03/1997	700																				
130302A	12/03/1997	700																				
130302A	12/03/1997	700	4.06	97.00	0.10		24	6.85	172					367								
130302A	26/03/1997	1345	0.95	1.38	0.20			7.53	304			183	57	60	30	6.6	24.9	6.5	154	20	0.13	2.0
130302A	26/03/1997	1345																				
130302A	26/03/1997	1345																				
130302A	26/03/1997	1345	0.95	1.38	0.20		24	7.80	309	5.00				91								
130302A	12/08/1997	1700	0.74	0.11	0.20		16	7.90	319	8.10												
130302A	12/08/1997	1720	0.74	0.11	0.20			7.76	315			168	13	1	37	4.2	20.1	6.0	146	28	0.08	0.0
130302A	12/08/1997	1720																				
130302A	12/08/1997	1720																				
130302A	19/11/1997	1330	2.22	14.19	0.20	19	23	6.90	157	5.00				2800								
130302A	19/11/1997	1340	2.22	14.19	0.20			7.16	164			102	1944	2761	23	4.6	7.8	1.7	61	14	0.11	4.8
130302A	19/11/1997	1340																				
130302A	19/11/1997	1340																				
130302A	27/03/1998	830	0.74	0.07	0.10			7.30	200			120	100	410	11	7.5	19.5	4.7	100	10	0.20	2.0
130302A	27/03/1998	830																				
130302A	27/03/1998	830																				
130302A	27/03/1998	830	0.74	0.07	0.10	23	24	7.26	199	2.15				463								
130302A	5/08/1998	730	0.76	0.15	0.20			8.10	265			140	10	10	29	4.1	16.5	5.1	120	22	0.10	2.0
130302A	5/08/1998	730																				
130302A	5/08/1998	730																				
130302A	5/08/1998	730	0.76	0.15	0.20	16	14	7.70	262	8.20				18								
130302A	20/08/1998	1415	0.78	0.14	0.30			7.52	265			141	14	20	30	4.2	16.4	5.1	122	23	0.13	0.4
130302A	20/08/1998	1415																				
130302A	20/08/1998	1415	0.77	0.14	0.30	28	18	7.85	265	7.55				24								
130302A	8/10/1998	1525	0.96	1.36	0.20			7.39	232			142	93	160	25	6.3	16.4	3.7	103	20	0.10	2.8
130302A	8/10/1998	1525																				
130302A	8/10/1998	1525																				
130302A	8/10/1998	1525	0.96	1.36	0.20	22	22	7.23	221	5.10				194								

Sample Collection Point	Sample Date	Time	Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
			Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
			500	50		20	700	5		371	1.4	200			8							
130302A	17/10/1985	1500					500			20		10	0.01	1.00		120.00		0.7	74	248.4		DNRW
130302A	17/10/1985	1500																				DNRW
130302A	7/11/1985	845																				DNRW
130302A	21/01/1986	1100					500			30		500	0.01	15.00		91.00		0.5	63	181.4		DNRW
130302A	21/01/1986	1100																				DNRW
130302A	15/04/1986	1427								30		80		8.00		109.00		1.2	82	208.6		DNRW
130302A	15/04/1986	1427																				DNRW
130302A	16/07/1986	1055								20		30		1.00		129.00		1.3	89	258.4		DNRW
130302A	16/07/1986	1055																				DNRW
130302A	14/10/1986	1642								10		30		1.00		116.00		0.9	78	231.1		DNRW
130302A	14/10/1986	1642																				DNRW
130302A	31/03/1987	1544								20		30		12.00		103.00		0.4	73	195		DNRW
130302A	31/03/1987	1544																				DNRW
130302A	14/07/1987	1616								10		20		1.00		116.00		0.5	75	231.2		DNRW
130302A	14/07/1987	1616																				DNRW
130302A	4/11/1987	1405					700					350		12.00		78.00		0.1	51	159.4		DNRW
130302A	4/11/1987	1405																				DNRW
130302A	10/02/1988	833					3400			20		110		11.00		86.00		0.1	64	157.1		DNRW
130302A	10/02/1988	833																				DNRW
130302A	19/05/1988	1240					1400					360		14.00		77.00		0.2	47	153.2		DNRW
130302A	19/05/1988	1240																				DNRW
130302A	24/09/1988	1145										40		3.00		104.00		0.6	71	206.1		DNRW
130302A	24/09/1988	1145																				DNRW
130302A	12/01/1989	800					800					1300		19.00		46.00			32	94.2		DNRW
130302A	12/01/1989	800																				DNRW
130302A	6/05/1989	1150					4700					190		12.00		72.00		0.3	56	159.4		DNRW
130302A	6/05/1989	1150																				DNRW
130302A	3/09/1989	1100					500			40		40		8.00		115.00		0.4	88	252.2		DNRW
130302A	3/09/1989	1100																				DNRW
130302A	3/12/1989	1720																				DNRW
130302A	25/03/1990	1310					1900			20		70		12.20		72.00	0.01	0.3	54	156.5		DNRW
130302A	25/03/1990	1310																				DNRW
130302A	13/07/1990	1415					1100			10		350		17.70		141.00	0.03	1.5	107	301.2		DNRW
130302A	13/07/1990	1415																				DNRW
130302A	15/11/1990	805							0.05	30	40			6.50		182.00	0.01	1	131	401		DNRW
130302A	15/11/1990	805																				DNRW
130302A	3/12/1990	1720					1700		0.15	10	20	80	0.01	16.00	10	110.00		0.5	83	230		DNRW
130302A	25/03/1991	920					500		0.04	40	40	20		13.20	10	94.00	0.00	0.1	66	186.3		DNRW
130302A	25/03/1991	920																				DNRW
130302A	3/08/1991	1630							0.04	10				1.30		128.00	0.02	0.8	85	269.1		DNRW
130302A	3/08/1991	1630																				DNRW
130302A	1/12/1991	1815					3300		0.06		20	20		2.70	10	170.00	0.01	0.5	117	353.8		DNRW
130302A	10/04/1992	853					1700		0.33		10	190		14.60		84.00	0.01	0.2	60	160.7		DNRW
130302A	10/04/1992	853																				DNRW
130302A	13/08/1992	745					1000		0.01					0.50		113.00	0.03	1.1	75	227.6		DNRW
130302A	13/08/1992	745																				DNRW
130302A	23/11/1992	1625																				DNRW
130302A	2/07/1993	1205																				DNRW
130302A	22/07/1993	827					200				10	10		4.90	10	126.00	0.01	0.4	87	256.7		DNRW
130302A	22/07/1993	827																				DNRW
130302A	23/11/1993	1625					3200				20	60		11.00		103.00	0.01	0.2	74	204		DNRW
130302A	16/12/1993	1400					5400				40			11.00		63.00	0.01	0.1	44	128.8		DNRW
130302A	13/04/1994	1723					1100		0.17		30	130		15.30		109.00	0.01	0.4	73	212.7		DNRW
130302A	13/04/1994	1723																				DNRW
130302A	31/08/1994	1535																				DNRW
130302A	31/08/1994	1600					300				10			0.30		115.00	0.01	0.5	74	234.8		DNRW
130302A	31/08/1994	1600		22.0																		DNRW
130302A	31/08/1994	1600			0.00	33.0																DNRW
130302A	25/10/1994	845					1000		0.37		40	210	0.01	5.90	10	93.00		0.1	56	206.2		DNRW
130302A	25/10/1994	845		330.0																		DNRW
130302A	25/10/1994	845			0.18	5.0																DNRW
130302A	25/10/1994	845						2.00														DNRW
130302A	25/10/1994	900																				DNRW
130302A	30/11/1994	1215					560		0.00			10	0.00	4.30		124.60	0.01	0.39	77.13	251.83		DNRW
130302A	30/11/1994	1215		65.7																		DNRW
130302A	30/11/1994	1215																				DNRW
130302A	16/02/1995	1253					4070		0.27			170	0.00	11.40		51.30	0.00	0.05	33.83	108.85		DNRW
130302A	16/02/1995	1253		509.4																		DNRW
130302A	16/02/1995	1253			0.16	6.7																DNRW
130302A	16/02/1995	1253						2.00														DNRW
130302A	16/02/1995	1253																				DNRW
130302A	28/03/1995	1730					1010		0.03		50	80	0.02	12.60		91.00	0.02	0.67	63.97	176.15		DNRW
130302A	28/03/1995	1730		113.4																		DNRW
130302A	28/03/1995	1730			0.02	35.0																DNRW
130302A	28/03/1995	1730																				DNRW
130302A	29/03/1995	1530																				DNRW
130302A	4/05/1995	1545					160		0.00		10		0.0	9.20	10	129.00	0.01	0.51	90.23	259.2		DNRW
130302A	4/05/1995	1545		24.5																		DNRW
130302A	4/05/1995	1545			0.01	7.1																DNRW
130302A	4/05/1995	1545																				DNRW
130302A	27/07/1995	1035																				DNRW
130302A	27/07/1995	1050							0.01		30		0.00	1.20	10	113.60	0.01	0.46	71.17	234.33		DNRW
130302A	27/07/1995	1050		4.0																		DNRW
130302A	27/07/1995	1050			0.00	27.4																DNRW
130302A	31/08/1995	1500					270		0.00		30	120	0.01	0.70		116.50	0.01	0.42	76.96	238.1		DNRW
130302A	31/08/1995	1500		12.6																		DNRW
130302A	31/08/1995	1500			0.00	30.3																DNRW
130302A	31/08/1995	1500																				DNRW
130302A	29/11/1995	1734					970		0.00		40		0.00	12.40		57.20	0.01	0.11	42.69	115.37		DNRW
130302A	29/11/1995	1734		312.9																		DNRW
130302A	29/11/1995	1734			0.05	67.1																DNRW
130302A	29/11/1995	1734																				DNRW
130302A	27/03/1996	1722							0.02		10	40	0.01	12.40		157.10	0.01	0.8	105.49	308.6		DNRW
130302A	27/03/1996	1722		45.6																		DNRW
130302A	27/03/1996	1722			0.01	43.6																DNRW
130302A	27/03/1996	1722																				DNRW
130302A	24/05/1996	1100					1300		0.00		20		0.00	10.90	10	85.60	0.00	0.14	46.33	170.84		DNRW
130302A	24/05/1996	1100		138.2																		DNRW
130302A	24/05/1996	1100			0.04	42.2																DNRW
130302A	24/05/1996	1100														80.00						DNRW
130302A	19/07/1996	1130																				DNRW
130302A	30/07/1996	1455							0.00			10	0.00	1.70	10	116.90	0.01	0.69	74.81	236.89		DNRW
130302A	30/07/1996	1455		16.6																		DNRW
130302A	30/07/1996	1455			0.00	10.2																DNRW
130302A	30/07/1996	1455																				DNRW
130302A	12/03/1997	700					1100		0.00		10	10	0.00	16.90	50	68.89	0.00	0.05	36.98	137.19		DNRW
130302A	12/03/1997	700		696.4																		DNRW
130302A	12/03/1997	700			0.30	163.0																DNRW
130302A	12/03/1997	700																				DNRW
130302A	26/03/1997	1345					1320		0.00		10		0.00	15.30		126.50	0.00	0.29	88.85	245.93		DNRW
130302A	26/03/1997	1345		136.1																		DNRW
130302A	26/03/1997	1345			0.04	61.6																DNRW
130302A	26/03/1997	1345																				DNRW
130302A	12/08/1997	1700																				DNRW
130302A	12/08/1997	1720							0.00		10		0.00	0.80		120.30	0.01	0.49	74.82	241.38		DNRW
130302A	12/08/1997	1720		9.2																		DNRW
130302A	12/08/1997	1720			0.01	31.8																DNRW
130302A	19/11/1997	1330																				DNRW
130302A	19/11/1997	1340					3270		0.00		10		0.00	12.70	60	50.10	0.00	0.05	26.45	120.23		DNRW
130302A	19/11/1997	1340		1033.3																		DNRW
130302A	19/11/1997	1340			0.19	56.7																DNRW
130302A	27/03/1998	830					2300		0.05	100	50	20	0.02	9.00	20	84.00	0.00	0.1	68	160		DNRW
130302A	27/03/1998	830		370.0																		DNRW
130302A	27/03/1998	830			0.09	84.0																DNRW
130302A	27/03/1998	830																				DNRW
130302A	5/08/1998	730					500		0.05	100	50	20	0.02	1.00	20	100.00	0.00	0.9	62	200		DNRW
130302A	5/08/1998	730		22.0																		DNRW
130302A	5/08/1998	730			0.00	6.0																DNRW
130302A	5/08/1998	730																				DNRW
130302A	20/08/1998	1415					210		0.02		10	20	0.00	1.60		100.60	0.01	0.22	61.89	201.86		DNRW
130302A	20/08/1998	1415	224.9	42.8																		DNRW
130302A	20/08/1998	1415														105.60						DNRW
130302A	8/10/1998	1525					1070		0.00		20		0.00	16.50		84.34	0.00	0.14	56.13	178.1		DNRW
130302A	8/10/1998	1525	1036.7	255.5																		DNRW
130302A	8/10/1998	1525			0.10	10.4																DNRW
130302A	8/10/1998	1525																				DNRW

Water Quality Data Summary

Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Physical: Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Cations/Anions: Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)
					MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*
130302A	18/11/1998	950	0.76	0.16	0.20			7.95	350			200	40	29	41	7.2	24.0	6.2	160	30	0.20	2.0
130302A	18/11/1998	950																				
130302A	18/11/1998	950																				
130302A	18/11/1998	950	0.76	0.16	0.20		25	7.15	401	3.30				39								
130302A	9/02/1999	720	2.08	18.30	0.10			7.55	145			96	300	375	14	6.2	10.0	2.6	80	6	0.10	2.0
130302A	9/02/1999	720																				
130302A	9/02/1999	720																				
130302A	9/02/1999	720	2.08	18.30	0.10	24	26	7.24	157	5.47				567								
130302A	23/02/1999	1710	0.91	0.98	0.20			8.05	200			120	80	170	21	5.9	14.0	3.9	98	13	0.10	2.0
130302A	23/02/1999	1710																				
130302A	23/02/1999	1710																				
130302A	23/02/1999	1740	0.91	0.98	0.20	32	28	7.30	232	4.40				181								
130302A	23/02/1999	1740	0.78	0.20	0.20		13	7.40	313					32								
130302A	9/03/1999	750	4.36	132.14	0.10			7.45	145			90	160	235	16	6.0	7.9	2.2	64	7	0.10	2.0
130302A	9/03/1999	750																				
130302A	9/03/1999	750																				
130302A	9/03/1999	750	4.36	132.14	0.10	24	25	7.05	161	3.80				302								
130302A	7/06/1999	1510	0.75	0.08	0.30			8.05	320			200	10	12	42	5.1	23.0	7.2	165	31	0.10	2.0
130302A	7/06/1999	1510																				
130302A	7/06/1999	1510	0.75	0.08	0.30	25	17	7.90	345	6.70				13								
130302A	7/07/1999	1715	0.78		0.10																	
130302A	7/07/1999	1715																				
130302A	7/07/1999	1715	0.78	0.22	0.10		14	7.50	325	8.20				32								
130302A	13/09/1999	1350	0.74	0.11	0.30			7.93	282			161	11	5	34	4.1	18.8	6.6	142	25	0.12	0.4
130302A	13/09/1999	1350																				
130302A	13/09/1999	1350	0.74	0.11	0.30	27	19	7.50	293	7.80				9								
130302A	8/12/1999	1650	0.71	0.03	0.20			7.79	321			190	9	9	41	5.5	21.0	7.8	162	31	0.16	0.0
130302A	8/12/1999	1650																				
130302A	8/12/1999	1650																				
130302A	8/12/1999	1650	0.71	0.03	0.20		27	7.60	337	6.92				10								
130302A	18/02/2000	927	3.66	68.53	0.20			7.02	145			92	149	197	12	7.5	10.5	2.6	61	12	0.11	2.6
130302A	18/02/2000	927																				
130302A	18/02/2000	927																				
130302A	18/02/2000	927	3.66	68.53	0.20		22	7.20	133	4.10												
130302A	22/03/2000	1520	0.89	0.84	0.20			8.16	410			221	39	37	57	6.7	18.1	6.2	185	30	0.21	1.0
130302A	22/03/2000	1520																				
130302A	22/03/2000	1520																				
130302A	22/03/2000	1520	0.89	0.84	0.20		26	7.60	376	4.40				52								
130302A	15/08/2000	1702	0.76		0.30			8.04	290			151	13	7	36	4.2	15.4	5.3	134	23	0.14	0.0
130302A	15/08/2000	1702	0.76		0.30																	
130302A	15/08/2000	1702	0.76		0.30																	
130302A	15/08/2000	1702	0.76	0.16	0.30		15	7.90	281	8.20				8								
130302A	1/11/2000	815	2.00	2.09	0.20			6.96	135			88	1050	1250	15	5.3	7.6	2.0	55	8	0.10	2.8
130302A	1/11/2000	815	2.00		0.20																	
130302A	1/11/2000	815	2.00		0.20																	
130302A	1/11/2000	815	2.00	2.09	0.20		19	6.70	126	6.60												
130302A	15/11/2000	1510	1.09	2.45	0.30			7.60	140			91	220	345	13	4.3	9.3	2.7	72	6	0.10	2.0
130302A	15/11/2000	1510	1.09		0.30																	
130302A	15/11/2000	1510	1.09		0.30																	
130302A	15/11/2000	1510	1.09	2.45	0.30		23	7.00	140	5.50				365								
130302A	27/02/2001	1657	0.74	0.10	0.20		29	6.60	160	3.30				120								
130302A	27/02/2001	1715	0.74	0.09	0.20			7.40	160			98	30	115	13	5.1	12.0	3.5	86	7	0.10	2.0
130302A	27/02/2001	1715	0.74		0.20																	
130302A	27/02/2001	1715	0.74		0.20																	
130302A	27/02/2001	1715	0.74		0.20		29	6.60	160	3.30				120								
130302A	7/06/2001	1340	0.69	0.02	0.30			7.95	220			120	10	11	18	5.3	17.0	5.1	115	11	0.10	2.0
130302A	7/06/2001	1340																				
130302A	7/06/2001	1340	0.69	0.02	0.30	29	18	7.50	220	6.30				12								
130302A	17/07/2001	1555	0.71	0.04	0.20			7.80	290			150	10	6	28	5.8	18.5	6.3	135	23	0.10	2.0
130302A	17/07/2001	1555																				
130302A	17/07/2001	1555																				
130302A	17/07/2001	1555																				
130302A	17/07/2001	1555	0.71	0.04	0.20		14	7.70	289	7.30				84								
130302A	9/10/2001	1335	0.62	0.30	0.30			7.76	310			161	11	4	34	4.3	18.9	6.2	140	27	0.14	0.0
130302A	9/10/2001	1335																				
130302A	9/10/2001	1335	0.62	0.30	0.30		19	7.70	311	6.10				7								
130302A	5/12/2001	1610	0.86	0.49			29	7.30	193	4.10												
130302A	5/12/2001	1620	0.86	0.49	0.20			7.45	195			120	650	890	24	4.9	11.0	2.8	85	11	0.10	4.0
130302A	5/12/2001	1620																				
130302A	5/12/2001	1620																				
130302A	5/12/2001	1620	0.71	0.49	0.20		29	7.30	193	4.10				914								
130302A	18/02/2002	1750	2.77	47.37	0.30			7.10	135			84	1100	1750	12	4.4	9.9	2.5	68	5	0.10	3.0
130302A	18/02/2002	1750																				
130302A	18/02/2002	1750																				
130302A	18/02/2002	1750	2.77	47.37	0.30		27	7.20	148	3.50				1170								
130302A	19/02/2002	748	3.45	47.73	0.30		27	7.10	89	3.00				882								
130302A	19/02/2002	1210	3.45	47.73	0.30			6.95	110			76	550	860	11	4.7	7.0	2.1	55	5	0.10	4.0
130302A	19/02/2002	1210																				
130302A	19/02/2002	1210																				
130302A	20/02/2002	910	2.92	29.43	0.30			6.95	87			60	340	580	8	4.1	5.3	1.7	45	4	0.10	2.0
130302A	20/02/2002	910																				
130302A	20/02/2002	910																				
130302A	20/02/2002	910	2.92	29.43	0.30		26	7.00	90	3.60				513								
130302A	12/03/2002	1545	0.95	1.66	0.20			7.55	190			110	90	225	19	4.3	12.5	3.7	90	9	0.10	2.0
130302A	12/03/2002	1545																				
130302A	12/03/2002	1545																				
130302A	12/03/2002	1545	0.95	1.66	0.20		26	7.30	185	8.00				214								
130302A	12/03/2002	1620	0.95	1.63	0.20		26	7.30	185	8.00												
130302A	7/05/2002	1455	0.68	0.91	0.10			7.73	268			152	35	114	36	4.6	15.2	4.3	137	13	0.16	1.1
130302A	7/05/2002	1455																				
130302A	7/05/2002	1455	0.67	0.91	0.10	28	20	7.30	265	3.60				113								
130302A	8/07/2002	1600	0.75	0.12	0.40			7.85	250			130	10	30	28	4.1	14.5	4.5	110	21	0.10	2.0
130302A	8/07/2002	1600																				
130302A	8/07/2002	1600																				
130302A	8/07/2002	1600	0.75		0.40		11	7.90	241	9.90				28								
130302A	8/10/2002	745	0.69		0.10			7.40	245			130	50	140	28	5.3	14.5	3.9	110	17	0.20	2.0
130302A	8/10/2002	745																				
130302A	19/11/2002	1545	0.74	0.56	0.20			7.60	345			190	220	250	53	6.4	14.0	4.0	165	24	0.20	2.0
130302A	19/11/2002	1545																				
130302A	19/11/2002	1545																				
130302A	19/11/2002	1545	0.84	0.56	0.20	33	25	7.40	342	2.90				373								
130302A	18/03/2003	1630	0.77		0.20			7.60	200			120	150	260	23	5.2	12.0	3.6	105	7	0.20	2.0
130302A	18/03/2003	1630																				
130302A	18/03/2003	1630																				
130302A	18/03/2003	1630	0.77		0.20		30	7.20	171	3.60				261								
130302A	15/05/2003	1500	0.78		0.20			7.57	210			122	78	255	24	4.2	13.0	3.6	104	11	0.12	0.8
130302A	15/05/2003	1500																				
130302A	15/05/2003	1500	0.78		0.20	24	20	7.40	221	4.80												
130302A	18/06/2003	1723	0.75		0.20			7.85	248			144	20	45	29	4.5	16.5	4.8	122	18	0.12	1.0
130302A	18/06/2003	1723	0.75		0.20																	
130302A	18/06/2003	1723	0.75		0.20																	
130302A	18/06/2003	1723	0.75		0.20		14	7.30	255	6.50				45								
130302A	9/09/2003	1635	0.75	0.12	0.10			8.10	280			150	10	14	32	3.9	16.0	5.2	130	22	0.10	2.0
130302A	9/09/2003	1635	0.75		0.10																	
130302A	9/09/2003	1635	0.75		0.10																	
130302A	9/09/2003	1650	0.75	0.12	0.20		19	8.10	279	7.50				16								
130302A	28/10/2003	810	0.70		0.20			7.60	305			160	20	12	34	4.8	19.0	6.1	150	24	0.20	2.0
130302A	28/10/2003	810	0.70		0.20																	
130302A	28/10/2003	810	0.70		0.20	27	23	7.70	313	3.10				12								
130302A	13/01/2004	1530	0.83		0.10			7.20	155			98	1300	2000	17	5.0	10.0	2.0	78	6	0.20	4.0
130302A	13/01/2004	1530	0.83		0.10																	
130302A	13/01/2004	1530	0.83		0.10																	
130302A	13/01/2004	1530	0.83		0.10		27	6.90	154	2.20				2000								
130302A	13/01/2004	1535	0.83	0.59			27	6.90	154	2.10				2000								
130302A	11/05/2004	1545	0.76		0.10			7.80	385			210	10	22	49	5.6	21.5	6.7	185	30	0.20	2.0
130302A	11/05/2004	1545	0.76		0.10																	
130302A	11/05/2004	1545	0.76		0.10																	
130302A	11/05/2004	1545	0.76		0.10		19	7.60	382	5.60				22								
130302A	22/05/2004	1050	999.99		0.20			7.85	380			210	20	13	46	5.0	21.0	7.0	180	31	0.20	2.0
130302A	22/05/2004	1050	999.99		0.20																	
130302A	22/05/2004	1050	999.99		0.20	24	16	7.90	378	7.20				16								
130302A	25/10/2004	1515	0.77		0.10			7.78	342			180	19	14	41	5.0	19.0	6.5	157	28	0.10	1.0
130302A	25/10/2004	1515	0.77		0.10																	
130302A	25/10/2004	1515	0.77		0.10																	
130302A	25/10/2004	1515	0.77		0.10		27	7.50	346	5.00				14								
130302A	28/10/2004	730	1.48		0.30			7.18	218			127	1760	2790	24	6.9	13.0	3.3	101	11	0.10	3.9

Sample Date	Time	Nutrients & Biological: Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Total Metals/Trace Elements: Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Alkalinity: Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
		500	*50*		*20*	*700*	*5*		*371*	*1.4*	*200*			*8*							
18/11/1998	950					900		0.05	100	50	20	0.02	11.00	20	135.00	0.00	0.8	85	270		DNRW
18/11/1998	950		120.0																		DNRW
18/11/1998	950			0.04	11.0																DNRW
18/11/1998	950																				DNRW
9/02/1999	720					1500		0.21	100	50	290	0.02	15.00	20	66.00	0.00	0.1	35.5	120		DNRW
9/02/1999	720		420.0																		DNRW
9/02/1999	720			0.12	32.0																DNRW
9/02/1999	720																				DNRW
23/02/1999	1710					1200		0.05	100	50	70	0.02	14.00	20	82.00	0.00	0.6	51	160		DNRW
23/02/1999	1710		230.0																		DNRW
23/02/1999	1710			0.09	26.0																DNRW
23/02/1999	1740																				DNRW
23/02/1999	1740																				DNRW
9/03/1999	750					1500		0.23	100	50	200	0.02	17.00	20	53.00	0.00	0.1	29	110		DNRW
9/03/1999	750		450.0																		DNRW
9/03/1999	750			0.18	26.0																DNRW
9/03/1999	750																				DNRW
7/06/1999	1510					500		0.05	100	50	20	0.02	6.00	20	135.00	0.00	1.1	87	270		DNRW
7/06/1999	1510		48.0																		DNRW
7/06/1999	1510														116.00						DNRW
7/07/1999	1715	336.4	33.5																		DNRW
7/07/1999	1715			0.01	11.1																DNRW
7/07/1999	1715																				DNRW
13/09/1999	1350					340		0.00				0.00	1.10	10	117.65	0.01	0.63	74.04	232.13		DNRW
13/09/1999	1350	286.7	42.0																		DNRW
13/09/1999	1350														193.20						DNRW
8/12/1999	1650					530		0.01				0.00	3.10	30	133.44	0.01	0.58	84.47	269.09		DNRW
8/12/1999	1650	348.8	39.4																		DNRW
8/12/1999	1650			0.01	33.4																DNRW
8/12/1999	1650																				DNRW
18/02/2000	927					1640		0.00				0.00	13.10		50.16	0.00	0.03	36.89	110.14		DNRW
18/02/2000	927	1221.0	562.0																		DNRW
18/02/2000	927			0.34	14.1																DNRW
18/02/2000	927																				DNRW
22/03/2000	1520					1030		0.00			250	0.00	9.00	30	150.00	0.02	1.52	70.65	304.73		DNRW
22/03/2000	1520	497.0	109.1																		DNRW
22/03/2000	1520			0.04	21.7																DNRW
22/03/2000	1520																				DNRW
15/08/2000	1702					190		0.00				0.00	0.60		111.20	0.02	0.85	60.22	218.55		DNRW
15/08/2000	1702	181.1	25.0																		DNRW
15/08/2000	1702			0.01	4.3																DNRW
15/08/2000	1702																				DNRW
1/11/2000	815					5000		1.23			510	0.00	15.20		45.00	0.00	0.03	27.19	100.55		DNRW
1/11/2000	815	3220.0	664.0																		DNRW
1/11/2000	815			0.16	32.6																DNRW
1/11/2000	815																				DNRW
15/11/2000	1510					1400		0.05	100	50	490	0.02	18.00	700	59.00	0.00	1	35	110		DNRW
15/11/2000	1510	1300.0	320.0																		DNRW
15/11/2000	1510			0.09	66.0																DNRW
15/11/2000	1510																				DNRW
27/02/2001	1657																				DNRW
27/02/2001	1715					800		0.17	100	50	320	0.02	14.00	20	71.00	0.00	1	44	130		DNRW
27/02/2001	1715	740.0	190.0																		DNRW
27/02/2001	1715			0.07	37.0																DNRW
27/02/2001	1715																				DNRW
7/06/2001	1340					500		0.05	100	50	20	0.02	9.00	20	94.00	0.00	0.5	63	170		DNRW
7/06/2001	1340	510.0	50.0																		DNRW
7/06/2001	1340														99.00						DNRW
17/07/2001	1555					500		0.05	100	50	20	0.02	3.00	20	110.00	0.00	0.5	72	220		DNRW
17/07/2001	1555	370.0	30.0																		DNRW
17/07/2001	1555			0.01	10.0																DNRW
17/07/2001	1555						7														DNRW
17/07/2001	1555																				DNRW
9/10/2001	1335							0.00	30			0.00	1.50	10	115.70	0.01	0.46	72.65	230.84		DNRW
9/10/2001	1335	339.6	31.1																		DNRW
9/10/2001	1335														112.40						DNRW
5/12/2001	1610																				DNRW
5/12/2001	1620					2500		0.24	200	30	170	0.03	15.00	30	70.00	0.00	0.1	39	150		DNRW
5/12/2001	1620	1700.0	370.0																		DNRW
5/12/2001	1620			0.15	59.0																DNRW
5/12/2001	1620																				DNRW
18/02/2002	1750					3600		0.05	100	30	10	0.03	10.00	40	56.00	0.00	0.1	35	110		DNRW
18/02/2002	1750	2100.0	640.0																		DNRW
18/02/2002	1750			0.05	29.0																DNRW
18/02/2002	1750																				DNRW
19/02/2002	748																				DNRW
19/02/2002	1210					2700		0.05	800	30	10	0.03	13.00	40	45.00	0.00	0	26	92		DNRW
19/02/2002	1210	1700.0	690.0																		DNRW
19/02/2002	1210			0.11	24.0																DNRW
20/02/2002	910					1500		0.05	700	30	10	0.03	11.00	40	37.00	0.00	0	20	71		DNRW
20/02/2002	910	1200.0	420.0																		DNRW
20/02/2002	910			0.08	34.0																DNRW
20/02/2002	910																				DNRW
12/03/2002	1545					1600		0.13	100	30	140	0.03	12.00	10	74.00	0.00	0.2	46	140		DNRW
12/03/2002	1545	700.0	140.0																		DNRW
12/03/2002	1545			0.05	33.0																DNRW
12/03/2002	1545																				DNRW
12/03/2002	1620																				DNRW
7/05/2002	1455					1090		0.01	50		40	0.01	9.90		112.60	0.01	0.4	55.61	211.69		DNRW
7/05/2002	1455	614.8	152.3																		DNRW
7/05/2002	1455																				DNRW
8/07/2002	1600					500		0.05	100	30	70	0.03	5.00	10	91.00	0.00	0.4	55	180		DNRW
8/07/2002	1600	300.0	44.0																		DNRW
8/07/2002	1600			0.01	11.0																DNRW
8/07/2002	1600																				DNRW
8/10/2002	745					900		0.07	100	30	110	0.03	7.00	40	92.00	0.00	0.2	52	180		DNRW
8/10/2002	745	830.0	220.0																		DNRW
19/11/2002	1545					1600		0.05	200	30	110	0.03	7.00	10	135.00	0.00	0.4	52	270		DNRW
19/11/2002	1545	280.0	1200.0																		DNRW
19/11/2002	1545			0.09	56.0																DNRW
19/11/2002	1545																				DNRW
18/03/2003	1630					1500		0.05	100	30	10	0.03	11.00	10	87.00	0.00	0.2	45.5	160		DNRW
18/03/2003	1630	900.0	290.0																		DNRW
18/03/2003	1630			0.03	36.0																DNRW
18/03/2003	1630																				DNRW
15/05/2003	1500					1310		0.05		10	100	0.01	12.81		85.77	0.01	0.21	47.33	162.41		DNRW
15/05/2003	1500	789.5	189.0																		DNRW
15/05/2003	1500														228.00						DNRW
18/06/2003	1723					260		0.04	100	10	60	0.03	9.99	10	101.17	0.01	0.47	60.98	196.71		DNRW
18/06/2003	1723	371.6	44.7																		DNRW
18/06/2003	1723			0.01	10.2																DNRW
18/06/2003	1723																				DNRW
9/09/2003	1635					500		0.05	200	30	10	0.03	1.00	10	110.00	0.00	0.9	61	210		DNRW
9/09/2003	1635	200.0	20.0																		DNRW
9/09/2003	1635			0.01	8.0																DNRW
9/09/2003	1650																				DNRW
28/10/2003	810					500		0.05	100	30	10	0.03	1.00	10	125.00	0.00	0.3	72	240		DNRW
28/10/2003	810	330.0	42.0																		DNRW
28/10/2003	810														135.00						DNRW
13/01/2004	1530					2600		0.05	100	30	20	0.03	14.00	50	64.00	0.00	0.1	33	120		DNRW
13/01/2004	1530	2300.0	850.0																		DNRW
13/01/2004	1530			0.23	73.0																DNRW
13/01/2004	1530																				DNRW
13/01/2004	1535																				DNRW
11/05/2004	1545					500		0.05	100	30	20	0.03	10.00	10	150.00	0.00	0.7	81	300		DNRW
11/05/2004	1545	350.0	41.0																		DNRW
11/05/2004	1545			0.01	9.0																DNRW
11/05/2004	1545																				DNRW
22/05/2004	1050					500		0.05	100	30	10	0.03	6.00	10	150.00	0.00	0.8	82	290		DNRW
22/05/2004	1050	210.0	29.0																		DNRW
22/05/2004	1050														157.60						DNRW
25/10/2004	1515					500		0.05	30	30	10	0.03	2.00	10	130.00	0.00	0.7	74	258		DNRW
25/10/2004	1515	380.0	40.0																		DNRW
25/10/2004	1515			0.01	4.7																DNRW
25/10/2004	1515																				DNRW
28/10/2004	730					2200		0.05	60	30	10	0.03	13.00	30	83.00	0.00	0.1	45	165		DNRW

Water Quality Data Summary

						Physical									Cations/Anions							
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)
					MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*
130302A	28/10/2004	730	1.48		0.30																	
130302A	28/10/2004	730	1.48		0.30																	
130302A	28/10/2004	730	1.48		0.30		20	7.20	215	3.20				**2000**								
130302A	16/11/2004	1200	1.62		0.30			7.48	201			123	**766**	**976**	20	5.7	15.0	3.6	99	12	0.10	1.7
130302A	16/11/2004	1200	1.62		0.30																	
130302A	16/11/2004	1200	1.62		0.30	33	26	7.60	145	4.00				**800**								
130302A	16/03/2005	820	0.69		0.10			7.74	**388**			227	**40**	**59**	59	6.8	18.0	5.1	213	22	0.20	1.0
130302A	16/03/2005	820	0.70		0.10																	
130302A	16/03/2005	820	0.70		0.10																	
130302A	16/03/2005	820	0.70		0.10		25	7.60	**386**	2.10				**62**								
130302A	7/07/2005	1730	0.89		0.00			7.57	204			120	**310**	**389**	26	4.3	9.3	3.0	92	15	0.10	2.3
130302A	7/07/2005	1730	0.90		0.00																	
130302A	7/07/2005	1730	0.90		0.00																	
130302A	7/07/2005	1730					15	7.50	205	8.10				**380**								
130302A	24/10/2005	1700	3.20		0.10			7.10	118			77	**1340**	**1830**	17	4.2	4.3	1.4	58	6	0.20	1.5
130302A	24/10/2005	1700	3.20		0.10																	
130302A	24/10/2005	1700			0.10		24	7.00	92	7.00				**999**								
130302A	15/11/2005	1520	0.89		0.20			7.48	193			115	**149**	**262**	19	5.0	13.0	3.9	97	12	0.10	1.2
130302A	15/11/2005	1520	0.00		0.00																	
130302A	15/11/2005	1520	0.00		0.00																	
130302A	15/11/2005	1520					27	7.20	194	5.30												
130302A	12/12/2005	1730			0.30			7.39	161			99	**716**	**759**	14	6.0	12.0	2.7	82	6	0.10	1.9
130302A	12/12/2005	1730			0.30																	
130302A	14/12/2005	1730			0.30	34	30	7.40	136	6.40				**660**								
130302A	7/02/2006	1505	0.00		0.10			7.40	234			136	**44**	**86**	22	6.9	17.0	4.1	120	10	0.10	1.0
130302A	7/02/2006	1505	0.72		0.10																	
130302A	7/02/2006	1505	0.72		0.10																	
130302A	7/02/2006	1505			0.10		29	7.40	246	2.00				**87**								
130302A	5/05/2006	810	0.68		0.10			7.37	199			118	**32**	**52**	18	5.6	15.0	3.9	110	8	0.20	1.0
130302A	5/05/2006	810			0.10																	
130302A	5/05/2006	810			0.10																	
130302A	5/05/2006	810			0.10		16	7.30	182	2.10				**54**								
130302A	23/08/2006	705	0.68		0.20			7.77	292			154	9	6	33	5.7	18.0	5.2	134	25	0.10	1.0
130302A	23/08/2006	705	0.68		0.20		15	7.60	297					8								
130302A	10/11/2006	1640			0.10			7.37	179			105	**916**	**1480**	17	5.6	13.0	2.8	85	10	0.13	3.0
130302A	10/11/2006	1640			0.10																	
130302A	10/11/2006	1640			0.10	26	25	7.30	166	8.20				**905**								
130302A	14/11/2006	810	1.72		0.10	22	26	7.50	259	7.50				**230**								
130302A	30/11/2006	945						7.52	**358**			200	**78**	**106**	40	6.3	23.0	6.2	172	23	0.20	2.3
130302A	30/11/2006	945																				
130302A	30/11/2006	945																				
130302A	30/11/2006	945	0.72		0.10		26	7.50	**361**					**121**								
130302A	20/03/2007	1600			0.10			7.38	131			89	**700**	**1090**	17	4.8	9.5	2.0	70	5	0.12	3.2
130302A	20/03/2007	1600																				
130302A	20/03/2007	1600			0.10	31	26	7.30	122	9.60				**999**								
130302A	21/03/2007	1220	0.94		0.20			7.35	137			86	**648**	**1010**	13	5.7	9.7	2.1	70	5	0.12	2.4
130302A	21/03/2007	1220																				
130302A	21/03/2007	1220																				
130302A	21/03/2007	1220	0.95		0.20		26	7.00	137	4.50				**900**								
130302A	6/05/2007	830		0.00	0.60			7.40	220			127	**86**	**106**	17	6.7	18.0	4.2	117	7	0.15	1.4
130302A	6/05/2007	830																				
130302A	8/05/2007	1130			0.10			7.46	195			120	**119**	**255**	16	6.3	16.0	3.7	108	8	0.14	2.4
130302A	8/05/2007	1130																				
130302A	8/05/2007	1130			0.10		20	7.20	182	8.00												
130302A	3/07/2007	1645			0.20			7.63	216			121	**131**	**275**	21	4.6	15.0	4.3	102	15	0.12	1.4
130302A	3/07/2007	1645			0.20																	
130302A	3/07/2007	1645																				
130302A	3/07/2007	1645	0.93		0.20		12	7.60	215	10.20				**290**								
130302A	25/09/2007	1500																				1.0
130302A	25/09/2007	1500			0.20	34	20	7.70	320	8.30				28								

			Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-*a* (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
			500	*50*		*20*	*700*	*5*		*371*	*1.4*	*200*			*8*							
130302A	28/10/2004	730	**3807.5**	**1387.1**																		DNRW
130302A	28/10/2004	730			0.16	**41.4**																DNRW
130302A	28/10/2004	730																				DNRW
130302A	16/11/2004	1200					**3100**		0.10	40	30	80	0.03	12.00	**20**	82.00	0.00	0.2	53	161		DNRW
130302A	16/11/2004	1200	**1549.4**	**417.9**																		DNRW
130302A	16/11/2004	1200														87.00						DNRW
130302A	16/03/2005	820					**1000**		0.05	80	30	10	0.03	9.00	**10**	176.00	0.00	0.6	65	326		DNRW
130302A	16/03/2005	820	**639.0**	**157.0**																		DNRW
130302A	16/03/2005	820			0.05	**35.0**																DNRW
130302A	16/03/2005	820																				DNRW
130302A	7/07/2005	1730					**2000**		0.05	50	30	10	0.03	12.00	**60**	76.00	0.00	0.2	35	154		DNRW
130302A	7/07/2005	1730	**1037.0**	**197.0**																		DNRW
130302A	7/07/2005	1730			0.09	**49.0**																DNRW
130302A	7/07/2005	1730																				DNRW
130302A	24/10/2005	1700					**3800**		0.05	70	30	10	0.03	10.00	**80**	48.00	0.00	0	17	97		DNRW
130302A	24/10/2005	1700	**2052.0**	**411.0**																		DNRW
130302A	24/10/2005	1700																				DNRW
130302A	15/11/2005	1520					**1200**		0.05	30	30	10	0.03	12.00	**10**	80.00	0.00	0.1	49	152		DNRW
130302A	15/11/2005	1520	**880.0**	**168.0**																		DNRW
130302A	15/11/2005	1520			0.03	**27.1**																DNRW
130302A	15/11/2005	1520																				DNRW
130302A	12/12/2005	1730					**2300**		0.05	50	30	50	0.03	14.00	**80**	68.00	0.00	0.1	41	127		DNRW
130302A	12/12/2005	1730	**1328.2**	**449.5**																		DNRW
130302A	14/12/2005	1730																				DNRW
130302A	7/02/2006	1505					**1000**		0.05	40	30	140	0.03	17.00	**10**	98.00	0.00	0.2	58	180		DNRW
130302A	7/02/2006	1505	**757.7**	**233.6**																		DNRW
130302A	7/02/2006	1505			0.10	**20.9**																DNRW
130302A	7/02/2006	1505																				DNRW
130302A	5/05/2006	810					500		0.05	30	30	60	0.03	12.00	**20**	90.00	0.00	0.1	54	162		DNRW
130302A	5/05/2006	810	**540.0**	**130.0**																		DNRW
130302A	5/05/2006	810			0.03	**41.7**																DNRW
130302A	5/05/2006	810																				DNRW
130302A	23/08/2006	705					500		0.05	60	30	10	0.03	1.00	**20**	111.00	0.00	0.4	67	222		DNRW
130302A	23/08/2006	705																				DNRW
130302A	10/11/2006	1640					**3000**		0.05	70	30	60	0.03	9.00	**60**	70.00	0.00	0.1	44	139		DNRW
130302A	10/11/2006	1640	**2370.0**	**519.0**																		DNRW
130302A	10/11/2006	1640																				DNRW
130302A	14/11/2006	810																				DNRW
130302A	30/11/2006	945					**1300**		0.05	40	30	10	0.01	12.00	**10**	142.00	0.00	0.3	82	275		DNRW
130302A	30/11/2006	945	**731.7**	**110.3**																		DNRW
130302A	30/11/2006	945			0.01	**22.6**																DNRW
130302A	30/11/2006	945																				DNRW
130302A	20/03/2007	1600					**1900**		0.11	140	30	100	0.01	11.00	**100**	58.00	0.00	0.1	32	114		DNRW
130302A	20/03/2007	1600	**1870.0**	**605.0**																		DNRW
130302A	20/03/2007	1600																				DNRW
130302A	21/03/2007	1220					**2700**		0.08	50	30	70	0.01	11.00	**30**	58.00	0.00	0.1	33	111		DNRW
130302A	21/03/2007	1220	**1445.1**	**356.3**																		DNRW
130302A	21/03/2007	1220			0.13	**51.7**																DNRW
130302A	21/03/2007	1220																				DNRW
130302A	6/05/2007	830					**900**		0.05	30	30	40	0.01	13.00	**10**	96.00	0.00	0.2	63	173		DNRW
130302A	6/05/2007	830	**583.6**	**184.5**																		DNRW
130302A	8/05/2007	1130					**700**		0.07	50	30	110	0.01	13.00	**30**	89.00	0.00	0.2	56	162		DNRW
130302A	8/05/2007	1130	**777.7**	**187.6**																		DNRW
130302A	8/05/2007	1130																				DNRW
130302A	3/07/2007	1645					**1400**		0.06	30	30	90	0.01	8.00	**20**	84.00	0.00	0.2	54	164		DNRW
130302A	3/07/2007	1645	**587.5**	**127.4**																		DNRW
130302A	3/07/2007	1645			0.04	**34.7**																DNRW
130302A	3/07/2007	1645																				DNRW
130302A	25/09/2007	1500								40	30	10	0.01		**10**		0.00					DNRW
130302A	25/09/2007	1500																				DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

Samples collected downstream of existing associated water discharge points

S - Santos

RH - River Health Report

DNRW - Department of Natural Resources and Water

Table B9
Upper Dawson Catchment - Dawson River at Utopia Downs
GLNG CSG Surface Water

		Physical										Cations				Anions				Nutrients & Biological					Trace Elements										Flow		
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-*a* (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity	Data source
		MTV	*na*	*0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*	
Utopia	25/05/2005			12	7.2	233	11.30	103	154	9		28	3	12	6	91	22	0.15	<10	70	**<50**	**<10**				<100	-	-	-	165					Low-mod	Mod	RH
Utopia	5/11/2006			12.3	7.9	223	14.20	132	136	**10**	4	29	4	11	4	91	21	0.1	1	100	**<10**	**<10**			<1	<100	<0.1	<1	<1	1	<1	<0.1	<1	**<10**	Mod	Mod	RH
Utopia	24/04/2007		29.8	19.8	7.6	286	8.08	89	200	**12**		37	6	22	7	150	23	0.22	<1	**680**	34	18	<44*	<1	<1	20	<1	<1	<2	**460**	<1	<0.5	<3	**<1**			RH
Utopia	20/11/1964	2359			7.7	310			174			47		19	9	156	40	0.2	2				55														DNRW
Utopia	2/02/1966	2359			7.4	288			161			35		20	7	140	30	0.1																			DNRW
Utopia	6/10/1966	2359			**8**	270			162			39		14	9	136	32	0.15	1																		DNRW
Utopia	11/08/1968	1510			7.6	273			170			40		20	6	137	28		9																		DNRW
Utopia	8/06/1970	1307			7.7	290			173			38		24	5	154	30	0.15																			DNRW
Utopia	24/04/1971	1310		19	**8**	**390**			212			32		40	9	195	35	0.1																			DNRW
Utopia	25/08/1971	1445		17	7.8	320			180			32		20	15	159	35	0.1																			DNRW
Utopia	25/11/1971	1000		24	**8**	**360**			102			44		34	4	178	36	0.2																			DNRW
Utopia	10/05/1972	800		18	**8**	270			167			40		17	8	146	30	0.25																			DNRW
Utopia	15/09/1972	1330		18																																	DNRW
Utopia	14/04/1973	1730		23	**8.2**	310			187	**13**		32	5	27	8	163	70	0.2								20											DNRW
Utopia	11/08/1973	1200		17	**8.1**	200			122			21	5	15	5	87	20																				DNRW
Utopia	5/12/1973	1100		27	**8.3**	270			161	**20**		24	5	23	7	131	26	0.16																			DNRW
Utopia	27/03/1974	1030		27	7.8	**355**			203			40	5	25	8	164	32	0.13																			DNRW
Utopia	26/06/1974	1215		15	7.7	300			178	**42**		34	4	21	7	139	31	0.13																			DNRW
Utopia	18/09/1974	1530		17	7.6	335			199	**54**		36	4	21	9	149	34	0.27																			DNRW
Utopia	16/12/1974	1730		27	7.5	330			171	9		35	5	20	8	158	14	0.16																			DNRW
Utopia	8/04/1975	1000		21.5																																	DNRW
Utopia	5/07/1975	1055		16	**8**	262			145	**33**		27	3	16	6	115	22	0.1																			DNRW
Utopia	17/10/1975	1300		26	7.6	311			165	**11**		32	4	16	7	140	26	0.2																			DNRW
Utopia	3/06/1976	1350		16	**8.1**	**430**			239			42	4	35	9	186	40	0.2	5				55														DNRW
Utopia	14/09/1976	1231		16	**8.3**	**375**			211	5		43	4	28	8	167	37	0.2					55														DNRW
Utopia	14/12/1976	1632		29	**8.2**	**360**			198	**11**		28	6	34	8	165	26	0.4	2				331														DNRW
Utopia	20/04/1977	1347		22	**8.2**	**385**			212	7		39	5	28	9	153	36		5				193														DNRW
Utopia	25/10/1977	937		24	**8.2**	325			181			35	4	21	8	150	28	0.1					166														DNRW
Utopia	11/04/1978	1305		77	**8**	280			164	**15**		30	4	19	7	142	26	0.1	2				83														DNRW
Utopia	24/10/1978	1154		21																																	DNRW
Utopia	11/11/1980	1505		29	7.8	330			172			34	4	18	8	150	24	0.1	1				138														DNRW
Utopia	18/12/1980	1200		29	7.6	320			170			31	4	19	9	148	25	0.1	1				55														DNRW
Utopia	4/02/1981	1440		18	7.6	78			77	**500**		8	4	5	2	24	3	0.1	6				**7724**														DNRW
Utopia	4/02/1981	1440			7.4	90			62	**500**		8	4	6	2	38	4	0.1	4				**1379**														DNRW
Utopia	5/02/1981	945		18	7.5	117			75	**500**		10	5	8	2	47	6	0.1	4				**1931**														DNRW
Utopia	8/02/1981	725			7.3	116			83	**100**		9	4	8	2	44	6	0.1	13				**1931**														DNRW
Utopia	24/03/1981	1755			**8.1**	285			144	**10**	16	24	5	21	7	133	20	0.1	1																		DNRW
Utopia	24/03/1981	1755		27																																	DNRW
Utopia	4/06/1981	1010		16	7.3	86			58	**200**	680	8	3	5	2	26	6	0.1	7				**1103**														DNRW
Utopia	23/07/1981	1640			**8.2**	**370**			195	**10**	10	37	4	25	8	155	31	0.1	2																		DNRW
Utopia	10/11/1981	915		24	**8.5**	**360**			200	**10**		33	4	24	8	150	27	0.2	13				276														DNRW
Utopia	25/03/1982	850		22	**8**	290			160	**50**	100	24	4	20	6	135	20	0.1	4				276														DNRW
Utopia	12/08/1982	1130		14	**8.1**	300			170	9	2	35	3	19	7	140	27	0.1	3				110														DNRW
Utopia	3/11/1982	1545		25	7.8	330			190	**10**	13	37	5	21	8	165	30	0.2	1				110														DNRW
Utopia	16/02/1983	1730		28																																	DNRW
Utopia	15/12/1983	800		24	**8.1**	320			190	**25**	72	31	4	24	7	145	28	0.1	3.3				138														DNRW
Utopia	24/03/1984	1045		26	7.3	290			220	5	3	37	4	28	9	175	33	0.1	7							30											DNRW
Utopia	23/06/1984	1210		12	7.8	330			200	5		41	3	25	8	150	36	0.1	2.5																		DNRW
Utopia	18/10/1984	1140		20	**8.3**	**480**			280	5		56	5	31	10	200	55	0.1	4.5				138			10											DNRW
Utopia	13/04/1985	1345		23	7.5	**350**			200	**10**	3	41	3	23	7	165	36	0.1								20											DNRW
Utopia	5/07/1985	1425			**8.1**	**340**			180	5	6	37	3	20	7	150	33	0.1																			DNRW
Utopia	18/10/1985	1330		22	7	90			77	**330**	100	9	3	8	2	50	8	0.1	2				138			10											DNRW
Utopia	22/01/1986	1714		30	**8**	292			160	5	5	33	5	19	7	140	26	0.2					331			20											DNRW
Utopia	18/07/1986	1440		16	**8.4**	238			160	**25**	9	32	3	19	7	130	26	0.1																			DNRW
Utopia	17/10/1986	1643		25	**8**	301			160	**10**	13	32	3	19	7	140	27	0.1					690														DNRW
Utopia	9/01/1987	1807		28	7.7	152			95	**2460**	100	11	5	13	3	72	7	0.1	2.6				**1324**														DNRW
Utopia	3/04/1987	930		23	7.9	288			160	**10**	7	32	4	20	6	140	26	0.1								20											DNRW
Utopia	17/07/1987	1530		11	**8.1**	314			150	**19**	9	31	3	17	6	125	22	0.1																			DNRW
Utopia	6/11/1987	1720		21	7.3	273			150	**44**	34	29	5	17	6	120	22	0.2																			DNRW
Utopia	12/02/1988	1645		28	7.3	142			97	**730**	100	12	5	11	4	69	9	0.1					524			10											DNRW
Utopia	17/05/1988	1452		18	7.5	250			130	**48**	38	26	3	16	5	115	21	0.1																			DNRW
Utopia	26/09/1988	1430		24	**8.1**	274			150	**12**	6	29	4	18	7	125	25	0.1																			DNRW
Utopia	12/01/1989	1437		27	7.1	175			89	**125**	100	10	5	13	3	73	9	0.1																			DNRW
Utopia	7/05/1989	852			7.8	308			150	**81**	80	24	6	19	6	105	27		3.2				**2152**														DNRW
Utopia	2/09/1989	1613			7.9	**434**			250	**10**	11	46	3	31	10	180	54	0.1	5							50											DNRW
Utopia	3/12/1989	1440		30	**8.5**	**405**			230	**76**	59	43	4	28	8	155	48	0.2	4				331			100			0.02								DNRW
Utopia	24/03/1990	1115		22	**8.1**	320			179	**47**	45	33	4	20	7	133	32	0.16	2.8				166			30											DNRW
Utopia	13/07/1990	1145		11	**8.2**	**475**			260		32	51	4	31	11	182	46	0.16	7				386			20											DNRW
Utopia	15/11/1990	1330		26	7.6	**498**			270	2		58	4	31	11	200	52	0.16	3.4							40			0.03								DNRW
Utopia	23/03/1991	915		22	7.8	**380**			217	4	5	47	5	24	8	167	44	0.19								30			0.03								DNRW
Utopia	3/08/1991	1405		8	**8**	303			176	**16**	4	37	3	19	7	141	33	0.13	2.8							20			0.04								DNRW
Utopia	29/11/1991	1340		27	7.5	294			182	4	3	41	4	17	8	143	32	0.16	0.6										0.03								DNRW
Utopia	12/04/1992	1003		17	7.6	302			158	**11**	3	33	3	19	7	135	26	0.14																			DNRW
Utopia	12/08/1992	1120		12	**8.3**	240			151	**11**	1	33	2	16	7	124	25	0.13	0.7				55														DNRW
Utopia	2/12/1992	1405		26	**8.1**	310			167	9	5	34	4	17	8	136	25	0.12	0.3				221						0.01								DNRW
Utopia	24/03/1993	1015		21.1	7.7	284			153	**11**	7	37	4	14	7	121	26	0.14					55						0.02								DNRW
Utopia	21/07/1993	915		14.2	7.9	249			137	**23**	15	30	3	15	6	115	20	0.12	0.6				28														DNRW
Utopia	24/11/1993	1455			7.6	190			110	**230**	100	15	4	13	4	79	19	0.1	2				**938**			100			0.05								DNRW
Utopia	24/11/1993	1455		24.6	7.75	163																															DNRW
Utopia	16/12/1993	1300			7.65	165			99	**290**	100	15	4	11	4	76	12	0.1	2				**1048**			100			0.05								DNRW
Utopia	13/04/1994	940		15.7	7.9	294			168	8	4	33	4	19	6	134	28	0.1	0.6				110						0.01								DNRW
Utopia	31/08/1994	1330		17.4	**8**	278			147	4	3	33	3	15	7	126	23	0.11	0.7		20	17															DNRW
Utopia	23/09/1994	1420		16.2	7.8	294			155	3		34	4	16	7	134	26	0.12			27	**20**							0.02								DNRW
Utopia	30/11/1994	920		24.3	7.79	312			170	**19**	9.8	31	4	20	9	150	22	0.14	0		**73**		149			0			0								DNRW
Utopia	11/01/1995	1250		27.4	7.25	182			110	**400**	100	18	5	12	4	76	14	0.2	2		**260**	**150**	**1434**			100			0.05								DNRW
Utopia	10/02/1995	919		25.1	7.18	95	6.21		65	**1220**	200	9	4	7	2	42	7	0.11	1.29		**487**	**30**	**1131**			0			0								DNRW
Utopia	9/03/1995	1539			7.58	185			114	**124**	200	18	4	13	4	85	17	0.1	1.8		**191**	**49**	414			0			0.01								DNRW

Water Quality Data Summary

Sample Collection Point	Sample Date		Physical									Cations				Anions				Nutrients & Biological					Trace Elements										Flow		Data source
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-a (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity	
		MTV	*na*	*0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*	
Utopia	29/03/1995	900		22.6	**8.31**	321	6.75		180	8	8.9	37	4	21	7	142	28	0.13	1.08		34	**20**	121			0			0.05								DNRW
Utopia	4/05/1995	1000			7.56	303			163	4	4.5	35	4	18	6	131	28	0.12	1.02		40	7				0			0.02								DNRW
Utopia	7/06/1995	1100			7.91	296			158	**10**	3.3	32	4	17	6	125	28	0.12	0.78		28	**27**	408			0			0.01								DNRW
Utopia	5/07/1995	845		9	7.95	292	10.85		159	**11**	7.9	33	3	16	7	132	27	0.11	0.47		21	9				0			0.02								DNRW
Utopia	26/07/1995	1530		10.4	7.81	292	11.48		163	0	9.74	37	3	17	6	133	28	0.14	0.63		3	**38**				0			0.02								DNRW
Utopia	31/08/1995	900		15.7	7.84	297	7.96		159	9	7.11	34	3	18	7	132	27	0.12	0.56		17	**21**	36			0			0.05								DNRW
Utopia	5/10/1995	1330		20.9	7.92	289	8.24		153	9	7.24	31	4	16	7	127	25	0.14	0		15	**26**				0			0.02								DNRW
Utopia	2/11/1995	1300			7.24	192			113	**196**		21	4	11	4	89	17	0.13	1.64		**158**	**25**	519			0			0.07								DNRW
Utopia	28/11/1995	1315		27	7.57	195	6.13		113	**208**	340	19	4	13	4	82	18	0.11	2.04		**184**	**58**	433			0			0.01								DNRW
Utopia	8/01/1996	750		25.4	7.94	262	6.53		117	**92**	143	20	3	15	5	117	5	0.11	0.9		**114**	**41**	339			0			0.04								DNRW
Utopia	1/02/1996	1120		28.1	7.35	218	5.82		132	**235**	371	22	5	15	5	99	18	0.11	1.9		**193**	**20**	**772**			0			0								DNRW
Utopia	4/03/1996	1432		24.1	7.81	**403**	9.66		224	**14**	17.1	45	5	27	8	182	35	0.13	0.9		**59**	**30**				0			0.02								DNRW
Utopia	27/03/1996	1021		21.9	7.96	**391**	6.64		211	**11**	12.8	44	4	24	8	174	35	0.14	0.54		42	**27**				0			0.01								DNRW
Utopia	9/05/1996	1540			7.48	203			123	**124**		29	4	10	3	97	16	0.15	1.9		**138**	**24**	359			0			0.02								DNRW
Utopia	4/06/1996	1450		15.9	7.78	303	9.90		169	8	22.2	35	5	18	6	135	27	0.1	0.79		32	**25**	251			0			0.01								DNRW
Utopia	3/07/1996	1530		10.9	7.98	307	11.38		166	9	11	35	3	18	7	135	27	0.1	0		20	14				0			0.05								DNRW
Utopia	30/07/1996	950		12.3	7.86	289	9.20		156	**20**	14	34	3	17	6	127	26	0.06	0.38		29	20				0			0								DNRW
Utopia	4/12/1996	925		26.1	7.98	338	3.50		189	**20**	18	43	5	18	8	153	28	0.15	0		**59**	**57**	193			0			0								DNRW
Utopia	25/03/1997	925		20.8	7.56	312	6.76		179	**30**	54	33	5	21	7	145	23	0.12	1.33		**92**	**37**	276			0			0.01								DNRW
Utopia	13/08/1997	1230		12.2	7.75	299			160	**10**		35	3	17	6	135	26	0.1	2		10	0	138			100			0.05								DNRW
Utopia	21/11/1997	1030	28.6	22.6	7.8	260	6.20		150	**800**	1120	45	5	8	2	130	11	0.2	2		**550**	**31**	662			100			0.05								DNRW
Utopia	25/03/1998	1230	31.9	25.9	7.75	285	7.90		160	**10**	16.1	28	6	21	6	140	21	0.1	2		**70**	**87**	138			100			0.05								DNRW
Utopia	25/03/1998	1250		25.9	7.8	285	7.90				16																										DNRW
Utopia	23/07/1998	1315	16.3	12.9	7.59	258	10.30		140	**15**	26	30	3	15	6	119	22	0.12	0.37		30	12	66			0			0								DNRW
Utopia	8/10/1998	800	14.7	18.4	7.96	240	7.40		155	**34**	79	28	5	18	5	115	24	0.1	1.56	**573**	**118**	6	190			0			0.01								DNRW
Utopia	24/02/1999	1330			**8.1**	230			140	**40**	60	25	5	16	5	115	16	0.1	2		**130**	5	193			100			0.05								DNRW
Utopia	24/02/1999	1400	22.5	23.2	7.8	272	7.00				72.3																										DNRW
Utopia	8/03/1999	1500		26.7	7.45	129	6.20		79	**160**	294	11	6	8	2	58	4	0.1	2		**330**	**20**	414			100			0.05								DNRW
Utopia	6/07/1999	1232		11.6	7.3	261	9.80				12																										DNRW
Utopia	6/07/1999	1500		11.8	**8.28**	262	9.80		152	4	12	32	3	16	7	127	24	0.11	0.38	105	22	4				0			0								DNRW
Utopia	8/12/1999	1215		24.5	**8.16**	**396**	7.40		234	6	8	63	5	16	7	207	29	0.21	0	301	**79**	**55**	138			100			0								DNRW
Utopia	28/02/2000	805																		**873**	**126**																DNRW
Utopia	22/03/2000	1025		24	**8.1**	248	6.90		146	**37**	86	32	5	13	5	117	20	0.15	1.04	434	**98**	**21**	406			0			0								DNRW
Utopia	16/08/2000	1620		13.3	**8.26**	284	11.20		142	**14**	10	31	3	14	6	124	22	0.13	0	147	27	10	47			0			0								DNRW
Utopia	15/11/2000	859		22.4	7.75	164	6.90		100	**150**	257	20	4	9	3	84	11	0.1	2	**990**	**250**	**23**	524			100			0.05								DNRW
Utopia	28/02/2001	1205		26.3	7.85	249	6.60		140	**10**	13	26	4	15	5	120	18	0.1	2	320	**80**	8	138			100			0.05								DNRW
Utopia	18/07/2001	1138		10.3	**8.1**	259	10.40		140	**10**	6	28	3	14	6	120	23	0.1	2	110	20		138			100			0.05								DNRW
Utopia	5/12/2001	1330		28.2	**8.1**	335	7.20		190	**20**	27	39	4	19	10	160	24	0.2	2	320	**55**	14	138			20			0.03								DNRW
Utopia	20/02/2002	1105		26.5	7.3	130	6.50		82	**240**	308	14	4	7	3	62	7	0.1	3	**1200**	**340**	**24**	497			100			0.03								DNRW
Utopia	9/07/2002	1255		8.3	**8.1**	273	11.00		150	**20**	12	36	3	14	6	125	24	0.1	2	100	19	4	138			100			0.03								DNRW
Utopia	20/11/2002	825		21.9	7.95	291	4.60		160	**20**	16	36	4	15	7	135	25	0.2	2	290	**59**	17	138			20			0.03								DNRW
Utopia	18/03/2003	1115		23.4	**8.1**	261	7.40		150	**30**	47	31	5	16	5	130	18	0.2	2	330	48	14	138			100			0.03								DNRW
Utopia	18/06/2003	1455		11	7.97	266	9.50		149	**10**	11	32	3	16	6	122	23	0.11	0.65	104	13	3	138			100			0.03								DNRW
Utopia	9/09/2003	1440			**8.25**	275			150	**10**	11	33	3	15	6	130	23	0.1	2	150	21	3	138			100			0.03								DNRW
Utopia	9/09/2003	1448		17.1		278	9.60				13																										DNRW
Utopia	13/01/2004	1245		29.3	7.7	304	5.50		170	**40**	28	43	5	13	6	145	25	0.2	2	310	**64**	**26**	138			100			0.03								DNRW
Utopia	12/05/2004	1250		14.4	**8.1**	291	9.60		160	**10**	9	35	3	16	6	135	25	0.1	2	130	23	6	138			100			0.03								DNRW
Utopia	26/10/2004	1215		25.3	7.76	302	4.70		160	**12**	8	36	4	15	7	139	24	0.1	1	244	43	7	138			30			0.03								DNRW
Utopia	15/03/2005	1130		24.2	7.83	270	6.10		147	**14**	17	33	5	14	5	129	24	0.1	1	312	41	11	138			40			0.03								DNRW
Utopia	6/07/2005	1415		13.5	**8.14**	**551**	9.50		317	**136**	311	112	4	6	3	289	32	0.3	1	**929**	**118**	**51**	524			170			0.03								DNRW
Utopia	16/11/2005	1008		23.3	7.57	167	8.60		109	**345**	444	19	4	11	3	85	14	0.1	2	**1030**	**230**	**25**	441			80			0.03								DNRW
Utopia	7/02/2006	1030			7.09	161			91	**207**	344	14	8	9	3	68	9	0.1	1				**745**			30			0.03								DNRW
Utopia	8/02/2006	1030		26.1	7.1	158					350									**1637**	**265**	**48**															DNRW
Utopia	4/05/2006	1540		15.5	7.99	222	9.40		131	**16**	19	27	4	13	5	114	21	0.1	1	164	34	6	138			20			0.03								DNRW
Utopia	22/08/2006	1230		14.6	7.98	297			141	**27**	8	32	3	14	6	120	23	0.1	1				138			70			0.03								DNRW
Utopia	29/11/2006	1025		26.1	7.8	**350**					87									**596**	**109**	**55**															DNRW
Utopia	20/03/2007	1040		22.2	7.4	196	4.30				195																										DNRW
Utopia	3/07/2007	1426		11.3	7.4	**427**	10.00				364																										DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

Samples collected downstream of existing associated water discharge points

S - Santos

RH - River Health Report

DNR - Department of Natural Resources

Comet-Brown Catchment Water Quality Data

Appendix C

Table C1
Comet Catchment URS Surface Water Parameters
GLNG CSG Surface Water

Site ID		Date/Time		Water Quality Parameters				
Number	Name	Date	Time (EST)	EC (µS/cm)*	DO (mg/L)	pH*	Turbidity (NTU)	Temp (°C)
			MTV	*340*		*6.5 - 8.0*	*50*	
C001	Arcadia Ck @ Arcadia Valley Rd #1	03-Feb-08	11:30	198	4.91	7.4	**91**	27.5
C001	Arcadia Ck @ Arcadia Valley Rd #1	06-Mar-08	11:10	210	nt	7.6	nt	nt
C001	Arcadia Ck @ Arcadia Valley Rd #1	14-May-08	10:30	-	-	-	-	-
C002	Basin Ck @ Arcadia Valley Rd	03-Feb-08	11:42	109.7	1.85	6.51	**170**	28.4
C002	Basin Ck @ Arcadia Valley Rd	06-Mar-08	10:45	141	nt	7.33	nt	nt
C002	Basin Ck @ Arcadia Valley Rd	14-May-08	10:45	228	7.21	7.11	**675**	16
C003	Arcadia Ck @ Arcadia Valley Rd #2	03-Feb-08	12:10	199	7.13	**5.85**	**58**	27.3
C003	Arcadia Ck @ Arcadia Valley Rd #2	06-Mar-08	12:20	184	nt	7.73	nt	nt
C003	Arcadia Ck @ Arcadia Valley Rd #2	14-May-08	12:45	207	4.87	6.95	44	19.5
C004	Arcadia Ck @ Arcadia Valley Rd #3	03-Feb-08	12:57	199.1	7.33	**5.59**	23	29.8
C004	Arcadia Ck @ Arcadia Valley Rd #3	06-Mar-08	13:00	173	-	7.59	-	-
C004	Arcadia Ck @ Arcadia Valley Rd #3	14-May-08		-	-	-	-	-
C005	Spring Ck @ Arcadia Rd	03-Feb-08	13:18	-	-	-	-	-
C005	Spring Ck @ Arcadia Rd	06-Mar-08		-	-	-	-	-
C005	Spring Ck @ Arcadia Rd	14-May-08	13:05	-	-	-	-	-
C012	Arcadia Ck @ Castle Hill	06-Mar-08	-	-	-	-	-	-
C012	Arcadia Ck @ Castle Hill	14-May-08	11:40	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	06-Mar-08	-	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	14-May-08	12:00	185.2	9.35	7.21	8	16.7
C007	Carnarvon Ck @ Carnarvon Hwy	03-Feb-08	14:20	**395**	6.96	**8.1**	46	31
C007	Carnarvon Ck @ Carnarvon Hwy	06-Mar-08	14:00	350	-	8.29	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	14-May-08	13:45	**490**	9.6	**8.23**	2	20.9
C006	Moolayember Ck @ Carnarvon Hwy	03-Feb-08	15:50	-	-	-	-	-
C006	Moolayember Ck @ Carnarvon Hwy	06-Mar-08	13:50	-	-	-	-	-
C006	Moolayember Ck @ Carnarvon Hwy	14-May-08	13:40	-	-	-	-	-
C008	Carnavon Ck @ Rewan (Plane Crash)	03-Feb-08	14:43	**449**	7.8	**8.08**	28	28.9
C008	Carnavon Ck @ Rewan (Plane Crash)	06-Mar-08		-	-	-	-	-
C008	Carnavon Ck @ Rewan (Plane Crash)	14-May-08	14:20	**500**	11.15	**8.42**	1	18.9
C009	Comet River @ Rolleston	03-Feb-08	16:10	212.7	4.88	7.39	**132**	30
C009	Comet River @ Rolleston	06-Mar-08		-	-	-	-	-
C011	Triumph Ck @ Rolleston Rd	04-Feb-08	9:50	128	1.05	**6.41**	566	27.6
C011	Triumph Ck @ Rolleston Rd	06-Mar-08		-	-	-	-	-
C010	Comet River @ Comet Weir	04-Feb-08	8:55	230	7.01	7.43	28	28.1
C010	Comet River @ Comet Weir	06-Mar-08		-	-	-	-	-
C013	Arcadia Ck @ Towrie	14-May-08	11:50	176	nt	7.69	nt	nt

NOTES
MTV Minimum trigger value
BOLD Greater than minimum trigger value
"-" stream dry
nt - parameters not taken due to instrument failure
* - Samples collected March 08 were analysed by laboratory due to instrument failure

Table C2
URS Surface Water Analytical Results Comet Catchment
GLNG CSG Surface Water

Location		Sample ID	Date Sampled	Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				
				Sample Type	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Suspended Solids (TSS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium
				Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				LOR	*2*	*5*	*1*	*1*	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*0.01*	*0.1*	*0.01*	*0.1*	*1*
				MTV				*10*	*0.007* [b]	*0.37*	*0.0002*	*0.001*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*			*0.05*	*0.5*	*1000*
C001	Arcadia Ck @ Arcadia Valley Rd #1	C001_06/03/08	6/03/2008	PS	-	85	<1	**64**	0.005	<0.1	<0.0001	<0.001	**0.002**	-	0.001	0.005	0.006	0.029	1.1	**0.18**	**1.1**	22
C001	Arcadia Ck @ Arcadia Valley Rd #1	C001_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	0.023	1.3	**0.18**	-	-
C002	Basin Ck @ Arcadia Valley Rd	C002_06/03/08	6/03/2008	PS	-	82	<1	**270**	0.002	<0.1	**0.0002**	**0.018**	**0.022**	-	**0.028**	**0.034**	**0.065**	0.09	2.4	**1.02**	**2.5**	15
C002	Basin Ck @ Arcadia Valley Rd	C002_14/05/08	14/05/2008	PS	37	5	-	**106**	<0.001	<0.05	**0.0002**	<0.001	**0.005**	**0.98**	**0.004**	0.003	<0.005	0.266	1.4	**0.38**	**1.6**	30
C002	Basin Ck @ Arcadia Valley Rd	C002_14/05/08CHK	14/05/2008	LD	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_06/03/08	6/03/2008	PS	-	46	<1	**52**	0.004	<0.1	0.0001	<0.001	**0.002**	-	<0.001	0.003	0.006	0.01	1.3	0.04	**1.3**	18
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_14/05/08	14/05/2008	PS	58	10	-	**27**	0.002	0.06	**0.0002**	<0.001	**0.002**	**0.98**	<0.001	0.003	<0.005	<0.01	1	**0.15**	**1**	19
C004	Arcadia Ck @ Arcadia Valley Rd #3	C004_06/03/08	6/03/2008	PS	-	66	<1	**128**	0.005	<0.1	<0.0001	**0.014**	**0.011**	-	**0.005**	**0.014**	**0.031**	0.018	2.3	**0.55**	**2.4**	12
C004	Arcadia Ck @ Arcadia Valley Rd #3	C004_06/03/08CHK	6/03/2008	LD	-	-	-	**138**	0.006	<0.1	<0.0001	**0.014**	**0.012**	-	**0.005**	**0.014**	**0.032**	-	-	-	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	C007_06/03/08	6/03/2008	PS	-	25	<1	**25**	0.002	<0.1	0.0001	<0.001*	**0.002**	-	<0.001	0.002	<0.005	0.044	0.6	0.08	**0.6**	36
C007	Carnarvon Ck @ Carnarvon Hwy	C007_06/03/08CHK	6/03/2008	LD	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	C007_14/5/08	14/05/2008	PS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42
C008	Carnavon Ck @ Rewan (Plane Crash)	C008_14/05/08	14/05/2008	PS	17	2	-	2	<0.001	<0.05	**0.0002**	<0.001	0.001	<0.05	<0.001	<0.001	<0.005	<0.01	<0.1	0.04	<0.1	44
C008	Carnavon Ck @ Rewan (Plane Crash)	C008_14/05/08CHK	14/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.04	-	
C013	Arcadia Ck @ Towrie	C013_06/03/08	6/03/2008	PS	-	46	<1	**25**	0.004	<0.1	0.0001	<0.001	**0.002**	-	<0.001	0.003	<0.005	0.013	1.2	**0.13**	**1.2**	16
C013	Arcadia Ck @ Towrie	C013_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	C014_14/05/08	14/05/2008	PS	41	9	-	**10**	0.001	<0.05	<0.0001	<0.001	**0.002**	**0.23**	<0.001	0.002	<0.005	<0.01	1	**0.07**	**1**	19
C014	Arcadia Ck @ Sunny Holt	QC02_14/05/08	14/05/2008	FD	93	9	-	**11**	<0.001	<0.05	<0.0001	<0.001	**0.002**	**0.26**	<0.001	0.002	<0.005	<0.01	1	**0.07**	**1**	
C014	Arcadia Ck @ Sunny Holt	QC02_14/05/08CHK	14/05/2008	LD	-	-	-	-	0.001	-	<0.0001	<0.001	**0.002**	-	<0.001	0.002	<0.005	-	-	-	-	

Notes

PS - Primary Sample
LD - Lab Duplicate
FD - Field Duplicate Sample
MTV - Minimum Trigger Value
a -Guideline physico-chemical parameter values for protection of aquatic ecosystems (central Coast Region)
b-AsIII/AsIV respectively
BOLD Greater than the MTV

Table C2
URS Surface Water Analytical Results Comet Catchment
GLNG CSG Surface Water

Location		Sample ID	Date Sampled	Analyte	Major Ions									Alkalinity			
				Sample Type	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
				Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				LOR	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
				MTV	*175*	*1*			*<115*	*250*							
C001	Arcadia Ck @ Arcadia Valley Rd #1	C001_06/03/08	6/03/2008	PS	2	0.1	6	12	8	<1	2.19	2.29	-	<1	<1	107	107
C001	Arcadia Ck @ Arcadia Valley Rd #1	C001_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-
C002	Basin Ck @ Arcadia Valley Rd	C002_06/03/08	6/03/2008	PS	<1	<0.1	4	6	4	1	1.37	1.41	-	<1	<1	67	67
C002	Basin Ck @ Arcadia Valley Rd	C002_14/05/08	14/05/2008	PS	4	0.2	8	8	-	6	2.43	2.61	-	-	-	-	-
C002	Basin Ck @ Arcadia Valley Rd	C002_14/05/08CHK	14/05/2008	LD	4	-	-	-	-	-	-	-	-	-	-	-	-
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_06/03/08	6/03/2008	PS	4	0.2	6	11	14	<1	2.06	2.25	-	<1	<1	98	98
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_06/03/08CHK	6/03/2008	LD	-	-	6	11	13	<1	-	-	-	-	-	-	-
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_14/05/08	14/05/2008	PS	3	0.2	7	8		13	2.11	2.29	-	-	-	-	-
C004	Arcadia Ck @ Arcadia Valley Rd #3	C004_06/03/08	6/03/2008	PS	4	0.2	4	8	22	2	1.9	2.08	-	<1	<1	87	87
C004	Arcadia Ck @ Arcadia Valley Rd #3	C004_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	C007_06/03/08	6/03/2008	PS	11	0.1	21	5	23	7	4.48	4.64	1.74	<1	<1	202	202
C007	Carnarvon Ck @ Carnarvon Hwy	C007_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	C007_14/5/08	14/05/2008	PS	19		27	4	-	26	5.49	5.56	0.64	-	-	-	-
C008	Carnavon Ck @ Rewan (Plane Crash)	C008_14/05/08	14/05/2008	PS	14	0.2	34	2	-	27	6.06	6.21	1.17	-	-	-	-
C008	Carnavon Ck @ Rewan (Plane Crash)	C008_14/05/08CHK	14/05/2008	LD		-	-	-	-	-	-	-	-	-	-	-	-
C013	Arcadia Ck @ Towrie	C013_06/03/08	6/03/2008	PS	2	0.1	5	12	10	<1	1.81	1.99	-	<1	<1	88	88
C013	Arcadia Ck @ Towrie	C013_06/03/08CHK	6/03/2008	LD	3	0.1	-	-	-	-	-	-	-	<1	<1	87	87
C014	Arcadia Ck @ Sunny Holt	C014_14/05/08	14/05/2008	PS	3	0.2	7	10	-	9	2.01	2.16	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	QC02_14/05/08	14/05/2008	FD		0.2	-	-	-	-	-	-	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	QC02_14/05/08CHK	14/05/2008	LD		-	-	-	-	-	-	-	-	-	-	-	-

Notes

PS - Primary Sample
LD - Lab Duplicate
FD - Field Duplicate Sample
MTV - Minimum Trigger Value
a -Guideline physico-chemical parameter values for protection of aquatic ecosystems (central Coast Reg
b-AsIII/AsIV respectively
BOLD Greater than the MTV

Table C3
Comet Catchment DNRW Surface Water Quality Results - Catchment Summary
GLNG CSG Surface Water

	Water Quality Parameter	Units	MTV	Brown River (u/s Rolleston)				Carnarvon Creek				Comet River (at Rolleston)				Meteor Ck				Planet Creek				Comet River (d/s Rolleston)				Humboldt + Rockland Creek				Comet River at Comet Weir			
				Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n
Physico-Chemical Parameters	Conductivity @ 25C	μS/cm	340	66	217.0	**545**	53	115	**343.3**	**436**	38	150	206.5	331	4	160	**615.5**	**810**	40	89	**698.3**	**1080**	50	101	233.9	**1030**	81	48	202.9	335	7	72	203.9	**510**	125
	Conductivity @ 25C F	μS/cm	340	65	176.4	**385**	23	113	**341.9**	**438**	43	147	233.5	**418**	8	310	**421.3**	**520**	4	**342**	**830.9**	**1120**	13	95	164.3	**458**	69		151.0	151	1	50	187.6	**479**	85
	Turbidity	NTU	50	1	**77.9**	**620**	37	1	26.9	**200**	27	1.5	**149.5**	**430**	3	2	27.8	**100**	12	1	7.6	26	22	2	**799.9**	**3110**	62	**70**	**654.0**	**1238**	2	1	**690.9**	**9310**	71
	Turbidity F	NTU	50	5	**112.1**	**330**	15	1	4.9	15	18	6	**160.7**	**538**	8									1	**1305.2**	**3180**	47		**1280.0**	**1280**	1	15.6	**1053.3**	**7740**	60
	Transparency (secchi depth) FLD	m																														0.14	0.5	1.02	4
	Colour True	Hazen Units		5	28.8	95	32	5	9.2	30	24	10	19.3	28	3	5	14.5	50	10	5	24.0	**70**	20	5	24.8	70	32	14	42.0	70	2	2	34.1	325	67
	Air Temp FLD			18	21.9	26	4	13	18.1	27	5	14.7	16.0	17.2	2									23.4	23.9	24.3	3					17	22.7	27.7	6
	Water Temp FLD		20-80%ile	8	22.2	32	33	10.3	20.6	32	48	16.5	20.7	24.9	8	4	24.8	34	30	14	24.1	35	36	10.9	23.0	35	57	19	21.3	28	5	14	24.7	34.2	109
	pH	pH Units	6.5-8.0	6.6	7.6	**8.5**	53	7.4	**8.3**	**8.8**	38	7	7.5	7.91	4	7.4	**8.3**	**8.8**	40	6.8	8.0	**8.8**	50	7.05	7.8	**8.72**	57	6.9	7.3	7.7	7	6.9	7.6	**8.6**	125
	pH FLD	pH Units	6.5-8.0	6.92	7.8	**8.9**	17	7.8	**8.5**	**8.8**	29	7.5	7.7	**8.1**	7					**8.3**	**8.4**	**8.4**	2	6.47	7.8	**8.88**	28		7.4	7.4	1	6.5	7.4	**8.53**	74
	Oxygen (Dissolved) FLD	mg/L		4.06	7.6	17.5	15	6.8	9.5	11.9	18	3.8	5.3	6.7	8									5.88	7.9	9.85	18		5.3	5.3	1	3.6	6.4	10.48	46
	Total Suspended Solids	mg/L	10	5	**148.6**	**3910**	47	2	**27.5**	**335**	37	5	**131.7**	**370**	3	1	**40.4**	**300**	32	2	**28.8**	**580**	41	2	**611.6**	**2350**	75	4	**119.3**	**360**	6	2	**455.9**	**5772**	99
	Total Diss. Solids	mg/L	500	39	126.0	296	52	88	202.0	251	38	89	126.6	170.79	3	99	357.8	485	40	50	405.5	**620**	50	69.69	167.1	**602**	57	45	128.6	204	7	52	125.5	271	117
Nutrients	Nitrate (NO3)	mg/L	50	0.17	1.4	3.8	36	0.2	0.8	3	17	0.44	1.5	3.6	4	0.4	0.9	2.9	16	0.2	1.1	5.2	23	0.1	1.5	5.5	34	1	3.5	5.3	3	0	1.8	9.7	73
	Nitrate + nitrite (N total)	mg/L																									0								
	Nitrate + nitrite (N soluble)	mg/L						0.0025	0.003	0.0042	3													0.0019	0.1	0.475	22					0	0.2	1.05	48
	Ammonia (N total)	mg/L	0.02																								0								
	Ammonia (N soluble)	mg/L	0.02	0.006	0.006	0.006	1	0.005	0.01	**0.0215**	4													0.0042	**0.025**	**0.0814**	23		**1.1**	**1.11**	1	0	**0.1**	**0.80**	51
	Kjeldahl Nitrogen	mg/L		0.685	1.1	1.4	5	0.175	0.18	0.175	1	0.543	1.3	2	2									1.581	3.3	11.882	11					715	715.0	715	1
	Total Nitrogen (TN)	mg/L	0.5	**0.5008**	**1.0**	**2.1024**	8	0.1	0.16	0.2158	2	**0.83**	**0.9**	**1.0419**	3									0.3712	**0.6**	**0.8278**	3					0.36	**1.5**	**4.48**	36
	Organic Nitrogen	mg/L		0.68	0.7	0.68	1	0.1132	0.19	0.3	4	0.59	0.6	0.59	1									0.41	2.4	17.8609	24					0.3	1.1	3.2	30
	Total Reactive Phosphorus	mg/L																									0								
	Total React Phosphorus (P soluble)	mg/L		0.067	0.1	0.067	1	0.0045		0.0223	4														0.1	0.164	22					0.003	0.1	0.27	50
	Total Phosphorus (P)	mg/L	0.05	**0.0961**	**0.3**	**0.581**	14	0.0162		**0.052**	8	0.0397	**0.3**	**0.74**	6									**0.0877**	**0.7**	**2.4338**	37		**0.4**	**0.39**	1	0.022	**0.7**	**2.84**	66
Metals	Boron as B	mg/L	0.37	0.01	0.037	0.1	21	0.01		0.2	15	0.04	0.1	0.1	2	0.02		0.03	12	0.02	0.1	0.1	22	0.02	0.032	0.05	11					0.01	0.1	0.11	41
	Aluminium (Al)	mg/L	0.055	0.01	0.044	**0.1**	9	0.01	**0.1**	**0.2**	7	0.05	**0.1**	**0.18**	3					**0.1**	**0.2**	**0.22**	2	0.01	0.031	**0.09**	14					0.01	**0.1**	0.59	40
	Copper (Cu)	mg/L	0.0014	**0.01**	**0.033**	**0.06**	9	**0.01**	**0.04**	**0.06**	8	**0.01**	**0.02**	**0.05**	3					**0.02**	**0.1**	**0.11**	4	**0.01**	**0.035**	**0.17**	19			**0.01**	1	**0.01**	**0.03**	**0.08**	27
	Bromide (Br)	mg/L										1	1.0	1	1												0								
	Cadmium (Cd total)	μg/L	0.2																								0					**2.6**	**3.1**	**3.5**	2
	Chromium (Cr total)	μg/L	1																								0					**3**	**5.0**	**7**	2
	Copper (Cu total)	μg/L	1.4																								0					**4**	**5.5**	**7**	2
	Flouride (F)	μg/L	1	0.1	0.2	0.65	50	0.1	0.1	0.2	37	0.11	0.2	0.24	3	0.1	0.2	0.63	40	0.01	0.2	0.3	42	0.04	0.1	0.42	53	0.1	0.3	0.8	6	0.02	0.2	0.83	124
Major Ions	Hydrogen (H)	mg/L						0.1	0.1	0.1	4				3	0.1	0.2	0.5	8	0.1	0.1	0.1	9	0.1	0.1	0.1	5					0.1	0.1	0.1	4
	Chloride (Cl)	mg/L	175	2.2	10.2	58	52	3.8	10.6	20	38	4.8	6.1	7.9	4	12	26.1	65	40	13.8	74.9	155	50	4	13.6	140	57	10	37.1	90	7	2	10.3	46.37	124
	Potassium (K)	mg/L		3.1	7.2	21.1	48	1.3	2.9	6.7	38	3.86	5.7	7	4	2.2	3.6	24	39	1.4	3.0	5.6	48	2.4	4.9	8.2	55	1.8	4.3	5.3	6	2.2	5.2	48	103
	Sodium (Na)	mg/L	115	4	13.3	39.9	53	11.5	17.5	22	38	8.6	11.3	14.5	4	3.4	37.3	80.4	40	11.1	71.4	**124**	50	4.8	16.8	**115**	57	5.6	24.1	40	7	4	12.3	36	125
	Total Dissolved Ions	mg/L		43.9	173.6	443.7	53	92.2	287.9	366.7	37	113	166.7	273.94	4	127.3	509.9	710.9	39	48.6	537.6	831.3	50	83.68	231.3	781.7	57	46.9	142.0	229.9	7	75	168.8	382.2	125
	Calcium (Ca)	mg/L	1000	2.8	17.1	63	53	6.4	27.4	38	38	8.8	15.8	29.4	4	12	35.6	51	40	1.5	30.9	57	50	6.4	19.1	45	81	1.5	9.5	20	7	5.6	16.9	48	125
	Sulphate (SO4)	mg/L	250	0.5	2.5	9.3	24	0.65	2.9	16	33	0.51	2.2	4.2	4	1	8.0	27.5	26	0.9	3.3	8.2	27	0.7	3.6	25	40	6	11.6	20	4	0.97	4.4	53.33	88
	Magnesium (Mg)	mg/L		1.5	8.2	20	53	4.2	19.5	25.3	38	4.7	9.2	18.7	4	4	41.9	54	40	2	33.1	54.2	50	3.3	11.8	45	81	1.9	5.8	8.8	7	2.6	8.8	27	125
Alkalinity	Total Alkalinity (CaCO3)	mg/L		8	95.6	256	53	47	173.7	223	38	63	108.7	168	3	41	301.7	416	40	10	267.3	470	50	42	115.0	355	57	15	43.9	80	7	26	92.1	222	125
	Total Alkalinity (CaCO3) FLD	mg/L		55	77.0	124	4	18.8	139.4	180	5	50	86.4	149.2	3			0						56	119.5	180	6		48.0	48	1	8.6	59.3	124	10
	Hydroxide (OH)	mg/L		0	0.0	0.02	11	0.02	0.1	0.1	20							0		0.04	0.1	0.1	5	0.09	0.1	0.09	1				5	0.01	0.0	0.1	13
	Carbonate (CO3)	mg/L		0.07	0.5	1.6	39	0.1	3.1	9.1	38	0.1	0.5	0.98	3	0.1	6.1	30	40	0.1	5.3	15	38	0.03	1.4	19	52			0.1	5	0.04	0.7	16.8	83
	Bicarbonate (HCO3)	mg/L		9.2	115.9	311	53	57	205.3	263	38	70	116.2	202.93	4	28	355.6	500	40	12	317.9	553.3	50	51.12	155.9	426	57	18.3	53.4	97	7	31.5	111.3	267	125
	Hardness (CaCO3)	mg/L		13	76.3	240	53	33	148.7	194	38	41.5	77.2	150.24	4	54	261.1	350	40	12	213.2	360	50	29.54	96.2	298	81	12	47.7	80	7	25	78.3	201	125

NOTES
MTV Minimum trigger value
BOLD Greater than MTV

Table C4
Comet Catchment DNRW Water Quality Results - Brown River
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Stream Water Level	Stream Discharge	Depth	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Colour True	Air Temp	Water Temp	pH	pH FLD	DO FLD	TSS	TDS	Nitrate (NO3)
					Hydrological Parameters			Physico-Chemical Parameters												Nutirients
				Units	m	cumecs	m	uS/cm	uS/cm	NTU	NTU	Hazen units	°C	°C	pH units	pH units	mg/L	mg/L	mg/L	mg/L
				MTV				340	340	50	50			20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50
1305001	Brown at Lake Nuga Nuga	185913	4/06/1998	1030	NA	0	0.2	**382**	**385**	17.6	19	32	22.8	21.8	7.62	**8.1**	5.7	**22**	218.7	0.22
1305009	Christmas Ck at Clematis	194127	10/09/1999	1450	NA		0.2	150	146	**300**	**284**	48		22.4	6.85	7.2	8	**400**	83	3.8
1305003	Brown at Clematis	192165	5/06/1999	1130	NA	0	0.2	200	203	3	10	22	20.8	16	7.6	7.7	6.4	**10**	120	1.1
1305027	Brown River Arcadia	185914	4/06/1998	1330	NA	0	0.2	117.8	119	**85.6**	**84**	8	26	20.8	7.12	7.5	4.5	**31**	70.11	1.32
1305027	Brown River Arcadia	192163	4/06/1999	910	NA	0	0.2	125	125	**58.4**	**61**	22	18	15.1	7.54	7.7	6	**29**	69.99	0.77
130502A	Brown R at Warrinilla	47666	14/11/1970	1625	1.35	7.193	0.1	80							7				43	
130502A	Brown R at Warrinilla	47665	16/11/1970	853	1.03	3.71	0.1	166							6.7				93	
130502A	Brown R at Warrinilla	49012	3/06/1971	1235	0.28	0.046	0.1	245							6.6				135	
130502A	Brown R at Warrinilla	52187	2/03/1972	1625	0.46	0.146	0.1	210							7.6					
130502A	Brown R at Warrinilla	56730	7/03/1973	1315	0.36	0.102	0.1	280							7.9				160	
130502A	Brown R at Warrinilla	61400	1/04/1974	1500	0.47	0.402	0.1	256							**8.1**			**30**	138	
130502A	Brown R at Warrinilla	62420	25/07/1974	1630	0.14	0.14	0.1	330						15	7.9			**10**	180	
130502A	Brown R at Warrinilla	64820	4/02/1975	1315	0.1	0.012	0.1	**350**						30	8			**99**	208	
130502A	Brown R at Warrinilla	64819	29/04/1975	1145	NA	0.01	0.1	300							7.7			**85**	173	
130502A	Brown R at Warrinilla	68491	9/04/1976	1210	0.22	0.805	0.1	243						21	7.6			**22**	140	
130502A	Brown R at Warrinilla	69369	22/07/1976	900	4	0.001	0.1	**545**						8	7.6			**17**	296	
130502A	Brown R at Warrinilla	72343	30/03/1977	1220	0.7	1.71	0.1	280						25	**8.3**			**41**	167	1.1
130502A	Brown R at Warrinilla	79175	27/09/1978	1305	0.17	0.416	0.1	275							7.5			**16**	153	3.6
130502A	Brown R at Warrinilla	79176	27/09/1978	1305	0.51	0.409	0.1	260							7.6			**25**	147	2
130502A	Brown R at Warrinilla	90318	3/03/1981	1115	0.02	0.138	0.1	190		12					7.9				109	
130502A	Brown R at Warrinilla	91549	11/08/1981	1140	NA	0.002	0.1	**340**		5		5		18	**8.1**			**10**	176	1
130502A	Brown R at Warrinilla	99542	25/10/1983	1221	1.24	0.002	0.1	**405**		1		5			7.5			**20**	220	
130502A	Brown R at Warrinilla	103228	14/12/1983	1210	1.34	0.064	0.1	255		19		15		31	7.9			**12**	150	1.7
130502A	Brown R at Warrinilla	103409	18/02/1984	1546	1.71	2.32	0.1	195		13		40		27	7.7			**15**	120	2.1
130502A	Brown R at Warrinilla	103410	18/02/1984	1546	0.72	2.38	0.1	190		6		30			7.8			**15**	110	2.3
130502A	Brown R at Warrinilla	104223	23/05/1984	1320	1.18	0.006	0.1	290				10		21	**8.2**			5	150	0.7
130502A	Brown R at Warrinilla	105891	12/09/1984	0	0.56	0.643	0.1	240		10					7.4			5	140	2.7
130502A	Brown R at Warrinilla	107270	16/01/1985	1340	1.26	0.005	0.1	210		15					**8.1**			**34**	120	1.4
130502A	Brown R at Warrinilla	113993	16/03/1986	1023	1.21	0.008	0.1	155	160	6		20			7.6			**30**	100	1.4
130502A	Brown R at Warrinilla	118018	11/12/1986	650	1.37	0.226	0.1	160	145	**80**		70		22	8			**40**	110	0.7
130502A	Brown R at Warrinilla	119006	27/02/1987	1005	1.28	0.001	0.2	140		1		30			**8.5**			**39**	81	0.5
130502A	Brown R at Warrinilla	131219	12/08/1989	1333	1.27	0.212	0.1	195	200	13		10		12	7.4			**22**	110	1.3
130502A	Brown R at Warrinilla	132784	20/11/1989	1245	1.37	0.576	0.1	215	221	**100**					7.8			**5**	130	3.1
130502A	Brown R at Warrinilla	133660	9/03/1990	938	1.76	2.38	0.1	158		**132**		10			7.3			**170**	94	1.7
130502A	Brown R at Warrinilla	137972	26/02/1991	1156	1.2	0.054	0.1	256							7.4			**14**	157	
130502B	Brown R at Lake Brown	984587	27/09/1978	1125	0.515	0.409								20						
130502B	Brown R at Lake Brown	984586	14/12/1983	925	0.42	0.065								23						
130502B	Brown R at Lake Brown	984585	18/02/1984	1300	0.72	2.38								27						
130502B	Brown R at Lake Brown	984584	12/09/1984	1545	0.56	0.643								20						
130502B	Brown R at Lake Brown	112228	18/12/1985	1405	0.95	6.159	0.1	87	70	**100**				20	7			**3910**	49	1.6
130502B	Brown R at Lake Brown	114000	16/03/1986	1023	0.36	0.001	0.1	160		21		30			**8.2**			**30**	95	1
130502B	Brown R at Lake Brown	118042	11/12/1986	650	0.64	0.27	0.1	165		**100**		70			**8.1**			**85**	110	0.5
130502B	Brown R at Lake Brown	131220	12/08/1989	1333	0.64	0.193	0.1	200		10		10			7.4			**18**	110	
130502B	Brown R at Lake Brown	132788	20/11/1989	1245	0.69	0.442	0.1	185		**100**					7.6			**79**	130	2.2
130502B	Brown R at Lake Brown	133664	6/03/1990	635	2.06	41.7	0.1	66		**200**		60			7			**419**	39	0.8
130502B	Brown R at Lake Brown	133663	6/03/1990	1225	1.58	27.3	0.1	75	65	**200**		40			7			**563**	45	0.8
130502B	Brown R at Lake Brown	137969	26/02/1991	832	0.54	0.062	0.1	230		1		5			7.4			8	145	
130502B	Brown R at Lake Brown	984583	26/02/1991	832	0.54	0.062										7.9				
130502B	Brown R at Lake Brown	156680	22/04/1994	1115	NA	0	0.1	247	241	5		15		21.4	7.9	**8.9**		**14**	135	1.4
130502B	Brown R at Lake Brown	171020	11/04/1995	1515	0.21	0	0.1	223	226	25	38.3	20		24.3	7.46	7.9	7.72	**22**	124.7	0.17
130502B	Brown R at Lake Brown	176467	4/12/1995	1105	0.68	0.223	0.2	165.8	166	7	15.6	38		27	7.44	7.61	4.06	**15**	98.83	0.9
130502B	Brown R at Lake Brown	178717	17/03/1996	1100	-0.1	0	0.1	278	275	8.4		22		24.6	7.67	**8.22**	7.7	**31**	151.6	ND
130502B	Brown R at Lake Brown	178691	17/12/1996	825	0.67	0.495	0.1	171	179	**143**	**181**	58		24.9	7.6	7.54	4.37	**92**	110.6	2.27
130502B	Brown R at Lake Brown	194039	29/11/1998	1800	0.72	0.891	0.1	140	138	**620**	**283**	16		25.8	7.29	6.92	4.8	**110**	89.56	1.59
130502B	Brown R at Lake Brown	201126	22/08/2000	1505	0.48	0.011	0.1	165	136	49	5	95		17.9	7.54	**8.2**	10.3	**95**	98.44	0.52
130502B	Brown R at Lake Brown	S004065	22/08/2000	1505	0.48	0.011	0.2		136		5			17.9		**8.2**	10.1			
130502B	Brown R at Lake Brown	201142	13/12/2000	1515	1.58	0.856	0.2	225	200	4	8	25		27	7.75	7.8	6.5	**10**	130	0.9
130502B	Brown R at Lake Brown	207538	6/03/2003	1525	0.78	20101	0.5	165	165	**110**	**157**	15		26.9	7.9	7.5		**80**	110	0.6
130502B	Brown R at Lake Brown	202891	16/12/2004	750	0.59		0.1	166	169	**303**	**201**	26		27.8	7.21	7.1	17.5	**132**	109	1.2
130502B	Brown R at Lake Brown	208530	1/03/2007	1530			0.1		188		**330**			32			10.7			

STATION ID	SAMPLE NO.	Nitrate + nitrite (N soluble)	Ammonia (N soluble)	Kjeldahl Nitrogen	TN	Organic Nitrogen	Total React P (P soluble)	TP	Boron as B	Aluminium (Al)	Copper (Cu)	Flouride (F)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
		Nutirients							Metals				Major Ions								Alkalinity					
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	MTV		0.02		0.5			0.05	0.37	0.055	0.0014	1		<175		<115		1000	250							
1305001	185913				**2.10**			**0.19**	0.1	ND	**0.03**	0.31	ND	24.56	21.1	39.9	307.03	18	0.67	10.1	157.9	124	0.01	0.4	192	86.44
1305009	194127			1.4				**0.26**	0.1	0.05	**0.05**	0.2	ND	14	8.6	9.2	110	8.1	2	4.9	46		ND	ND	56	40.5
1305003	192165					0.68		**0.11**	<0.1	0.05	**<0.05**	<0.1	ND	5.5	8.8	11.5	170	16.5	2	8	97	56	ND	0.2	120	74
1305027	185914				**0.82**			**0.17**	ND	ND	**0.01**	0.14	ND	4.68	4.6	8.9	94.66	10	0.5	2.6	50.79	73	ND	ND	62	35.64
1305027	192163				**0.50**			**0.10**	ND	ND	ND	ND	ND	3.18	4.1	9.7	103.53	10.7	0.56	3.1	58.65	55	ND	0.1	71	39.44
130502A	47666											0.3	ND	4		8	66.3	4		4	38		ND		46	26
130502A	47665											0.3	ND	9		12	143.3	19		5	80		ND		98	68
130502A	49012											0.2	ND	12		15	209.2	28		8	120		ND		146	103
130502A	52187											0.65	ND	12		19	200.7	19		11	114			ND	139	93
130502A	56730											0.17	ND	14		20	250.2	26		14	144				176	123
130502A	61400											0.15		16	13	18	196.6	19		7.5	102		ND	0.9	122	78
130502A	62420											0.26	ND	20	11	17	266.8	26		14.5	146		ND	ND	178	125
130502A	64820											0.16	ND	17.5	6.6	15	293.9	32		16.6	170		ND	1.0	205	148
130502A	64819											0.14	ND	12	5	14	244.1	27		13.5	142		ND	0.5	172	123
130502A	68491											0.2		12	9.2	14	194.7	20		8	108		ND	0.3	131	83
130502A	69369											0.1		21	8.8	19	443.7	63		20	256		ND	0.8	311	240
130502A	72343											0.1		7	4.8	14	224.6	23	5	13	130		ND	1.6	155	111
130502A	79175											0.1		14	11	20	207	18	1	8.1	108			0.2	131	78
130502A	79176											0.1		14	10	20	200.6	17	2	8.2	105			0.3	127	76
130502A	90318											0.2		5	4.5	10	155	13	9	7.9	87			0.4	105	65
130502A	91549											0.1		12	8.4	18	255.8	26	1	13	146			1.3	175	118
130502A	99542								0.03			0.1		12	9.2	14	327.7	41		16	193			0.4	235	168
130502A	103228								0.01			0.2		7.1	5.4	13	206.4	20	2.2	11	120			0.7	145	95
130502A	103409											0.1		10	8.1	12	161.6	15	2.5	6.4	87			0.3	105	64
130502A	103410								0.01			0.1		11	7.9	12	156.5	14	2.5	6.2	83			0.3	100	61
130502A	104223								0.03			0.1		8.8	7.7	15	222.8	24		10	130			1.5	155	101
130502A	105891								0.03			0.2		15	11	14	205	20		6.9	111			0.2	135	78
130502A	107270								0.03			0.2		2.5	5	12	168.2	17		9.1	100			0.9	120	80
130502A	113993								0.02			0.1		6.3	6	10.5	120	10		5.4	66			0.2	80	47
130502A	118018								0.03			0.2		8.1	6.2	14.5	123.3	9.6		5.4	64			0.4	77	46
130502A	119006								0.01	**0.1**	**<0.01**	0.2	ND	9	8.9	9.5	98	12	2	2	47		ND	0.9	55	38
130502A	131219								0.05			0.1		8.6	8.2	13	153.1	16		5.7	82			0.1	100	63
130502A	132784								0.01			0.2		9.4	6.6	14	165.3	14.5	3.4	8.6	87			0.4	105	72
130502A	133660											0.13	ND	5	6.5	7.7	114.5	10	1.9	5.7	62			ND	76	48
130502A	137972								0.06	0.02	**0.06**	0.2	ND	5.9	6.1	13.3	215.7	21.7		12.6	128		ND	0.2	156	105
130502B	984587																									
130502B	984586																									
130502B	984585																									
130502B	984584																									
130502B	112228								0.02			0.1		3	4	4	58.8	6		3	30				37	27
130502B	114000								0.02			0.1		6.2	7	8.1	118.4	11		5.4	66			0.6	79	50
130502B	118042								0.02			0.4		8.9	6	16	130.5	9.9	9.3	5.3	61			0.5	73	47
130502B	131220								0.05			0.1		8.8	8	13	152.1	16		6	82			0.1	100	65
130502B	132788								0.02			0.2		58	6.5	13.5	110.5	13		7.3	8				9	63
130502B	133664											0.11	ND	2.2	3.1	4.4	43.9	2.8	2.3	1.5	21		ND	ND	27	13
130502B	133663											0.11	ND	2.7	3.3	4.8	52.1	3.7	2.3	2.1	26		ND	ND	32	17
130502B	137969								0.06	0.01	**0.05**	0.2	ND	5.5	5.9	12.8	198.3	19.8		11.3	117		ND	0.2	143	95
130502B	984583																									
130502B	156680										**0.06**	0.17		7.1	6.8	14.3	200.2	18.5		10.3	116		0.02	0.7	141	88
130502B	171020			1.2628				**0.12**	ND	ND	**0.02**	0.18	ND	7.67	7.9	13.2	188.57	17.1	ND	9.6	109		0	0.2	133	82.14
130502B	176467			0.685				**0.17**	ND	ND	ND	0.16	ND	3.58	5.2	9.7	129.59	11.9	ND	6.8	75		0	0.1	91	57.65
130502B	178717			1.134				**0.17**	ND	ND	**0.01**	0.22	ND	6.06	5	14.9	224.67	22.2	ND	12.2	134.9		0.01	0.5	164	105.55
130502B	178691			1.1				**0.34**	ND		ND	0.18	ND		6	11.3	141.78	12.2		7.3	78.69		0.01	0.2	96	60.46
130502B	194039				**1.05**			**0.58**	ND	ND	**0.01**	0.18	ND	11.34	6.1	13.6	108.87	7.4	0.73	4.5	52.05		0	0.1	63	36.97
130502B	201126				**1.06**			**0.42**	ND	0.02	ND	ND	ND	7.82	5.2	11.9	125.31	9.3	0.65	6.6	68.43		0.01	0.2	83	50.34
130502B	S004065																									
130502B	201142	<0.002	0.006		**0.61**		0.067	**0.13**	<0.1	0.05	**<0.05**	0.1	ND	5	4	11.5	180	16	2	10.5	110		0	<1	135	84
130502B	207538				**0.62**			**0.30**	<0.1	0.05	**<0.02**	0.1	ND	6	3.9	8.3	130	12.5	2	7.1	74		0	0.4	89	61
130502B	202891				**1.61**			**0.57**	0.06	0.05	**<0.03**	0.2	ND	6.3	7.3	14	131	8.8	1.8	5.1	70		0	0.1	86	43
130502B	208530																									

Notes

MTV	minimum trigger value
BOLD	Greater than MTV
135	Historic Water Quality Data\044 Quality poor.
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Brown-Comet Catchment Water Quality Data

Table C5
Comet Catchment DNRW Water Quality Results - Canarvon Creek
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Hydrological Parameters			Physico-Chemical Parameters												Nutrients								Metals				Major Ions								Alkalinity					
					Stream Water Level	Stream Discharge	Depth	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	Oxygen (Dissolved) FLD	Total Suspended Solids	Total Diss. Solids	Nitrate (NO3)	Nitrate + nitrite (N soluble)	Ammonia (N soluble)	Kjeldahl Nitrogen	TN	Organic Nitrogen	Total React Phosphorus (P soluble)	TP	Boron as B	Aluminium (Al)	Copper (Cu)	Flouride (F)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity as CaCO3	Total Alkalinity as CaCO3 FLD	Hydroxide as OH	Carbonate as CO3	Bicarbonate as HCO3	Hardness as CaCO3
				Units	*m*	*cumsecs*	*m*	*uS/cm*	*uS/cm*	*NTU*	*NTU*	*Hazen units*	*°C*	*°C*	*pH units*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340		50				20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50		0.02		0.5			0.05	0.37	0.055	0.0014	1		<175		<115		1000	250							
1305020	Carnarvon at Ingelara	163095	26/10/1994	1030	NA	0.04	0.2		**393**				27	24.4		**8.5**	9.26				<0.002	0.005			0.3	0.015	0.041																		
1305020	Carnarvon at Ingelara	171719	16/05/1995	1400	1.29	0.063	0.2	335.3	**361**	12.2	15	5		23.5	**8.7**	**8.8**	10.2	**13.0**	211.62	ND	0.0042	**0.022**			0.1462	0.0066	0.0195	ND	ND	**0.01**	0.14	ND	8.87	1.3	18	304	27.1	1.02	22.6	189.6		0.07	5.65	219.6	160.54
1305020	Carnarvon at Ingelara	171899	11/09/1995	1400	1.27	0.044	0.2	**356.2**	250	5.6	6	10	23.3	24.2	**8.6**	**8.6**	11.5	**10.0**	209.33	0.3	0.0036	0.0111			0.2189	0.0045	0.0288	ND	ND	**0.06**	0.15	ND	9.04	2	18.3	311	28.3	0.65	23.4	192.1	180	0.07	5.13	223.69	166.83
1305020	Carnarvon at Ingelara	171364	23/05/1996	900	1.3	0.055	0.2	**381**	**388**	5.4	7	11	13	12.8	**8.3**	**8.2**	9.1	5	227.24	ND	0.0025	0.0088			0.1132	0.0223	0.0485	ND	ND	ND	0.15	ND	10.38	2	17.8	324	29.5	1.58	23.4	198.8	18.8	0.03	2.99	236.33	169.82
1305020	Carnarvon at Ingelara	185768	13/06/1997	850	1.29	0.05	0.2	**375**	**360**	3	14	10	13.4	12.8	**8.2**	**8.5**	8.9	**13.0**	191.89	ND			0.175				0.0337			ND	0.16	ND	8.03	1.64	15.8	309	26.9	0.7	23.5	192	168	0.03	2.19	229.7	163.74
1305020	Carnarvon at Ingelara	207650	31/05/2001	900	NA		0.2	**385**	**340**	2	2	<1	14	10.3	**8.5**	**8.6**	8	**10.0**	220	0.5				0.1			**0.050**	<0.1	0.05	**<0.05**	0.1	ND	9	1.4	16.5	320	28.5	2	23.5	195	172.4	0.1	4.1	230	170
1305020	Carnarvon at Ingelara	207671	10/10/2001	1500	0.28		0.3	**372**	**374**	2.6	2	10		23.1	**8.7**	**8.6**	11.9	2	215.65	ND				0.216			0.0162	0.02	0.01	ND	0.14	ND	9.26	1.4	18.2	312	26.8	0.71	25.3	193.7	158	0.08	6.05	223.75	170.9
1305022	Carnarvon Ck at Gorge	185769	13/06/1997	1200	NA		0.2	320		7		10			**8.5**			**10.0**	160	0.5			<0.1				**0.052**			**<0.05**	0.1	ND	6.7	1.4	12.5	260	23	2	20.5	165		0.1	3.3	190	145
1305022	Carnarvon Ck at Gorge	185769	13/06/1997	1300	NA		0.2		307					13.9																															
130503A	Carnarvon Ck at Wyseby	61612	26/06/1974	1645	-0.11	0.015	0.2	**430**							7.9			**20.0**	233												0.16		12	3.8	17		38		24	206			1.2	249	194
130503A	Carnarvon Ck at Wyseby	77580	14/06/1978	1705	0.01	0.068	0.1	**375**						13	**8.3**				235	0.3											0.2		11	2.6	21	340	35	2.5	22	204			2.8	243	178
130503A	Carnarvon Ck at Wyseby	91548	11/08/1981	1525	-0.01	0.005	0.1	**425**		5		5		18	**8.8**			**10.0**	246	1											0.1	0.1	20	4	19	346	35	5	22	205			9.1	231	178
130503A	Carnarvon Ck at Wyseby	93090	11/11/1981	815	0.13	0.192	0.1	230						25	7.5			**50.0**	140	3											0.2		8	6.7	16	181	13	16	8.1	91			0.2	110	66
130503A	Carnarvon Ck at Wyseby	103659	18/02/1984	847	0.01	0.135	0.1	335		10		20		21	**8.3**			5	200												0.1		8.6	3.6	16	278	29	7.2	16	164			2.4	195	138
130503A	Carnarvon Ck at Wyseby	105890	13/09/1984	1325	0.03	0.065	0.1	**355**		3				18	8.0			5	190														20	3.5	17	272	29	3.2	18	150			1.2	180	147
130503A	Carnarvon Ck at Wyseby	109565	6/07/1985	0	1.15	0.095	0.1	**355**		17		5			**8.4**			**20.0**	210									0.02			0.1		3.8	2.3	19	308	30	2	22	190			3.2	225	166
130503A	Carnarvon Ck at Wyseby	128390	13/01/1989	1345	0.17	0.426	0.1	235	195	**100**				32	**8.3**			**335.0**	140	1.1								0.01			0.1		6	4.4	13.5	185	18.5		10	109			1.6	130	87
130503A	Carnarvon Ck at Wyseby	130207	6/05/1989	1550	0.22	0.625	0.2	290		15		10			**8.8**			**17.0**	190	0.5								<0.01	**0.1**	**0.05**	0.1	ND	14	2.9	16	260	26.5	2	15.5	160		0.1	6.8	180	130
130503A	Carnarvon Ck at Wyseby	131267	12/08/1989	1535	0.1	0.064	0.1	**390**	**390**					14	**8.3**			5	240									0.04			0.2		12	3	18	342	36	3.2	22	206			3	245	181
130503A	Carnarvon Ck at Wyseby	132781	21/11/1989	823	0.18	0.574	0.1	115	113	**100**					7.4			**87.0**	88	1.4											0.2		5.5	3.8	11.5	92	6.4		4.2	47			0.1	57	33
130503A	Carnarvon Ck at Wyseby	134592	26/05/1990	1622	0.27	1.64	0.1	226		**200**		15			8.0			**55.0**	142	0.7											0.13	ND	5.6	3.4	13	184	18.4	3.7	10.9	106		0.02	0.7	127.7	90
130509A	Carnarvon Ck at Rewan	984570	6/07/1985	1645	1.15	0.089			257					16																															
130509A	Carnarvon Ck at Rewan	984569	4/09/1985	1400	1.11	0.023								22																															
130509A	Carnarvon Ck at Rewan	112243	19/12/1985	1110	1.13	0.035	0.1	**415**	**380**	5		5		32	**8.5**			**10.0**	230	0.5								0.02			0.2	0.1	13	3.6	22	328	31	2	21	196			4.7	230	164
130509A	Carnarvon Ck at Rewan	114883	18/06/1986	1440	1.12	0.02	0.1	**370**	**375**	1		5		17	**8.5**			5	220									0.01			0.2	0.1	11	2.3	18	322	30		21	201			4.7	235	161
130509A	Carnarvon Ck at Rewan	119000	26/02/1987	1435	1.1	0.038	0.1	265	**340**			5		32	**8.8**			**20.0**	160	0.5								0.01			0.2	0.1	18.5	4.4	20	227	7	2	19	132			5.2	150	96
130509A	Carnarvon Ck at Rewan	120678	3/06/1987	1115	1.13	0.035	0.1	320		18		5		14	**8.2**			**33.0**	170	0.5								0.01			0.1		10	2.6	19	260	18	3.1	20	155			1.7	185	127
130509A	Carnarvon Ck at Rewan	122164	9/09/1987	1645	1.09	0.023	0.1	**380**	**350**			5		19	**8.3**			5	210												0.2		11	2.5	18	313	32		21	189			2.8	225	166
130509A	Carnarvon Ck at Rewan	126556	21/06/1988	1315	1.05	0.025	0.1	**345**	300	3		5		18	**8.3**			**10.0**	200	0.5								0.01			0.1		10	2	16	298	29	2	21	181			2.8	215	159
130509A	Carnarvon Ck at Rewan	128373	13/01/1989	1300	1.15	0.413	0.2	285	250	**100**		>70		32	**8.4**			**132.0**	170	0.5								<0.1	**0.2**	**<0.01**	0.1	ND	6	4	16	230	24	2	13.5	140		0.1	3	165	115
130509A	Carnarvon Ck at Rewan	130210	6/05/1989	1325	1.12	0.618	0.2	320	330	11		10		21.5	**8.2**			**12.0**	200	1.1								0.2	**0.1**	**0.05**	0.1	ND	9	2.4	15.5	280	28.5	3	19.5	165		ND	1.7	200	150
130509A	Carnarvon Ck at Rewan	131266	12/08/1989	1623	1.05	0.172	0.1	**400**	**400**					14	**8.4**			5	250									0.04			0.1		12	2.3	19	356	36	3.3	24	216			4	255	189
130509A	Carnarvon Ck at Rewan	132800	21/11/1989	723	1	0.071	0.1	**360**	**425**	**51**		10			**8.2**			**42.0**	222									0.01			0.17	ND	19.6	2.6	20	309	29.7	3.7	20	176		0.03	1.9	211.5	156
130509A	Carnarvon Ck at Rewan	133662	7/03/1990	1512	1.07	0.274	0.1	293		13		30			8.0			**10.0**	173												0.16	ND	6.7	3.1	13.7	237	21.3	2.9	14.1	144		0.02	0.9	173.6	111
130509A	Carnarvon Ck at Rewan	134561	27/05/1990	1605	1.15	1.08	0.1	317		27		10			**8.3**			**22.0**	210									0.01			0.14	ND	12.6	2.3	18.4	277	26.9	5.6	18.7	160		0.03	2.2	190.5	144
130509A	Carnarvon Ck at Rewan	984566	9/10/1990	1515	0.95	0.089			252																																				
130509A	Carnarvon Ck at Rewan	137959	25/02/1991	1335	1.01	0.124	0.1	**390**							8.0			4	242									0.05	0.03	**0.03**	0.17	ND	9.5	4	20	348	34.4	2.9	22.6	210		0.02	1.7	252.9	178
130509A	Carnarvon Ck at Rewan	984565	25/02/1991	1335	1.01	0.124										**8.5**																													
130509A	Carnarvon Ck at Rewan	143342	20/07/1991	1250	0.96	0.067	0.1	**389**	**390**	1				15	**8.4**	**8.5**		8	230										0.02	**0.06**	0.15	ND	10	2.7	18.9	333	32.6	2.8	23.4	202		0.04	3.6	238.8	178
130509A	Carnarvon Ck at Rewan	145417	31/03/1992	1500	0.94	0.018	0.1	**377**		2		5		29	**8.3**			5	217									0.02			0.2	ND	17.3	3.8	20.1	309	28.9	2	20.1	180		0.04	2.7	213.8	154
130509A	Carnarvon Ck at Rewan	149600	3/08/1992	1749	0.94	0.041	0.1	**379**	**407**					17.5	**8.2**	**8.8**		4	214												0.15	ND	8.9	1.4	19.6	319	30.2	1.2	22.5	195		0.04	2.8	232.5	167
130509A	Carnarvon Ck at Rewan	151605	18/07/1993	1745	0.96	0.035	0.1	**377**	**378**			5		16.2	**8.3**	**8.5**		3	214												0.14	ND	9.7	2.4	18.3	319	30.2	1.7	22.5	194		0.04	3.4	230.5	167
130509A	Carnarvon Ck at Rewan	156615	29/11/1993	1902	0.96	0.038	0.1	**343**	**347**	6		10		30	**8.4**	**8.6**		9	203	0.2										**0.04**	0.14	ND	8.8	3.7	17.1	291	29.5	1.3	18	176		0.04	3.1	208.4	147
130509A	Carnarvon Ck at Rewan	156681	21/04/1994	1500	1.03	0.05	0.1	**436**	**432**					23.6	**8.4**	**8.8**		7	251											**0.02**	0.13		12.1	3.9	22	367	35.6	1.5	24	223		0.05	4.3	263	187
130509A	Carnarvon Ck at Rewan	984564	12/04/1995	1208	0.965	0.014			**369**					19.3		**8.4**																													
130509A	Carnarvon Ck at Rewan	984563	23/08/1995	1716	0.967	0.007			**382**					20.1		**8.7**																													
130509A	Carnarvon Ck at Rewan	984562	4/12/1995	1747	1.04	0.093			329					31		**8.6**																													
130509A	Carnarvon Ck at Rewan	984561	17/03/1996	1609	0.85	0.012			281					30.5		**8.7**																													
130509A	Carnarvon Ck at Rewan	984849	31/03/1999	1715	0.903	0.046	0.2		**360**		2.2			25.9		**8.5**	8.6																												
130509A	Carnarvon Ck at Rewan	S994007	30/07/1999	1042	0.89	0.06			**350**		3			12.7		**8.3**	10.1																												
130509A	Carnarvon Ck at Rewan	S004066	5/04/2000	926	0.83	0.014			331		3			23		7.8	6.8																												
130509A	Carnarvon Ck at Rewan	S004067	23/08/2000	1120	0.88	0.08			309		2			14.5		**8.6**	9.9																												
130509A	Carnarvon Ck at Rewan	S014012	13/12/2000	1135	0.91	0.238			**352**		3			27.3		**8.2**	8.1																												
130509A	Carnarvon Ck at Rewan	S014033	27/02/2001	1225	0.88	0.113	0.1		**438**		1			32		**8.5**	10.3																												
130509A	Carnarvon Ck at Rewan	S014034	22/05/2001	1100	0.83	0.052	0.1		**400**		2			12.8		**8.6**																													
130509A	Carnarvon Ck at Rewan	S024013	22/06/2002	1025	0.81	0.054			290		2			10.6		**8.6**	10.5																												
130509A	Carnarvon Ck at Rewan	S034039	28/05/2003	1650	0.84	0.038	0.2		**399**		9			14.6		**8.4**	9																												

Notes
MTV minimum trigger value
BOLD Greater than MTV
135 Historic Water Quality Data\044 Quality poor.
NA Not available (Gauge Height < Instrument Threshold)
ND Not detected
E Estimate

Table C6

Comet Catchment DNRW Water Quality Results - Comet River Rolleston

GLNG CSG Surface Water

					Hydrological Parameters			Physico-Chemical Parameters												Nutrients					Metals				
STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Stream Water Level	Stream Discharge	Dist. Below water surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	Oxygen (Dissolved) FLD	Total Suspended Solids	Total Diss. Solids	Nitrate (NO3)	Kjeldahl Nitrogen	Total Nitrogen (TN)	Organic Nitrogen	Total Phosphorus (P)	Boron as B (mg/L)	Aluminium as Al soluble (mg/L)	Copper as Cu soluble mg/L	Bromide as Br (mg/L)	Flouride as F (mg/L)
				Units	*m*	*cumsecs*	*m*	*uS/cm*	*uS/cm*	*NTU*	*NTU*	*Hazen units*	*°C*	*°C*	*pH units*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340		50				20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50		0.5		0.05	0.37	0.055	0.0014		1
1305002	Comet at Rolleston	192164	5/06/1999	800	NA	ND	0.2	195	199	17	26	20	14.7	16.5	7.7	7.8	6.2	**20**	120	1			0.59	**0.082**	<0.1	0.05	**<0.05**		<0.1
1305002	Comet at Rolleston	194128	11/09/1999	740	NA		0.2	150	147	**430**	**538**	28		18	7.3	7.5	3.8	**370**	89	3.6	2			**0.74**	0.1	0.05	**0.05**		0.2
1305002	Comet at Rolleston	205211	29/02/2000	730	NA	2	0.2	150	148		**228**			24.9	7	7.5	3.9			0.81		**1.0419**		**0.3571**	0.04	**0.18**	**0.01**	1	0.24
1305002	Comet at Rolleston	205256	29/02/2000	730																		**0.84**		**0.36**					
1305002	Comet at Rolleston	205256	7/03/2000	645		0.0001	0.2		168		**58**			24.8		7.7	5.3												
1305002	Comet at Rolleston	205285	28/03/2000	700		ND	0.1		**418**		**108**			22.3			5.6					**0.83**		**0.27**					
1305023	Panorama Ck at Rolleston	185767	12/06/1997	1700	NA	ND	0.2	331	321	1.5	6	10	17.2	17.5	7.91	**8.1**	6.7	5.0	170.8	0.4	0.543			0.0397			**0.01**		0.11

Notes

MTV	minimum trigger value
xxx	Greater than MTV
xxx	Historic Water Quality Data\044 Quality poor.
xxx	Greater than MTV and Historic WQ Data
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C6
Comet Catchment DNRW Water Quality Results - Comet River R
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	Major Ions								Alkalinity					
				Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
				mg/L	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
					<175		<115		1000	250							
1305002	Comet at Rolleston	192164	5/06/1999	0	4.8	6.8	11	160	16	2	8.4	95	60	ND	0.3	115	75
1305002	Comet at Rolleston	194128	11/09/1999	0	5.6	5.2	14.5	120	8.8	2	4.8	63	50	ND	0.1	77	41.5
1305002	Comet at Rolleston	205211	29/02/2000		7.9	7	8.6	113	9	4.2	4.7					70	42
1305002	Comet at Rolleston	205256	29/02/2000														
1305002	Comet at Rolleston	205256	7/03/2000														
1305002	Comet at Rolleston	205285	28/03/2000														
1305023	Panorama Ck at Rolleston	185767	12/06/1997	0	5.9	3.86	11.1	273.9	29.4	0.51	18.7	168	149.2	ND	1.0	202.9	150.2

Notes

MTV	minimum trigger value
xxx	Greater than MTV
xxx	Historic Water Quality Data\044 Quality poor.
xxx	Greater than MTV and Historic WQ Data
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C7
Comet Catchment DNRW Water Quality Results - Meteor Creek
GLNG CSG Surface Water

					Hydrological Parameters			Physico-Chemical Parameters									Nutrients	Metals		Major Ions								Alkalinity				
STATION ID	**STATION NAME**	**SAMPLE NO.**	**DATE**	**TIME**	Stream Water Level	Stream Discharge	Dist. Below water surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Colour True	Water Temp FLD	pH	pH FLD	Total Suspended Solids	Total Diss. Solids	Nitrate (NO3)	Boron as B (mg/L)	Flouride as F (mg/L)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
				Units	*m*	*cumsecs*	*m*	*uS/cm*	*uS/cm*	*NTU*	*Hazen units*	*°C*	*pH units*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340		50		20%ile-80%ile	6.5-8.0	6.5-8.0	10	500	50	0.37	1		<175		<115		1000	250						
130508A	Meteor Ck at Springwood	56735	9/03/1973	1200	0.8	0.11	0.1	**490**				29	**8.7**			285			0.2		20		33	421.2	38.4	1	31.6	268		29	268	226
130508A	Meteor Ck at Springwood	57844	5/06/1973	1615	0.67	0.006	0.1	**780**					**8.4**		4	485		0.02	0.18		65	4.2	80.4	664.3	35	27.5	50	355		30	372	293
130508A	Meteor Ck at Springwood	59132	27/09/1973	930	0.64	0.004	0.1	**720**					**8.6**		2	417			0.22	0.5	55	4.6	61	608.3	34		48	340	ND	9	396	282
130508A	Meteor Ck at Springwood	61407	2/04/1974	1540	0.22	0.22	0.1	**640**				29	**8.3**		1	365			0.17		30	3.2	32	516.2	50		40	300	ND	4.8	356	290
130508A	Meteor Ck at Springwood	61614	26/06/1974	1115	0.68	0.05	0.1	**680**				16	**8.1**		**60**	370			0.16		20	2.5	32	559.1	40		51	342	ND	3.4	410	310
130508A	Meteor Ck at Springwood	63102	30/09/1974	1640	0.63	0.051	0.1	**690**				24	**8.2**		**21**	394			0.19	ND	25	3.2	40	604.9	48		48	365		4.5	436	317
130508A	Meteor Ck at Springwood	64850	11/12/1974	1630	0.62	0.06	0.1	**610**				33	**8.3**		**74**	370			0.17	ND	25	4.1	38	530.7	36	6.4	41	315		4	376	259
130508A	Meteor Ck at Springwood	64849	5/02/1975	1030	0.71	0.28	0.1	**630**				27	**8.3**		**76**	394			0.16	ND	25	3.5	30	568.4	47		44	347		4.7	414	299
130508A	Meteor Ck at Springwood	64825	28/04/1975	1700	0.69	0.276	0.1	**630**					**8.5**		**80**	395			0.18	ND	20	2.8	30	565.8	50		44	350		7.8	411	306
130508A	Meteor Ck at Springwood	65709	22/07/1975	1715	0.62	0.079	0.1	**710**					**8.2**		2	414			0.3	ND	22	2.5	40	621.8	44	5	50	380		5	453	316
130508A	Meteor Ck at Springwood	66496	7/10/1975	1740	0.58	0.043	0.2	**715**					**8.07**		**26**	388			0.19		24	4	40		32	1	53	356		3.4	427	299
130508A	Meteor Ck at Springwood	67015	16/12/1975	820	0.58	0.013	0.1	**665**				27	**8.3**		**47**	367			0.63	ND	26	2.4	51	545.4	17		52	330	ND	5.4	391	256
130508A	Meteor Ck at Springwood	68128	31/03/1976	1025	0.6	1.3	0.1	**590**				23	**8.2**		**16**	354			0.4		16	2.4	26	517.3	49		40	317		3.5	380	287
130508A	Meteor Ck at Springwood	69374	23/07/1976	1420	0.46	0.273	0.1	**730**					8			396			0.2		20	2.4	36	587.5	45		46	362	ND	2.9	435	302
130508A	Meteor Ck at Springwood	70384	25/10/1976	1520	0.4	0.092	0.1	**680**				28	**8.4**		**23**	393	1.8		0.3	0.1	26	2.8	41	561.1	34		49	338	ND	6.1	400	287
130508A	Meteor Ck at Springwood	72316	29/03/1977	1353	0.63	1.48	0.1	**500**				26	**8.4**			327	0.8		0.1		20	2.2	24	445.8	45		32	268		4.7	317	244
130508A	Meteor Ck at Springwood	73168	5/07/1977	1445	0.45	0.443	0.1	**600**					**8.1**			351			0.2		18	2.8	30	501.9	34	10	44	300		2.9	360	266
130508A	Meteor Ck at Springwood	74102	5/10/1977	1235	0.31	0.095	0.1	**690**				30	**8.3**		**10**	389	0.5		0.2		24	3	40	573.1	28	10	52	345		5.4	410	284
130508A	Meteor Ck at Springwood	75696	4/01/1978	1040	0.26	0.022	0.1	**675**				31	**8.4**			405	1.5		0.2		31	3.3	50	580.6	22	8	51	344		5.6	408	265
130508A	Meteor Ck at Springwood	76018	15/03/1978	1115	0.35	0.096	0.1	**680**				30	**8.2**			324	1		0.2		24	3	36	455.1	19		46	270		2.9	323	237
130508A	Meteor Ck at Springwood	77583	13/06/1978	1450	0.34	0.084	0.1	**610**				16	**8.4**			378	0.7		0.2		25	2.5	40	545.7	32	5	50	325		5.3	385	286
130508A	Meteor Ck at Springwood	79181	26/09/1978	1200	0.44	0.482	0.1	**600**				22	**8.4**		9	367	0.4		0.1	0.1	18	2.3	30	529.9	47	3.6	39	325		6.4	383	278
130508A	Meteor Ck at Springwood	90324	4/03/1981	1040	0.34	0.096	0.1	**415**		**65**	15		7.8			258			0.1		20	3.8	20	349.8	31	11	23	198		0.9	240	172
130508A	Meteor Ck at Springwood	91763	12/08/1981	1325	0.26	0.04	0.1	**738**		5	5	19	**8.2**		**10**	428	1		0.1		30	2.5	42	644.5	45	11	51	383		4.9	457	322
130508A	Meteor Ck at Springwood	92989	12/11/1981	1310	0.24	0.022	0.1	**510**			5	34	**8.8**		**300**	300	0.4		0.2	0.1	20	3.3	31	167	34	7	32	41		11	28	217
130508A	Meteor Ck at Springwood	95099	17/06/1982	1230	0.15	0.004	0.1	**790**		5		4	**8.2**		9	430	0.4		0.2		35	3	56	642.5	37	16	50	369		4.9	440	298
130508A	Meteor Ck at Springwood	98161	28/09/1982	1450	0.08	0	0.1	**780**		6			**8.3**		9	440	0.9		0.2		44	3.5	63	634.8	33	13	52	353		5.2	420	296
130508A	Meteor Ck at Springwood	99414	20/08/1983	935	0.16	0.207	0.1	**660**				17	**8.5**		**10**	390		0.02	0.2		20	2.5	33	568.7	49	3.7	46	343		4.2	410	312
130508A	Meteor Ck at Springwood	99520	26/10/1983	1435	0.09	0.04	0.1	**700**				27	7.8		**10**	420		0.03	0.2		26	3.8	43	611.7	47	6.3	48	360		2	435	315
130508A	Meteor Ck at Springwood	103172	14/12/1983	1655	0.08	0.044	0.1	**620**		4		29	**8.3**		5	360		0.03	0.2		25	3	34	529.1	39	8	40	316		4.9	375	262
130508A	Meteor Ck at Springwood	103458	19/02/1984	1435	0.81	5.64	0.1	**460**		17	30	27	**8.6**		**20**	270			0.1	0.1	16	24	3.4	372.2	22		35	228		6.6	265	199
130508A	Meteor Ck at Springwood	104305	25/05/1984	1150	0.1	0.032	0.1	**810**			10	17	8		5	480		0.02	0.2		32	2.9	50	710.9	51	17	54	416		3.8	500	350
130508A	Meteor Ck at Springwood	105889	11/09/1984	1735	0.14	0.095	0.1	**620**		5		22	**8.2**		5	360			0.2		35	2.4	33	533.9	40	4.1	45	310		4.2	370	285
130508A	Meteor Ck at Springwood	106797	14/12/1984	1500	0.15	0.113	0.1	**530**			10	23	7.8		5	320		0.02	0.2		23	3.3	29	465	32		36	281		1.5	340	228
130508A	Meteor Ck at Springwood	109489	18/05/1985	1230	0.03	0.006	0.1	**730**		2	5	20	**8.4**		**10**	410	0.5	0.02	0.2		40	2.8	54	608.8	28	11	51	351		6.3	415	280
130508A	Meteor Ck at Springwood	112242	17/12/1985	1045	0.02	0.009	0.1	**495**	**425**	5	10	33	**8.5**		**10**	280	2.9	0.03	0.2	0.1	20	3.6	29	390.1	28	5.7	30	227		5.6	265	193
130508A	Meteor Ck at Springwood	118017	10/12/1986	1030	0.03	0.002	0.1	**455**	**430**	19	50	27	**8.7**		**25**	260	0.7	0.03	0.2	0.1	22.5	3.4	28	364	31	4.5	25.5	210		7.9	240	182
130508A	Meteor Ck at Springwood	119001	25/02/1987	1130	0.01	0.001	0.1	**495**	**520**		5	26	**8.8**		**10**	290	0.5	0.02	0.2	0.1	28	2.5	46	401.3	12	2	35	234		10	265	174
130508A	Meteor Ck at Springwood	122163	10/09/1987	1220	0.02	0.003	0.1	160		**100**			7.4		**180**	99		0.02	0.2		12	4	13	127.3	15	6.3	4	59		0.1	72	54
130508A	Meteor Ck at Springwood	123236	10/12/1987	1217	0.07	0.002	0.1	335	310	**100**		29	**8.2**		**220**	190	0.8	0.02	0.3		16	3.1	24	260.9	22	3	15	146		1.7	175	117

Notes
MTV minimum trigger value
xxx Greater than MTV
xxx Historic Water Quality Data\044 Quality poor.
xxx Greater than MTV and Historic WQ Data
NA Not available (Gauge Height < Instrument Threshold)
ND Not detected
E Estimate

Table C8
Comet Catchment DNRW Water Quality Results - Planet Creek
GLNG CSG Surface Water

					Hydrological Parameters			Physico-Chemical Parameters										Nutrients	Metals				Major Ions								Alkalinity				
STATION ID	STATION NAME	SAMPLE NO	DATE	TIME	Stream Water Level	Stream Discharge	Dist. Below water surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Colour True	Water Temp FLD	pH	pH FLD	Oxygen (Dissolved) FLD	Total Suspended Solids	Total Diss. Solids	Nitrate (NO3)	Boron as B (mg/L)	Aluminium as Al soluble (mg/L)	Copper as Cu soluble mg/L	Flouride as F (mg/L)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
				Units	*m*	*cumsecs*	*m*	*uS/cm*	*uS/cm*	*NTU*	*Hazen units*	*°C*	*pH units*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340		50		20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50	0.37	0.055	0.0014	1		175		115		1000	250						
130507A	Planet Ck_Planet Dns	56714	20/01/1973	1120	0.09	0.002	0.1	**490**					7.7				267					0.15	ND	64		60	373.1	24	0.9	17	170	ND	ND	207	130
130507A	Planet Ck_Planet Dns	56736	7/03/1973	810	0.07	0	0.1	**842**					7.9				343					0.22	ND	70		16	505.1	56	0.9	45	260	ND	ND	317	325
130507A	Planet Ck_Planet Dns	57843	6/06/1973	1600	0.3	0.006	0.1	**910**					**8.1**			**17**	**559**		0.05			0.16	ND	120	4.6	109	743.1	47.5		40	345	ND	ND	421	283
130507A	Planet Ck_Planet Dns	60951	13/12/1973	1300	0.11	0	0.1	**750**					**8.4**				463					0.16	ND	90	5	79	615.8	42.5		37	300	ND	6.1	353	258
130507A	Planet Ck_Planet Dns	61616	25/06/1974	1730	0.12	0.004	0.1	**1000**				16	**8.1**			**10**	**549**					0.17	ND	98	3.3	88	732.3	49		47	370	ND	3.8	443	316
130507A	Planet Ck_Planet Dns	63105	30/09/1974	1410	0.12	0.003	0.1	**925**				28	**8.1**				522					0.21	ND	100	3.2	96	736.2	40		44	375	ND	3.8	449	281
130507A	Planet Ck_Planet Dns	63618	11/12/1974	1400	0.13	0.001	0.1	**1000**					7.9			2	**579**					0.26	ND	155	5.6	**124**	746.1	28		41.2	321	ND	ND	392	239
130507A	Planet Ck_Planet Dns	64854	3/02/1975	1510	0.25	0.05	0.1	165				35	7.5			**17**	93						ND	21	2.5	17	109.3	5		5.8	48	ND	ND	58	36
130507A	Planet Ck_Planet Dns	61412	3/04/1975	1145	0.29	0.12	0.1	150					7.7			5	86						ND	25	2.6	17.5	101.5	3.7		4.7	39	ND	ND	48	29
130507A	Planet Ck_Planet Dns	64827	28/04/1975	1400	0.15	0.003	0.1	**890**					**8.3**			**72**	**531**					0.15	ND	100	4	92	702.9	44		41.6	350	ND	5.1	416	281
130507A	Planet Ck_Planet Dns	65712	22/07/1975	1350	0.14	0.004	0.1	**980**					**8.1**			**11**	**571**					0.2	ND	97	3.3	100	769	50		47	390	ND	3.5	468	318
130507A	Planet Ck_Planet Dns	66499	10/10/1975	1030	0.12	0.003	0.1	**1080**				28	7.9			8	**600**					0.3	ND	110	4.5	105	807.6	45		50	406	ND	2.8	490	318
130507A	Planet Ck_Planet Dns	68496	8/04/1976	830	0.43	0.485	0.1	115				15	6.8				66							18	1.8	13	67.9	2.8		3.3	24	ND		29	21
130507A	Planet Ck_Planet Dns	69375	23/07/1976	1113	0.19	0.005	0.1	**990**				17	7.9			6	**546**					0.1		88	2.4	94	729.6	56		40	370	ND	2.1	447	305
130507A	Planet Ck_Planet Dns	70385	26/10/1976	1725	0.17	0.004	0.1	**840**				28	**8.6**			**25**	492	1.8				0.3	0.1	95	3.2	101	623	20		40	305	ND	9.6	352	215
130507A	Planet Ck_Planet Dns	70386	27/10/1976	810	0.2	0.023	0.1	**820**				21	**8.7**			**30**	472	1.8				0.3	0.1	100	3.6	91	600.7	39		32	281	ND	9.9	323	229
130507A	Planet Ck_Planet Dns	72325	31/03/1977	1130	0.54	1.28	0.1	97				30	7.9			6	54	0.5						18	1.6	13	48.6	1.5		2	10			12	12
130507A	Planet Ck_Planet Dns	72406	27/04/1977	1645	0.31	0.152	0.1	130				24	7.8				73	0.6						21	2.4	16	82.4	3.1		3.2	30	ND	0.1	36	21
130507A	Planet Ck_Planet Dns	75698	6/01/1978	840	0.27	0.067	0.1	170				25	7			**580**	98	5.2				0.2		20	4.2	16	119.6	5	6	5	48			58	33
130507A	Planet Ck_Planet Dns	76019	16/03/1978	1500	0.16	0.006	0.1	**605**				32	7.7				349	2.7				0.1		55	4	53	460.6	31		26	237	ND	0.8	288	184
130507A	Planet Ck_Planet Dns	77584	15/06/1978	1140	0.18	0.005	0.1	**860**				17	**8.1**			7	**550**	0.5				0.2		94	3	92	720.7	48	3.5	44	360		3.5	432	301
130507A	Planet Ck_Planet Dns	79183	26/09/1978	1517	0.27	0.073	0.1	180				26	7.5			**13**	104	0.3						22	2	20	131.3	6.6	1	6.3	60		0.1	73	42
130507A	Planet Ck_Planet Dns	87363	19/09/1980	1215	0.18	0.001	0.1	**910**				28	7.8			**15**	**567**					0.2		62	1.5	82	767.9	57	5	47	423		2.2	511	336
130507A	Planet Ck_Planet Dns	89190	12/12/1980	900	0.19	0.005	0.1	**910**				25	**8.2**				**561**	1				0.2		57	1.8	73	757.2	54	5	49	428		5.2	511	337
130507A	Planet Ck_Planet Dns	91769	10/08/1981	1705	0.12	0.004	0.2	**838**		5	5	19	**8.75**			**10**	489	ND				0.2	ND	99	1.8	98	623	14	8	45	304	0.1	13	344	220
130507A	Planet Ck_Planet Dns	95113	15/06/1982	1430	0.12	0.002	0.1	**920**		1		18	**8.7**			9	**510**	0.4				0.1	0.1	110	2.3	105	640.9	16	4	46	303		12	345	229
130507A	Planet Ck_Planet Dns	98120	27/09/1982	1540	0.09	0	0.1	**940**		6		24	8			**10**	**580**	0.4				0.2		59	3	85	783.5	57	3.3	52	432		3.6	520	356
130507A	Planet Ck_Planet Dns	99418	6/07/1983	900	0.46	0.555	0.1	115			15	14	7.5			**10**	69		0.02			0.1		20	1.6	17	72.8	2.5	2.6	3.3	21			25.5	20
130507A	Planet Ck_Planet Dns	99471	24/10/1983	1610	0.41	0.333	0.1	105		20	70	28	**8.5**			**23**	61	0.5	0.04			0.1	0.1	16	2.2	13	64.2	2.6	2.2	2.5	21		0.4	24.5	17
130507A	Planet Ck_Planet Dns	103289	13/12/1983	1345	0.17	0.015	0.1	**800**		3	10	31	**8.8**			5	470	1.2	0.08			0.2	0.1	86	2.8	94	601.4	14	4	44	304		15	340	216
130507A	Planet Ck_Planet Dns	103730	17/02/1984	1630	0.2	0.002	0.1	**940**		5	10	31	7.9			5	**560**		0.08			0.2		105	3.3	105	752.3	37	8.2	46	369		2.5	445	282
130507A	Planet Ck_Planet Dns	204221	22/05/1984	1640	0.21	0.002	0.1	**1050**			10	22	7.9			5	**570**		0.07			0.2		110	3.6	105	759.1	40	3.5	49	369		2.7	445	302
130507A	Planet Ck_Planet Dns	105887	14/09/1984	1130	0.22	0.004	0.1	**950**		5		23	7.8			5	**540**		0.06			0.2		130	2.3	105	699.7	37	3.3	45	311		1.8	375	278
130507A	Planet Ck_Planet Dns	109516	20/05/1985	940	0.27	0.001	0.1	**1000**		1	5		8			5	**580**		0.08			0.2		110	2.5	105	790.5	40		49.5	399		3.1	480	304
130507A	Planet Ck_Planet Dns	112298	19/12/1985	1725	0.24	0.001	0.1	**900**	850	1		33	**8.3**			**10**	**530**	0.5	0.09			0.2	0.1	65	2.5	83	715.4	46	2	44	393		7	465	296
130507A	Planet Ck_Planet Dns	113991	15/03/1986	840	0.26	0.001	0.1	**700**	700	8	5		**8.6**			**50**	450		0.08			0.2	0.1	54	1.4	75	575.7	19	2.6	44	319		9.3	370	229
130507A	Planet Ck_Planet Dns	114885	18/06/1986	1030	0.32	0.002	0.1	**880**	1000	26	20	18	**8.5**			**50**	**520**	0.5	0.08			0.2	0.1	115	3.2	100	681.2	27	2.5	44	326		8.6	380	249
130507A	Planet Ck_Planet Dns	116718	3/10/1986	1613	0.29	0.002	0.1	**960**	900	26	30	26	**8.6**			**35**	**540**	0.5	0.08			0.2	0.1	125	4.1	110	709.5	36.5	2	40	330		11	380	256
130507A	Planet Ck_Planet Dns	117465	10/12/1986	1310	0.39	0.001	0.1	**670**	625	9	40	34	**8.2**			**10**	380	1.2	0.06			0.1		53	2.6	58	528.8	37.5	2	30.5	285		3.8	340	219
130507A	Planet Ck_Planet Dns	122159	8/09/1987	1220	0.41	0.002	0.1	**990**	810	1	15	19	**8.3**			5	**590**		0.07			0.2		125	2.3	**115**	792.3	33		50	388		6.7	460	288
130507A	Planet Ck_Planet Dns	126559	19/06/1988	1420	0.5	0.002	0.1	**1050**	940	2	10	19	**8.2**			**11**	**620**	1.6	0.07			0.2		130	3.2	**115**	827.7	45	6.9	50	395		5.7	470	318
130507A	Planet Ck_Planet Dns	128387	12/01/1989	1750	0.58	0.005	0.1	**750**	720	4	40	31	7.9			**20**	430		0.06			0.1		83	3.7	69	576.4	43.5		30	286		1.9	345	232
130507A	Planet Ck_Planet Dns	130205	7/05/1989	835	0.66	0.033	0.2	240		12	60		**8.3**			**22**	140	0.5	<0.01	**0.1**	**0.09**	<0.1	ND	29	3.6	24	190	13	2	9.4	94	0.1	2	110	71
130507A	Planet Ck_Planet Dns	131265	13/08/1989	1235	0.5	0.004	0.1	**820**	840			17	**8.2**			5	490		0.08			0.1		89	2.9	80	689.8	48		40	356		4.7	425	285
130507A	Planet Ck_Planet Dns	132782	21/11/1989	1042	0.59	0.009	0.1	295	342	2			**8.1**			5	180	0.9	0.02			0.1		26	2.9	27	234	18.5	3.5	14	116		1	140	104
130507A	Planet Ck_Planet Dns	134535	29/05/1990	1215	0.81	0.647	0.1	89		22	70		7.1				50	0.4	0.03				ND	13.8	1.6	11.1	49.9	2.7		2.5	14		ND	17.7	17
130507A	Planet Ck_Planet Dns	137975	24/02/1991	1655	0.78	0.72	0.1	94		2	40		6.8			9	54		0.08	**0.22**	**0.02**	0.01		15.5	2.4	12.4	57	2.3		2.6	17	ND	ND	21.8	16
130507A	Planet Ck_Planet Dns	143345	20/07/1991	1527	0.54	0.002	0.1	**942**	970	1	5	21	**8.4**			**15**	**563**		0.07		**0.11**	0.18	ND	101.9	3.9	101.2	759.2	46.6	3	44.7	381	0.05	7.8	449.8	300
130507A	Planet Ck_Planet Dns	145499	4/08/1992	1754	0.6	0.002	0.1	**1080**	1120		10	19	**8.3**	**8.3**		5	**605**	0.2			**0.02**	0.17	ND	111.4	1.9	103.4	820.6	50.4	1.5	53.8	414	0.04	7.7	489.9	346
130507A	Planet Ck_Planet Dns	149658	21/03/1993	825	0.58	0	0.1	**986**	985	6	10	26	**8.4**	**8.4**		**16**	**609**	1.4	0.1			0.2	ND	63.9	4	88.1	831.3	55.1	1	54.2	470	0.05	10	553.3	360

Notes

MTV	minimum trigger value
BOLD	Greater than MTV
123	Historic Water Quality Data\044 Quality poor.
BOLD	Greater than MTV and Historic WQ Data
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C9
Comet Catchment DNRW Water Quality Results - Comet River Downstream Rolleston
GLNG CSG Surface Water

STATION ID	STATION NAME	DATE	TIME	Hydrological Parameters			Physico-Chemical Parameters												Nutrients							Metals				Major Ions								Alkalinity					
				Stream Water Level	Stream Discharge	Dist. Below water surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	DO FLD	Total Suspended Solids	Total Diss. Solids	Nitrate (NO3)	Nitrate + nitrite (N soluble)	Ammonia (N soluble)	Kjeldahl Nitrogen	Organic Nitrogen	Total React Phosphorus (P soluble)	Total Phosphorus (P)	Boron as B (mg/L)	Aluminium as Al soluble (mg/L)	Copper as Cu soluble mg/L	Flouride as F (mg/L)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
			Units	m	cumsecs	m	uS/cm	uS/cm	NTU	NTU	Hazen units	°C	°C	pH units	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
			MTV				340		50				20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50		0.02				0.05	0.37	0.055	0.0014	1		175		115		1000	250							
1305004	Comet at Springsure Rd	3/06/1999	1315	NA	0	0.2	480	458	15	21	17	23.9	17.4	8.25	8.2	8.1	20	270	0.8				0.41		0.11	<0.1	0.05	<0.05	<0.1	ND	22.5	6	27	390	38	2.3	24.5	220	176	ND	2.7	265	195
130506A	Comet River AMTD 124.2km	30/08/1972	1820	-0.1	0	0.1	500							7.9				295											0.04	ND	25		35	448	42		29	260			ND	317	224
130506A	Comet River AMTD 124.2km	7/03/1973	1845	1.43	1.698	0.1	270						27	7.9				157											0.17	ND	14		21	241.9	25.6	1	12.1	138			ND	168	114
130506A	Comet River AMTD 124.2km	7/06/1973	2359	0.33	0	0.1	340							8.3			7	187								0.05			0.16	ND	16	4.5	12	269.9	32		17.6	169			19	168	152
130506A	Comet River AMTD 124.2km	22/09/1973	1710	0.91	0.104	0.1	1030						23	8.1				602											0.26	0.1	140	6.5	115	781.7	45		45	355		ND	3.2	426	298
130506A	Comet River AMTD 124.2km	31/03/1974	1625	1.53	0.123	0.1	370						27	7.9			30	218											0.14	ND	20	4.2	18	299.3	28		20	172		ND	1	208	152
130506A	Comet River AMTD 124.2km	27/06/1974	1435	1.27	0.366	0.1	410						16	8.3			10	232											0.15	ND	12	2.8	18	325.3	34		24	194		ND	2.3	232	184
130506A	Comet River AMTD 124.2km	2/10/1974	1100	1.13	0.007	0.1	330						22	8			8	187											0.17	ND	13	2.8	18	278.7	26		17.7	165		ND	ND	201	138
130506A	Comet River AMTD 124.2km	12/12/1974	1630	1.07	0	0.1	320						33	8			82	184											0.15	ND	13	4.6	17	255.4	22.5		16.2	150		ND	0.9	181	123
130506A	Comet River AMTD 124.2km	5/02/1975	1515	1.33	0.886								27																														
130506A	Comet River AMTD 124.2km	21/02/1975	1545	1.22	0.521	0.1	470						28.5	7.9			143	275											0.27	ND	52	2.8	52	361.3	28	9.7	16.5	165		ND	1	199	138
130506A	Comet River AMTD 124.2km	9/10/1975	1645	0.84	0	0.1	351						23	7.7			11	175											0.1	ND	10	3.8	18	272.9	21		20	164		ND	N	200	135
130506A	Comet River AMTD 124.2km	5/12/1975	2359	1.33	0.886	0.1	540							8.2			82	319											0.15	ND	25	5.3	25	456.2	45		29	270		ND	2.7	324	232
130506A	Comet River AMTD 124.2km	17/12/1975	1405	0.57	0	0.1	355						32	7.7			80	181											0.42	ND	12	4.4	22	278.8	17		21	166		ND	N	202	129
130506A	Comet River AMTD 124.2km	8/04/1976	1400	1.88	4.456								22																														
130506A	Comet River AMTD 124.2km	22/07/1976	1600	1.21	0.657	0.1	460						13	8.1			2	249											0.1		14	2.4	23	357.3	34		25	214		ND	1.8	257	188
130506A	Comet River AMTD 124.2km	18/11/1976	840	1.55	2.602	0.1	305						25	8.6			103	184	0.6										0.1	0.1	10	3.1	15	248.6	25	2	14	150		ND	3.7	175	120
130506A	Comet River AMTD 124.2km	24/04/1977	1335	1.69	2.88	0.1	390							8.3				232	0.1										0.1		12	2.6	19	328.6	32	5	22	196		ND	2.8	233	171
130506A	Comet River AMTD 124.2km	27/04/1977	1335	1.69	2.883								20																														
130506A	Comet River AMTD 124.2km	6/10/1977	1500	0.98	0.158	0.1	390						26	8.6			5	233											0.2	0.1	12	2.4	19	324.2	30	5	23	195			5.5	227	170
130506A	Comet River AMTD 124.2km	16/03/1978	1255	1.03	0.231	0.1	465						28	7.9				272	0.8										0.1		16	4	23	385.1	37	5	25	226			1.2	273	195
130506A	Comet River AMTD 124.2km	15/06/1978	925	1.05	0.23	0.1	310						12	8.1				193	0.7										0.2		9	2.4	16	275.7	29	3	19	162			1.4	195	151
130506A	Comet River AMTD 124.2km	28/09/1978	1010	1.47	2.154								19																														
130506A	Comet River AMTD 124.2km	6/07/1981	1512	1.28	0.605								16																														
130506A	Comet River AMTD 124.2km	13/08/1981	1020	1.09	0.105	0.1	425		10		5		14	8.5			10	250											0.1	0.1	10	3.9	20	353.6	33	25	23	199			4.5	234	177
130506A	Comet River AMTD 124.2km	12/11/1981	935	1.29	0.876	0.1	185		100				26	8			200	110	4.1										0.1		6.7	2.8	9.9	141.8	14	8.9	6.8	73			0.5	88	63
130506A	Comet River AMTD 124.2km	27/10/1983	1210	0.8	0.072	0.1	230		30		5		26	7.5			10	120								0.02			0.1		16	3.8	14	163.2	15		9	86			0.2	105	75
130506A	Comet River AMTD 124.2km	13/12/1983	1620	1.15	0.747	0.1	240		100					7.8			30	140	1.3							0.03			0.1		11	6.3	13	187.1	17	3	9.9	103			0.4	125	83
130506A	Comet River AMTD 124.2km	24/05/1984	1600	0.86	0.07	0.1	455				10		20	8.4			5	240											0.1	0.1	14	4.1	21	356.3	34	4.9	24	212			4.1	250	184
130506A	Comet River AMTD 124.2km	11/09/1984	1330	0.95	0.246	0.1	305		100				23	7.6			25	170								0.02					13	6.8	17	246.3	22	4.1	13	140			0.4	170	108
130506A	Comet River AMTD 124.2km	19/12/1984	1030	1.62	2.52	0.1	195		100				29	7.4			600	130								0.03					6.1	5.5	10	161.1	15		8.9	95			0.2	115	74
130506A	Comet River AMTD 124.2km	17/12/1985	855	0.74	0.74	0.1	190	170	100		70		26	7.6			430	100	0.5							0.03			0.2		5	4.3	10	138.6	13	2	7	79			0.2	96	61
130506A	Comet River AMTD 124.2km	15/03/1986	1420	0.65	0.032	0.1	205	190	35		50			7.6			55	130	1.5							0.04			0.2		13	8	9.5	166.9	17		7.5	91			0.2	110	73
130506A	Comet River AMTD 124.2km	11/12/1986	1630	1.33	1.499	0.1	160	130	100				28	7.5			275	110	1.9							0.04			0.1		9.1	8	10	117.8	12		5	58			0.1	70	51
130506A	Comet River AMTD 124.2km	27/02/1987	1415	0.61	0.006	0.1	200	180	91		70		35	8			89	120	0.5							0.04			0.2		10	8.1	9.8	153.2	15	2	6.9	83			0.6	100	66
130506A	Comet River AMTD 124.2km	11/08/1989	1755	1.17	0.396	0.1	305	310	4		5		13	7.9			5	180								0.03			0.1		9	3.4	15	250.5	26	5.2	16	145			0.8	175	131
130506A	Comet River AMTD 124.2km	21/11/1989	1345	1.03	0.159	0.1	205	209	100					7.8			81	120	1.4										0.2		4.9	3.7	9.9	156.9	15.5	6.7	9	87			0.4	105	76
130506A	Comet River AMTD 124.2km	11/10/1990	1125	0.83	0.023								28		7.7																												
130506A	Comet River AMTD 124.2km	27/02/1991	1305	1.35	1.53										7.9																												
130506A	Comet River AMTD 124.2km	20/07/1991	1825	0.86	0.025	0.1	370	370	2					8.1			11	207								0.02	0.05	0.17	0.15	ND	9.9	4	18.8	312.3	30.8	3.8	21	185		ND	1.6	222.2	163
130506A	Comet River AMTD 124.2km	30/11/1993	1430	1.16	0.101	0.1	169	169	200		15		33.3	7.9	8.2		301	102	1.1									0.03	0.13	ND	4.6	3.9	8	133.8	13.4	1.5	7.7	76		ND	0.4	92.8	65
130506A	Comet River AMTD 124.2km	8/02/1995	1600	0.78	0	0.2	197.2		25		40			8.72			45	111.01	ND	ND	0.0042		0.5159	0.02	0.0946	ND	ND	0.01	0.13	ND	6.85	4.6	12.3	148.82	11.5	2.13	9.2	86.3		0.09	2.86	99.16	66.52
130506A	Comet River AMTD 124.2km	8/03/1995	1209	1.05	0	0.2	212.2	205	160		50			7.35			83	129.83	3.6	0.0081	0.0448		1.6062	0.1054	0.3159	ND	0.02	0.06	0.14	ND	7.5	6.5	11	170.66	16.4	2.4	9.2	93.5		ND	0.14	113.77	78.75
130506A	Comet River AMTD 124.2km	17/05/1995	900	NA	0	0.2	230	251	18	45	10		20.6	7.2	8.6	6.7	30	130	5.5	0.006	0.041		1.5	<0.002	0.1	<0.1	0.05	<0.05	0.2	ND	6.8	5.6	12	200	20.5	2	11.5	115		ND	0.1	140	98
130506A	Comet River AMTD 124.2km	1/11/1995	1640	1.48	0.542	0.2	112.3	114	453	1192	30		27.7	7.05	6.47		498	72.62	1.11	0.0457	0.0814		1.6576	0.11	0.6914	ND	0.06	0.06	0.15	ND	6.21	4.6	9.3	90.73	6.4	2.35	3.3	47		ND	0.03	57.27	29.54
130506A	Comet River AMTD 124.2km	5/12/1995	1230	1.31	0.65	0.2	174.5	178	486	704	34		30.1	7.34	7.7	6.13	333	107.36	1.53	0.116	0.0169		1.5381	0.162	0.7752	ND	0.01	0.05	0.17	ND	7.02	7.1	9.2	137.32	14.1	0.97	6.7	74.3		ND	0.11	90.41	62.73
130506A	Comet River AMTD 124.2km	7/01/1996	1245	2.21	6.48	0.2		111		1026			27.8		6.74	6.26																											
130506A	Comet River AMTD 124.2km	7/01/1996	1745	2.21		0.2	145		807		35			7.26			470	69.69	1.06	0.0698	0.0596		1.6314	0.0842	0.7576	ND	0.09	0.05	0.12	ND	4.74	4.6	7.6	83.68	8.8	1.28	4.3	42		ND	0.05	51.12	39.64
130506A	Comet River AMTD 124.2km	2/02/1996	835	1.61	3.592	0.2	230	229	57.1	70.8	38		28.6	7.38	7.59	5.88	58	136.02	3.69	0.475	0.0249		1.1511	0.0742	0.1558	ND	0.01	0.01	0.14	ND	7.13	7.4	10.6	180.55	18.6	1.47	9.7	100		ND	0.17	121.65	86.29
130506A	Comet River AMTD 124.2km	5/03/1996	1144	0.97	0	0.2	325	321	2	20.2	20		26.1	7.95	8.61	9.75	20	180	0.5	0.012	0.011		1.4	0.007	0.098	<0.1	0.05	<0.05	0.2	ND	10	8.2	14	270	29.5	2	14.5	155	133.6	ND	1	185	135
130506A	Comet River AMTD 124.2km	3/04/1996	920	0.73	0	0.15	374	372	12.5	28.3	18		21.5	7.91	8.88	7.85	20	200.9	2.27	0.0315	0.0073		1.1827	0	0.0877	ND	ND	0.02	0.2	ND	11.06	8.2	16.5	311.96	33.8	ND	18.4	182.5		ND	1.05	220.46	159.99
130506A	Comet River AMTD 124.2km	9/05/1996	1020	1.46	0.41	0.1	122	121	485		11			7.07			117	81.81	2.1	0.339	0.0468		1.2102	0.13	0.368	ND	ND	0.03	0.13	ND	9	5.6	9.8	95.23	8.1	3.1	4	43.8		ND	0.03	53.37	36.66
130506A	Comet River AMTD 124.2km	22/05/1996	1400	1.17	0.08	0.2	147	145	198	193	60	24.3	19.4	7.3	7.7	9	92	110.42	2.01	0.0748	0.0111		1.0279	0.0995	0.2657	ND	ND	ND	0.14	ND	20.01	6.1	11.5	133.81	10.9	3.41	5.3	61.1	56	ND	0.08	74.36	48.99
130506A	Comet River AMTD 124.2km	5/06/1996	1120	1.01	0.066	0.1	162	159	128	118	10		17.3	7.41	7.15	7.55	49	105.23	1.8	0.0244	0.0187		0.7913	0.0742	0.2005	ND	ND	0.01	0.11	ND	11.49	6.5	11.5	131.65	11.8	2.72	5.9	65.5		ND	0.11	79.71	53.7
130506A	Comet River AMTD 124.2km	4/07/1996	1141	0.74	0.038	0.2	176	178	92	85	8		13.7	7.45	7.78	8.87	13	106.91	0.3	0.0116	0.0161		0.8489	0.0493	0.1515	ND	0.01	0.07	0.12	ND	8.8	5.9	11.9	139.58	12.4	1.9	6.9	75.0	81.6	ND	0.13	91.22	59.31
130506A	Comet River AMTD 124.2km	13/08/1996	830	0.37	0	0.1	187	191	52	66.7	37		10.9	7.72	7.95	9.85	10	116.04	ND	0.0163	0.0177		0.7793	0.0318	0.0879	ND	0.01	0.03	0.14	ND	14.6	6.1	12.9	156.4	14.3	2.5	7.7	80.7		ND	0.27	97.88	67.34
130506A	Comet River AMTD 124.2km	3/02/1997	1015	5	155.341	4.5		100												0.004	0.0161		17.8609	0.0445	0.97																		
130506A	Comet River AMTD 124.2km	3/02/1997	1315	5.54	155.453	5.04		100												0.0019	0.0099		9.6211	0.052	0.514																		
130506A	Comet River AMTD 124.2km	3/02/1997	1615	5.55	155.565	5.05		100														11.882			0.5191																		
130506A	Comet River AMTD 124.2km	4/02/1997	824	8.42	156.165	0.2	101	95	2340		17			7.05			2344	72.07	1.7	0.144	0.0125		4.0075	0.108	2.4338	ND	ND	ND	0.15	ND	4	3	4.8	84.38	9.2	ND	5.2	46.2		ND	0.03	56.3	44.34
130506A	Comet River AMTD 124.2km	4/02/1997	930	8.508	156.206			95					23.5		7.7																												
130506A	Comet River AMTD 124.2km	4/02/1997	1422	8.605	167.11			108					23.9																														
130506A	Comet River AMTD 124.2km	4/02/1997	1521	8.61	166.6	5.44	119	108	1200	3180							2040																		17		8.4						77
130506A	Comet River AMTD 124.2km	4/02/1997	1527	8.61	166.6	1.36	125	108	1450	3160							1950																		14		7.1						64
130506A	Comet River AMTD 124.2km	4/02/1997	1537	8.61	166.6	6.32	118	108	2500	3120							1950																		15		7.5						68
130506A	Comet River AMTD 124.2km	4/02/1997	1540	8.61	166.6	1.58	110	108	2500	3060							2350																		15		7.3						67
130506A	Comet River AMTD 124.2km	4/02/1997	1600	8.61	166.6	0.5	109	108	3110	2910	21			7.08			2324	75.96	2	0.189	0.0219		2.2791	0.129	1.2699	ND	ND	0.01	0.14	ND	4	3.8	6.1	91.03	9.2	0.7	5.1	49.2		ND	0.04	59.95	43.92
130506A	Comet River AMTD 124.2km	4/02/1997	1603	8.61	166.6	1.58	114	108	2350	2820							2200					3.288			1.734										13		6.8						60
130506A	Comet River AMTD 124.2km	4/02/1997	1606	8.61	166.6	3.16	111	108	2400	2800							2040					3.536			2.0566										14		6.9						63
130506A	Comet River AMTD 124.2km	4/02/1997	1609	8.61	166.6	4.74	115	108	1650	3090							2050					2.566			2.1877										14		6.9						63
130506A	Comet River AMTD 124.2km	4/02/1997	1613	8.61	166.6	6.32	114	108	2000	2900							2250					3.88			1.0372										16		7.9						72
130506A	Comet River AMTD 124.2km	4/02/1997	1617	8.61	166.6	7.75		108		2830												2.647			1.3767																		
130506A	Comet River AMTD 124.2km	4/02/1997	1626	8.61	166.6	1.53	111	108	2500	3000							2200																		16		7.9						72
130506A	Comet River AMTD 124.2km	4/02/1997	1630	8.61	166.6	6.12	127	108	1000	2630							1100																		14		7.2						64
130506A	Comet River AMTD 124.2km	4/02/1997	1637	8.61	166.6	1.16	113	108	2450	2830							1950																		7		6.8						45
130506A	Comet River AMTD 124.2km	4/02/1997	1639	8.61	166.6	4.64	124	108	2350	2870							1750																		15		7.6						69
130506A	Comet River AMTD 124.2km	5/02/1997	1313	7.36	97.7	5.28	109	110	1200	1140							930																		13		6.5						59
130506A	Comet River AMTD 124.2km	5/02/1997	1321	7.36	97.7	1.32	112	110	930	1200							770																		12		5.8						54
130506A	Comet River AMTD 124.2km	5/02/1997	1325	7.36	97.7	5.5	110	110	840	1140							790																		12		5.6						53
130506A	Comet River AMTD 124.2km	5/02/1997	1328	7.36	97.7	1.36	110	110	1120	1160							890																		12		5.7						53
130506A	Comet River AMTD 124.2km	5/02/1997	1342	7.36	97.691	0.5	109	110	1320	1130	22			7.13			860	76.49	1.1	0.0657	0.0232		1.2608	0.153	0.8795	ND	0.01	0.01	0.14	ND	5.4	4.6	6.6	90.06	8.6	1.5	4.7	47.1		ND	0.04	57.38	40.78
130506A	Comet River AMTD 124.2km	5/02/1997	1349	7.36	97.686	1.34	110	110	1070	1150							880					1.581			1.1										14		6.7						63
130506A	Comet River AMTD 124.2km	5/02/1997	1352	7.36	97.684	2.68	110	110	950	1150							740					1.609			1										13		6.1						58
130506A	Comet River AMTD 124.2km	5/02/1997	1354	7.36	97.683	4.02	111	110	870	1160							850					1.995			0.8589										13		6.3						58
130506A	Comet River AMTD 124.2km	5/02/1997	1356	7.36	97.681	5.36	110	110	1100	1150							890					1.729			1.03										13		6.5						59
130506A	Comet River AMTD 124.2km	5/02/1997	1359	7.36	97.679	6.2		110		1140												1.751			1.04																		
130506A	Comet River AMTD 124.2km	5/02/1997	1416	7.36	97.668	1.26	111	110	820	1130							720																		12		6.2						55
130506A	Comet River AMTD 124.2km	5/02/1997	1417	7.36	97.667	5.04	111	110	960	1130							870																		13		6.5						59
130506A	Comet River AMTD 124.2km	5/02/1997	1421	7.36	97.665	1	109	110	680	1160							720																		13		6.5						59
130506A	Comet River AMTD 124.2km	5/02/1997	1422	7.36	97.664	4	112	110	510	1130							560																		12		6.1						55
130506A	Comet River AMTD 124.2km	5/02/1997	1428	7.182	97.66			110					24.9		7.1																												
130506A	Comet River AMTD 124.2km	5/02/1997	2025	6.07	78.543	0.2	114	127	1060		22			7.22			764	80.72	1	0.0694	0.0116		1.2034	0.15	0.6896	ND	0.01	0.01	0.11	ND	4.3	4.4	6.3	96.75	9.4	1.4	5	53.2		ND	0.06	64.79	44.01
130506A	Comet River AMTD 124.2km	6/02/1997	606	4.1	47.431	0.2	128		917		15			7.31			674	87.85	0.7	0.1009	0.0112		1.4908	0.156	0.814	ND	ND	0.01	0.12	ND	5.7	4.4	6.8	105.37	10.5	1.5	5.7	57.4		ND	0.07	69.87	49.64
130506A	Comet River AMTD 124.2km	6/02/1997	1510	3.25	18.3	0.2	136	140	750		9		26.5	7.4	7.2		586	93.99	0.7	0.11	0.0185		1.4555	0.162	0.8675	ND	ND	0.01	0.12	ND	6.8	4.4	7.1	113.71	11.4	1.6	6.3	61.8		ND	0.1	75.18	54.35
130506A	Comet River AMTD 124.2km	8/02/1997	905	2.56		0.2	139		606		18			7.43			286	93.6	0.6	0.121	0.0388		1.3062	0.164	0.753	ND	ND	0.01	0.13	ND	6.5	5.8	8.2	114.3	10.7	1.8	5.9	61.3		ND	0.11	74.56	50.96
130506A	Comet River AMTD 124.2km	8/02/1997	940	2.56	8.775	0.2		146					25.8		7.74																												
130506A	Comet River AMTD 124.2km	25/02/1997	1510	1.618	1.548			206					27		7.5																												
130506A	Comet River AMTD 124.2km	1/04/1999	1300	1.23	0.206	0.2		378		15.1			24.9		7.9	6.9																											
130506A	Comet River AMTD 124.2km	3/06/1999	1650	0.98	0	0.2	345	378	10.3	15	11	23.4	18.6	8.2	8.2	7.7	18	223.38	0.74						0.0979	ND	0.01	ND	ND	ND	8.07	4.6	20.3	328.66	31.2	3.26	21.9	195	180	ND	2.12	236.45	167.89
130506A	Comet River AMTD 124.2km	10/09/1999	905	0.65	0	0.2	323.31	335	20.2	21	12		18.3	7.94	8.2	8.5	23	190.72	1.44						0.0891	ND	ND	ND	0.16	ND	8.46	4.1	19.6	289.95	24.5	4.74	19.7	170.75	90	ND	1	206.24	142.13
130506A	Comet River AMTD 124.2km	28/03/2000	700	NA	0	0.1																																					
130506A	Comet River AMTD 124.2km	4/04/2000	1155	1.04	0.001	0.2		271		7			25.2		8.3	9.4																											
130506A	Comet River AMTD 124.2km	11/08/2000	1225	1.37	1.536	0.2		152		334			17.2		7.9	8.7																											
130506A	Comet River AMTD 124.2km	21/05/2001	1536	1	0.031	0.2		386		1			15.7		8.3																												
130506A	Comet River AMTD 124.2km	21/06/2002	1020	1.04	0.24	0.2		118					13.2		7.9	8.7																											
130506A	Comet River AMTD 124.2km	22/04/2003	1434	0.95	0.153			178		109			22		7.5	7.1																											

Notes
MTV minimum trigger value
BOLD Greater than MTV
123 Historic Water Quality Data\044 Quality poor.
BOLD Greater than MTV and Historic WQ Data
NA Not available (Gauge Height < Instrument Threshold)
ND Not detected
E Estimate

Table C10
Comet Catchment DNRW Water Quality Results -Humboldt and Rockland Creeks
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Hydrological Parameters			Physico-Chemical Parameters								Nutrients		
					Stream Water Level	Stream Discharge	Dist. Below water surface	Conductivity @ 25C	Turbidity	Turbidity FLD	Colour True	Water Temp FLD	pH	Total Suspended Solids	Total Diss. Solids	Nitrate (NO3)	Ammonia (N soluble)	Total Phosphorus (P)
				Units	*m*	*cumsecs*	*m*	*uS/cm*	*NTU*	*NTU*	*Hazen units*	*°C*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340	50	50		20%ile-80%ile	6.5-8.0	10	500	50	0.02	0.05
1305025	Rockland_Humboldt Rd	185787	23/06/1997	1640	NA	0	0.2	167	**1238**	**1280**	14	18.7	6.88	**229**	105.01	4.12	**1.11**	**0.39**
130505A	Humboldt Ck_Sunlight	56711	19/01/1973	1450	0.38	0.047	0.1	150					7.7		81			
130505A	Humboldt Ck_Sunlight	61406	31/03/1974	1100	0.27	0.001	0.1	335					7.4	4	204			
130505A	Humboldt Ck_Sunlight	63101	30/09/1974	1200	NA	0	0.1	330				20	6.9	**96**	192			
130505A	Humboldt Ck_Sunlight	68599	6/05/1976	1245	0.32	0.006	0.1	260				21	7.3	**17**	159			
130505A	Humboldt Ck_Sunlight	70383	27/10/1976	1045	0.33	0.005	0.1	130				28	7.2	**360**	114	5.3		
130505A	Humboldt Ck_Sunlight	90509	1/06/1981	1645	0.62	0.482	0.1	48	**70**		70	19	7.7	**10**	45	1		

STATION ID	Metals				Major Ions								Alkalinity					
	Boron as B	Aluminium (Al)	Copper (Cu)	Flouride (F)	Hydrogen (H)	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
MTV	0.37	0.055	0.0014	1		175		115		1000	400							
1305025	ND	ND	**0.01**	0.17	ND	20.59	4.8	20.1	121.03	6.7	8.55	4.2	42.47	48	0	0.02	51.77	33.99
130505A				0.2	ND	18		16	114.5	8		6.3	54		0	0	66	46
130505A				0.12	ND	65	5	38	229.9	16		8.8	80		0	0	97	76
130505A						90	4.4	40	192	20	12	7.3	15		0	0	18.3	80
130505A				0.2		36	4.3	30	176.3	11		6.7	72		0	0.1	88	55
130505A				0.8		20	5.3	19	113.3	3.5	20	5.4	28				34	31
130505A				0.1		10	1.8	5.6	46.9	1.5	6	1.9	16				19	12

Notes

MTV	minimum trigger value
BOLD	Greater than MTV
123	Historic Water Quality Data\044 Quality poor.
BOLD	Greater than MTV and Historic WQ Data
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C12
Comet Catchment DNRW Water Quality Results - Comet River at Comet Weir
GLNG CSG Surface Water

					Hydrological Parameters					Physico-Chemical Parameters													Nutrients											Metals							Major Ions									Alkalinity				
STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Stream Water Level	Stream Discharge	Total Stream Width	Distance from left bank	Dist. below Water Surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Transparency (secchi depth) FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	DO FLD	TSS	TDS	Nitrate (NO3)	Nitrate + nitrite (N total)	Nitrate + nitrite (N soluble)	Ammonia (N total)	Ammonia (N soluble)	Kjeldahl Nitrogen	Total Nitrogen (TN)	Organic Nitrogen	Total Reactive Phosphorus (totol P)	Total React Phosphorus (P soluble)	Total Phosphorus (P)	Boron as B	Aluminium (Al)	Copper (Cu)	Bromide (Br)	Cadmium (Cd total)	Chromium (Cr total)	Copper (Cu total)	Flouride (F)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)
				Units	m	cumsecs	m	m		uS/cm	uS/cm	NTU	NTU	m	Hazen units	°C	°C	pH units	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
				MTV						340		50					20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50			0.02	0.02		0.5				0.05	0.37	0.055	0.0014		0.2	1	1.4	1		<175		<115		1000	400						
130504A	Comet at AMTD 17.2km	52195	26/02/1971	1110	3.66	58.4			0.1	130								7.2				ND																			0.15	ND	8		9	111.2	14		4	62		ND		76
130504A	Comet at AMTD 17.2km	50569	16/11/1971	0	NA	0			0.1	315								7.3				ND																			0.15	ND	15		20	270.2	26	2	17	156		ND		190
130504A	Comet at AMTD 17.2km	52196	27/02/1972	935	2.02	3.85			0.1	138							25	7.3				ND																			0.15	ND	10		8	116.2	14		6	64		ND		78
130504A	Comet at AMTD 17.2km	52197	28/02/1972	814	2.26	27.8			0.1	143							25	7.4				ND																			0.15	ND	10		8	116.2	14		6	64		ND		78
130504A	Comet at AMTD 17.2km	52198	1/03/1972	940	1.45	13.3			0.1	155							25	7.4																							0.15	ND	12		12	135.2	19		4	72				88
130504A	Comet at AMTD 17.2km	52199	3/03/1972	940	1.03	7.42			0.1	167							25	7.5				ND																			0.15	ND	12		13	143.2	19		4	78		ND		95
130504A	Comet at AMTD 17.2km	52200	4/03/1972	940	0.88	5.69			0.1	175							25	7.5				ND																			0.15	ND	12		12	148.2	16		8	82		ND		100
130504A	Comet at AMTD 17.2km	54344	29/08/1972	0	NA				0.1	400								8.1																							0.17	ND	25		30	375.2	48	1	15	210				256
130504A	Comet at AMTD 17.2km	56717	21/01/1973	1320	1.04	7.519			0.1	100								7.4				66																			0.15	ND	12		13	95.6	5.6		5.8	48			ND	59
130504A	Comet at AMTD 17.2km	57963	22/02/1973	1023	5.44	167.853			0.1	111							24.5	8.1			875	70												0.01							0.17	ND	8	2.8	7.1	106.9	8		5	54			ND	66
130504A	Comet at AMTD 17.2km	57965	22/02/1973	1700	5.36	164.709			0.1	111								7.4			883	72												0.01							0.17	ND	8	2.6	7.1	110.9	7.5		5	58			ND	71
130504A	Comet at AMTD 17.2km	57966	23/02/1973	940	5.67	184.76			0.1	114							25	7.7			577	70												0.01							0.16	ND	8	3.1	7.9	105.1	8		5	52			ND	63
130504A	Comet at AMTD 17.2km	57967	24/02/1973	955	5.9	203.762			0.1	117							26	7.8			489	76												0.01							0.16	ND	10	4.2	7.5	114.4	8.5		5.5	56			ND	68
130504A	Comet at AMTD 17.2km	57964	25/02/1973	925	5.45	162.868			0.1	126							26.5	7.8			437	78												0.01							0.16	ND	10	3.6	7.2	118.3	8.5		5.5	60			ND	73
130504A	Comet at AMTD 17.2km	57968	25/02/1973	1400	5.08	137.465			0.1	130								8.2			446	81												0.01							0.17	ND	10	4.6	7.6	122.3	8.5		5.5	62			ND	76
130504A	Comet at AMTD 17.2km	57969	26/02/1973	750	4.35	101.952			0.1	135							28	8.0			453	81												0.01							0.17	ND	10	5.2	7.6	122.5	8.5		5.5	62			ND	76
130504A	Comet at AMTD 17.2km	57970	26/02/1973	1235	3.99	87.962			0.1	139								8.2			468	84												0.02							0.18	ND	10	5.5	8.1	126.7	9		6	64			ND	78
130504A	Comet at AMTD 17.2km	56731	6/03/1973	1600	0.79	4.324			0.1	203							29	7.5				117																			0.17	ND	14		17	178.2	18		9	98			ND	120
130504A	Comet at AMTD 17.2km	57865	18/03/1973	1530	0.24	0.26			0.1	280								7.8			48	176												0.03							0.2	ND	14	5.9	18	243.7	24.7		11.8	138			ND	168
130504A	Comet at AMTD 17.2km	57824	30/05/1973	0	NA				0.1	260								8.2			9	156												0.06							0.18	ND	14	5.7	10.8	202.5	23.5		11.3	126			16.8	119.6
130504A	Comet at AMTD 17.2km	59127	20/09/1973	0	NA				0.1	240								8.0				137																			0.22	0.1	12	4.4	14.5	187.6	19		10	104		ND	0.6	126
130504A	Comet at AMTD 17.2km	61608	25/06/1974	1100	0.15	0.021			0.1	400							18	7.7			20	223																			0.15		14	4.6	19	318.6	34.1		21	186		ND	0.7	225
130504A	Comet at AMTD 17.2km	63095	30/09/1974	945	NA	0.01			0.1	375							20	8.0			5	213																			0.17	ND	17.5	48	20	361.7	30		20	185			ND	226
130504A	Comet at AMTD 17.2km	64846	11/12/1974	1000	0.12	0.002			0.1	250							27	7.9			114	149																			0.18	ND	9	4.8	14	196.5	19		11	114		ND	0.5	138
130504A	Comet at AMTD 17.2km	64843	7/02/1975	1200	0.37	0.92			0.1	350							26	7.9			86	204																			0.14	ND	15	6.1	16.5	282.6	29		16	165		ND	0.9	199
130504A	Comet at AMTD 17.2km	64817	22/02/1975	1330	0.25	0.39			0.1	420							28	8.1			67	244																			0.18	ND	15	6.4	20	347.9	38		20.6	205		ND	1.7	246
130504A	Comet at AMTD 17.2km	64818	30/04/1975	1600	0.32	0.694			0.1	360								8.0			121	216																			0.15	ND	15	4.2	17	300.1	30	4.2	17.5	175		ND	1	211
130504A	Comet at AMTD 17.2km	67019	18/12/1975	1110	NA	0			0.1	205							30.5	7.3			268	125																			0.83	ND	10	3.4	15	152.7	14		7.5	84		ND	ND	102
130504A	Comet at AMTD 17.2km	68493	7/04/1976	1055	0.85	5.24			0.1	380							24	7.9			77	228																			0.2	ND	16	3.4	18	309.8	30	3.4	20	180		ND	0.8	218
130504A	Comet at AMTD 17.2km	69368	20/07/1976	1155	0.3	0.577			0.1	510							14	8.0			11	251																			0.1		18	2.4	26	382.2	36	4	27	222			1.7	267
130504A	Comet at AMTD 17.2km	72404	28/04/1977	1500	0.61	2.74			0.1	390							22	8.4				241	0.5																		0.1	0.1	13	2.8	19	329	32	5	21	196			3.5	232
130504A	Comet at AMTD 17.2km	74095	31/08/1977	1005	0.22	0.246			0.1	440							19	8.5			6	242																			0.2	0.1	16	2.8	26	359.9	30	10	26	208			4.8	244
130504A	Comet at AMTD 17.2km	75695	6/01/1978	1150	NA	0				335								7.8			25	200	6.5																		0.3	ND	28	4.6	23	177	22	6	13	122		ND	0.5	148
130504A	Comet at AMTD 17.2km	77086	23/03/1978	1020	0.16	0.059			0.1	385							28	7.8				271	1.5																		0.3	ND	15	5.7	22	358.4	35	9	20	206			0.9	249
130504A	Comet at AMTD 17.2km	77577	9/06/1978	1135	0.07	3.249			0.1	345							19	7.9			10	201	0.6																		0.2		12	4.4	19	298.2	30	2	19	174		ND	1	210
130504A	Comet at AMTD 17.2km	79177	20/09/1978	1140	0.96	7.46			0.1	200							18	7.9			165	122	0.8																		0.1		10	4.5	13	151.4	14	3	8.6	80			0.4	97
130504A	Comet at AMTD 17.2km	88929	19/01/1981	1110	0.25	0.3			0.1	210							26	7.3			110	123	1																		0.1		5.7	5.9	7.9	164.2	16	7	9.5	91			0.1	111
130504A	Comet at AMTD 17.2km	94249	30/03/1982	1235	0.33	0.64			0.1	220		100			20		26	7.3			20	130	0.4																		0.1		7	4.5	10	179.1	16	2	9	107			0.1	130
130504A	Comet at AMTD 17.2km	99475	7/10/1983	1120	0.17	0.031			0.1	385		7			10		22	7.5			15	200	1.2											0.03							0.2		19	6.4	24	297.3	28	12	16	156			0.4	190
130504A	Comet at AMTD 17.2km	105888	10/09/1984	1720	0.43	1.36			0.1	290		7					22	8.0			5	160												0.01							0.1		20	6.8	16	227.2	22	3.4	13	120			0.9	145
130504A	Comet at AMTD 17.2km	113208	17/02/1986	1545	0.83	5.169			0.1	165	140	100					29	8.1			710	110	0.5											0.03							0.2		5.5	5.3	8.1	131.5	14	3.5	5.8	73			0.6	88
130504A	Comet at AMTD 17.2km	116707	2/10/1986	1305	0.24	0.131			0.1	84	50	100			70		24	7.2			1095	89	9.7											0.01							0.1		5.1	3.8	7	75	5.9	5.3	2.6	26				31.5
130504A	Comet at AMTD 17.2km	118040	12/12/1986	805	0.59	2.44			0.1	145	130	100			70		27	7.9			390	92	1.2											0.03							0.1		8.2	7.8	10.5	110.1	11	2	4.5	53			0.3	64
130504A	Comet at AMTD 17.2km	120770	28/08/1987	1420	4.29	2.216			0.1	115		100						7.6			866	82	2											0.04							0.1		7	4.4	11	89.9	8	3	3	41			0.1	50
130504A	Comet at AMTD 17.2km	128400	9/01/1989	1550	0.48	1.783			0.1	195	180	100					30	7.3			755	130												0.03							0.2		6	5	10.5	155.5	17	5	6.6	86			0.1	105
130504A	Comet at AMTD 17.2km	131271	7/08/1989	1720	0.26	0.422			0.1	265	280						14.5	7.9			10	160												0.04							0.2		9	3.8	14	223.7	23	5	13	128			0.7	155
130504A	Comet at AMTD 17.2km	131322	7/09/1989	0	0.12	0			0.1	290		24			20			8.3			40	160												0.04							0.1		9.1	4.2	15	240	25	5.1	14.5	139			2	165
130504A	Comet at AMTD 17.2km	131404	7/09/1989	0	0.12	0.001			0.1	275		20			10			8.2			30	160												0.04							0.1		9.4	3.9	14.5	238.4	24.5	4.8	14.5	138			1.7	165
130504A	Comet at AMTD 17.2km	133760	22/04/1990	930	7.22	309			0.1	122	120	200			70		23	7.3			751	85	1.7											0.04							0.11	ND	4.2	3.5	6.1	94.8	9.8	2.8	4.5	51			ND	62
130504A	Comet at AMTD 17.2km	145420	24/03/1992	1845	0.16	0.005			0.1	196		175			40		25	6.9			103	132	0.6											0.03	0.59						0.18		15.4	5	10.1	160.3	16.2	3.1	8.4	83		ND	ND	101.1
130504A	Comet at AMTD 17.2km	149657	16/03/1993	958	0.16	0.001			0.1	101	104	84			70		28.3	7.3	7.2		43	68	2.5												0.14	0.01					0.02	ND	3.6	5.9	4.9	81	8.5	1.2	3.7	41			ND	50.4
130504A	Comet at AMTD 17.2km	164722	26/08/1994	1700	NA	0			0.1	373	382	30			20		19.4	7.7	7.8		36	201	1.1													0.01					0.13		9.1	8.9	17.5	308.4	34.8	1.9	16.8	179		0.01	0.8	217.3
130504A	Comet at AMTD 17.2km	171823	4/04/1995	1445	0.06	0			0.15	180	204	100	146		40		29	7.5	7.5	6.2	70	120	0.5		0.004		0.005			0.8		0.05	0.22	<0.1	0.05	<0.05		2.6	3	4	0.2	ND	4.4	4.4	9.1	160	19.5	2.4	8.6	89		ND	0.2	110
130504A	Comet at AMTD 17.2km	171718	12/05/1995	1230	0.33	0			0.2	234.7	250	6	16		20		21.3	7.7	8.3	6.6	10	142.4	0.47		0		0			0.5436		0.0069	0.04	ND	ND	0.01					0.16	ND	5.71	4.6	10.2	203.72	25.2	2.46	10.5	119		0.01	0.37	144.05
130504A	Comet at AMTD 17.2km	176300	22/08/1995	1545	NA	0			0.2	233	261	303			ND			7.4			53	133.4	1.4		0.105		0.15			0.878		0.0237	0.2789	ND	ND	0.02		3.5	7	7	0.23	ND	8.6	4.3	12.4	192.35	24.4	3	8.3	107		ND	0.2	129.52
130504A	Comet at AMTD 17.2km	171898	8/09/1995	1200	-0.1	0			0.2	256.2	265	203	207	0.15	42	26.3	14.9	7.6	7.4	9.4	99	147	1.04		0.0756		0.0233			0.8377		0.0197	0.189	0.1	0.11	0.08					0.26	ND	5.93	4.6	13.6	220.53	28.2	3.08	9.9	127	120	0.01	0.38	153.54
130504A	Comet at AMTD 17.2km	176457	29/11/1995	1255	0.75	4.056			0.2	149.5	140	1087			23			7.2			620	88.67	5.55		0.196		0.0163			2.1637		0.1114	0.7768	ND	ND	0.04					0.15	ND	8.04	5.7	9	106.42	10	1.56	4.5	51		ND	0.05	61.87
130504A	Comet at AMTD 17.2km	171362	22/05/1996	900	0.21	0.027			0.2	153	154	358	352		12	17	16.2	7.5	7.3	7.3	191	103.6	1.83		0.324		0.0387			0.8083		0.0998	0.295	ND	ND	ND					0.14	ND	13.6	4.3	9.9	126.58	13	4.14	6.2	60	56	0.01	0.13	73.33
130504A	Comet at AMTD 17.2km	178667	7/08/1996	1605	-0.32	0			0.2	197	188	209	284		12		20	7.2	8.4	10.48	61	120.6	0		0.0568		0.0255			2.0865		0.0116	0.241	ND	ND	0.03					0.14	ND	11.4	5.9	11.9	158.22	16.6	4	7.6	83		ND	0.08	100.6
130504A	Comet at AMTD 17.2km	178690	11/12/1996	926	2.56	34.5			0.1	141	138		2900		22		25.6	7.2	7.7	5.14		98.3	3.92				0.0266			3.2			0.85	ND	ND						0.16	ND		4.4	10.6	120.68	10.7	3.83	4.5	61		ND	0.06	74.71
130504A	Comet at AMTD 17.2km	178757	30/01/1997	1000	2.2	25.42			0.1	154	170	9310	7740		8		28.2	7.3	7.5	3.6	5772	102	5.84		0.977		0.0541			1.8039		0.129	0.9875	0.1	ND	0.02					0.21	ND	4.63	3.9	11.7	123.93	11.2	2.51	5.4	64		ND	0.09	78.45
130504A	Comet at AMTD 17.2km	183600	6/02/1997	1500	4.32	24.111			0.2	110	114	3365			17		27.6	7.2	6.9		2008	78.76	1.3		1.05		0.798			1.04		0.102	2.0176	ND	ND	0.02					0.13	ND	4.7	3.7	5.8	94.69	9.9	1	4.9	52		ND	0.06	63.2
130504A	Comet at AMTD 17.2km	183601	7/02/1997	1630	4.66	23.918			0.2	112	116	1614			24		26.7	7.3	7.3		932	77.74	0.5		0.406		0.148			1.582		0.127	1.08	ND	0.01	0.01					0.13	ND	4	4.1	6.1	94.15	9.3	1.2	4.6	53		ND	0.07	64.15
130504A	Comet at AMTD 17.2km	185850	7/04/1997	1448	0.23	13.222			0.2	389	415	169	221		34		24.8	7.4	7.6	6.2	98	237.7	2.61		0.0331		0.0543			1.0177		0.0752	0.1923	ND	ND	0.01					0.14	ND	41.5	6.4	33.7	271.64	24.6	53.33	12.7	79		ND	0.14	96.51
130504A	Comet at AMTD 17.2km	185781	19/06/1997	1100	-0.12	0			0.2	387	369	54.5	64		14	21.9	15.5	7.9	8.1	7.7	18	211.7	0.92		0.0889		0.0384			0.6006		0.0299	0.0912			ND					0.17	ND	46.37	5.23	26	281.14	22	26.26	17	113	124	0.01	0.62	136.56
130504A	Comet at AMTD 17.2km	185874	11/08/1997	1515	-0.5	0			0.1	400	416	43	51		17		19.9	7.6	7.7	8.2	20	220	1.2											<0.1	0.08	<0.05					0.2	ND	34	6.8	36	300	26	28.5	13	125		ND	0.4	150
130504A	Comet at AMTD 17.2km	187777	24/11/1997	1000	0.41	0			0.1	145	140	720	971		7		28	7.1	6.9	5	500	100	2.6		0.085		0.098			1.6		0.19	0.68	<0.1	0.05	<0.05					0.2	ND	12	5	12.5	120	10.5	3.7	4.7	53		ND	ND	64
130504A	Comet at AMTD 17.2km	185801	27/04/1998	1545	4.2	0			0.2	120	113	670	856		115		22.6	7.2	7.0	5.4	340	79	3.3		0.21		0.07			1.8		0.19	0.69	0.1	0.11	<0.05					0.1	ND	7.5	6.2	10.5	95	6.9	2.3	3.2	46		ND	ND	55
130504A	Comet at AMTD 17.2km	192217	18/08/1998	830	0.075	0			0.3	169	166	114	120		46	20	16.2	7.4	7.6	6.12	21	121.8	0.77						0.672	0.67			0.2903	ND	ND	0.01					0.13	ND	23.99	5.8	12.3	151.04	13.4	3.72	5.9	70	64	ND	0.11	84.92
130504A	Comet at AMTD 17.2km	194165	28/10/1998	1300	7.02	214.858			0.2	142	139	764	933		8	27.7	24.6	7.1	7.4	5.1	511	99.95	1.84		0.194		0.0197		1.2716			0.194	0.7407	ND	ND	0.01					0.12	ND	10.64	5.2	9.8	114.5	12	3.28	4.8	55	59	ND	0.04	66.77
130504A	Comet at AMTD 17.2km	194026	29/10/1998	1710	6.15	218.4			0.1	155		387			7			7.4			211	107.3	1.16		0.0769		0.0115		1.0177			0.183	0.5672	ND	ND	0.01					0.12	ND	11.87	6.1	10.8	126.8	12.8	3.33	5.2	62		ND	0.09	75.33
130504A	Comet at AMTD 17.2km	194040	2/12/1998	1550	1.53	204.03			0.1	160	161	620	801		9		27	7.9	7.1	7.34	496	103.4	1.91		0.125		0.0347		1			0.216	0.7211	ND	ND	0.01					0.13	ND	10.04	6.4	10.9	126.54	12.1	2.66	5.6	63		0.01	0.31	76.47
130504A	Comet at AMTD 17.2km	184707	6/01/1999	1455	6.52	189.226			0.2	160	148	610	620		61		27.8	8.1	7.8	3.8	390	100	1.6		0.12		0.036			1.2		0.18	0.58	<0.1	0.05	ND					0.1	ND	5.4	5.4	9.5	120	12	3.6	5.2	63		ND	0.5	75
130504A	Comet at AMTD 17.2km	192153	9/03/1999	1015	3.8	163.08			0.2	130	121	680	902		325		27.3	7.4	6.5	5.4	486	86.83	1.06		0.0535		0.0047		0.9368			0.138	0.7135	ND	0.41	0.01					0.1	ND	4.43	3.5	6.1	100.55	10.2	0.97	5.6	56		ND	0.08	68.51
130504A	Comet at AMTD 17.2km	184729	20/03/1999	1030	0.46	158.396			0.2	215.85	225	69.9	77.7		28		28.1	7.9	8.1	6.2	54	145	0.6		0.0121		0.0039		0.4957			0.138	0.2939	ND	0.02	ND					0.14	ND	6.39	5	11	187.1	19.2	1.67	10.6	109		0.01	0.63	131.85
130504A	Comet at AMTD 17.2km	198017	23/02/2000	1530	0.82	14.355			0.1	175	170	210	291		64		24.3	7.3	7.4	8.2	232	115.1	1.03		0.0567		0.0255		0.6969			0.2275	0.46	ND	0.01	ND					0.11	ND	11.44	4.8	9.4	136.63	13.6	2.39	7.4	71		ND	0.08	86.37
130504A	Comet at AMTD 17.2km	205291	28/03/2000	1305	0.13	0.002			0.2		479		27				26.7			6.7									0.4195				0.19																					
130504A	Comet at AMTD 17.2km	201125	21/08/2000	1315	0.23	0.291			0.2	182	154	175	309		51		17.5	7.7	7.9	7.7	75	108.7	0.82		0.0814		0.034		0.8215			0.1668	0.2753	ND	0.01	ND					ND	ND	7.39	2.4	11.1	142.11	13.1	2.85	8.8	79		0.01	0.23	95.42
130504A	Comet at AMTD 17.2km	201168	24/11/2000	1320	6.29	0.277			0.2	140	134	330	371		82		26.5	7.2	7.2	5.5	260	99	4.3		0.026		0.08		1.5			0.27	0.6	<0.1	0.05	<0.05					0.1	ND	4	5	5.7	110	11	2	5.3	61		ND	1	74
130504A	Comet at AMTD 17.2km	S014056	2/03/2001	1003	0.34	0.808			0.2		337						29.2		7.8																																			
130504A	Comet at AMTD 17.2km	202807	12/03/2001	1420	0.4	0.18			0.2	260	280	150	315		29		29.8	7.9	7.8	5.9	130	160	1.6		0.1		0.024		0.6			0.18	0.28	<0.1	0.05	0.05					0.1	ND	8	3.9	11	210	21.5	4	13.5	120		ND	<1	145
130504A	Comet at AMTD 17.2km	210495	7/01/2002	1150	NA	733.596			0.1		100		5354						7.1										4.4792				2.8401																					
130504A	Comet at AMTD 17.2km	207507	7/01/2002	1230	7.8	729.518			0.2	110	99	2000	4830		49		27.2	7.4	6.9		4950	71	3.7		0.58		0.047		4			0.27	2.5	0.1	0.06	<0.03					0.1	ND	2	2.2	6.5	83	8.4	2	3.4	45		ND	0.1	54
130504A	Comet at AMTD 17.2km	210496	8/01/2002	1115	NA	477.971			0.1		108		3343						6.8										2.7403				1.6768																					
130504A	Comet at AMTD 17.2km	207505	8/01/2002	1305	6.22	350	180	90	0.2	115	108	2000	3620		56		28.7	7.3	6.8	4.5	3000	76	2.3		0.33		0.037		2.6			0.2	1.7	0.1	0.05	<0.03					0.1	ND	3	2.3	7	91	8.6	3	3.7	50		ND	0.1	61
130504A	Comet at AMTD 17.2km	210497	9/01/2002	745	NA	263.169			0.1		105		1989						6.8										2.0117				1.3228																					
130504A	Comet at AMTD 17.2km	210498	10/01/2002	1140	NA	175.622			0.1		117		994						6.8										1.5301				0.9884																					
130504A	Comet at AMTD 17.2km	210499	12/01/2002	800	NA	99.448			0.1		137		561						6.8										1.1603				0.7881																					
130504A	Comet at AMTD 17.2km	207711	28/02/2002	1500	0.26	0.399			0.2	215	214	165	199		13		29.3	7.7	7.6	6.7	130	130	1.1		0.098		0.038		0.76			0.14	0.23	0.1	0.05	<0.03					0.2	ND	7	3.8	10.5	170	20.5	3	9.1	97		ND	0.3	115
130504A	Comet at AMTD 17.2km	207718	12/06/2002	1030	0.17						206		307				17.3		7.7	8.3																																		
130504A	Comet at AMTD 17.2km	207718	12/06/2002	1115	1.18	0.043				220		215			34			7.7			60	130	1		0.11		0.052		0.49			0.046	0.1	<0.1	0.05	0.03					0.2	ND	8	4.2	11	170	19.5	3	8.3	93		ND	0.3	115
130504A	Comet at AMTD 17.2km	210573	13/02/2003	1240	NA				0.1																				1.7344				0.9009																					

Brown-Comet Catchment Water Quality Data

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Stream Water Level	Stream Discharge	Total Stream Width	Distance from left bank	Dist. below Water Surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Transparency (secchi depth) FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	DO FLD	TSS	TDS	Nitrate (NO3)	Nitrate + nitrite (N total)	Nitrate + nitrite (N soluble)	Ammonia (N total)	Ammonia (N soluble)	Kjeldahl Nitrogen	Total Nitrogen (TN)	Organic Nitrogen
				Units	m	cumsecs	m	m		uS/cm	uS/cm	NTU	NTU	m	Hazen units	°C	°C	pH units	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
130501A	Comet R at Comet Weir	30503	10/12/1964	0	0.26	0			0.1	225								7.4				120								
130501A	Comet R at Comet Weir	31661	15/07/1965	0	-0.4	0			0.1	128								7.2				90								
130501A	Comet R at Comet Weir	34095	7/12/1965	1555	0.51	4.928			0.1	142								7.7				85								
130501A	Comet R at Comet Weir	34096	9/12/1965	1105	0.66	14.33			0.1	129								7.5				77								
130501A	Comet R at Comet Weir	52188	19/02/1972	1455	5.37	402.257			0.1	72							25	7.4				52								
130501A	Comet R at Comet Weir	52189	20/02/1972	925	5.78	460.738			0.1	73								6.9				54								
130501A	Comet R at Comet Weir	52190	20/02/1972	1830	5.41	403.815			0.1	81								7.1				68								
130501A	Comet R at Comet Weir	52191	21/02/1972	935	4.94	347.033			0.1	100								7.0				66								
130501A	Comet R at Comet Weir	52192	22/02/1972	855	4.3	285.834			0.1	100								7.0				70								
130501A	Comet R at Comet Weir	52193	23/02/1972	855	3.83	243.75			0.1	105								7.0				74								
130501A	Comet R at Comet Weir	52194	25/02/1972	855	2.6	159.045			0.1	124								7.0				72								
130501A	Comet R at Comet Weir	51830	16/03/1972	820	0.25	0.821			0.1	218								7.3				140								
130501A	Comet R at Comet Weir	57825	19/03/1973	1115	0.24	0.257			0.1	243								8.0			98	152								
130501A	Comet R at Comet Weir	59154	13/08/1973	1030	0.16	0.097			0.1	195								7.8			10	123								
130501A	Comet R at Comet Weir	63094	2/10/1974	1400	-0.39	0											24													
130501A	Comet R at Comet Weir	66494	10/10/1975	1450	0.63	0			0.1	450							26	7.9			24	250								
130501A	Comet R at Comet Weir	164717	26/08/1994	1515	2.46	0			0.2	242	256	2			20		19	8.1	8.5		10	152	0.7		0.003		0.032			0.6
130501A	Comet R at Comet Weir	164744	21/09/1994	1825	2.7	0			0.2	279	277	1		0.14	20		20.7	7.7	7.9		2	160			<0.02		0.02			0.5
130501A	Comet R at Comet Weir	163087	20/10/1994	930	1.5	0			0.2	280	277	3		1.02	30		25.1	8.6			10	170	0.5		0.003		0.028			0.8
130501A	Comet R at Comet Weir	164604	1/12/1994	1520	NA	0			0.2	295	304	2		0.52	30		29.5	7.7	8.4		10	170	1.3		0.024		0.005			0.9
130501A	Comet R at Comet Weir	164613	10/01/1995	940	4.09	0			0.2	285	320	16			20		30	8.2	8.1		20	170	1.1		<0.002		0.005			0.8
130501A	Comet R at Comet Weir	171805	8/02/1995	1254		2.73			0.2	150	146	100			70		29.7	7.8	7.2	3.65	490	98	3.5		0.73		0.003			1.4
130501A	Comet R at Comet Weir	171874	8/03/1995	845					0.2	155		100			50			7.3			10	95	2.6		0.14		0.049			1.1
130501A	Comet R at Comet Weir	171824	4/04/1995	1615	1.66	0			0.2	160	171	100	175		40		29.7	7.5	7.5		70	110	1.8		0.032		0.013			0.7
130501A	Comet R at Comet Weir	171024	8/05/1995	1721		0			0.1	170	209	50	62.5		40		22.1	7.7	7.8	9.05	30	110	1		0.006		0.008			0.5
130501A	Comet R at Comet Weir	171756	2/06/1995	1550	2.87	0			0.1	194.5	197	17	32.3		20		20.9	7.6	7.8	8.6	28	119.2	2.42		0.0331		0.0224			0.7641
130501A	Comet R at Comet Weir	171036	28/06/1995	1447	NA				0.2	205	200	10	27.3		20		16.3	7.5	7.6	8.85	10	120	1.9		0.0842		0.0098			0.6464
130501A	Comet R at Comet Weir	171772	24/07/1995	1635					0.2	195	231	8			13			7.8			10	120	0.5		0.043		0.12			0.3
130501A	Comet R at Comet Weir	176451	29/09/1995	1219					0.2 E		237		24.9				25.2		8.2	7.83										
130501A	Comet R at Comet Weir	176314	1/11/1995	1610					0.1 E		125		2000				28.7		6.6	4.15										
130501A	Comet R at Comet Weir	176458	29/11/1995	1535					0.2 E		135		1140				28.7		7.3	5.56										
130501A	Comet R at Comet Weir	176483	6/01/1996	1500					0.2 E		104		2430				25.9		6.7	5.63										
130501A	Comet R at Comet Weir	178658	2/02/1996	1117					0.2 E		209		559				30.8		7.4	5.2										
130501A	Comet R at Comet Weir	178731	2/04/1996	1830					0.2 E		252		15.6				29		7.6	4.9										
130501A	Comet R at Comet Weir	171357	3/05/1996	1000	0.3	2			0.2	128	127	2220	3456		11	23	20.2	7.2	7.8		1382	81.52	5.1		0.978		0.07			1.835
130501A	Comet R at Comet Weir	178742	5/06/1996	1630					0.1 E		167		115				19.7		7.7	6.55										
130501A	Comet R at Comet Weir	176377	5/07/1996	930					0.2 E		181		68				15.7		7.5	5.73										
130501A	Comet R at Comet Weir	178668	10/08/1996	1436					0.2 E		187		65.6				16.1		7.7	7.27										
130501A	Comet R at Comet Weir	205215	24/02/2000	1240	0.79	4.5			0.2		161		262				25.3		7.4	6.6										
130501A	Comet R at Comet Weir	205262	7/03/2000	1240	0				0.2		407		360				27.1		7.4	5.9									0.36	
130504B	Comet R at Comet Weir	207532	13/02/2003	1255	1.97	25.372		10	0.4	115.5	113	1126	1547		44		26.1	7.2	7.0		834	87.63	1.59		0.168		0.0314		1.3309	
130504B	Comet R at Comet Weir	207533	14/02/2003	1230	1.79	16.031		10	0.4	128.5	138	594	747		46		26.8	7.5	7.0		406	88.66	0.87		0.0927		0.0249		0.8878	
130504B	Comet R at Comet Weir	207534	24/02/2003	1445	0.2	1.068			0.2	185	188	210	227		21		29.2	7.7	7.6		90	120	1		0.069		0.078		0.89	
130504B	Comet R at Comet Weir	S034197	23/04/2003	1230	1.23	0.279			0.2		142		265				23		7.5	6.8										
130504B	Comet R at Comet Weir	S034037	26/05/2003	1244	0.92	0			0.2		157						17.8		7.5											
130504B	Comet R at Comet Weir	S044006	7/01/2004	1427	1.03	0			0.2		163						26.1		7.1											
130504B	Comet R at Comet Weir	S044005	17/01/2004	1121	4.46	195.909			0.2		108						27.6		7.0											
130504B	Comet R at Comet Weir	S044004	18/01/2004	827	4.82	224.252			0.2		118						27.5		7.1											
130504B	Comet R at Comet Weir	216326	19/01/2004	930	4.69			0	0.1																				1.9382	
130504B	Comet R at Comet Weir	202863	19/01/2004	1057	4.72				0.3	115	114	2000	1892		7		29.1	7.2	6.9	4.2	1300	79	1.3		0.12		0.041		1.9	
130504B	Comet R at Comet Weir	216327	20/01/2004	920	4.87			0	0.1																				2.0569	
130504B	Comet R at Comet Weir	202864	20/01/2004	1545	5.07				0.2	120	121	2000	1582		9		29.6	7.3	6.9		1100	83	1.7		0.15		0.053		2.4	
130504B	Comet R at Comet Weir	216360	21/01/2004	1415	5.75			0	0.1																				2.0346	
130504B	Comet R at Comet Weir	202865	21/01/2004	1500	5.79				0.2	125	128	2000	1760		10		31.1	7.2	6.9		1200	87	1.7		0.14		0.052		1.6	
130504B	Comet R at Comet Weir	202868	22/01/2004	1045	6.13				0.2	125		1750			2			7.4			1000	86	1.3							
130504B	Comet R at Comet Weir	202869	22/01/2004	1046	6.13				0.2	125		1850			7			7.3			950	87	1.3							
130504B	Comet R at Comet Weir	202870	22/01/2004	1047	6.13				0.2	125		1850			8			7.3			900	87	1.4							
130504B	Comet R at Comet Weir	202871	22/01/2004	1048	6.13				0.2	125		1850			12			7.3			1000	87	1.3							
130504B	Comet R at Comet Weir	202866	22/01/2004	1110	6.13				0.2	125	129	1700	1364		10		28.7	7.3	7.1		900	88	1.3		0.096		0.064		1.7	
130504B	Comet R at Comet Weir	216361	23/01/2004	800	6.03			0	0.1																				1.6776	
130504B	Comet R at Comet Weir	202867	23/01/2004	930	6.03				0.2	130	133	1150	1024		9		28.9	7.3	6.9		650	89	1.3		0.065		0.071		1.6	
130504B	Comet R at Comet Weir	216362	27/01/2004	830	1.89			0	0.1																				1.9348	
130504B	Comet R at Comet Weir	202894	7/03/2005	1340	1.18				0.2 E	154	154	487	533		22		34.2	7.3	7.4	7.5	132	93	2.3		0.038		0.166		1.5043	
130504B	Comet R at Comet Weir	208528	27/02/2007	1230					0.1 E		132		640				29.1		7.5	7.4										

STATION ID	SAMPLE NO.	DATE	Total Reactive Phosphorus (totol P)	Total React Phosphorus (P soluble)	Total Phosphorus (P)	Boron as B	Aluminium (Al)	Copper (Cu)	Bromide (Br)	Cadmium (Cd total)	Chromium (Cr total)	Copper (Cu total)	Flouride (F)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
130501A	30503	10/12/1964											0.2	ND	15		19	198.2	20		10	110			ND	134
130501A	31661	15/07/1965											0.5	ND	12		4	85.5	8	4	8	40		ND	ND	49
130501A	34095	7/12/1965											0.2	ND	10		16	143.2	16	10	5	71			ND	86
130501A	34096	9/12/1965											0.2	ND	10		6	105.2	12	9	7	50		ND	ND	61
130501A	52188	19/02/1972											0.2	ND	8		11	77.2	6		3	40			ND	49
130501A	52189	20/02/1972											0.2		10		12	85.9	6		4	42		ND	ND	51
130501A	52190	20/02/1972											0.2	ND	12		15	99.2	8		3	50			ND	61
130501A	52191	21/02/1972											0.15	ND	8		11	99.2	10		4	54		ND	ND	66
130501A	52192	22/02/1972											0.15	ND	10		12	104.2	10		4	56		ND	ND	68
130501A	52193	23/02/1972											0.05	ND	10		14	111.1	10		4	60		ND	ND	73
130501A	52194	25/02/1972											0.15	ND	10		11	108.2	12		4	58		ND	ND	71
130501A	51830	16/03/1972											0.45	ND	16		18	216.5	18		15	122			ND	149
130501A	57825	19/03/1973				0.05							0.17	ND	16	5.4	10	210.8	22		10.6	118			ND	144
130501A	59154	13/08/1973											0.13	0.1	10	3.9	12	168.1	17.5		9	94		ND	0.4	114
130501A	63094	2/10/1974																								
130501A	66494	10/10/1975											0.2	ND	15	5.6	21	365.8	36		23	217		ND	ND	265
130501A	164717	26/08/1994		0.057	0.11			0.03					0.13		6.9	6.6	12.7	210.2	21.7	2.5	11.1	122		0.02	1.1	146.6
130501A	164744	21/09/1994		0.03	0.083			0.06					0.16		6.7	7.2	12.8	225	24.1	2.4	11.7	131		0.01	0.5	159.4
130501A	163087	20/10/1994		0.003	0.055	<0.1	0.05	<0.05					0.2	ND	7.6	7.4	14	240	25	2	12.5	140		0.1	3.9	165
130501A	164604	1/12/1994		0.003	0.087	<0.1	0.05	<0.05					0.2	ND	8.3	8.1	14.5	240	25	2	13	140		ND	0.5	170
130501A	164613	10/01/1995		0.003	0.049	<0.1	0.05	<0.05					0.2	ND	10	9.1	15	250	22	2	14	145		ND	1.5	175
130501A	171805	8/02/1995		0.18	1	<0.1	0.05	<0.05					0.2	ND	7.4	3.2	12.5	120	10.5	4.4	4.3	57		ND	0.2	69
130501A	171874	8/03/1995		0.1	0.38	<0.1	0.05	0.07					0.1	ND	4.7	4.2	7.9	120	12.5	2.1	5.9	66		ND	0.1	80
130501A	171824	4/04/1995		0.068	0.26	<0.1	0.05	<0.05					0.1	ND	4.6	4.2	8.4	140	15.5	2	7.1	78	17.6	ND	0.1	95
130501A	171024	8/05/1995		0.017	0.072	<0.1	0.05	<0.05					0.1	ND	3.9	4.1	8	150	17	2	7.7	91		ND	0.3	110
130501A	171756	2/06/1995		0.0037	0.0623	ND	ND	0.01					0.15	ND	5.33	4.3	8.2	158.25	18	2.06	8.1	90	21.7	0.01	0.22	109.47
130501A	171036	28/06/1995		0.0049	0.057	<0.1	0.06	<0.05					0.2	ND	4.3	4.3	8.3	160	19	2.5	8.4	95	8.6	ND	0.2	115
130501A	171772	24/07/1995		0.003	0.022	<0.1	0.05	0.06					0.2	ND	4.3	4.1	8.1	170	20	2.5	8.7	100		ND	0.4	125
130501A	176451	29/09/1995																								
130501A	176314	1/11/1995																					46.4			
130501A	176458	29/11/1995																								
130501A	176483	6/01/1996																								
130501A	178658	2/02/1996																								
130501A	178731	2/04/1996																								
130501A	171357	3/05/1996		0.0866	0.8809	ND	ND	0.04					0.14	ND	10.4	2.8	13.9	96.8	7.7	2.1	3.1	42		ND	0.04	51.52
130501A	178742	5/06/1996																								
130501A	176377	5/07/1996																					75.2			
130501A	178668	10/08/1996																								
130501A	205215	24/02/2000																								
130501A	205262	7/03/2000			0.23																					
130504B	207532	13/02/2003		0.1621	0.9796	0.01	ND	0.01					0.12	ND	9.17	3.98	8.94	94.43	9.88	5.51	4.78	41		ND	0.04	50.41
130504B	207533	14/02/2003		0.155	0.5861	0.05	0.01	0.01					0.11	ND	6.6	4.02	7.98	96.97	9.87	3.39	5.08	48		ND	0.09	58.95
130504B	207534	24/02/2003		0.18	0.36	<0.1	0.05	<0.03					0.1	ND	10	5.2	8.9	140	15	4	7.4	76		ND	0.2	92
130504B	S034197	23/04/2003																								
130504B	S034037	26/05/2003																								
130504B	S044006	7/01/2004																								
130504B	S044005	17/01/2004																								
130504B	S044004	18/01/2004																								
130504B	216326	19/01/2004			0.988																					
130504B	202863	19/01/2004		0.18	1.2	0.1	0.05	<0.03					0.1	ND	2	3.6	6	92	8.6	2	4.2	53		ND	0.1	64
130504B	216327	20/01/2004			1.102																					
130504B	202864	20/01/2004		0.24	1.5	0.1	0.05	<0.03					0.1	ND	3	4.4	5.9	98	9.4	2	4.2	55		ND	0.1	67
130504B	216360	21/01/2004			1.0874																					
130504B	202865	21/01/2004		0.26	0.95	0.1	0.05	<0.03					0.1	ND	3	4.6	6.7	100	10	2	4.2	57		ND	0.1	70
130504B	202868	22/01/2004				0.1	0.05	<0.03					0.2	ND	4	4.7	6.8	100	10	2	4.1	57		ND	0.1	70
130504B	202869	22/01/2004				0.1	0.05	<0.03					0.2	ND	4	4.5	7.1	100	10	2	4.1	57		ND	0.1	70
130504B	202870	22/01/2004				0.1	0.05	<0.03					0.2	ND	4	4.5	7.1	100	9.9	2	4.1	57		ND	0.1	70
130504B	202871	22/01/2004				0.1	0.05	<0.03					0.2	ND	4	4.8	6.8	100	10	2	4.1	57		ND	0.1	69
130504B	202866	22/01/2004		0.27	1	0.1	0.05	<0.03					0.1	ND	4	4.5	7.5	100	10	2	4.2	57		ND	0.1	69
130504B	216361	23/01/2004			0.8759																					
130504B	202867	23/01/2004		0.25	0.95	0.1	0.05	<0.03					0.1	ND	4	5	7.3	110	10	2	4.3	59		ND	0.1	71
130504B	216362	27/01/2004			0.7793																					
130504B	202894	7/03/2005		0.057	0.4473	0.11	0.05	<0.03					0.2	ND	7.1	4.8	10	118	11	2.5	4.3	61		ND	0.1	75
130504B	208528	27/02/2007																								

Notes
MTV minimum trigger value
BOLD Greater than MTV
123 Historic Water Quality Data\044 Quality poor.
BOLD Greater than MTV and Historic WQ Data
NA Not available (Gauge Height < Instrument Threshold)
ND Not detected
E Estimate

Calibration Certificates & Records

Appendix D

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☐ pH
Conductivity	☑ 0.0mS/cm	☐ 2.76mS/cm	☐ 12.88mS/cm	☑ 58.6mS/cm	☐ mS/cm
TDS	☑ 0.0 ppk	☑ 36 ppk	☐ ppk		
Turbidity	☑ 0.0 NTU	☐ 90NTU	☑ 360NTU	☐ ____NTU	
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☑ 100% Saturation in Air	
☑ Electrodes cleaned/checked		☑ Charged 8 v (min 7.2V)		☑ Temperature	

* Calibration solution traceability information is available upon request.

Date: 21 - 1 Checked by: AZ

Signed: AW

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 7.96v
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Turbidity sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	____________
☐	☐	☐	____________

Processors Signature/ Initials [signature]

EE Quote Reference	5351.	Condition on return
Customer Ref		
Equipment ID	90FLT A.	
Equipment serial no.		
Return Date	/ /	
Return Time		

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS WP88 Turbidity Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

Turbidity	☑ 0 NTU	☐ 90 NTU	☑ 360 NTU	☑ 900 NTU	☐ NTU
☑ Electrodes cleaned/checked		☑ Charged			

* Calibration solution traceability information is available upon request.

Date: 22 JAN 08 Checked by: HOWARD

Signed: HJones

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $30 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	WP88 Operational check / Battery Voltage @ 100%
☑	☐	☐	Turbidity Sensor
☑	☐	☐	Turbidity Sensor Shroud (installed)
☑	☐	☐	Turbidity Sensor cable 20 m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide Sheet
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials HJones 22 JAN 08

EE Quote Reference	5351	Condition on return
Customer Ref		
Equipment ID	WP88WA1	
Equipment serial no.	T8195	
Return Date	/ /	
Return Time		

43270896 5000 / T0035

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☐ pH
Conductivity	☑ 0.0mS/cm	☐ 2.76mS/cm	☐ 12.88mS/cm	☑ 58.6mS/cm	☐ mS/cm
TDS	☑ 0.0 ppk	☑ 36 ppk	☐ ppk	Redox	☐ ____mV
Turbidity	☑ 0.0 NTU	☐ 90NTU	☑ 360NTU	☐ ____NTU	
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☐ 100% Saturation in Air	
☑ Electrodes cleaned/checked		☑ Charged 7.7 v (min 7.2V)		☑ Temperature	

* Calibration solution traceability information is available upon request.

Date: 27 FEB 08 Checked by: HANS

Signed: [signature]

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 7.7
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Turbidity sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials [initials]

EE Quote Reference	6221	Condition on return
Customer Ref		
Equipment ID	90FLT A	
Equipment serial no.		
Return Date	/ /	
Return Time		

Melbourne Sydney Brisbane Perth Auckland Kuala Lumpur

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ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLMV Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	[x] pH 6.88	[ ] pH 7.00	[x] pH 4.00	[ ] pH 10.00	[x] pH
Conductivity	[x] 0.0mS/cm	[ ] 2.76mS/cm	[ ] 12.88mS/cm	[x] 58.6mS/cm	[x] mS/cm
TDS	[x] 0.0 ppk	[x] 36 ppk	[x] ppk		
Dissolved Oxygen	[x] 0.00ppm in Sodium Sulphite			[x] 100% Saturation in Air	
Redox (ORP)**	[x] Electrode operability test 240mV +/- 10%. Actual: 245mV				

[x] Electrodes cleaned/checked — [x] Charged — v (min 7.2V) — [ ] Temperature

* Calibration solution traceability information is available upon request.
** This meter uses an Ag/AgCl ORP electrode. To convert readings to SHE (Standard Hydrogen Electrode), add 199mV to the mV reading. For further information, refer to www.enviroequip.com/quipnotes/ORP.htm.

Date: 9th May 2008 Checked by: PETER H

Signed: [signature]

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
[x]	[ ]	[ ]	90FLMV Unit. Ops check / Battery Voltage @ 8.21v
[x]	[ ]	[ ]	pH sensor 5m
[x]	[ ]	[ ]	Conductivity / TDS / Temperature k=10 sensor 5m
[x]	[ ]	[ ]	Dissolved Oxygen YSI5739 sensor 5m
[x]	[ ]	[ ]	Redox (ORP) sensor 5m
[x]	[ ]	[ ]	Battery charger: 240V AC to 12V DC 200mA
[x]	[ ]	[ ]	Instruction Manual
[x]	[ ]	[ ]	Quick Guide
[x]	[ ]	[ ]	Syringe with storage solution for pH & ORP sensors
[x]	[ ]	[ ]	Carry Case
[ ]	[ ]	[ ]	
[ ]	[ ]	[ ]	

Processors Signature/ Initials [signature]

EE Quote Reference	7705	Condition on return
Customer Ref		
Equipment ID	90FLMV T -	
Equipment serial no.		
Return Date	/ /	
Return Time		

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Head Office Fax: +61-3-9646-4195
Internet: www.rentals.enviroequip.com

URS

Project Notes

Subject: Santos Stream Assess.

By: H. Frock

Date:

Verified By:

Date: 30-6-08.

Project/Task No:

File Structure/Doc No:

Date:

Sheet of

30/6/08.

EC + pH Calibration check.

90 FLTWA1

EC - standard = 1413 μS @ 25°

Reading = 1480 @ 13.9°C

pH - standard = pH 4

Reading = 4.06

90 FLT SA

EC - standard = 1413μS @ 25°

Reading = 1217 @ 8.8°C

pH - standard = pH 4

Reading = 3.87

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☐ pH
Conductivity	☑ 0.0mS/cm	☑ 2.76mS/cm	☐ 12.88mS/cm	☐ 58.6mS/cm	☐ mS/cm
TDS	☑ 0 ppk	☑ 36 ppk	☐ ppk		
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☑ 100% Saturation in Air	
Redox (ORP)**	☑ Electrode operability test 240mV +/- 10%. Actual: 236 mV				
Turbidity	☑ 0NTU	☑ 900NTU			
Temperature	☑				

☑ Electrodes cleaned/checked ☑ Charged 8.12 v (min 7.2V)

* Calibration solution traceability information is available upon request.
** This meter uses an Ag/AgCl ORP electrode. To convert readings to SHE (Standard Hydrogen Electrode), add 199mV to the mV reading. For further information, refer to www.enviroequip.com/quipnotes/ORP.htm.

Date: 18 Jun 08 Checked by: Howard

Signed: HJones

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $30 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 8.12 ✓
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Redox (ORP) sensor 5m
☑	☐	☐	Turbidity sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	

Processors Signature/ Initials HJones 18 Jun 08

EE Quote Reference	8602	Condition on return
Customer Ref	TBC	
Equipment ID	90FLTWA1	
Equipment serial no.	U4348	
Return Date	/ /	
Return Time		

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	pH 6.88	✓ pH 7.00	✓ pH 4.00	pH 10.00	pH
Conductivity	✓ 0.0mS/cm	✓ 2.76mS/cm	12.88mS/cm	58.6mS/cm	mS/cm
TDS	✓ 0.0 ppk	✓ 36 ppk	ppk		
Turbidity	✓ 0.0 NTU	90NTU	✓ 360NTU	____NTU	
Dissolved Oxygen	✓ 0.00ppm in Sodium Sulphite			✓ 100% Saturation in Air	
Temperature	✓				

✓ Electrodes cleaned/checked ✓ Charged 8.3v (min 7.2V)

* Calibration solution traceability information is available upon request.

Date: 19.06.08 Checked by: PEPE

Signed: [signature]

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
✓			90FLT Unit. Ops check / Battery Voltage @ 8.3
✓			pH sensor 5m
✓			Conductivity / TDS / Temperature k=10 sensor 5m
✓			Dissolved Oxygen YSI5739 sensor 5m
✓			Turbidity sensor 5m
✓			Battery charger: 240V AC to 12V DC 200mA
✓			Instruction Manual
✓			Quick Guide
✓			Syringe with storage solution for pH & ORP sensors
✓			Carry Case

Processors Signature/ Initials [signature]

EE Quote Reference	8602	Condition on return
Customer Ref	391961	
Equipment ID	90FLTSA	
Equipment serial no.	T5471	
Return Date	03/07/08	
Return Time		

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ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☑ pH
Conductivity	☑ 0.0mS/cm	☐ 2.76mS/cm	☐ 12.88mS/cm	☑ 58.6mS/cm	☑ mS/cm
TDS	☑ 0.0 ppk	☑ 36 ppk	☑ ppk	Redox	☑ 25 mV
Turbidity	☐ 0.0 NTU	☐ 90NTU	☐ 360NTU	☐ ____NTU	
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☑ 100% Saturation in Air	

☑ Electrodes cleaned/checked ☑ Charged 8.16 v (min 7.2V) ☑ Temperature

* Calibration solution traceability information is available upon request.

Date: 29th July 2008 Checked by: PETER H

Signed: [signature]

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 8.24V
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Turbidity sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials [signature]

EE Quote Reference	9541	Condition on return
Customer Ref		
Equipment ID	90FLT MA	
Equipment serial no.		
Return Date	/ /	
Return Time		

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Full Statistics of Associated Water Quality – Fairview and Roma Fields

Appendix E

Fairview Field Associated Water Quality Statistics (all unit mg/L unless specified)

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
pH	1702	8.5165	0.00952	0.3928	5.0000	8.3000	8.6000	8.7600	10.0000
Colour - True	2	0.880	0.120	0.170	0.760	*	0.880	*	1.000
Conductivity	3929	2422	52.5	3290	0.0	1419	1840	2458	121800
Resistivity	309	6.089	0.197	3.464	0.008	4.760	6.020	7.190	41.700
Total Dissolved Salt	122	2425	437	4824	87	905	1168	1774	29248
Total Dissolved Solids	57	2862	427	3227	114	1420	2000	2985	16350
Total Dissolved Solids:	1201	1218.8	22.5	779.6	0.0	843.2	975.1	1285.6	9241.2
Total Dissolved Solids:	309	1299.7	46.7	821.7	146.0	895.0	1070.0	1350.0	7000.0
Dissolved O2	127	4.244	0.129	1.456	1.000	3.400	4.100	5.000	11.950
Turbidity	4	1.025	0.494	0.988	0.100	0.225	0.800	2.050	2.400
Redox Potential	127	93.62	5.01	56.48	3.30	47.70	89.50	139.90	247.00
Chemical Oxygen Demand	54	484	152	1115	5	23	72	546	7300
Specific Gravity	6	1.000	0.365	0.894	0.000	0.000	1.000	2.000	2.000
Suspended Solids	192	2403	740	10257	5	5	10	209	87307
Total Residue	1	0.90000	*	*	0.90000	*	0.90000	*	0.90000
Aggressive CO2	193	1.363	0.123	1.712	1.000	1.000	1.000	1.000	16.000
Free CO2	193	5.326	0.606	8.413	1.000	2.000	3.000	5.000	72.000
Tot Alkalinity	566	958.7	21.6	513.2	18.3	750.8	861.5	1040.0	6430.2
Bicarbonate Alkalinity	608	862.5	14.9	367.5	18.0	691.0	788.0	958.8	4554.0
Carbonate Alkalinity	605	76.84	7.84	192.73	1.00	36.00	60.00	88.00	4039.00
Hydroxide Alkalinity	558	3.96	2.21	52.30	1.00	1.00	1.00	1.00	1130.00
Residual Alkali	2	20.50	9.40	13.29	11.10	*	20.50	*	29.90
Alkalinity-Phenolp	48	40.04	9.97	69.10	1.00	20.40	30.35	38.63	501.18
Total Hardness	310	5.396	0.336	5.919	1.000	2.000	4.000	7.000	73.000
Carbonate Hardness	5	1.60	1.60	3.58	0.00	0.00	0.00	4.00	8.00
Non-Carbonate Hardness	4	0.1500	0.0289	0.0577	0.1000	0.1000	0.1500	0.2000	0.2000
Ammonia N	426	0.5399	0.0308	0.6356	0.0040	0.3200	0.4125	0.5845	7.8500
Nitrate	171	0.171	0.133	1.744	0.010	0.010	0.010	0.030	22.800
Nitrate N by FIA (Calc)	236	0.01995	0.00221	0.03402	0.01000	0.01000	0.01000	0.01000	0.33300
Nitrite	49	0.002204	0.000167	0.001172	0.002000	0.002000	0.002000	0.002000	0.010000
Nitrite N by FIA	140	0.03834	0.00543	0.06421	0.00200	0.02000	0.02000	0.02000	0.46000
Nitrite N for NO3 only (	48	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Nitrite+Nitrate as N	196	0.03962	0.00552	0.07727	0.00200	0.00525	0.02000	0.02000	0.47000
NOX for NO3 only (Calc)	48	0.01688	0.00336	0.02329	0.00200	0.00425	0.00900	0.01875	0.13900
Total Organic Carbon as	64	95.0	30.8	246.6	0.5	7.6	21.0	61.0	1785.0
Dissolved Organic Carbon	64	31.9	16.8	134.8	0.5	1.1	3.4	7.0	980.0
Aluminium	411	6.01	2.05	41.53	0.01	0.02	0.09	0.22	580.00
Antimony	11	0.001818	0.000818	0.002714	0.001000	0.001000	0.001000	0.001000	0.010000
Arsenic	410	0.01778	0.00247	0.05008	0.00100	0.00500	0.01000	0.01000	0.62900
Barium	68	2.321	0.975	8.037	0.041	0.281	0.604	1.887	65.165
Beryllium	391	0.006870	0.000519	0.010254	0.001000	0.005000	0.005000	0.010000	0.150000
Boron as B	430	0.8595	0.0374	0.7758	0.0200	0.5160	0.7105	1.0193	11.5370
Bromide	57	2.190	0.489	3.691	0.100	0.300	0.900	2.200	20.000
Cadmium	427	0.002659	0.000340	0.007029	0.000100	0.001000	0.001000	0.005000	0.131000
Calcium	608	10.16	2.67	65.93	0.14	1.00	1.20	2.46	1137.24
Chloride	359	171.2	19.0	360.4	1.0	20.0	55.0	125.0	2640.0
Chromium	405	0.02601	0.00631	0.12693	0.00100	0.00100	0.00100	0.01000	1.19600
Cobalt	384	0.01177	0.00250	0.04890	0.00100	0.00200	0.00200	0.01000	0.61700
Copper	434	0.235	0.103	2.139	0.001	0.002	0.005	0.020	30.806
Cyanide	10	0.010000	0.000000	0.000000	0.010000	0.010000	0.010000	0.010000	0.010000
Fluoride by ISE	602	2.2193	0.0586	1.4379	0.0500	1.4000	1.9000	2.7125	16.6400
Iron	605	20.88	5.66	139.28	0.01	0.10	0.27	0.81	2300.00
Iron (Soluble)	57	0.914	0.419	3.165	0.005	0.091	0.226	0.647	23.810
Lead	323	0.0652	0.0102	0.1827	0.0010	0.0050	0.0090	0.0400	2.1800
Lithium	1	0.030000	*	*	0.030000	*	0.030000	*	0.030000
Magnesium	564	3.028	0.770	18.292	0.100	0.897	1.000	1.000	296.114
Manganese	432	0.724	0.225	4.670	0.001	0.004	0.010	0.022	57.000
Manganese (Soluble)	56	0.289	0.263	1.969	0.001	0.006	0.016	0.031	14.760
Mercury	408	0.05195	0.00687	0.13869	0.00010	0.00010	0.00060	0.10000	1.40103
Molybdenum	413	0.01053	0.00116	0.02357	0.00100	0.00500	0.00500	0.01000	0.35800
Nickel	414	0.02055	0.00475	0.09655	0.00100	0.00200	0.00300	0.01000	1.23500
Phosphorous	180	0.05683	0.00834	0.11184	0.01000	0.02000	0.04000	0.06000	1.41000
Ortho Phosphorus	243	0.05565	0.00458	0.07137	0.00200	0.02000	0.02800	0.06400	0.64400
Potassium	608	121.7	64.8	1596.8	0.5	2.0	2.4	4.6	33915.5
Selenium	394	0.009553	0.000579	0.011489	0.003000	0.005000	0.010000	0.010000	0.125000
Silica	62	66.68	9.88	77.81	6.24	23.64	37.67	80.73	467.80
Silver	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Sodium	560	619.8	25.7	608.0	2.1	366.3	466.2	657.0	9402.8
Sodium Adsorption Ratio	358	149.6	14.9	281.8	2.9	84.6	106.0	122.0	2160.5
Strontium	70	2.499	0.714	5.971	0.029	0.359	0.902	2.225	45.600
Sulphate	3	1.500	0.500	0.866	1.000	1.000	1.000	2.500	2.500
Sulphide	9	0.10000	0.000000	0.000000	0.10000	0.10000	0.10000	0.10000	0.10000
Sulphur as SO4	559	4.371	0.913	21.580	1.000	1.000	2.000	2.000	393.436
Tellurium	1	0.000500	*	*	0.000500	*	0.000500	*	0.000500
Variable	**N**	**Mean**	**SE Mean**	**StDev**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
Thallium	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000

Total Cyanide	10	0.010000	0.000000	0.000000	0.010000	0.010000	0.010000	0.010000	0.010000
Uranium	141	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Vanadium	382	0.02487	0.00859	0.16779	0.00500	0.00500	0.00500	0.01000	2.30100
Zinc	441	0.1127	0.0273	0.5734	0.0010	0.0060	0.0180	0.0600	8.3580
Colif. (MF)	17	1.235	0.235	0.970	1.000	1.000	1.000	1.000	5.000
Colif. Faecal	6	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
Colif. Pres	10	1.700	0.700	2.214	1.000	1.000	1.000	1.000	8.000
Coliforms Faecal (MF)	11	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
Escherichia coli	16	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
1,2,4 Trimethylbenzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
1,3,5 Trimethylbenzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
2,3,4,6 Tetrachloropheno	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
2,4 Dichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4 Dimethylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4,5 Trichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4,6 Trichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,6 Dichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Chlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Methylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Nitrophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
3 & 4 Methylphenol	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
4-Chloro-3-Methylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Acenaphthalene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Acenaphthene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benz(a)anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benzene	49	1.0000	0.0291	0.2040	0.0010	1.0000	1.0000	1.0000	2.0000
Benzo(a)pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benzo(b)&(k)fluoranthene	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Benzo(g,h,i)perylene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
C10-C14 Fraction	49	0.0643	0.0133	0.0930	0.0500	0.0500	0.0500	0.0500	0.7000
C15-C28 Fraction	49	0.1420	0.0807	0.5651	0.0500	0.0500	0.0500	0.0500	4.0000
C29-C36 Fraction	49	0.0616	0.0106	0.0745	0.0500	0.0500	0.0500	0.0500	0.5700
C6-C9 Fraction	49	0.010204	0.000204	0.001429	0.010000	0.010000	0.010000	0.010000	0.020000
Chlorobenzene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000
Chrysene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Dibenz(a,h)anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Ethyl Benzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
HPC	17	478	226	933	1	2	10	510	2800
Ideno(1,2,3-cd)pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
meta & para-Xylene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000
Fluoranthene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Fluorene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Naphthalene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Ortho-Xylene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
PCB	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
PCB by Aroclor	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Pentachlorophenol	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Phenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Phenanthrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Polyaromatic Hydroca	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Speciated Phenols	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Toluene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000

Note – Nutrient (NOx) results removed due to uncertainties in analytical methods and reporting standards (see below):

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Nitrate	171	0.171	0.133	1.744	0.010	0.010	0.010	0.030	22.800
Nitrate N by FIA (Calc)	236	0.01995	0.00221	0.03402	0.01000	0.01000	0.01000	0.01000	0.33300
Nitrite	49	0.002204	0.000167	0.001172	0.002000	0.002000	0.002000	0.002000	0.010000
Nitrite N by FIA	140	0.03834	0.00543	0.06421	0.00200	0.02000	0.02000	0.02000	0.46000
Nitrite N for NO3 only (	48	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Nitrite+Nitrate as N	196	0.03962	0.00552	0.07727	0.00200	0.00525	0.02000	0.02000	0.47000
NOX for NO3 only (Calc)	48	0.01688	0.00336	0.02329	0.00200	0.00425	0.00900	0.01875	0.13900

Full Statistics of Associated Water Quality – Fairview and Roma Fields

Appendix E

Roma Field Associated Water Quality Statistics (all units mg/L unless specified)

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Top Depth (m RT)	66	305.9	22.3	180.8	99.0	142.0	293.0	305.0	782.3
Bottom Depth (m RT)	92	545.0	15.8	151.3	150.0	409.0	575.0	665.2	857.0
Na	103	855.6	35.5	359.9	233.0	630.0	792.0	950.0	1980.0
K	103	710	178	1807	2	4	47	769	14800
Ca	103	112.6	21.7	220.7	0.5	3.0	10.1	73.4	870.0
Mg	101	26.39	5.20	52.23	0.10	0.90	4.00	24.00	290.00
Fe	80	121.6	27.9	249.9	0.0	0.1	3.0	117.5	1200.0
Sr	57	9.47	1.95	14.68	0.33	1.01	2.45	9.94	66.00
Ba	7	0.2804	0.0479	0.1266	0.1350	0.2230	0.2460	0.3090	0.5410
Cl	103	1614	399	4046	78	555	701	1130	39200
HCO3	103	842.6	33.7	341.9	10.0	651.0	821.0	991.0	1864.0
CO3	103	75.60	7.32	74.26	0.90	28.00	58.00	95.00	436.00
SO4	103	16.76	3.48	35.31	0.90	1.66	4.00	18.00	244.00
F	100	2.650	0.765	7.654	0.000	1.162	2.000	2.797	77.869
NO3 (Nitrite+Nitrate)	34	0.0479	0.0187	0.1091	0.0020	0.0090	0.0190	0.0200	0.6000
OH	103	1.2087	0.0943	0.9567	0.9000	0.9000	1.0000	1.0000	7.0000
Conductivity uS/cm @25 C	103	7065	1472	14943	1200	3200	3610	6200	115000
Resistivity ohm.m@25 C	54	2.625	0.134	0.986	0.110	2.428	2.799	3.125	4.630
Reaction - pH	102	8.6361	0.0582	0.5875	5.1000	8.4425	8.7000	8.9000	9.7000
TDS(EC)	97	3964	704	6935	740	1918	2300	4040	66000
TDS (HCO3=CO3)	31	5819	2254	12547	1390	1840	2180	4810	71300

Condamine-Balonne Catchment Water Quality Data

Appendix A

Upper Dawson Catchment Water Quality Data

Appendix B

Comet-Brown Catchment Water Quality Data

Appendix C

Calibration Certificates & Records

Appendix D

Full Statistics of Associated Water Quality – Fairview and Roma Fields

Appendix E

Fairview Field Associated Water Quality Statistics (all unit mg/L unless specified)

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
pH	1702	8.5165	0.00952	0.3928	5.0000	8.3000	8.6000	8.7600	10.0000
Colour - True	2	0.880	0.120	0.170	0.760	*	0.880	*	1.000
Conductivity	3929	2422	52.5	3290	0.0	1419	1840	2458	121800
Resistivity	309	6.089	0.197	3.464	0.008	4.760	6.020	7.190	41.700
Total Dissolved Salt	122	2425	437	4824	87	905	1168	1774	29248
Total Dissolved Solids	57	2862	427	3227	114	1420	2000	2985	16350
Total Dissolved Solids:	1201	1218.8	22.5	779.6	0.0	843.2	975.1	1285.6	9241.2
Total Dissolved Solids:	309	1299.7	46.7	821.7	146.0	895.0	1070.0	1350.0	7000.0
Dissolved O2	127	4.244	0.129	1.456	1.000	3.400	4.100	5.000	11.950
Turbidity	4	1.025	0.494	0.988	0.100	0.225	0.800	2.050	2.400
Redox Potential	127	93.62	5.01	56.48	3.30	47.70	89.50	139.90	247.00
Chemical Oxygen Demand	54	484	152	1115	5	23	72	546	7300
Specific Gravity	6	1.000	0.365	0.894	0.000	0.000	1.000	2.000	2.000
Suspended Solids	192	2403	740	10257	5	5	10	209	87307
Total Residue	1	0.90000	*	*	0.90000	*	0.90000	*	0.90000
Aggressive CO2	193	1.363	0.123	1.712	1.000	1.000	1.000	1.000	16.000
Free CO2	193	5.326	0.606	8.413	1.000	2.000	3.000	5.000	72.000
Tot Alkalinity	566	958.7	21.6	513.2	18.3	750.8	861.5	1040.0	6430.2
Bicarbonate Alkalinity	608	862.5	14.9	367.5	18.0	691.0	788.0	958.8	4554.0
Carbonate Alkalinity	605	76.84	7.84	192.73	1.00	36.00	60.00	88.00	4039.00
Hydroxide Alkalinity	558	3.96	2.21	52.30	1.00	1.00	1.00	1.00	1130.00
Residual Alkali	2	20.50	9.40	13.29	11.10	*	20.50	*	29.90
Alkalinity-Phenolp	48	40.04	9.97	69.10	1.00	20.40	30.35	38.63	501.18
Total Hardness	310	5.396	0.336	5.919	1.000	2.000	4.000	7.000	73.000
Carbonate Hardness	5	1.60	1.60	3.58	0.00	0.00	0.00	4.00	8.00
Non-Carbonate Hardness	4	0.1500	0.0289	0.0577	0.1000	0.1000	0.1500	0.2000	0.2000
Ammonia N	426	0.5399	0.0308	0.6356	0.0040	0.3200	0.4125	0.5845	7.8500
Nitrate	171	0.171	0.133	1.744	0.010	0.010	0.010	0.030	22.800
Nitrate N by FIA (Calc)	236	0.01995	0.00221	0.03402	0.01000	0.01000	0.01000	0.01000	0.33300
Nitrite	49	0.002204	0.000167	0.001172	0.002000	0.002000	0.002000	0.002000	0.010000
Nitrite N by FIA	140	0.03834	0.00543	0.06421	0.00200	0.02000	0.02000	0.02000	0.46000
Nitrite N for NO3 only (	48	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Nitrite+Nitrate as N	196	0.03962	0.00552	0.07727	0.00200	0.00525	0.02000	0.02000	0.47000
NOX for NO3 only (Calc)	48	0.01688	0.00336	0.02329	0.00200	0.00425	0.00900	0.01875	0.13900
Total Organic Carbon as	64	95.0	30.8	246.6	0.5	7.6	21.0	61.0	1785.0
Dissolved Organic Carbon	64	31.9	16.8	134.8	0.5	1.1	3.4	7.0	980.0
Aluminium	411	6.01	2.05	41.53	0.01	0.02	0.09	0.22	580.00
Antimony	11	0.001818	0.000818	0.002714	0.001000	0.001000	0.001000	0.001000	0.010000
Arsenic	410	0.01778	0.00247	0.05008	0.00100	0.00500	0.01000	0.01000	0.62900
Barium	68	2.321	0.975	8.037	0.041	0.281	0.604	1.887	65.165
Beryllium	391	0.006870	0.000519	0.010254	0.001000	0.005000	0.005000	0.010000	0.150000
Boron as B	430	0.8595	0.0374	0.7758	0.0200	0.5160	0.7105	1.0193	11.5370
Bromide	57	2.190	0.489	3.691	0.100	0.300	0.900	2.200	20.000
Cadmium	427	0.002659	0.000340	0.007029	0.000100	0.001000	0.001000	0.005000	0.131000
Calcium	608	10.16	2.67	65.93	0.14	1.00	1.20	2.46	1137.24
Chloride	359	171.2	19.0	360.4	1.0	20.0	55.0	125.0	2640.0
Chromium	405	0.02601	0.00631	0.12693	0.00100	0.00100	0.00100	0.01000	1.19600
Cobalt	384	0.01177	0.00250	0.04890	0.00100	0.00200	0.00200	0.01000	0.61700
Copper	434	0.235	0.103	2.139	0.001	0.002	0.005	0.020	30.806
Cyanide	10	0.010000	0.000000	0.000000	0.010000	0.010000	0.010000	0.010000	0.010000
Fluoride by ISE	602	2.2193	0.0586	1.4379	0.0500	1.4000	1.9000	2.7125	16.6400
Iron	605	20.88	5.66	139.28	0.01	0.10	0.27	0.81	2300.00
Iron (Soluble)	57	0.914	0.419	3.165	0.005	0.091	0.226	0.647	23.810
Lead	323	0.0652	0.0102	0.1827	0.0010	0.0050	0.0090	0.0400	2.1800
Lithium	1	0.030000	*	*	0.030000	*	0.030000	*	0.030000
Magnesium	564	3.028	0.770	18.292	0.100	0.897	1.000	1.000	296.114
Manganese	432	0.724	0.225	4.670	0.001	0.004	0.010	0.022	57.000
Manganese (Soluble)	56	0.289	0.263	1.969	0.001	0.006	0.016	0.031	14.760
Mercury	408	0.05195	0.00687	0.13869	0.00010	0.00010	0.00060	0.10000	1.40103
Molybdenum	413	0.01053	0.00116	0.02357	0.00100	0.00500	0.00500	0.01000	0.35800
Nickel	414	0.02055	0.00475	0.09655	0.00100	0.00200	0.00300	0.01000	1.23500
Phosphorous	180	0.05683	0.00834	0.11184	0.01000	0.02000	0.04000	0.06000	1.41000
Ortho Phosphorus	243	0.05565	0.00458	0.07137	0.00200	0.02000	0.02800	0.06400	0.64400
Potassium	608	121.7	64.8	1596.8	0.5	2.0	2.4	4.6	33915.5
Selenium	394	0.009553	0.000579	0.011489	0.003000	0.005000	0.010000	0.010000	0.125000
Silica	62	66.68	9.88	77.81	6.24	23.64	37.67	80.73	467.80
Silver	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Sodium	560	619.8	25.7	608.0	2.1	366.3	466.2	657.0	9402.8
Sodium Adsorption Ratio	358	149.6	14.9	281.8	2.9	84.6	106.0	122.0	2160.5
Strontium	70	2.499	0.714	5.971	0.029	0.359	0.902	2.225	45.600
Sulphate	3	1.500	0.500	0.866	1.000	1.000	1.000	2.500	2.500
Sulphide	9	0.10000	0.000000	0.000000	0.10000	0.10000	0.10000	0.10000	0.10000
Sulphur as SO4	559	4.371	0.913	21.580	1.000	1.000	2.000	2.000	393.436
Tellurium	1	0.000500	*	*	0.000500	*	0.000500	*	0.000500
Variable	**N**	**Mean**	**SE Mean**	**StDev**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
Thallium	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000

Full Statistics of Associated Water Quality – Fairview and Roma Fields

Total Cyanide	10	0.010000	0.000000	0.000000	0.010000	0.010000	0.010000	0.010000	0.010000
Uranium	141	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Vanadium	382	0.02487	0.00859	0.16779	0.00500	0.00500	0.00500	0.01000	2.30100
Zinc	441	0.1127	0.0273	0.5734	0.0010	0.0060	0.0180	0.0600	8.3580
Colif. (MF)	17	1.235	0.235	0.970	1.000	1.000	1.000	1.000	5.000
Colif. Faecal	6	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
Colif. Pres	10	1.700	0.700	2.214	1.000	1.000	1.000	1.000	8.000
Coliforms Faecal (MF)	11	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
Escherichia coli	16	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
1,2,4 Trimethylbenzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
1,3,5 Trimethylbenzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
2,3,4,6 Tetrachloropheno	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
2,4 Dichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4 Dimethylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4,5 Trichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4,6 Trichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,6 Dichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Chlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Methylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Nitrophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
3 & 4 Methylphenol	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
4-Chloro-3-Methylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Acenaphthalene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Acenaphthene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benz(a)anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benzene	49	1.0000	0.0291	0.2040	0.0010	1.0000	1.0000	1.0000	2.0000
Benzo(a)pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benzo(b)&(k)fluoranthene	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Benzo(g,h,i)perylene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
C10-C14 Fraction	49	0.0643	0.0133	0.0930	0.0500	0.0500	0.0500	0.0500	0.7000
C15-C28 Fraction	49	0.1420	0.0807	0.5651	0.0500	0.0500	0.0500	0.0500	4.0000
C29-C36 Fraction	49	0.0616	0.0106	0.0745	0.0500	0.0500	0.0500	0.0500	0.5700
C6-C9 Fraction	49	0.010204	0.000204	0.001429	0.010000	0.010000	0.010000	0.010000	0.020000
Chlorobenzene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000
Chrysene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Dibenz(a,h)anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Ethyl Benzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
HPC	17	478	226	933	1	2	10	510	2800
Ideno(1,2,3-cd)pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
meta & para-Xylene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000
Fluoranthene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Fluorene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Naphthalene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Ortho-Xylene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
PCB	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
PCB by Aroclor	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Pentachlorophenol	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Phenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Phenanthrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Polyaromatic Hydroca	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Speciated Phenols	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Toluene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000

Note – Nutrient (NOx) results removed due to uncertainties in analytical methods and reporting standards (see below):

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Nitrate	171	0.171	0.133	1.744	0.010	0.010	0.010	0.030	22.800
Nitrate N by FIA (Calc)	236	0.01995	0.00221	0.03402	0.01000	0.01000	0.01000	0.01000	0.33300
Nitrite	49	0.002204	0.000167	0.001172	0.002000	0.002000	0.002000	0.002000	0.010000
Nitrite N by FIA	140	0.03834	0.00543	0.06421	0.00200	0.02000	0.02000	0.02000	0.46000
Nitrite N for NO3 only (	48	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Nitrite+Nitrate as N	196	0.03962	0.00552	0.07727	0.00200	0.00525	0.02000	0.02000	0.47000
NOX for NO3 only (Calc)	48	0.01688	0.00336	0.02329	0.00200	0.00425	0.00900	0.01875	0.13900

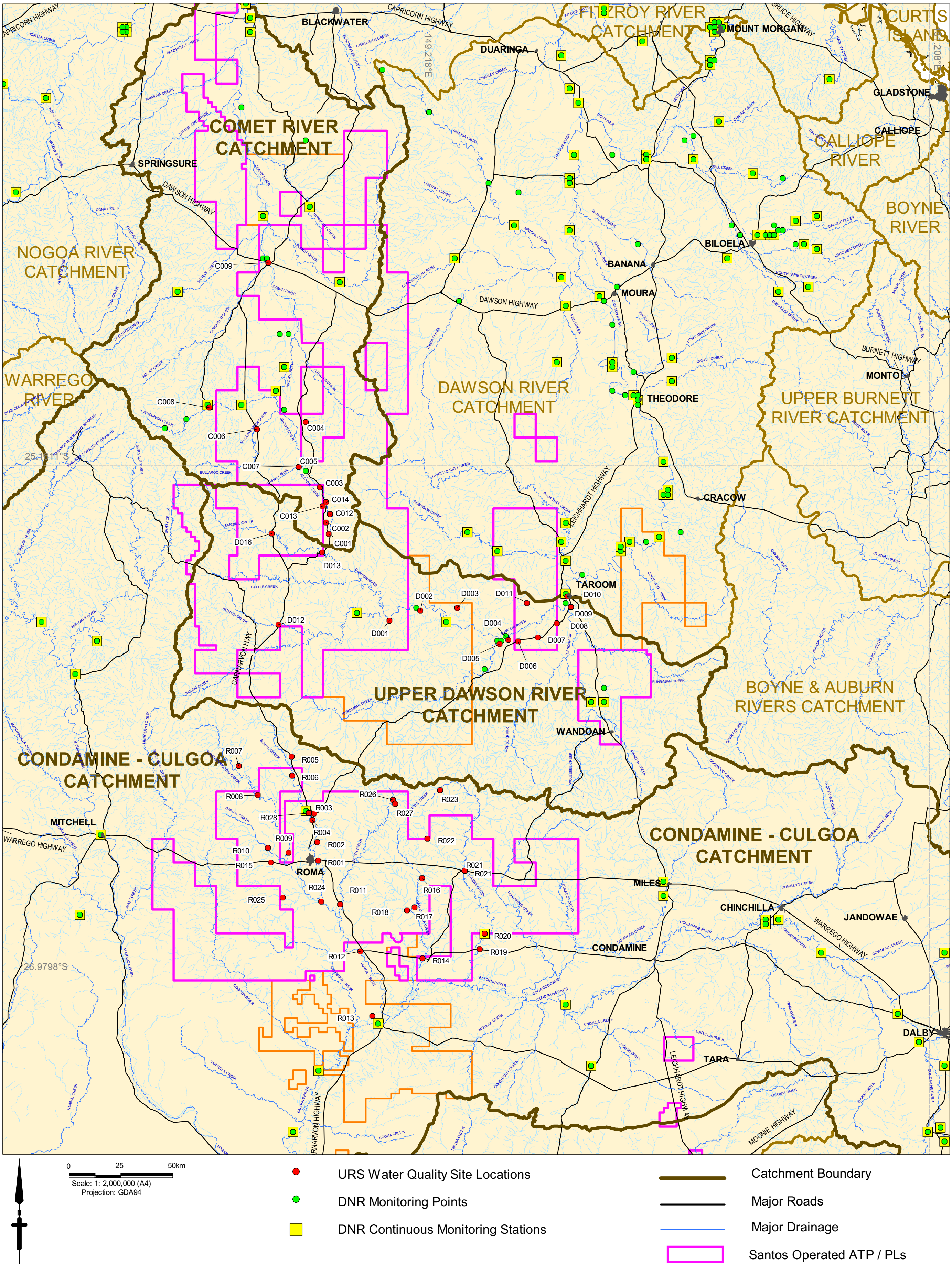
Full Statistics of Associated Water Quality – Fairview and Roma Fields

Appendix E

Roma Field Associated Water Quality Statistics (all units mg/L unless specified)

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Top Depth (m RT)	66	305.9	22.3	180.8	99.0	142.0	293.0	305.0	782.3
Bottom Depth (m RT)	92	545.0	15.8	151.3	150.0	409.0	575.0	665.2	857.0
Na	103	855.6	35.5	359.9	233.0	630.0	792.0	950.0	1980.0
K	103	710	178	1807	2	4	47	769	14800
Ca	103	112.6	21.7	220.7	0.5	3.0	10.1	73.4	870.0
Mg	101	26.39	5.20	52.23	0.10	0.90	4.00	24.00	290.00
Fe	80	121.6	27.9	249.9	0.0	0.1	3.0	117.5	1200.0
Sr	57	9.47	1.95	14.68	0.33	1.01	2.45	9.94	66.00
Ba	7	0.2804	0.0479	0.1266	0.1350	0.2230	0.2460	0.3090	0.5410
Cl	103	1614	399	4046	78	555	701	1130	39200
HCO3	103	842.6	33.7	341.9	10.0	651.0	821.0	991.0	1864.0
CO3	103	75.60	7.32	74.26	0.90	28.00	58.00	95.00	436.00
SO4	103	16.76	3.48	35.31	0.90	1.66	4.00	18.00	244.00
F	100	2.650	0.765	7.654	0.000	1.162	2.000	2.797	77.869
NO3 (Nitrite+Nitrate)	34	0.0479	0.0187	0.1091	0.0020	0.0090	0.0190	0.0200	0.6000
OH	103	1.2087	0.0943	0.9567	0.9000	0.9000	1.0000	1.0000	7.0000
Conductivity uS/cm @25 C	103	7065	1472	14943	1200	3200	3610	6200	115000
Resistivity ohm.m@25 C	54	2.625	0.134	0.986	0.110	2.428	2.799	3.125	4.630
Reaction - pH	102	8.6361	0.0582	0.5875	5.1000	8.4425	8.7000	8.9000	9.7000
TDS(EC)	97	3964	704	6935	740	1918	2300	4040	66000
TDS (HCO3=CO3)	31	5819	2254	12547	1390	1840	2180	4810	71300

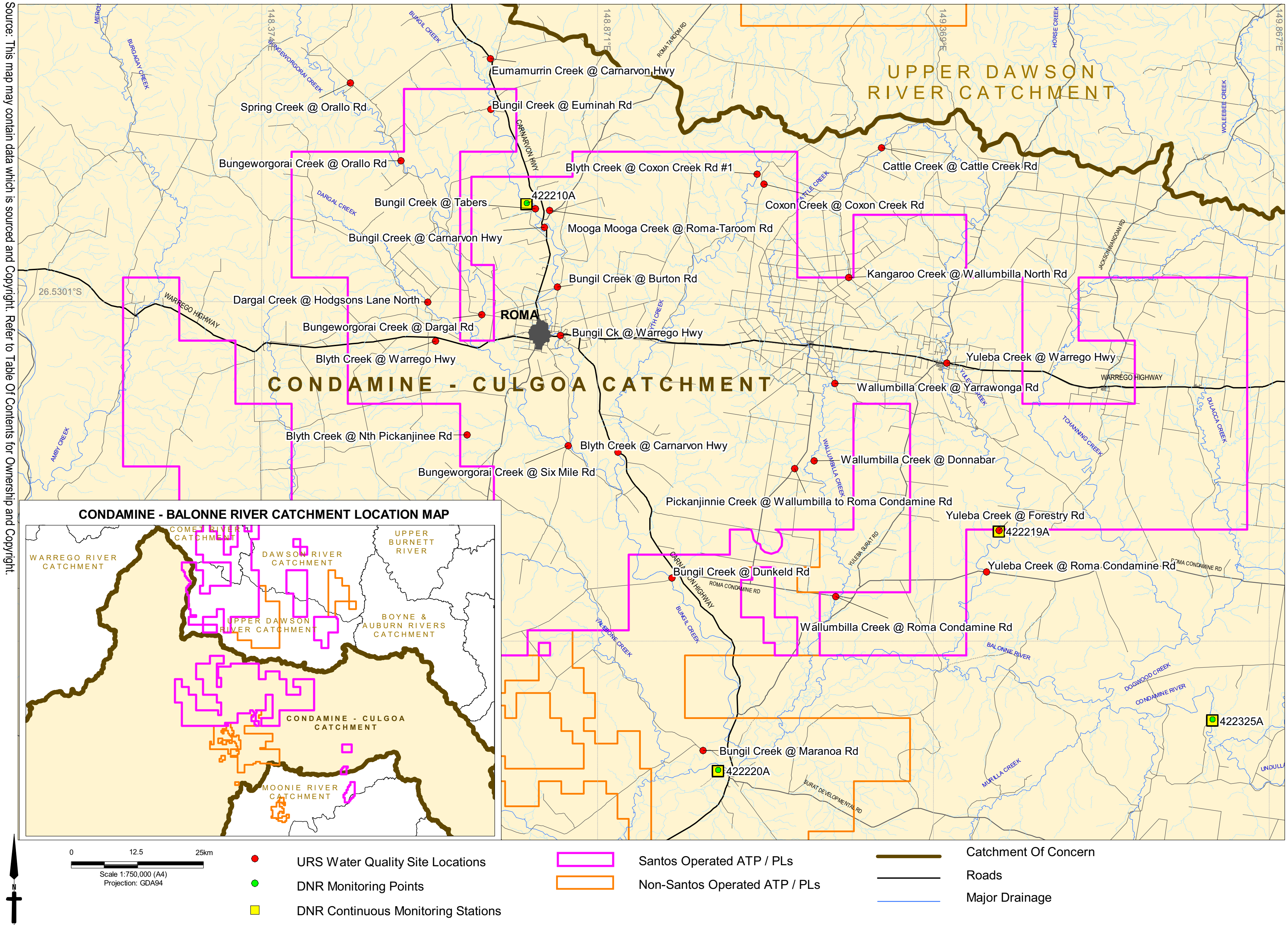
Figures



● (red)	URS Water Quality Site Locations
● (green)	DNR Monitoring Points
■ (yellow)	DNR Continuous Monitoring Stations
	Catchment Boundary
	Major Roads
	Major Drainage
	Santos Operated ATP / PLs
	Non-Santos Operated ATP / PLs

Source: This map may contain data which is sourced and Copyright. Refer to Table Of Contents for Ownership and Copyright.

Client	Project	Title
Santos / URS	GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT	**SURFACE WATER CATCHMENT AREAS AND WATER QUALITY SITE LOCATIONS** (Draft)
	Drawn: CA / Approved: JB / Date: 17-10-2008	Figure: 1 / Rev:A
	Job No: **4262 6220** / File No: 42626220-g-527.wor	A4



Client: Santos LNG / URS

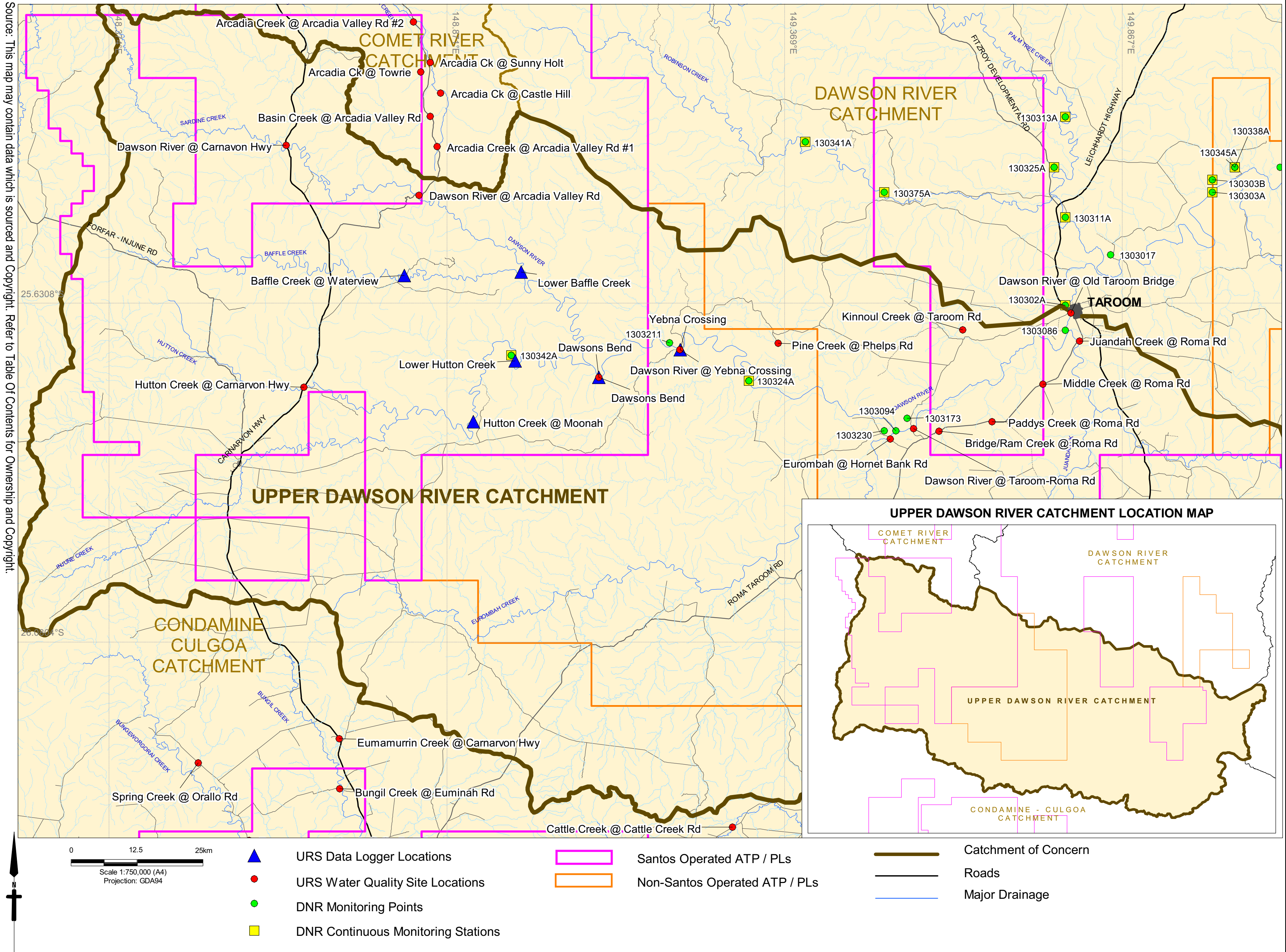
Project: GLADSTONE LNG PROJECT
CSG FIELD SURFACE WATER REPORT

Title: CONDAMINE - BALONNE RIVER CATCHMENT WATER QUALITY SITES AND DNR MONITORING SITES

Drawn: CA | Approved: JB | Date: 17-10-2008

Job No: 4262 6220 | File No: 42626220-g-530.wor

Figure: 2 | Rev: A | A4



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Client: URS / Santos LNG

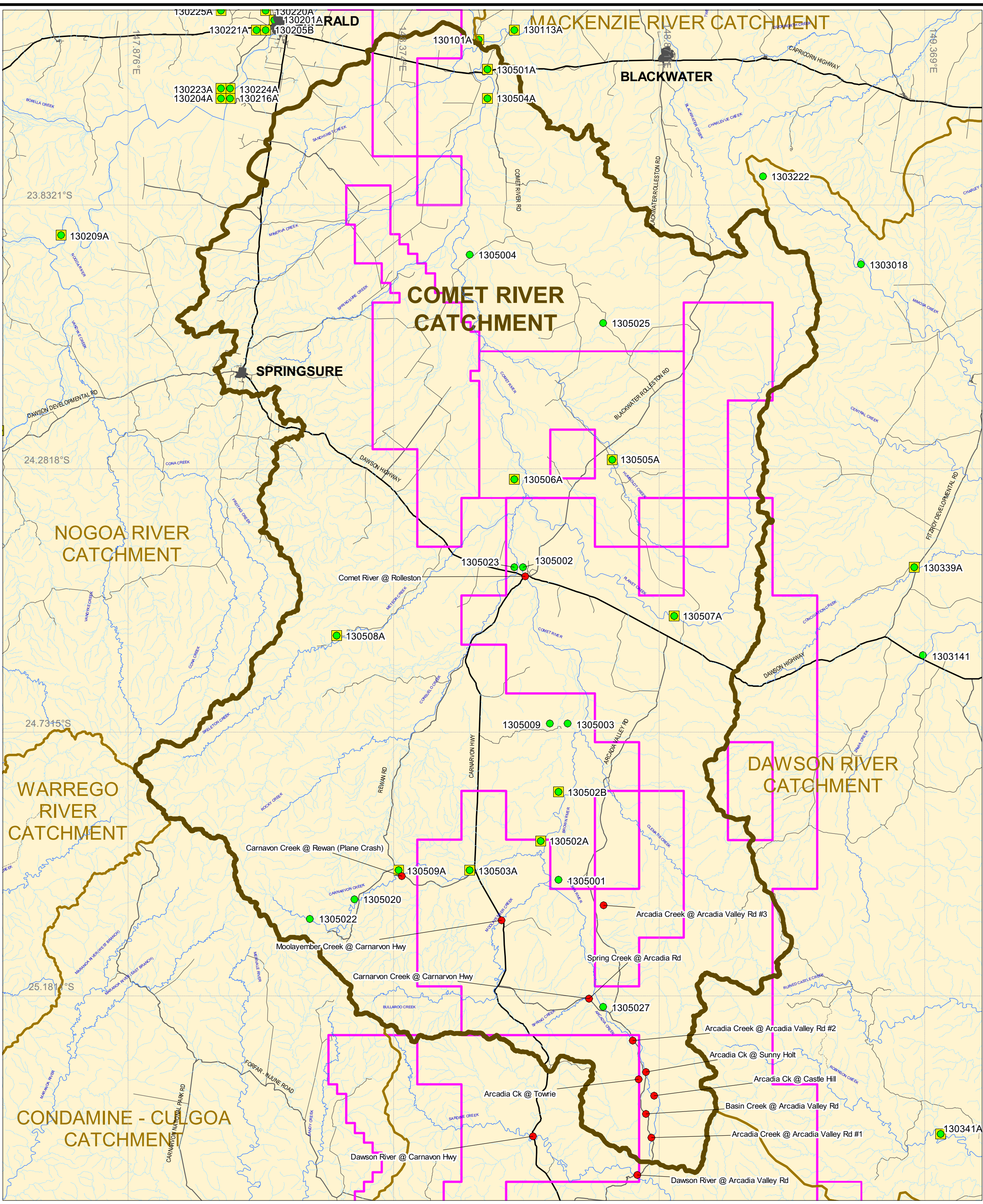
Project: GLADSTONE LNG PROJECT
CSG FIELD SURFACE WATER REPORT

Title: UPPER DAWSON RIVER CATCHMENT WATER QUALITY SITES AND DNR MONITORING SITES

Drawn: CA | Approved: JB | Date: 17-10-2008

Job No: 4262 6220 | File No: 42626220-g-529.wor

Figure: 3 | Rev: A | A4



0 12.5 25km
Scale 1:1,000,000 (A4)
Projection: GDA94

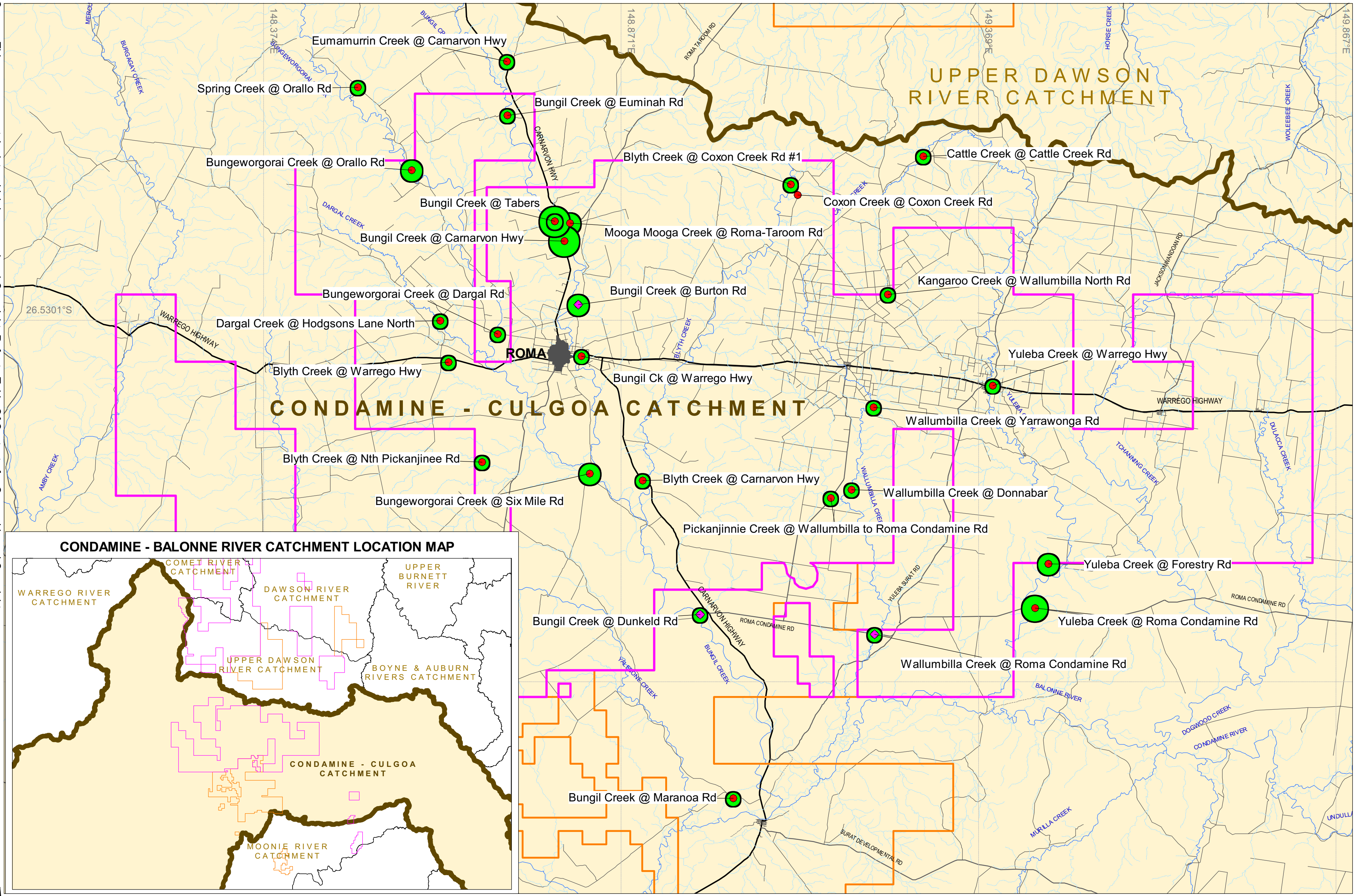
N

- URS Water Quality Site Locations
- DNR Monitoring Points
- DNR Continuous Monitoring Stations
- Catchment Boundary
- Roads
- Major Drainage
- Santos Operated ATP / PLs
- Non-Santos Operated ATP / PLs

Source: This map may contain data which is sourced and Copyright. Refer to Table Of Contents for Ownership and Copyright.

Client	Project	Title
Santos / URS	GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT	COMET RIVER CATCHMENT WATER QUALITY SITES AND DNR MONITORING SITES (Draft)

Drawn: CA	Approved: JB	Date: 17-10-2008	Figure: 4	Rev:A
Job No: **4262 6220**	File No: 42626220-g-528.wor			A4



0 12.5 25km

Scale 1:750,000 (A4)
Projection: GDA94

- Stream Gauging Site (URS, Installed July 2008)
- URS Water Quality Site Locations
- L → H Relative maximum EC Concentration (µS/cm) (From lowest to highest concentration)
- Santos Operated ATP / PLs
- Non-Santos Operated ATP / PLs
- Catchment Of Concern
- Roads
- Major Drainage

Results compiled from DNRW data, URS monitoring (February - August 2008) and information provided by Santos.

Source: This map may contain data which is sourced and Copyright. Refer to Table Of Contents for Ownership and Copyright.

Client: URS / Santos

Project: GLADSTONE LNG PROJECT
CSG FIELD SURFACE WATER REPORT

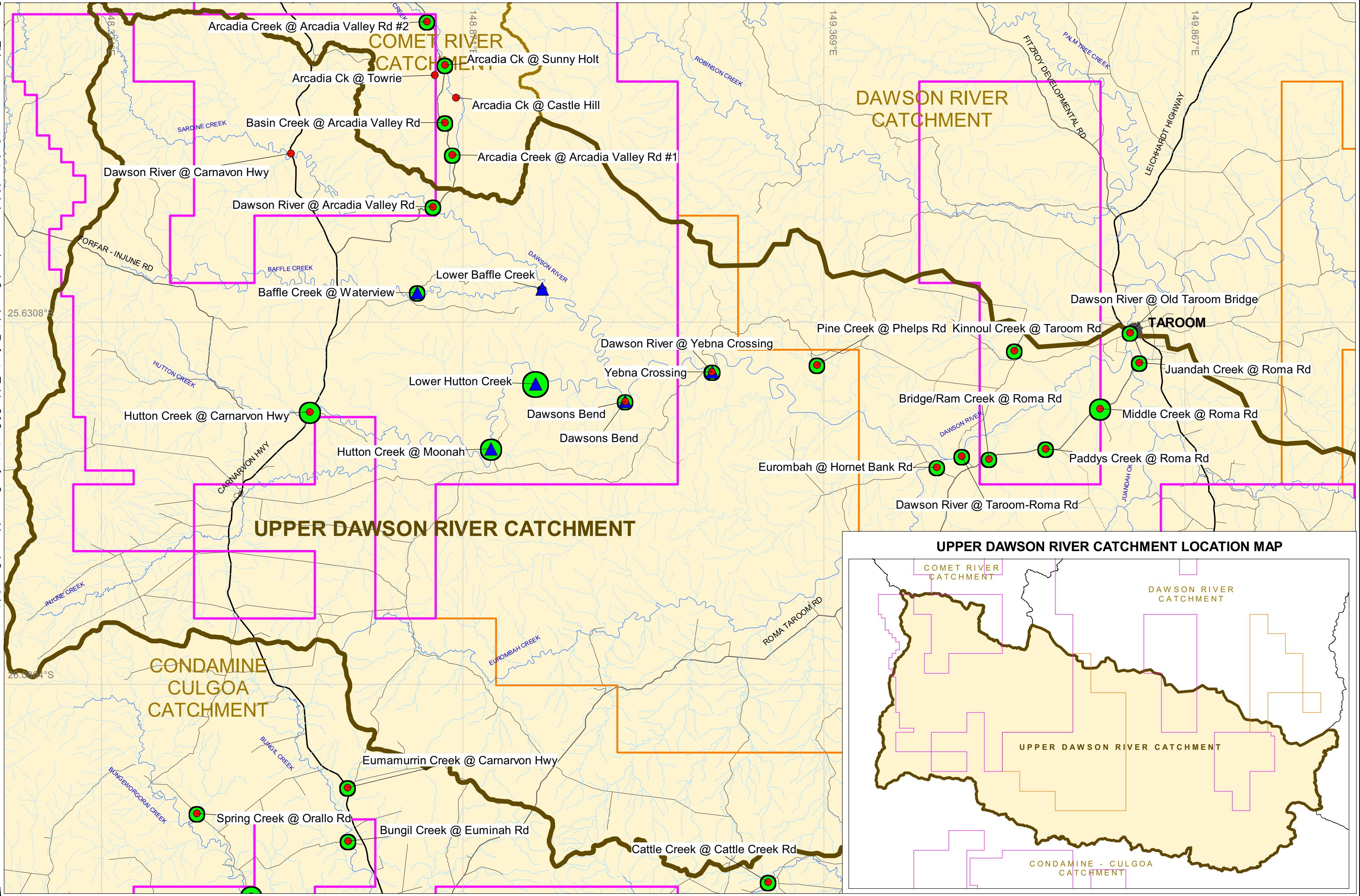
Title: CONDAMINE - BALONNE RIVER CATCHMENT EC CONCENTRATIONS

DRAFT

Drawn: CA | Approved: JB | Date: 17-10-2008

Job No: 4262 6220 | File No: 42626220-g-535.wor

Figure: 5 | Rev: A | A4



0 12.5 25km

Scale 1:750,000 (A4)
Projection: GDA94

- URS Data Logger Locations
- URS Water Quality Site Locations
- Relative maximum EC Concentration (μS/cm) (From lowest to highest concentration) L → H
- Santos Operated ATP / PLs
- Non-Santos Operated ATP / PLs
- Catchment Of Concern
- Roads
- Major Drainage

Results compiled from DNRW data, URS monitoring (February - August 2008) and information provided by Santos.

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Client: URS / Santos GLNG

Project: GLADSTONE LNG PROJECT
CSG FIELD SURFACE WATER REPORT

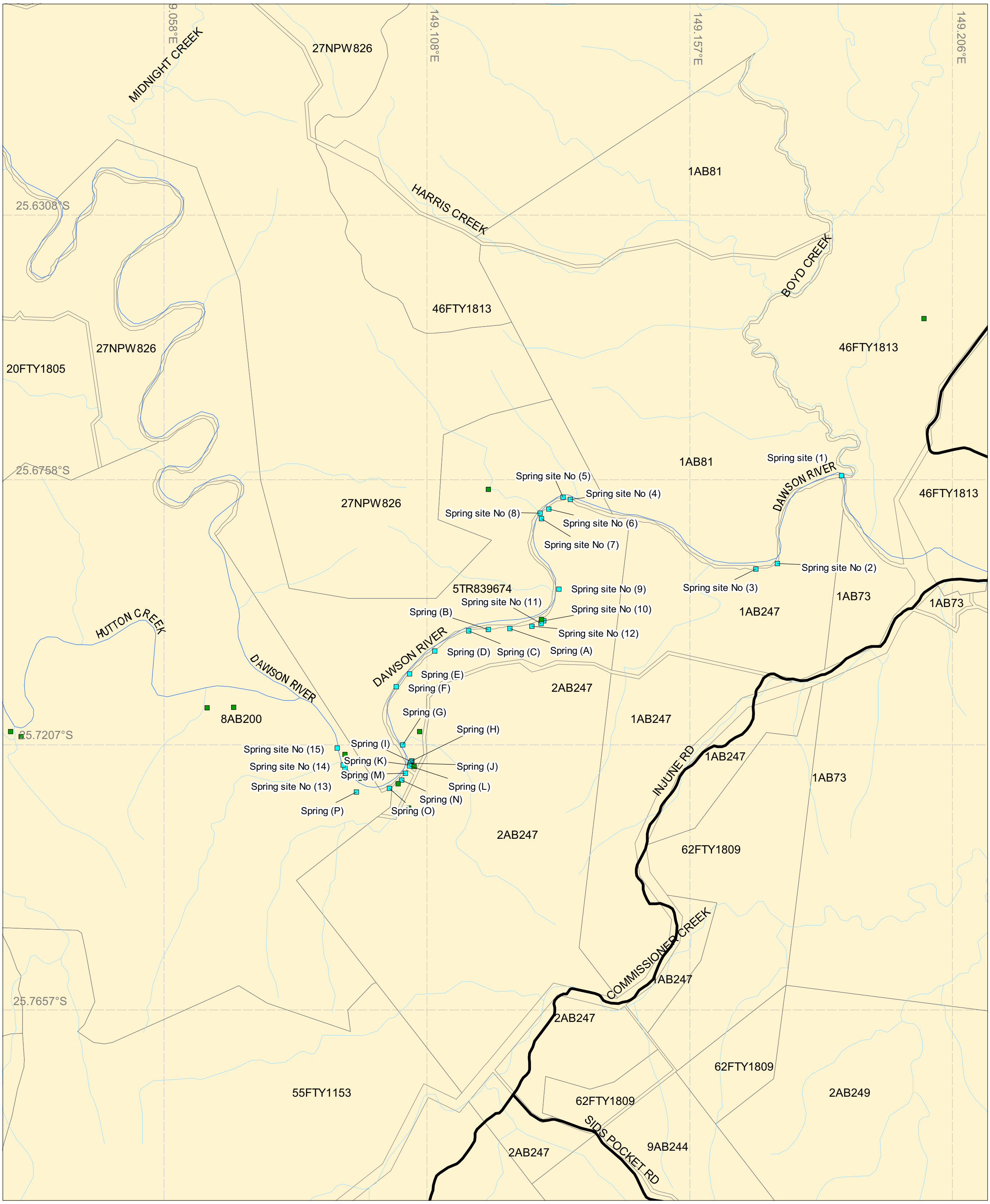
Title: UPPER DAWSON RIVER CATCHMENT
EC CONCENTRATIONS

Draft

Drawn: CA | Approved: JB | Date: 17-10-2008

Job No: 4262 6220 | File No: 42626220-g-533.wor

Figure: 6 | Rev: A | A4



0 1.25 2.5km

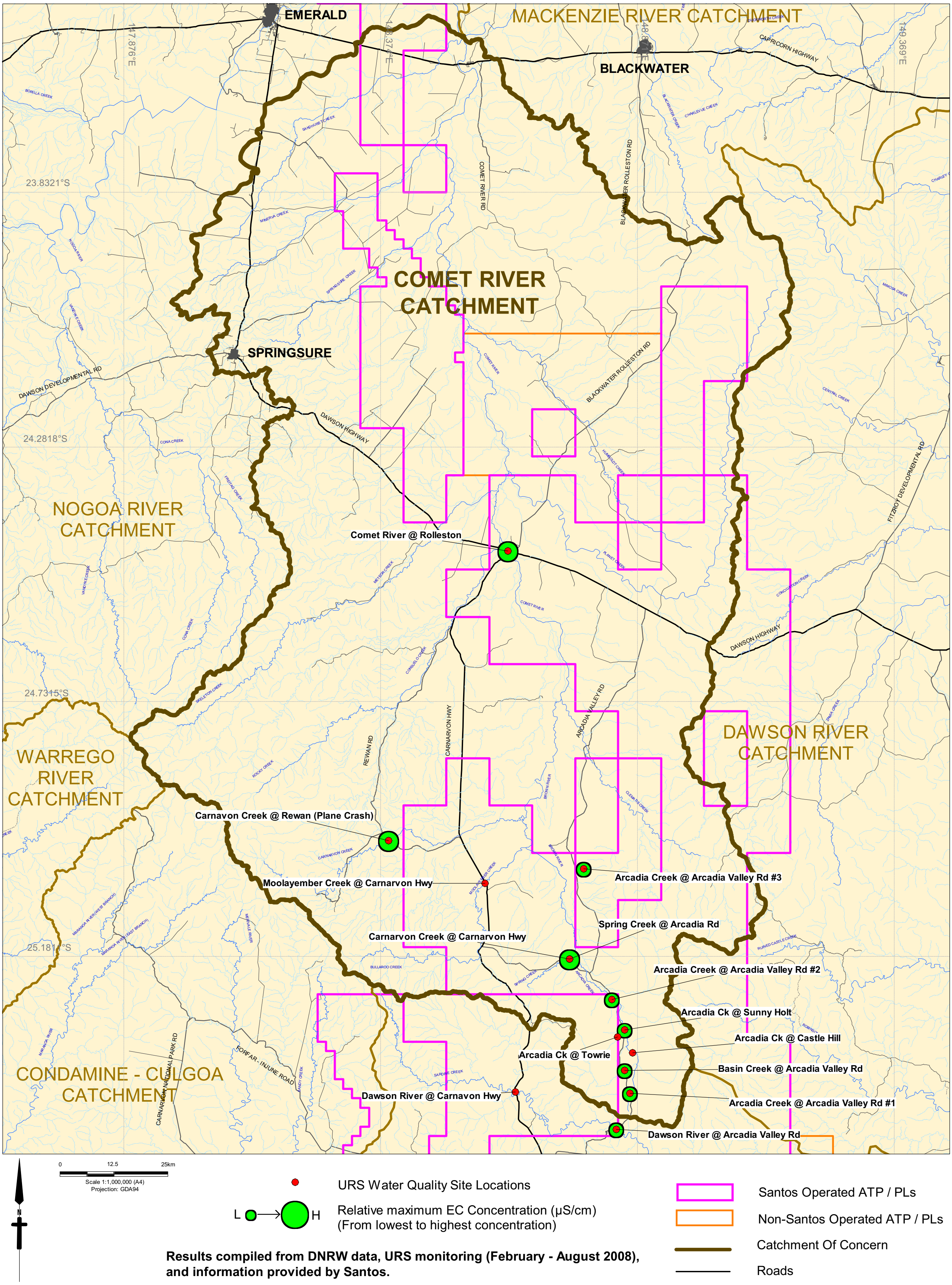
Scale 1:100,000 (A4)
Projection: GDA94

N

(cyan square)	Springs Identified April 2008
(green square)	EPA Listed Active Springs 2006
(orange square)	EPA Listed Inactive Springs 2006
(blue line)	Major Drainage
(black line)	Road

Source: This map may contain data which is sourced and Copyright. Refer to Table Of Contents for Ownership and Copyright.

Client	Project	Title
LNG Santos	GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT	SPRINGS ON DAWSON RIVER Draft
URS	Drawn: CA · Approved: JB · Date: 17-10-2008	Figure: 7 · Rev:A
	Job No: **4262 6220** · File No: 42626220-g-538.wor	A4



URS Water Quality Site Locations

L → H Relative maximum EC Concentration (µS/cm) (From lowest to highest concentration)

Results compiled from DNRW data, URS monitoring (February - August 2008), and information provided by Santos.

Santos Operated ATP / PLs
Non-Santos Operated ATP / PLs
Catchment Of Concern
Roads
Major Drainage

Client	Project	Title
Santos / URS	GLADSTONE LNG PROJECT CSG FIELD SURFACE WATER REPORT	COMET RIVER CATCHMENT EC CONCENTRATIONS (Draft)
	Drawn: CA / Approved: JB / Date: 17-10-2008	Figure: 8 / Rev:A
	Job No: **4262 6220** / File No: 42626220-g-531.wor	A4

Condamine-Balonne Catchment Water Quality Data

Appendix A

Table A1
Upper Balonne Catchment - URS Water Quality Parameters
GLNG CSG Surface Water

Site ID		Date/Time	Water Quality Parameters					
Number	**Name**	**Date**	**Time (EST)**	**EC (µS/cm)**	**DO (mg/L)**	**pH**	**Turbidity (NTU)**	**Temp (°C)**
			WQO	*325*	*na*	*6.5-8.0*	*50*	*na*
Bungil Creek & Tributaries								
R005	Eumamurrin Ck @ Carnarvon Hwy	31-Jan-08	10:00	244	4.35	6.97	24	24.3
R005	Eumamurrin Ck @ Carnarvon Hwy	04-Mar-08	11:00	135	3.8	6.8	**145**	23.6
R005	Eumamurrin Ck @ Carnarvon Hwy	14-May-08	11:26	198	4.64	7.58	**150**	16.9
R006	Bungil Ck @ Euminah Rd	31-Jan-08	10:25	225	4.22	6.8	38	25.7
R006	Bungil Ck @ Euminah Rd	04-Mar-08	10:00	105	2.64	6.7	**212**	22.8
R006	Bungil Ck @ Euminah Rd	14-May-08	10:52	-	-	-	-	-
R028	Bungil Ck @ Tabers	04-Mar-08	17:40	232	6.93	6.93	**307**	24.1
R028	Bungil Ck @ Tabers	14-May-08	10:01	**1287**	6.37	**8.19**	27	15.7
R003	Mooga Mooga Ck @ Roma-Taroom Rd	31-Jan-08	9:00	285	2.3	6.64	**66**	26.3
R003	Mooga Mooga Ck @ Roma-Taroom Rd	04-Mar-08	9:30	**500**	2.24	6.6	47	23.4
R003	Mooga Mooga Ck @ Roma-Taroom Rd	14-May-08	9:34	-	-	-	-	-
R002	Bungil Ck @ Burton Rd	31-Jan-08	8:30	**744**	6.12	7.35	10	24
R002	Bungil Ck @ Burton Rd	04-Mar-08	8:10	275	5.2	7.2	**280**	20.5
R004	Bungil Ck @ Carnarvon Hwy	31-Jan-08	-	**568**	6.65	7.25	10	24.9
R004	Bungil Ck @ Carnarvon Hwy	04-Mar-08	15:00	148	6.3	7.8	**223**	24.5
R004	Bungil Ck @ Carnarvon Hwy	14-May-08	9:22	**1418**	3.05	7.32		14.9
R001	Bungil Ck @ Warrego Hwy	31-Jan-08	7:29	**367**	2.4	6.9	**116**	24
R001	Bungil Ck @ Warrego Hwy	04-Mar-08	-	193	4.32	7.39	**151**	23.9
R001	Bungil Ck @ Warrego Hwy	15-May-08	8:45	**350**	3.37	6.72	**58**	15.9
R012	Bungil Ck @ Dunkeld Rd	31-Jan-08	15:05	201	5.73	7.35	**1122**	27
R012	Bungil Ck @ Dunkeld Rd	05-Mar-08	12:00	288	6.31	7.12	**218**	21.5
R012	Bungil Ck @ Dunkeld Rd	14-May-08	16:17	305	2.9	6.35	**108**	18.7
R013	Bungil Ck @ Maranoa Rd	31-Jan-08	16:00	172	5.42	6.97	**1645**	27.7
R013	Bungil Ck @ Maranoa Rd	05-Mar-08	12:40	201	6.65	7.32	**429**	22.6
R013	Bungil Ck @ Maranoa Rd	15-May-08	14:03	**327**	7.44	6.96	**117**	19.2
Bungeworgorai Creek & Tributaries								
R007	Spring Ck @ Orallo Rd	31-Jan-08	11:20	199	5.14	7.2	**278**	27.5
R007	Spring Ck @ Orallo Rd	04-Mar-08	12:00	**301**	5.8	7.9	**98**	28.7
R007	Spring Ck @ Orallo Rd	14-May-08	12:05	-	-	-	-	-
R008	Bungeworgorai Ck @ Orallo Rd	04-Mar-08	12:20	**446**	5.7	**8**	**76**	26.8
R008	Bungeworgorai Ck @ Orallo Rd	31-Jan-08	11:45	283	6.74	7.2	**62**	27.5
R008	Bungeworgorai Ck @ Orallo Rd	00-Jan-00	12:25	**467**	11.84	**8.03**	30	20.5
R024	Bungeworgorai Ck @ Six Mile Rd	01-Feb-08	18:43	**363**	6.2	7.21	**228**	28.2
R024	Bungeworgorai Ck @ Six Mile Rd	05-Mar-08	10:20	**348**	7.9	7.48	**119**	20.6
R024	Bungeworgorai Ck @ Six Mile Rd	14-May-08	15:12	**535**	7.22	6.7	27	21.2
R010	Dargal Ck @ Hodgsons Lane North	31-Jan-08		205	3.12	**6.48**	**671**	26.8
R010	Dargal Ck @ Hodgsons Lane North	04-Mar-08	13:15	3	2.6	6.9	**535**	24.3
R010	Dargal Ck @ Hodgsons Lane North	14-May-08	13:30	292	2.32	6.5	**>1000**	16.5
R009	Bungeworgorai Ck @ Dargal Rd	31-Jan-08	12:33	**334**	6.15	7.2	**98**	26.8
R009	Bungeworgorai Ck @ Dargal Rd	04-Mar-08	14:15	251	6.02	7.76	**51**	24
R009	Bungeworgorai Ck @ Dargal Rd	14-May-08	14:05	-	-	-	-	-
Wallumbilla Creek & Tributaries								
R014	Wallumbilla Ck @ Roma Condamine Rd	31-Jan-08	17:30	178	4.73	6.85	**282**	27.7
R014	Wallumbilla Ck @ Roma Condamine Rd	04-Mar-08	12:40	202	1.92	7.13	**282**	19.8
R014	Wallumbilla Ck @ Roma Condamine Rd	15-May-08	12:00	**321**	3.53	6.6	**187**	16.3
R016	Wallumbilla Ck @ Yarrawonga Rd	01-Feb-08	10:00	206	6.22	6.91	**164**	28.3
R016	Wallumbilla Ck @ Yarrawonga Rd	04-Mar-08	11:30	261	6.64	7.23	**71**	22.6
R016	Wallumbilla Ck @ Yarrawonga Rd	15-May-08	9:45	**376**	6.63	**6.25**	**277**	177
R017	Wallumbilla Ck @ Donnabar	04-Mar-08	15:05	156	3.58	6.66	**86**	23
R017	Wallumbilla Ck @ Donnabar	01-Feb-08		-	-	-	-	-
R017	Wallumbilla Ck @ Donnabar	15-May-08	10:40	188	6.51	5.99	**119**	18.8
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	01-Feb-08	10:41	123	2.98	**6.39**	**700**	25.3
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	04-Mar-08	11:50	192	6.2	7.27	**102**	24.4
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	15-May-08	11:15	308	7.03	6.67	**77**	18.6
Yuleba Creek & Tributaries								
R023	Cattle Ck @ Cattle Ck Rd	01-Feb-08	15:25	112	5.09	6.51	**84**	29
R023	Cattle Ck @ Cattle Ck Rd	05-Mar-08	15:45	112	7.7	7.29	**78**	25.7
R023	Cattle Ck @ Cattle Ck Rd	15-May-08	11:50	92	6.95	6.61	**250**	18.7
R022	Kangaroo Ck @ Wallumbilla North Rd	01-Feb-08	15:00	130	2.8	6.58	**160**	28.2
R022	Kangaroo Ck @ Wallumbilla North Rd	05-Mar-08	15:00	114	1.92	6.98	**124**	22.5
R022	Kangaroo Ck @ Wallumbilla North Rd	15-May-08	11:20	162	7.04	7	**92**	18.8
R021	Yuleba Ck @ Warrego Hwy	01-Feb-08		-	-	-	-	-
R021	Yuleba Ck @ Warrego Hwy	06-Mar-08	9:20	126	3.77	**6.3**	**202**	19.2
R021	Yuleba Ck @ Warrego Hwy	13-May-08		178	2.66	**6.12**	**108**	15.8
R019	Yuleba Ck @ Roma Condamine Rd	01-Feb-08	11:32	124	3.61	6.5	**434**	25.1
R019	Yuleba Ck @ Roma Condamine Rd	04-Mar-08	13:20	213	4	7.22	**366**	23.6
R019	Yuleba Ck @ Roma Condamine Rd	15-May-08	12:45	**989**	2.53	7.2	**471**	18.4
Blyth Creek & Tributaries								
R026	Blyth Ck @ Coxon Ck Rd #1	05-Feb-08	17:15	**333**	10.58	**8.55**	**88**	31
R026	Blyth Ck @ Coxon Ck Rd #1	05-Mar-08	17:15	**397**	7.03	7.83	**3268**	26.8
R026	Blyth Ck @ Coxon Ck Rd #2	05-Feb-08	17:15	259	8.35	**8.55**	**83**	32.1
R026	Blyth Ck @ Coxon Ck Rd #1-2	15-May-08	10:40	-	-	-	-	-
R027	Coxon Ck @ Coxon Ck Rd	05-Feb-08		-	-	-	-	-
R027	Coxon Ck @ Coxon Ck Rd	15-May-08	10:05	-	-	-	-	-
R025	Blyth Ck @ Nth Pickanjinee Rd	05-Feb-08	9:30	267	5.29	7.83	-	32.5
R025	Blyth Ck @ Nth Pickanjinee Rd	05-Mar-08	16:50	-	-	-	-	-
R025	Blyth Ck @ Nth Pickanjinee Rd	15-May-08	10:20	-	-	-	-	-
R015	Blyth Ck @ Warrego Hwy	01-Feb-08	9:00					
R015	Blyth Ck @ Warrego Hwy	04-Mar-08	10:00	193	6.65	6.78	**72**	21.4
R015	Blyth Ck @ Warrego Hwy	15-May-08	9:15	-	-	-	-	-
R011	Blyth Ck @ Carnarvon Hwy	31-Jan-08	14:36	156	5.45	6.76	**227**	28.1
R011	Blyth Ck @ Carnarvon Hwy	14-May-08	16:50	280	8.47	**6.17**	**78**	18.2

Notes:

- \- Parameters not taken, creek dry or no access possible
- **Bold** Greater than relevant WQO (refer table xx)

Table A2
Roma - URS Surface Water Analytical Results Summary
GLNG CSG Surface Water

Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				Major Ions										Alkalinity			
	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Suspended Solids (TSS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
LOR	*2*	*5*	*1*	*1*	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*0.01*	*0.1*	*0.01*	*0.1*	*1*	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
MTV	*na*	*na*	*na*	*10*	*0.007*	*0.37*	*0.0002*	*0.001*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*	*na*	*na*	*0.05*	*0.5*	*1000*	*175*	*1*	*na*	*na*	*115*	*400*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
Bungil Creek & Tributaries																															
Number	8	11	6	11	11	11	11	11	11	4	7	10	11	11	10	10	10	10	9	11	10	10	7	10	9	9	5	6	6	6	6
Min	<2	<5	<1	15	0.001	<0.05	<0.0001	<0.001	0.001	**0.14**	0.002	0.002	<0.005	<0.01	0.4	0.01	0.4	12	5	<0.1	2	5	14	1	1.8	2	1.47	<1	<1	80	80
Median	37	18.5	7	61	0.002	0.05	**0.0002**	**0.002**	**0.004**	**0.53**	0.002	0.004	**0.015**	0.027	0.85	**0.12**	**0.9**	22	14	0.2	6	7	30	11.5	2.7	3	1.57	<1	<1	101.5	101.5
Max	41	95	12	187	0.003	<0.1	**0.0014**	**0.006**	**0.006**	**0.98**	0.003	0.006	**0.022**	0.057	1.2	**1.36**	**1.2**	33	22	0.3	7	11	32	33	3.7	4	4.06	<1	<1	120	120
Bungeworgorai Creek & Tributaries																															
Number	7	8	4	8	6	6	6	6	5	3	3	6	6	7	6	6	6	7	6	6	7	7	4	7	6	6	5	3	3	3	3
Min	<2	6	6	16	<0.001	0.05	<0.0001	<0.001	<0.002	**0.13**	0.13	<0.001	<0.005	<0.01	0.7	**0.05**	**0.7**	18	2	<0.1	4	5	18	5	2.1	2.2	<0.01	<1	<1	65	65
Median	33	9	6	50	0.00125	0.05	<0.0001	**0.002**	**0.0025**	**0.5**	0.00125	0.003	**0.013**	0.041	0.8	**0.07**	**0.85**	34	22.5	0.2	8	6	23.5	31	4.075	4.23	1.96	<1	<1	159	159
Max	41	81	7	178	0.005	<0.1	<0.0001	**0.012**	**0.008**	**17.1**	**0.006**	0.006	**0.034**	0.132	1.8	**0.28**	**2**	49	34	0.3	13	9	33	50	5.28	5.25	3.52	<1	<1	165	165
Wallumbilla Creek & Tributaries																															
Number	10	10	4	9	8	8	8	8	8	5	8	8	8	9	9	9	8	9	8	9	9	9	4	9	7	7	6	4	4	4	4
Min	<2	<5	7	37	<0.001	0.05	<0.0001	<0.001	**0.002**	**0.31**	<0.001	0.002	0.006	0.01	0.6	<0.01	**0.6**	4	7	<0.1	2	6	20	3	1.73	1.87	0.44	<1	<1	70	70
Median	31	8	10.5	60	0.00075	0.05	0.0001	0.00125	**0.002**	**1.02**	0.0015	0.004	**0.0115**	0.03	0.7	**0.08**	**0.7**	16	12.5	0.1	6	7	23	22	2.56	2.69	2.12	<1	<1	72.5	72.5
Max	49	18	12	131	0.004	<0.1	**0.0003**	**0.008**	**0.004**	**3.01**	**0.004**	0.007	**0.021**	0.058	1.2	**0.17**	**1.2**	29	28	0.4	9	8	38	29	3.53	3.66	6.09	<1	<1	75	75
Yuleba Creek & Tributaries																															
Number	6	9	5	10	11	10	11	11	11	4	11	11	11	10	11	11	9	9	9	9	9	9	5	9	9	9	3	5	5	5	5
Min	<2	7	<1	25	0.001	0.05	0.0001	<0.001	0.001	**3.2**	0.002	0.002	0.006	0.01	0.5	**0.05**	**0.6**	4	<1	<0.1	2	4	13	2	1.22	1.32	1.05	<1	<1	55	55
Median	27	17	9	50.5	0.003	0.05	<0.0001	0.003	**0.003**	**4.475**	0.002	0.004	**0.015**	0.058	1.2	**0.21**	**1.3**	9	7	0.1	4	7	15	7	1.5	1.66	2.38	<1	<1	58	58
Max	69	109	50	148	0.005	**0.82**	**0.0003**	**0.007**	**0.004**	**5.38**	**0.004**	0.006	**0.032**	0.109	2.9	**0.28**	**3**	14	77	0.8	6	8	38	230	10	10.5	5.52	<1	<1	85	85

NOTES

For the purposes of calculating the median where results are less than the LOR, a value of half the LOR has been adopted.

MTV - minimum trigger value

Table A3
Roma - URS Surface Water Analytical Results
GLNG CSG Surface Water

	Location	Sample ID	Date Sampled	Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				Major Ions										Alkalinity			
					Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Suspended Solids (TSS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
				Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/l	meq/l	%	mg/L	mg/L	mg/L	mg/L
				LOR	2	5	1	1	0.001	0.1	0.0001	0.001	0.001	0.05	0.001	0.001	0.005	0.01	0.1	0.01	0.1	1	1	0.1	1	1	1	1	0.01	0.01	0.01	1	1	1	1
				MTV	na	na	na	10	0.007	0.37	0.0002	0.001	0.0014	0.2	0.0034	0.011	0.008	na	na	0.05	0.5	1000	<175	1	na	na	115	400	na	na	na	na	na	na	na
Bungil Creek & Tributaries																																			
R006	Bungil Ck @ Euminah Rd	R006_04/03/08	4/03/2008		<2	23	6	48	0.002	<0.1	<0.0001	0.003	0.005		0.003	0.004	0.014	0.057	0.6	1.36	0.7	12	5	<0.1	2	9	19	1	2.07	1.91	4.06	<1	<1	95	95
R006	Bungil Ck @ Euminah Rd	R006_04/03/08CHK	4/03/2008					48																											
R028	Bungil Ck @ Tabers	R028_04/03/08	4/03/2008			80	<1	142	0.002	<0.1	0.0002	0.006	0.006		0.003	0.006	0.022	0.027	1	0.16	1	21	14	0.1	4	6	31	13	2.83	2.92		<1	<1	108	108
R028	Bungil Ck @ Tabers	QC03_14/05/08	14/05/2008		32	8		20	0.001	0.08	<0.0001	<0.001	0.001	0.14	<0.001	<0.001	0.017	<0.01	0.5	0.05	0.5			0.2											
R028	Bungil Ck @ Tabers	R028_14/05/08	14/05/2008		37	8		15	0.002	0.08	<0.0001	<0.001	0.002	0.16	<0.001	0.002	<0.005	<0.01	0.6	0.04	0.6	21	5	0.2	7	11		10	2.17	2.34					
R028	Bungil Ck @ Tabers	R028_14/05/08CHK	14/05/2008		37																														
R028	Bungil Ck @ Tabers	QC03_14/05/08CHK	14/05/2008																					0.2											
R002	Bungil Ck @ Burton Rd	R002_04/03/08	4/03/2008		<2	14	7	187	0.002	<0.1	<0.0001	0.006	0.006		0.003	0.005	0.02	0.039	0.4	0.01	0.4	19	21	<0.1	4	6	30	8	2.65	2.74	1.62	<1	<1	95	95
R001	Bungil Ck @ Warrego Hwy	R001_04/03/08	4/03/2008		<2	<5	7	109	0.002	<0.1	0.0002	0.002	0.004		0.003	0.004	0.019	0.05	1.2	0.13	1.2	25	22	<0.1	6	7	32	9	3.19	3.29	1.57	<1	<1	120	120
R001	Bungil Ck @ Warrego Hwy	R001_04/03/08CHK	4/03/2008						0.002	<0.1	0.0002	0.003	0.004		0.003	0.004	0.018																		
R001	Bungil Ck @ Warrego Hwy	R001_15/05/08	15/05/2008		38	8		61	0.001	<0.05	<0.0001	<0.001	0.002	0.9	0.002	0.002	<0.005	<0.01	0.9	0.13	0.9	33	20	0.2	7	6		33	3.74	3.85	1.5				
R011	Blyth Ck @ Carnarvon Hwy	R011_06/03/08	7/03/2008			95	12	16	0.003	<0.1	0.0003	<0.001	0.002		<0.001	0.003	0.006	0.047	0.8	0.07	0.9	14	6	<0.1	4	8	14	2	1.82	1.86		<1	<1	80	80
R011	Blyth Ck @ Carnarvon Hwy	R011_06/03/08CHK	7/03/2008			95																													
R012	Bungil Ck @ Dunkeld Rd	R012_05/03/08	5/03/2008			89	8	106	0.002	<0.1	0.0014	0.004	0.004		0.002	0.004	0.015	0.03	0.9	0.13	0.9	23	16	0.2	5	7	28	17	3.1	3.01	1.47	<1	<1	114	114
R012	Bungil Ck @ Dunkeld Rd	R012_05/03/08CHK	5/03/2008																			26			6	8	31	17							
R012	Bungil Ck @ Dunkeld Rd	R012_14/05/08	14/05/2008		41	7		67	<0.001	0.06	0.0002	<0.001	0.001	0.98	<0.001	0.002	0.011	<0.01	1.2	0.1	1.2	23	13	0.3	6	5		23	2.65	2.77					
R012	Bungil Ck @ Dunkeld Rd	R012_14/05/08CHK	14/05/2008															<0.01																	
Bungeworgorai Creek																																			
R008	Bungeworgorai Ck @ Orallo Rd	R008_14/05/08	14/05/2008		40	6		25	<0.001	0.06	<0.0001	<0.001	0.002	0.13	<0.001	0.002	0.009	<0.01	0.7	0.05	0.7	34	34	0.2	8	6		50	4.49	4.68	1.96				
R008	Bungeworgorai Ck @ Orallo Rd	R008_14/05/08CHK	14/05/2008					24																											
R010	Dargal Ck @ Hodgsons Lane North	R010_04/03/08	4/03/2008		<2	26	7	75	0.005	<0.1	<0.0001	0.012	0.008		0.006	0.008	0.034	0.105	0.8	0.24	0.9	18	5	<0.1	4	5	18	31	2.1	2.2	2.13	<1	<1	65	65
R010	Dargal Ck @ Hodgsons Lane North	R010_04/03/08CHK	4/03/2008		<2	24	6											0.107				18			4	6	18	32							
R010	Dargal Ck @ Hodgsons Lane North	R010_14/05/08	14/05/2008		41	9		178	0.003	0.05	<0.0001	0.009	0.005	17.1	0.005	0.007	0.028	0.033	1.3	0.28	1.4	29	2	0.3	6	5		19	2.77	2.9					
R010	Dargal Ck @ Hodgsons Lane North	R010_14/05/08CHK	14/05/2008		41	8																													
R009	Bungeworgorai Ck @ Dargal Rd	R009_04/03/08	4/03/2008		<2	9	6	16	<0.001	<0.1	<0.0001	<0.001*	0.002		<0.001	0.002	<0.005	0.041	0.8	0.06	0.8	43	30	<0.1	9	9	33	5	4.25	4.56	3.52	<1	<1	165	165
R024	Bungeworgorai Ck @ Six Mile Rd	R024_05/03/08	5/03/2008			81	6	101	0.002	<0.1	0.0001	0.002	0.003		0.002	0.004	0.017	0.132	1.8	0.08	2	36	15	0.2	8	8	29	15	3.9	3.9	<0.01	<1	<1	159	159
R024	Bungeworgorai Ck @ Six Mile Rd	R024_05/03/08CHK	5/03/2008					100																											
R024	Bungeworgorai Ck @ Six Mile Rd	R024_14/05/08	14/05/2008		33	9		17	<0.001	<0.05	<0.0001	<0.001	<0.001	0.5	<0.001	<0.001	<0.005	<0.01	0.7	0.06	0.7	49	30	0.3	13	9		35	5.28	5.25	0.36				
Wallumbilla Creek & Tributaries																																			
R016	Wallumbilla Ck @ Yarrawonga Rd	R016_04/03/08	4/03/2008		5	18	11	95	0.004	<0.1	0.0002	0.008	0.004		0.003	0.007	0.021	0.052	0.7	0.12	0.7	13	14	<0.1	6	8	20	4	1.99	2.19	4.94	<1	<1	75	75
R016	Wallumbilla Ck @ Yarrawonga Rd	R016_04/03/08CHK	4/03/2008		5	17	12	95										0.058				13		<0.1	6	8	20	4				<1	<1	75	75
R016	Wallumbilla Ck @ Yarrawonga Rd	R016_15/05/08	15/05/2008		33	7		131	<0.001	0.06	<0.0001	0.002	0.004	3.01	0.002	0.005	0.011	<0.01	1.2	0.15	1.2	29	28	0.4	9	7		29	3.53	3.66	1.66				
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	R018_15/05/08	15/05/2008		40	8		38	<0.001	0.05	0.0001	<0.001	0.002	0.31	<0.001	0.002	0.013	<0.01	0.8	0.08	0.8	27	10	0.3	8	7		23	3.12	3.16	0.57				
R018	Pickanjinnie Ck @ Wallumbilla to Roma Condamine Rd	R018_15/05/08CHK	15/05/2008																				10												
R017	Wallumbilla Ck @ Donnabar	R017_04/03/08	4/03/2008		<2	<5	7	60	0.004	0.1	<0.0001	0.008	0.004		0.004	0.006	0.016	0.033	0.6	<0.01	0.7	4	18	<0.1	2	6	38	3	1.98	2.24	6.09	<1	<1	70	70
R017	Wallumbilla Ck @ Donnabar	QC04_15/05/08	15/05/2008		32	7		42	0.001	<0.05	0.0003	<0.001	0.002	1.02	0.001	0.002	0.006	0.03	0.6	0.09	0.6			0.1											
R017	Wallumbilla Ck @ Donnabar	R017_15/05/08	15/05/2008		43	6		39	<0.001	<0.05	0.0002	<0.001	0.002	0.97	0.001	0.002	0.01	0.029	0.6	0.08	0.6	13	7	0.1	5	6		15	1.73	1.87					
R017	Wallumbilla Ck @ Donnabar	QC04_15/05/08CHK	15/05/2008		30																														
R014	Wallumbilla Ck @ Roma Condamine Rd	R014_04/03/08	4/03/2008		2	15	10	37	0.001	<0.1	0.0001	0.002	0.002		<0.001	0.004	0.007	0.037	0.6	0.05	0.7	16	24	<0.1	6	8	26	23	2.56	2.69	2.58	<1	<1	70	70
R014	Wallumbilla Ck @ Roma Condamine Rd	R014_04/03/08CHK	4/03/2008																0.7	0.05															
R014	Wallumbilla Ck @ Roma Condamine Rd	R014_15/05/08	15/05/2008		49	9		92	<0.001	<0.05	<0.0001	<0.001	0.002	2.02	0.002	0.004	0.012	<0.01	1.2	0.17	1.2	23	11	0.2	9	7		22	3.04	3.07	0.44				
R014	Wallumbilla Ck @ Roma Condamine Rd	R014_15/05/08CHK	15/05/2008			8																26			9	8		24							
Yuleba Creek																																			
R023	Cattle Ck @ Cattle Ck Rd	R023_05/03/08	5/03/2008			96	16	30	0.003	<0.1	0.0001	0.003	0.002		0.002	0.004	0.016	0.062	2.2	0.09	2.3	7	2	<0.1	2	6	14	3	1.22	1.32		<1	<1	55	55
R023	Cattle Ck @ Cattle Ck Rd	R023_05/03/08CHK	5/03/2008						0.002	<0.1	<0.0001	0.003	0.002		0.002	0.004	0.015																		
R023	Cattle Ck @ Cattle Ck Rd	R023_15/05/08	15/05/2008		68	18		147	0.003	0.05	0.0002	0.002	0.003	4.47	0.004	0.004	0.01	0.014	1.9	0.26	1.9	10	<1	<0.1	3	6		15	1.37	1.55					
R023	Cattle Ck @ Cattle Ck Rd	R023_15/05/08CHK	15/05/2008					148																											
R022	Kangaroo Ck @ Wallumbilla North Rd	R022_05/03/08	5/03/2008			94	50	30	0.005	<0.1	<0.0001	0.003	0.002		0.002	0.005	0.032	0.109	1.1	0.21	1.2	9	2	0.1	4	7	13	2	1.28	1.47		<1	<1	58	58
R022	Kangaroo Ck @ Wallumbilla North Rd	R022_05/03/08CHK	5/03/2008															0.104	1.1	0.23															
R022	Kangaroo Ck @ Wallumbilla North Rd	R022_15/05/08	15/05/2008		69	14		54	0.001	0.06	<0.0001	0.002	0.003	4.48	0.002	0.003	0.014	<0.01	1.5	0.2	1.5	14	7	0.2	6	7		15	2.02	2					
R022	Kangaroo Ck @ Wallumbilla North Rd	R022_15/05/08CHK	15/05/2008						0.002		<0.0001	0.002	0.003		0.002	0.004	0.016																		
R021	Yuleba Ck @ Warrego Hwy	R021_06/03/08	6/03/2008			109	<1	71	0.005	<0.1	0.0001	0.004	0.003		0.002	0.006	0.015	0.096	2.9	0.28	3	9	3	0.1	4	8	15	3	1.46	1.62		<1	<1	66	66
R021	Yuleba Ck @ Warrego Hwy	R021_13/05/08	13/05/2008		8	8		25	0.003	<0.05	<0.0001	<0.001	0.001	5.38	0.002	0.002	0.018	0.044	1	0.14	1	11	8	0.2	5	7		12	1.5	1.66					
R019	Yuleba Ck @ Roma Condamine Rd	QC01_04/03/08	4/03/2008		<2	17	7	66	0.004	0.1	<0.0001	0.007	0.004		0.003	0.006	0.016	0.041	0.7	0.08	0.7	4	18	<0.1	2	6	38	3	2.28	2.24	1.05	<1	<1	85	85
R019	Yuleba Ck @ Roma Condamine Rd	R019_04/03/08	4/03/2008		<2	12	9	37	0.003	<0.1	0.0002	0.003	0.003		0.002	0.004	0.015	0.099	0.5	0.05	0.6	9	11	<0.1	4	8	18	7	1.56	1.75	5.52	<1	<1	55	55
R019	Yuleba Ck @ Roma Condamine Rd	R019_15/05/08	15/05/2008		46	7		47	<0.001	0.82	0.0003	<0.001	0.002	3.2	0.002	0.002	0.006	0.054	1.2	0.28	1.3	5	77	0.8	2	4		230	10	10.5	2.38				
R019	Yuleba Ck @ Roma Condamine Rd	R019_15/05/08CHK	15/05/2008																1.2	0.28															

NOTES

CHK - Lab Duplicate sample
LOR - Limit of reporting
MTV - minimum trigger value

Table A4
GLNG CSG Surface Water
Roma - DNRW Surface Water Analytical Results Summary

Parameter	Physico-Chemical Parameters												Nutrients									
	Colour True	Conductivity @ 25C	Conductivity @ 25C FLD	Dissolved Oxygen FLD	pH	pH FLD	Air Temp	Water Temp	Turbidity	Turbidity FLD	Total Diss. Solids	Total Suspended Solids	Chlorophyll-a	Nitrate as NO3	Nitrate + nitrite as N - total	Ammonia as N - soluble	Faecal Coliform	Kjeldahl Nitrogen	Total Nitrogen	Nitrate + nitrite as N - soluble	Total React P sol	Total Phosphorus as P
Units	*Hazen units*	*uS/cm*	*uS/cm*	*mg/L*	*pH units*	*pH units*	*° C*	*° C*	*NTU*	*NTU*	*mg/L*	*mg/L*	*ug/L*	*mg/L*	*mg/L*	*mg/L*	*CFU/100 ml*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
WQO	*325*	*325*	*325*		*6.5-8.0*	*6.5-8.0*		*20%ile-80%ile*	*50*	*50*	*500*	*10*	*5*	*0.05*		*0.01*			*0.5*			*0.05*
Bungil Creek Tabers																						
Number	31	41	30	21	40	24	21	40	34	21	41	42	0	30	1	2	0	10	17	2	2	27
Minimum	4.00	66.30	65	3.70	6.80	6.60	8.50	8.70	1.10	4.70	41	5	0	**0.27**	0.34	0.002	0	0.39	0.43	0.002	0.06	0.01
Median	30	160.3	227	6.9	7.5	7.8	23.8	22.15	**100**	**58.05**	110	**96.5**		**1.9**	0.3356	0.002		0.83	**1.212**	0.002	0.0615	**0.2**
Maximum	200	**1890**	**1647**	14.20	**8.50**	**8.70**	34.50	28.40	**700**	**>1000**	**1306**	**1500**	0	**4.20**	0.34	0.002	0	2.93	**2.51**	0.002	0.06	**0.68**
Balonne River Surat																						
Number	6	6	0	0	6	0	0	0	6	0	6	6	0	6	0	1	0	0	9	1	1	9
Minimum	2	74	#REF!	#REF!	6.81	#REF!	#REF!	0	**583**		53	**148**		**1.40**		0.01			**0.92**	0.39	0.04	**0.32**
Median	9	95			6.88				**1295**		67	**857.5**		**2.35**		0.009			**1.7**	0.39	0.0355	**0.62**
Maximum	14	154	#REF!	#REF!	7.24	#REF!	#REF!	0	**3620**		97	**2810**		**3.80**		**0.01**			**3.60**	0.39	0.04	**1.60**
Yuleba Creek Forestry																						
Number	5	21	1	1	17	1	5	20	15	1	11	14	2	10	1	3	3	2	3	3	3	5
Minimum	16	72	#REF!	#REF!	6.6	#REF!	22.1	12	**80**		54	10	**9**	**0.5**		**0.018**	18	1.255	**1.6**	0.037	0.008	**0.27**
Median	70	164			7.4		29.4	24.95	**245**		107	**107**	**18.5**	**1.475**		**0.02**	70	1.4915	**1.9**	0.07	0.014	**0.39**
Maximum	92	**455**	#REF!	#REF!	7.9	#REF!	38.9	29.5	**802**		250	**360**	**28**	**4**		**0.037**	110	1.728	**2.1**	0.25	0.03	**0.55**

Table A4
GLNG CSG
Roma - DNI

Parameter	**Major Ions**								**Metals**								**Alkalinity**					
	Calcium as Ca soluble	Chloride as Cl	Hydrogen as H	Magnesium as Mg soluble	Potassium as K	Sodium as Na	Sulphate as SO4	Total Diss. Ions	Aluminium as Al soluble	Boron as B	Copper as Cu soluble	Flouride as F	Iron as Fe soluble	Manganese as Mn soluble (mg/L)	Silica as SiO_2 soluble	Zinc as Zn soluble	Total Alkalinity as CaCO3	Total Alkalinity as CaCO3 FLD	Hydroxide as OH	Carbonate as CO3	Bicarbonate as HCO3	Hardness as CaCO3
Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
WQO	*1000*	*175*				*115*	*400*		*0.055*	*0.37*	*0.0014*	*1*	*0.2*			*0.008*						
Bungil Creek																						
Number	41	38	2	40	40	41	37	41	22	23	16	34	0	0	0	0	41	2	11	32	41	40
Minimum	4.30	2.55	0.10	1.10	2.2	5.6	1	50.16	0.01	<0.02	**<0.01**	<0.02	0	0	0	0	25.00	70.80	0.01	0.02	21.50	15.50
Median	14.6	10.65	1.35	3.25	5	19	6.3	132.7	0.05	0.05	**0.01**	0.1					71.4	134.4	0.01	0.39	86.9	53.2
Maximum	130.2	**350**	2.60	22	11	320	558	1458.3	**0.24**	0.14	**0.07**	0.50	0	0	0	0	422.2	198.0	0.03	15.5	502.9	402.2
Balonne Rive																						
Number	6	6	0	6	6	6	6	6	6	6	6	6	0	0	0	0	6	0	0	1	6	6
Minimum	2.60	<4	0	1.30	3.6	8	4	58	0.05	0.05	**<0.03**	<0.1					24.00		0	0.10	29	12
Median	2.95	11		1.65	4	12.5	5	72.5	0.05	0.05		0.1					30			0.1	36.5	14.5
Maximum	7.70	11	0	3.70	4.2	15	6	112	**0.08**	<0.1	<0.03	0.10					52.00		0	0.10	64	35
Yuleba Creek																						
Number	11	11	1	11	11	11	11	11	2	6	2	8	8	5	11	2	13	1	1	7	11	1
Minimum	4	4.2		1.8	3.4	9	1	57	0	0	0	0.09	0	0	10	0.01	20			0.06	24	
Median	8.2	16.17		4	5.3	18.7	7.52	122.51	**0.91**	0.03	**0.005**	0.1	**1.95**	0.01	20	0.03	52.41			0.1	55	
Maximum	25	64		11	8.1	45	14	318.2	**1.81**	0.1	**0.01**	0.13	**5.7**	0.03	63	0.05	124			0.4	150	

Table A5
GLNG CSG Surface Water
Roma - DNRW Surface Water Analytical Results Summary
422210A Bungil Creek Tabers

Physico-Chemical Parameters

DATE	TIME	Stream Water Level	Stream Discharge	Depth	Colour True	Conductivity @ 25C	Conductivity @ 25C FLD	Dissolved Oxygen FLD	pH	pH FLD	Air Temp	Water Temp	Turbidity	Turbidity FLD	Total Diss. Solids	Total Suspended Solids
	Units	m	Cumecs	m	Hazen units	uS/cm	uS/cm	mg/L	pH units	pH units	°C	°C	NTU	NTU	mg/L	mg/L
	WQO					325	325		6.5-8.0	6.5-8.0		20%ile-80%ile	50	50	<500	10
18/01/1972	1400	1.08	4.276	0.1		137			7			21			77	
27/05/1974	1633	0.75	0.099	0.1		1540			7.8			14			988	100
12/01/1976	1620	0.73	0.048	0.1								25				
18/01/1976	0925	0.78	0.196	0.1								27				
14/02/1980	1300	0.74	0.131	0.1		125			7.2			24			85	10
9/12/1980	1700	0.77	0.249	0.1								26				
24/05/1983	0910	6.67	427	0.1		87			7.5						55	710
28/05/1983	1555	4.93	115	0.1		110			7.5						63	215
23/06/1983	1530	1.46	13.5	0.1		145			7.5				100		100	285
30/07/1983	1415	0.74	0.038	0.1		930			7.5			16			550	10
6/02/1984	1000	0.83	0.409	0.1	40	520			8.5			24	20		310	15
1/09/1984	1620	0.74	0.024	0.1	5	1300			7.8				19		800	20
2/12/1984	1100	0.58	0	0.1	10	1050			7.9			28			650	5
9/03/1985	1145	0.79	0.132	0.1		140			6.9			18	100		110	1177
19/02/1986	1035	0.73	0.019	0.1			180					28				
2/09/1986	0900	0.09	0	0.1		155							100		84	510
13/11/1986	1010	1.13	4.806	0.1	70	74	65		7.1			17	100		61	1500
15/02/1987	1215	0.75	0.054	0.1	15	730	710		8			27	18		460	23
28/05/1989	1630	0.82	0.358	0.1			560					17				
31/05/1990	1115	0.74	0.0787	0.1			250					16				
8/12/1993	1115	1.148		0.1			99.3			7.5		24.1				
3/02/1994	1440	0.77	0.129	0.1		144	128.5		7	8.5		21.6	200		98	735
10/03/1994	0900	3.24	54.13	0.1	70	129	120		7.6			22.9	182		81	340
29/11/1994	1600	0.58	0	0.3	200	160.3	151		7.31	7.3		22	200		95.61	86
12/04/1995	1500	NA	0	0.2	40	307.3	315	14.2	7.58	7.3	24.7	19.6	7.1	19.5	179.71	22
21/02/1996	1700	0.67		0.3	16	688	684	6.7	7.97	7.5	34.5	27	14.2	19	420.39	22
21/06/1996	1615	0.578	0	0.3	59	340	343	11.1	8.1	8.5	23.8	16.2	11	14.7	200	20
9/10/1996	0850	0.22	0	0.3	30	445	462	6	7.75	8	16.9	17.7	16	21	260	30
19/02/1997	0800	0.96	2.177	0.2	37	159	160	6.9	7.36	8	24.9	25	230	328	106.43	180
12/05/1997	1420	0.7	0.007	0.2	13	1174	1249	5.4	7.9	7.6	23.4	18.1	5.7	9	767.09	10
18/06/1997	0900	0.66	0.002	0.1	12	1600	1647	9.3	8.18	7.8	8.5	9.2	3.4	4.7	1056.64	8
7/10/1997	1420	0.67	0	0.1	28	1440	1343	6.5	7.73	8.5	20	22.3	100	93.6	930.59	93
24/11/1997	1615	0.66	0.003	0.1	40	204	203	6.3	7.5	7.6	32.8	27.2	218	190	123.76	188
12/08/1998	0830	0.59	0	0.1	6	144	141	5	6.88	7.9	9.1	8.7	287	306	100.13	123
12/01/1999	1115															
29/01/1999	1100	0.48	0	0.1	58	241	238	3.7	7.77	7.5	27.5	28.4	37.7	69.1	146.66	39
12/04/1999	1115															65
21/04/1999	0930															
21/04/1999	1340	0.41		0.1	59	269	288	7.2	7.47	7.8	21.3	23.1	24.2	38	177.21	24
21/05/1999	0930															81
9/07/1999	1200	0.3	0	0.1	20	257	237	8.6	8.05	8.4	16.7	14.5	12.6	21	152.8	5
13/04/2000	1250	0.3	0	0.1	49	221	217	7.9	7.52	8.7	21.5	22.8	131	192	128.67	128
30/10/2000	1830	2.41		0.1	72	72	65	8.1	6.8	8.1	19.2	17	700	>1000	49	750
31/10/2000	1020	1.34		0.1	95	97.1	93	11.2	6.87	7.9	17.4	17.8	441	726	66.26	458
1/11/2000	1420	1.2		0.1	79	98.6	92	7.6	7.03	7.7	28	20.2	612	913	62.15	594
27/02/2002	1510	5.85		0.1	13	66.3	67	5.3	7.03	6.6	29.2	24.5	662	936	40.64	664
28/02/2002	1025	1.18		0.1	33	124.9	124	5.2	7.33	7.2	28.5	25.3	475	656	76.91	509
9/04/2002	1038	0.66		0.1	24	1401	430	5.5	8.04	7.6	27.8	22.8	7.1	47	947.71	12
12/08/2002	1355	0.55		0.1	11	1890	1644	10.2	8.18	8.2	26.5	18.8	1.1	5	1305.76	7
30/06/2005	1120	0.68		0.1	4	116			7.21				474		87	248
25/10/2005	1300	0.71		0.1	7	111			7.17				624		72	472
6/12/2005	1445	0.78		0.2												
3/11/2006	1208	0.79		0.1	16	91			7.07				160		55	826

Nutrients / Major Ions

DATE	TIME	Chlorophyll-a	Nitrate as NO3	Nitrate + nitrite as N - total	Ammonia as N - soluble	Faecal Coliform	Kjeldahl Nitrogen	Total Nitrogen	Nitrate + nitrite as N - soluble	Total React P sol	Total Phosphorus as P	Calcium as Ca soluble	Chloride as Cl	Hydrogen as H	Magnesium as Mg soluble	Potassium as K	Sodium as Na	Sulphate as SO4	Total Diss. Ions
	Units	ug/L	mg/L	mg/L	mg/L	CFU/100 ml	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	WQO	5	0.05		0.01			0.5			0.05	1000	<175				115	400	
18/01/1972	1400											12	8		5		12		118.5
27/05/1974	1633											85	350		22	11	240	100	1146.7
12/01/1976	1620																		
18/01/1976	0925																		
14/02/1980	1300		2									10	10		2.2	4	11	5	105.3
9/12/1980	1700																		
24/05/1983	0910		2.4									6.3			1.7	3.9	9.6		66.9
28/05/1983	1555		1.4									8.4			1.9	3.9	8		72.7
23/06/1983	1530		2.5									11.5	4		2.5	4.1	15	2.7	121.3
30/07/1983	1415											77	91		13	4.7	100	96	662.4
6/02/1984	1000											50	32	0.1	8.1	5.3	49	32	401.1
1/09/1984	1620											97	115		16	5	160	180	985.1
2/12/1984	1100											62	105		12	7.4	155	135	803.7
9/03/1985	1145		3.8									12	5.6		2.6	4.6	11	12	123
19/02/1986	1035																		
2/09/1986	0900											12	11	2.6		5	15		82.8
13/11/1986	1010		0.9									5.6	4		1.7	3.7	6.8	2	58.6
15/02/1987	1215		1.8									74	46		11	6.1	70	84	590.3
28/05/1989	1630																		
31/05/1990	1115																		
8/12/1993	1115																		
3/02/1994	1440		4.2								0.59	7.9	7.5	ND	1.7	2.6	22.2	12.4	121.4
10/03/1994	0900		2.3									8.9	5.4	ND	2.1	5.3	12.9	1.8	98.8
29/11/1994	1600		3.77									10	8.33	ND	2.3	5.5	15.5	3.71	119.73
12/04/1995	1500		1.41				0.8761				0.1324	24.8	12.28	ND	5.9	9.7	34.5	6.3	266.05
21/02/1996	1700		0.27				0.606				0.0397	77.2	25.59	ND	11.3	6.3	56.8	74.59	554.83
21/06/1996	1615		0.5				0.658				0.0408	29	13.5	ND	5	6.7	35.5	24.5	270
9/10/1996	0850		0.5				1.033				0.0522	32	22	ND	6.9	7.4	56	23	370
19/02/1997	0800		0.8				1.308				0.2765	14.6	5.1	ND	3	7.1	13.8	1.2	132.7
12/05/1997	1420		0.44				0.517				0.033	108.2	103.23	ND	17.3	7	148.3	127.5	979.92
18/06/1997	0900		ND				0.391				0.0137	130.2	81.32	ND	18.8	5.2	222.4	320.04	1286.94
7/10/1997	1420		ND				0.827				0.0866	54.5	98.06	ND	15.5	6.1	252	354.06	1068.99
24/11/1997	1615		0.63				0.833				0.2269	19.2	10.29	ND	3.2	5	19	6.52	161.19
12/08/1998	0830		2.29					2.37			0.4347	11.6	13.62	ND	2.1	3.6	16.7	7.03	119.1
12/01/1999	1115				0.002			0.94	0.002	0.06	0.2								
29/01/1999	1100		1.51					0.66			0.1342	20.7	9.5	ND	3.8	7.3	22.9	2.35	194.02
12/04/1999	1115																		
21/04/1999	0930				0.002				0.002	0.063									
21/04/1999	1340		3.16					1.94			0.3688	25.6	11.58	ND	4.7	8.9	26.2	3.52	237.74
21/05/1999	0930							0.61			0.06								
9/07/1999	1200		ND					0.74			0.0802	23	11.22	ND	4.6	6.8	29.1	2.2	229.55
13/04/2000	1250		2.4					1.12			0.1821	16.8	8.18	ND	3.3	6	23.7	2.95	174
30/10/2000	1830		2.5					2.10			0.46	4.3	<4	ND	1.1	3.3	7.9	2	57
31/10/2000	1020		2.89					1.79			0.44	6.2	5.03	ND	1.5	4.5	9.1	1.43	77.21
1/11/2000	1420		1.47					1.47			0.435	7	3.62	ND	1.4	4.3	9	1.05	73.38
27/02/2002	1510		1.07					1.29			0.3286	4.9	2.55	ND	1.1	2.2	5.6	1	50.16
28/02/2002	1025		1.28					1.21			0.3079	11.3	3.52	ND	2.2	3.2	9.6	2.68	100.25
9/04/2002	1038		ND					0.43			0.0433	130	72.1	ND	15.2	4.7	178.5	316.96	1134.44
12/08/2002	1355		1.23					0.61			0.0156	100	116.76	ND	20.6	5.1	320.1	558	1458.29
30/06/2005	1120		2.6					1.20			0.21	4.3	5.3	ND	1.2	2.7	17	5.6	89
25/10/2005	1300		2.3									9.1	3.1	ND	1.9	3.8	10	1.6	94
6/12/2005	1445			0.3356			2.93	2.16			0.576								
3/11/2006	1208		2.5					2.51			0.6782	5.5	4.8	ND	1.3	3.6	8	2.3	68

Metals / Alkalinity

DATE	TIME	Aluminium as Al soluble	Boron as B	Copper as Cu soluble	Flouride as F	Iron as Fe soluble	Manganese as Mn soluble (mg/L)	Silica as SiO_2 soluble	Zinc as Zn soluble	Total Alkalinity as CaCO3	Total Alkalinity as CaCO3 FLD	Hydroxide as OH	Carbonate as CO3	Bicarbonate as HCO3	Hardness as CaCO3
	Units	mg/L	mg/L	mg/L	mg/L					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	WQO	0.055	0.37	0.0014	1	0.2			0.008						
18/01/1972	1400				0.5					66				81	51
27/05/1974	1633				0.14					279			1.6	337	303
12/01/1976	1620														
18/01/1976	0925														
14/02/1980	1300				0.1					50				61	34
9/12/1980	1700														
24/05/1983	0910		0.01							35			0.1	42.5	23
28/05/1983	1555		0.01							40			0.1	48.5	29
23/06/1983	1530									64			0.1	78	39
30/07/1983	1415		0.04		0.1					222			0.1	270	246
6/02/1984	1000		0.03							188			4.6	220	158
1/09/1984	1620		0.04							340			2.1	410	308
2/12/1984	1100		0.05		0.2					270			2	325	204
9/03/1985	1145		0.01		0.1					57				69	41
19/02/1986	1035														
2/09/1986	0900				0.2					44			15.5	21.5	
13/11/1986	1010		0.01		0.1					25				30.5	21
15/02/1987	1215		0.05		0.1					245			2.1	295	230
28/05/1989	1630														
31/05/1990	1115														
8/12/1993	1115														
3/02/1994	1440			0.07	0.02					51		ND	ND	62.7	26
10/03/1994	0900	0.24		0.06	0.02					49		0.01	0.1	59.8	30
29/11/1994	1600	0.16	ND	ND	0.07					57.9		ND	0.08	70.47	34
12/04/1995	1500	0.05	ND	0.05	0.14					140.5		0.01	0.37	170.64	86
21/02/1996	1700	ND	0.1	ND	ND					249.8		0.02	1.87	300.89	239
21/06/1996	1615	0.05	<0.1	<0.05	<0.1					130		ND	1.1	160	93
9/10/1996	0850	0.05	<0.1	<0.05	0.1					185		ND	0.8	225	110
19/02/1997	0800	0.01	ND	0.01	0.1					71.4		ND	0.1	86.89	49
12/05/1997	1420	ND	0.1	0.01	0.22					385.6	198	0.01	2.58	465.13	341
18/06/1997	0900	ND	0.1	0.01	0.13					422.2		0.03	5.96	502.87	402
7/10/1997	1420	0.1	0.1	ND	0.15					237.6		0.01	1.18	287.43	200
24/11/1997	1615	0.01	ND	ND	0.12					79.85	70.8	0.01	0.17	97.05	61
12/08/1998	0830	ND	ND	0.01	0.02					50.95		ND	0.02	62.11	38
12/01/1999	1115														
29/01/1999	1100	0.07	ND	ND	0.12					103.5		0.01	0.4	125.44	67
12/04/1999	1115														
21/04/1999	0930														
21/04/1999	1340	0.01	ND	ND	0.12					126.42		ND	0.25	153.7	83
21/05/1999	0930														
9/07/1999	1200	0.01	ND	ND	0.1					125.84		0.02	0.93	151.58	76
13/04/2000	1250	0.03	ND	ND	0.04					90.85		ND	0.19	110.44	55
30/10/2000	1830	0.06	0.1	<0.05	<0.1					27		ND	ND	33	16
31/10/2000	1020	0.07	ND	ND	0.02					38.16		ND	0.02	46.52	22
1/11/2000	1420	0.04	ND	ND	0.02					37.33		ND	0.03	45.49	23
27/02/2002	1510	0.01	0.03	0.01	0.02					26.01		ND	0.02	31.7	17
28/02/2002	1025	0.02	0.02	0.01	0.03					54.52		ND	0.07	66.36	37
9/04/2002	1038	0.02	0.12	0.01	0.17					344.57		0.02	3.4	413.39	387
12/08/2002	1355	0.01	0.14	ND	ND					279.2		0.03	3.92	332.56	334
30/06/2005	1120	0.05	0.05	<0.03	<0.1					42		ND	ND	51	16
25/10/2005	1300	0.05	0.05	<0.03	0.1					51		ND	ND	62	30
6/12/2005	1445														
3/11/2006	1208	0.05	<0.02	<0.03	0.1					33		ND	ND	40	19

Notes
123 Greater than WQO
Various data collected prior to 1994 considered to be of poor quality

Table A6
GLNG CSG Surface Water
Roma - DNRW Surface Water Analytical Results Summary
422220A Balonne River @ Surat

				Physico-Chemical Parameters							Nutrients					
DATE	TIME	Stream Water Level	Depth	Colour True	Conductivity @ 25C	pH	Water Temp	Turbidity	Total Diss. Solids	Total Suspended Solids	Nitrate as NO3	Ammonia as N - soluble	Total Nitrogen	Nitrate + nitrite as N - soluble	Total React P sol	Total Phosphorus as P
	Units	*m*	*m*	*Hazen units*	*uS/cm*	*pH units*	*°C*	*NTU*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
	WQO				*325*	*6.5-8.0*	*20%ile-80%ile*	*50*	*<500*	*10*	*0.05*	*0.01*	*0.5*			*0.05*
9/12/2004	0922	5.15	0.1	3	80	6.82		**3620**	54	**2810**	**2.9**		**3.6**			**1.6**
9/12/2004	1227	5.53	0.1	8	74	6.81		**2880**	53	**2100**	**2.7**		**2.8**			**1.2**
13/12/2004	1716	5.15	0.1	14	102	6.84		**1480**	71	**1030**	**3.8**		**2.1**			**0.62**
14/12/2004	0812	4.8	0.1	13	92	6.91		**1110**	65	**685**	**2**		**2**			**0.59**
16/12/2004	1043	3.59	0.1	10	98	6.94		**826**	69	**522**	**1.7**		**1.7**			**0.42**
6/12/2005	1350	5.11	0.2									0.0091		0.39	0.0355	
22/12/2005	1900	3.17	0.2										**1.58**			**0.4**
21/01/2006	0700	3.35	0.2										**1.647**			**0.69**
21/01/2006	1830	3.24	0.2										**1.646**			**0.68**
21/02/2006	1730	3.1	0.2										**0.92**			**0.32**
6/05/2006	1600	0	0.2	2	154	7.24		**583**	97	**148**	**1.4**					

		Major Ions								Metals				Alkalinity				
DATE	TIME	Calcium as Ca soluble	Chloride as Cl	Hydrogen as H	Magnesium as Mg soluble	Potassium as K	Sodium as Na	Sulphate as SO4	Total Diss. Ions	Aluminium as Al soluble	Boron as B	Copper as Cu soluble	Flouride as F	Total Alkalinity as CaCO3	Hydroxide as OH	Carbonate as CO3	Bicarbonate as HCO3	Hardness as CaCO3
	Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
	WQO	*1000*	*<175*				*115*	*400*		*0.055*	*0.37*	*0.0014*	*1*					
9/12/2004	0922	2.8	<5	-	1.4	3.6	9	6	58	**0.08**	<0.1	**<0.03**	0.1	24	-	-	29	13
9/12/2004	1227	2.6	<4	-	1.3	3.7	8	5	58	0.05	<0.1	**<0.03**	<0.1	26	-	-	31	12
13/12/2004	1716	3.1	<8	-	1.7	4.2	14	6	76	0.05	<0.1	**<0.03**	<0.1	30	-	-	36	15
14/12/2004	0812	2.8	<7	-	1.6	3.8	12	5	71	0.05	<0.1	**<0.03**	<0.1	30	-	-	37	14
16/12/2004	1043	3.1	<7	-	1.8	4.2	13	4	74	0.05	<0.1	**<0.03**	0.1	33	-	-	40	15
6/12/2005	1350																	
22/12/2005	1900																	
21/01/2006	0700																	
21/01/2006	1830																	
21/02/2006	1730																	
6/05/2006	1600	7.7	11	-	3.7	4.2	15	4.3	112	0.05	0.05	**<0.03**	0.1	52	-	0.1	64	35

123 Greater than WQO

Table A7
GLNG CSG Surface Water
Roma - DNRW Surface Water Analytical Results Summary
422219A Yuleba Creek @ Forestry

DATE	TIME	Stream Water Level	Stream Discharge	Depth	Physico-Chemical Parameters: Colour True	Conductivity @ 25C	pH	Air Temp	Water Temp	Turbidity	Total Diss. Solids	Total Suspended Solids	Nutrients: Chlorophyll-a	Nitrate as NO3	Ammonia as N - soluble	Faecal Coliform	Kjeldahl Nitrogen	Total Nitrogen	Nitrate + nitrite as N - soluble	Total React P sol	Total Phosphorus as P
	Units	m	Cumecs	m	Hazen units	uS/cm	pH units	°C	°C	NTU	mg/L	mg/L	ug/L	mg/L	mg/L	CFU/100 ml	mg/L	mg/L	mg/L	mg/L	mg/L
	WQO					325	6.5-8.0		20%ile-80%ile	50	<500	10	5	0.05	0.01			0.5			0.05
2/10/1973	1705	1.17	0.089	0.1		164	7				107	**252**									
2/10/1973	1705								20												
3/03/1974	1145	1.103	0.007						27												
18/01/1975	1200	1.245	0.309						27												
18/01/1976	1240	1.55	1.276						26												
13/09/1978	1145	1.48	1.131	0.1		105	6.6				70	**175**		**0.7**							
13/09/1978	1145								14												
5/02/1982	1420	1.14	0.006	0.1		150	7.7			**100**	110	**50**		**4**							
5/02/1982	1420								29												
29/05/1983	1430	7.65	125	0.1		72	7.9			**100**	54	**360**		**4**							
27/07/1983	1550	1.28	0.223	0.1		250	7.5				200	**58**		**3.3**							
27/07/1983	1550								12												
9/11/1983	1515	1.31	0.213	0.1	20	**455**	7.6				250	**10**		**0.6**							
9/11/1983	1515								27												
3/02/1984	1440	2.5	6.529						27												
31/08/1984	1600	1.35	0.286	0.1	70	205	7.2			**80**	140	**10**		**2.2**							
30/11/1984	1700	1.04	0						27												
17/11/1986	1230	1.31	0.379	0.1	70	115	7.2			**100**	93	**300**		**0.5**							
17/11/1986	1230					106			22												
21/05/1988	1040	1.13	0.008	0.1		115	6.9			**100**	85	**154**		**1.6**							
21/05/1988	1040					88			13												
29/05/1989	1147	1.165	0.061			132			15												
9/01/1992	1115	1.25	0.39			94			25												
19/12/1995	1145	1.24	0.202			209	7.4	29.4	24.9	**597**											
20/02/1996	1635	1.288	0.142			202	7.8	36.3	26.2	**180**											
8/10/1996	1415	1.18	0.021			190	7.4		19	**213**											
11/03/1997	1445	1.61	1.329			112	7.4	28.2	24.4	**802**											
27/05/1997	1645	0.77	0	0.2	16	166	7.25			**323**	105.67	**51**		**1.35**							
27/05/1997	1645																1.255				**0.268**
27/05/1997	1645	0.77	0			173	7.25	22.1	15.5	**322**											
27/11/1997	1405	1.17	0	0.1	92	238	7.21			**327**	148.05	**84**		**1.19**							
27/11/1997	1405																1.728				**0.39**
27/11/1997	1405					245	7.4	38.9	29.5	**245**											
12/01/1999	930											**200**									
12/01/1999	930																	**2.1**			**0.36**
12/01/1999	930														**0.02**				0.25	0.03	
12/01/1999	930															70					
12/04/1999	1300									**680**		**130**									
12/04/1999	1300																	**1.9**			**0.55**
12/04/1999	1300														**0.037**				0.037	0.014	
12/04/1999	1300												**28**								
12/04/1999	1300															110					
1/07/1999	0									**500**		**75**									
1/07/1999	0																	**1.6**			**0.48**
1/07/1999	0														**0.018**				0.07	0.008	
1/07/1999	0												**9**								
1/07/1999	0															18					

DATE	Major Ions: Calcium as Ca soluble	Chloride as Cl	Magnesium as Mg soluble	Potassium as K	Sodium as Na	Sulphate as SO4	Total Diss. Ions	Metals: Aluminium as Al soluble	Boron as B	Copper as Cu soluble	Flouride as F	Iron as Fe soluble	Manganese as Mn soluble (mg/L)	Silica as SiO_2 soluble	Zinc as Zn soluble	Alkalinity: Total Alkalinity as CaCO3	Carbonate as CO3	Bicarbonate as HCO3
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WQO	1000	<175			115	400		0.055	0.37	0.0014	1	0.2			0.008			
2/10/1973	10	30	5.5	3.4	18.7	1	127.7				0.11	**5**		12		44		54
2/10/1973																		
3/03/1974																		
18/01/1975																		
18/01/1976																		
13/09/1978	5.5	11	2.3	4.5	12	7	67							15		20		24
13/09/1978																		
5/02/1982	8	13	4.3	5.3	17	10	116.8				0.09			23		45	0.1	55
5/02/1982																		
29/05/1983	4	4.2	1.8	4	9	3.7	57				0.1	**0.6**	0.01	11		21	0.1	25.5
27/07/1983	13	31	6.3	4.9	28	11	182.4		0.06			**5.7**	0.01	63		65	0.1	79
27/07/1983																		
9/11/1983	25	64	11	8.1	45	14	318.2		0.03		0.1			10		124	0.4	150
9/11/1983																		
3/02/1984																		
31/08/1984	9	28	4	5.5	26	12	161.8		0.02			**2**		20		60	0.1	73
30/11/1984																		
17/11/1986	5.7	7.1	2.7	5.5	10	7.7	82.8		0.03		0.1	**3.5**	0.03	34		33		40
17/11/1986																		
21/05/1988	5.8	7.3	2.7	4.3	13	6.1	84.3				0.1	**1.9**		24		34		41.5
21/05/1988																		
29/05/1989																		
9/01/1992																		
19/12/1995																		
20/02/1996																		
8/10/1996																		
11/03/1997																		
27/05/1997	8.2	16.17	3.6	6.2	19	3.98	122.51	0	0.00	**0.01**	0.13	0.00	0.00	15.60	**0.01**	52.41	0.06	63.82
27/05/1997																		
27/05/1997																53.6		
27/11/1997	11.9	26.26	5.5	7.7	29.4	7.52	167.74	**1.81**	0.1	0	0.12	**1.06**	0	20	**0.05**	64.12	0.07	78.07
27/11/1997																		
27/11/1997																72		
12/01/1999																		
12/01/1999																		
12/01/1999																		
12/01/1999																		
12/04/1999																		
12/04/1999																		
12/04/1999																		
12/04/1999																		
12/04/1999																		
1/07/1999																		
1/07/1999																		
1/07/1999																		
1/07/1999																		
1/07/1999																		

Notes
Bold Greater than WQO

Upper Dawson Catchment Water Quality Data

Appendix B

Table B1
URS Water Quality Parameters Upper Dawson Catchment
GLNG CSG Surface Water

Site ID		Date/Time	Water Quality Parameters					
Number	Name	Date	Time (EST)	EC (µS/cm)	DO (mg/L)	pH	Turbidity (NTU)	Temp (oC)
			MTV	*340*		*6.5-8*	*50*	
D002	Dawson River @ Yebna Crossing	05-Mar-08	12:00	107	6.2	7.1	**270**	23.9
D002	Dawson River @ Yebna Crossing	02-Feb-08	10:35	264	5.47	6.76	**166**	25.4
D002	Dawson River @ Yebna Crossing	14-May-08	16:20	265	11.3	7.5	9	17.3
D003	Pine Creek @ Phelps Rd	05-Mar-08	-	-	-	-	-	-
D003	Pine Creek @ Phelps Rd	02-Feb-08	12:20	227.2	4	6.59	**266**	29.2
D003	Pine Creek @ Phelps Rd	13-May-08	15:45	-	-	-	-	-
D004	Dawson River @ Taroom-Roma Rd	05-Mar-08	16:40	150	6.01	7.73	**555**	23.3
D004	Dawson River @ Taroom-Roma Rd	02-Feb-08	13:36	270	5.23	6.82	**215**	27.3
D004	Dawson River @ Taroom-Roma Rd	13-May-08	10:55	**368**	9.84	7.78	14	14.6
D005	Eurombah @ Hornet Bank Rd	05-Mar-08	17:10	118	6.15	7.5	**492**	24.4
D005	Eurombah @ Hornet Bank Rd	02-Feb-08	14:15	317	5.95	7.16	**191**	28.8
D005	Eurombah @ Hornet Bank Rd	13-May-08	10:00	**340**	6.22	7.3	13	16.1
D006	Bridge/Ram Creek @ Roma Rd	05-Mar-08	16:30	192	7.43	**8.41**	**111**	28.1
D006	Bridge/Ram Creek @ Roma Rd	02-Feb-08	14:43	271	6.18	7.51	32	30.9
D006	Bridge/Ram Creek @ Roma Rd	13-May-08	11:30	-	-	-	-	-
D007	Paddys Creek @ Roma Rd	05-Mar-08	16:05	65.3	8.62	**8.41**	2	31.2
D007	Paddys Creek @ Roma Rd	02-Feb-08	14:56	232	4.57	**8.05**	**408**	30.8
D007	Paddys Creek @ Roma Rd	13-May-08	11:45	265	7.9	7.4	**240**	17.4
D008	Middle Creek @ Roma Rd	05-Mar-08	15:40	186	6.4	**8.5**	**152**	28.6
D008	Middle Creek @ Roma Rd	02-Feb-08	15:30	234	8.58	**8.34**	**54**	33.7
D008	Middle Creek @ Roma Rd	13-May-08	12:15	**488**	11.3	**8.5**	**160**	20.7
D009	Juandah Creek @ Roma Rd	05-Mar-08	15:20	120.2	2.26	7.14	**473**	28.5
D009	Juandah Creek @ Roma Rd	02-Feb-08	15:46	244	6.04	**8.06**	**163**	30.4
D009	Juandah Creek @ Roma Rd	13-May-08	12:30	218	6.36	6.8	**410**	20.5
D010	Dawson River @ Old Taroom Bridge	05-Mar-08	14:50	157.2	5.39	7.42	**427**	24.2
D010	Dawson River @ Old Taroom Bridge	02-Feb-08	16:23	225.1	4.15	6.98	**243**	27.8
D010	Dawson River @ Old Taroom Bridge	13-May-08	13:35	**420**	8.22	7.77		18.9
D011	Kinnoul Creek @ Taroom Rd	05-Mar-08	10:50	104	4.3	7.2	30	25.1
D011	Kinnoul Creek @ Taroom Rd	02-Feb-08	17:00	245	6.48	7.49	28	28.8
D011	Kinnoul Creek @ Taroom Rd	13-May-08	14:10	205	9.5	7.43	28	20.2
D012	Hutton Creek @ Carnarvon Hwy	05-Mar-08	-	-	-	-	-	-
D012	Hutton Creek @ Carnarvon Hwy	03-Feb-08	9:00	**485**	4.5	7.2	5	26.8
D012	Hutton Creek @ Carnarvon Hwy	13-May-08	9:15	260	6.7	6.98	22	14.9
D013	Dawson River @ Arcadia Valley Rd	06-Mar-08	10:00	136	-	7.1	-	-
D013	Dawson River @ Arcadia Valley Rd	03-Feb-08		222.9	6.33	7	31	25.5
D014	Dawson River @ Hornet Bank Rd	02-Feb-08	14:00	-	-	-	-	-
D015	Dawson River @ Baralaba	04-Feb-08	12:45	132	7.88	6.58	**180**	27.6
D016	Dawson River @ Carnavon Hwy	03-Feb-08		-	-	-	-	-

Notes:

MTV	minimum trigger value
BOLD	Greater than MTV
"-"	Creek dry

Table B2
Upper Dawson Catchment - URS Surface Water Analytical Results
GLNG CSG Surface Water

Location	Sample ID	Date Sampled	Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				Major Ions										Alkalinity			
			Sample Type	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Suspended Solids (SS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
			Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
			LOR	*2*	*5*	*1*	*1*	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*0.01*	*0.1*	*0.01*	*0.1*	*1*	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
			MTV	*na*	*na*	*na*	*10*	*0.024/0.013*	*0.37*	*0.0002*	*0.05*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*	*na*	*na*	*0.05*	*0.5*	*1000*	*175*	*1*	*na*	*na*	*115*	*400*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
D002	D002_05/03/08	5/03/2008	PS	-	31	8	**152**	0.002	<0.1	**0.0002**	0.004	**0.005**	-	**0.004**	0.004	**0.016**	**0.141**	1	**0.2**	**1.1**	12	8	0.1	4	6	20	2	1.74	1.9	-	<1	<1	73	73
D002	D002_05/03/08CHK	5/03/2008	LD	-	-	-	**146**	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	4	5	22	2	-	-	-	-	-	-	-
D002	D002_13/05/08	13/05/2008	PS	<5	1	-	3	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.67**	<0.001	<0.001	<0.005	<0.01	0.4	0.02	0.4	19	25	0.1	7	3		31	2.93	2.97	-	-	-	-	-
D004	D004_05/03/08	5/03/2008	PS	-	47	10	**152**	0.002	<0.1	0.0001	0.006	**0.008**	-	**0.007**	0.008	**0.031**	**0.174**	0.9	**0.19**	**1.1**	18	16	0.1	5	6	28	2	2.54	2.68	-	<1	<1	102	102
D004	D004_05/03/08CHK	5/03/2008	LD	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D004	QC02_05/3/08	5/03/2008	FD	-	49	<1	**290**	0.003	<0.1	0.0018	0.009	**0.008**	-	**0.007**	0.008	**0.04**	**0.149**	1.4	**0.19**	**1.6**	16	15	0.1	4	5	28	2	2.51	2.52	-	-	-	102	102
D004	D004_13/05/08	13/05/2008	PS	49	2	-	8	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.4**	<0.001	<0.001	<0.005	<0.01	0.1	0.03	0.1	27	35	<0.1	9	4		43	3.94	4.02	1.05	-	-	-	-
D004	D004_13/05/08CHK	13/05/2008	LD	-	2	-	-	-	-	-	-	-	-	-	-	-	**0.012**	-	-	-	28	-	-	9	4		49	-	-	-	-	-	-	-
D005	D005_05/03/08	5/03/2008	PS	-	44	<1	**270**	0.002	0.1	**0.0007**	0.003	**0.009**	-	**0.005**	0.005	**0.028**	**0.28**	0.8	**0.21**	**1.1**	16	9	0.1	3	6	20	2	1.93	2.05	-	<1	<1	82	82
D005	D005_13/05/08	13/05/2008	PS	<5	7	-	5	<0.001	0.08	<0.0001	<0.001	<0.001	**0.23**	<0.001	0.001	<0.005	<0.01	0.8	**0.05**	**0.8**	35	19	0.2	6	6		33	3.69	3.83	1.82	-	-	-	-
D007	D007_05/03/08	5/03/2008	PS	-	54	<1	**74**	0.002	<0.1	<0.0001	0.003	**0.007**	-	0.003	0.004	**0.02**	<0.01	1.8	**0.56**	**1.8**	13	8	0.1	2	9	20	2	1.84	1.95	-	<1	<1	78	78
D007	D007_13/05/08	13/05/2008	PS	28	9	-	**119**	0.002	0.05	<0.0001	0.002	**0.002**	**2.91**	0.001	0.002	<0.005	**0.012**	1.2	**0.22**	**1.2**	24	14	0.4	5	9		25	2.88	2.92	-	-	-	-	-
D007	D007_13/05/08CHK	13/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.2**	-	-	14	0.3	-	-		-	-	-	-	-	-	-	-
D009	D009_05/03/08	5/03/2008	PS	-	49	<1	**214**	0.004	<0.1	**0.0002**	0.005	**0.01**	-	**0.006**	0.007	**0.034**	**0.353**	1.7	**0.42**	**2.1**	12	6	0.1	2	8	23	3	1.89	2	-	<1	<1	83	83
D009	D009_13/05/08	13/05/2008	PS	16	7	-	**122**	0.002	<0.05	<0.0001	0.005	**0.007**	**9.62**	**0.005**	0.006	**0.025**	**0.177**	1.4	**0.37**	**1.6**	17	9	0.2	4	7		26	2.23	2.41	-	-	-	-	-
D009	D009_13/05/08CHK	13/05/2008	LD	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-								-	-	-	-
D010	D010_05/03/08	5/03/2008	PS	-	42	<1	**260**	0.002	<0.1	**0.0002**	0.005	**0.007**	-	**0.006**	0.005	**0.025**	**0.182**	1.3	**0.17**	**1.5**	13	16	0.2	3	6	35	2	2.53	2.63	-	<1	<1	102	102
D010	D010_05/03/08CHK	5/03/2008	LD	-	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	0.2	-	-	-	-	-	-	-	<1	<1	102	102
D010	D010_13/05/08	13/05/2008	PS	<5	3	-	6	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.28**	<0.001	<0.001	<0.005	<0.01	0.3	<0.01	0.3	28	39	0.2	10	5		49	4.34	4.45	1.18	-	-	-	-
D011	D011_05/03/08	5/03/2008	PS	-	82	<1	**26**	0.002	<0.1	<0.0001	<0.001	**0.003**		<0.001	0.002	<0.005	**0.015**	1	**0.3**	**1**	14	1	<0.1	3	8	17	1	1.74	1.91	-	<1	<1	84	84
D011	D011_13/05/08	13/05/2008	PS	8	7	-	**21**	0.001	0.05	**0.0005**	<0.001	**0.003**	**0.81**	<0.001	0.001	<0.005	<0.01	0.7	**0.09**	**0.7**	21	<1	0.1	4	7		16	2.02	2.22	-	-	-	-	-
D012	D012_14/05/08	14/05/2008	PS	45	10	-	**13**	<0.001	<0.05	0.0001	<0.001	**0.003**	**0.21**	<0.001	0.002	<0.005	<0.01	0.9	**0.07**	**0.9**	26	12	0.2	7	8		26	3.09	3.2	1.69	-	-	-	-
D012	D012_14/05/08CHK	14/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	-	-	-	25	-	0.1	7	7		25	-	-	-	-	-	-	-

NOTES

MTV - minimum trigger value

BOLD greater than MTV

PS - Primary Sample

LD - Lab Duplicate

FD - Field Duplicate Sample

Table B3
Upper Dawson Catchment - Upstream Dawson River Water Quality Data
GLNG CSG Surface Water

			Physical									Cations				Anions				Nutrients & Biological					Trace Elements										Flow			
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-a (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity	Physical Appearance	Data Source
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*		
Dawson River - Arcadia Valley	4/05/2002																																				No Flow	S
Dawson River - Arcadia Valley	1/01/2002																																				No Flow	S
Dawson River - Arcadia Valley	1/01/2002																																				No Flow	S
Dawson River - Arcadia Valley	22/06/2001																																				No Flow	S
Dawson River - Arcadia Valley	25/05/2001																																				No Flow	S
Dawson River - Arcadia Valley	20/04/2001																																				No Flow	S
Dawson River - Arcadia Valley	8/03/2001			26		199			135																												Clear	S
Dawson River - Arcadia Valley	8/02/2001	11:00		26		285			194																												Clear	S
Dawson River - Arcadia Valley	5/01/2001	13:00		27		279			190																												Clear	S
Dawson River - Arcadia Valley	17/12/2000	14:00		25		231			157																												Clear	S
Dawson River - Arcadia Valley	18/11/2000	15:30		25		231			157																												Clear	S
Dawson River - Arcadia Valley	5/10/2000																																					S
Dawson River - Arcadia Valley	5/09/2000																																				No Water	S
Dawson River - Arcadia Valley	3/08/2000																																				No Water	S
Dawson River - Arcadia Valley	13/07/2000																																				No Flow	S
Dawson River - Arcadia Valley	15/06/2000																																				No Sample	S
Dawson River - Arcadia Valley	2/06/2000																																					S
Dawson River - Arcadia Valley	29/04/2000																																					S
Dawson River - Arcadia Valley	1/04/2000																																				Not Flowing	S
Dawson River - Arcadia Valley	2/03/2000																																				No Flow	S
Dawson River - Arcadia Valley	30/01/2000																																					S
Dawson River - Arcadia Valley	30/12/1999																																					S
Dawson River - Arcadia Valley	29/11/1999																																					S
Dawson River - Arcadia Valley	30/10/1999																																					S
Dawson River - Arcadia Valley	30/09/1999																																				Not Flowing	S
Dawson River - Arcadia Valley	29/08/1999																																				No Water	S
Dawson River - Arcadia Valley	29/07/1999																																				No Water	S
Dawson River - Arcadia Valley	1/06/1999																																				No Water	S
Dawson River - Arcadia Valley	7/05/1999																																				No Water	S
Dawson River - Arcadia Valley	5/04/1999			28		135			92																												No flow, mud hole	S
Dawson River - Arcadia Valley	6/03/1999	15:00		27		176			120																												slight flow, murky	S
Dawson River - Arcadia Valley	26/02/1999																																				No Water	S
Dawson River - Arcadia Valley	1/01/1999																																				No Flow	S
Dawson River - Arcadia Valley	21/12/1998																																				No Flow	S
Dawson River - Arcadia Valley	29/11/1998																																				No Flow	S
Upstream Dawson Waterhole	9/10/2003			26.5	7.1	170	6.80	86	109			17	11	3	3	98	8	0.1	<5							**<100**									Isolated	No flow		RH
Upstream Dawson Waterhole	22/04/04			24.9	7	273	7.90	96	156	**52**		22	6	14	5	151	12	0.1	<10	**7780**	**140**					**500**									Isolated	Low		RH
Upstream Dawson Waterhole	17/11/04			24.5	6.6	**1702**	5.70	**69**	108	**82**		3	<1	6	6	70	8	0.24	<10		**1900**	**380**				**<100**									Low-Mod	Mod		RH
Dawson Road Crossing	5/09/2006			15.4	7	50	8.61	**84**	46	**125**	**101**	3	4	1	1	28	3	0.1	4	**570**	<10	10			4	<100	<0.1	16	2	**4407**	3	<0.1	4	**14**				RH
Dawson Road Crossing	26/04/2007		19.5	18.9	6.6	159	0.81	**9**	160	**68**		11	10	18	6	95	6	0.24	<1	**3300**	**110**	**590**	128*	**8.8**	2.8	23	<1	<1	**<2**	**5100**	<1	<0.5	<3	<1				RH

NOTES

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

All samples collected upstream of existing associated water discharge

S - Santos

Water Quality Data Summary

			Physical									Cations				Anions				Nutrients				Trace Elements										Biologica	Flow			
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-a (µg/L)	Level	Velocity	Physical Appearance	Data source
		MTV	*na*	*0-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1.2*	*400*	*500*	*50*	*20*		*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*		
Upper Baffle Creek	4/05/2002	15:40		21		**1585**			1078																												Clear	S
Upper Baffle Creek	1/01/2002	10:30		24		**1570**			1068																												Slight cloudy brown	S
Upper Baffle Creek	1/01/2002	10:30		24		**1570**			1068																												Slight cloudy brown	S
Upper Baffle Creek	1/01/2002	14:35		25		147			100																												Not Flowing - Yellow Brown	S
Upper Baffle Creek	1/01/2002	13:35		27		128			87																												Slight flow, muddy	S
Upper Baffle Creek	1/01/2002					97			66																												Slow Flow - Yellow Brown	S
Upper Baffle Creek	1/01/2002	13:10		29		115			78																												Slight flow, muddy	S
Upper Baffle Creek	1/01/2002	9:00		27		144			98																												Mod flow, muddy	S
Upper Baffle Creek	22/06/2001								0																												No Flow	S
Upper Baffle Creek	25/05/2001								0																												No Flow	S
Upper Baffle Creek	20/04/2001								0																												No Flow	S
Upper Baffle Creek	8/03/2001								0																												No Flow	S
Upper Baffle Creek	5/10/2000								0																													S
Upper Baffle Creek	5/09/2000								0																												No Flow	S
Upper Baffle Creek	3/08/2000								0																												No Flow	S
Upper Baffle Creek	13/07/2000	14:29		24		142			97																												Cloudy, some sediment	S
Upper Baffle Creek	15/06/2000	14:22		24		**1296**			881																												Cloudy, some sediment	S
Upper Baffle Creek	2/06/2000	10:30		19		**1901**			1293																												Slight cloudy brown	S
Upper Baffle Creek	29/04/2000	10:30		21		**1490**			1013																												Slight cloudy brown	S
Upper Baffle Creek	1/04/2000	10:30		24		**1456**			990																												Slight cloudy brown	S
Upper Baffle Creek	2/03/2000			24		**1467**			998																												Slight cloudy brown	S
Upper Baffle Creek	30/01/2000	10:30		24		**1856**			1262																												Slight cloudy brown	S
Upper Baffle Creek	30/12/1999	16:00		25		200			136																												Not Flowing	S
Upper Baffle Creek	29/11/1999	11:17		24		280			190																												Not Flowing	S
Upper Baffle Creek	30/10/1999	15:42		25		**460**			313																												Not Flowing	S
Upper Baffle Creek	30/09/1999			21		211			143																												Not Flowing	S
Upper Baffle Creek	29/07/1999			15		185			126																												No Flow	S
Upper Baffle Creek	29/07/1999			19		191			130																												Not Flowing	S
Upper Baffle Creek	1/06/1999	14:00		14		162			110																												Not Flowing	S
Upper Baffle Creek	7/05/1999	16:00		18		86			58																												Not Flowing	S
Upper Baffle Creek	5/04/1999			27		98			67																												slight flow, murky	S
Upper Baffle Creek	9/09/2003			17.5	6.8	67	8.90	94	43			6	5	1	2	54	<0.5	0.1	<5						**<100**										Mod	Low		RH
Upper Baffle Creek	21/04/2004			26.5	6.6	152	12.30	155	64	6		8	6	6	4	77	7	<.1	<10	**1350**	**60**				**500**										Low	Low		RH
Upper Baffle Creek	16/11/2004			32.7	7.8	134	8.60	119	84	**49**		<1	7	4	3	67	7	0.32	<10		**1000**	**100**			**<100**										Low	Low		RH
Upper Baffle Creek	23/05/2005				7.4	108			114	**30**		5	5	4	4	47	6	0.43	<10	**810**	**50**	**30**			**<100**				**1800**						Mod	Low		RH
Upper Baffle Creek	5/08/2006			15.8	7.1	212	9.87	99	126	**48**	**105**	17	6	11	7	99	9	0.4	3	480	**<10**	**<10**		<1	**<100**	<0.1	<1	<1	81	<1	<0.1	<1	**<10**		Mod	Low		RH
Upper Baffle Creek	22/04/2007		27.5	22.9	7.6	138	7.23	**85**	160	**49**		17	12	15	7	93	5	0.32	<1	**1100**	**<20**	**77**	318*	<1	25	<1	<1	**<2**	**750**	<1	<0.5	<3	**8.3**	**6.5**				RH
Baffle Creek	7/01/2002					**1520**			1034																												Clear	S
Baffle Creek	5/11/2001			22		**1384**			941																												Brown tinge	S
Baffle Creek	12/10/2001			22		**1484**			1009																												Brown tinge	S
Baffle Creek	29/08/2001			23		**1484**			1009																												Brown tinge	S
Baffle Creek	1/07/2001			22		**1530**			1040																												Clear, slight brown tinge	S
Baffle Creek Outflow	5/04/1999	11:50		23		**775**			527																												Slow flow - murky	S
Baffle Creek Outflow	4/05/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002					188			128																												Slow flow - murky	S
Baffle Creek Outflow	1/01/2002	11:30		27		328			223																												Mod flow, muddy	S
Baffle Creek Outflow	22/06/2001			19		**1260**			857																												Slightly cloudy Brown	S
Baffle Creek Outflow	25/05/2001			23		**1340**			911																												Slightly cloudy Brown	S
Baffle Creek Outflow	20/04/2001			25		**1350**			918																												Slightly cloudy Brown	S
Baffle Creek Outflow	8/03/2001			26		**1459**			992																												Clear, slight brown tinge	S
Baffle Creek Outflow	5/09/2000								0																												No Sample	S
Baffle Creek Outflow	3/08/2000								0																												No Sample	S
Baffle Creek Outflow	23/07/2000								0																												No Sample	S
Baffle Creek Outflow	15/06/2000								0																												No Sample	S
Baffle Creek Outflow	1/04/2000								0																												Not Flowing	S
Baffle Creek Outflow	1/04/2000	13:00		21		**1150**			782																												Slight cloudy brown	S
Baffle Creek Outflow	1/04/2000	13:00		19		**1348**			917																												Slight cloudy brown	S
Baffle Creek Outflow	2/03/2000								0																												No Tested	S
Baffle Creek Outflow	30/01/2000	13:00		24		**1252**			851																												Slight cloudy brown	S
Baffle Creek Outflow	30/12/1999								0																												Not Flowing	S
Baffle Creek Outflow	29/11/1999	14:22		22		**860**			585																												Not Flowing	S
Baffle Creek Outflow	29/10/1999	9:24		21		**880**			598																												Not Flowing	S
Baffle Creek Outflow	30/09/1999			18		**1281**			871																												Slow Flow	S
Baffle Creek Outflow	29/07/1999			16		**867**			590																												Slow flow - murky	S
Baffle Creek Outflow	29/07/1999			13		**1233**			838																												Slow - Med. Flow	S
Baffle Creek Outflow	1/06/1999	12:13		14		**553**			376																												Slow flow - murky	S
Baffle Creek Outflow	7/05/1999	11:00		19		**621**			422																												Slow - Med. Flow	S
Baffle Creek Outflow	5/04/1999			26		**649**			441																												Slow- med flow	S
Baffle Creek Outflow	9/10/2003			19		**1444**	7.30	**79**	925			**347**	4	1	1	726	55	**2**	<5						200										Low	Low		RH
Baffle Creek Outflow	22/04/2004			20		**870**	5.10	**56**	612	**37**		**162**	5	5	3	916	36	0	<10	**3970**	**220**				**700**										Low	Low		RH
Baffle Creek Outflow	17/11/2004			23		**1403**	0.40	**5**	852	**76**		**232**	8	<1	2	623	56	1	<10	**1800**	**350**				**400**										Mod	Low		RH
Baffle Creek Outflow	21/05/2005			14		**1373**	10.10	98	1030	**10**		**349**	6	<1	2	664	68	**2**	<10	**720**	**150**	**120**			**500**				**6013**						Low	Low		RH
Baffle Creek Outflow	5/09/2006			12		**1864**	7.90	**73**	1168	**39**	**154**	**437**	6	1	2	723	93	**2**	24	**770**	**<10**	**<10**		9	**600**	<0.1	16	3	**6362**	**8**	<0.1	3	**14**		Mod	Low		RH
Baffle Creek Outflow	22/04/2007		31	19	7.8	**832**	3.01	**33**	640	**16**		**200**	6	7	3	570	40	1	<1	**1100**	**66**	16	<44*	2	360	<1	<1	<2	**1300**	<1	<0.5	<3	3	**5**				RH

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

Upper Baffle Creek samples upstream of existing associated water discharge

Baffle Creek & Baffle Creek Outflow samples downstream of existing associated water discharge

S - Santos

Table B5
Upper Dawson Catchment - Baffle Creek Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date		Physical								Cations				Anions				Nutrients				Trace Elements										Biologica	Physical Appearance	Data source
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-*a* (µg/L)		
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*		
Dawson Downstream Baffle	4/05/2002																																	Not tested	S
Dawson Downstream Baffle	1/01/2002																																	Not tested	S
Dawson Downstream Baffle	1/01/2002																																	Not tested	S
Dawson Downstream Baffle	22/06/2001			19		**1130**			768																									Silty cloudy Brown	S
Dawson Downstream Baffle	25/05/2001			23		**980**			666																									Silty cloudy Brown	S
Dawson Downstream Baffle	22/06/2001	11:00		24		**844**			574																									Slow flow, lt Brown	S
Dawson Downstream Baffle	22/06/2001	12:15		26		**853**			580																									Slow flow, muddy	S
Dawson Downstream Baffle	22/06/2001					182			124																									Slow flow - lt Brown	S
Dawson Downstream Baffle	22/06/2001	11:05		26		**783**			532																									Slt flow, muddy	S
Dawson Downstream Baffle	22/06/2001	11:45		27		**353**			240																									Mod flow, muddy	S
Dawson Downstream Baffle	22/06/2001			28		**673**			458																									Slow - med flow	S
Dawson Downstream Baffle	20/04/2001			24		**800**			544																									Silty cloudy Brown	S
Dawson Downstream Baffle	8/03/2001			25		288			196																									Clear, slt brown tinge	S
Dawson Downstream Baffle	5/10/2000	10:30		24		**1367**			930																									Clear, slt sediment	S
Dawson Downstream Baffle	5/09/2000	10:00		24		**1498**			1019																									Clear, slt sediment	S
Dawson Downstream Baffle	3/08/2000	10:00		20		**1358**			923																									Clear, slt sediment	S
Dawson Downstream Baffle	23/07/2000																																	No Sample	S
Dawson Downstream Baffle	15/06/2000																																	No Sample	S
Dawson Downstream Baffle	2/06/2000																																		S
Dawson Downstream Baffle	29/04/2000																																		S
Dawson Downstream Baffle	1/04/2000	1.00PM		24		**1060**			721																									Silty cloudy brown	S
Dawson Downstream Baffle	2/03/2000			24		**1152**			783																									Silty cloudy brown	S
Dawson Downstream Baffle	30/01/2000																																		S
Dawson Downstream Baffle	31/12/1999	2:30		21		**1050**			714																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	29/11/1999	15:00		22		**880**			598																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	29/10/1999	10:52		21		**910**			619																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	30/09/1999			18		**1402**			953																									Slow Flow	S
Dawson Downstream Baffle	29/07/1999			15		**872**			593																									Slow flow - murcky	S
Dawson Downstream Baffle	29/07/1999			15		**1319**			897																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	1/06/1999	11:30		13		**556**			378																									Slow flow - murcky	S
Dawson Downstream Baffle	7/05/1999	11:15		19		**664**			452																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	25/4/07		24.6	19.5	**8.3**	**1296**	6.05	**67.0**	990	**99.0**	**280.0**	10	10	5.5	820	120	**1.4**	<1	**1600.0**	**90.0**	**82.0**	305*	3.4	**480.0**	<1	8.3	**<2**	**1700**	<1	<0.5	4.2	1.5	**15**		RH

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources
*by calcuation from Nitrate as N

Table B6
Upper Dawson Catchment - Hutton Creek Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date	Time	Physical: Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)
		MTV	*na*	*0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*
Upper Hutton Creek	9/10/2003			18.8	7.9	**1478**	9.10	98	1139		
Upper Hutton Creek	25/04/2007		27.7	22.5	6.6	156	4.31	**49**	190	**570**	
Hutton Creek	19/04/2004			24.4	7.2	**358**	3.60	**41**	292	**10**	
Hutton Creek	16/11/2004			23.2	7.6	**461**	5.60	**66**	284	**36**	
Hutton Creek	26/05/2005			9.7	7	195	9.90	88	195	**170**	
Hutton Creek	5/08/2006			14.9	6.6	183	8.00	**78**	116	**123**	**116**
Hutton Creek	21/04/2007		34.3	21.3	7.1	273	3.49	**39**	220	**32**	
Hutton Creek	8/08/1973	1450		19	**8.1**	155			96	**116**	
Hutton Creek	15/12/1976	1317		31	7.9	**390**			198	7	
Hutton Creek	8/09/1980	1405			**8.2**	215			122	**10**	**75**
Hutton Creek	25/03/1982	1405		27	8	160			97	**200**	**100**
Hutton Creek	16/12/1983	930		24	**8.2**	195			130	**20**	25
Hutton Creek	20/03/1984	1400		27	7.8	250			150	**10**	12
Hutton Creek	24/06/1984	1405		14	7.5	270			150	5	
Hutton Creek	19/10/1984	1500		20	7.9	**570**			320	5	
Hutton Creek	15/01/1985	920		24	7.8	200			120	**445**	**100**
Hutton Creek	20/10/1985	1025		20	**8.2**	**390**			1010	**10**	1
Hutton Creek	14/02/1988	1109		25	7.2	131			84	**630**	**100**

Sample Collection Point	Sample Date	Cations: Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Anions: Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Nutrients: Total nitrogen (µg/L)	Total phosphorous (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)
		115	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*
Upper Hutton Creek	9/10/2003	**133**	9.4	91	16	314	**267**	0.1	120				
Upper Hutton Creek	25/04/2007	14		20			6	0.31	<1	**1800**	**170**	**51**	**168***
Hutton Creek	19/04/2004	27	7.0	27	7	171	28	<.1	<10	**2340**	**70**		
Hutton Creek	16/11/2004	39	10.0	30	9	190	39	0.36	<10	**1300**	**100**		
Hutton Creek	26/05/2005	18	7.0	9	4	87	12	0.43	<10	**1330**	**230**	**240**	
Hutton Creek	5/08/2006	24	6.0	5	2	83	12	0.2	5	**680**	**<10**	**<10**	
Hutton Creek	21/04/2007	59	7.4	12	4	130	20	0.31	<1	**1200**	**76**	**93**	**101***
Hutton Creek	8/08/1973	14	5.4	11	3	65	10	0.14					
Hutton Creek	15/12/1976	30	6.8	36	7	145	37	0.5	4				**1200**
Hutton Creek	8/09/1980	17	4.1	16	4	88	15	0.1	5				**4000**
Hutton Creek	25/03/1982	12	4.2	12	3	77	8		5.4				**2100**
Hutton Creek	16/12/1983	17	4.6	16	4	90	15		2.7				**1200**
Hutton Creek	20/03/1984	20	4.9	20	5	110	25	0.1	6.3				
Hutton Creek	24/06/1984	22	4.8	22	5	135	19	0.1	3.3				
Hutton Creek	19/10/1984	70	1.6	34	11	185	81	0.1	12				**1100**
Hutton Creek	15/01/1985	17	5.2	15	4	88	16	0.1	2				**1100**
Hutton Creek	20/10/1985	**175**	4.5	85	67	275	**355**	0.3	170				**500**
Hutton Creek	14/02/1988	9	4.3	12	3	65	4	0.1	2.1				**3800**

Sample Collection Point	Sample Date	Trace Elements: Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Biologica: Chl-*a* (µg/L)	Flow: Level	Velocity	Data source
		24/13	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*	
Upper Hutton Creek	9/10/2003		<100										Isolated	No flow	RH
Upper Hutton Creek	25/04/2007	<1	32	**<1**	<1	**2**	**1900**	**4.8**	<0.5	6.3	1.5	**13**	-	-	RH
Hutton Creek	19/04/2004		**800**										Moderate	Low	RH
Hutton Creek	16/11/2004		<100										Low	Low	RH
Hutton Creek	26/05/2005		<100				**2358**						Low	Low	RH
Hutton Creek	5/08/2006	2	<100	<0.1	5	**<1**	62	2	<0.1	<1	**<10**		Mod	Low	RH
Hutton Creek	21/04/2007	1.6	79	**<1**	<1	**<2**	**2300**	<1	<0.5	<3	**20**	**6.6**			RH
Hutton Creek	8/08/1973														DNRW
Hutton Creek	15/12/1976														DNRW
Hutton Creek	8/09/1980														DNRW
Hutton Creek	25/03/1982														DNRW
Hutton Creek	16/12/1983		20												DNRW
Hutton Creek	20/03/1984		20												DNRW
Hutton Creek	24/06/1984		20												DNRW
Hutton Creek	19/10/1984		10												DNRW
Hutton Creek	15/01/1985		20												DNRW
Hutton Creek	20/10/1985		100												DNRW
Hutton Creek	14/02/1988		10												DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources

Table B7
Upper Dawson Catchment - Dawson Downstream Hutton Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date	Physical										Cations				Anions				Nutrients				Trace Elements										Biologica	Flow		Physical Appearance	Data source
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-*a* (µg/L)	Level	Velocity		
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*		
Dawson d/s Hutton-1	23/04/2004			22.2	6.8	264	4.90	**56**	108	**66**		20	3	15	6	138	14	<.1	<10	**1050**	**190**				**400**										Moderate	Moderate		RH
Dawson d/s Hutton-1	19/11/2004			22.1	7	129	7.90	91	88	**316**		15	5	1	2	54	8	0.1	<10	**4100**	**580**				<100										Moderate	Moderate		RH
Dawson d/s Hutton-1	22/05/2005			9.3	7.4	266	13.40	116	160	3		21	3	15	8	111	14	0.21	<10	120	**<50**	<10			<100										No flow			RH
Dawson d/s Hutton-1	24/05/2005			12.4	**6**	265	8.10	**75**	143	3		21	3	16	9	113	16	0.2	<10	170	**<50**	**40**			<100										Low-Mod	Low		RH
Dawson d/s Hutton-1	5/10/2006			14.6	7.3	226	7.20	**70**	108	**15**	6	18	3	14	7	104	10	0.2	<1	60	**<10**	<10		<1	<100	<0.1	<1	<1	60	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawson d/s Hutton-1	23/04/2007		31.9	22.5	6.9	265	4.16	**49**	160	9		23	3	21	9	150	11	0.21	<1	**550**	**<20**	**30**	<44*	<1	16	<1	<1	<2		<1	<0.5	<3	**17**	<1				RH
Dawson d/s Hutton-2	23/04/2004			25.1	7.6	260	5.40	**66**	132	**20**		20	3	14	6	138	14	<.1	<10	280	**110**				**400**										Low	Moderate		RH
Dawson d/s Hutton-2	19/11/2004			22.7	7.2	134	8.00	93	922	**292**		15	6	1	2	56	8	0.08	<10	**3100**	**680**				<100										Moderate	Moderate		RH
Dawson d/s Hutton-2	24/05/2005			13.8	7	249	9.50	93	172	3		21	3	16	9	111	14	0.17	<10	190	**<50**	<10			<100				66						Low-Mod	Low		RH
Dawson d/s Hutton-2	5/10/2006			15.4	7.6	228	7.20	**71**	124	**11**	4	19	3	14	7	106	12	0.2	<1	60	**<10**	<10		<1	<100	<0.1	<1	<1	97	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawson d/s Hutton-2	23/04/2007		31.5	21.8	7	282	5.93	**68**	160	3		28	4	26	11	150	12	0.21	<1	**560**	**<20**	<6	<44*	<1	15	<1	<1	<2		<1	<0.5	<3	<1	<1				RH
Dawsons Bend	9/11/2003			19.2	6.7	258	5.10	**55**	95			27	2	14	7	157	12	0.1	<5						<100										Low	Low		RH
Dawsons Bend	20/04/2004			24.6	**6**	270	4.50	**54**	92			21	3	14	7	131	15	<.1	<10	270	**60**				**500**										Low	Low		RH
Dawsons Bend	19/11/2004			21.2	6.9	136	7.40	**84**	136	**366**		15	5	1	<1	55	9	0.17	<10	**3400**	**750**				<100										Moderate	Moderate		RH
Dawsons Bend	24/05/2005			17.9	7.1	244	8.40	89	148	4		21	3	14	9	106	15	0.21	<10	40	**<50**	<10			<100				62						Low	Mod		RH
Dawsons Bend	5/10/2006			16.7	7.3	228	7.00	**72**	122	**10**	2	21	3	13	8	102	13	0.2	<1	90	20	<10		<1	<100	<0.1	<1	<1	23	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawsons Bend	23/04/2007		23.1	24.1	6.9	273	5.03	**60**	220	**14**		22	3	19	9	130	14	0.28	<1	**540**	46	<6	<44*	<1	14	<1	<1	<2		<1	<0.5	<3	<1	<1				RH
Yebna Crossing	31/09/1999			19		**430**			292																												Slow Flow	S
Yebna Crossing	1/04/2002	15:00		22		182			124																												Slightly cloudy brown	S
Yebna Crossing	7/01/2002					244			166																												Muddy	S
Yebna Crossing	1/01/2002	15:00		25		318			216																												Very slight cloudy brown	S
Yebna Crossing	1/01/2002	15:00		25		318			216																												Very slight cloudy brown	S
Yebna Crossing	9/11/2001			21		234			159																												Clear	S
Yebna Crossing	10/10/2001					234			159																												Clear	S
Yebna Crossing	29/08/2001			22		241			164																												Clear	S
Yebna Crossing	1/07/2001			21		250			170																												Clear	S
Yebna Crossing	22/06/2001			18		215			146																												Slightly Murky	S
Yebna Crossing	25/05/2001			24		165			112																												Slightly Murky	S
Yebna Crossing	20/04/2001			24		160			109																												Slightly Murky	S
Yebna Crossing	8/03/2001			25		176			120																												Clear	S
Yebna Crossing	4/02/2001	15:00		26		186			126																												Slightly cloudy	S
Yebna Crossing	23/01/2001	14:00		25		151			103																												Slightly cloudy	S
Yebna Crossing	19/12/2000	16:00		25		249			169																												Slightly cloudy	S
Yebna Crossing	21/11/2000	13:00		26		266			181																												Clear	S
Yebna Crossing	10/10/2000	11:30		25		290			197																												Clear	S
Yebna Crossing	2/09/2000	11:00		25		297			202																												Clear	S
Yebna Crossing	3/08/2000	14:37		25		257			175																												Clear	S
Yebna Crossing	23/07/2000	14:32		25		266			181																												Clear	S
Yebna Crossing	21/06/2000	14:24		25		275			187																												Clear	S
Yebna Crossing	14/04/2000	15:00		25		241			164																												Very slight cloudy brown	S
Yebna Crossing	21/06/2000	12:30		22		305			207																												Faint Cloudy brown	S
Yebna Crossing	14/04/2000	12:30		21		279			190																												Faint Cloudy brown	S
Yebna Crossing	6/03/2000			24		**344**			234																												Very slight cloudy brown	S
Yebna Crossing	30/01/2000	12:30		25		282			192																												Very slight cloudy brown	S
Yebna Crossing	30/12/1999	10:45		20		260			177																												Flow	S
Yebna Crossing	29/11/1999	16:35		22		**380**			258																												Flow	S
Yebna Crossing	29/10/1999	16:00		23		**430**			292																												Flow	S
Yebna Crossing	29/07/1999			15		**348**			237																												Slow flow - murky	S
Yebna Crossing	29/07/1999			17		**435**			296																												Slow Flow - Clear to Yellow	S
Yebna Crossing	1/06/1999	8:00		12		245			167																												Slow flow - murky	S
Yebna Crossing	8/05/1999	9:30		18		194	4.00		132																												Mod flow - murky	S
Yebna Crossing	23/02/1999	9:50		25		110			75																												Mod flow, murky	S
Yebna Crossing	23/02/1999	10:00		28		187			127																												Mod flow, muddy	S
Yebna Crossing	23/02/1999			26		231			157																												Mod flow, muddy	S
Yebna Crossing	28/11/1998	11:30		17		286			194																												Med Flow - Brown	S
Yebna Crossing	28/11/1998	14:30		28		200			136																												Mod flow, murky	S
Yebna Crossing	28/11/1998	15:00				176			120																												Med Flow - Brown	S
Yebna Crossing	9/08/2003			19.1	7.8	214	9.50	103	89			31	3	11	5	127	19	0.1	<5						<100										Moderate	Moderate		RH
Yebna Crossing	20/04/2004			20.8	7.2	292	7.20	**81**	92	4		27	3	14	6	124	22	<.1	<10	**500**	40				**600**										Moderate	Low		RH
Yebna Crossing	18/11/2004			24.6	7.3	273	5.00	**60**	172	**142**		29	6	7	5	103	19	0.23	<10	**1100**	**280**				<100										Mod-High	Mod		RH
Yebna Crossing	25/05/2005			13	7.7	226	13.00	124	127	2		27	3	11	6	88	22	0.16	<10	50	<50	<10			<100				156						Low	Mod		RH
Yebna Crossing	5/11/2006			13.4	7.8	228	14.30	135	134	8	4	27	3	9	4	87	21	0.1	<1	30	<10	<10		<1	<100	<0.1	<1	<1	76	<1	<0.1	<1	**<10**		Mod	Mod		RH
Yebna Crossing	24/04/2007		27.4	21.6	**8**	242	9.28	107	180	**11**		33	4	17	6	130	20	0.22	<1	**500**	22	14	<44*	<1	16	<1	<1	<2	**390**	<1	<0.5	<3	<1	<1				RH

BOLD Exceeds adopted guideline value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources
*by calcuation from Nitrate as N

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400	500	50		20	700	5		371	1.4	200			8							
Dawson Taroom	31/09/1999						19		445			303																													Med Flow	S
Dawson Taroom	1/04/2002	14:00					24		96			65																													Cloudy brown	S
Dawson Taroom	1/04/2002	12:45					19		257			175																													Rapid Flow - Flood level 4.35 m, Brown	S
Dawson Taroom	1/04/2002	16:00					28		300			204																													Mod flow, muddy	S
Dawson Taroom	1/04/2002	17:00							193			131																													Rapid Flow - Brown	S
Dawson Taroom	1/04/2002	11:10					25		117			80																													Mod flow, muddy	S
Dawson Taroom	1/04/2002	11:30					27		140			95																													Mod flow, murky	S
Dawson Taroom	1/04/2002						27		258			175																													Mod flow, murky	S
Dawson Taroom	7/01/2002								216			147																													Muddy	S
Dawson Taroom	1/01/2002	16:00					24		247			168																													Clear	S
Dawson Taroom	1/01/2002	16:00					24		247			168																													Clear	S
Dawson Taroom	9/11/2001						21		242			165																													Clear	S
Dawson Taroom	10/10/2001								242			165																													Clear	S
Dawson Taroom	10/08/2001						22		214			146																													Brown tinge	S
Dawson Taroom	1/07/2001						20		234			159																													Clear	S
Dawson Taroom	22/06/2001						19		220			150																													Slightly Murky	S
Dawson Taroom	25/05/2001						24		155			105																													Slightly Murky	S
Dawson Taroom	20/04/2001						24		145			99																													Slightly Murky	S
Dawson Taroom	8/03/2001						25		118			80																													Clear	S
Dawson Taroom	5/02/2001	13:00					27		364			248																													Clear	S
Dawson Taroom	18/01/2001	10:30					26		381			259																													Clear	S
Dawson Taroom	20/12/2000	13:20					25		213			145																													Clear	S
Dawson Taroom	20/11/2000	14:00					26		268			182																													Clear	S
Dawson Taroom	2/10/2000	13:30					24		321			218																													Clear	S
Dawson Taroom	2/09/2000	13:00					24		324			220																													Clear	S
Dawson Taroom	3/08/2000	14:35					24		301			205																													Clear	S
Dawson Taroom	22/07/2000	14:33					24		297			202																													Slight cloudy, brown sediment	S
Dawson Taroom	20/06/2000	14:18					24		284			193																													Slight cloudy, brown sediment	S
Dawson Taroom	14/04/2000	16:00					24																																		Clear	S
Dawson Taroom	14/04/2000	11:45					22		410			279																													Clear	S
Dawson Taroom	14/04/2000	11:45					21		410			279																													Clear	S
Dawson Taroom	6/03/2000						23		314			214																													Clear	S
Dawson Taroom	30/01/2000	11:45					24		377			256																													Clear	S
Dawson Taroom	30/12/1999	11:30					22		340			231																													Flow	S
Dawson Taroom	29/11/1999	15:04					24		310			211																													Flow	S
Dawson Taroom	29/10/1999	14:28					24		410			279																													Flow	S
Dawson Taroom	29/07/1999						16		367			250																													Slow flow - murcky	S
Dawson Taroom	29/07/1999						17		450			306																													Slow Flow - Murky	S
Dawson Taroom	1/06/1999	9:10					14		319			217																													Mod. Flow - clear/murcky	S
Dawson Taroom	8/05/1999	11:00					19		209			142																													Moderate flow- murky	S
130302A	1/12/1963	1630	0.81	0.60	0.10			8.10	290			200			33		21.0	11.0	143	36	0.20	2.0														117.00	0.00		98	246.2		DNRW
130302A	28/05/1964	2359	0.71	0.20	0.10			8.00	244			148			36		22.0	8.0	146	32	0.60	1.0														120.00			88	245.6		DNRW
130302A	30/11/1964	1520	0.65	0.07	0.10			7.30	287			148			41		16.0	7.0	138	33	0.40															113.00	0.00		69	235.4		DNRW
130302A	7/09/1965	950	0.69	0.13	0.10			7.40	290			164			36		18.0	8.0	132	32	0.20	1.0														108.00	0.00		78	227.2		DNRW
130302A	3/02/1966	830	0.71	0.20	0.10			8.20	310						42		35.0	8.0	195	32	0.30	7.0														160.00			120	319.3		DNRW
130302A	3/02/1966	830					29																																			DNRW
130302A	14/04/1966	1430	0.84	0.23	0.10			7.80	172						22		14.0	5.0	93	12	0.15	11.0														76.00			56	157.2		DNRW
130302A	14/04/1966	1430					24																																			DNRW
130302A	11/05/1966	1645	0.69	0.18	0.10			7.60	196						22		19.0	5.0	112	14	0.10	4.0														92.00			68	176.1		DNRW
130302A	11/05/1966	1645					17																																			DNRW
130302A	25/04/1971	830	0.74	0.34	0.10			7.90	435						34		44.0	11.0	220	35	0.15															180.00	0.00		155	344.2		DNRW
130302A	25/04/1971	830	0.73	0.34			18																																			DNRW
130302A	26/08/1971	1500	0.72	0.22	0.10			7.90	390						35		32.0	10.0	189	30	0.15															155.00	0.00		121	296.2		DNRW
130302A	26/08/1971	1500	0.72	0.22			17																																			DNRW
130302A	16/09/1972	845	0.64	0.05			20																																			DNRW
130302A	14/12/1972	1615	0.65	0.02	0.10			7.70	282						30		23.0	6.0	142	24	0.20															116.00	0.00		82	225.2		DNRW
130302A	14/12/1972	1615					31																																			DNRW
130302A	13/04/1973	835	0.66	0.14	0.10			7.60	165			113	197		15	6.7	14.5	3.5	93	10	0.19						10000			90		400		7.00		76.00			51	153.2		DNRW
130302A	13/04/1973	835					21																																			DNRW
130302A	10/08/1973	1630	0.86	1.56	0.10			7.80	180			115	2		18	5.2	13.7	3.5	73	18		7.0										2100		13.00		60.00		0.2	49	141.1		DNRW
130302A	10/08/1973	1630					18																																			DNRW
130302A	5/12/1973	1630	0.70	0.22	0.10			7.80	230			134	70		18	6.1	22.0	4.7	116	16	0.17											300		10.00		96.00	0.00	0.4	74	183.8		DNRW
130302A	5/12/1973	1630					29																																			DNRW
130302A	27/03/1974	755	0.70	0.24	0.10			7.70	360			204	20		36	6.8	27.0	8.5	170	28	0.13													14.00		140.00	0.00	0.5	102	276.9		DNRW
130302A	27/03/1974	755					25																																			DNRW
130302A	24/06/1974	1700	0.78	0.52	0.10			7.60	265			152	85		28	5.5	20.0	5.3	122	24	0.15													9.00		100.00	0.00	0	72	205		DNRW
130302A	24/06/1974	1700					15																																			DNRW
130302A	19/09/1974	1710	0.69	0.21	0.10			7.80	315			175			37	3.7	18.0	7.0	146	34	0.27													3.00		120.00	0.00	0	74	246		DNRW
130302A	19/09/1974	1710					19																																			DNRW
130302A	16/10/1974	1038	0.69	0.25	0.10			7.70	290			158			31	3.3	17.0	6.0	129	30	0.17													7.00		106.00	0.00	0	67	216.5		DNRW
130302A	16/10/1974	1038	0.69	0.25			22																																			DNRW
130302A	16/12/1974	1405	0.58	0.02	0.10			7.50	310			192	31		32	6.3	19.5	6.8	136	30	0.22													30.00		112.00	0.00	0	77	230.8		DNRW
130302A	16/12/1974	1405					30																																			DNRW
130302A	7/04/1975	1610	0.85	1.60			23																																			DNRW
130302A	2/07/1975	1615	0.71	0.15			18																																			DNRW
130302A	27/08/1975	1645	0.62	0.08	0.10			7.70	267			140	14		28	3.5	14.0	5.9	125	24														2.00		103.00	0.00	0	59	200.4		DNRW
130302A	27/08/1975	1645					16																																			DNRW
130302A	14/10/1975	1630	0.59	0.03	0.10			7.90	261			140	20		31	3.3	12.0	5.7	115	26	0.10													2.00		94.00	0.00	0	53	193.1		DNRW
130302A	14/10/1975	1630					23																																			DNRW
130302A	15/10/1975	1640	0.58	0.03			24																																			DNRW
130302A	12/01/1976	1606	0.85	1.85	0.20			8.15	258			158	72		23	6.4	21.0	6.1	115	22	0.20	3.0					2400									96.00		0.8	78			DNRW
130302A	12/01/1976	1606	0.86	1.85			27																																			DNRW
130302A	13/09/1976	1542	0.64	0.16	0.10			8.50	370			201			43	3.4	24.0	7.8	165	38							200									141.00	0.00	3.2	92	284.7		DNRW
130302A	13/12/1976	1642	0.72	0.54	0.10			7.30	230			128	159		18	5.2	20.0	4.3	102	14	0.70	2.0					1700							12.00		84.00	0.00	0.1	68	168		DNRW
130302A	13/12/1976	1642					31																																			DNRW
130302A	18/04/1977	1637	0.69	0.40	0.10			8.00	310			172	27		28	5.7	24.0	7.2	120	26	0.10	5.0					700							16.00		100.00		0.7	90	217.4		DNRW
130302A	18/04/1977	1637					24																																			DNRW
130302A	28/10/1977	1210	0.60	0.12	0.10			8.20	335			174			41	3.4	13.0	7.8	142	33	0.20						200							4.00		118.00		1.1	65	241.7		DNRW
130302A	28/10/1977	1210					26																																			DNRW
130302A	12/04/1978	1428	0.62	0.21	0.10			7.90	250			149	19		21	5.0	21.0	5.8	128	18	0.20	2.5					900							11.00		106.00		0.6	76	203		DNRW
130302A	12/04/1978	1428					24																																			DNRW
130302A	28/07/1978	1124	0.69	0.48			14																																			DNRW
130302A	25/10/1978	1605	0.61	0.18			23																																			DNRW
130302A	5/01/1981	1045	1.25	2.73	0.10			7.50	200			122	1270		16	7.4	17.0	4.5	95	7	0.10	5.0					5000							13.00		78.00		0.2	61	156.8		DNRW
130302A	5/01/1981	1045					25																																			DNRW
130302A	25/03/1981	1425	0.66	0.26			26																																			DNRW
130302A	24/07/1981	1630	0.71	0.43	0.10			7.70	370			189	10	13	34	4.2	25.0	7.6	160	30	0.10	1.0					2000							6.00		132.00		0.5	94	264.4		DNRW
130302A	24/07/1981	1630					16																																			DNRW
130302A	9/09/1981	1410	1.19	1.47	0.10			7.90	160			101	50	100	13	5.3	12.0	3.1	65	11	0.10	8.0					4000							12.00		54.00		0.3	43	121.8		DNRW
130302A	9/09/1981	1410					17																																			DNRW
130302A	9/09/1981	1410	0.61	0.25	0.10			8.00	400			212	10	5	40	3.7	27.0	8.6	183	34	0.10	5.0												3.00		152.00		1.1	103	302.5		DNRW
130302A	9/10/1981	800	0.57	0.09	0.10			7.80	390			207	10	5	41	3.6	23.0	8.2	177	34	0.10	5.0					1000							3.00		146.00		0.6	91	293.5		DNRW
130302A	9/10/1981	800					21																																			DNRW
130302A	20/04/1982	1620	0.81	0.22			23																																			DNRW
130302A	9/08/1982	1645	0.79	0.14	0.10			8.50	320			170	9	2	36	3.7	21.0	6.4	140	29	0.10	3.0					400			20		20		1.00		119.00		2.7	79	242.4		DNRW
130302A	9/08/1982	1645					15																																			DNRW
130302A	2/11/1982	1105	0.70	0.02	0.10			8.10	310			170	10	8	39	3.8	15.5	6.6	140	34	0.20	1.0					600									116.00		1	66	241.2		DNRW
130302A	2/11/1982	1105					25																																			DNRW
130302A	23/03/1984	1625	0.98	0.80	0.10			7.40	355			200	20	17	33	4.9	27.0	7.3	170	25	0.10	8.3					500			20		100		14.00		140.00		0.3	98	276.5		DNRW
130302A	23/03/1984	1625					26		330																																	DNRW
130302A	20/06/1984	1600	0.85	0.25	0.10			7.40	450			250	5		51	3.9	32.0	9.7	195	42	0.10	3.7								10				7.00		161.00		0.4	120	337.8		DNRW
130302A	20/06/1984	1600					15		425																																	DNRW
130302A	29/07/1984	715	6.56	976.38	0.10			7.00	165			160	1000	100	22	6.4	9.5	3.0	95	8		4.1								40		4600	0.03	56.00		78.00		0.1	36	152.6		DNRW
130302A	29/07/1984	715					13																																			DNRW
130302A	29/07/1984	1350	6.52	1050.59	0.10			6.90	175			120	800	100	21	6.4	10.0	2.3	85	9		5.0					2300			1000		1200	1.00	19.00		70.00			34	144		DNRW
130302A	30/07/1984	855	6.43	602.20	0.10			6.50	120			120	80	100	12	6.0	8.1	2.7	60	6		3.3								20		4800	0.02	52.00		49.00			31	102.5		DNRW
130302A	31/07/1984	835	6.13	605.58	0.10			6.80	115			110	80	100	11	5.1	7.7	2.6	67	6		3.1								20		4000	0.01	44.00		55.00			30	106.1		DNRW
130302A	16/10/1984	945	0.87	0.40	0.10			8.00	425			240	5		55	2.4	26.0	8.9	185	40	0.10	9.0								10		200		6.00		154.00		1.2	102	327.8		DNRW
130302A	16/10/1984	945					24																																			DNRW
130302A	10/04/1985	840	0.81	0.16	0.10			7.80	270			160	60	63	25	5.5	22.0	5.0	140	20	0.20	2.1					600			30		390		12.00		116.00		0.5	76	221.3		DNRW
130302A	10/04/1985	840					23		250																																	DNRW
130302A	2/07/1985	1635	0.81	0.15	0.10			8.10	450			180	10	24	38	3.8	22.0	6.4	145	33	0.10						600			20		240		5.00		121.00		1	81	250.1		DNRW
130302A	2/07/1985	1635					13		284																																	DNRW

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-*a* (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*		*20*	*700*	*5*		*371*	*1.4*	*200*			*8*							
130302A	17/10/1985	1500	1.07	1.07	0.10			7.90	330			170	20	20	36	3.6	19.0	6.4	145	35	0.20	2.0					500			20		10	0.01	1.00		120.00		0.7	74	248.4		DNRW
130302A	17/10/1985	1500					23		315																																	DNRW
130302A	7/11/1985	845	0.92	0.38			23		170																																	DNRW
130302A	21/01/1986	1100	0.82	0.12	0.10			7.90	255			140	80	89	22	5.7	17.0	5.0	110	18	0.20	2.0					500			30		500	0.01	15.00		91.00		0.5	63	181.4		DNRW
130302A	21/01/1986	1100					29		134																																	DNRW
130302A	15/04/1986	1427	0.78	0.05	0.10			8.20	275			150	105	2	24	5.0	23.0	6.0	130	17	0.20	2.1								30		80		8.00		109.00		1.2	82	208.6		DNRW
130302A	15/04/1986	1427					23		275																																	DNRW
130302A	16/07/1986	1055	0.81	0.11	0.10			8.10	345			180	20	8	36	5.0	24.0	7.0	155	30	0.10									20		30		1.00		129.00		1.3	89	258.4		DNRW
130302A	16/07/1986	1055					15		363																																	DNRW
130302A	14/10/1986	1642	0.95	0.07	0.10			8.00	310			160	5	7	33	3.7	20.5	6.4	140	27	0.10									10		30		1.00		116.00		0.9	78	231.1		DNRW
130302A	14/10/1986	1642					25		300																																	DNRW
130302A	31/03/1987	1544	0.80	0.03	0.10			7.80	260			140	28		22	5.4	21.0	5.0	125	16	0.20									20		30		12.00		103.00		0.4	73	195		DNRW
130302A	31/03/1987	1544					25		246																																	DNRW
130302A	14/07/1987	1616	0.85	0.09	0.10			7.80	305			160	5	3	33	4.6	20.0	6.0	140	27	0.10									10		20		1.00		116.00		0.5	75	231.2		DNRW
130302A	14/07/1987	1616					13		361																																	DNRW
130302A	4/11/1987	1405	0.77	0.23	0.10			7.20	205			120	142	100	25	5.8	15.0	3.3	95	14	0.10						700					350		12.00		78.00		0.1	51	159.4		DNRW
130302A	4/11/1987	1405					26		208																																	DNRW
130302A	10/02/1988	833	3.29	43.20	0.10			7.10	195			110	4900	100	12	5.6	20.0	3.3	105	5	0.20	2.6					3400			20		110		11.00		86.00		0.1	64	157.1		DNRW
130302A	10/02/1988	833					23		181																																	DNRW
130302A	19/05/1988	1240	0.85	0.13	0.10			7.70	210			120	302	100	21	3.9	14.0	3.0	93	14	0.10	2.2					1400					360		14.00		77.00		0.2	47	153.2		DNRW
130302A	19/05/1988	1240					18																																			DNRW
130302A	24/09/1988	1145	0.80	0.06	0.10			7.90	250			150	60	38	29	3.2	20.0	5.2	125	23	0.10											40		3.00		104.00		0.6	71	206.1		DNRW
130302A	24/09/1988	1145					21		295																																	DNRW
130302A	12/01/1989	800	1.46	4.43	0.10			7.00	125			83	280	100	10	5.3	8.9	2.4	56	10	0.10						800					1300		19.00		46.00			32	94.2		DNRW
130302A	12/01/1989	800					26		138																																	DNRW
130302A	6/05/1989	1150	1.95	11.78	0.10			7.80	190			130	124	100	19	7.4	15.5	4.1	87	19		2.2					4700					190		12.00		72.00		0.3	56	159.4		DNRW
130302A	6/05/1989	1150							230																																	DNRW
130302A	3/09/1989	1100	0.97	0.58	0.10			7.70	325			190	100	100	35	3.5	23.0	7.3	140	38	0.10	4.4					500			40		40		8.00		115.00		0.4	88	252.2		DNRW
130302A	3/09/1989	1100							347																																	DNRW
130302A	3/12/1989	1720	1.05	1.07			29		96																																	DNRW
130302A	25/03/1990	1310	0.94	0.45	0.10			7.80	211			124	74	200	22	5.5	14.3	4.5	87	17	0.14	3.6					1900			20		70		12.20		72.00	0.01	0.3	54	156.5		DNRW
130302A	25/03/1990	1310					23		282																																	DNRW
130302A	13/07/1990	1415	1.03	0.83	0.10			8.20	394			233	36	58	44	4.5	28.1	9.2	169	38	0.13	6.0					1100			10		350		17.70		141.00	0.03	1.5	107	301.2		DNRW
130302A	13/07/1990	1415					10	8.20	423																																	DNRW
130302A	15/11/1990	805	0.84	0.13	0.10			7.90	525			295	11	8	66	5.2	33.0	11.8	221	60	0.19	3.3							0.05	30	40			6.50		182.00	0.01	1	131	401		DNRW
130302A	15/11/1990	805					25	8.30	522																																	DNRW
130302A	3/12/1990	1720	0.83	1.07				7.80	280			180	103	100	30	4.6	24.0	5.8	130	27	0.20	4.8					1700		0.15	10	20	80	0.01	16.00	10	110.00		0.5	83	230		DNRW
130302A	25/03/1991	920	0.78	0.07	0.10			7.30	241			140	57	3	22	6.4	17.9	5.4	115	16	0.17	1.9					500		0.04	40	40	20		13.20	10	94.00	0.00	0.1	66	186.3		DNRW
130302A	25/03/1991	920					24	7.90	230																																	DNRW
130302A	3/08/1991	1630	0.83	0.13	0.10			7.90	350			191	10	5	42	5.0	21.9	7.5	155	37	0.15								0.04	10				1.30		128.00	0.02	0.8	85	269.1		DNRW
130302A	3/08/1991	1630					9	8.40	303																																	DNRW
130302A	1/12/1991	1815	0.45	0.47	0.10			7.60	470			251	13	5	52	6.3	30.1	10.4	206	44	0.18						3300		0.06		20	20		2.70	10	170.00	0.01	0.5	117	353.8		DNRW
130302A	10/04/1992	853	0.83	0.12	0.10			7.60	204			123	158	200	19	4.7	17.5	4.1	102	9	0.16	1.9					1700		0.33		10	190		14.60		84.00	0.01	0.2	60	160.7		DNRW
130302A	10/04/1992	853					19		201																																	DNRW
130302A	13/08/1992	745	0.79	0.09	0.10			8.10	304			159	9		34	3.0	19.5	6.5	135	26	0.13	0.4					1000		0.01					0.50		113.00	0.03	1.1	75	227.6		DNRW
130302A	13/08/1992	745					14	7.70	310																																	DNRW
130302A	23/11/1992	1625	1.48	5.88			27	7.52	249																																	DNRW
130302A	2/07/1993	1205	0.73	0.07			14	7.40	320																																	DNRW
130302A	22/07/1993	827	0.77	0.13	0.10			7.60	335			183	12	3	37	5.6	21.5	8.2	154	28	0.14	1.8					200				10	10		4.90	10	126.00	0.01	0.4	87	256.7		DNRW
130302A	22/07/1993	827					15	7.60	325																																	DNRW
130302A	23/11/1993	1625	1.48	5.88	0.10			7.60	259			151	71	36	22	6.7	21.0	5.3	126	19	0.14	1.5					3200				20	60		11.00		103.00	0.01	0.2	74	204		DNRW
130302A	16/12/1993	1400	1.70	9.30	0.10			7.40	165			100	515	200	14	5.4	12.7	3.2	78	8	0.11	2.3					5400				40			11.00		63.00	0.01	0.1	44	128.8		DNRW
130302A	13/04/1994	1723	0.78	0.19	0.10			7.70	263			160	46	43	27	6.0	20.5	5.4	132	19	0.11	1.4					1100		0.17		30	130		15.30		109.00	0.01	0.4	73	212.7		DNRW
130302A	13/04/1994	1723					21	7.50	269																																	DNRW
130302A	31/08/1994	1535					20	8.10	313																																	DNRW
130302A	31/08/1994	1600	0.72	0.03	0.10			7.80	314			164	3	1	37	4.4	19.5	6.3	139	27	0.11	0.4					300				10			0.30		115.00	0.01	0.5	74	234.8		DNRW
130302A	31/08/1994	1600																						22.0																		DNRW
130302A	31/08/1994	1600																							0.00	33.0																DNRW
130302A	25/10/1994	845	7.20		0.10			7.20	263			154	120	200	35	4.8	15.0	4.6	113	31	0.14	1.1					1000		0.37		40	210	0.01	5.90	10	93.00		0.1	56	206.2		DNRW
130302A	25/10/1994	845																						330.0																		DNRW
130302A	25/10/1994	845																							0.18	5.0																DNRW
130302A	25/10/1994	845																										2.00														DNRW
130302A	25/10/1994	900	0.64	0.00	0.20	25	20	7.29	270	3.21																																DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30			7.65	331			179	7	2	38	6.0	20.2	6.5	151	29	0.15	0.0					560		0.00			10	0.00	4.30		124.60	0.01	0.39	77.13	251.83		DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30																			65.7																		DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30		27	7.40	342																																	DNRW
130302A	16/02/1995	1253	6.00	540.00	0.20			7.14	146			88	461	200	14	5.5	10.1	2.1	62	8	0.11	2.1					4070		0.27			170	0.00	11.40		51.30	0.00	0.05	33.83	108.85		DNRW
130302A	16/02/1995	1253																						509.4																		DNRW
130302A	16/02/1995	1253																							0.16	6.7																DNRW
130302A	16/02/1995	1253																										2.00														DNRW
130302A	16/02/1995	1253	6.00	540.00	0.20		23	6.71	135																																	DNRW
130302A	28/03/1995	1730	0.78	0.26	0.30			8.04	213			133	46	78	22	5.1	17.4	5.0	110	14	0.13	1.3					1010		0.03		50	80	0.02	12.60		91.00	0.02	0.67	63.97	176.15		DNRW
130302A	28/03/1995	1730																						113.4																		DNRW
130302A	28/03/1995	1730																							0.02	35.0																DNRW
130302A	28/03/1995	1730	0.78		0.30		27	6.88	228	3.78																																DNRW
130302A	29/03/1995	1530	0.78	0.26			27	6.88	228	3.78																																DNRW
130302A	4/05/1995	1545	0.74		0.30			7.77	317			189	15	12	35	5.6	24.3	7.2	156	28	0.13	1.5					160		0.00		10		0.0	9.20	10	129.00	0.01	0.51	90.23	259.2		DNRW
130302A	4/05/1995	1545																						24.5																		DNRW
130302A	4/05/1995	1545																							0.01	7.1																DNRW
130302A	4/05/1995	1545	0.74	0.06	0.20		21	7.80	342	4.40				15																												DNRW
130302A	27/07/1995	1035	0.76	0.13	0.20		11	7.50	312	10.55				6																												DNRW
130302A	27/07/1995	1050	0.76	0.13	0.20			7.78	303			166	11	6	38	3.7	18.8	5.9	138	29	0.14	0.5							0.01		30		0.00	1.20	10	113.60	0.01	0.46	71.17	234.33		DNRW
130302A	27/07/1995	1050																						4.0																		DNRW
130302A	27/07/1995	1050																							0.00	27.4																DNRW
130302A	31/08/1995	1500	0.73	0.46	0.20			7.71	298			167	17	11	37	3.7	20.3	6.4	141	29	0.12	0.0					270		0.00		30	120	0.01	0.70		116.50	0.01	0.42	76.96	238.1		DNRW
130302A	31/08/1995	1500																						12.6																		DNRW
130302A	31/08/1995	1500																							0.00	30.3																DNRW
130302A	31/08/1995	1500	0.73	0.46	0.20	25	20	7.80	317	6.20				11																												DNRW
130302A	29/11/1995	1734	1.42	5.11	0.10			7.47	169			92	320	450	14	5.0	12.0	3.1	70	9	0.11	1.1					970		0.00		40		0.00	12.40		57.20	0.01	0.11	42.69	115.37		DNRW
130302A	29/11/1995	1734																						312.9																		DNRW
130302A	29/11/1995	1734																							0.05	67.1																DNRW
130302A	29/11/1995	1734	1.42	5.11	0.10		27	7.30	156	5.12				589																												DNRW
130302A	27/03/1996	1722	0.76	0.11	0.20			7.84	396			224	17	11	42	6.2	28.6	8.3	190	32	0.15	1.0							0.02		10	40	0.01	12.40		157.10	0.01	0.8	105.49	308.6		DNRW
130302A	27/03/1996	1722																						45.6																		DNRW
130302A	27/03/1996	1722																							0.01	43.6																DNRW
130302A	27/03/1996	1722	0.75	0.11	0.20		24	7.68	410	4.11				16																												DNRW
130302A	24/05/1996	1100	0.72		0.20			7.41	214			129	50	205	28	4.7	12.8	3.5	104	14	0.16	1.8					1300		0.00		20		0.00	10.90	10	85.60	0.00	0.14	46.33	170.84		DNRW
130302A	24/05/1996	1100																						138.2																		DNRW
130302A	24/05/1996	1100																							0.04	42.2																DNRW
130302A	24/05/1996	1100	0.82	0.31	0.20	21	15	7.30	217	6.80				216																						80.00						DNRW
130302A	19/07/1996	1130	0.76	0.14			10	7.80	317																																	DNRW
130302A	30/07/1996	1455	0.77	0.19	0.10			7.95	309			167	14	9	37	4.0	19.6	6.3	141	28	0.11	0.5							0.00			10	0.00	1.70	10	116.90	0.01	0.69	74.81	236.89		DNRW
130302A	30/07/1996	1455																						16.6																		DNRW
130302A	30/07/1996	1455																							0.00	10.2																DNRW
130302A	30/07/1996	1455	0.07	0.19	0.10		14	7.94	318	8.71				12																												DNRW
130302A	12/03/1997	700	4.06	97.00	0.10			7.01	172			111	197	327	19	7.2	10.7	2.5	84	10	0.08	2.5					1100		0.00		10	10	0.00	16.90	50	68.89	0.00	0.05	36.98	137.19		DNRW
130302A	12/03/1997	700																						696.4																		DNRW
130302A	12/03/1997	700																							0.30	163.0																DNRW
130302A	12/03/1997	700	4.06	97.00	0.10		24	6.85	172					367																												DNRW
130302A	26/03/1997	1345	0.95	1.38	0.20			7.53	304			183	57	60	30	6.6	24.9	6.5	154	20	0.13	2.0					1320		0.00		10		0.00	15.30		126.50	0.00	0.29	88.85	245.93		DNRW
130302A	26/03/1997	1345																						136.1																		DNRW
130302A	26/03/1997	1345																							0.04	61.6																DNRW
130302A	26/03/1997	1345	0.95	1.38	0.20		24	7.80	309	5.00				91																												DNRW
130302A	12/08/1997	1700	0.74	0.11	0.20		16	7.90	319	8.10																																DNRW
130302A	12/08/1997	1720	0.74	0.11	0.20			7.76	315			168	13	1	37	4.2	20.1	6.0	146	28	0.08	0.0							0.00		10		0.00	0.80		120.30	0.01	0.49	74.82	241.38		DNRW
130302A	12/08/1997	1720																						9.2																		DNRW
130302A	12/08/1997	1720																							0.01	31.8																DNRW
130302A	19/11/1997	1330	2.22	14.19	0.20	19	23	6.90	157	5.00				2800																												DNRW
130302A	19/11/1997	1340	2.22	14.19	0.20			7.16	164			102	1944	2761	23	4.6	7.8	1.7	61	14	0.11	4.8					3270		0.00		10		0.00	12.70	60	50.10	0.00	0.05	26.45	120.23		DNRW
130302A	19/11/1997	1340																						1033.3																		DNRW
130302A	19/11/1997	1340																							0.19	56.7																DNRW
130302A	27/03/1998	830	0.74	0.07	0.10			7.30	200			120	100	410	11	7.5	19.5	4.7	100	10	0.20	2.0					2300		0.05	100	50	20	0.02	9.00	20	84.00	0.00	0.1	68	160		DNRW
130302A	27/03/1998	830																						370.0																		DNRW
130302A	27/03/1998	830																							0.09	84.0																DNRW
130302A	27/03/1998	830	0.74	0.07	0.10	23	24	7.26	199	2.15				463																												DNRW
130302A	5/08/1998	730	0.76	0.15	0.20			8.10	265			140	10	10	29	4.1	16.5	5.1	120	22	0.10	2.0					500		0.05	100	50	20	0.02	1.00	20	100.00	0.00	0.9	62	200		DNRW
130302A	5/08/1998	730																						22.0																		DNRW
130302A	5/08/1998	730																							0.00	6.0																DNRW
130302A	5/08/1998	730	0.76	0.15	0.20	16	14	7.70	262	8.20				18																												DNRW
130302A	20/08/1998	1415	0.78	0.14	0.30			7.52	265			141	14	20	30	4.2	16.4	5.1	122	23	0.13	0.4					210		0.02		10	20	0.00	1.60		100.60	0.01	0.22	61.89	201.86		DNRW
130302A	20/08/1998	1415																					224.9	42.8																		DNRW
130302A	20/08/1998	1415	0.77	0.14	0.30	28	18	7.85	265	7.55				24																						105.60						DNRW
130302A	8/10/1998	1525	0.96	1.36	0.20			7.39	232			142	93	160	25	6.3	16.4	3.7	103	20	0.10	2.8					1070		0.00		20		0.00	16.50		84.34	0.00	0.14	56.13	178.1		DNRW
130302A	8/10/1998	1525																					1036.7	255.5																		DNRW
130302A	8/10/1998	1525																							0.10	10.4																DNRW
130302A	8/10/1998	1525	0.96	1.36	0.20	22	22	7.23	221	5.10				194																												DNRW

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological						Total Metals/Trace Elements							Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400	500	50		20	700	5		371	1.4	200			8							
130302A	18/11/1998	950	0.76	0.16	0.20			7.95	350			200	40	29	41	7.2	24.0	6.2	160	30	0.20	2.0					900		0.05	100	50	20	0.02	11.00	20	135.00	0.00	0.8	85	270		DNRW
130302A	18/11/1998	950																						120.0																		DNRW
130302A	18/11/1998	950																							0.04	11.0																DNRW
130302A	18/11/1998	950	0.76	0.16	0.20		25	7.15	401	3.30				39																												DNRW
130302A	9/02/1999	720	2.08	18.30	0.10			7.55	145			96	300	375	14	6.2	10.0	2.6	80	6	0.10	2.0					1500		0.21	100	50	290	0.02	15.00	20	66.00	0.00	0.1	35.5	120		DNRW
130302A	9/02/1999	720																						420.0																		DNRW
130302A	9/02/1999	720																							0.12	32.0																DNRW
130302A	9/02/1999	720	2.08	18.30	0.10	24	26	7.24	157	5.47				567																												DNRW
130302A	23/02/1999	1710	0.91	0.98	0.20			8.05	200			120	80	170	21	5.9	14.0	3.9	98	13	0.10	2.0					1200		0.05	100	50	70	0.02	14.00	20	82.00	0.00	0.6	51	160		DNRW
130302A	23/02/1999	1710																						230.0																		DNRW
130302A	23/02/1999	1710																							0.09	26.0																DNRW
130302A	23/02/1999	1740	0.91	0.98	0.20	32	28	7.30	232	4.40				181																												DNRW
130302A	23/02/1999	1740	0.78	0.20	0.20		13	7.40	313					32																												DNRW
130302A	9/03/1999	750	4.36	132.14	0.10			7.45	145			90	160	235	16	6.0	7.9	2.2	64	7	0.10	2.0					1500		0.23	100	50	200	0.02	17.00	20	53.00	0.00	0.1	29	110		DNRW
130302A	9/03/1999	750																						450.0																		DNRW
130302A	9/03/1999	750																							0.18	26.0																DNRW
130302A	9/03/1999	750	4.36	132.14	0.10	24	25	7.05	161	3.80				302																												DNRW
130302A	7/06/1999	1510	0.75	0.08	0.30			8.05	320			200	10	12	42	5.1	23.0	7.2	165	31	0.10	2.0					500		0.05	100	50	20	0.02	6.00	20	135.00	0.00	1.1	87	270		DNRW
130302A	7/06/1999	1510																						48.0																		DNRW
130302A	7/06/1999	1510	0.75	0.08	0.30	25	17	7.90	345	6.70				13																						116.00						DNRW
130302A	7/07/1999	1715	0.78		0.10																		336.4	33.5																		DNRW
130302A	7/07/1999	1715																							0.01	11.1																DNRW
130302A	7/07/1999	1715	0.78	0.22	0.10		14	7.50	325	8.20				32																												DNRW
130302A	13/09/1999	1350	0.74	0.11	0.30			7.93	282			161	11	5	34	4.1	18.8	6.6	142	25	0.12	0.4					340		0.00				0.00	1.10	10	117.65	0.01	0.63	74.04	232.13		DNRW
130302A	13/09/1999	1350																					286.7	42.0																		DNRW
130302A	13/09/1999	1350	0.74	0.11	0.30	27	19	7.50	293	7.80				9																						193.20						DNRW
130302A	8/12/1999	1650	0.71	0.03	0.20			7.79	321			190	9	9	41	5.5	21.0	7.8	162	31	0.16	0.0					530		0.01				0.00	3.10	30	133.44	0.01	0.58	84.47	269.09		DNRW
130302A	8/12/1999	1650																					348.8	39.4																		DNRW
130302A	8/12/1999	1650																							0.01	33.4																DNRW
130302A	8/12/1999	1650	0.71	0.03	0.20		27	7.60	337	6.92				10																												DNRW
130302A	18/02/2000	927	3.66	68.53	0.20			7.02	145			92	149	197	12	7.5	10.5	2.6	61	12	0.11	2.6					1640		0.00				0.00	13.10		50.16	0.00	0.03	36.89	110.14		DNRW
130302A	18/02/2000	927																					1221.0	562.0																		DNRW
130302A	18/02/2000	927																							0.34	14.1																DNRW
130302A	18/02/2000	927	3.66	68.53	0.20		22	7.20	133	4.10																																DNRW
130302A	22/03/2000	1520	0.89	0.84	0.20			8.16	410			221	39	37	57	6.7	18.1	6.2	185	30	0.21	1.0					1030		0.00			250	0.00	9.00	30	150.00	0.02	1.52	70.65	304.73		DNRW
130302A	22/03/2000	1520																					497.0	109.1																		DNRW
130302A	22/03/2000	1520																							0.04	21.7																DNRW
130302A	22/03/2000	1520	0.89	0.84	0.20		26	7.60	376	4.40				52																												DNRW
130302A	15/08/2000	1702	0.76		0.30			8.04	290			151	13	7	36	4.2	15.4	5.3	134	23	0.14	0.0					190		0.00				0.00	0.60		111.20	0.02	0.85	60.22	218.55		DNRW
130302A	15/08/2000	1702	0.76		0.30																		181.1	25.0																		DNRW
130302A	15/08/2000	1702	0.76		0.30																				0.01	4.3																DNRW
130302A	15/08/2000	1702	0.76	0.16	0.30		15	7.90	281	8.20				8																												DNRW
130302A	1/11/2000	815	2.00	2.09	0.20			6.96	135			88	1050	1250	15	5.3	7.6	2.0	55	8	0.10	2.8					5000		1.23			510	0.00	15.20		45.00	0.00	0.03	27.19	100.55		DNRW
130302A	1/11/2000	815	2.00		0.20																		3220.0	664.0																		DNRW
130302A	1/11/2000	815	2.00		0.20																				0.16	32.6																DNRW
130302A	1/11/2000	815	2.00	2.09	0.20		19	6.70	126	6.60																																DNRW
130302A	15/11/2000	1510	1.09	2.45	0.30			7.60	140			91	220	345	13	4.3	9.3	2.7	72	6	0.10	2.0					1400		0.05	100	50	490	0.02	18.00	700	59.00	0.00	1	35	110		DNRW
130302A	15/11/2000	1510	1.09		0.30																		1300.0	320.0																		DNRW
130302A	15/11/2000	1510	1.09		0.30																				0.09	66.0																DNRW
130302A	15/11/2000	1510	1.09	2.45	0.30		23	7.00	140	5.50				365																												DNRW
130302A	27/02/2001	1657	0.74	0.10	0.20		29	6.60	160	3.30				120																												DNRW
130302A	27/02/2001	1715	0.74	0.09	0.20			7.40	160			98	30	115	13	5.1	12.0	3.5	86	7	0.10	2.0					800		0.17	100	50	320	0.02	14.00	20	71.00	0.00	1	44	130		DNRW
130302A	27/02/2001	1715	0.74		0.20																		740.0	190.0																		DNRW
130302A	27/02/2001	1715	0.74		0.20																				0.07	37.0																DNRW
130302A	27/02/2001	1715	0.74		0.20		29	6.60	160	3.30				120																												DNRW
130302A	7/06/2001	1340	0.69	0.02	0.30			7.95	220			120	10	11	18	5.3	17.0	5.1	115	11	0.10	2.0					500		0.05	100	50	20	0.02	9.00	20	94.00	0.00	0.5	63	170		DNRW
130302A	7/06/2001	1340																					510.0	50.0																		DNRW
130302A	7/06/2001	1340	0.69	0.02	0.30	29	18	7.50	220	6.30				12																						99.00						DNRW
130302A	17/07/2001	1555	0.71	0.04	0.20			7.80	290			150	10	6	28	5.8	18.5	6.3	135	23	0.10	2.0					500		0.05	100	50	20	0.02	3.00	20	110.00	0.00	0.5	72	220		DNRW
130302A	17/07/2001	1555																					370.0	30.0																		DNRW
130302A	17/07/2001	1555																							0.01	10.0																DNRW
130302A	17/07/2001	1555																										7														DNRW
130302A	17/07/2001	1555	0.71	0.04	0.20		14	7.70	289	7.30				84																												DNRW
130302A	9/10/2001	1335	0.62	0.30	0.30			7.76	310			161	11	4	34	4.3	18.9	6.2	140	27	0.14	0.0							0.00	30			0.00	1.50	10	115.70	0.01	0.46	72.65	230.84		DNRW
130302A	9/10/2001	1335																					339.6	31.1																		DNRW
130302A	9/10/2001	1335	0.62	0.30	0.30		19	7.70	311	6.10				7																						112.40						DNRW
130302A	5/12/2001	1610	0.86	0.49			29	7.30	193	4.10																																DNRW
130302A	5/12/2001	1620	0.86	0.49	0.20			7.45	195			120	650	890	24	4.9	11.0	2.8	85	11	0.10	4.0					2500		0.24	200	30	170	0.03	15.00	30	70.00	0.00	0.1	39	150		DNRW
130302A	5/12/2001	1620																					1700.0	370.0																		DNRW
130302A	5/12/2001	1620																							0.15	59.0																DNRW
130302A	5/12/2001	1620	0.71	0.49	0.20		29	7.30	193	4.10				914																												DNRW
130302A	18/02/2002	1750	2.77	47.37	0.30			7.10	135			84	1100	1750	12	4.4	9.9	2.5	68	5	0.10	3.0					3600		0.05	100	30	10	0.03	10.00	40	56.00	0.00	0.1	35	110		DNRW
130302A	18/02/2002	1750																					2100.0	640.0																		DNRW
130302A	18/02/2002	1750																							0.05	29.0																DNRW
130302A	18/02/2002	1750	2.77	47.37	0.30		27	7.20	148	3.50				1170																												DNRW
130302A	19/02/2002	748	3.45	47.73	0.30		27	7.10	89	3.00				882																												DNRW
130302A	19/02/2002	1210	3.45	47.73	0.30			6.95	110			76	550	860	11	4.7	7.0	2.1	55	5	0.10	4.0					2700		0.05	800	30	10	0.03	13.00	40	45.00	0.00	0	26	92		DNRW
130302A	19/02/2002	1210																					1700.0	690.0																		DNRW
130302A	19/02/2002	1210																							0.11	24.0																DNRW
130302A	20/02/2002	910	2.92	29.43	0.30			6.95	87			60	340	580	8	4.1	5.3	1.7	45	4	0.10	2.0					1500		0.05	700	30	10	0.03	11.00	40	37.00	0.00	0	20	71		DNRW
130302A	20/02/2002	910																					1200.0	420.0																		DNRW
130302A	20/02/2002	910																							0.08	34.0																DNRW
130302A	20/02/2002	910	2.92	29.43	0.30		26	7.00	90	3.60				513																												DNRW
130302A	12/03/2002	1545	0.95	1.66	0.20			7.55	190			110	90	225	19	4.3	12.5	3.7	90	9	0.10	2.0					1600		0.13	100	30	140	0.03	12.00	10	74.00	0.00	0.2	46	140		DNRW
130302A	12/03/2002	1545																					700.0	140.0																		DNRW
130302A	12/03/2002	1545																							0.05	33.0																DNRW
130302A	12/03/2002	1545	0.95	1.66	0.20		26	7.30	185	8.00				214																												DNRW
130302A	12/03/2002	1620	0.95	1.63	0.20		26	7.30	185	8.00																																DNRW
130302A	7/05/2002	1455	0.68	0.91	0.10			7.73	268			152	35	114	36	4.6	15.2	4.3	137	13	0.16	1.1					1090		0.01	50		40	0.01	9.90		112.60	0.01	0.4	55.61	211.69		DNRW
130302A	7/05/2002	1455																					614.8	152.3																		DNRW
130302A	7/05/2002	1455	0.67	0.91	0.10	28	20	7.30	265	3.60				113																												DNRW
130302A	8/07/2002	1600	0.75	0.12	0.40			7.85	250			130	10	30	28	4.1	14.5	4.5	110	21	0.10	2.0					500		0.05	100	30	70	0.03	5.00	10	91.00	0.00	0.4	55	180		DNRW
130302A	8/07/2002	1600																					300.0	44.0																		DNRW
130302A	8/07/2002	1600																							0.01	11.0																DNRW
130302A	8/07/2002	1600	0.75		0.40		11	7.90	241	9.90				28																												DNRW
130302A	8/10/2002	745	0.69		0.10			7.40	245			130	50	140	28	5.3	14.5	3.9	110	17	0.20	2.0					900		0.07	100	30	110	0.03	7.00	40	92.00	0.00	0.2	52	180		DNRW
130302A	8/10/2002	745																					830.0	220.0																		DNRW
130302A	19/11/2002	1545	0.74	0.56	0.20			7.60	345			190	220	250	53	6.4	14.0	4.0	165	24	0.20	2.0					1600		0.05	200	30	110	0.03	7.00	10	135.00	0.00	0.4	52	270		DNRW
130302A	19/11/2002	1545																					280.0	1200.0																		DNRW
130302A	19/11/2002	1545																							0.09	56.0																DNRW
130302A	19/11/2002	1545	0.84	0.56	0.20	33	25	7.40	342	2.90				373																												DNRW
130302A	18/03/2003	1630	0.77		0.20			7.60	200			120	150	260	23	5.2	12.0	3.6	105	7	0.20	2.0					1500		0.05	100	30	10	0.03	11.00	10	87.00	0.00	0.2	45.5	160		DNRW
130302A	18/03/2003	1630																					900.0	290.0																		DNRW
130302A	18/03/2003	1630																							0.03	36.0																DNRW
130302A	18/03/2003	1630	0.77		0.20		30	7.20	171	3.60				261																												DNRW
130302A	15/05/2003	1500	0.78		0.20			7.57	210			122	78	255	24	4.2	13.0	3.6	104	11	0.12	0.8					1310		0.05		10	100	0.01	12.81		85.77	0.01	0.21	47.33	162.41		DNRW
130302A	15/05/2003	1500																					789.5	189.0																		DNRW
130302A	15/05/2003	1500	0.78		0.20	24	20	7.40	221	4.80																										228.00						DNRW
130302A	18/06/2003	1723	0.75		0.20			7.85	248			144	20	45	29	4.5	16.5	4.8	122	18	0.12	1.0					260		0.04	100	10	60	0.03	9.99	10	101.17	0.01	0.47	60.98	196.71		DNRW
130302A	18/06/2003	1723	0.75		0.20																		371.6	44.7																		DNRW
130302A	18/06/2003	1723	0.75		0.20																				0.01	10.2																DNRW
130302A	18/06/2003	1723	0.75		0.20		14	7.30	255	6.50				45																												DNRW
130302A	9/09/2003	1635	0.75	0.12	0.10			8.10	280			150	10	14	32	3.9	16.0	5.2	130	22	0.10	2.0					500		0.05	200	30	10	0.03	1.00	10	110.00	0.00	0.9	61	210		DNRW
130302A	9/09/2003	1635	0.75		0.10																		200.0	20.0																		DNRW
130302A	9/09/2003	1635	0.75		0.10																				0.01	8.0																DNRW
130302A	9/09/2003	1650	0.75	0.12	0.20		19	8.10	279	7.50				16																												DNRW
130302A	28/10/2003	810	0.70		0.20			7.60	305			160	20	12	34	4.8	19.0	6.1	150	24	0.20	2.0					500		0.05	100	30	10	0.03	1.00	10	125.00	0.00	0.3	72	240		DNRW
130302A	28/10/2003	810	0.70		0.20																		330.0	42.0																		DNRW
130302A	28/10/2003	810	0.70		0.20	27	23	7.70	313	3.10				12																						135.00						DNRW
130302A	13/01/2004	1530	0.83		0.10			7.20	155			98	1300	2000	17	5.0	10.0	2.0	78	6	0.20	4.0					2600		0.05	100	30	20	0.03	14.00	50	64.00	0.00	0.1	33	120		DNRW
130302A	13/01/2004	1530	0.83		0.10																		2300.0	850.0																		DNRW
130302A	13/01/2004	1530	0.83		0.10																				0.23	73.0																DNRW
130302A	13/01/2004	1530	0.83		0.10		27	6.90	154	2.20				2000																												DNRW
130302A	13/01/2004	1535	0.83	0.59			27	6.90	154	2.10				2000																												DNRW
130302A	11/05/2004	1545	0.76		0.10			7.80	385			210	10	22	49	5.6	21.5	6.7	185	30	0.20	2.0					500		0.05	100	30	20	0.03	10.00	10	150.00	0.00	0.7	81	300		DNRW
130302A	11/05/2004	1545	0.76		0.10																		350.0	41.0																		DNRW
130302A	11/05/2004	1545	0.76		0.10																				0.01	9.0																DNRW
130302A	11/05/2004	1545	0.76		0.10		19	7.60	382	5.60				22																												DNRW
130302A	22/05/2004	1050	999.99		0.20			7.85	380			210	20	13	46	5.0	21.0	7.0	180	31	0.20	2.0					500		0.05	100	30	10	0.03	6.00	10	150.00	0.00	0.8	82	290		DNRW
130302A	22/05/2004	1050	999.99		0.20																		210.0	29.0																		DNRW
130302A	22/05/2004	1050	999.99		0.20	24	16	7.90	378	7.20				16																						157.60						DNRW
130302A	25/10/2004	1515	0.77		0.10			7.78	342			180	19	14	41	5.0	19.0	6.5	157	28	0.10	1.0					500		0.05	30	30	10	0.03	2.00	10	130.00	0.00	0.7	74	258		DNRW
130302A	25/10/2004	1515	0.77		0.10																		380.0	40.0																		DNRW
130302A	25/10/2004	1515	0.77		0.10																				0.01	4.7																DNRW
130302A	25/10/2004	1515	0.77		0.10		27	7.50	346	5.00				14																												DNRW
130302A	28/10/2004	730	1.48		0.30			7.18	218			127	1760	2790	24	6.9	13.0	3.3	101	11	0.10	3.9					2200		0.05	60	30	10	0.03	13.00	30	83.00	0.00	0.1	45	165		DNRW

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-*a* (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*		*20*	*700*	*5*		*371*	*1.4*	*200*			*8*							
130302A	28/10/2004	730	1.48		0.30																		**3807.5**	**1387.1**																		DNRW
130302A	28/10/2004	730	1.48		0.30																				0.16	**41.4**																DNRW
130302A	28/10/2004	730	1.48		0.30		20	7.20	215	3.20				**2000**																												DNRW
130302A	16/11/2004	1200	1.62		0.30			7.48	201			123	**766**	**976**	20	5.7	15.0	3.6	99	12	0.10	1.7					**3100**		0.10	40	30	80	0.03	12.00	**20**	82.00	0.00	0.2	53	161		DNRW
130302A	16/11/2004	1200	1.62		0.30																		**1549.4**	**417.9**																		DNRW
130302A	16/11/2004	1200	1.62		0.30	33	26	7.60	145	4.00				**800**																						87.00						DNRW
130302A	16/03/2005	820	0.69		0.10			7.74	**388**			227	**40**	**59**	59	6.8	18.0	5.1	213	22	0.20	1.0					**1000**		0.05	80	30	10	0.03	9.00	**10**	176.00	0.00	0.6	65	326		DNRW
130302A	16/03/2005	820	0.70		0.10																		**639.0**	**157.0**																		DNRW
130302A	16/03/2005	820	0.70		0.10																				0.05	**35.0**																DNRW
130302A	16/03/2005	820	0.70		0.10		25	7.60	**386**	2.10				**62**																												DNRW
130302A	7/07/2005	1730	0.89		0.00			7.57	204			120	**310**	**389**	26	4.3	9.3	3.0	92	15	0.10	2.3					**2000**		0.05	50	30	10	0.03	12.00	**60**	76.00	0.00	0.2	35	154		DNRW
130302A	7/07/2005	1730	0.90		0.00																		**1037.0**	**197.0**																		DNRW
130302A	7/07/2005	1730	0.90		0.00																				0.09	**49.0**																DNRW
130302A	7/07/2005	1730					15	7.50	205	8.10				**380**																												DNRW
130302A	24/10/2005	1700	3.20		0.10			7.10	118			77	**1340**	**1830**	17	4.2	4.3	1.4	58	6	0.20	1.5					**3800**		0.05	70	30	10	0.03	10.00	**80**	48.00	0.00	0	17	97		DNRW
130302A	24/10/2005	1700	3.20		0.10																		**2052.0**	**411.0**																		DNRW
130302A	24/10/2005	1700			0.10		24	7.00	92	7.00				**999**																												DNRW
130302A	15/11/2005	1520	0.89		0.20			7.48	193			115	**149**	**262**	19	5.0	13.0	3.9	97	12	0.10	1.2					**1200**		0.05	30	30	10	0.03	12.00	**10**	80.00	0.00	0.1	49	152		DNRW
130302A	15/11/2005	1520	0.00		0.00																		**880.0**	**168.0**																		DNRW
130302A	15/11/2005	1520	0.00		0.00																				0.03	**27.1**																DNRW
130302A	15/11/2005	1520					27	7.20	194	5.30																																DNRW
130302A	12/12/2005	1730			0.30			7.39	161			99	**716**	**759**	14	6.0	12.0	2.7	82	6	0.10	1.9					**2300**		0.05	50	30	50	0.03	14.00	**80**	68.00	0.00	0.1	41	127		DNRW
130302A	12/12/2005	1730			0.30																		**1328.2**	**449.5**																		DNRW
130302A	14/12/2005	1730			0.30	34	30	7.40	136	6.40				**660**																												DNRW
130302A	7/02/2006	1505	0.00		0.10			7.40	234			136	**44**	**86**	22	6.9	17.0	4.1	120	10	0.10	1.0					**1000**		0.05	40	30	140	0.03	17.00	**10**	98.00	0.00	0.2	58	180		DNRW
130302A	7/02/2006	1505	0.72		0.10																		**757.7**	**233.6**																		DNRW
130302A	7/02/2006	1505	0.72		0.10																				0.10	**20.9**																DNRW
130302A	7/02/2006	1505			0.10		29	7.40	246	2.00				**87**																												DNRW
130302A	5/05/2006	810	0.68		0.10			7.37	199			118	**32**	**52**	18	5.6	15.0	3.9	110	8	0.20	1.0					500		0.05	30	30	60	0.03	12.00	**20**	90.00	0.00	0.1	54	162		DNRW
130302A	5/05/2006	810			0.10																		**540.0**	**130.0**																		DNRW
130302A	5/05/2006	810			0.10																				0.03	**41.7**																DNRW
130302A	5/05/2006	810			0.10		16	7.30	182	2.10				**54**																												DNRW
130302A	23/08/2006	705	0.68		0.20			7.77	292			154	9	6	33	5.7	18.0	5.2	134	25	0.10	1.0					500		0.05	60	30	10	0.03	1.00	**20**	111.00	0.00	0.4	67	222		DNRW
130302A	23/08/2006	705	0.68		0.20		15	7.60	297					8																												DNRW
130302A	10/11/2006	1640			0.10			7.37	179			105	**916**	**1480**	17	5.6	13.0	2.8	85	10	0.13	3.0					**3000**		0.05	70	30	60	0.03	9.00	**60**	70.00	0.00	0.1	44	139		DNRW
130302A	10/11/2006	1640			0.10																		**2370.0**	**519.0**																		DNRW
130302A	10/11/2006	1640			0.10	26	25	7.30	166	8.20				**905**																												DNRW
130302A	14/11/2006	810	1.72		0.10	22	26	7.50	259	7.50				**230**																												DNRW
130302A	30/11/2006	945						7.52	**358**			200	**78**	**106**	40	6.3	23.0	6.2	172	23	0.20	2.3					**1300**		0.05	40	30	10	0.01	12.00	**10**	142.00	0.00	0.3	82	275		DNRW
130302A	30/11/2006	945																					**731.7**	**110.3**																		DNRW
130302A	30/11/2006	945																							0.01	**22.6**																DNRW
130302A	30/11/2006	945	0.72		0.10		26	7.50	**361**					**121**																												DNRW
130302A	20/03/2007	1600			0.10			7.38	131			89	**700**	**1090**	17	4.8	9.5	2.0	70	5	0.12	3.2					**1900**		0.11	140	30	100	0.01	11.00	**100**	58.00	0.00	0.1	32	114		DNRW
130302A	20/03/2007	1600																					**1870.0**	**605.0**																		DNRW
130302A	20/03/2007	1600			0.10	31	26	7.30	122	9.60				**999**																												DNRW
130302A	21/03/2007	1220	0.94		0.20			7.35	137			86	**648**	**1010**	13	5.7	9.7	2.1	70	5	0.12	2.4					**2700**		0.08	50	30	70	0.01	11.00	**30**	58.00	0.00	0.1	33	111		DNRW
130302A	21/03/2007	1220																					**1445.1**	**356.3**																		DNRW
130302A	21/03/2007	1220																							0.13	**51.7**																DNRW
130302A	21/03/2007	1220	0.95		0.20		26	7.00	137	4.50				**900**																												DNRW
130302A	6/05/2007	830		0.00	0.60			7.40	220			127	**86**	**106**	17	6.7	18.0	4.2	117	7	0.15	1.4					**900**		0.05	30	30	40	0.01	13.00	**10**	96.00	0.00	0.2	63	173		DNRW
130302A	6/05/2007	830																					**583.6**	**184.5**																		DNRW
130302A	8/05/2007	1130			0.10			7.46	195			120	**119**	**255**	16	6.3	16.0	3.7	108	8	0.14	2.4					**700**		0.07	50	30	110	0.01	13.00	**30**	89.00	0.00	0.2	56	162		DNRW
130302A	8/05/2007	1130																					**777.7**	**187.6**																		DNRW
130302A	8/05/2007	1130			0.10		20	7.20	182	8.00																																DNRW
130302A	3/07/2007	1645			0.20			7.63	216			121	**131**	**275**	21	4.6	15.0	4.3	102	15	0.12	1.4					**1400**		0.06	30	30	90	0.01	8.00	**20**	84.00	0.00	0.2	54	164		DNRW
130302A	3/07/2007	1645			0.20																		**587.5**	**127.4**																		DNRW
130302A	3/07/2007	1645																							0.04	**34.7**																DNRW
130302A	3/07/2007	1645	0.93		0.20		12	7.60	215	10.20				**290**																												DNRW
130302A	25/09/2007	1500																				1.0								40	30	10	0.01		**10**		0.00					DNRW
130302A	25/09/2007	1500			0.20	34	20	7.70	320	8.30				28																												DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

Samples collected downstream of existing associated water discharge points

S - Santos

RH - River Health Report

DNRW - Department of Natural Resources and Water

Table B9
Upper Dawson Catchment - Dawson River at Utopia Downs
GLNG CSG Surface Water

Sample Collection Point	Sample Date		Physical										Cations				Anions				Nutrients & Biological					Trace Elements										Flow		Data source
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-*a* (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity	
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*	
Utopia	25/05/2005			12	7.2	233	11.30	103	154	9		28	3	12	6	91	22	0.15	<10	70	**<50**	**<10**				<100	-	-	-	165					Low-mod	Mod	RH
Utopia	5/11/2006			12.3	7.9	223	14.20	132	136	**10**	4	29	4	11	4	91	21	0.1	1	100	**<10**	**<10**			<1	<100	<0.1	<1	<1	1	<1	<0.1	<1	**<10**	Mod	Mod	RH
Utopia	24/04/2007		29.8	19.8	7.6	286	8.08	89	200	**12**		37	6	22	7	150	23	0.22	<1	**680**	34	18	<44*	<1	<1	20	<1	<1	<2	**460**	<1	<0.5	<3	**<1**			RH
Utopia	20/11/1964	2359			7.7	310			174			47		19	9	156	40	0.2	2				55														DNRW
Utopia	2/02/1966	2359			7.4	288			161			35		20	7	140	30	0.1																			DNRW
Utopia	6/10/1966	2359			**8**	270			162			39		14	9	136	32	0.15	1																		DNRW
Utopia	11/08/1968	1510			7.6	273			170			40		20	6	137	28		9																		DNRW
Utopia	8/06/1970	1307			7.7	290			173			38		24	5	154	30	0.15																			DNRW
Utopia	24/04/1971	1310		19	**8**	**390**			212			32		40	9	195	35	0.1																			DNRW
Utopia	25/08/1971	1445		17	7.8	320			180			32		20	15	159	35	0.1																			DNRW
Utopia	25/11/1971	1000		24	**8**	**360**			102			44		34	4	178	36	0.2																			DNRW
Utopia	10/05/1972	800		18	**8**	270			167			40		17	8	146	30	0.25																			DNRW
Utopia	15/09/1972	1330		18																																	DNRW
Utopia	14/04/1973	1730		23	**8.2**	310			187	**13**		32	5	27	8	163	70	0.2								20											DNRW
Utopia	11/08/1973	1200		17	**8.1**	200			122			21	5	15	5	87	20																				DNRW
Utopia	5/12/1973	1100		27	**8.3**	270			161	**20**		24	5	23	7	131	26	0.16																			DNRW
Utopia	27/03/1974	1030		27	7.8	**355**			203			40	5	25	8	164	32	0.13																			DNRW
Utopia	26/06/1974	1215		15	7.7	300			178	**42**		34	4	21	7	139	31	0.13																			DNRW
Utopia	18/09/1974	1530		17	7.6	335			199	**54**		36	4	21	9	149	34	0.27																			DNRW
Utopia	16/12/1974	1730		27	7.5	330			171	9		35	5	20	8	158	14	0.16																			DNRW
Utopia	8/04/1975	1000		21.5																																	DNRW
Utopia	5/07/1975	1055		16	**8**	262			145	**33**		27	3	16	6	115	22	0.1																			DNRW
Utopia	17/10/1975	1300		26	7.6	311			165	**11**		32	4	16	7	140	26	0.2																			DNRW
Utopia	3/06/1976	1350		16	**8.1**	**430**			239			42	4	35	9	186	40	0.2	5				55														DNRW
Utopia	14/09/1976	1231		16	**8.3**	**375**			211	5		43	4	28	8	167	37	0.2					55														DNRW
Utopia	14/12/1976	1632		29	**8.2**	**360**			198	**11**		28	6	34	8	165	26	0.4	2				331														DNRW
Utopia	20/04/1977	1347		22	**8.2**	**385**			212	7		39	5	28	9	153	36		5				193														DNRW
Utopia	25/10/1977	937		24	**8.2**	325			181			35	4	21	8	150	28	0.1					166														DNRW
Utopia	11/04/1978	1305		77	**8**	280			164	**15**		30	4	19	7	142	26	0.1	2				83														DNRW
Utopia	24/10/1978	1154		21																																	DNRW
Utopia	11/11/1980	1505		29	7.8	330			172			34	4	18	8	150	24	0.1	1				138														DNRW
Utopia	18/12/1980	1200		29	7.6	320			170			31	4	19	9	148	25	0.1	1				55														DNRW
Utopia	4/02/1981	1440		18	7.6	78			77	**500**		8	4	5	2	24	3	0.1	6				**7724**														DNRW
Utopia	4/02/1981	1440			7.4	90			62	**500**		8	4	6	2	38	4	0.1	4				**1379**														DNRW
Utopia	5/02/1981	945		18	7.5	117			75	**500**		10	5	8	2	47	6	0.1	4				**1931**														DNRW
Utopia	8/02/1981	725			7.3	116			83	**100**		9	4	8	2	44	6	0.1	13				**1931**														DNRW
Utopia	24/03/1981	1755			**8.1**	285			144	**10**	16	24	5	21	7	133	20	0.1	1																		DNRW
Utopia	24/03/1981	1755		27																																	DNRW
Utopia	4/06/1981	1010		16	7.3	86			58	**200**	680	8	3	5	2	26	6	0.1	7				**1103**														DNRW
Utopia	23/07/1981	1640			**8.2**	**370**			195	**10**	10	37	4	25	8	155	31	0.1	2																		DNRW
Utopia	10/11/1981	915		24	**8.5**	**360**			200	**10**		33	4	24	8	150	27	0.2	13				276														DNRW
Utopia	25/03/1982	850		22	**8**	290			160	**50**	100	24	4	20	6	135	20	0.1	4				276														DNRW
Utopia	12/08/1982	1130		14	**8.1**	300			170	9	2	35	3	19	7	140	27	0.1	3				110														DNRW
Utopia	3/11/1982	1545		25	7.8	330			190	**10**	13	37	5	21	8	165	30	0.2	1				110														DNRW
Utopia	16/02/1983	1730		28																																	DNRW
Utopia	15/12/1983	800		24	**8.1**	320			190	**25**	72	31	4	24	7	145	28	0.1	3.3				138														DNRW
Utopia	24/03/1984	1045		26	7.3	290			220	5	3	37	4	28	9	175	33	0.1	7							30											DNRW
Utopia	23/06/1984	1210		12	7.8	330			200	5		41	3	25	8	150	36	0.1	2.5																		DNRW
Utopia	18/10/1984	1140		20	**8.3**	**480**			280	5		56	5	31	10	200	55	0.1	4.5				138			10											DNRW
Utopia	13/04/1985	1345		23	7.5	**350**			200	**10**	3	41	3	23	7	165	36	0.1								20											DNRW
Utopia	5/07/1985	1425			**8.1**	**340**			180	5	6	37	3	20	7	150	33	0.1																			DNRW
Utopia	18/10/1985	1330		22	7	90			77	**330**	100	9	3	8	2	50	8	0.1	2				138			10											DNRW
Utopia	22/01/1986	1714		30	**8**	292			160	5	5	33	5	19	7	140	26	0.2					331			20											DNRW
Utopia	18/07/1986	1440		16	**8.4**	238			160	**25**	9	32	3	19	7	130	26	0.1																			DNRW
Utopia	17/10/1986	1643		25	**8**	301			160	**10**	13	32	3	19	7	140	27	0.1					690														DNRW
Utopia	9/01/1987	1807		28	7.7	152			95	**2460**	100	11	5	13	3	72	7	0.1	2.6				**1324**														DNRW
Utopia	3/04/1987	930		23	7.9	288			160	**10**	7	32	4	20	6	140	26	0.1								20											DNRW
Utopia	17/07/1987	1530		11	**8.1**	314			150	**19**	9	31	3	17	6	125	22	0.1																			DNRW
Utopia	6/11/1987	1720		21	7.3	273			150	**44**	34	29	5	17	6	120	22	0.2																			DNRW
Utopia	12/02/1988	1645		28	7.3	142			97	**730**	100	12	5	11	4	69	9	0.1					524			10											DNRW
Utopia	17/05/1988	1452		18	7.5	250			130	**48**	38	26	3	16	5	115	21	0.1																			DNRW
Utopia	26/09/1988	1430		24	**8.1**	274			150	**12**	6	29	4	18	7	125	25	0.1																			DNRW
Utopia	12/01/1989	1437		27	7.1	175			89	**125**	100	10	5	13	3	73	9	0.1																			DNRW
Utopia	7/05/1989	852			7.8	308			150	**81**	80	24	6	19	6	105	27		3.2				**2152**														DNRW
Utopia	2/09/1989	1613			7.9	**434**			250	**10**	11	46	3	31	10	180	54	0.1	5							50											DNRW
Utopia	3/12/1989	1440		30	**8.5**	**405**			230	**76**	59	43	4	28	8	155	48	0.2	4				331			100			0.02								DNRW
Utopia	24/03/1990	1115		22	**8.1**	320			179	**47**	45	33	4	20	7	133	32	0.16	2.8				166			30											DNRW
Utopia	13/07/1990	1145		11	**8.2**	**475**			260		32	51	4	31	11	182	46	0.16	7				386			20											DNRW
Utopia	15/11/1990	1330		26	7.6	**498**			270	2		58	4	31	11	200	52	0.16	3.4							40			0.03								DNRW
Utopia	23/03/1991	915		22	7.8	**380**			217	4	5	47	5	24	8	167	44	0.19								30			0.03								DNRW
Utopia	3/08/1991	1405		8	**8**	303			176	**16**	4	37	3	19	7	141	33	0.13	2.8							20			0.04								DNRW
Utopia	29/11/1991	1340		27	7.5	294			182	4	3	41	4	17	8	143	32	0.16	0.6										0.03								DNRW
Utopia	12/04/1992	1003		17	7.6	302			158	**11**	3	33	3	19	7	135	26	0.14																			DNRW
Utopia	12/08/1992	1120		12	**8.3**	240			151	**11**	1	33	2	16	7	124	25	0.13	0.7				55														DNRW
Utopia	2/12/1992	1405		26	**8.1**	310			167	9	5	34	4	17	8	136	25	0.12	0.3				221						0.01								DNRW
Utopia	24/03/1993	1015		21.1	7.7	284			153	**11**	7	37	4	14	7	121	26	0.14					55						0.02								DNRW
Utopia	21/07/1993	915		14.2	7.9	249			137	**23**	15	30	3	15	6	115	20	0.12	0.6				28														DNRW
Utopia	24/11/1993	1455			7.6	190			110	**230**	100	15	4	13	4	79	19	0.1	2				**938**			100			0.05								DNRW
Utopia	24/11/1993	1455		24.6	7.75	163																															DNRW
Utopia	16/12/1993	1300			7.65	165			99	**290**	100	15	4	11	4	76	12	0.1	2				**1048**			100			0.05								DNRW
Utopia	13/04/1994	940		15.7	7.9	294			168	8	4	33	4	19	6	134	28	0.1	0.6				110						0.01								DNRW
Utopia	31/08/1994	1330		17.4	**8**	278			147	4	3	33	3	15	7	126	23	0.11	0.7		20	17															DNRW
Utopia	23/09/1994	1420		16.2	7.8	294			155	3		34	4	16	7	134	26	0.12			27	**20**							0.02								DNRW
Utopia	30/11/1994	920		24.3	7.79	312			170	**19**	9.8	31	4	20	9	150	22	0.14	0		**73**		149			0			0								DNRW
Utopia	11/01/1995	1250		27.4	7.25	182			110	**400**	100	18	5	12	4	76	14	0.2	2		**260**	**150**	**1434**			100			0.05								DNRW
Utopia	10/02/1995	919		25.1	7.18	95	6.21		65	**1220**	200	9	4	7	2	42	7	0.11	1.29		**487**	**30**	**1131**			0			0								DNRW
Utopia	9/03/1995	1539			7.58	185			114	**124**	200	18	4	13	4	85	17	0.1	1.8		**191**	**49**	414			0			0.01								DNRW

Water Quality Data Summary

Sample Collection Point	Sample Date		Physical										Cations				Anions				Nutrients & Biological					Trace Elements										Flow		Data source
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-*a* (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity	
		MTV	*na*	*20-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*	
Utopia	29/03/1995	900		22.6	**8.31**	321	6.75		180	8	8.9	37	4	21	7	142	28	0.13	1.08		34	**20**	121			0			0.05								DNRW
Utopia	4/05/1995	1000			7.56	303			163	4	4.5	35	4	18	6	131	28	0.12	1.02		40	7				0			0.02								DNRW
Utopia	7/06/1995	1100			7.91	296			158	**10**	3.3	32	4	17	6	125	28	0.12	0.78		28	**27**	408			0			0.01								DNRW
Utopia	5/07/1995	845		9	7.95	292	10.85		159	**11**	7.9	33	3	16	7	132	27	0.11	0.47		21	9				0			0.02								DNRW
Utopia	26/07/1995	1530		10.4	7.81	292	11.48		163	0	9.74	37	3	17	6	133	28	0.14	0.63		3	**38**				0			0.02								DNRW
Utopia	31/08/1995	900		15.7	7.84	297	7.96		159	9	7.11	34	3	18	7	132	27	0.12	0.56		17	**21**	36			0			0.05								DNRW
Utopia	5/10/1995	1330		20.9	7.92	289	8.24		153	9	7.24	31	4	16	7	127	25	0.14	0		15	**26**				0			0.02								DNRW
Utopia	2/11/1995	1300			7.24	192			113	**196**		21	4	11	4	89	17	0.13	1.64		**158**	**25**	519			0			0.07								DNRW
Utopia	28/11/1995	1315		27	7.57	195	6.13		113	**208**	340	19	4	13	4	82	18	0.11	2.04		**184**	**58**	433			0			0.01								DNRW
Utopia	8/01/1996	750		25.4	7.94	262	6.53		117	**92**	143	20	3	15	5	117	5	0.11	0.9		**114**	**41**	339			0			0.04								DNRW
Utopia	1/02/1996	1120		28.1	7.35	218	5.82		132	**235**	371	22	5	15	5	99	18	0.11	1.9		**193**	**20**	**772**			0			0								DNRW
Utopia	4/03/1996	1432		24.1	7.81	**403**	9.66		224	**14**	17.1	45	5	27	8	182	35	0.13	0.9		**59**	**30**				0			0.02								DNRW
Utopia	27/03/1996	1021		21.9	7.96	**391**	6.64		211	**11**	12.8	44	4	24	8	174	35	0.14	0.54		42	**27**				0			0.01								DNRW
Utopia	9/05/1996	1540			7.48	203			123	**124**		29	4	10	3	97	16	0.15	1.9		**138**	**24**	359			0			0.02								DNRW
Utopia	4/06/1996	1450		15.9	7.78	303	9.90		169	8	22.2	35	5	18	6	135	27	0.1	0.79		32	**25**	251			0			0.01								DNRW
Utopia	3/07/1996	1530		10.9	7.98	307	11.38		166	9	11	35	3	18	7	135	27	0.1	0		20	14				0			0.05								DNRW
Utopia	30/07/1996	950		12.3	7.86	289	9.20		156	**20**	14	34	3	17	6	127	26	0.06	0.38		29	20				0			0								DNRW
Utopia	4/12/1996	925		26.1	7.98	338	3.50		189	**20**	18	43	5	18	8	153	28	0.15	0		**59**	**57**	193			0			0								DNRW
Utopia	25/03/1997	925		20.8	7.56	312	6.76		179	**30**	54	33	5	21	7	145	23	0.12	1.33		**92**	**37**	276			0			0.01								DNRW
Utopia	13/08/1997	1230		12.2	7.75	299			160	**10**		35	3	17	6	135	26	0.1	2		10	0	138			100			0.05								DNRW
Utopia	21/11/1997	1030	28.6	22.6	7.8	260	6.20		150	**800**	1120	45	5	8	2	130	11	0.2	2		**550**	**31**	662			100			0.05								DNRW
Utopia	25/03/1998	1230	31.9	25.9	7.75	285	7.90		160	**10**	16.1	28	6	21	6	140	21	0.1	2		**70**	**87**	138			100			0.05								DNRW
Utopia	25/03/1998	1250		25.9	7.8	285	7.90				16																										DNRW
Utopia	23/07/1998	1315	16.3	12.9	7.59	258	10.30		140	**15**	26	30	3	15	6	119	22	0.12	0.37		30	12	66			0			0								DNRW
Utopia	8/10/1998	800	14.7	18.4	7.96	240	7.40		155	**34**	79	28	5	18	5	115	24	0.1	1.56	**573**	**118**	6	190			0			0.01								DNRW
Utopia	24/02/1999	1330			**8.1**	230			140	**40**	60	25	5	16	5	115	16	0.1	2		**130**	5	193			100			0.05								DNRW
Utopia	24/02/1999	1400	22.5	23.2	7.8	272	7.00				72.3																										DNRW
Utopia	8/03/1999	1500		26.7	7.45	129	6.20		79	**160**	294	11	6	8	2	58	4	0.1	2		**330**	**20**	414			100			0.05								DNRW
Utopia	6/07/1999	1232		11.6	7.3	261	9.80				12																										DNRW
Utopia	6/07/1999	1500		11.8	**8.28**	262	9.80		152	4	12	32	3	16	7	127	24	0.11	0.38	105	22	4				0			0								DNRW
Utopia	8/12/1999	1215		24.5	**8.16**	**396**	7.40		234	6	8	63	5	16	7	207	29	0.21	0	301	**79**	**55**	138			100			0								DNRW
Utopia	28/02/2000	805																		**873**	**126**																DNRW
Utopia	22/03/2000	1025		24	**8.1**	248	6.90		146	**37**	86	32	5	13	5	117	20	0.15	1.04	434	**98**	**21**	406			0			0								DNRW
Utopia	16/08/2000	1620		13.3	**8.26**	284	11.20		142	**14**	10	31	3	14	6	124	22	0.13	0	147	27	10	47			0			0								DNRW
Utopia	15/11/2000	859		22.4	7.75	164	6.90		100	**150**	257	20	4	9	3	84	11	0.1	2	**990**	**250**	**23**	524			100			0.05								DNRW
Utopia	28/02/2001	1205		26.3	7.85	249	6.60		140	**10**	13	26	4	15	5	120	18	0.1	2	320	**80**	8	138			100			0.05								DNRW
Utopia	18/07/2001	1138		10.3	**8.1**	259	10.40		140	**10**	6	28	3	14	6	120	23	0.1	2	110	20		138			100			0.05								DNRW
Utopia	5/12/2001	1330		28.2	**8.1**	335	7.20		190	**20**	27	39	4	19	10	160	24	0.2	2	320	**55**	14	138			20			0.03								DNRW
Utopia	20/02/2002	1105		26.5	7.3	130	6.50		82	**240**	308	14	4	7	3	62	7	0.1	3	**1200**	**340**	**24**	497			100			0.03								DNRW
Utopia	9/07/2002	1255		8.3	**8.1**	273	11.00		150	**20**	12	36	3	14	6	125	24	0.1	2	100	19	4	138			100			0.03								DNRW
Utopia	20/11/2002	825		21.9	7.95	291	4.60		160	**20**	16	36	4	15	7	135	25	0.2	2	290	**59**	17	138			20			0.03								DNRW
Utopia	18/03/2003	1115		23.4	**8.1**	261	7.40		150	**30**	47	31	5	16	5	130	18	0.2	2	330	48	14	138			100			0.03								DNRW
Utopia	18/06/2003	1455		11	7.97	266	9.50		149	**10**	11	32	3	16	6	122	23	0.11	0.65	104	13	3	138			100			0.03								DNRW
Utopia	9/09/2003	1440			**8.25**	275			150	**10**	11	33	3	15	6	130	23	0.1	2	150	21	3	138			100			0.03								DNRW
Utopia	9/09/2003	1448		17.1		278	9.60				13																										DNRW
Utopia	13/01/2004	1245		29.3	7.7	304	5.50		170	**40**	28	43	5	13	6	145	25	0.2	2	310	**64**	**26**	138			100			0.03								DNRW
Utopia	12/05/2004	1250		14.4	**8.1**	291	9.60		160	**10**	9	35	3	16	6	135	25	0.1	2	130	23	6	138			100			0.03								DNRW
Utopia	26/10/2004	1215		25.3	7.76	302	4.70		160	**12**	8	36	4	15	7	139	24	0.1	1	244	43	7	138			30			0.03								DNRW
Utopia	15/03/2005	1130		24.2	7.83	270	6.10		147	**14**	17	33	5	14	5	129	24	0.1	1	312	41	11	138			40			0.03								DNRW
Utopia	6/07/2005	1415		13.5	**8.14**	**551**	9.50		317	**136**	311	112	4	6	3	289	32	0.3	1	**929**	**118**	**51**	524			170			0.03								DNRW
Utopia	16/11/2005	1008		23.3	7.57	167	8.60		109	**345**	444	19	4	11	3	85	14	0.1	2	**1030**	**230**	**25**	441			80			0.03								DNRW
Utopia	7/02/2006	1030			7.09	161			91	**207**	344	14	8	9	3	68	9	0.1	1				**745**			30			0.03								DNRW
Utopia	8/02/2006	1030		26.1	7.1	158					350									**1637**	**265**	**48**															DNRW
Utopia	4/05/2006	1540		15.5	7.99	222	9.40		131	**16**	19	27	4	13	5	114	21	0.1	1	164	34	6	138			20			0.03								DNRW
Utopia	22/08/2006	1230		14.6	7.98	297			141	**27**	8	32	3	14	6	120	23	0.1	1				138			70			0.03								DNRW
Utopia	29/11/2006	1025		26.1	7.8	**350**					87									**596**	**109**	**55**															DNRW
Utopia	20/03/2007	1040		22.2	7.4	196	4.30				195																										DNRW
Utopia	3/07/2007	1426		11.3	7.4	**427**	10.00				364																										DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources

Comet-Brown Catchment Water Quality Data

Appendix C

Table C1
Comet Catchment URS Surface Water Parameters
GLNG CSG Surface Water

Site ID		Date/Time		Water Quality Parameters				
Number	**Name**	**Date**	**Time (EST)**	**EC (µS/cm)***	**DO (mg/L)**	**pH***	**Turbidity (NTU)**	**Temp (°C)**
			MTV	*340*		*6.5 - 8.0*	*50*	
C001	Arcadia Ck @ Arcadia Valley Rd #1	03-Feb-08	11:30	198	4.91	7.4	**91**	27.5
C001	Arcadia Ck @ Arcadia Valley Rd #1	06-Mar-08	11:10	210	nt	7.6	nt	nt
C001	Arcadia Ck @ Arcadia Valley Rd #1	14-May-08	10:30	-	-	-	-	-
C002	Basin Ck @ Arcadia Valley Rd	03-Feb-08	11:42	109.7	1.85	6.51	**170**	28.4
C002	Basin Ck @ Arcadia Valley Rd	06-Mar-08	10:45	141	nt	7.33	nt	nt
C002	Basin Ck @ Arcadia Valley Rd	14-May-08	10:45	228	7.21	7.11	**675**	16
C003	Arcadia Ck @ Arcadia Valley Rd #2	03-Feb-08	12:10	199	7.13	**5.85**	**58**	27.3
C003	Arcadia Ck @ Arcadia Valley Rd #2	06-Mar-08	12:20	184	nt	7.73	nt	nt
C003	Arcadia Ck @ Arcadia Valley Rd #2	14-May-08	12:45	207	4.87	6.95	44	19.5
C004	Arcadia Ck @ Arcadia Valley Rd #3	03-Feb-08	12:57	199.1	7.33	**5.59**	23	29.8
C004	Arcadia Ck @ Arcadia Valley Rd #3	06-Mar-08	13:00	173	-	7.59	-	-
C004	Arcadia Ck @ Arcadia Valley Rd #3	14-May-08		-	-	-	-	-
C005	Spring Ck @ Arcadia Rd	03-Feb-08	13:18	-	-	-	-	-
C005	Spring Ck @ Arcadia Rd	06-Mar-08		-	-	-	-	-
C005	Spring Ck @ Arcadia Rd	14-May-08	13:05	-	-	-	-	-
C012	Arcadia Ck @ Castle Hill	06-Mar-08	-	-	-	-	-	-
C012	Arcadia Ck @ Castle Hill	14-May-08	11:40	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	06-Mar-08	-	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	14-May-08	12:00	185.2	9.35	7.21	8	16.7
C007	Carnarvon Ck @ Carnarvon Hwy	03-Feb-08	14:20	**395**	6.96	**8.1**	46	31
C007	Carnarvon Ck @ Carnarvon Hwy	06-Mar-08	14:00	350	-	8.29	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	14-May-08	13:45	**490**	9.6	**8.23**	2	20.9
C006	Moolayember Ck @ Carnarvon Hwy	03-Feb-08	15:50	-	-	-	-	-
C006	Moolayember Ck @ Carnarvon Hwy	06-Mar-08	13:50	-	-	-	-	-
C006	Moolayember Ck @ Carnarvon Hwy	14-May-08	13:40	-	-	-	-	-
C008	Carnavon Ck @ Rewan (Plane Crash)	03-Feb-08	14:43	**449**	7.8	**8.08**	28	28.9
C008	Carnavon Ck @ Rewan (Plane Crash)	06-Mar-08		-	-	-	-	-
C008	Carnavon Ck @ Rewan (Plane Crash)	14-May-08	14:20	**500**	11.15	**8.42**	1	18.9
C009	Comet River @ Rolleston	03-Feb-08	16:10	212.7	4.88	7.39	**132**	30
C009	Comet River @ Rolleston	06-Mar-08		-	-	-	-	-
C011	Triumph Ck @ Rolleston Rd	04-Feb-08	9:50	128	1.05	**6.41**	566	27.6
C011	Triumph Ck @ Rolleston Rd	06-Mar-08		-	-	-	-	-
C010	Comet River @ Comet Weir	04-Feb-08	8:55	230	7.01	7.43	28	28.1
C010	Comet River @ Comet Weir	06-Mar-08		-	-	-	-	-
C013	Arcadia Ck @ Towrie	14-May-08	11:50	176	nt	7.69	nt	nt

NOTES
MTV Minimum trigger value
BOLD Greater than minimum trigger value
"-" stream dry
nt - parameters not taken due to instrument failure
* - Samples collected March 08 were analysed by laboratory due to instrument failure

Table C2
URS Surface Water Analytical Results Comet Catchment
GLNG CSG Surface Water

Location		Sample ID	Date Sampled	Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				
				Sample Type	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Total Suspended Solids (TSS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium
				Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				LOR	*2*	*5*	*1*	*1*	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*0.01*	*0.1*	*0.01*	*0.1*	*1*
				MTV				*10*	*0.007* [b]	*0.37*	*0.0002*	*0.001*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*			*0.05*	*0.5*	*1000*
C001	Arcadia Ck @ Arcadia Valley Rd #1	C001_06/03/08	6/03/2008	PS	-	85	<1	**64**	0.005	<0.1	<0.0001	<0.001	**0.002**	-	0.001	0.005	0.006	0.029	1.1	**0.18**	**1.1**	22
C001	Arcadia Ck @ Arcadia Valley Rd #1	C001_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	0.023	1.3	**0.18**	-	-
C002	Basin Ck @ Arcadia Valley Rd	C002_06/03/08	6/03/2008	PS	-	82	<1	**270**	0.002	<0.1	**0.0002**	**0.018**	**0.022**	-	**0.028**	**0.034**	**0.065**	0.09	2.4	**1.02**	**2.5**	15
C002	Basin Ck @ Arcadia Valley Rd	C002_14/05/08	14/05/2008	PS	37	5	-	**106**	<0.001	<0.05	**0.0002**	<0.001	**0.005**	**0.98**	**0.004**	0.003	<0.005	0.266	1.4	**0.38**	**1.6**	30
C002	Basin Ck @ Arcadia Valley Rd	C002_14/05/08CHK	14/05/2008	LD	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_06/03/08	6/03/2008	PS	-	46	<1	**52**	0.004	<0.1	0.0001	<0.001	**0.002**	-	<0.001	0.003	0.006	0.01	1.3	0.04	**1.3**	18
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_14/05/08	14/05/2008	PS	58	10	-	**27**	0.002	0.06	**0.0002**	<0.001	**0.002**	**0.98**	<0.001	0.003	<0.005	<0.01	1	**0.15**	**1**	19
C004	Arcadia Ck @ Arcadia Valley Rd #3	C004_06/03/08	6/03/2008	PS	-	66	<1	**128**	0.005	<0.1	<0.0001	**0.014**	**0.011**	-	**0.005**	**0.014**	**0.031**	0.018	2.3	**0.55**	**2.4**	12
C004	Arcadia Ck @ Arcadia Valley Rd #3	C004_06/03/08CHK	6/03/2008	LD	-	-	-	**138**	0.006	<0.1	<0.0001	**0.014**	**0.012**	-	**0.005**	**0.014**	**0.032**	-	-	-	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	C007_06/03/08	6/03/2008	PS	-	25	<1	**25**	0.002	<0.1	0.0001	<0.001*	**0.002**	-	<0.001	0.002	<0.005	0.044	0.6	0.08	**0.6**	36
C007	Carnarvon Ck @ Carnarvon Hwy	C007_06/03/08CHK	6/03/2008	LD	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	C007_14/5/08	14/05/2008	PS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42
C008	Carnavon Ck @ Rewan (Plane Crash)	C008_14/05/08	14/05/2008	PS	17	2	-	2	<0.001	<0.05	**0.0002**	<0.001	0.001	<0.05	<0.001	<0.001	<0.005	<0.01	<0.1	0.04	<0.1	44
C008	Carnavon Ck @ Rewan (Plane Crash)	C008_14/05/08CHK	14/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.04	-	
C013	Arcadia Ck @ Towrie	C013_06/03/08	6/03/2008	PS	-	46	<1	**25**	0.004	<0.1	0.0001	<0.001	**0.002**	-	<0.001	0.003	<0.005	0.013	1.2	**0.13**	**1.2**	16
C013	Arcadia Ck @ Towrie	C013_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	C014_14/05/08	14/05/2008	PS	41	9	-	**10**	0.001	<0.05	<0.0001	<0.001	**0.002**	**0.23**	<0.001	0.002	<0.005	<0.01	1	**0.07**	**1**	19
C014	Arcadia Ck @ Sunny Holt	QC02_14/05/08	14/05/2008	FD	93	9	-	**11**	<0.001	<0.05	<0.0001	<0.001	**0.002**	**0.26**	<0.001	0.002	<0.005	<0.01	1	**0.07**	**1**	
C014	Arcadia Ck @ Sunny Holt	QC02_14/05/08CHK	14/05/2008	LD	-	-	-	-	0.001	-	<0.0001	<0.001	**0.002**	-	<0.001	0.002	<0.005	-	-	-	-	

Notes

PS - Primary Sample

LD - Lab Duplicate

FD - Field Duplicate Sample

MTV - Minimum Trigger Value

a -Guideline physico-chemical parameter values for protection of aquatic ecosystems (central Coast Region)

b-AsIII/AsIV respectively

BOLD Greater than the MTV

Table C2
URS Surface Water Analytical Results Comet Catchment
GLNG CSG Surface Water

Location		Sample ID	Date Sampled	Analyte / Sample Type	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
					Major Ions									Alkalinity			
				Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				LOR	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
				MTV	*175*	*1*			*<115*	*250*							
C001	Arcadia Ck @ Arcadia Valley Rd #1	C001_06/03/08	6/03/2008	PS	2	0.1	6	12	8	<1	2.19	2.29	-	<1	<1	107	107
C001	Arcadia Ck @ Arcadia Valley Rd #1	C001_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-
C002	Basin Ck @ Arcadia Valley Rd	C002_06/03/08	6/03/2008	PS	<1	<0.1	4	6	4	1	1.37	1.41	-	<1	<1	67	67
C002	Basin Ck @ Arcadia Valley Rd	C002_14/05/08	14/05/2008	PS	4	0.2	8	8	-	6	2.43	2.61	-	-	-	-	-
C002	Basin Ck @ Arcadia Valley Rd	C002_14/05/08CHK	14/05/2008	LD	4	-	-	-	-	-	-	-	-	-	-	-	-
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_06/03/08	6/03/2008	PS	4	0.2	6	11	14	<1	2.06	2.25	-	<1	<1	98	98
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_06/03/08CHK	6/03/2008	LD	-	-	6	11	13	<1	-	-	-	-	-	-	-
C003	Arcadia Ck @ Arcadia Valley Rd #2	C003_14/05/08	14/05/2008	PS	3	0.2	7	8		13	2.11	2.29	-	-	-	-	-
C004	Arcadia Ck @ Arcadia Valley Rd #3	C004_06/03/08	6/03/2008	PS	4	0.2	4	8	22	2	1.9	2.08	-	<1	<1	87	87
C004	Arcadia Ck @ Arcadia Valley Rd #3	C004_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	C007_06/03/08	6/03/2008	PS	11	0.1	21	5	23	7	4.48	4.64	1.74	<1	<1	202	202
C007	Carnarvon Ck @ Carnarvon Hwy	C007_06/03/08CHK	6/03/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-
C007	Carnarvon Ck @ Carnarvon Hwy	C007_14/5/08	14/05/2008	PS	19		27	4	-	26	5.49	5.56	0.64	-	-	-	-
C008	Carnavon Ck @ Rewan (Plane Crash)	C008_14/05/08	14/05/2008	PS	14	0.2	34	2	-	27	6.06	6.21	1.17	-	-	-	-
C008	Carnavon Ck @ Rewan (Plane Crash)	C008_14/05/08CHK	14/05/2008	LD		-	-	-	-	-	-	-	-	-	-	-	-
C013	Arcadia Ck @ Towrie	C013_06/03/08	6/03/2008	PS	2	0.1	5	12	10	<1	1.81	1.99	-	<1	<1	88	88
C013	Arcadia Ck @ Towrie	C013_06/03/08CHK	6/03/2008	LD	3	0.1	-	-	-	-	-	-	-	<1	<1	87	87
C014	Arcadia Ck @ Sunny Holt	C014_14/05/08	14/05/2008	PS	3	0.2	7	10	-	9	2.01	2.16	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	QC02_14/05/08	14/05/2008	FD		0.2	-	-	-	-	-	-	-	-	-	-	-
C014	Arcadia Ck @ Sunny Holt	QC02_14/05/08CHK	14/05/2008	LD		-	-	-	-	-	-	-	-	-	-	-	-

Notes

PS - Primary Sample

LD - Lab Duplicate

FD - Field Duplicate Sample

MTV - Minimum Trigger Value

a -Guideline physico-chemical parameter values for protection of aquatic ecosystems (central Coast Reg

b-AsIII/AsIV respectively

BOLD Greater than the MTV

Table C3
Comet Catchment DNRW Surface Water Quality Results - Catchment Summary
GLNG CSG Surface Water

Water Quality Parameter		Units	MTV	Brown River (u/s Rolleston)				Carnarvon Creek				Comet River (at Rolleston)				Meteor Ck				Planet Creek				Comet River (d/s Rolleston)				Humboldt + Rockland Creek				Comet River at Comet Weir			
				Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n
Physico-Chemical Parameters	Conductivity @ 25C	µS/cm	340	66	217.0	**545**	53	115	**343.3**	**436**	38	150	206.5	331	4	160	**615.5**	**810**	40	89	**698.3**	**1080**	50	101	233.9	**1030**	81	48	202.9	335	7	72	203.9	**510**	125
	Conductivity @ 25C F	µS/cm	340	65	176.4	**385**	23	113	**341.9**	**438**	43	147	233.5	**418**	8	310	**421.3**	**520**	4	**342**	**830.9**	**1120**	13	95	164.3	**458**	69		151.0	151	1	50	187.6	**479**	85
	Turbidity	NTU	50	1	**77.9**	**620**	37	1	26.9	**200**	27	1.5	**149.5**	**430**	3	2	27.8	**100**	12	1	7.6	26	22	2	**799.9**	**3110**	62	**70**	**654.0**	**1238**	2	1	**690.9**	**9310**	71
	Turbidity F	NTU	50	5	**112.1**	**330**	15	1	4.9	15	18	6	**160.7**	**538**	8									1	**1305.2**	**3180**	47		**1280.0**	**1280**	1	15.6	**1053.3**	**7740**	60
	Transparency (secchi depth) FLD	m																														0.14	0.5	1.02	4
	Colour True	Hazen Units		5	28.8	95	32	5	9.2	30	24	10	19.3	28	3	5	14.5	50	10	5	24.0	**70**	20	5	24.8	70	32	14	42.0	70	2	2	34.1	325	67
	Air Temp FLD			18	21.9	26	4	13	18.1	27	5	14.7	16.0	17.2	2									23.4	23.9	24.3	3					17	22.7	27.7	6
	Water Temp FLD		20-80%ile	8	22.2	32	33	10.3	20.6	32	48	16.5	20.7	24.9	8	4	24.8	34	30	14	24.1	35	36	10.9	23.0	35	57	19	21.3	28	5	14	24.7	34.2	109
	pH	pH Units	6.5-8.0	6.6	7.6	**8.5**	53	7.4	**8.3**	**8.8**	38	7	7.5	7.91	4	7.4	**8.3**	**8.8**	40	6.8	8.0	**8.8**	50	7.05	7.8	**8.72**	57	6.9	7.3	7.7	7	6.9	7.6	**8.6**	125
	pH FLD	pH Units	6.5-8.0	6.92	7.8	**8.9**	17	7.8	**8.5**	**8.8**	29	7.5	7.7	**8.1**	7					**8.3**	**8.4**	**8.4**	2	6.47	7.8	**8.88**	28		7.4	7.4	1	6.5	7.4	**8.53**	74
	Oxygen (Dissolved) FLD	mg/L		4.06	7.6	17.5	15	6.8	9.5	11.9	18	3.8	5.3	6.7	8									5.88	7.9	9.85	18		5.3	5.3	1	3.6	6.4	10.48	46
	Total Suspended Solids	mg/L	10	5	**148.6**	**3910**	47	2	**27.5**	**335**	37	5	**131.7**	**370**	3	1	**40.4**	**300**	32	2	**28.8**	**580**	41	2	**611.6**	**2350**	75	4	**119.3**	**360**	6	2	**455.9**	**5772**	99
	Total Diss. Solids	mg/L	500	39	126.0	296	52	88	202.0	251	38	89	126.6	170.79	3	99	357.8	485	40	50	405.5	**620**	50	69.69	167.1	**602**	57	45	128.6	204	7	52	125.5	271	117
Nutrients	Nitrate (NO3)	mg/L	50	0.17	1.4	3.8	36	0.2	0.8	3	17	0.44	1.5	3.6	4	0.4	0.9	2.9	16	0.2	1.1	5.2	23	0.1	1.5	5.5	34	1	3.5	5.3	3	0	1.8	9.7	73
	Nitrate + nitrite (N total)	mg/L																									0								
	Nitrate + nitrite (N soluble)	mg/L						0.0025	0.003	0.0042	3													0.0019	0.1	0.475	22					0	0.2	1.05	48
	Ammonia (N total)	mg/L	0.02																								0								
	Ammonia (N soluble)	mg/L	0.02	0.006	0.006	0.006	1	0.005	0.01	**0.0215**	4													0.0042	**0.025**	**0.0814**	23		**1.1**	**1.11**	1	0	**0.1**	**0.80**	51
	Kjeldahl Nitrogen	mg/L		0.685	1.1	1.4	5	0.175	0.18	0.175	1	0.543	1.3	2	2									1.581	3.3	11.882	11					715	715.0	715	1
	Total Nitrogen (TN)	mg/L	0.5	**0.5008**	**1.0**	**2.1024**	8	0.1	0.16	0.2158	2	**0.83**	**0.9**	**1.0419**	3									0.3712	**0.6**	**0.8278**	3					0.36	**1.5**	**4.48**	36
	Organic Nitrogen	mg/L		0.68	0.7	0.68	1	0.1132	0.19	0.3	4	0.59	0.6	0.59	1									0.41	2.4	17.8609	24					0.3	1.1	3.2	30
	Total Reactive Phosphorus	mg/L																									0								
	Total React Phosphorus (P soluble)	mg/L		0.067	0.1	0.067	1	0.0045		0.0223	4														0.1	0.164	22					0.003	0.1	0.27	50
	Total Phosphorus (P)	mg/L	0.05	**0.0961**	**0.3**	**0.581**	14	0.0162		**0.052**	8	0.0397	**0.3**	**0.74**	6									**0.0877**	**0.7**	**2.4338**	37		**0.4**	**0.39**	1	0.022	**0.7**	**2.84**	66
Metals	Boron as B	mg/L	0.37	0.01	0.037	0.1	21	0.01		0.2	15	0.04	0.1	0.1	2	0.02		0.03	12	0.02	0.1	0.1	22	0.02	0.032	0.05	11					0.01	0.1	0.11	41
	Aluminium (Al)	mg/L	0.055	0.01	0.044	**0.1**	9	0.01	**0.1**	**0.2**	7	0.05	**0.1**	**0.18**	3					**0.1**	**0.2**	**0.22**	2	0.01	0.031	**0.09**	14					0.01	**0.1**	0.59	40
	Copper (Cu)	mg/L	0.0014	**0.01**	**0.033**	**0.06**	9	**0.01**	**0.04**	**0.06**	8	**0.01**	**0.02**	**0.05**	3					**0.02**	**0.1**	**0.11**	4	**0.01**	**0.035**	**0.17**	19			**0.01**	1	**0.01**	**0.03**	**0.08**	27
	Bromide (Br)	mg/L										1	1.0	1	1												0								
	Cadmium (Cd total)	µg/L	0.2																								0					**2.6**	**3.1**	**3.5**	2
	Chromium (Cr total)	µg/L	1																								0					**3**	**5.0**	**7**	2
	Copper (Cu total)	µg/L	1.4																								0					**4**	**5.5**	**7**	2
	Flouride (F)	µg/L	1	0.1	0.2	0.65	50	0.1	0.1	0.2	37	0.11	0.2	0.24	3	0.1	0.2	0.63	40	0.01	0.2	0.3	42	0.04	0.1	0.42	53	0.1	0.3	0.8	6	0.02	0.2	0.83	124
Major Ions	Hydrogen (H)	mg/L						0.1	0.1	0.1	4				3	0.1	0.2	0.5	8	0.1	0.1	0.1	9	0.1	0.1	0.1	5					0.1	0.1	0.1	4
	Chloride (Cl)	mg/L	175	2.2	10.2	58	52	3.8	10.6	20	38	4.8	6.1	7.9	4	12	26.1	65	40	13.8	74.9	155	50	4	13.6	140	57	10	37.1	90	7	2	10.3	46.37	124
	Potassium (K)	mg/L		3.1	7.2	21.1	48	1.3	2.9	6.7	38	3.86	5.7	7	4	2.2	3.6	24	39	1.4	3.0	5.6	48	2.4	4.9	8.2	55	1.8	4.3	5.3	6	2.2	5.2	48	103
	Sodium (Na)	mg/L	115	4	13.3	39.9	53	11.5	17.5	22	38	8.6	11.3	14.5	4	3.4	37.3	80.4	40	11.1	71.4	**124**	50	4.8	16.8	**115**	57	5.6	24.1	40	7	4	12.3	36	125
	Total Dissolved Ions	mg/L		43.9	173.6	443.7	53	92.2	287.9	366.7	37	113	166.7	273.94	4	127.3	509.9	710.9	39	48.6	537.6	831.3	50	83.68	231.3	781.7	57	46.9	142.0	229.9	7	75	168.8	382.2	125
	Calcium (Ca)	mg/L	1000	2.8	17.1	63	53	6.4	27.4	38	38	8.8	15.8	29.4	4	12	35.6	51	40	1.5	30.9	57	50	6.4	19.1	45	81	1.5	9.5	20	7	5.6	16.9	48	125
	Sulphate (SO4)	mg/L	250	0.5	2.5	9.3	24	0.65	2.9	16	33	0.51	2.2	4.2	4	1	8.0	27.5	26	0.9	3.3	8.2	27	0.7	3.6	25	40	6	11.6	20	4	0.97	4.4	53.33	88
	Magnesium (Mg)	mg/L		1.5	8.2	20	53	4.2	19.5	25.3	38	4.7	9.2	18.7	4	4	41.9	54	40	2	33.1	54.2	50	3.3	11.8	45	81	1.9	5.8	8.8	7	2.6	8.8	27	125
Alkalinity	Total Alkalinity (CaCO3)	mg/L		8	95.6	256	53	47	173.7	223	38	63	108.7	168	3	41	301.7	416	40	10	267.3	470	50	42	115.0	355	57	15	43.9	80	7	26	92.1	222	125
	Total Alkalinity (CaCO3) FLD	mg/L		55	77.0	124	4	18.8	139.4	180	5	50	86.4	149.2	3			0						56	119.5	180	6		48.0	48	1	8.6	59.3	124	10
	Hydroxide (OH)	mg/L		0	0.0	0.02	11	0.02	0.1	0.1	20							0		0.04	0.1	0.1	5	0.09	0.1	0.09	1				5	0.01	0.0	0.1	13
	Carbonate (CO3)	mg/L		0.07	0.5	1.6	39	0.1	3.1	9.1	38	0.1	0.5	0.98	3	0.1	6.1	30	40	0.1	5.3	15	38	0.03	1.4	19	52			0.1	5	0.04	0.7	16.8	83
	Bicarbonate (HCO3)	mg/L		9.2	115.9	311	53	57	205.3	263	38	70	116.2	202.93	4	28	355.6	500	40	12	317.9	553.3	50	51.12	155.9	426	57	18.3	53.4	97	7	31.5	111.3	267	125
	Hardness (CaCO3)	mg/L		13	76.3	240	53	33	148.7	194	38	41.5	77.2	150.24	4	54	261.1	350	40	12	213.2	360	50	29.54	96.2	298	81	12	47.7	80	7	25	78.3	201	125

NOTES

MTV	Minimum trigger value
BOLD	Greater than MTV

Table C4
Comet Catchment DNRW Water Quality Results - Brown River
GLNG CSG Surface Water

					Hydrological Parameters			Physico-Chemical Parameters												Nutirients								Metals				Major Ions								Alkalinity					
STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Stream Water Level	Stream Discharge	Depth	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Colour True	Air Temp	Water Temp	pH	pH FLD	DO FLD	TSS	TDS	Nitrate (NO3)	Nitrate + nitrite (N soluble)	Ammonia (N soluble)	Kjeldahl Nitrogen	TN	Organic Nitrogen	Total React P (P soluble)	TP	Boron as B	Aluminium (Al)	Copper (Cu)	Flouride (F)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
				Units	*m*	*cumecs*	*m*	*uS/cm*	*uS/cm*	*NTU*	*NTU*	*Hazen units*	*°C*	*°C*	*pH units*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340	340	50	50			20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50		0.02		0.5			0.05	0.37	0.055	0.0014	1		<175		<115		1000	250							
1305001	Brown at Lake Nuga Nuga	185913	4/06/1998	1030	NA	0	0.2	**382**	**385**	17.6	19	32	22.8	21.8	7.62	**8.1**	5.7	**22**	218.7	0.22				**2.10**			**0.19**	0.1	ND	**0.03**	0.31	ND	24.56	21.1	39.9	307.03	18	0.67	10.1	157.9	124	0.01	0.4	192	86.44
1305009	Christmas Ck at Clematis	194127	10/09/1999	1450	NA		0.2	150	146	**300**	**284**	48		22.4	6.85	7.2	8	**400**	83	3.8			1.4				**0.26**	0.1	0.05	**0.05**	0.2	ND	14	8.6	9.2	110	8.1	2	4.9	46		ND	ND	56	40.5
1305003	Brown at Clematis	192165	5/06/1999	1130	NA	0	0.2	200	203	3	10	22	20.8	16	7.6	7.7	6.4	**10**	120	1.1					0.68		**0.11**	<0.1	0.05	**<0.05**	<0.1	ND	5.5	8.8	11.5	170	16.5	2	8	97	56	ND	0.2	120	74
1305027	Brown River Arcadia	185914	4/06/1998	1330	NA	0	0.2	117.8	119	**85.6**	**84**	8	26	20.8	7.12	7.5	4.5	**31**	70.11	1.32				**0.82**			**0.17**	ND	ND	**0.01**	0.14	ND	4.68	4.6	8.9	94.66	10	0.5	2.6	50.79	73	ND	ND	62	35.64
1305027	Brown River Arcadia	192163	4/06/1999	910	NA	0	0.2	125	125	**58.4**	**61**	22	18	15.1	7.54	7.7	6	**29**	69.99	0.77				**0.50**			**0.10**	ND	ND	ND	ND	ND	3.18	4.1	9.7	103.53	10.7	0.56	3.1	58.65	55	ND	0.1	71	39.44
130502A	Brown R at Warrinilla	47666	14/11/1970	1625	1.35	7.193	0.1	80							7				43												0.3	ND	4		8	66.3	4		4	38		ND		46	26
130502A	Brown R at Warrinilla	47665	16/11/1970	853	1.03	3.71	0.1	166							6.7				93												0.3	ND	9		12	143.3	19		5	80		ND		98	68
130502A	Brown R at Warrinilla	49012	3/06/1971	1235	0.28	0.046	0.1	245							6.6				135												0.2	ND	12		15	209.2	28		8	120		ND		146	103
130502A	Brown R at Warrinilla	52187	2/03/1972	1625	0.46	0.146	0.1	210							7.6																0.65	ND	12		19	200.7	19		11	114			ND	139	93
130502A	Brown R at Warrinilla	56730	7/03/1973	1315	0.36	0.102	0.1	280							7.9				160												0.17	ND	14		20	250.2	26		14	144				176	123
130502A	Brown R at Warrinilla	61400	1/04/1974	1500	0.47	0.402	0.1	256							**8.1**			**30**	138												0.15		16	13	18	196.6	19		7.5	102		ND	0.9	122	78
130502A	Brown R at Warrinilla	62420	25/07/1974	1630	0.14	0.14	0.1	330						15	7.9			**10**	180												0.26	ND	20	11	17	266.8	26		14.5	146		ND	ND	178	125
130502A	Brown R at Warrinilla	64820	4/02/1975	1315	0.1	0.012	0.1	**350**						30	8			**99**	208												0.16	ND	17.5	6.6	15	293.9	32		16.6	170		ND	1.0	205	148
130502A	Brown R at Warrinilla	64819	29/04/1975	1145	NA	0.01	0.1	300							7.7			**85**	173												0.14	ND	12	5	14	244.1	27		13.5	142		ND	0.5	172	123
130502A	Brown R at Warrinilla	68491	9/04/1976	1210	0.22	0.805	0.1	243						21	7.6			**22**	140												0.2		12	9.2	14	194.7	20		8	108		ND	0.3	131	83
130502A	Brown R at Warrinilla	69369	22/07/1976	900	4	0.001	0.1	**545**						8	7.6			**17**	296												0.1		21	8.8	19	443.7	63		20	256		ND	0.8	311	240
130502A	Brown R at Warrinilla	72343	30/03/1977	1220	0.7	1.71	0.1	280						25	**8.3**			**41**	167	1.1											0.1		7	4.8	14	224.6	23	5	13	130		ND	1.6	155	111
130502A	Brown R at Warrinilla	79175	27/09/1978	1305	0.17	0.416	0.1	275							7.5			**16**	153	3.6											0.1		14	11	20	207	18	1	8.1	108			0.2	131	78
130502A	Brown R at Warrinilla	79176	27/09/1978	1305	0.51	0.409	0.1	260							7.6			**25**	147	2											0.1		14	10	20	200.6	17	2	8.2	105			0.3	127	76
130502A	Brown R at Warrinilla	90318	3/03/1981	1115	0.02	0.138	0.1	190		12					7.9				109												0.2		5	4.5	10	155	13	9	7.9	87			0.4	105	65
130502A	Brown R at Warrinilla	91549	11/08/1981	1140	NA	0.002	0.1	**340**		5		5		18	**8.1**			**10**	176	1											0.1		12	8.4	18	255.8	26	1	13	146			1.3	175	118
130502A	Brown R at Warrinilla	99542	25/10/1983	1221	1.24	0.002	0.1	**405**		1		5			7.5			**20**	220									0.03			0.1		12	9.2	14	327.7	41		16	193			0.4	235	168
130502A	Brown R at Warrinilla	103228	14/12/1983	1210	1.34	0.064	0.1	255		19		15		31	7.9			**12**	150	1.7								0.01			0.2		7.1	5.4	13	206.4	20	2.2	11	120			0.7	145	95
130502A	Brown R at Warrinilla	103409	18/02/1984	1546	1.71	2.32	0.1	195		13		40		27	7.7			**15**	120	2.1											0.1		10	8.1	12	161.6	15	2.5	6.4	87			0.3	105	64
130502A	Brown R at Warrinilla	103410	18/02/1984	1546	0.72	2.38	0.1	190		6		30			7.8			**15**	110	2.3								0.01			0.1		11	7.9	12	156.5	14	2.5	6.2	83			0.3	100	61
130502A	Brown R at Warrinilla	104223	23/05/1984	1320	1.18	0.006	0.1	290				10		21	**8.2**			5	150	0.7								0.03			0.1		8.8	7.7	15	222.8	24		10	130			1.5	155	101
130502A	Brown R at Warrinilla	105891	12/09/1984	0	0.56	0.643	0.1	240		10					7.4			5	140	2.7								0.03			0.2		15	11	14	205	20		6.9	111			0.2	135	78
130502A	Brown R at Warrinilla	107270	16/01/1985	1340	1.26	0.005	0.1	210		15					**8.1**			**34**	120	1.4								0.03			0.2		2.5	5	12	168.2	17		9.1	100			0.9	120	80
130502A	Brown R at Warrinilla	113993	16/03/1986	1023	1.21	0.008	0.1	155	160	6		20			7.6			**30**	100	1.4								0.02			0.1		6.3	6	10.5	120	10		5.4	66			0.2	80	47
130502A	Brown R at Warrinilla	118018	11/12/1986	650	1.37	0.226	0.1	160	145	**80**		70		22	8			**40**	110	0.7								0.03			0.2		8.1	6.2	14.5	123.3	9.6		5.4	64			0.4	77	46
130502A	Brown R at Warrinilla	119006	27/02/1987	1005	1.28	0.001	0.2	140		1		30			**8.5**			**39**	81	0.5								0.01	**0.1**	**<0.01**	0.2	ND	9	8.9	9.5	98	12	2	2	47		ND	0.9	55	38
130502A	Brown R at Warrinilla	131219	12/08/1989	1333	1.27	0.212	0.1	195	200	13		10		12	7.4			**22**	110	1.3								0.05			0.1		8.6	8.2	13	153.1	16		5.7	82			0.1	100	63
130502A	Brown R at Warrinilla	132784	20/11/1989	1245	1.37	0.576	0.1	215	221	**100**					7.8			**5**	130	3.1								0.01			0.2		9.4	6.6	14	165.3	14.5	3.4	8.6	87			0.4	105	72
130502A	Brown R at Warrinilla	133660	9/03/1990	938	1.76	2.38	0.1	158		**132**		10			7.3			**170**	94	1.7											0.13	ND	5	6.5	7.7	114.5	10	1.9	5.7	62			ND	76	48
130502A	Brown R at Warrinilla	137972	26/02/1991	1156	1.2	0.054	0.1	256							7.4			**14**	157									0.06	0.02	**0.06**	0.2	ND	5.9	6.1	13.3	215.7	21.7		12.6	128		ND	0.2	156	105
130502B	Brown R at Lake Brown	984587	27/09/1978	1125	0.515	0.409								20																															
130502B	Brown R at Lake Brown	984586	14/12/1983	925	0.42	0.065								23																															
130502B	Brown R at Lake Brown	984585	18/02/1984	1300	0.72	2.38								27																															
130502B	Brown R at Lake Brown	984584	12/09/1984	1545	0.56	0.643								20																															
130502B	Brown R at Lake Brown	112228	18/12/1985	1405	0.95	6.159	0.1	87	70	**100**				20	7			**3910**	49	1.6								0.02			0.1		3	4	4	58.8	6		3	30				37	27
130502B	Brown R at Lake Brown	114000	16/03/1986	1023	0.36	0.001	0.1	160		21		30			**8.2**			**30**	95	1								0.02			0.1		6.2	7	8.1	118.4	11		5.4	66			0.6	79	50
130502B	Brown R at Lake Brown	118042	11/12/1986	650	0.64	0.27	0.1	165		**100**		70			**8.1**			**85**	110	0.5								0.02			0.4		8.9	6	16	130.5	9.9	9.3	5.3	61			0.5	73	47
130502B	Brown R at Lake Brown	131220	12/08/1989	1333	0.64	0.193	0.1	200		10		10			7.4			**18**	110									0.05			0.1		8.8	8	13	152.1	16		6	82			0.1	100	65
130502B	Brown R at Lake Brown	132788	20/11/1989	1245	0.69	0.442	0.1	185		**100**					7.6			**79**	130	2.2								0.02			0.2		58	6.5	13.5	110.5	13		7.3	8				9	63
130502B	Brown R at Lake Brown	133664	6/03/1990	635	2.06	41.7	0.1	66		**200**		60			7			**419**	39	0.8											0.11	ND	2.2	3.1	4.4	43.9	2.8	2.3	1.5	21		ND	ND	27	13
130502B	Brown R at Lake Brown	133663	6/03/1990	1225	1.58	27.3	0.1	75	65	**200**		40			7			**563**	45	0.8											0.11	ND	2.7	3.3	4.8	52.1	3.7	2.3	2.1	26		ND	ND	32	17
130502B	Brown R at Lake Brown	137969	26/02/1991	832	0.54	0.062	0.1	230		1		5			7.4			8	145									0.06	0.01	**0.05**	0.2	ND	5.5	5.9	12.8	198.3	19.8		11.3	117		ND	0.2	143	95
130502B	Brown R at Lake Brown	984583	26/02/1991	832	0.54	0.062										7.9																													
130502B	Brown R at Lake Brown	156680	22/04/1994	1115	NA	0	0.1	247	241	5		15		21.4	7.9	**8.9**		**14**	135	1.4										**0.06**	0.17		7.1	6.8	14.3	200.2	18.5		10.3	116		0.02	0.7	141	88
130502B	Brown R at Lake Brown	171020	11/04/1995	1515	0.21	0	0.1	223	226	25	38.3	20		24.3	7.46	7.9	7.72	**22**	124.7	0.17			1.2628				**0.12**	ND	ND	**0.02**	0.18	ND	7.67	7.9	13.2	188.57	17.1	ND	9.6	109		0	0.2	133	82.14
130502B	Brown R at Lake Brown	176467	4/12/1995	1105	0.68	0.223	0.2	165.8	166	7	15.6	38		27	7.44	7.61	4.06	**15**	98.83	0.9			0.685				**0.17**	ND	ND	ND	0.16	ND	3.58	5.2	9.7	129.59	11.9	ND	6.8	75		0	0.1	91	57.65
130502B	Brown R at Lake Brown	178717	17/03/1996	1100	-0.1	0	0.1	278	275	8.4		22		24.6	7.67	**8.22**	7.7	**31**	151.6	ND			1.134				**0.17**	ND	ND	**0.01**	0.22	ND	6.06	5	14.9	224.67	22.2	ND	12.2	134.9		0.01	0.5	164	105.55
130502B	Brown R at Lake Brown	178691	17/12/1996	825	0.67	0.495	0.1	171	179	**143**	**181**	58		24.9	7.6	7.54	4.37	**92**	110.6	2.27			1.1				**0.34**	ND		ND	0.18	ND		6	11.3	141.78	12.2		7.3	78.69		0.01	0.2	96	60.46
130502B	Brown R at Lake Brown	194039	29/11/1998	1800	0.72	0.891	0.1	140	138	**620**	**283**	16		25.8	7.29	6.92	4.8	**110**	89.56	1.59				**1.05**			**0.58**	ND	ND	**0.01**	0.18	ND	11.34	6.1	13.6	108.87	7.4	0.73	4.5	52.05		0	0.1	63	36.97
130502B	Brown R at Lake Brown	201126	22/08/2000	1505	0.48	0.011	0.1	165	136	49	5	95		17.9	7.54	**8.2**	10.3	**95**	98.44	0.52				**1.06**			**0.42**	ND	0.02	ND	ND	ND	7.82	5.2	11.9	125.31	9.3	0.65	6.6	68.43		0.01	0.2	83	50.34
130502B	Brown R at Lake Brown	S004065	22/08/2000	1505	0.48	0.011	0.2		136		5			17.9		**8.2**	10.1																												
130502B	Brown R at Lake Brown	201142	13/12/2000	1515	1.58	0.856	0.2	225	200	4	8	25		27	7.75	7.8	6.5	**10**	130	0.9	<0.002	0.006		**0.61**		0.067	**0.13**	<0.1	0.05	**<0.05**	0.1	ND	5	4	11.5	180	16	2	10.5	110		0	<1	135	84
130502B	Brown R at Lake Brown	207538	6/03/2003	1525	0.78	20101	0.5	165	165	**110**	**157**	15		26.9	7.9	7.5		**80**	110	0.6				**0.62**			**0.30**	<0.1	0.05	**<0.02**	0.1	ND	6	3.9	8.3	130	12.5	2	7.1	74		0	0.4	89	61
130502B	Brown R at Lake Brown	202891	16/12/2004	750	0.59		0.1	166	169	**303**	**201**	26		27.8	7.21	7.1	17.5	**132**	109	1.2				**1.61**			**0.57**	0.06	0.05	**<0.03**	0.2	ND	6.3	7.3	14	131	8.8	1.8	5.1	70		0	0.1	86	43
130502B	Brown R at Lake Brown	208530	1/03/2007	1530			0.1		188		**330**			32			10.7																												

Notes

MTV	minimum trigger value
BOLD	Greater than MTV
135	Historic Water Quality Data\044 Quality poor.
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C5
Comet Catchment DNRW Water Quality Results - Canarvon Creek
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Hydrological Parameters: Stream Water Level	Stream Discharge	Depth	Physico-Chemical Parameters: Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	Oxygen (Dissolved) FLD	Total Suspended Solids	Total Diss. Solids
				Units	m	cumsecs	m	uS/cm	uS/cm	NTU	NTU	Hazen units	°C	°C	pH units	pH units	mg/L	mg/L	mg/L
				MTV				340		50				20%ile-80%ile	6.5-8.0	6.5-8.0		10	500
1305020	Carnarvon at Ingelara	163095	26/10/1994	1030	NA	0.04	0.2		**393**				27	24.4		**8.5**	9.26		
1305020	Carnarvon at Ingelara	171719	16/05/1995	1400	1.29	0.063	0.2	335.3	**361**	12.2	15	5		23.5	**8.7**	**8.8**	10.2	**13.0**	211.62
1305020	Carnarvon at Ingelara	171899	11/09/1995	1400	1.27	0.044	0.2	**356.2**	250	5.6	6	10	23.3	24.2	**8.6**	**8.6**	11.5	**10.0**	209.33
1305020	Carnarvon at Ingelara	171364	23/05/1996	900	1.3	0.055	0.2	**381**	**388**	5.4	7	11	13	12.8	**8.3**	**8.2**	9.1	5	227.24
1305020	Carnarvon at Ingelara	185768	13/06/1997	850	1.29	0.05	0.2	**375**	**360**	3	14	10	13.4	12.8	**8.2**	**8.5**	8.9	**13.0**	191.89
1305020	Carnarvon at Ingelara	207650	31/05/2001	900	NA		0.2	**385**	**340**	2	2	<1	14	10.3	**8.5**	**8.6**	8	**10.0**	220
1305020	Carnarvon at Ingelara	207671	10/10/2001	1500	0.28		0.3	**372**	**374**	2.6	2	10		23.1	**8.7**	**8.6**	11.9	2	215.65
1305022	Carnarvon Ck at Gorge	185769	13/06/1997	1200	NA		0.2	320		7		10			**8.5**			**10.0**	160
1305022	Carnarvon Ck at Gorge	185769	13/06/1997	1300	NA		0.2		307					13.9					
130503A	Carnarvon Ck at Wyseby	61612	26/06/1974	1645	-0.11	0.015	0.2	**430**							7.9			**20.0**	233
130503A	Carnarvon Ck at Wyseby	77580	14/06/1978	1705	0.01	0.068	0.1	**375**						13	**8.3**				235
130503A	Carnarvon Ck at Wyseby	91548	11/08/1981	1525	-0.01	0.005	0.1	**425**		5		5		18	**8.8**			**10.0**	246
130503A	Carnarvon Ck at Wyseby	93090	11/11/1981	815	0.13	0.192	0.1	230						25	7.5			**50.0**	140
130503A	Carnarvon Ck at Wyseby	103659	18/02/1984	847	0.01	0.135	0.1	335		10		20		21	**8.3**			5	200
130503A	Carnarvon Ck at Wyseby	105890	13/09/1984	1325	0.03	0.065	0.1	**355**		3				18	8.0			5	190
130503A	Carnarvon Ck at Wyseby	109565	6/07/1985	0	1.15	0.095	0.1	**355**		17		5			**8.4**			**20.0**	210
130503A	Carnarvon Ck at Wyseby	128390	13/01/1989	1345	0.17	0.426	0.1	235	195	**100**				32	**8.3**			**335.0**	140
130503A	Carnarvon Ck at Wyseby	130207	6/05/1989	1550	0.22	0.625	0.2	290		15		10			**8.8**			**17.0**	190
130503A	Carnarvon Ck at Wyseby	131267	12/08/1989	1535	0.1	0.064	0.1	**390**	**390**					14	**8.3**			5	240
130503A	Carnarvon Ck at Wyseby	132781	21/11/1989	823	0.18	0.574	0.1	115	113	**100**					7.4			**87.0**	88
130503A	Carnarvon Ck at Wyseby	134592	26/05/1990	1622	0.27	1.64	0.1	226		**200**		15			8.0			**55.0**	142
130509A	Carnarvon Ck at Rewan	984570	6/07/1985	1645	1.15	0.089			257					16					
130509A	Carnarvon Ck at Rewan	984569	4/09/1985	1400	1.11	0.023								22					
130509A	Carnarvon Ck at Rewan	112243	19/12/1985	1110	1.13	0.035	0.1	**415**	**380**	5		5		32	**8.5**			**10.0**	230
130509A	Carnarvon Ck at Rewan	114883	18/06/1986	1440	1.12	0.02	0.1	**370**	**375**	1		5		17	**8.5**			5	220
130509A	Carnarvon Ck at Rewan	119000	26/02/1987	1435	1.1	0.038	0.1	265	**340**			5		32	**8.8**			**20.0**	160
130509A	Carnarvon Ck at Rewan	120678	3/06/1987	1115	1.13	0.035	0.1	320		18		5		14	**8.2**			**33.0**	170
130509A	Carnarvon Ck at Rewan	122164	9/09/1987	1645	1.09	0.023	0.1	**380**	**350**			5		19	**8.3**			5	210
130509A	Carnarvon Ck at Rewan	126556	21/06/1988	1315	1.05	0.025	0.1	**345**	300	3		5		18	**8.3**			**10.0**	200
130509A	Carnarvon Ck at Rewan	128373	13/01/1989	1300	1.15	0.413	0.2	285	250	**100**		>70		32	**8.4**			**132.0**	170
130509A	Carnarvon Ck at Rewan	130210	6/05/1989	1325	1.12	0.618	0.2	320	330	11		10		21.5	**8.2**			**12.0**	200
130509A	Carnarvon Ck at Rewan	131266	12/08/1989	1623	1.05	0.172	0.1	**400**	**400**					14	**8.4**			5	250
130509A	Carnarvon Ck at Rewan	132800	21/11/1989	723	1	0.071	0.1	**360**	**425**	**51**		10			**8.2**			**42.0**	222
130509A	Carnarvon Ck at Rewan	133662	7/03/1990	1512	1.07	0.274	0.1	293		13		30			8.0			**10.0**	173
130509A	Carnarvon Ck at Rewan	134561	27/05/1990	1605	1.15	1.08	0.1	317		27		10			**8.3**			**22.0**	210
130509A	Carnarvon Ck at Rewan	984566	9/10/1990	1515	0.95	0.089			252										
130509A	Carnarvon Ck at Rewan	137959	25/02/1991	1335	1.01	0.124	0.1	**390**							8.0			4	242
130509A	Carnarvon Ck at Rewan	984565	25/02/1991	1335	1.01	0.124										**8.5**			
130509A	Carnarvon Ck at Rewan	143342	20/07/1991	1250	0.96	0.067	0.1	**389**	**390**	1				15	**8.4**	**8.5**		8	230
130509A	Carnarvon Ck at Rewan	145417	31/03/1992	1500	0.94	0.018	0.1	**377**		2		5		29	**8.3**			5	217
130509A	Carnarvon Ck at Rewan	149600	3/08/1992	1749	0.94	0.041	0.1	**379**	**407**					17.5	**8.2**	**8.8**		4	214
130509A	Carnarvon Ck at Rewan	151605	18/07/1993	1745	0.96	0.035	0.1	**377**	**378**			5		16.2	**8.3**	**8.5**		3	214
130509A	Carnarvon Ck at Rewan	156615	29/11/1993	1902	0.96	0.038	0.1	**343**	**347**	6		10		30	**8.4**	**8.6**		9	203
130509A	Carnarvon Ck at Rewan	156681	21/04/1994	1500	1.03	0.05	0.1	**436**	**432**					23.6	**8.4**	**8.8**		7	251
130509A	Carnarvon Ck at Rewan	984564	12/04/1995	1208	0.965	0.014			**369**					19.3		**8.4**			
130509A	Carnarvon Ck at Rewan	984563	23/08/1995	1716	0.967	0.007			**382**					20.1		**8.7**			
130509A	Carnarvon Ck at Rewan	984562	4/12/1995	1747	1.04	0.093			329					31		**8.6**			
130509A	Carnarvon Ck at Rewan	984561	17/03/1996	1609	0.85	0.012			281					30.5		**8.7**			
130509A	Carnarvon Ck at Rewan	984849	31/03/1999	1715	0.903	0.046	0.2		**360**		2.2			25.9		**8.5**	8.6		
130509A	Carnarvon Ck at Rewan	S994007	30/07/1999	1042	0.89	0.06			**350**		3			12.7		**8.3**	10.1		
130509A	Carnarvon Ck at Rewan	S004066	5/04/2000	926	0.83	0.014			331		3			23		7.8	6.8		
130509A	Carnarvon Ck at Rewan	S004067	23/08/2000	1120	0.88	0.08			309		2			14.5		**8.6**	9.9		
130509A	Carnarvon Ck at Rewan	S014012	13/12/2000	1135	0.91	0.238			**352**		3			27.3		**8.2**	8.1		
130509A	Carnarvon Ck at Rewan	S014033	27/02/2001	1225	0.88	0.113	0.1		**438**		1			32		**8.5**	10.3		
130509A	Carnarvon Ck at Rewan	S014034	22/05/2001	1100	0.83	0.052	0.1		**400**		2			12.8		**8.6**			
130509A	Carnarvon Ck at Rewan	S024013	22/06/2002	1025	0.81	0.054			290		2			10.6		**8.6**	10.5		
130509A	Carnarvon Ck at Rewan	S034039	28/05/2003	1650	0.84	0.038	0.2		**399**		9			14.6		**8.4**	9		

STATION ID	SAMPLE NO.	Nutrients: Nitrate (NO3)	Nitrate + nitrite (N soluble)	Ammonia (N soluble)	Kjeldahl Nitrogen	TN	Organic Nitrogen	Total React Phosphorus (P soluble)	TP	Metals: Boron as B	Aluminium (Al)	Copper (Cu)	Flouride (F)	Major Ions: Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Alkalinity: Total Alkalinity as CaCO3	Total Alkalinity as CaCO3 FLD	Hydroxide as OH	Carbonate as CO3	Bicarbonate as HCO3	Hardness as CaCO3
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MTV		50		0.02		0.5			0.05	0.37	0.055	0.0014	1		<175		<115		1000	250							
1305020	163095		<0.002	0.005			0.3	0.015	0.041																		
1305020	171719	ND	0.0042	**0.022**			0.1462	0.0066	0.0195	ND	ND	**0.01**	0.14	ND	8.87	1.3	18	304	27.1	1.02	22.6	189.6		0.07	5.65	219.6	160.54
1305020	171899	0.3	0.0036	0.0111			0.2189	0.0045	0.0288	ND	ND	**0.06**	0.15	ND	9.04	2	18.3	311	28.3	0.65	23.4	192.1	180	0.07	5.13	223.69	166.83
1305020	171364	ND	0.0025	0.0088			0.1132	0.0223	0.0485	ND	ND	ND	0.15	ND	10.38	2	17.8	324	29.5	1.58	23.4	198.8	18.8	0.03	2.99	236.33	169.82
1305020	185768	ND			0.175				0.0337			ND	0.16	ND	8.03	1.64	15.8	309	26.9	0.7	23.5	192	168	0.03	2.19	229.7	163.74
1305020	207650	0.5				0.1			**0.050**	<0.1	0.05	**<0.05**	0.1	ND	9	1.4	16.5	320	28.5	2	23.5	195	172.4	0.1	4.1	230	170
1305020	207671	ND				0.216			0.0162	0.02	0.01	ND	0.14	ND	9.26	1.4	18.2	312	26.8	0.71	25.3	193.7	158	0.08	6.05	223.75	170.9
1305022	185769	0.5			<0.1				**0.052**			**<0.05**	0.1	ND	6.7	1.4	12.5	260	23	2	20.5	165		0.1	3.3	190	145
1305022	185769																										
130503A	61612												0.16		12	3.8	17		38		24	206			1.2	249	194
130503A	77580	0.3											0.2		11	2.6	21	340	35	2.5	22	204			2.8	243	178
130503A	91548	1											0.1	0.1	20	4	19	346	35	5	22	205			9.1	231	178
130503A	93090	3											0.2		8	6.7	16	181	13	16	8.1	91			0.2	110	66
130503A	103659												0.1		8.6	3.6	16	278	29	7.2	16	164			2.4	195	138
130503A	105890														20	3.5	17	272	29	3.2	18	150			1.2	180	147
130503A	109565									0.02			0.1		3.8	2.3	19	308	30	2	22	190			3.2	225	166
130503A	128390	1.1								0.01			0.1		6	4.4	13.5	185	18.5		10	109			1.6	130	87
130503A	130207	0.5								<0.01	**0.1**	**0.05**	0.1	ND	14	2.9	16	260	26.5	2	15.5	160		0.1	6.8	180	130
130503A	131267									0.04			0.2		12	3	18	342	36	3.2	22	206			3	245	181
130503A	132781	1.4											0.2		5.5	3.8	11.5	92	6.4		4.2	47			0.1	57	33
130503A	134592	0.7											0.13	ND	5.6	3.4	13	184	18.4	3.7	10.9	106		0.02	0.7	127.7	90
130509A	984570																										
130509A	984569																										
130509A	112243	0.5								0.02			0.2	0.1	13	3.6	22	328	31	2	21	196			4.7	230	164
130509A	114883									0.01			0.2	0.1	11	2.3	18	322	30		21	201			4.7	235	161
130509A	119000	0.5								0.01			0.2	0.1	18.5	4.4	20	227	7	2	19	132			5.2	150	96
130509A	120678	0.5								0.01			0.1		10	2.6	19	260	18	3.1	20	155			1.7	185	127
130509A	122164												0.2		11	2.5	18	313	32		21	189			2.8	225	166
130509A	126556	0.5								0.01			0.1		10	2	16	298	29	2	21	181			2.8	215	159
130509A	128373	0.5								<0.1	**0.2**	**<0.01**	0.1	ND	6	4	16	230	24	2	13.5	140		0.1	3	165	115
130509A	130210	1.1								0.2	**0.1**	**0.05**	0.1	ND	9	2.4	15.5	280	28.5	3	19.5	165		ND	1.7	200	150
130509A	131266									0.04			0.1		12	2.3	19	356	36	3.3	24	216			4	255	189
130509A	132800									0.01			0.17	ND	19.6	2.6	20	309	29.7	3.7	20	176		0.03	1.9	211.5	156
130509A	133662												0.16	ND	6.7	3.1	13.7	237	21.3	2.9	14.1	144		0.02	0.9	173.6	111
130509A	134561									0.01			0.14	ND	12.6	2.3	18.4	277	26.9	5.6	18.7	160		0.03	2.2	190.5	144
130509A	984566																										
130509A	137959									0.05	0.03	**0.03**	0.17	ND	9.5	4	20	348	34.4	2.9	22.6	210		0.02	1.7	252.9	178
130509A	984565																										
130509A	143342										0.02	**0.06**	0.15	ND	10	2.7	18.9	333	32.6	2.8	23.4	202		0.04	3.6	238.8	178
130509A	145417									0.02			0.2	ND	17.3	3.8	20.1	309	28.9	2	20.1	180		0.04	2.7	213.8	154
130509A	149600												0.15	ND	8.9	1.4	19.6	319	30.2	1.2	22.5	195		0.04	2.8	232.5	167
130509A	151605												0.14	ND	9.7	2.4	18.3	319	30.2	1.7	22.5	194		0.04	3.4	230.5	167
130509A	156615	0.2										**0.04**	0.14	ND	8.8	3.7	17.1	291	29.5	1.3	18	176		0.04	3.1	208.4	147
130509A	156681											**0.02**	0.13		12.1	3.9	22	367	35.6	1.5	24	223		0.05	4.3	263	187
130509A	984564																										
130509A	984563																										
130509A	984562																										
130509A	984561																										
130509A	984849																										
130509A	S994007																										
130509A	S004066																										
130509A	S004067																										
130509A	S014012																										
130509A	S014033																										
130509A	S014034																										
130509A	S024013																										
130509A	S034039																										

Notes
MTV minimum trigger value
BOLD Greater than MTV
135 Historic Water Quality Data\044 Quality poor.
NA Not available (Gauge Height < Instrument Threshold)
ND Not detected
E Estimate

Table C6
Comet Catchment DNRW Water Quality Results - Comet River Rolleston
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Hydrological Parameters			Physico-Chemical Parameters												Nutrients					Metals				
					Stream Water Level	Stream Discharge	Dist. Below water surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	Oxygen (Dissolved) FLD	Total Suspended Solids	Total Diss. Solids	Nitrate (NO3)	Kjeldahl Nitrogen	Total Nitrogen (TN)	Organic Nitrogen	Total Phosphorus (P)	Boron as B (mg/L)	Aluminium as Al soluble (mg/L)	Copper as Cu soluble mg/L	Bromide as Br (mg/L)	Flouride as F (mg/L)
				Units	*m*	*cumsecs*	*m*	*uS/cm*	*uS/cm*	*NTU*	*NTU*	*Hazen units*	*° C*	*° C*	*pH units*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340		50				20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50		0.5		0.05	0.37	0.055	0.0014		1
1305002	Comet at Rolleston	192164	5/06/1999	800	NA	ND	0.2	195	199	17	26	20	14.7	16.5	7.7	7.8	6.2	**20**	120	1			0.59	**0.082**	<0.1	0.05	**<0.05**		<0.1
1305002	Comet at Rolleston	194128	11/09/1999	740	NA		0.2	150	147	**430**	**538**	28		18	7.3	7.5	3.8	**370**	89	3.6	2			**0.74**	0.1	0.05	**0.05**		0.2
1305002	Comet at Rolleston	205211	29/02/2000	730	NA	2	0.2	150	148		**228**			24.9	7	7.5	3.9			0.81		**1.0419**		**0.3571**	0.04	**0.18**	**0.01**	1	0.24
1305002	Comet at Rolleston	205256	29/02/2000	730																		**0.84**		**0.36**					
1305002	Comet at Rolleston	205256	7/03/2000	645		0.0001	0.2		168		**58**			24.8		7.7	5.3												
1305002	Comet at Rolleston	205285	28/03/2000	700		ND	0.1		**418**		**108**			22.3			5.6					**0.83**		**0.27**					
1305023	Panorama Ck at Rolleston	185767	12/06/1997	1700	NA	ND	0.2	331	321	1.5	6	10	17.2	17.5	7.91	**8.1**	6.7	5.0	170.8	0.4	0.543			0.0397			**0.01**		0.11

Notes
MTV minimum trigger value
xxx Greater than MTV
xxx Historic Water Quality Data\044 Quality poor.
xxx Greater than MTV and Historic WQ Data
NA Not available (Gauge Height < Instrument Threshold)
ND Not detected
E Estimate

Table C6

Comet Catchment DNRW Water Quality Results - Comet River R

GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	Major Ions								Alkalinity					
				Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
				mg/L	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
					<175		<115		1000	250							
1305002	Comet at Rolleston	192164	5/06/1999	0	4.8	6.8	11	160	16	2	8.4	95	60	ND	0.3	115	75
1305002	Comet at Rolleston	194128	11/09/1999	0	5.6	5.2	14.5	120	8.8	2	4.8	63	50	ND	0.1	77	41.5
1305002	Comet at Rolleston	205211	29/02/2000		7.9	7	8.6	113	9	4.2	4.7					70	42
1305002	Comet at Rolleston	205256	29/02/2000														
1305002	Comet at Rolleston	205256	7/03/2000														
1305002	Comet at Rolleston	205285	28/03/2000														
1305023	Panorama Ck at Rolleston	185767	12/06/1997	0	5.9	3.86	11.1	273.9	29.4	0.51	18.7	168	149.2	ND	1.0	202.9	150.2

Notes

MTV	minimum trigger value
xxx	Greater than MTV
xxx	Historic Water Quality Data\044 Quality poor.
xxx	Greater than MTV and Historic WQ Data
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C7
Comet Catchment DNRW Water Quality Results - Meteor Creek
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Hydrological Parameters: Stream Water Level	Stream Discharge	Dist. Below water surface	Physico-Chemical Parameters: Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Colour True	Water Temp FLD	pH	pH FLD	Total Suspended Solids	Total Diss. Solids	Nutrients: Nitrate (NO3)	Metals: Boron as B (mg/L)	Flouride as F (mg/L)	Major Ions: Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Alkalinity: Total Alkalinity (CaCO3)	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
				Units	*m*	*cumsecs*	*m*	*uS/cm*	*uS/cm*	*NTU*	*Hazen units*	*°C*	*pH units*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340		50		20%ile-80%ile	6.5-8.0	6.5-8.0	10	500	50	0.37	1		<175		<115		1000	250						
130508A	Meteor Ck at Springwood	56735	9/03/1973	1200	0.8	0.11	0.1	490				29	8.7			285			0.2		20		33	421.2	38.4	1	31.6	268		29	268	226
130508A	Meteor Ck at Springwood	57844	5/06/1973	1615	0.67	0.006	0.1	780					8.4		4	485		0.02	0.18		65	4.2	80.4	664.3	35	27.5	50	355		30	372	293
130508A	Meteor Ck at Springwood	59132	27/09/1973	930	0.64	0.004	0.1	720					8.6		2	417			0.22	0.5	55	4.6	61	608.3	34		48	340	ND	9	396	282
130508A	Meteor Ck at Springwood	61407	2/04/1974	1540	0.22	0.22	0.1	640				29	8.3		1	365			0.17		30	3.2	32	516.2	50		40	300	ND	4.8	356	290
130508A	Meteor Ck at Springwood	61614	26/06/1974	1115	0.68	0.05	0.1	680				16	8.1		60	370			0.16		20	2.5	32	559.1	40		51	342	ND	3.4	410	310
130508A	Meteor Ck at Springwood	63102	30/09/1974	1640	0.63	0.051	0.1	690				24	8.2		21	394			0.19	ND	25	3.2	40	604.9	48		48	365		4.5	436	317
130508A	Meteor Ck at Springwood	64850	11/12/1974	1630	0.62	0.06	0.1	610				33	8.3		74	370			0.17	ND	25	4.1	38	530.7	36	6.4	41	315		4	376	259
130508A	Meteor Ck at Springwood	64849	5/02/1975	1030	0.71	0.28	0.1	630				27	8.3		76	394			0.16	ND	25	3.5	30	568.4	47		44	347		4.7	414	299
130508A	Meteor Ck at Springwood	64825	28/04/1975	1700	0.69	0.276	0.1	630					8.5		80	395			0.18	ND	20	2.8	30	565.8	50		44	350		7.8	411	306
130508A	Meteor Ck at Springwood	65709	22/07/1975	1715	0.62	0.079	0.1	710					8.2		2	414			0.3	ND	22	2.5	40	621.8	44	5	50	380		5	453	316
130508A	Meteor Ck at Springwood	66496	7/10/1975	1740	0.58	0.043	0.2	715					8.07		26	388			0.19		24	4	40		32	1	53	356		3.4	427	299
130508A	Meteor Ck at Springwood	67015	16/12/1975	820	0.58	0.013	0.1	665				27	8.3		47	367			0.63	ND	26	2.4	51	545.4	17		52	330	ND	5.4	391	256
130508A	Meteor Ck at Springwood	68128	31/03/1976	1025	0.6	1.3	0.1	590				23	8.2		16	354			0.4		16	2.4	26	517.3	49		40	317		3.5	380	287
130508A	Meteor Ck at Springwood	69374	23/07/1976	1420	0.46	0.273	0.1	730					8			396			0.2		20	2.4	36	587.5	45		46	362	ND	2.9	435	302
130508A	Meteor Ck at Springwood	70384	25/10/1976	1520	0.4	0.092	0.1	680				28	8.4		23	393	1.8		0.3	0.1	26	2.8	41	561.1	34		49	338	ND	6.1	400	287
130508A	Meteor Ck at Springwood	72316	29/03/1977	1353	0.63	1.48	0.1	500				26	8.4			327	0.8		0.1		20	2.2	24	445.8	45		32	268		4.7	317	244
130508A	Meteor Ck at Springwood	73168	5/07/1977	1445	0.45	0.443	0.1	600					8.1			351			0.2		18	2.8	30	501.9	34	10	44	300		2.9	360	266
130508A	Meteor Ck at Springwood	74102	5/10/1977	1235	0.31	0.095	0.1	690				30	8.3		10	389	0.5		0.2		24	3	40	573.1	28	10	52	345		5.4	410	284
130508A	Meteor Ck at Springwood	75696	4/01/1978	1040	0.26	0.022	0.1	675				31	8.4			405	1.5		0.2		31	3.3	50	580.6	22	8	51	344		5.6	408	265
130508A	Meteor Ck at Springwood	76018	15/03/1978	1115	0.35	0.096	0.1	680				30	8.2			324	1		0.2		24	3	36	455.1	19		46	270		2.9	323	237
130508A	Meteor Ck at Springwood	77583	13/06/1978	1450	0.34	0.084	0.1	610				16	8.4			378	0.7		0.2		25	2.5	40	545.7	32	5	50	325		5.3	385	286
130508A	Meteor Ck at Springwood	79181	26/09/1978	1200	0.44	0.482	0.1	600				22	8.4		9	367	0.4		0.1	0.1	18	2.3	30	529.9	47	3.6	39	325		6.4	383	278
130508A	Meteor Ck at Springwood	90324	4/03/1981	1040	0.34	0.096	0.1	415		65	15		7.8			258			0.1		20	3.8	20	349.8	31	11	23	198		0.9	240	172
130508A	Meteor Ck at Springwood	91763	12/08/1981	1325	0.26	0.04	0.1	738		5	5	19	8.2		10	428	1		0.1		30	2.5	42	644.5	45	11	51	383		4.9	457	322
130508A	Meteor Ck at Springwood	92989	12/11/1981	1310	0.24	0.022	0.1	510			5	34	8.8		300	300	0.4		0.2	0.1	20	3.3	31	167	34	7	32	41		11	28	217
130508A	Meteor Ck at Springwood	95099	17/06/1982	1230	0.15	0.004	0.1	790		5		4	8.2		9	430	0.4		0.2		35	3	56	642.5	37	16	50	369		4.9	440	298
130508A	Meteor Ck at Springwood	98161	28/09/1982	1450	0.08	0	0.1	780		6			8.3		9	440	0.9		0.2		44	3.5	63	634.8	33	13	52	353		5.2	420	296
130508A	Meteor Ck at Springwood	99414	20/08/1983	935	0.16	0.207	0.1	660				17	8.5		10	390		0.02	0.2		20	2.5	33	568.7	49	3.7	46	343		4.2	410	312
130508A	Meteor Ck at Springwood	99520	26/10/1983	1435	0.09	0.04	0.1	700				27	7.8		10	420		0.03	0.2		26	3.8	43	611.7	47	6.3	48	360		2	435	315
130508A	Meteor Ck at Springwood	103172	14/12/1983	1655	0.08	0.044	0.1	620		4		29	8.3		5	360		0.03	0.2		25	3	34	529.1	39	8	40	316		4.9	375	262
130508A	Meteor Ck at Springwood	103458	19/02/1984	1435	0.81	5.64	0.1	460		17	30	27	8.6		20	270			0.1	0.1	16	24	3.4	372.2	22		35	228		6.6	265	199
130508A	Meteor Ck at Springwood	104305	25/05/1984	1150	0.1	0.032	0.1	810			10	17	8		5	480		0.02	0.2		32	2.9	50	710.9	51	17	54	416		3.8	500	350
130508A	Meteor Ck at Springwood	105889	11/09/1984	1735	0.14	0.095	0.1	620		5		22	8.2		5	360			0.2		35	2.4	33	533.9	40	4.1	45	310		4.2	370	285
130508A	Meteor Ck at Springwood	106797	14/12/1984	1500	0.15	0.113	0.1	530			10	23	7.8		5	320		0.02	0.2		23	3.3	29	465	32		36	281		1.5	340	228
130508A	Meteor Ck at Springwood	109489	18/05/1985	1230	0.03	0.006	0.1	730		2	5	20	8.4		10	410	0.5	0.02	0.2		40	2.8	54	608.8	28	11	51	351		6.3	415	280
130508A	Meteor Ck at Springwood	112242	17/12/1985	1045	0.02	0.009	0.1	495	425	5	10	33	8.5		10	280	2.9	0.03	0.2	0.1	20	3.6	29	390.1	28	5.7	30	227		5.6	265	193
130508A	Meteor Ck at Springwood	118017	10/12/1986	1030	0.03	0.002	0.1	455	430	19	50	27	8.7		25	260	0.7	0.03	0.2	0.1	22.5	3.4	28	364	31	4.5	25.5	210		7.9	240	182
130508A	Meteor Ck at Springwood	119001	25/02/1987	1130	0.01	0.001	0.1	495	520		5	26	8.8		10	290	0.5	0.02	0.2	0.1	28	2.5	46	401.3	12	2	35	234		10	265	174
130508A	Meteor Ck at Springwood	122163	10/09/1987	1220	0.02	0.003	0.1	160		100			7.4		180	99		0.02	0.2		12	4	13	127.3	15	6.3	4	59		0.1	72	54
130508A	Meteor Ck at Springwood	123236	10/12/1987	1217	0.07	0.002	0.1	335	310	100		29	8.2		220	190	0.8	0.02	0.3		16	3.1	24	260.9	22	3	15	146		1.7	175	117

Notes

MTV	minimum trigger value
xxx	Greater than MTV
xxx	Historic Water Quality Data\044 Quality poor.
xxx	Greater than MTV and Historic WQ Data
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C8
Comet Catchment DNRW Water Quality Results - Planet Creek
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO	DATE	TIME	Hydrological Parameters: Stream Water Level	Stream Discharge	Dist. Below water surface	Physico-Chemical Parameters: Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Colour True	Water Temp FLD	pH	pH FLD	Oxygen (Dissolved) FLD	Total Suspended Solids	Total Diss. Solids	Nutrients: Nitrate (NO3)	Metals: Boron as B (mg/L)	Aluminium as Al soluble (mg/L)	Copper as Cu soluble mg/L	Flouride as F (mg/L)	Major Ions: Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Alkalainity: Total Alkalinity (CaCO3)	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
				Units	m	cumsecs	m	uS/cm	uS/cm	NTU	Hazen units	°C	pH units	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
				MTV				340		50		20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50	0.37	0.055	0.0014	1		175		115		1000	250						
130507A	Planet Ck_Planet Dns	56714	20/01/1973	1120	0.09	0.002	0.1	490					7.7				267					0.15	ND	64		60	373.1	24	0.9	17	170	ND	ND	207	130
130507A	Planet Ck_Planet Dns	56736	7/03/1973	810	0.07	0	0.1	842					7.9				343					0.22	ND	70		16	505.1	56	0.9	45	260	ND	ND	317	325
130507A	Planet Ck_Planet Dns	57843	6/06/1973	1600	0.3	0.006	0.1	910					8.1			17	559		0.05			0.16	ND	120	4.6	109	743.1	47.5		40	345	ND	ND	421	283
130507A	Planet Ck_Planet Dns	60951	13/12/1973	1300	0.11	0	0.1	750					8.4				463					0.16	ND	90	5	79	615.8	42.5		37	300	ND	6.1	353	258
130507A	Planet Ck_Planet Dns	61616	25/06/1974	1730	0.12	0.004	0.1	1000				16	8.1			10	549					0.17	ND	98	3.3	88	732.3	49		47	370	ND	3.8	443	316
130507A	Planet Ck_Planet Dns	63105	30/09/1974	1410	0.12	0.003	0.1	925				28	8.1				522					0.21	ND	100	3.2	96	736.2	40		44	375	ND	3.8	449	281
130507A	Planet Ck_Planet Dns	63618	11/12/1974	1400	0.13	0.001	0.1	1000					7.9			2	579					0.26	ND	155	5.6	124	746.1	28		41.2	321	ND	ND	392	239
130507A	Planet Ck_Planet Dns	64854	3/02/1975	1510	0.25	0.05	0.1	165				35	7.5			17	93						ND	21	2.5	17	109.3	5		5.8	48	ND	ND	58	36
130507A	Planet Ck_Planet Dns	61412	3/04/1975	1145	0.29	0.12	0.1	150					7.7			5	86						ND	25	2.6	17.5	101.5	3.7		4.7	39	ND	ND	48	29
130507A	Planet Ck_Planet Dns	64827	28/04/1975	1400	0.15	0.003	0.1	890					8.3			72	531					0.15	ND	100	4	92	702.9	44		41.6	350	ND	5.1	416	281
130507A	Planet Ck_Planet Dns	65712	22/07/1975	1350	0.14	0.004	0.1	980					8.1			11	571					0.2	ND	97	3.3	100	769	50		47	390	ND	3.5	468	318
130507A	Planet Ck_Planet Dns	66499	10/10/1975	1030	0.12	0.003	0.1	1080				28	7.9			8	600					0.3	ND	110	4.5	105	807.6	45		50	406	ND	2.8	490	318
130507A	Planet Ck_Planet Dns	68496	8/04/1976	830	0.43	0.485	0.1	115				15	6.8				66							18	1.8	13	67.9	2.8		3.3	24	ND		29	21
130507A	Planet Ck_Planet Dns	69375	23/07/1976	1113	0.19	0.005	0.1	990				17	7.9			6	546					0.1		88	2.4	94	729.6	56		40	370	ND	2.1	447	305
130507A	Planet Ck_Planet Dns	70385	26/10/1976	1725	0.17	0.004	0.1	840				28	8.6			25	492	1.8				0.3	0.1	95	3.2	101	623	20		40	305	ND	9.6	352	215
130507A	Planet Ck_Planet Dns	70386	27/10/1976	810	0.2	0.023	0.1	820				21	8.7			30	472	1.8				0.3	0.1	100	3.6	91	600.7	39		32	281	ND	9.9	323	229
130507A	Planet Ck_Planet Dns	72325	31/03/1977	1130	0.54	1.28	0.1	97				30	7.9			6	54	0.5						18	1.6	13	48.6	1.5		2	10			12	12
130507A	Planet Ck_Planet Dns	72406	27/04/1977	1645	0.31	0.152	0.1	130				24	7.8				73	0.6						21	2.4	16	82.4	3.1		3.2	30	ND	0.1	36	21
130507A	Planet Ck_Planet Dns	75698	6/01/1978	840	0.27	0.067	0.1	170				25	7			580	98	5.2				0.2		20	4.2	16	119.6	5	6	5	48			58	33
130507A	Planet Ck_Planet Dns	76019	16/03/1978	1500	0.16	0.006	0.1	605				32	7.7				349	2.7				0.1		55	4	53	460.6	31		26	237	ND	0.8	288	184
130507A	Planet Ck_Planet Dns	77584	15/06/1978	1140	0.18	0.005	0.1	860				17	8.1			7	550	0.5				0.2		94	3	92	720.7	48	3.5	44	360		3.5	432	301
130507A	Planet Ck_Planet Dns	79183	26/09/1978	1517	0.27	0.073	0.1	180				26	7.5			13	104	0.3						22	2	20	131.3	6.6	1	6.3	60		0.1	73	42
130507A	Planet Ck_Planet Dns	87363	19/09/1980	1215	0.18	0.001	0.1	910				28	7.8			15	567					0.2		62	1.5	82	767.9	57	5	47	423		2.2	511	336
130507A	Planet Ck_Planet Dns	89190	12/12/1980	900	0.19	0.005	0.1	910				25	8.2				561	1				0.2		57	1.8	73	757.2	54	5	49	428		5.2	511	337
130507A	Planet Ck_Planet Dns	91769	10/08/1981	1705	0.12	0.004	0.2	838		5	5	19	8.75			10	489	ND				0.2	ND	99	1.8	98	623	14	8	45	304	0.1	13	344	220
130507A	Planet Ck_Planet Dns	95113	15/06/1982	1430	0.12	0.002	0.1	920		1		18	8.7			9	510	0.4				0.1	0.1	110	2.3	105	640.9	16	4	46	303		12	345	229
130507A	Planet Ck_Planet Dns	98120	27/09/1982	1540	0.09	0	0.1	940		6		24	8			10	580	0.4				0.2		59	3	85	783.5	57	3.3	52	432		3.6	520	356
130507A	Planet Ck_Planet Dns	99418	6/07/1983	900	0.46	0.555	0.1	115			15	14	7.5			10	69		0.02			0.1		20	1.6	17	72.8	2.5	2.6	3.3	21			25.5	20
130507A	Planet Ck_Planet Dns	99471	24/10/1983	1610	0.41	0.333	0.1	105		20	70	28	8.5			23	61	0.5	0.04			0.1	0.1	16	2.2	13	64.2	2.6	2.2	2.5	21		0.4	24.5	17
130507A	Planet Ck_Planet Dns	103289	13/12/1983	1345	0.17	0.015	0.1	800		3	10	31	8.8			5	470	1.2	0.08			0.2	0.1	86	2.8	94	601.4	14	4	44	304		15	340	216
130507A	Planet Ck_Planet Dns	103730	17/02/1984	1630	0.2	0.002	0.1	940		5	10	31	7.9			5	560		0.08			0.2		105	3.3	105	752.3	37	8.2	46	369		2.5	445	282
130507A	Planet Ck_Planet Dns	204221	22/05/1984	1640	0.21	0.002	0.1	1050			10	22	7.9			5	570		0.07			0.2		110	3.6	105	759.1	40	3.5	49	369		2.7	445	302
130507A	Planet Ck_Planet Dns	105887	14/09/1984	1130	0.22	0.004	0.1	950		5		23	7.8			5	540		0.06			0.2		130	2.3	105	699.7	37	3.3	45	311		1.8	375	278
130507A	Planet Ck_Planet Dns	109516	20/05/1985	940	0.27	0.001	0.1	1000		1	5		8			5	580		0.08			0.2		110	2.5	105	790.5	40		49.5	399		3.1	480	304
130507A	Planet Ck_Planet Dns	112298	19/12/1985	1725	0.24	0.001	0.1	900	850	1		33	8.3			10	530	0.5	0.09			0.2	0.1	65	2.5	83	715.4	46	2	44	393		7	465	296
130507A	Planet Ck_Planet Dns	113991	15/03/1986	840	0.26	0.001	0.1	700	700	8	5		8.6			50	450		0.08			0.2	0.1	54	1.4	75	575.7	19	2.6	44	319		9.3	370	229
130507A	Planet Ck_Planet Dns	114885	18/06/1986	1030	0.32	0.002	0.1	880	1000	26	20	18	8.5			50	520	0.5	0.08			0.2	0.1	115	3.2	100	681.2	27	2.5	44	326		8.6	380	249
130507A	Planet Ck_Planet Dns	116718	3/10/1986	1613	0.29	0.002	0.1	960	900	26	30	26	8.6			35	540	0.5	0.08			0.2	0.1	125	4.1	110	709.5	36.5	2	40	330		11	380	256
130507A	Planet Ck_Planet Dns	117465	10/12/1986	1310	0.39	0.001	0.1	670	625	9	40	34	8.2			10	380	1.2	0.06			0.1		53	2.6	58	528.8	37.5	2	30.5	285		3.8	340	219
130507A	Planet Ck_Planet Dns	122159	8/09/1987	1220	0.41	0.002	0.1	990	810	1	15	19	8.3			5	590		0.07			0.2		125	2.3	115	792.3	33		50	388		6.7	460	288
130507A	Planet Ck_Planet Dns	126559	19/06/1988	1420	0.5	0.002	0.1	1050	940	2	10	19	8.2			11	620	1.6	0.07			0.2		130	3.2	115	827.7	45	6.9	50	395		5.7	470	318
130507A	Planet Ck_Planet Dns	128387	12/01/1989	1750	0.58	0.005	0.1	750	720	4	40	31	7.9			20	430		0.06			0.1		83	3.7	69	576.4	43.5		30	286		1.9	345	232
130507A	Planet Ck_Planet Dns	130205	7/05/1989	835	0.66	0.033	0.2	240		12	60		8.3			22	140	0.5	<0.01	0.1	0.09	<0.1	ND	29	3.6	24	190	13	2	9.4	94	0.1	2	110	71
130507A	Planet Ck_Planet Dns	131265	13/08/1989	1235	0.5	0.004	0.1	820	840			17	8.2			5	490		0.08			0.1		89	2.9	80	689.8	48		40	356		4.7	425	285
130507A	Planet Ck_Planet Dns	132782	21/11/1989	1042	0.59	0.009	0.1	295	342	2			8.1			5	180	0.9	0.02			0.1		26	2.9	27	234	18.5	3.5	14	116		1	140	104
130507A	Planet Ck_Planet Dns	134535	29/05/1990	1215	0.81	0.647	0.1	89		22	70		7.1				50	0.4	0.03				ND	13.8	1.6	11.1	49.9	2.7		2.5	14		ND	17.7	17
130507A	Planet Ck_Planet Dns	137975	24/02/1991	1655	0.78	0.72	0.1	94		2	40		6.8			9	54		0.08	0.22	0.02	0.01		15.5	2.4	12.4	57	2.3		2.6	17	ND	ND	21.8	16
130507A	Planet Ck_Planet Dns	143345	20/07/1991	1527	0.54	0.002	0.1	942	970	1	5	21	8.4			15	563		0.07		0.11	0.18	ND	101.9	3.9	101.2	759.2	46.6	3	44.7	381	0.05	7.8	449.8	300
130507A	Planet Ck_Planet Dns	145499	4/08/1992	1754	0.6	0.002	0.1	1080	1120		10	19	8.3	8.3		5	605	0.2			0.02	0.17	ND	111.4	1.9	103.4	820.6	50.4	1.5	53.8	414	0.04	7.7	489.9	346
130507A	Planet Ck_Planet Dns	149658	21/03/1993	825	0.58	0	0.1	986	985	6	10	26	8.4	8.4		16	609	1.4	0.1			0.2	ND	63.9	4	88.1	831.3	55.1	1	54.2	470	0.05	10	553.3	360

Notes

MTV	minimum trigger value
BOLD	Greater than MTV
123	Historic Water Quality Data\044 Quality poor.
BOLD	Greater than MTV and Historic WQ Data
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C9
Comet Catchment DNRW Water Quality Results - Comet River Downstream Rolleston
GLNG CSG Surface Water

STATION ID	STATION NAME	DATE	TIME	Hydrological Parameters: Stream Water Level	Stream Discharge	Dist. Below water surface	Physico-Chemical Parameters: Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	DO FLD	Total Suspended Solids	Total Diss. Solids
			Units	m	cumsecs	m	uS/cm	uS/cm	NTU	NTU	Hazen units	°C	°C	pH units	pH units	mg/L	mg/L	mg/L
			MTV				340		50				20%ile-80%ile	6.5-8.0	6.5-8.0		10	500
1305004	Comet at Springsure Rd	3/06/1999	1315	NA	0	0.2	480	458	15	21	17	23.9	17.4	8.25	8.2	8.1	20	270
130506A	Comet River AMTD 124.2km	30/08/1972	1820	-0.1	0	0.1	500							7.9				295
130506A	Comet River AMTD 124.2km	7/03/1973	1845	1.43	1.698	0.1	270						27	7.9				157
130506A	Comet River AMTD 124.2km	7/06/1973	2359	0.33	0	0.1	340							8.3			7	187
130506A	Comet River AMTD 124.2km	22/09/1973	1710	0.91	0.104	0.1	1030						23	8.1				602
130506A	Comet River AMTD 124.2km	31/03/1974	1625	1.53	0.123	0.1	370						27	7.9			30	218
130506A	Comet River AMTD 124.2km	27/06/1974	1435	1.27	0.366	0.1	410						16	8.3			10	232
130506A	Comet River AMTD 124.2km	2/10/1974	1100	1.13	0.007	0.1	330						22	8			8	187
130506A	Comet River AMTD 124.2km	12/12/1974	1630	1.07	0	0.1	320						33	8			82	184
130506A	Comet River AMTD 124.2km	5/02/1975	1515	1.33	0.886								27					
130506A	Comet River AMTD 124.2km	21/02/1975	1545	1.22	0.521	0.1	470						28.5	7.9			143	275
130506A	Comet River AMTD 124.2km	9/10/1975	1645	0.84	0	0.1	351						23	7.7			11	175
130506A	Comet River AMTD 124.2km	5/12/1975	2359	1.33	0.886	0.1	540							8.2			82	319
130506A	Comet River AMTD 124.2km	17/12/1975	1405	0.57	0	0.1	355						32	7.7			80	181
130506A	Comet River AMTD 124.2km	8/04/1976	1400	1.88	4.456								22					
130506A	Comet River AMTD 124.2km	22/07/1976	1600	1.21	0.657	0.1	460						13	8.1			2	249
130506A	Comet River AMTD 124.2km	18/11/1976	840	1.55	2.602	0.1	305						25	8.6			103	184
130506A	Comet River AMTD 124.2km	24/04/1977	1335	1.69	2.88	0.1	390							8.3				232
130506A	Comet River AMTD 124.2km	27/04/1977	1335	1.69	2.883								20					
130506A	Comet River AMTD 124.2km	6/10/1977	1500	0.98	0.158	0.1	390						26	8.6			5	233
130506A	Comet River AMTD 124.2km	16/03/1978	1255	1.03	0.231	0.1	465						28	7.9				272
130506A	Comet River AMTD 124.2km	15/06/1978	925	1.05	0.23	0.1	310						12	8.1				193
130506A	Comet River AMTD 124.2km	28/09/1978	1010	1.47	2.154								19					
130506A	Comet River AMTD 124.2km	6/07/1981	1512	1.28	0.605								16					
130506A	Comet River AMTD 124.2km	13/08/1981	1020	1.09	0.105	0.1	425		10		5		14	8.5			10	250
130506A	Comet River AMTD 124.2km	12/11/1981	935	1.29	0.876	0.1	185		100				26	8			200	110
130506A	Comet River AMTD 124.2km	27/10/1983	1210	0.8	0.072	0.1	230		30		5		26	7.5			10	120
130506A	Comet River AMTD 124.2km	13/12/1983	1620	1.15	0.747	0.1	240		100					7.8			30	140
130506A	Comet River AMTD 124.2km	24/05/1984	1600	0.86	0.07	0.1	455				10		20	8.4			5	240
130506A	Comet River AMTD 124.2km	11/09/1984	1330	0.95	0.246	0.1	305		100				23	7.6			25	170
130506A	Comet River AMTD 124.2km	19/12/1984	1030	1.62	2.52	0.1	195		100				29	7.4			600	130
130506A	Comet River AMTD 124.2km	17/12/1985	855	0.74	0.74	0.1	190	170	100		70		26	7.6			430	100
130506A	Comet River AMTD 124.2km	15/03/1986	1420	0.65	0.032	0.1	205	190	35		50			7.6			55	130
130506A	Comet River AMTD 124.2km	11/12/1986	1630	1.33	1.499	0.1	160	130	100				28	7.5			275	110
130506A	Comet River AMTD 124.2km	27/02/1987	1415	0.61	0.006	0.1	200	180	91		70		35	8			89	120
130506A	Comet River AMTD 124.2km	11/08/1989	1755	1.17	0.396	0.1	305	310	4		5		13	7.9			5	180
130506A	Comet River AMTD 124.2km	21/11/1989	1345	1.03	0.159	0.1	205	209	100					7.8			81	120
130506A	Comet River AMTD 124.2km	11/10/1990	1125	0.83	0.023								28		7.7			
130506A	Comet River AMTD 124.2km	27/02/1991	1305	1.35	1.53										7.9			
130506A	Comet River AMTD 124.2km	20/07/1991	1825	0.86	0.025	0.1	370	370	2					8.1			11	207
130506A	Comet River AMTD 124.2km	30/11/1993	1430	1.16	0.101	0.1	169	169	200		15		33.3	7.9	8.2		301	102
130506A	Comet River AMTD 124.2km	8/02/1995	1600	0.78	0	0.2	197.2		25		40			8.72			45	111.01
130506A	Comet River AMTD 124.2km	8/03/1995	1209	1.05	0	0.2	212.2	205	160		50			7.35			83	129.83
130506A	Comet River AMTD 124.2km	17/05/1995	900	NA	0	0.2	230	251	18	45	10		20.6	7.2	8.6	6.7	30	130
130506A	Comet River AMTD 124.2km	1/11/1995	1640	1.48	0.542	0.2	112.3	114	453	1192	30		27.7	7.05	6.47		498	72.62
130506A	Comet River AMTD 124.2km	5/12/1995	1230	1.31	0.65	0.2	174.5	178	486	704	34		30.1	7.34	7.7	6.13	333	107.36
130506A	Comet River AMTD 124.2km	7/01/1996	1245	2.21	6.48	0.2		111		1026			27.8		6.74	6.26		
130506A	Comet River AMTD 124.2km	7/01/1996	1745	2.21		0.2	145		807		35			7.26			470	69.69
130506A	Comet River AMTD 124.2km	2/02/1996	835	1.61	3.592	0.2	230	229	57.1	70.8	38		28.6	7.38	7.59	5.88	58	136.02
130506A	Comet River AMTD 124.2km	5/03/1996	1144	0.97	0	0.2	325	321	2	20.2	20		26.1	7.95	8.61	9.75	20	180
130506A	Comet River AMTD 124.2km	3/04/1996	920	0.73	0	0.15	374	372	12.5	28.3	18		21.5	7.91	8.88	7.85	20	200.9
130506A	Comet River AMTD 124.2km	9/05/1996	1020	1.46	0.41	0.1	122	121	485		11			7.07			117	81.81
130506A	Comet River AMTD 124.2km	22/05/1996	1400	1.17	0.08	0.2	147	145	198	193	60	24.3	19.4	7.3	7.7	9	92	110.42
130506A	Comet River AMTD 124.2km	5/06/1996	1120	1.01	0.066	0.1	162	159	128	118	10		17.3	7.41	7.15	7.55	49	105.23
130506A	Comet River AMTD 124.2km	4/07/1996	1141	0.74	0.038	0.2	176	178	92	85	8		13.7	7.45	7.78	8.87	13	106.91
130506A	Comet River AMTD 124.2km	13/08/1996	830	0.37	0	0.1	187	191	52	66.7	37		10.9	7.72	7.95	9.85	10	116.04
130506A	Comet River AMTD 124.2km	3/02/1997	1015	5	155.341	4.5		100										
130506A	Comet River AMTD 124.2km	3/02/1997	1315	5.54	155.453	5.04		100										
130506A	Comet River AMTD 124.2km	3/02/1997	1615	5.55	155.565	5.05		100										
130506A	Comet River AMTD 124.2km	4/02/1997	824	8.42	156.165	0.2	101	95	2340		17			7.05			2344	72.07
130506A	Comet River AMTD 124.2km	4/02/1997	930	8.508	156.206			95					23.5		7.7			
130506A	Comet River AMTD 124.2km	4/02/1997	1422	8.605	167.11			108					23.9					
130506A	Comet River AMTD 124.2km	4/02/1997	1521	8.61	166.6	5.44	119	108	1200	3180							2040	
130506A	Comet River AMTD 124.2km	4/02/1997	1527	8.61	166.6	1.36	125	108	1450	3160							1950	
130506A	Comet River AMTD 124.2km	4/02/1997	1537	8.61	166.6	6.32	118	108	2500	3120							1950	
130506A	Comet River AMTD 124.2km	4/02/1997	1540	8.61	166.6	1.58	110	108	2500	3060							2350	
130506A	Comet River AMTD 124.2km	4/02/1997	1600	8.61	166.6	0.5	109	108	3110	2910	21			7.08			2324	75.96
130506A	Comet River AMTD 124.2km	4/02/1997	1603	8.61	166.6	1.58	114	108	2350	2820							2200	
130506A	Comet River AMTD 124.2km	4/02/1997	1606	8.61	166.6	3.16	111	108	2400	2800							2040	
130506A	Comet River AMTD 124.2km	4/02/1997	1609	8.61	166.6	4.74	115	108	1650	3090							2050	
130506A	Comet River AMTD 124.2km	4/02/1997	1613	8.61	166.6	6.32	114	108	2000	2900							2250	
130506A	Comet River AMTD 124.2km	4/02/1997	1617	8.61	166.6	7.75		108		2830								
130506A	Comet River AMTD 124.2km	4/02/1997	1626	8.61	166.6	1.53	111	108	2500	3000							2200	
130506A	Comet River AMTD 124.2km	4/02/1997	1630	8.61	166.6	6.12	127	108	1000	2630							1100	
130506A	Comet River AMTD 124.2km	4/02/1997	1637	8.61	166.6	1.16	113	108	2450	2830							1950	
130506A	Comet River AMTD 124.2km	4/02/1997	1639	8.61	166.6	4.64	124	108	2350	2870							1750	
130506A	Comet River AMTD 124.2km	5/02/1997	1313	7.36	97.7	5.28	109	110	1200	1140							930	
130506A	Comet River AMTD 124.2km	5/02/1997	1321	7.36	97.7	1.32	112	110	930	1200							770	
130506A	Comet River AMTD 124.2km	5/02/1997	1325	7.36	97.7	5.5	110	110	840	1140							790	
130506A	Comet River AMTD 124.2km	5/02/1997	1328	7.36	97.7	1.36	110	110	1120	1160							890	
130506A	Comet River AMTD 124.2km	5/02/1997	1342	7.36	97.691	0.5	109	110	1320	1130	22			7.13			860	76.49
130506A	Comet River AMTD 124.2km	5/02/1997	1349	7.36	97.686	1.34	110	110	1070	1150							880	
130506A	Comet River AMTD 124.2km	5/02/1997	1352	7.36	97.684	2.68	110	110	950	1150							740	
130506A	Comet River AMTD 124.2km	5/02/1997	1354	7.36	97.683	4.02	111	110	870	1160							850	
130506A	Comet River AMTD 124.2km	5/02/1997	1356	7.36	97.681	5.36	110	110	1100	1150							890	
130506A	Comet River AMTD 124.2km	5/02/1997	1359	7.36	97.679	6.2		110		1140								
130506A	Comet River AMTD 124.2km	5/02/1997	1416	7.36	97.668	1.26	111	110	820	1130							720	
130506A	Comet River AMTD 124.2km	5/02/1997	1417	7.36	97.667	5.04	111	110	960	1130							870	
130506A	Comet River AMTD 124.2km	5/02/1997	1421	7.36	97.665	1	109	110	680	1160							720	
130506A	Comet River AMTD 124.2km	5/02/1997	1422	7.36	97.664	4	112	110	510	1130							560	
130506A	Comet River AMTD 124.2km	5/02/1997	1428	7.182	97.66			110					24.9		7.1			
130506A	Comet River AMTD 124.2km	5/02/1997	2025	6.07	78.543	0.2	114	127	1060		22			7.22			764	80.72
130506A	Comet River AMTD 124.2km	6/02/1997	606	4.1	47.431	0.2	128		917		15			7.31			674	87.85
130506A	Comet River AMTD 124.2km	6/02/1997	1510	3.25	18.3	0.2	136	140	750		9		26.5	7.4	7.2		586	93.99
130506A	Comet River AMTD 124.2km	8/02/1997	905	2.56		0.2	139		606		18			7.43			286	93.6
130506A	Comet River AMTD 124.2km	8/02/1997	940	2.56	8.775	0.2		146					25.8		7.74			
130506A	Comet River AMTD 124.2km	25/02/1997	1510	1.618	1.548			206					27		7.5			
130506A	Comet River AMTD 124.2km	1/04/1999	1300	1.23	0.206	0.2		378		15.1			24.9		7.9	6.9		
130506A	Comet River AMTD 124.2km	3/06/1999	1650	0.98	0	0.2	345	378	10.3	15	11	23.4	18.6	8.2	8.2	7.7	18	223.38
130506A	Comet River AMTD 124.2km	10/09/1999	905	0.65	0	0.2	323.31	335	20.2	21	12		18.3	7.94	8.2	8.5	23	190.72
130506A	Comet River AMTD 124.2km	28/03/2000	700	NA	0	0.1												
130506A	Comet River AMTD 124.2km	4/04/2000	1155	1.04	0.001	0.2		271		7			25.2		8.3	9.4		
130506A	Comet River AMTD 124.2km	11/08/2000	1225	1.37	1.536	0.2		152		334			17.2		7.9	8.7		
130506A	Comet River AMTD 124.2km	21/05/2001	1536	1	0.031	0.2		386		1			15.7		8.3			
130506A	Comet River AMTD 124.2km	21/06/2002	1020	1.04	0.24	0.2		118					13.2		7.9	8.7		
130506A	Comet River AMTD 124.2km	22/04/2003	1434	0.95	0.153			178		109			22		7.5	7.1		

DATE	TIME	Nutrients: Nitrate (NO3)	Nitrate + nitrite (N soluble)	Ammonia (N soluble)	Kjeldahl Nitrogen	Organic Nitrogen	Total React Phosphorus (P soluble)	Total Phosphorus (P)	Metals: Boron as B (mg/L)	Aluminium as Al soluble (mg/L)	Copper as Cu soluble mg/L	Flouride as F (mg/L)	Major Ions: Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Alkalinity: Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
	Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	MTV	50		0.02				0.05	0.37	0.055	0.0014	1		175		115		1000	250							
3/06/1999	1315	0.8				0.41		0.11	<0.1	0.05	<0.05	<0.1	ND	22.5	6	27	390	38	2.3	24.5	220	176	ND	2.7	265	195
30/08/1972	1820											0.04	ND	25		35	448	42		29	260			ND	317	224
7/03/1973	1845											0.17	ND	14		21	241.9	25.6	1	12.1	138			ND	168	114
7/06/1973	2359								0.05			0.16	ND	16	4.5	12	269.9	32		17.6	169			19	168	152
22/09/1973	1710											0.26	0.1	140	6.5	115	781.7	45		45	355		ND	3.2	426	298
31/03/1974	1625											0.14	ND	20	4.2	18	299.3	28		20	172		ND	1	208	152
27/06/1974	1435											0.15	ND	12	2.8	18	325.3	34		24	194		ND	2.3	232	184
2/10/1974	1100											0.17	ND	13	2.8	18	278.7	26		17.7	165		ND	ND	201	138
12/12/1974	1630											0.15	ND	13	4.6	17	255.4	22.5		16.2	150		ND	0.9	181	123
5/02/1975	1515																									
21/02/1975	1545											0.27	ND	52	2.8	52	361.3	28	9.7	16.5	165		ND	1	199	138
9/10/1975	1645											0.1	ND	10	3.8	18	272.9	21		20	164		ND	N	200	135
5/12/1975	2359											0.15	ND	25	5.3	25	456.2	45		29	270		ND	2.7	324	232
17/12/1975	1405											0.42	ND	12	4.4	22	278.8	17		21	166		ND	N	202	129
8/04/1976	1400																									
22/07/1976	1600											0.1		14	2.4	23	357.3	34		25	214		ND	1.8	257	188
18/11/1976	840	0.6										0.1	0.1	10	3.1	15	248.6	25	2	14	150		ND	3.7	175	120
24/04/1977	1335	0.1										0.1		12	2.6	19	328.6	32	5	22	196		ND	2.8	233	171
27/04/1977	1335																									
6/10/1977	1500											0.2	0.1	12	2.4	19	324.2	30	5	23	195			5.5	227	170
16/03/1978	1255	0.8										0.1		16	4	23	385.1	37	5	25	226			1.2	273	195
15/06/1978	925	0.7										0.2		9	2.4	16	275.7	29	3	19	162			1.4	195	151
28/09/1978	1010																									
6/07/1981	1512																									
13/08/1981	1020											0.1	0.1	10	3.9	20	353.6	33	25	23	199			4.5	234	177
12/11/1981	935	4.1										0.1		6.7	2.8	9.9	141.8	14	8.9	6.8	73			0.5	88	63
27/10/1983	1210								0.02			0.1		16	3.8	14	163.2	15		9	86			0.2	105	75
13/12/1983	1620	1.3							0.03			0.1		11	6.3	13	187.1	17	3	9.9	103			0.4	125	83
24/05/1984	1600											0.1	0.1	14	4.1	21	356.3	34	4.9	24	212			4.1	250	184
11/09/1984	1330								0.02					13	6.8	17	246.3	22	4.1	13	140			0.4	170	108
19/12/1984	1030								0.03					6.1	5.5	10	161.1	15		8.9	95			0.2	115	74
17/12/1985	855	0.5							0.03			0.2		5	4.3	10	138.6	13	2	7	79			0.2	96	61
15/03/1986	1420	1.5							0.04			0.2		13	8	9.5	166.9	17		7.5	91			0.2	110	73
11/12/1986	1630	1.9							0.04			0.1		9.1	8	10	117.8	12		5	58			0.1	70	51
27/02/1987	1415	0.5							0.04			0.2		10	8.1	9.8	153.2	15	2	6.9	83			0.6	100	66
11/08/1989	1755								0.03			0.1		9	3.4	15	250.5	26	5.2	16	145			0.8	175	131
21/11/1989	1345	1.4										0.2		4.9	3.7	9.9	156.9	15.5	6.7	9	87			0.4	105	76
11/10/1990	1125																									
27/02/1991	1305																									
20/07/1991	1825								0.02	0.05	0.17	0.15	ND	9.9	4	18.8	312.3	30.8	3.8	21	185		ND	1.6	222.2	163
30/11/1993	1430	1.1									0.03	0.13	ND	4.6	3.9	8	133.8	13.4	1.5	7.7	76		ND	0.4	92.8	65
8/02/1995	1600	ND	ND	0.0042		0.5159	0.02	0.0946	ND	ND	0.01	0.13	ND	6.85	4.6	12.3	148.82	11.5	2.13	9.2	86.3		0.09	2.86	99.16	66.52
8/03/1995	1209	3.6	0.0081	0.0448		1.6062	0.1054	0.3159	ND	0.02	0.06	0.14	ND	7.5	6.5	11	170.66	16.4	2.4	9.2	93.5		ND	0.14	113.77	78.75
17/05/1995	900	5.5	0.006	0.041		1.5	<0.002	0.1	<0.1	0.05	<0.05	0.2	ND	6.8	5.6	12	200	20.5	2	11.5	115		ND	0.1	140	98
1/11/1995	1640	1.11	0.0457	0.0814		1.6576	0.11	0.6914	ND	0.06	0.06	0.15	ND	6.21	4.6	9.3	90.73	6.4	2.35	3.3	47		ND	0.03	57.27	29.54
5/12/1995	1230	1.53	0.116	0.0169		1.5381	0.162	0.7752	ND	0.01	0.05	0.17	ND	7.02	7.1	9.2	137.32	14.1	0.97	6.7	74.3		ND	0.11	90.41	62.73
7/01/1996	1245																									
7/01/1996	1745	1.06	0.0698	0.0596		1.6314	0.0842	0.7576	ND	0.09	0.05	0.12	ND	4.74	4.6	7.6	83.68	8.8	1.28	4.3	42		ND	0.05	51.12	39.64
2/02/1996	835	3.69	0.475	0.0249		1.1511	0.0742	0.1558	ND	0.01	0.01	0.14	ND	7.13	7.4	10.6	180.55	18.6	1.47	9.7	100		ND	0.17	121.65	86.29
5/03/1996	1144	0.5	0.012	0.011		1.4	0.007	0.098	<0.1	0.05	<0.05	0.2	ND	10	8.2	14	270	29.5	2	14.5	155	133.6	ND	1	185	135
3/04/1996	920	2.27	0.0315	0.0073		1.1827	0	0.0877	ND	ND	0.02	0.2	ND	11.06	8.2	16.5	311.96	33.8	ND	18.4	182.5		ND	1.05	220.46	159.99
9/05/1996	1020	2.1	0.339	0.0468		1.2102	0.13	0.368	ND	ND	0.03	0.13	ND	9	5.6	9.8	95.23	8.1	3.1	4	43.8		ND	0.03	53.37	36.66
22/05/1996	1400	2.01	0.0748	0.0111		1.0279	0.0995	0.2657	ND	ND	ND	0.14	ND	20.01	6.1	11.5	133.81	10.9	3.41	5.3	61.1	56	ND	0.08	74.36	48.99
5/06/1996	1120	1.8	0.0244	0.0187		0.7913	0.0742	0.2005	ND	ND	0.01	0.11	ND	11.49	6.5	11.5	131.65	11.8	2.72	5.9	65.5		ND	0.11	79.71	53.7
4/07/1996	1141	0.3	0.0116	0.0161		0.8489	0.0493	0.1515	ND	0.01	0.07	0.12	ND	8.8	5.9	11.9	139.58	12.4	1.9	6.9	75.0	81.6	ND	0.13	91.22	59.31
13/08/1996	830	ND	0.0163	0.0177		0.7793	0.0318	0.0879	ND	0.01	0.03	0.14	ND	14.6	6.1	12.9	156.4	14.3	2.5	7.7	80.7		ND	0.27	97.88	67.34
3/02/1997	1015		0.004	0.0161		17.8609	0.0445	0.97																		
3/02/1997	1315		0.0019	0.0099		9.6211	0.052	0.514																		
3/02/1997	1615				11.882			0.5191																		
4/02/1997	824	1.7	0.144	0.0125		4.0075	0.108	2.4338	ND	ND	ND	0.15	ND	4	3	4.8	84.38	9.2	ND	5.2	46.2		ND	0.03	56.3	44.34
4/02/1997	930																									
4/02/1997	1422																									
4/02/1997	1521																	17		8.4						77
4/02/1997	1527																	14		7.1						64
4/02/1997	1537																	15		7.5						68
4/02/1997	1540																	15		7.3						67
4/02/1997	1600	2	0.189	0.0219		2.2791	0.129	1.2699	ND	ND	0.01	0.14	ND	4	3.8	6.1	91.03	9.2	0.7	5.1	49.2		ND	0.04	59.95	43.92
4/02/1997	1603				3.288			1.734										13		6.8						60
4/02/1997	1606				3.536			2.0566										14		6.9						63
4/02/1997	1609				2.566			2.1877										14		6.9						63
4/02/1997	1613				3.88			1.0372										16		7.9						72
4/02/1997	1617				2.647			1.3767																		
4/02/1997	1626																	16		7.9						72
4/02/1997	1630																	14		7.2						64
4/02/1997	1637																	7		6.8						45
4/02/1997	1639																	15		7.6						69
5/02/1997	1313																	13		6.5						59
5/02/1997	1321																	12		5.8						54
5/02/1997	1325																	12		5.6						53
5/02/1997	1328																	12		5.7						53
5/02/1997	1342	1.1	0.0657	0.0232		1.2608	0.153	0.8795	ND	0.01	0.01	0.14	ND	5.4	4.6	6.6	90.06	8.6	1.5	4.7	47.1		ND	0.04	57.38	40.78
5/02/1997	1349				1.581			1.1										14		6.7						63
5/02/1997	1352				1.609			1										13		6.1						58
5/02/1997	1354				1.995			0.8589										13		6.3						58
5/02/1997	1356				1.729			1.03										13		6.5						59
5/02/1997	1359				1.751			1.04																		
5/02/1997	1416																	12		6.2						55
5/02/1997	1417																	13		6.5						59
5/02/1997	1421																	13		6.5						59
5/02/1997	1422																	12		6.1						55
5/02/1997	1428																									
5/02/1997	2025	1	0.0694	0.0116		1.2034	0.15	0.6896	ND	0.01	0.01	0.11	ND	4.3	4.4	6.3	96.75	9.4	1.4	5	53.2		ND	0.06	64.79	44.01
6/02/1997	606	0.7	0.1009	0.0112		1.4908	0.156	0.814	ND	ND	0.01	0.12	ND	5.7	4.4	6.8	105.37	10.5	1.5	5.7	57.4		ND	0.07	69.87	49.64
6/02/1997	1510	0.7	0.11	0.0185		1.4555	0.162	0.8675	ND	ND	0.01	0.12	ND	6.8	4.4	7.1	113.71	11.4	1.6	6.3	61.8		ND	0.1	75.18	54.35
8/02/1997	905	0.6	0.121	0.0388		1.3062	0.164	0.753	ND	ND	0.01	0.13	ND	6.5	5.8	8.2	114.3	10.7	1.8	5.9	61.3		ND	0.11	74.56	50.96
8/02/1997	940																									
25/02/1997	1510																									
1/04/1999	1300																									
3/06/1999	1650	0.74						0.0979	ND	0.01	ND	ND	ND	8.07	4.6	20.3	328.66	31.2	3.26	21.9	195	180	ND	2.12	236.45	167.89
10/09/1999	905	1.44						0.0891	ND	ND	ND	0.16	ND	8.46	4.1	19.6	289.95	24.5	4.74	19.7	170.75	90	ND	1	206.24	142.13
28/03/2000	700																									
4/04/2000	1155																									
11/08/2000	1225																									
21/05/2001	1536																									
21/06/2002	1020																									
22/04/2003	1434																									

Notes
- MTV minimum trigger value
- **BOLD** Greater than MTV
- 123 Historic Water Quality Data\044 Quality poor.
- **BOLD** Greater than MTV and Historic WQ Data
- NA Not available (Gauge Height < Instrument Threshold)
- ND Not detected
- E Estimate

Table C10
Comet Catchment DNRW Water Quality Results -Humboldt and Rockland Creeks
GLNG CSG Surface Water

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Hydrological Parameters			Physico-Chemical Parameters								Nutrients			Metals				Major Ions								Alkalinity					
					Stream Water Level	Stream Discharge	Dist. Below water surface	Conductivity @ 25C	Turbidity	Turbidity FLD	Colour True	Water Temp FLD	pH	Total Suspended Solids	Total Diss. Solids	Nitrate (NO3)	Ammonia (N soluble)	Total Phosphorus (P)	Boron as B	Aluminium (Al)	Copper (Cu)	Flouride (F)	Hydrogen (H)	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)	Hardness (CaCO3)
				Units	*m*	*cumsecs*	*m*	*uS/cm*	*NTU*	*NTU*	*Hazen units*	*°C*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
				MTV				340	50	50		20%ile-80%ile	6.5-8.0	10	500	50	0.02	0.05	0.37	0.055	0.0014	1		175		115		1000	400							
1305025	Rockland_Humboldt Rd	185787	23/06/1997	1640	NA	0	0.2	167	**1238**	**1280**	14	18.7	6.88	**229**	105.01	4.12	**1.11**	**0.39**	ND	ND	**0.01**	0.17	ND	20.59	4.8	20.1	121.03	6.7	8.55	4.2	42.47	48	0	0.02	51.77	33.99
130505A	Humboldt Ck_Sunlight	56711	19/01/1973	1450	0.38	0.047	0.1	150					7.7		81							0.2	ND	18		16	114.5	8		6.3	54		0	0	66	46
130505A	Humboldt Ck_Sunlight	61406	31/03/1974	1100	0.27	0.001	0.1	335					7.4	4	204							0.12	ND	65	5	38	229.9	16		8.8	80		0	0	97	76
130505A	Humboldt Ck_Sunlight	63101	30/09/1974	1200	NA	0	0.1	330				20	6.9	**96**	192									90	4.4	40	192	20	12	7.3	15		0	0	18.3	80
130505A	Humboldt Ck_Sunlight	68599	6/05/1976	1245	0.32	0.006	0.1	260				21	7.3	**17**	159							0.2		36	4.3	30	176.3	11		6.7	72		0	0.1	88	55
130505A	Humboldt Ck_Sunlight	70383	27/10/1976	1045	0.33	0.005	0.1	130				28	7.2	**360**	114	5.3						0.8		20	5.3	19	113.3	3.5	20	5.4	28				34	31
130505A	Humboldt Ck_Sunlight	90509	1/06/1981	1645	0.62	0.482	0.1	48	**70**		70	19	7.7	**10**	45	1						0.1		10	1.8	5.6	46.9	1.5	6	1.9	16				19	12

Notes

MTV	minimum trigger value
BOLD	Greater than MTV
123	Historic Water Quality Data\044 Quality poor.
BOLD	Greater than MTV and Historic WQ Data
NA	Not available (Gauge Height < Instrument Threshold)
ND	Not detected
E	Estimate

Table C12
Comet Catchment DNRW Water Quality Results - Comet River at Comet Weir
GLNG CSG Surface Water

					Hydrological Parameters					Physico-Chemical Parameters													Nutrients											Metals							Major Ions									Alkalinity				
STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Stream Water Level	Stream Discharge	Total Stream Width	Distance from left bank	Dist. below Water Surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Transparency (secchi depth) FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	DO FLD	TSS	TDS	Nitrate (NO3)	Nitrate + nitrite (N total)	Nitrate + nitrite (N soluble)	Ammonia (N total)	Ammonia (N soluble)	Kjeldahl Nitrogen	Total Nitrogen (TN)	Organic Nitrogen	Total Reactive Phosphorus (totol P)	Total React Phosphorus (P soluble)	Total Phosphorus (P)	Boron as B	Aluminium (Al)	Copper (Cu)	Bromide (Br)	Cadmium (Cd total)	Chromium (Cr total)	Copper (Cu total)	Flouride (F)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)
				Units	m	cumsecs	m	m		uS/cm	uS/cm	NTU	NTU	m	Hazen units	°C	°C	pH units	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
				MTV						340		50					20%ile-80%ile	6.5-8.0	6.5-8.0		10	500	50			0.02	0.02		0.5				0.05	0.37	0.055	0.0014		0.2	1	1.4	1		<175		<115		1000	400						
130504A	Comet at AMTD 17.2km	52195	26/02/1971	1110	3.66	58.4			0.1	130								7.2				ND																			0.15	ND	8		9	111.2	14		4	62		ND		76
130504A	Comet at AMTD 17.2km	50569	16/11/1971	0	NA	0			0.1	315								7.3				ND																			0.15	ND	15		20	270.2	26	2	17	156		ND		190
130504A	Comet at AMTD 17.2km	52196	27/02/1972	935	2.02	3.85			0.1	138							25	7.3				ND																			0.15	ND	10		8	116.2	14		6	64		ND		78
130504A	Comet at AMTD 17.2km	52197	28/02/1972	814	2.26	27.8			0.1	143							25	7.4				ND																			0.15	ND	10		8	116.2	14		6	64		ND		78
130504A	Comet at AMTD 17.2km	52198	1/03/1972	940	1.45	13.3			0.1	155							25	7.4																							0.15	ND	12		12	135.2	19		4	72				88
130504A	Comet at AMTD 17.2km	52199	3/03/1972	940	1.03	7.42			0.1	167							25	7.5				ND																			0.15	ND	12		13	143.2	19		4	78		ND		95
130504A	Comet at AMTD 17.2km	52200	4/03/1972	940	0.88	5.69			0.1	175							25	7.5				ND																			0.15	ND	12		12	148.2	16		8	82		ND		100
130504A	Comet at AMTD 17.2km	54344	29/08/1972	0	NA				0.1	400								8.1																							0.17	ND	25		30	375.2	48	1	15	210				256
130504A	Comet at AMTD 17.2km	56717	21/01/1973	1320	1.04	7.519			0.1	100								7.4				66																			0.15	ND	12		13	95.6	5.6		5.8	48			ND	59
130504A	Comet at AMTD 17.2km	57963	22/02/1973	1023	5.44	167.853			0.1	111							24.5	8.1			875	70												0.01							0.17	ND	8	2.8	7.1	106.9	8		5	54			ND	66
130504A	Comet at AMTD 17.2km	57965	22/02/1973	1700	5.36	164.709			0.1	111								7.4			883	72												0.01							0.17	ND	8	2.6	7.1	110.9	7.5		5	58			ND	71
130504A	Comet at AMTD 17.2km	57966	23/02/1973	940	5.67	184.76			0.1	114							25	7.7			577	70												0.01							0.16	ND	8	3.1	7.9	105.1	8		5	52			ND	63
130504A	Comet at AMTD 17.2km	57967	24/02/1973	955	5.9	203.762			0.1	117							26	7.8			489	76												0.01							0.16	ND	10	4.2	7.5	114.4	8.5		5.5	56			ND	68
130504A	Comet at AMTD 17.2km	57964	25/02/1973	925	5.45	162.868			0.1	126							26.5	7.8			437	78												0.01							0.16	ND	10	3.6	7.2	118.3	8.5		5.5	60			ND	73
130504A	Comet at AMTD 17.2km	57968	25/02/1973	1400	5.08	137.465			0.1	130								8.2			446	81												0.01							0.17	ND	10	4.6	7.6	122.3	8.5		5.5	62			ND	76
130504A	Comet at AMTD 17.2km	57969	26/02/1973	750	4.35	101.952			0.1	135							28	8.0			453	81												0.01							0.17	ND	10	5.2	7.6	122.5	8.5		5.5	62			ND	76
130504A	Comet at AMTD 17.2km	57970	26/02/1973	1235	3.99	87.962			0.1	139								8.2			468	84												0.02							0.18	ND	10	5.5	8.1	126.7	9		6	64			ND	78
130504A	Comet at AMTD 17.2km	56731	6/03/1973	1600	0.79	4.324			0.1	203							29	7.5				117																			0.17	ND	14		17	178.2	18		9	98			ND	120
130504A	Comet at AMTD 17.2km	57865	18/03/1973	1530	0.24	0.26			0.1	280								7.8			48	176												0.03							0.2	ND	14	5.9	18	243.7	24.7		11.8	138			ND	168
130504A	Comet at AMTD 17.2km	57824	30/05/1973	0	NA				0.1	260								8.2			9	156												0.06							0.18	ND	14	5.7	10.8	202.5	23.5		11.3	126			16.8	119.6
130504A	Comet at AMTD 17.2km	59127	20/09/1973	0	NA				0.1	240								8.0				137																			0.22	0.1	12	4.4	14.5	187.6	19		10	104		ND	0.6	126
130504A	Comet at AMTD 17.2km	61608	25/06/1974	1100	0.15	0.021			0.1	400							18	7.7			20	223																			0.15		14	4.6	19	318.6	34.1		21	186		ND	0.7	225
130504A	Comet at AMTD 17.2km	63095	30/09/1974	945	NA	0.01			0.1	375							20	8.0			5	213																			0.17	ND	17.5	48	20	361.7	30		20	185			ND	226
130504A	Comet at AMTD 17.2km	64846	11/12/1974	1000	0.12	0.002			0.1	250							27	7.9			114	149																			0.18	ND	9	4.8	14	196.5	19		11	114		ND	0.5	138
130504A	Comet at AMTD 17.2km	64843	7/02/1975	1200	0.37	0.92			0.1	350							26	7.9			86	204																			0.14	ND	15	6.1	16.5	282.6	29		16	165		ND	0.9	199
130504A	Comet at AMTD 17.2km	64817	22/02/1975	1330	0.25	0.39			0.1	420							28	8.1			67	244																			0.18	ND	15	6.4	20	347.9	38		20.6	205		ND	1.7	246
130504A	Comet at AMTD 17.2km	64818	30/04/1975	1600	0.32	0.694			0.1	360								8.0			121	216																			0.15	ND	15	4.2	17	300.1	30	4.2	17.5	175		ND	1	211
130504A	Comet at AMTD 17.2km	67019	18/12/1975	1110	NA	0			0.1	205							30.5	7.3			268	125																			0.83	ND	10	3.4	15	152.7	14		7.5	84		ND	ND	102
130504A	Comet at AMTD 17.2km	68493	7/04/1976	1055	0.85	5.24			0.1	380							24	7.9			77	228																			0.2	ND	16	3.4	18	309.8	30	3.4	20	180		ND	0.8	218
130504A	Comet at AMTD 17.2km	69368	20/07/1976	1155	0.3	0.577			0.1	510							14	8.0			11	251																			0.1		18	2.4	26	382.2	36	4	27	222			1.7	267
130504A	Comet at AMTD 17.2km	72404	28/04/1977	1500	0.61	2.74			0.1	390							22	8.4				241	0.5																		0.1	0.1	13	2.8	19	329	32	5	21	196			3.5	232
130504A	Comet at AMTD 17.2km	74095	31/08/1977	1005	0.22	0.246			0.1	440							19	8.5			6	242																			0.2	0.1	16	2.8	26	359.9	30	10	26	208			4.8	244
130504A	Comet at AMTD 17.2km	75695	6/01/1978	1150	NA	0				335								7.8			25	200	6.5																		0.3	ND	28	4.6	23	177	22	6	13	122		ND	0.5	148
130504A	Comet at AMTD 17.2km	77086	23/03/1978	1020	0.16	0.059			0.1	385							28	7.8				271	1.5																		0.3	ND	15	5.7	22	358.4	35	9	20	206			0.9	249
130504A	Comet at AMTD 17.2km	77577	9/06/1978	1135	0.07	3.249			0.1	345							19	7.9			10	201	0.6																		0.2		12	4.4	19	298.2	30	2	19	174		ND	1	210
130504A	Comet at AMTD 17.2km	79177	20/09/1978	1140	0.96	7.46			0.1	200							18	7.9			165	122	0.8																		0.1		10	4.5	13	151.4	14	3	8.6	80			0.4	97
130504A	Comet at AMTD 17.2km	88929	19/01/1981	1110	0.25	0.3			0.1	210							26	7.3			110	123	1																		0.1		5.7	5.9	7.9	164.2	16	7	9.5	91			0.1	111
130504A	Comet at AMTD 17.2km	94249	30/03/1982	1235	0.33	0.64			0.1	220		100			20		26	7.3			20	130	0.4																		0.1		7	4.5	10	179.1	16	2	9	107			0.1	130
130504A	Comet at AMTD 17.2km	99475	7/10/1983	1120	0.17	0.031			0.1	385		7			10		22	7.5			15	200	1.2											0.03							0.2		19	6.4	24	297.3	28	12	16	156			0.4	190
130504A	Comet at AMTD 17.2km	105888	10/09/1984	1720	0.43	1.36			0.1	290		7					22	8.0			5	160												0.01							0.1		20	6.8	16	227.2	22	3.4	13	120			0.9	145
130504A	Comet at AMTD 17.2km	113208	17/02/1986	1545	0.83	5.169			0.1	165	140	100					29	8.1			710	110	0.5											0.03							0.2		5.5	5.3	8.1	131.5	14	3.5	5.8	73			0.6	88
130504A	Comet at AMTD 17.2km	116707	2/10/1986	1305	0.24	0.131			0.1	84	50	100			70		24	7.2			1095	89	9.7											0.01							0.1		5.1	3.8	7	75	5.9	5.3	2.6	26				31.5
130504A	Comet at AMTD 17.2km	118040	12/12/1986	805	0.59	2.44			0.1	145	130	100			70		27	7.9			390	92	1.2											0.03							0.1		8.2	7.8	10.5	110.1	11	2	4.5	53			0.3	64
130504A	Comet at AMTD 17.2km	120770	28/08/1987	1420	4.29	2.216			0.1	115		100						7.6			866	82	2											0.04							0.1		7	4.4	11	89.9	8	3	3	41			0.1	50
130504A	Comet at AMTD 17.2km	128400	9/01/1989	1550	0.48	1.783			0.1	195	180	100					30	7.3			755	130												0.03							0.2		6	5	10.5	155.5	17	5	6.6	86			0.1	105
130504A	Comet at AMTD 17.2km	131271	7/08/1989	1720	0.26	0.422			0.1	265	280						14.5	7.9			10	160												0.04							0.2		9	3.8	14	223.7	23	5	13	128			0.7	155
130504A	Comet at AMTD 17.2km	131322	7/09/1989	0	0.12	0			0.1	290		24			20			8.3			40	160												0.04							0.1		9.1	4.2	15	240	25	5.1	14.5	139			2	165
130504A	Comet at AMTD 17.2km	131404	7/09/1989	0	0.12	0.001			0.1	275		20			10			8.2			30	160												0.04							0.1		9.4	3.9	14.5	238.4	24.5	4.8	14.5	138			1.7	165
130504A	Comet at AMTD 17.2km	133760	22/04/1990	930	7.22	309			0.1	122	120	200			70		23	7.3			751	85	1.7											0.04							0.11	ND	4.2	3.5	6.1	94.8	9.8	2.8	4.5	51			ND	62
130504A	Comet at AMTD 17.2km	145420	24/03/1992	1845	0.16	0.005			0.1	196		175			40		25	6.9			103	132	0.6											0.03	0.59						0.18		15.4	5	10.1	160.3	16.2	3.1	8.4	83		ND	ND	101.1
130504A	Comet at AMTD 17.2km	149657	16/03/1993	958	0.16	0.001			0.1	101	104	84			70		28.3	7.3	7.2		43	68	2.5												0.14	0.01					0.02	ND	3.6	5.9	4.9	81	8.5	1.2	3.7	41			ND	50.4
130504A	Comet at AMTD 17.2km	164722	26/08/1994	1700	NA	0			0.1	373	382	30			20		19.4	7.7	7.8		36	201	1.1													0.01					0.13		9.1	8.9	17.5	308.4	34.8	1.9	16.8	179		0.01	0.8	217.3
130504A	Comet at AMTD 17.2km	171823	4/04/1995	1445	0.06	0			0.15	180	204	100	146		40		29	7.5	7.5	6.2	70	120	0.5		0.004		0.005			0.8		0.05	0.22	<0.1	0.05	<0.05		2.6	3	4	0.2	ND	4.4	4.4	9.1	160	19.5	2.4	8.6	89		ND	0.2	110
130504A	Comet at AMTD 17.2km	171718	12/05/1995	1230	0.33	0			0.2	234.7	250	6	16		20		21.3	7.7	8.3	6.6	10	142.4	0.47		0		0			0.5436		0.0069	0.04	ND	ND	0.01					0.16	ND	5.71	4.6	10.2	203.72	25.2	2.46	10.5	119		0.01	0.37	144.05
130504A	Comet at AMTD 17.2km	176300	22/08/1995	1545	NA	0			0.2	233	261	303			ND			7.4			53	133.4	1.4		0.105		0.15			0.878		0.0237	0.2789	ND	ND	0.02		3.5	7	7	0.23	ND	8.6	4.3	12.4	192.35	24.4	3	8.3	107		ND	0.2	129.52
130504A	Comet at AMTD 17.2km	171898	8/09/1995	1200	-0.1	0			0.2	256.2	265	203	207	0.15	42	26.3	14.9	7.6	7.4	9.4	99	147	1.04		0.0756		0.0233			0.8377		0.0197	0.189	0.1	0.11	0.08					0.26	ND	5.93	4.6	13.6	220.53	28.2	3.08	9.9	127	120	0.01	0.38	153.54
130504A	Comet at AMTD 17.2km	176457	29/11/1995	1255	0.75	4.056			0.2	149.5	140	1087			23			7.2			620	88.67	5.55		0.196		0.0163			2.1637		0.1114	0.7768	ND	ND	0.04					0.15	ND	8.04	5.7	9	106.42	10	1.56	4.5	51		ND	0.05	61.87
130504A	Comet at AMTD 17.2km	171362	22/05/1996	900	0.21	0.027			0.2	153	154	358	352		12	17	16.2	7.5	7.3	7.3	191	103.6	1.83		0.324		0.0387			0.8083		0.0998	0.295	ND	ND	ND					0.14	ND	13.6	4.3	9.9	126.58	13	4.14	6.2	60	56	0.01	0.13	73.33
130504A	Comet at AMTD 17.2km	178667	7/08/1996	1605	-0.32	0			0.2	197	188	209	284		12		20	7.2	8.4	10.48	61	120.6	0		0.0568		0.0255			2.0865		0.0116	0.241	ND	ND	0.03					0.14	ND	11.4	5.9	11.9	158.22	16.6	4	7.6	83		ND	0.08	100.6
130504A	Comet at AMTD 17.2km	178690	11/12/1996	926	2.56	34.5			0.1	141	138		2900		22		25.6	7.2	7.7	5.14		98.3	3.92				0.0266			3.2			0.85	ND	ND						0.16	ND		4.4	10.6	120.68	10.7	3.83	4.5	61		ND	0.06	74.71
130504A	Comet at AMTD 17.2km	178757	30/01/1997	1000	2.2	25.42			0.1	154	170	9310	7740		8		28.2	7.3	7.5	3.6	5772	102	5.84		0.977		0.0541			1.8039		0.129	0.9875	0.1	ND	0.02					0.21	ND	4.63	3.9	11.7	123.93	11.2	2.51	5.4	64		ND	0.09	78.45
130504A	Comet at AMTD 17.2km	183600	6/02/1997	1500	4.32	24.111			0.2	110	114	3365			17		27.6	7.2	6.9		2008	78.76	1.3		1.05		0.798			1.04		0.102	2.0176	ND	ND	0.02					0.13	ND	4.7	3.7	5.8	94.69	9.9	1	4.9	52		ND	0.06	63.2
130504A	Comet at AMTD 17.2km	183601	7/02/1997	1630	4.66	23.918			0.2	112	116	1614			24		26.7	7.3	7.3		932	77.74	0.5		0.406		0.148			1.582		0.127	1.08	ND	0.01	0.01					0.13	ND	4	4.1	6.1	94.15	9.3	1.2	4.6	53		ND	0.07	64.15
130504A	Comet at AMTD 17.2km	185850	7/04/1997	1448	0.23	13.222			0.2	389	415	169	221		34		24.8	7.4	7.6	6.2	98	237.7	2.61		0.0331		0.0543			1.0177		0.0752	0.1923	ND	ND	0.01					0.14	ND	41.5	6.4	33.7	271.64	24.6	53.33	12.7	79		ND	0.14	96.51
130504A	Comet at AMTD 17.2km	185781	19/06/1997	1100	-0.12	0			0.2	387	369	54.5	64		14	21.9	15.5	7.9	8.1	7.7	18	211.7	0.92		0.0889		0.0384			0.6006		0.0299	0.0912			ND					0.17	ND	46.37	5.23	26	281.14	22	26.26	17	113	124	0.01	0.62	136.56
130504A	Comet at AMTD 17.2km	185874	11/08/1997	1515	-0.5	0			0.1	400	416	43	51		17		19.9	7.6	7.7	8.2	20	220	1.2											<0.1	0.08	<0.05					0.2	ND	34	6.8	36	300	26	28.5	13	125		ND	0.4	150
130504A	Comet at AMTD 17.2km	187777	24/11/1997	1000	0.41	0			0.1	145	140	720	971		7		28	7.1	6.9	5	500	100	2.6		0.085		0.098			1.6		0.19	0.68	<0.1	0.05	<0.05					0.2	ND	12	5	12.5	120	10.5	3.7	4.7	53		ND	ND	64
130504A	Comet at AMTD 17.2km	185801	27/04/1998	1545	4.2	0			0.2	120	113	670	856		115		22.6	7.2	7.0	5.4	340	79	3.3		0.21		0.07			1.8		0.19	0.69	0.1	0.11	<0.05					0.1	ND	7.5	6.2	10.5	95	6.9	2.3	3.2	46		ND	ND	55
130504A	Comet at AMTD 17.2km	192217	18/08/1998	830	0.075	0			0.3	169	166	114	120		46	20	16.2	7.4	7.6	6.12	21	121.8	0.77						0.672	0.67			0.2903	ND	ND	0.01					0.13	ND	23.99	5.8	12.3	151.04	13.4	3.72	5.9	70	64	ND	0.11	84.92
130504A	Comet at AMTD 17.2km	194165	28/10/1998	1300	7.02	214.858			0.2	142	139	764	933		8	27.7	24.6	7.1	7.4	5.1	511	99.95	1.84		0.194		0.0197		1.2716			0.194	0.7407	ND	ND	0.01					0.12	ND	10.64	5.2	9.8	114.5	12	3.28	4.8	55	59	ND	0.04	66.77
130504A	Comet at AMTD 17.2km	194026	29/10/1998	1710	6.15	218.4			0.1	155		387			7			7.4			211	107.3	1.16		0.0769		0.0115		1.0177			0.183	0.5672	ND	ND	0.01					0.12	ND	11.87	6.1	10.8	126.8	12.8	3.33	5.2	62		ND	0.09	75.33
130504A	Comet at AMTD 17.2km	194040	2/12/1998	1550	1.53	204.03			0.1	160	161	620	801		9		27	7.9	7.1	7.34	496	103.4	1.91		0.125		0.0347		1			0.216	0.7211	ND	ND	0.01					0.13	ND	10.04	6.4	10.9	126.54	12.1	2.66	5.6	63		0.01	0.31	76.47
130504A	Comet at AMTD 17.2km	184707	6/01/1999	1455	6.52	189.226			0.2	160	148	610	620		61		27.8	8.1	7.8	3.8	390	100	1.6		0.12		0.036			1.2		0.18	0.58	<0.1	0.05	ND					0.1	ND	5.4	5.4	9.5	120	12	3.6	5.2	63		ND	0.5	75
130504A	Comet at AMTD 17.2km	192153	9/03/1999	1015	3.8	163.08			0.2	130	121	680	902		325		27.3	7.4	6.5	5.4	486	86.83	1.06		0.0535		0.0047		0.9368			0.138	0.7135	ND	0.41	0.01					0.1	ND	4.43	3.5	6.1	100.55	10.2	0.97	5.6	56		ND	0.08	68.51
130504A	Comet at AMTD 17.2km	184729	20/03/1999	1030	0.46	158.396			0.2	215.85	225	69.9	77.7		28		28.1	7.9	8.1	6.2	54	145	0.6		0.0121		0.0039		0.4957			0.138	0.2939	ND	0.02	ND					0.14	ND	6.39	5	11	187.1	19.2	1.67	10.6	109		0.01	0.63	131.85
130504A	Comet at AMTD 17.2km	198017	23/02/2000	1530	0.82	14.355			0.1	175	170	210	291		64		24.3	7.3	7.4	8.2	232	115.1	1.03		0.0567		0.0255		0.6969			0.2275	0.46	ND	0.01	ND					0.11	ND	11.44	4.8	9.4	136.63	13.6	2.39	7.4	71		ND	0.08	86.37
130504A	Comet at AMTD 17.2km	205291	28/03/2000	1305	0.13	0.002			0.2		479		27				26.7			6.7									0.4195				0.19																					
130504A	Comet at AMTD 17.2km	201125	21/08/2000	1315	0.23	0.291			0.2	182	154	175	309		51		17.5	7.7	7.9	7.7	75	108.7	0.82		0.0814		0.034		0.8215			0.1668	0.2753	ND	0.01	ND					ND	ND	7.39	2.4	11.1	142.11	13.1	2.85	8.8	79		0.01	0.23	95.42
130504A	Comet at AMTD 17.2km	201168	24/11/2000	1320	6.29	0.277			0.2	140	134	330	371		82		26.5	7.2	7.2	5.5	260	99	4.3		0.026		0.08		1.5			0.27	0.6	<0.1	0.05	<0.05					0.1	ND	4	5	5.7	110	11	2	5.3	61		ND	1	74
130504A	Comet at AMTD 17.2km	S014056	2/03/2001	1003	0.34	0.808			0.2		337						29.2		7.8																																			
130504A	Comet at AMTD 17.2km	202807	12/03/2001	1420	0.4	0.18			0.2	260	280	150	315		29		29.8	7.9	7.8	5.9	130	160	1.6		0.1		0.024		0.6			0.18	0.28	<0.1	0.05	0.05					0.1	ND	8	3.9	11	210	21.5	4	13.5	120		ND	<1	145
130504A	Comet at AMTD 17.2km	210495	7/01/2002	1150	NA	733.596			0.1		100		5354						7.1										4.4792				2.8401																					
130504A	Comet at AMTD 17.2km	207507	7/01/2002	1230	7.8	729.518			0.2	110	99	2000	4830		49		27.2	7.4	6.9		4950	71	3.7		0.58		0.047		4			0.27	2.5	0.1	0.06	<0.03					0.1	ND	2	2.2	6.5	83	8.4	2	3.4	45		ND	0.1	54
130504A	Comet at AMTD 17.2km	210496	8/01/2002	1115	NA	477.971			0.1		108		3343						6.8										2.7403				1.6768																					
130504A	Comet at AMTD 17.2km	207505	8/01/2002	1305	6.22	350	180	90	0.2	115	108	2000	3620		56		28.7	7.3	6.8	4.5	3000	76	2.3		0.33		0.037		2.6			0.2	1.7	0.1	0.05	<0.03					0.1	ND	3	2.3	7	91	8.6	3	3.7	50		ND	0.1	61
130504A	Comet at AMTD 17.2km	210497	9/01/2002	745	NA	263.169			0.1		105		1989						6.8										2.0117				1.3228																					
130504A	Comet at AMTD 17.2km	210498	10/01/2002	1140	NA	175.622			0.1		117		994						6.8										1.5301				0.9884																					
130504A	Comet at AMTD 17.2km	210499	12/01/2002	800	NA	99.448			0.1		137		561						6.8										1.1603				0.7881																					
130504A	Comet at AMTD 17.2km	207711	28/02/2002	1500	0.26	0.399			0.2	215	214	165	199		13		29.3	7.7	7.6	6.7	130	130	1.1		0.098		0.038		0.76			0.14	0.23	0.1	0.05	<0.03					0.2	ND	7	3.8	10.5	170	20.5	3	9.1	97		ND	0.3	115
130504A	Comet at AMTD 17.2km	207718	12/06/2002	1030	0.17						206		307				17.3		7.7	8.3																																		
130504A	Comet at AMTD 17.2km	207718	12/06/2002	1115	1.18	0.043				220		215			34			7.7			60	130	1		0.11		0.052		0.49			0.046	0.1	<0.1	0.05	0.03					0.2	ND	8	4.2	11	170	19.5	3	8.3	93		ND	0.3	115
130504A	Comet at AMTD 17.2km	210573	13/02/2003	1240	NA				0.1																				1.7344				0.9009																					

Brown-Comet Catchment Water Quality Data

STATION ID	STATION NAME	SAMPLE NO.	DATE	TIME	Stream Water Level	Stream Discharge	Total Stream Width	Distance from left bank	Dist. below Water Surface	Conductivity @ 25C	Conductivity @ 25C (FLD)	Turbidity	Turbidity FLD	Transparency (secchi depth) FLD	Colour True	Air Temp FLD	Water Temp FLD	pH	pH FLD	DO FLD	TSS	TDS	Nitrate (NO3)	Nitrate + nitrite (N total)	Nitrate + nitrite (N soluble)	Ammonia (N total)	Ammonia (N soluble)	Kjeldahl Nitrogen	Total Nitrogen (TN)	Organic Nitrogen
				Units	*m*	*cumsecs*	*m*	*m*		*uS/cm*	*uS/cm*	*NTU*	*NTU*	*m*	*Hazen units*	*°C*	*°C*	*pH units*	*pH units*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
130501A	Comet R at Comet Weir	30503	10/12/1964	0	0.26	0			0.1	225								7.4				120								
130501A	Comet R at Comet Weir	31661	15/07/1965	0	-0.4	0			0.1	128								7.2				90								
130501A	Comet R at Comet Weir	34095	7/12/1965	1555	0.51	4.928			0.1	142								7.7				85								
130501A	Comet R at Comet Weir	34096	9/12/1965	1105	0.66	14.33			0.1	129								7.5				77								
130501A	Comet R at Comet Weir	52188	19/02/1972	1455	5.37	402.257			0.1	72							25	7.4				52								
130501A	Comet R at Comet Weir	52189	20/02/1972	925	5.78	460.738			0.1	73								6.9				54								
130501A	Comet R at Comet Weir	52190	20/02/1972	1830	5.41	403.815			0.1	81								7.1				68								
130501A	Comet R at Comet Weir	52191	21/02/1972	935	4.94	347.033			0.1	100								7.0				66								
130501A	Comet R at Comet Weir	52192	22/02/1972	855	4.3	285.834			0.1	100								7.0				70								
130501A	Comet R at Comet Weir	52193	23/02/1972	855	3.83	243.75			0.1	105								7.0				74								
130501A	Comet R at Comet Weir	52194	25/02/1972	855	2.6	159.045			0.1	124								7.0				72								
130501A	Comet R at Comet Weir	51830	16/03/1972	820	0.25	0.821			0.1	218								7.3				140								
130501A	Comet R at Comet Weir	57825	19/03/1973	1115	0.24	0.257			0.1	243								8.0			**98**	152								
130501A	Comet R at Comet Weir	59154	13/08/1973	1030	0.16	0.097			0.1	195								7.8			**10**	123								
130501A	Comet R at Comet Weir	63094	2/10/1974	1400	-0.39	0											24													
130501A	Comet R at Comet Weir	66494	10/10/1975	1450	0.63	0			0.1	**450**							26	7.9			**24**	250								
130501A	Comet R at Comet Weir	164717	26/08/1994	1515	2.46	0			0.2	242	256	2			20		19	**8.1**	**8.5**		**10**	152	0.7		0.003		0.032			0.6
130501A	Comet R at Comet Weir	164744	21/09/1994	1825	2.7	0			0.2	279	277	1		0.14	20		20.7	7.7	7.9		2	160			<0.02		0.02			0.5
130501A	Comet R at Comet Weir	163087	20/10/1994	930	1.5	0			0.2	280	277	3		1.02	30		25.1	**8.6**			**10**	170	0.5		0.003		0.028			0.8
130501A	Comet R at Comet Weir	164604	1/12/1994	1520	NA	0			0.2	295	304	2		0.52	30		29.5	7.7	**8.4**		**10**	170	1.3		0.024		0.005			0.9
130501A	Comet R at Comet Weir	164613	10/01/1995	940	4.09	0			0.2	285	320	16			20		30	**8.2**	**8.1**		**20**	170	1.1		<0.002		0.005			0.8
130501A	Comet R at Comet Weir	171805	8/02/1995	1254		2.73			0.2	150	146	**100**			70		29.7	7.8	7.2	3.65	**490**	98	3.5		0.73		0.003			1.4
130501A	Comet R at Comet Weir	171874	8/03/1995	845					0.2	155		**100**			50			7.3			**10**	95	2.6		0.14		0.049			1.1
130501A	Comet R at Comet Weir	171824	4/04/1995	1615	1.66	0			0.2	160	171	**100**	**175**		40		29.7	7.5	7.5		**70**	110	1.8		0.032		0.013			0.7
130501A	Comet R at Comet Weir	171024	8/05/1995	1721		0			0.1	170	209	**50**	**62.5**		40		22.1	7.7	7.8	9.05	**30**	110	1		0.006		0.008			0.5
130501A	Comet R at Comet Weir	171756	2/06/1995	1550	2.87	0			0.1	194.5	197	17	32.3		20		20.9	7.6	7.8	8.6	**28**	119.2	2.42		0.0331		0.0224			0.7641
130501A	Comet R at Comet Weir	171036	28/06/1995	1447	NA				0.2	205	200	10	27.3		20		16.3	7.5	7.6	8.85	**10**	120	1.9		0.0842		0.0098			0.6464
130501A	Comet R at Comet Weir	171772	24/07/1995	1635					0.2	195	231	8			13			7.8			**10**	120	0.5		0.043		0.12			0.3
130501A	Comet R at Comet Weir	176451	29/09/1995	1219					0.2 E		237		24.9				25.2		**8.2**	7.83										
130501A	Comet R at Comet Weir	176314	1/11/1995	1610					0.1 E		125		**2000**				28.7		6.6	4.15										
130501A	Comet R at Comet Weir	176458	29/11/1995	1535					0.2 E		135		**1140**				28.7		7.3	5.56										
130501A	Comet R at Comet Weir	176483	6/01/1996	1500					0.2 E		104		**2430**				25.9		6.7	5.63										
130501A	Comet R at Comet Weir	178658	2/02/1996	1117					0.2 E		209		**559**				30.8		7.4	5.2										
130501A	Comet R at Comet Weir	178731	2/04/1996	1830					0.2 E		252		15.6				29		7.6	4.9										
130501A	Comet R at Comet Weir	171357	3/05/1996	1000	0.3	2			0.2	128	127	**2220**	**3456**		11	23	20.2	7.2	7.8		**1382**	81.52	5.1		0.978		0.07			1.835
130501A	Comet R at Comet Weir	178742	5/06/1996	1630					0.1 E		167		**115**				19.7		7.7	6.55										
130501A	Comet R at Comet Weir	176377	5/07/1996	930					0.2 E		181		**68**				15.7		7.5	5.73										
130501A	Comet R at Comet Weir	178668	10/08/1996	1436					0.2 E		187		**65.6**				16.1		7.7	7.27										
130501A	Comet R at Comet Weir	205215	24/02/2000	1240	0.79	4.5			0.2		161		**262**				25.3		7.4	6.6										
130501A	Comet R at Comet Weir	205262	7/03/2000	1240	0				0.2		**407**		**360**				27.1		7.4	5.9									0.36	
130504B	Comet R at Comet Weir	207532	13/02/2003	1255	1.97	25.372		10	0.4	115.5	113	**1126**	**1547**		44		26.1	7.2	7.0		**834**	87.63	1.59		0.168		0.0314		**1.3309**	
130504B	Comet R at Comet Weir	207533	14/02/2003	1230	1.79	16.031		10	0.4	128.5	138	**594**	**747**		46		26.8	7.5	7.0		**406**	88.66	0.87		0.0927		0.0249		**0.8878**	
130504B	Comet R at Comet Weir	207534	24/02/2003	1445	0.2	1.068			0.2	185	188	**210**	**227**		21		29.2	7.7	7.6		**90**	120	1		0.069		0.078		**0.89**	
130504B	Comet R at Comet Weir	S034197	23/04/2003	1230	1.23	0.279			0.2		142		**265**				23		7.5	6.8										
130504B	Comet R at Comet Weir	S034037	26/05/2003	1244	0.92	0			0.2		157						17.8		7.5											
130504B	Comet R at Comet Weir	S044006	7/01/2004	1427	1.03	0			0.2		163						26.1		7.1											
130504B	Comet R at Comet Weir	S044005	17/01/2004	1121	4.46	195.909			0.2		108						27.6		7.0											
130504B	Comet R at Comet Weir	S044004	18/01/2004	827	4.82	224.252			0.2		118						27.5		7.1											
130504B	Comet R at Comet Weir	216326	19/01/2004	930	4.69			0	0.1																				**1.9382**	
130504B	Comet R at Comet Weir	202863	19/01/2004	1057	4.72				0.3	115	114	**2000**	**1892**		7		29.1	7.2	6.9	4.2	**1300**	79	1.3		0.12		0.041		**1.9**	
130504B	Comet R at Comet Weir	216327	20/01/2004	920	4.87			0	0.1																				**2.0569**	
130504B	Comet R at Comet Weir	202864	20/01/2004	1545	5.07				0.3	120	121	**2000**	**1582**		9		29.6	7.3	6.9		**1100**	83	1.7		0.15		0.053		**2.4**	
130504B	Comet R at Comet Weir	216360	21/01/2004	1415	5.75			0	0.1																				**2.0346**	
130504B	Comet R at Comet Weir	202865	21/01/2004	1500	5.79				0.2	125	128	**2000**	**1760**		10		31.1	7.2	6.9		**1200**	87	1.7		0.14		0.052		**1.6**	
130504B	Comet R at Comet Weir	202868	22/01/2004	1045	6.13				0.2	125		**1750**			2			7.4			**1000**	86	1.3							
130504B	Comet R at Comet Weir	202869	22/01/2004	1046	6.13				0.2	125		**1850**			7			7.3			**950**	87	1.3							
130504B	Comet R at Comet Weir	202870	22/01/2004	1047	6.13				0.2	125		**1850**			8			7.3			**900**	87	1.4							
130504B	Comet R at Comet Weir	202871	22/01/2004	1048	6.13				0.2	125		**1850**			12			7.3			**1000**	87	1.3							
130504B	Comet R at Comet Weir	202866	22/01/2004	1110	6.13				0.2	125	129	**1700**	**1364**		10		28.7	7.3	7.1		**900**	88	1.3		0.096		0.064		**1.7**	
130504B	Comet R at Comet Weir	216361	23/01/2004	800	6.03			0	0.1																				**1.6776**	
130504B	Comet R at Comet Weir	202867	23/01/2004	930	6.03				0.2	130	133	**1150**	**1024**		9		28.9	7.3	6.9		**650**	89	1.3		0.065		0.071		**1.6**	
130504B	Comet R at Comet Weir	216362	27/01/2004	830	1.89			0	0.1																				**1.9348**	
130504B	Comet R at Comet Weir	202894	7/03/2005	1340	1.18				0.2 E	154	154	**487**	**533**		22		34.2	7.3	7.4	7.5	**132**	93	2.3		0.038		0.166		**1.5043**	
130504B	Comet R at Comet Weir	208528	27/02/2007	1230					0.1 E		132		**640**				29.1		7.5	7.4										

SAMPLE NO.	Total Reactive Phosphorus (totol P)	Total React Phosphorus (P soluble)	Total Phosphorus (P)	Boron as B	Aluminium (Al)	Copper (Cu)	Bromide (Br)	Cadmium (Cd total)	Chromium (Cr total)	Copper (Cu total)	Flouride (F)	Hydrogen as H	Chloride (Cl)	Potassium (K)	Sodium (Na)	Total Dissolved Ions	Calcium (Ca)	Sulphate (SO4)	Magnesium (Mg)	Total Alkalinity (CaCO3)	Total Alkalinity (CaCO3) FLD	Hydroxide (OH)	Carbonate (CO3)	Bicarbonate (HCO3)
	mg/L	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
30503											0.2	ND	15		19	198.2	20		10	110			ND	134
31661											0.5	ND	12		4	85.5	8	4	8	40		ND	ND	49
34095											0.2	ND	10		16	143.2	16	10	5	71			ND	86
34096											0.2	ND	10		6	105.2	12	9	7	50		ND	ND	61
52188											0.2	ND	8		11	77.2	6		3	40			ND	49
52189											0.2		10		12	85.9	6		4	42		ND	ND	51
52190											0.2	ND	12		15	99.2	8		3	50			ND	61
52191											0.15	ND	8		11	99.2	10		4	54		ND	ND	66
52192											0.15	ND	10		12	104.2	10		4	56		ND	ND	68
52193											0.05	ND	10		14	111.1	10		4	60		ND	ND	73
52194											0.15	ND	10		11	108.2	12		4	58		ND	ND	71
51830											0.45	ND	16		18	216.5	18		15	122			ND	149
57825				0.05							0.17	ND	16	5.4	10	210.8	22		10.6	118			ND	144
59154											0.13	0.1	10	3.9	12	168.1	17.5		9	94		ND	0.4	114
63094																								
66494											0.2	ND	15	5.6	21	365.8	36		23	217		ND	ND	265
164717		0.057	0.11			0.03					0.13		6.9	6.6	12.7	210.2	21.7	2.5	11.1	122		0.02	1.1	146.6
164744		0.03	0.083			0.06					0.16		6.7	7.2	12.8	225	24.1	2.4	11.7	131		0.01	0.5	159.4
163087		0.003	0.055	<0.1	0.05	**<0.05**					0.2	ND	7.6	7.4	14	240	25	2	12.5	140		0.1	3.9	165
164604		0.003	0.087	<0.1	0.05	**<0.05**					0.2	ND	8.3	8.1	14.5	240	25	2	13	140		ND	0.5	170
164613		0.003	0.049	<0.1	0.05	**<0.05**					0.2	ND	10	9.1	15	250	22	2	14	145		ND	1.5	175
171805		0.18	1	<0.1	0.05	**<0.05**					0.2	ND	7.4	3.2	12.5	120	10.5	4.4	4.3	57		ND	0.2	69
171874		0.1	0.38	<0.1	0.05	**0.07**					0.1	ND	4.7	4.2	7.9	120	12.5	2.1	5.9	66		ND	0.1	80
171824		0.068	0.26	<0.1	0.05	**<0.05**					0.1	ND	4.6	4.2	8.4	140	15.5	2	7.1	78	17.6	ND	0.1	95
171024		0.017	0.072	<0.1	0.05	**<0.05**					0.1	ND	3.9	4.1	8	150	17	2	7.7	91		ND	0.3	110
171756		0.0037	0.0623	ND	ND	**0.01**					0.15	ND	5.33	4.3	8.2	158.25	18	2.06	8.1	90	21.7	0.01	0.22	109.47
171036		0.0049	0.057	<0.1	**0.06**	**<0.05**					0.2	ND	4.3	4.3	8.3	160	19	2.5	8.4	95	8.6	ND	0.2	115
171772		0.003	0.022	<0.1	0.05	**0.06**					0.2	ND	4.3	4.1	8.1	170	20	2.5	8.7	100		ND	0.4	125
176451																								
176314																					46.4			
176458																								
176483																								
178658																								
178731																								
171357		0.0866	0.8809	ND	ND	**0.04**					0.14	ND	10.4	2.8	13.9	96.8	7.7	2.1	3.1	42		ND	0.04	51.52
178742																								
176377																					75.2			
178668																								
205215																								
205262			0.23																					
207532		0.1621	0.9796	0.01	ND	**0.01**					0.12	ND	9.17	3.98	8.94	94.43	9.88	5.51	4.78	41		ND	0.04	50.41
207533		0.155	0.5861	0.05	0.01	**0.01**					0.11	ND	6.6	4.02	7.98	96.97	9.87	3.39	5.08	48		ND	0.09	58.95
207534		0.18	0.36	<0.1	0.05	**<0.03**					0.1	ND	10	5.2	8.9	140	15	4	7.4	76		ND	0.2	92
S034197																								
S034037																								
S044006																								
S044005																								
S044004																								
216326			0.988																					
202863		0.18	1.2	0.1	0.05	**<0.03**					0.1	ND	2	3.6	6	92	8.6	2	4.2	53		ND	0.1	64
216327			1.102																					
202864		0.24	1.5	0.1	0.05	**<0.03**					0.1	ND	3	4.4	5.9	98	9.4	2	4.2	55		ND	0.1	67
216360			1.0874																					
202865		0.26	0.95	0.1	0.05	**<0.03**					0.1	ND	3	4.6	6.7	100	10	2	4.2	57		ND	0.1	70
202868				0.1	0.05	**<0.03**					0.2	ND	4	4.7	6.8	100	10	2	4.1	57		ND	0.1	70
202869				0.1	0.05	**<0.03**					0.2	ND	4	4.5	7.1	100	10	2	4.1	57		ND	0.1	70
202870				0.1	0.05	**<0.03**					0.2	ND	4	4.5	7.1	100	9.9	2	4.1	57		ND	0.1	70
202871				0.1	0.05	**<0.03**					0.2	ND	4	4.8	6.8	100	10	2	4.1	57		ND	0.1	69
202866		0.27	1	0.1	0.05	**<0.03**					0.1	ND	4	4.5	7.5	100	10	2	4.2	57		ND	0.1	69
216361			0.8759																					
202867		0.25	0.95	0.1	0.05	**<0.03**					0.1	ND	4	5	7.3	110	10	2	4.3	59		ND	0.1	71
216362			0.7793																					
202894		0.057	0.4473	0.11	0.05	**<0.03**					0.2	ND	7.1	4.8	10	118	11	2.5	4.3	61		ND	0.1	75
208528																								

Notes
- MTV minimum trigger value
- **BOLD** Greater than MTV
- 123 Historic Water Quality Data\044 Quality poor.
- **BOLD** Greater than MTV and Historic WQ Data
- NA Not available (Gauge Height < Instrument Threshold)
- ND Not detected
- E Estimate

Calibration Certificates & Records

Appendix D

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☐ pH
Conductivity	☑ 0.0mS/cm	☐ 2.76mS/cm	☐ 12.88mS/cm	☑ 58.6mS/cm	☐ mS/cm
TDS	☑ 0.0 ppk	☑ 36 ppk	☐ ppk		
Turbidity	☑ 0.0 NTU	☐ 90NTU	☑ 360NTU	☐ _____NTU	
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☑ 100% Saturation in Air	
☑ Electrodes cleaned/checked		☑ Charged 8 v (min 7.2V)		☑ Temperature	

* Calibration solution traceability information is available upon request.

Date: 21 - 1 Checked by: AZ

Signed: AW

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 7.96v
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Turbidity sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	______________
☐	☐	☐	______________

Processors Signature/ Initials [signature]

EE Quote Reference	5351.	Condition on return
Customer Ref		
Equipment ID	90FLT A.	
Equipment serial no.		
Return Date	/ /	
Return Time		

Melbourne **Sydney** **Brisbane** **Perth** **Auckland** **Kuala Lumpur**

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Email: rentals.melb@enviroequip.com Internet: www.rentals.enviroequip.com

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS WP88 Turbidity Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

Turbidity	☑ 0 NTU	☐ 90 NTU	☑ 360 NTU	☑ 900 NTU	☐ NTU
☑ Electrodes cleaned/checked		☑ Charged			

* Calibration solution traceability information is available upon request.

Date: 22 JAN 08 Checked by: HOWARD

Signed: HJones

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $30 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	WP88 Operational check / Battery Voltage @ 100%
☑	☐	☐	Turbidity Sensor
☑	☐	☐	Turbidity Sensor Shroud (installed)
☑	☐	☐	Turbidity Sensor cable 20 m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide Sheet
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials HJones 22 JAN 08

EE Quote Reference	5351	Condition on return
Customer Ref		
Equipment ID	WP88WA1	
Equipment serial no.	T8195	
Return Date	/ /	
Return Time		

Melbourne Sydney Brisbane Perth Auckland Kuala Lumpur

Perth – Unit 4, 100 Belmont Avenue, Belmont, WA, 6104 Australia
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Email: perth@enviroequip.com Internet: www.rentals.enviroequip.com

43270896 5000 | T0035

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☐ pH
Conductivity	☑ 0.0mS/cm	☐ 2.76mS/cm	☐ 12.88mS/cm	☑ 58.6mS/cm	☐ mS/cm
TDS	☑ 0.0 ppk	☑ 36 ppk	☐ ppk	Redox	☐ ____mV
Turbidity	☑ 0.0 NTU	☐ 90NTU	☑ 360NTU	☐ ____NTU	
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☐ 100% Saturation in Air	
☑ Electrodes cleaned/checked		☑ Charged 7.7 v (min 7.2V)		☑ Temperature	

* Calibration solution traceability information is available upon request.

Date: 27 FEB 08 Checked by: HANS

Signed: [signature]

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 7.7
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Turbidity sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials [initials]

EE Quote Reference	6221	Condition on return
Customer Ref		
Equipment ID	90FLT A	
Equipment serial no.		
Return Date	/ /	
Return Time		

Melbourne **Sydney** **Brisbane** **Perth** **Auckland** **Kuala Lumpur**

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Internet: www.rentals.enviroequip.com

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLMV Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☑ pH
Conductivity	☑ 0.0mS/cm	☐ 2.76mS/cm	☐ 12.88mS/cm	☑ 58.6mS/cm	☑ mS/cm
TDS	☑ 0.0 ppk	☑ 36 ppk	☑ ppk		
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☑ 100% Saturation in Air	
Redox (ORP)**	☑ Electrode operability test 240mV +/- 10%. Actual: 245mV				
☑ Electrodes cleaned/checked		☑ Charged	v (min 7.2V)	☐ Temperature	

* Calibration solution traceability information is available upon request.
** This meter uses an Ag/AgCl ORP electrode. To convert readings to SHE (Standard Hydrogen Electrode), add 199mV to the mV reading. For further information, refer to www.enviroequip.com/quipnotes/ORP.htm.

Date: 9th May 2008 Checked by: PETER H

Signed: [signature]

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLMV Unit. Ops check / Battery Voltage @ 8.21v
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Redox (ORP) sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials [signature]

EE Quote Reference	7705	Condition on return
Customer Ref		
Equipment ID	90FLMV T -	
Equipment serial no.		
Return Date	/ /	
Return Time		

Melbourne Sydney Brisbane Perth Auckland Kuala Lumpur

Melbourne - 13A Rocklea Drive, Port Melbourne VIC 3207 Australia
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Email: rentals.melb@enviroequip.com Internet: www.rentals.enviroequip.com

URS

Project Notes

Subject: Santos Stream Assess.

By: H. Fnock

Date:

Verified By:

Date: 30-6-08.

Project/Task No:

File Structure/Doc No:

Date:

Sheet of

30/6/08.

EC + pH Calibration check.

90 FLTWA1	90 FLT SA
EC - standard = 1413 μS @ 25°	EC - standard = 1413μS @ 25°
Reading = 1430 @ 13.9°C	Reading = 1217 @ 8.8°C
pH - standard = pH 4	pH - standard = pH 4
Reading = 4.06	Reading = 3.87

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☐ pH
Conductivity	☑ 0.0mS/cm	☑ 2.76mS/cm	☐ 12.88mS/cm	☐ 58.6mS/cm	☐ mS/cm
TDS	☑ 0 ppk	☑ 36 ppk	☐ ppk		
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☑ 100% Saturation in Air	
Redox (ORP)**	☑ Electrode operability test 240mV +/- 10%. Actual: 236 mV				
Turbidity	☑ 0NTU	☑ 900NTU			
Temperature	☑				

☑ Electrodes cleaned/checked ☑ Charged 8.12 v (min 7.2V)

* Calibration solution traceability information is available upon request.
** This meter uses an Ag/AgCl ORP electrode. To convert readings to SHE (Standard Hydrogen Electrode), add 199mV to the mV reading. For further information, refer to www.enviroequip.com/quipnotes/ORP.htm.

Date: 18 Jun 08 Checked by: Howard

Signed: HJones

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $30 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 8.12 ✓
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Redox (ORP) sensor 5m
☑	☐	☐	Turbidity sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	

Processors Signature/ Initials HJones 18 Jun 08

EE Quote Reference	8602	Condition on return
Customer Ref	TBC	
Equipment ID	90FLTWA1	
Equipment serial no.	U4348	
Return Date	/ /	
Return Time		

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☐ pH 6.88	✓ pH 7.00	✓ pH 4.00	☐ pH 10.00	☐ pH
Conductivity	✓ 0.0mS/cm	✓ 2.76mS/cm	☐ 12.88mS/cm	☐ 58.6mS/cm	☐ mS/cm
TDS	✓ 0.0 ppk	✓ 36 ppk	☐ ppk		
Turbidity	✓ 0.0 NTU	☐ 90NTU	✓ 360NTU	☐ ____NTU	
Dissolved Oxygen	✓ 0.00ppm in Sodium Sulphite			✓ 100% Saturation in Air	
Temperature	✓				

✓ Electrodes cleaned/checked ✓ Charged 8.3v (min 7.2V)

* Calibration solution traceability information is available upon request.

Date: 19.06.08 Checked by: PEPE

Signed: [signature]

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
✓	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 8.3
✓	☐	☐	pH sensor 5m
✓	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
✓	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
✓	☐	☐	Turbidity sensor 5m
✓	☐	☐	Battery charger: 240V AC to 12V DC 200mA
✓	☐	☐	Instruction Manual
✓	☐	☐	Quick Guide
✓	☐	☐	Syringe with storage solution for pH & ORP sensors
✓	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials [signature]

EE Quote Reference	8602	Condition on return
Customer Ref	391961	
Equipment ID	90FLTSA	
Equipment serial no.	T5471	
Return Date	03/07/08	
Return Time		

Melbourne Sydney Brisbane Perth Auckland Kuala Lumpur

Sydney – Unit 1, 28 Barcoo St, Chatswood NSW 2067 Australia
Tel: +61-2-9417-1513 Fax: +61-2-9417-7669
Email: rentals.syd@enviroequip.com Internet: www.rentals.enviroequip.com

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS 90FLT Water Quality Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

pH	☑ pH 6.88	☐ pH 7.00	☑ pH 4.00	☐ pH 10.00	☑ pH
Conductivity	☑ 0.0mS/cm	☐ 2.76mS/cm	☐ 12.88mS/cm	☑ 58.6mS/cm	☑ mS/cm
TDS	☑ 0.0 ppk	☑ 36 ppk	☑ ppk	Redox	☑ 25 mV
Turbidity	☐ 0.0 NTU	☐ 90NTU	☐ 360NTU	☐ ____ NTU	
Dissolved Oxygen	☑ 0.00ppm in Sodium Sulphite			☑ 100% Saturation in Air	

☑ Electrodes cleaned/checked ☑ Charged 8.16 v (min 7.2V) ☑ Temperature

* Calibration solution traceability information is available upon request.

Date: 29th July, 2008 Checked by: PETER H

Signed: [signature]

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	90FLT Unit. Ops check / Battery Voltage @ 8.24 V
☑	☐	☐	pH sensor 5m
☑	☐	☐	Conductivity / TDS / Temperature k=10 sensor 5m
☑	☐	☐	Dissolved Oxygen YSI5739 sensor 5m
☑	☐	☐	Turbidity sensor 5m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide
☑	☐	☐	Syringe with storage solution for pH & ORP sensors
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials [signature]

EE Quote Reference	9541	Condition on return
Customer Ref		
Equipment ID	90FLT MA	
Equipment serial no.		
Return Date	/ /	
Return Time		

Full Statistics of Associated Water Quality – Fairview and Roma Fields

Appendix E

Fairview Field Associated Water Quality Statistics (all unit mg/L unless specified)

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
pH	1702	8.5165	0.00952	0.3928	5.0000	8.3000	8.6000	8.7600	10.0000
Colour - True	2	0.880	0.120	0.170	0.760	*	0.880	*	1.000
Conductivity	3929	2422	52.5	3290	0.0	1419	1840	2458	121800
Resistivity	309	6.089	0.197	3.464	0.008	4.760	6.020	7.190	41.700
Total Dissolved Salt	122	2425	437	4824	87	905	1168	1774	29248
Total Dissolved Solids	57	2862	427	3227	114	1420	2000	2985	16350
Total Dissolved Solids:	1201	1218.8	22.5	779.6	0.0	843.2	975.1	1285.6	9241.2
Total Dissolved Solids:	309	1299.7	46.7	821.7	146.0	895.0	1070.0	1350.0	7000.0
Dissolved O2	127	4.244	0.129	1.456	1.000	3.400	4.100	5.000	11.950
Turbidity	4	1.025	0.494	0.988	0.100	0.225	0.800	2.050	2.400
Redox Potential	127	93.62	5.01	56.48	3.30	47.70	89.50	139.90	247.00
Chemical Oxygen Demand	54	484	152	1115	5	23	72	546	7300
Specific Gravity	6	1.000	0.365	0.894	0.000	0.000	1.000	2.000	2.000
Suspended Solids	192	2403	740	10257	5	5	10	209	87307
Total Residue	1	0.90000	*	*	0.90000	*	0.90000	*	0.90000
Aggressive CO2	193	1.363	0.123	1.712	1.000	1.000	1.000	1.000	16.000
Free CO2	193	5.326	0.606	8.413	1.000	2.000	3.000	5.000	72.000
Tot Alkalinity	566	958.7	21.6	513.2	18.3	750.8	861.5	1040.0	6430.2
Bicarbonate Alkalinity	608	862.5	14.9	367.5	18.0	691.0	788.0	958.8	4554.0
Carbonate Alkalinity	605	76.84	7.84	192.73	1.00	36.00	60.00	88.00	4039.00
Hydroxide Alkalinity	558	3.96	2.21	52.30	1.00	1.00	1.00	1.00	1130.00
Residual Alkali	2	20.50	9.40	13.29	11.10	*	20.50	*	29.90
Alkalinity-Phenolp	48	40.04	9.97	69.10	1.00	20.40	30.35	38.63	501.18
Total Hardness	310	5.396	0.336	5.919	1.000	2.000	4.000	7.000	73.000
Carbonate Hardness	5	1.60	1.60	3.58	0.00	0.00	0.00	4.00	8.00
Non-Carbonate Hardness	4	0.1500	0.0289	0.0577	0.1000	0.1000	0.1500	0.2000	0.2000
Ammonia N	426	0.5399	0.0308	0.6356	0.0040	0.3200	0.4125	0.5845	7.8500
Nitrate	171	0.171	0.133	1.744	0.010	0.010	0.010	0.030	22.800
Nitrate N by FIA (Calc)	236	0.01995	0.00221	0.03402	0.01000	0.01000	0.01000	0.01000	0.33300
Nitrite	49	0.002204	0.000167	0.001172	0.002000	0.002000	0.002000	0.002000	0.010000
Nitrite N by FIA	140	0.03834	0.00543	0.06421	0.00200	0.02000	0.02000	0.02000	0.46000
Nitrite N for NO3 only (	48	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Nitrite+Nitrate as N	196	0.03962	0.00552	0.07727	0.00200	0.00525	0.02000	0.02000	0.47000
NOX for NO3 only (Calc)	48	0.01688	0.00336	0.02329	0.00200	0.00425	0.00900	0.01875	0.13900
Total Organic Carbon as	64	95.0	30.8	246.6	0.5	7.6	21.0	61.0	1785.0
Dissolved Organic Carbon	64	31.9	16.8	134.8	0.5	1.1	3.4	7.0	980.0
Aluminium	411	6.01	2.05	41.53	0.01	0.02	0.09	0.22	580.00
Antimony	11	0.001818	0.000818	0.002714	0.001000	0.001000	0.001000	0.001000	0.010000
Arsenic	410	0.01778	0.00247	0.05008	0.00100	0.00500	0.01000	0.01000	0.62900
Barium	68	2.321	0.975	8.037	0.041	0.281	0.604	1.887	65.165
Beryllium	391	0.006870	0.000519	0.010254	0.001000	0.005000	0.005000	0.010000	0.150000
Boron as B	430	0.8595	0.0374	0.7758	0.0200	0.5160	0.7105	1.0193	11.5370
Bromide	57	2.190	0.489	3.691	0.100	0.300	0.900	2.200	20.000
Cadmium	427	0.002659	0.000340	0.007029	0.000100	0.001000	0.001000	0.005000	0.131000
Calcium	608	10.16	2.67	65.93	0.14	1.00	1.20	2.46	1137.24
Chloride	359	171.2	19.0	360.4	1.0	20.0	55.0	125.0	2640.0
Chromium	405	0.02601	0.00631	0.12693	0.00100	0.00100	0.00100	0.01000	1.19600
Cobalt	384	0.01177	0.00250	0.04890	0.00100	0.00200	0.00200	0.01000	0.61700
Copper	434	0.235	0.103	2.139	0.001	0.002	0.005	0.020	30.806
Cyanide	10	0.010000	0.000000	0.000000	0.010000	0.010000	0.010000	0.010000	0.010000
Fluoride by ISE	602	2.2193	0.0586	1.4379	0.0500	1.4000	1.9000	2.7125	16.6400
Iron	605	20.88	5.66	139.28	0.01	0.10	0.27	0.81	2300.00
Iron (Soluble)	57	0.914	0.419	3.165	0.005	0.091	0.226	0.647	23.810
Lead	323	0.0652	0.0102	0.1827	0.0010	0.0050	0.0090	0.0400	2.1800
Lithium	1	0.030000	*	*	0.030000	*	0.030000	*	0.030000
Magnesium	564	3.028	0.770	18.292	0.100	0.897	1.000	1.000	296.114
Manganese	432	0.724	0.225	4.670	0.001	0.004	0.010	0.022	57.000
Manganese (Soluble)	56	0.289	0.263	1.969	0.001	0.006	0.016	0.031	14.760
Mercury	408	0.05195	0.00687	0.13869	0.00010	0.00010	0.00060	0.10000	1.40103
Molybdenum	413	0.01053	0.00116	0.02357	0.00100	0.00500	0.00500	0.01000	0.35800
Nickel	414	0.02055	0.00475	0.09655	0.00100	0.00200	0.00300	0.01000	1.23500
Phosphorous	180	0.05683	0.00834	0.11184	0.01000	0.02000	0.04000	0.06000	1.41000
Ortho Phosphorus	243	0.05565	0.00458	0.07137	0.00200	0.02000	0.02800	0.06400	0.64400
Potassium	608	121.7	64.8	1596.8	0.5	2.0	2.4	4.6	33915.5
Selenium	394	0.009553	0.000579	0.011489	0.003000	0.005000	0.010000	0.010000	0.125000
Silica	62	66.68	9.88	77.81	6.24	23.64	37.67	80.73	467.80
Silver	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Sodium	560	619.8	25.7	608.0	2.1	366.3	466.2	657.0	9402.8
Sodium Adsorption Ratio	358	149.6	14.9	281.8	2.9	84.6	106.0	122.0	2160.5
Strontium	70	2.499	0.714	5.971	0.029	0.359	0.902	2.225	45.600
Sulphate	3	1.500	0.500	0.866	1.000	1.000	1.000	2.500	2.500
Sulphide	9	0.10000	0.000000	0.000000	0.10000	0.10000	0.10000	0.10000	0.10000
Sulphur as SO4	559	4.371	0.913	21.580	1.000	1.000	2.000	2.000	393.436
Tellurium	1	0.000500	*	*	0.000500	*	0.000500	*	0.000500
Variable	**N**	**Mean**	**SE Mean**	**StDev**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
Thallium	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000

Total Cyanide	10	0.010000	0.000000	0.000000	0.010000	0.010000	0.010000	0.010000	0.010000
Uranium	141	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Vanadium	382	0.02487	0.00859	0.16779	0.00500	0.00500	0.00500	0.01000	2.30100
Zinc	441	0.1127	0.0273	0.5734	0.0010	0.0060	0.0180	0.0600	8.3580
Colif. (MF)	17	1.235	0.235	0.970	1.000	1.000	1.000	1.000	5.000
Colif. Faecal	6	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
Colif. Pres	10	1.700	0.700	2.214	1.000	1.000	1.000	1.000	8.000
Coliforms Faecal (MF)	11	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
Escherichia coli	16	1.0000	0.000000	0.000000	1.0000	1.0000	1.0000	1.0000	1.0000
1,2,4 Trimethylbenzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
1,3,5 Trimethylbenzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
2,3,4,6 Tetrachloropheno	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
2,4 Dichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4 Dimethylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4,5 Trichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,4,6 Trichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2,6 Dichlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Chlorophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Methylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
2-Nitrophenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
3 & 4 Methylphenol	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
4-Chloro-3-Methylphenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Acenaphthalene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Acenaphthene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benz(a)anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benzene	49	1.0000	0.0291	0.2040	0.0010	1.0000	1.0000	1.0000	2.0000
Benzo(a)pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Benzo(b)&(k)fluoranthene	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Benzo(g,h,i)perylene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
C10-C14 Fraction	49	0.0643	0.0133	0.0930	0.0500	0.0500	0.0500	0.0500	0.7000
C15-C28 Fraction	49	0.1420	0.0807	0.5651	0.0500	0.0500	0.0500	0.0500	4.0000
C29-C36 Fraction	49	0.0616	0.0106	0.0745	0.0500	0.0500	0.0500	0.0500	0.5700
C6-C9 Fraction	49	0.010204	0.000204	0.001429	0.010000	0.010000	0.010000	0.010000	0.020000
Chlorobenzene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000
Chrysene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Dibenz(a,h)anthracene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Ethyl Benzene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
HPC	17	478	226	933	1	2	10	510	2800
Ideno(1,2,3-cd)pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
meta & para-Xylene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000
Fluoranthene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Fluorene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Naphthalene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Ortho-Xylene	49	0.001020	0.000020	0.000143	0.001000	0.001000	0.001000	0.001000	0.002000
PCB	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
PCB by Aroclor	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Pentachlorophenol	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Phenol	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Phenanthrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Polyaromatic Hydroca	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Pyrene	10	0.001000	0.000000	0.000000	0.001000	0.001000	0.001000	0.001000	0.001000
Speciated Phenols	10	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Toluene	49	0.002041	0.000041	0.000286	0.002000	0.002000	0.002000	0.002000	0.004000

Note – Nutrient (NOx) results removed due to uncertainties in analytical methods and reporting standards (see below):

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Nitrate	171	0.171	0.133	1.744	0.010	0.010	0.010	0.030	22.800
Nitrate N by FIA (Calc)	236	0.01995	0.00221	0.03402	0.01000	0.01000	0.01000	0.01000	0.33300
Nitrite	49	0.002204	0.000167	0.001172	0.002000	0.002000	0.002000	0.002000	0.010000
Nitrite N by FIA	140	0.03834	0.00543	0.06421	0.00200	0.02000	0.02000	0.02000	0.46000
Nitrite N for NO3 only (	48	0.002000	0.000000	0.000000	0.002000	0.002000	0.002000	0.002000	0.002000
Nitrite+Nitrate as N	196	0.03962	0.00552	0.07727	0.00200	0.00525	0.02000	0.02000	0.47000
NOX for NO3 only (Calc)	48	0.01688	0.00336	0.02329	0.00200	0.00425	0.00900	0.01875	0.13900

Full Statistics of Associated Water Quality – Fairview and Roma Fields

Appendix E

Roma Field Associated Water Quality Statistics (all units mg/L unless specified)

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Top Depth (m RT)	66	305.9	22.3	180.8	99.0	142.0	293.0	305.0	782.3
Bottom Depth (m RT)	92	545.0	15.8	151.3	150.0	409.0	575.0	665.2	857.0
Na	103	855.6	35.5	359.9	233.0	630.0	792.0	950.0	1980.0
K	103	710	178	1807	2	4	47	769	14800
Ca	103	112.6	21.7	220.7	0.5	3.0	10.1	73.4	870.0
Mg	101	26.39	5.20	52.23	0.10	0.90	4.00	24.00	290.00
Fe	80	121.6	27.9	249.9	0.0	0.1	3.0	117.5	1200.0
Sr	57	9.47	1.95	14.68	0.33	1.01	2.45	9.94	66.00
Ba	7	0.2804	0.0479	0.1266	0.1350	0.2230	0.2460	0.3090	0.5410
Cl	103	1614	399	4046	78	555	701	1130	39200
HCO3	103	842.6	33.7	341.9	10.0	651.0	821.0	991.0	1864.0
CO3	103	75.60	7.32	74.26	0.90	28.00	58.00	95.00	436.00
SO4	103	16.76	3.48	35.31	0.90	1.66	4.00	18.00	244.00
F	100	2.650	0.765	7.654	0.000	1.162	2.000	2.797	77.869
NO3 (Nitrite+Nitrate)	34	0.0479	0.0187	0.1091	0.0020	0.0090	0.0190	0.0200	0.6000
OH	103	1.2087	0.0943	0.9567	0.9000	0.9000	1.0000	1.0000	7.0000
Conductivity uS/cm @25 C	103	7065	1472	14943	1200	3200	3610	6200	115000
Resistivity ohm.m@25 C	54	2.625	0.134	0.986	0.110	2.428	2.799	3.125	4.630
Reaction - pH	102	8.6361	0.0582	0.5875	5.1000	8.4425	8.7000	8.9000	9.7000
TDS(EC)	97	3964	704	6935	740	1918	2300	4040	66000
TDS (HCO3=CO3)	31	5819	2254	12547	1390	1840	2180	4810	71300

Fairview Case Study

Appendix F

REPORT

Fairview Field - Case Study of Associated Water Discharges

Prepared for

Santos Pty Ltd

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Brisbane QLD

21 January 2009

43270896

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…………………………….
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Date:	21 January 2009
Reference:	Fairview Field – Case Study of Associated Water Discharges
Status:	FINAL

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Executive Summary

The Fairview Field provides a unique opportunity to investigate the impacts of discharge of untreated associated water that has occurred since at least 1993. The field is part of the larger Gladstone Liquid Natural Gas (GLNG) development but any surface water impacts are effectively isolated from other well fields by surface catchment boundaries. The Fairview Field (Petroleum Leases 90, 91, 92, 99, 100 and 232) lies entirely within the Upper Dawson River catchment.

The document is effectively an update of an earlier piece of work submitted to the Queensland EPA as an attachment in support of the Fairview Environmental Management Plan (Santos & URS, 2008).

Key additions are:

- A report on spring flows in and around Dawsons Bend which are believed to maintain flow in the river downstream of this point;
- The capture, interpretation and reporting of continuous water quality information;
- Updates to spot water quality data; and
- The investigation of stratification in pools.
- The report identified the environmental values for all the major streams in the vicinity of the Fairview Field (Dawson River, Hutton Creek and Baffle Creek) as:
- Protection of slightly to moderately disturbed aquatic ecosystems.
- Primary Industries: irrigation, water for farm use, stock watering, and human consumption of wild or stocked fish or crustaceans.
- Recreation & aesthetics: primary recreation with direct contact, and visual appreciation with no contact.
- Industrial uses.

Based on the protection of these values and taking into account local water quality records, a set of minimum guideline trigger levels are recommended in Section 3.

In Section 4, the existing flowing water environment is described in detail. Hutton Creek is largely ephemeral compared with the Dawson River which is found to be a permanently flowing stream maintained by spring flows in the vicinity of Dawsons Bend.

Water quality data is examined in Section 5 to understand the impacts of current associated water discharges to small intermittent streamlines on Baffle Creek, Hutton Creek and Dawson River. Significant differences in salinity concentrations were found between Dawson River waters upstream of associated discharge and downstream of the Hutton Creek outflow. By Yebna Crossing however, dilution is sufficient under existing associated water discharges to reduce salinity to background levels.

Sites receiving associated water discharge on Hutton Creek, Baffle Creek and the Dawson River generally exhibit similar characteristics, with the exception of increased concentrations of one or more of fluoride, sodium, boron, EC and occasional pH.

The river health of major streams is examined in Section 6 and it is concluded that there is some evidence that Hutton Creek at FV66 and Baffle Creek fauna may be affected by associated water discharges. The changes

Executive Summary

are subtle and are not reflected in AusRivas bands. In general, the data set is minimal and differences may simply arise from sampling variability.

In Section 7, consideration is given to the environmental impacts of permeate discharge from the planned Pony Hills Water Treatment Plant (PHWTP) and the possible Central Treatment Plant (CTP). It is concluded that permeate release from PHWTP should be no higher than 500 µS/cm in order to maintain the salinity at Utopia below Central Queensland Guideline value of 340 µS/cm. Moderate improvements in water quality in Hutton Creek are expected from the permeate discharge and little loss of habitat is likely to occur due to increased flows.

For the CTP, the increased volume of permeate means that releases should be no greater than the guideline value if Utopia salinity is to be maintained at this level. Additional investigations are required to understand the environmental impact of releases from this plant.

1.1 Introduction

The Fairview Project Area lies within the Upper Dawson River catchment that extends upstream and westwards from Taroom encompassing the townships of Injune and Wandoan (Figure 1-1). The catchment contains extensive but largely ephemeral or intermittent stream networks. Major streams in the area are the Dawson River, Hutton Creek, Baffle Creek, Juandah Creek, Eurombah Creek, Commissioner Creek and Broken Creek.

Coal Seam Gas (CSG) production at Fairview has occurred since at least 1993 initially under the control of the Tri-Star Petroleum Company (1993 – 2002), then Tipperary Oil and Gas (Australia) Pty Ltd. (TOGA, 2002 – 2005). In September (June) 2005 TOGA was purchased by Santos Ltd.

Associated water discharge to grade has occurred throughout this period into small, often intermittent, streamlines or gullies that, in turn, discharge to Baffle Creek, the Dawson River or Hutton Creek. Santos captures associated water with salinity greater than 3,500 µS/cm for plant works or for injection into the basement Timbury Hills Formation.

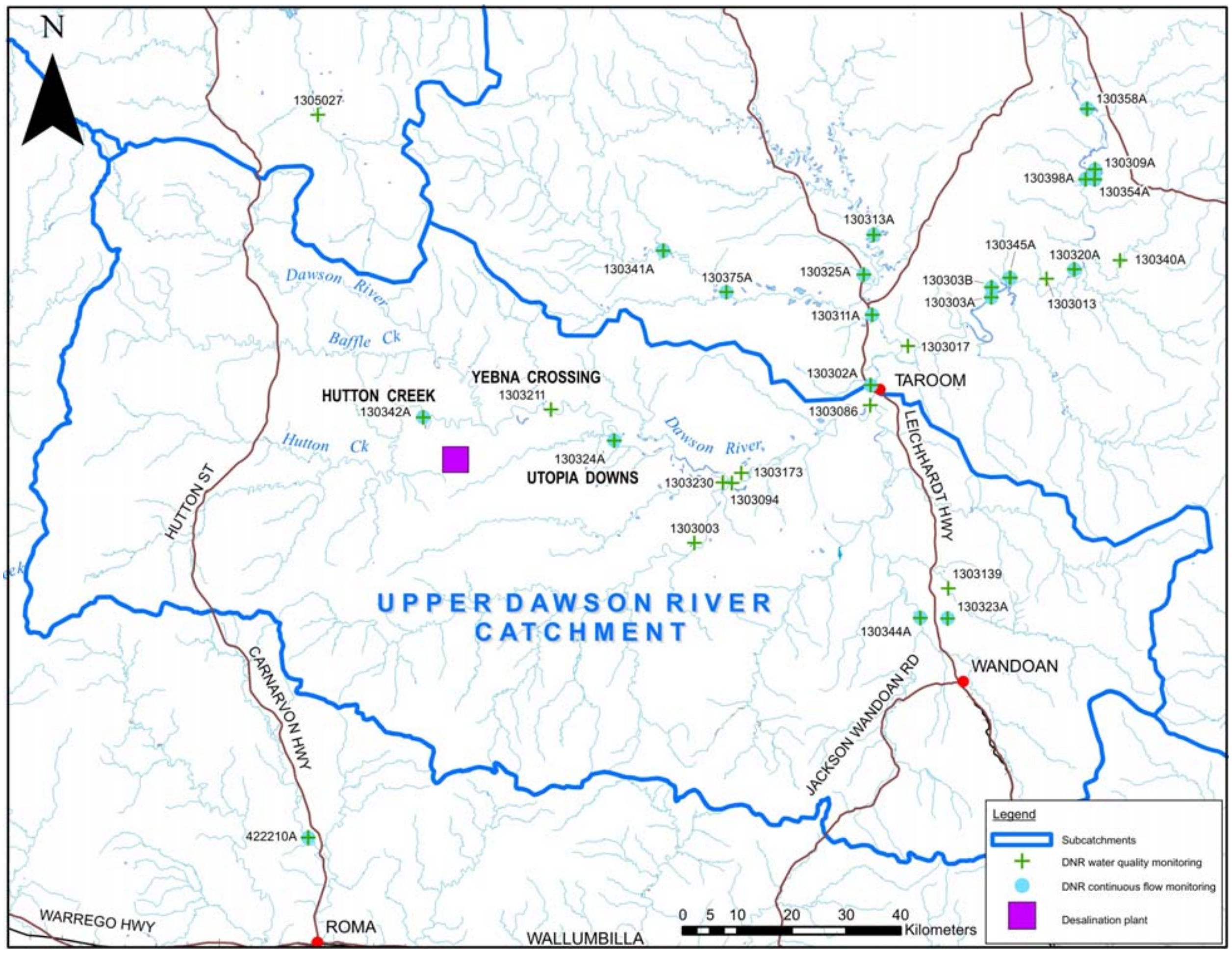


Figure 1-1 Upper Dawson River Catchment

Section 1 Introduction and Catchment Context

1.2 Catchment Context

Since the initial settlement of Taroom circa 1850, the primary land use in the Dawson River catchment has traditionally been sheep and cattle grazing. This remains the predominant land use in the Upper Dawson River circa the Fairview and Springwater homesteads.

Downstream of Hutton Creek, grazing, forestry and cropping are widespread. A number of water storages and weirs are located on the Dawson River from Taroom downstream and are used for irrigation and recreational purposes supporting regional industry and urban communities.

The State of River report (Telfer, 1995) provides indicators of the physical condition of the Dawson River and its tributaries upstream of Utopia Downs station. In general the condition of land immediately adjacent to the State of River study reaches (i.e. the reach environs index) is rated very good for the Upper Dawson River, moderate for the Hutton Creek, poor for Christmas Creek, and good for Baffle Creek. Only 9% of land was considered in poor condition.

Bed and bar stability has been rated as moderate to very stable along 90% of the catchment stream lengths. However, evidence of both aggradation and erosion is widespread. Large-scale land clearing of native vegetation across the catchment has resulted in land degradation with evidence of sheet, rill and gully erosion on over 80% of the cultivated areas of the catchment (Telfer, 1995).

Although stream bank stabilities in the upper Dawson River catchment area stream banks were ranked as moderate to very stable across approximately 95% of the stream lengths, widespread streambed erosion is common. This has been largely attributed to overgrazing of the streambed and banks, and runoff from cattle pads leading to watercourse or adjacent to streams causing bank scouring (Simmons and Bristow, 2007). Much of the soil displaced as a result of the widespread erosion of cultivated and grazed areas has been deposited in tributaries and alluvial plains in the downstream area.

Riparian vegetation along Dawson River at Yebna crossing has been rated exceptionally high. Baffle Creek and Hutton Creek also have areas of dense riparian vegetation in inaccessible areas. However, in the more accessible areas of these creeks and in agricultural areas of the Dawson River upstream of the confluence with Baffle Creek animal access and clearing has lead to significant degradation of riparian condition. Over 70% of stream lengths in the area are ranked as having moderate to poor aquatic vegetation.

Aquatic vegetation along the entire upper Dawson River catchment is rated as poor to very poor. This is likely due to extreme dry conditions experienced at the time of survey. Aquatic habitats within the region are considered moderate to very good in over 80% of the stream length due to the relatively good riparian vegetation. However instream passage for aquatic organisms over reach lengths is restricted by logs or low to non-existent flows. Numerous road crossings, bridges and fords are also evident throughout the area, which in a number of locations, provide significant barriers to upstream fish movement under low flow conditions (e.g. Yebna crossing).

Scenic and recreational value ratings within the upper Dawson River catchment are predominantly good to very good. This is substantiated by the range of activities recorded as currently being undertaken in the Upper Dawson such as BBQs and picnics, day bushwalking, car camping, shore fishing and swimming. Areas of inherent natural beauty and scenic natural settings were identified in the State of River Report as major factors contributing to the overall scenic value.

Environmental Values Section 2

Environmental values are broadly defined in the EPP(Water) as maintaining water quality suitable for the biological integrity of an aquatic ecosystem (modified or pristine); recreational use; minimal treatment before supply as drinking water; agricultural use; and industrial use. Queensland EPA (2005) provides further clarity on the definition of environmental values based on the EPP (Water) and National Water Quality Management Strategy (NWQMS):

- Protection of aquatic ecosystems: ranging from high conservation/ecological value systems, slightly to moderately disturbed ecosystems, and highly disturbed systems.
- Primary Industries: irrigation, water for farm use (such as in fruit packing or milking sheds), stock watering, and human consumption of wild or stocked fish or crustaceans.
- Recreation & aesthetics: primary recreation with direct contact, and visual appreciation with no contact.
- Drinking Water: raw drinking water for human consumption.
- Industrial uses: includes power generation, manufacturing plants.

Dawson River and Hutton Creek and its tributaries do not have prescribed environmental values listed under EPP (Water) Schedule 1. Since similar land uses exist across the entire Upper Dawson River catchment it is expected that the same environmental values will apply to all streams. The relevance of each of the above environmental values to these streams is therefore considered at the catchment scale in the following discussion.

Protection of aquatic ecosystems is applicable to all stream lengths within the proposed development area. The waterways of the upper Dawson River catchment are considered predominantly to consist of “slightly to moderately disturbed ecosystems” based on the State of the River Report for the region (Telfer, 2005). These are “systems that have undergone some changes, with aquatic biological diversity affected to some degree but the natural communities are still largely intact and functioning”.

Water allocations under the Dawson Valley Water Supply Scheme are primarily for the purposes of ‘agriculture’ or ‘any’ (DNRM, 2006). Significant allocations are made along the Dawson River from approximately 20 km downstream of Taroom to the Fitzroy River junction. Some allocations are also made upstream of Taroom approximately 90 km downstream from Fairview. Allocations are for stock watering, irrigation and industrial water use. Between the Hutton Creek Junction and Fairview it is evident from river health surveys (EnviroTest various, Simmonds and Bristow, 2007 & 2008) that stock access waterways in this area from time to time. However, stock access to the Dawson River is generally limited due to steep banks.

Fishing is a widespread recreational activity along the Dawson River including upstream of Yebna Crossing only 12 km downstream of Fairview (Mr Radel pers. comm.). Other recreational activities such as swimming are possible but realistically only along the Dawson River downstream of Yebna Station. Access along the Dawson River is restricted due to steep banks and limited road crossings. Swimming is probably occasional and intermittent. At Taroom, treated groundwater supplies are used to maintain the local swimming pool. Without specific evidence of swimming, primary contact recreation has not been identified as an environmental value.

Along the Dawson River downstream of Taroom, the Glebe Weir is utilised for primary recreation (such as swimming) and secondary recreation purposes (such as canoeing and fishing) (Taroom Shire Council pers. comm.). It is possible that other waterholes upstream and downstream along the Dawson River are also used for local recreational purposes. The aesthetics of the waterways are of relevance with parts of the region considered to be of “inherent natural beauty” (Telfer, 1995).

Section 2 Environmental Values

The towns of Taroom and Injune draw drinking water from an artesian groundwater supply. Water from the Dawson River is used in the urban setting for irrigation of schools and sports fields only. It is understood that residential properties within the catchment but outside of the townships utilise rainwater or borewater for drinking purposes (Taroom Shire Council pers. comm.). On this basis the environmental value of drinking water is not considered to apply to the upper Dawson catchment. Whilst the possibility exists that local properties not connected to water supply will draw water from the river for personal use under riparian rights this is considered unlikely.

The following environmental values have therefore been identified as relevant to the Hutton Tributary, Hutton Creek and Dawson Rivers (Table 2-1).

Table 2-1 Environmental Values for Major Streams - Upper Dawson River

- Protection of slightly to moderately disturbed aquatic ecosystems.
- Primary Industries: irrigation, water for farm use, stock watering, and human consumption of wild or stocked fish or crustaceans.
- Recreation & aesthetics: primary recreation with direct contact, and visual appreciation with no contact.
- Industrial uses.

Water Quality Guidelines and Objectives

3.1 Water Quality Guidelines

The National Water Quality Management Strategy (ARMCANZ & ANZECC, 1994) has been adopted in Queensland through the EPP (Water).

The relevant water quality guidelines for Queensland in order of preferred use are:

- Locally derived guideline values;
- Queensland Water Quality Guidelines (QWQG) which provide guideline values tailored to Queensland regions and water types and were published in 2006 (there have been various updates since that time); , or
- Where the QWQG or local guidelines are not available, the default guidelines are the Australian Water Quality Guidelines (AWQG) published by ANZECC & ARMCANZ (2000).

The EPP(Water) specifies WQOs for some water bodies throughout Queensland (Schedule 1). The water bodies within the Fairview field area are not listed, therefore WQOs become are the minimum set of water quality parameter values that will ensure each of the identified environmental values is maintained. However, the derivation of WQOs must also take into account social, economic and current condition factors. In many instances the technical guideline value may prove to be technically and economically unacceptable. Queensland EPA provides guidance on establishing draft WQOs for a waterway (QLD, 2005).

There have been no officially endorsed WQOs developed for the catchments influenced by the GLNG field development. For the purposes of evaluating and comparing the existing surface water quality and the predicted quality of associated water the appropriate guideline trigger values have been used as a point of comparison. Where several trigger values are available to protect different environmental values the most conservative, or minimum trigger value (MTV), has been adopted.

The QWQG defines fresh waterways as either:

- Upland stream: small (first, second and third order) upland streams (surrogate = altitude >250m): moderate-to-fast flowing due to steep gradients, substrate usually cobbles and bedrock, sometimes gravel, rarely sand or mud; or
- Lowland stream: larger (third, fourth and fifth order), slow-flowing and meandering streams and rivers, gradient very slight, substrates sometimes cobble and gravel but more often sand, silt or mud.

The predominant characteristics of the discharge streamlines, Hutton Creek, Baffle Creek and the Dawson Rivers are in keeping with the definition of lowland freshwater waterways.

3.1.1 Water Quality Trigger Values Based on Guidelines

Based on an examination of the Queensland and national water quality guidelines a set of MTVs has been identified for the Dawson River, Baffle Creek and Hutton Creek (**Table 3-2**). Since aquatic ecosystem protection generally provides the most restrictive guidelines which protect all environmental values only those water quality parameters identified for this purpose have been included in the table.

3.1.2 Minimum Trigger Values Based on Local Data

The QWQG also establish a framework for deriving and applying local guidelines for Queensland waters. Development of local guideline values is important as they reflect existing local conditions which may vary substantially from broader guidelines developed at the regional scale. Local guidelines can therefore take into account natural and anthropogenic influences on water quality and flow that would not otherwise be recognised.

The preferred means of establishing local water quality guidelines is to establish reference condition (background condition, most commonly subject to minimal disturbance, but may be modified from natural condition) immediately upstream of an activity, or in the immediate region. Guidelines for reference condition must be derived from a minimum of at least 18 samples from one or more reference sites (QWQG, 2006).

Sufficient spot water quality data is available to establish local guideline values at the sites shown in Table 3-1. Twentieth and eightieth percentile values of water quality data from Dawson River at Utopia Downs are shown in **Table 3-2** for comparison with the guidelines. Cells are shaded where local data exceeds water quality guidelines.

Table 3-1 Spot water quality sampling sites with significant data

Sampling Site	Water Quality Parameter
Upper Baffle Creek[1]	Temp, EC, TDS
Lower Baffle Creek[2]	Temp, EC, TDS
Dawson R d/s Baffle Ck[2]	Temp, EC, TDS
Dawson R at Yebna Crossing[2]	Temp, EC, TDS
Dawson R at Utopia Downs[2]	Temp, pH, DO, EC, TDS, TSS, Na, K, Mg, Ca, HCO3, Cl, F, SO4, TN, TP, NH4, NO3, B, Cu
Dawson R at Taroom[2]	Temp, EC, TDS

Note:

1 upstream of associated water discharges

2 downstream of associated water discharges

It should be noted that while the site Dawson River at Utopia Downs (1964 – 2007) has the most significant set of spot sample water quality data, it also lies downstream of existing associated water discharges. The data from this site were therefore examined for differences in median water quality parameter values before and after associated water discharges commenced using two sided Mann-Whitney U tests at 95% significance. The only water quality parameter with a significant increase in median concentration was Boron. Other parameters with significant shifts in median values were EC, TDS, Ca, Mg, Alkalinity, Cl and SO_4. All these parameters exhibit a reduction in concentration pre to post associated water discharges. Details of the statistical tests are provided in Section **5.4.4**.

The data from Dawson R at Utopia Downs was therefore used to derive 20th and 80th percentile water quality values for comparison with the guideline based water quality objectives (**Table 3-2**). The local data suggests that guideline trigger values should be relaxed for nutrients, turbidity and suspended solids. These parameters are not of particular interest in the following discussion of the impacts of associated water discharges.

Table 3-2 Relevant MTV for major streams in the Upper Dawson River catchment

WQ PARAMETER	UNITS	QWQG 2006[a]		ANZECC GUIDELINES 2000				MTV	Local Data[#]	
		Lowland	Upland	Aquatic Ecosystems[b]	StockWater	Irrigation[c]	Recreation		20%ile	80%ile
Temperature*	°C	20%ile-80%ile	20%ile-80%ile	NA	NA	NA	15-35	**	14.7	26.1
pH	units	6.5-8.0	6.5-7.5	NA	NA	6-9	6.5-8.5	6.5-8.0	7.56	8.1
Electrical Conductivity (at 25°C)	µS/cm	340[d]	340[d]	NA	NA	<650[e]	NA	340[a]	223	330
Dissolved Oxygen	% Sat.	85-110	90-110	NA	NA	NA	>80	85-110	**72**	86
Total dissolved solids	mg/L	-	-	-	4000[f]	-	1000	1000	131	189
Total suspended solids	mg/L	10	-	NA	NA	NA	1000	10	9	**124**
Turbidity	NTU	50	25	NA	NA	NA	NA	50	7.0	**100**
Sodium	mg/L	-	-			<115[e]	300	<115	24	38.1
Potassium	mg/L							-	3.3	4.7
Calcium	mg/L	-	-		1000	-	-	1000	13.0	21.0
Magnesium	mg/L							-	4.48	8
Alkalinity HCO_3	mg/L							-	104	153
Chloride	mg/L	-	-	-	-	<175[e]	400	<175	18.0	32
Fluoride	mg/L	-	-		2[g]	1		1	0.1	0.16
Sulphate	mg/L	-	-		<1000		400	400	1	3.2
Total nitrogen	µg/L	500	250	NA	NA	5000	NA	500	118	**795.8**
Total phosphorous	µg/L	50	30	NA	NA	50	NA	50	21.7	**146**
Ammonia	µg/L	20[1]	10	900	NA	NA	NA	20	8	**37.3**

[1] It is noted that the Queensland guideline table suggests that trigger values for ammonia-N are equivalent to ANZECC (2000) guidelines. This is incorrect and possibly indicates that EPA has misinterpreted the national guideline triggers for ammonia- N and ammonium ion concentrations.

Section 3 Water Quality Guidelines and Objectives

WQ PARAMETER	UNITS	QWQG 2006[a]		ANZECC GUIDELINES 2000				MTV	Local Data[#]	
		Lowland	Upland	Aquatic Ecosystems[b]	StockWater	Irrigation[c]	Recreation		20%ile	80%ile
Oxidised nitrogen (NOx)	µg/L	60	15	NA	400,000[k]	NA	NA	60	**138**	**524**
Boron	µg/L	-	-	370	5000[i]	500	1000	370	20	100
Copper	µg/L	-	-	1.4	1000[g]	200	1000	1.4	0.02	0.05
Chlorophyll-a	µg/L	5	n/a	NA	NA	NA	NA	5		
Arsenic	µg/L	-	-	24/13[j]	500[g]	100	50	24/13	-	-
Cadmium	µg/L	-	-	0.2	10[g]	10	5	0.2	-	-
Chromium	µg/L	-	-	1.0 (CrVI)	1000[g]	100	50	50	-	-
Iron	µg/L	-	-	300 (interim)	-	200	300	200	-	-
Lead	µg/L	-	-	3.4	100[g]	2000	50	3.4	-	-
Mercury	µg/L	-	-	0.6	2[h]	2	1	0.6	-	-
Nickel	µg/L	-	-	11	1000[g]	200	100	11	-	-
Zinc	µg/L	-	-	8	<20000	2000	5000	8	-	-

NOTES

a Guideline trigger values for protection of aquatic ecosystems (Central Coast Region)

b Values for 95% protection of aquatic ecosystems

c Values for long term irrigation trigger chosen as most conservative

d 75th percentile of EC in relevant salinity zone (Fitzroy Central). Source QWQG (2006)

e For sensitive crops

f Suitable for beef cattle and horses

g May be hazardous to animal health if exceeded

h Mercury may accumulate in edible animal tissues >2 µg/L and may therefore pose a human health risk

i Higher concentrations of Boron (>5000µg/L) may be tolerated for short periods of time.

j AsIII/AsV respectively

k For nitrate

NA indicates not applicable as QWQG take precedence

\- indicates no applicable guideline value

(yellow) These cells are the most conservative parameter values to satisfy all environmental values

(green) These cells are the relevant water quality objectives for streams in the Upper Dawson River catchment.

n/a Not available

^ MTV – minimum trigger value

Based on analysis of data from Dawson R at Utopia (1964 – 2007) DO in mg/L converted to % saturation assuming observed temperatures for samples with DO similar to percentiles

* The QWQG recommends setting temperature guidelines for protection of aquatic ecosystems so that median discharge temperature lies within the 20th and 80th percentiles of observed temperature variations. Significant diel and seasonal variation in temperature are evident within river systems. Ensuring an appropriate data set from which to identify these percentiles is problematic since samples are often collected in particular seasons and during daylight hours.

3.2 Application of Water Quality Guidelines

The guideline trigger values can be used as a benchmark against which potential developments or discharges can be assessed. However, in assessing the impacts of any discharge to the environment the guidelines should not be used on a pass or fail basis, but rather within a risk assessment framework (s3.1.1.3, ANZECC & ARMCANZ, 2000).

The in-stream dynamics of water flow and quality (as well as the interactions between contaminants) make it difficult to make definitive statements regarding the environmental effects of particular levels of water quality. QWQG and AWQG suggest the use of aquatic health measures in preference to physico-chemical measures since ecological systems reflect the full range of conditions encountered including droughts, floods, and episodic changes in water quality.

Setting water quality guideline values for ephemeral streams is problematic and is not dealt with definitively by either by the QWQG or the AWQG. Notes within the QWQG recognise that ephemeral streams and residual pools will have poorer water quality (particularly dissolved oxygen and nutrients) than flowing streams. Due to evaporative concentration of salts within pools, it can be expected that salinity would also be marginally poorer in such systems when compared with flowing waters.

Smith *et. al.* (2004) completed a literature review of the effects of mining discharges to ephemeral waters identifying a wide range of ecological responses to water quality. Responses were dependent upon factors such as the level and continuity of exposure to contaminants, the type of contaminants, and the nature of the fauna.

It is therefore appropriate to consider the ecological risks of any changes in water quality likely to arise from any discharges. There is significant local information on flows, water quality and river health in the Upper Dawson River catchment to support this type of assessment.

Section 4 Existing Environment - Flow Regimes

4.1 Upper Dawson River and Tributaries

Baffle Creek, Dawson River upstream of Baffle Creek and Hutton Creek are predominately ephemeral streams. Under natural dry season conditions, Baffle and Hutton Creeks have dry beds interspersed with reasonably deep freshwater pools that probably act as refugia for flora and fauna. While no flow records are available for Baffle Creek, the nature of the streamline, catchment size, geology, aspect and close proximity to Hutton Creek suggest similar flow regimes can be expected.

The Dawson River dries up above the confluence with Baffle Creek, with some pools observed higher up the catchment. Downstream of Baffle Creek the Dawson River appears to maintain deep pools even during dry periods. Downstream of Hutton Creek, the Dawson River appears to be a continuously flowing stream probably maintained by spring flows.

Minor streamlines that feed these watercourses have intermittent flows and few refugia even during the wet season.

Flow and water quality records are available from a number of DNRW stations in the area (Figure 4-1).

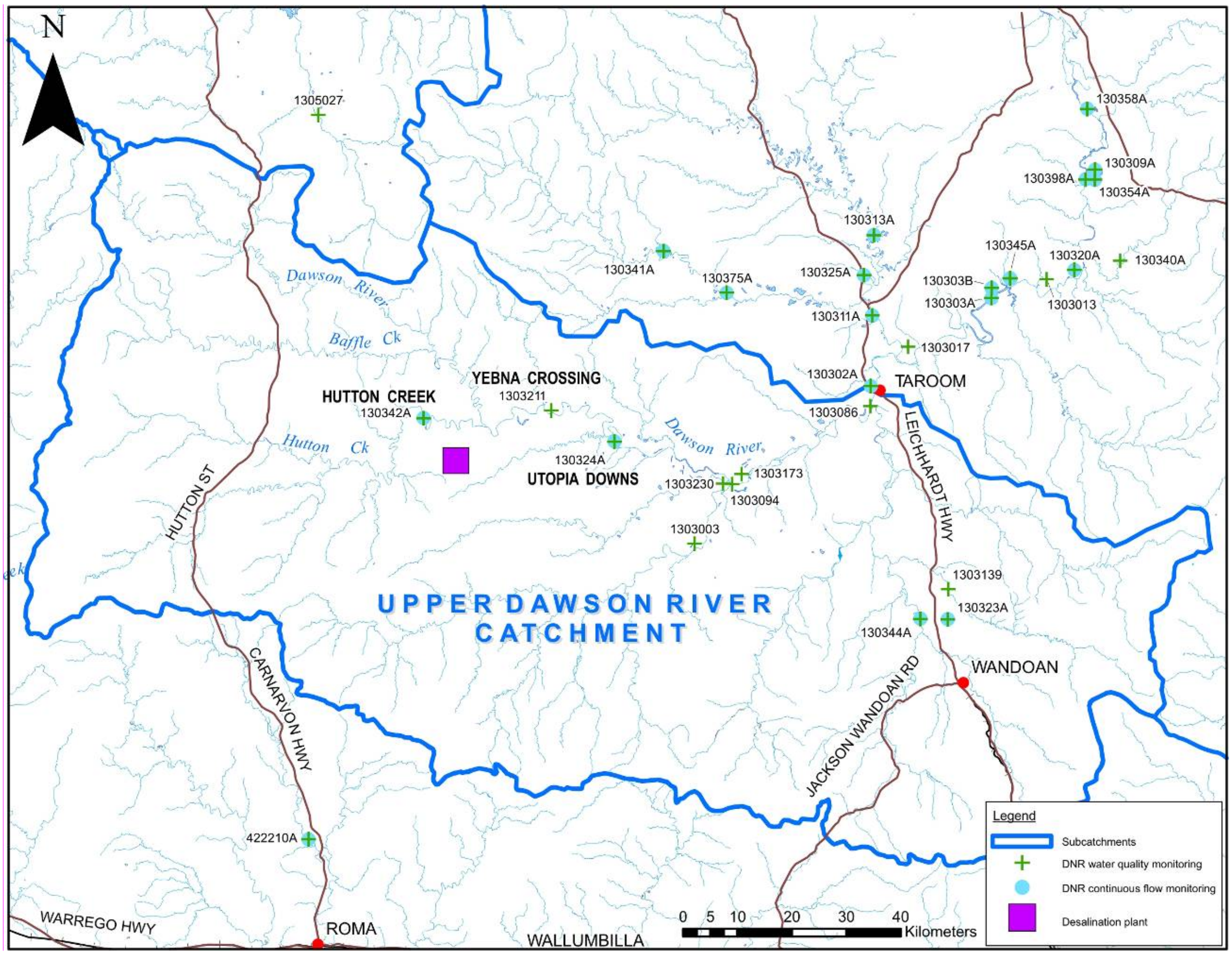


Figure 4-1 DNRW Data Collection in the Upper Dawson Catchment

Existing Environment - Flow Regimes

Flow records from Hutton Creek (1972 - 1988) show substantial seasonal variation in flows. Monthly average flows exceed 33 ML/day (~1000ML per month) in Hutton Creek on average one month in three. For wet season months there is a 50:50 chance of monthly flows exceeding 33 ML/day. Maximum recorded average monthly flow in Hutton Creek is 18,275 ML/day. The maximum recorded peak flow rate in Hutton Creek is 36,542 ML/day.

Flow records from Dawson River at Utopia (1966 – current) and from Dawson R at Taroom also show substantial seasonal variation in flows. The relative magnitude and peakiness of monthly average flows are shown for Hutton Creek, Dawson R at Utopia and Dawson R at Taroom in Figure 4-2.

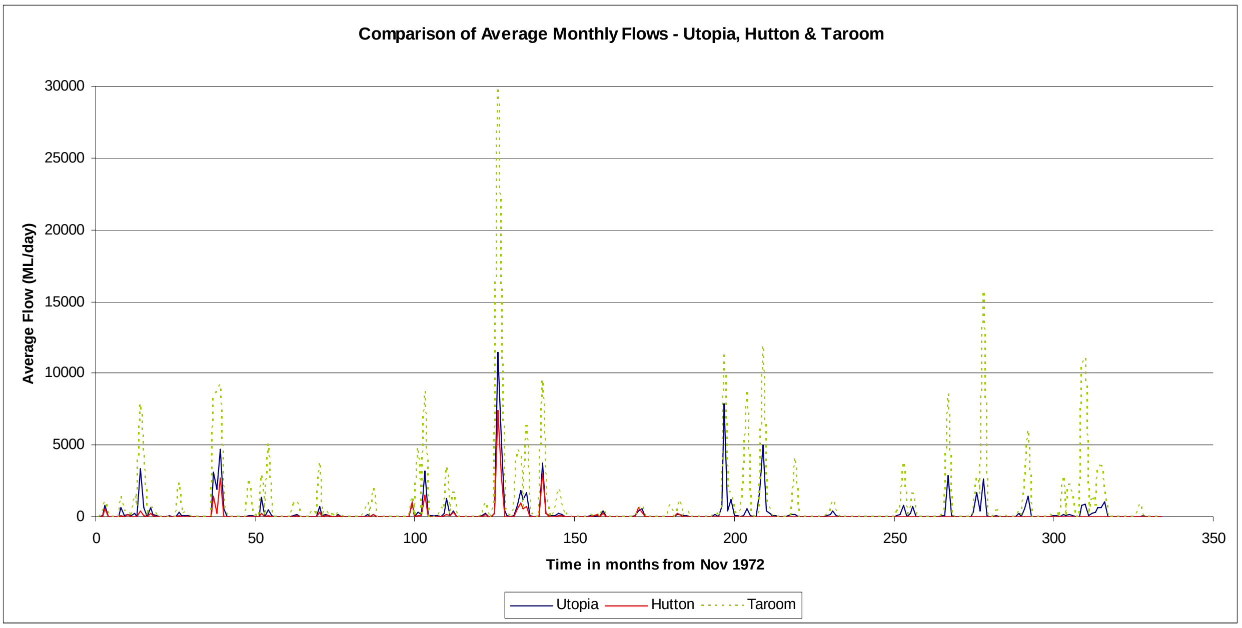


Figure 4-2 Observed Average Monthly flows in Upper Dawson Catchment

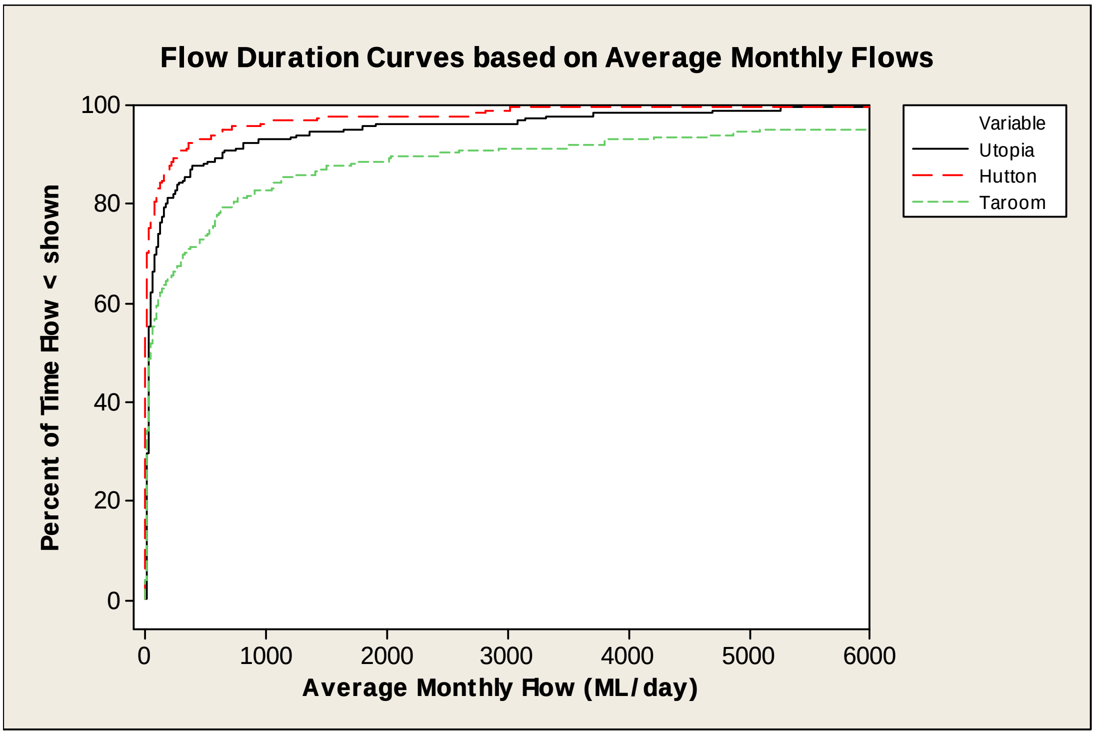
Comparison of flow regimes is difficult from simple time series plots like the one shown above.

Flow duration curves are empirical cumulative distribution functions derived from observed flow data. They demonstrate the proportion of time that flows are less than or greater than particular values.

Figure 4-3a) is the flow duration curve for Hutton Creek, Dawson R at Utopia and Dawson R at Taroom truncated at 6000 ML/day for clarity - it normally extends to 35000 ML/day.

Figure 4-3 b) has been further truncated to demonstrate the low flow behaviour of each of the streams. It is clear that Hutton Creek regularly dries up. Based on the records, Dawson R at Utopia and Dawson R at Taroom are continuously flowing streams.

a) Full Duration Curve



b) Low Flow Portion of Flow Duration Curve

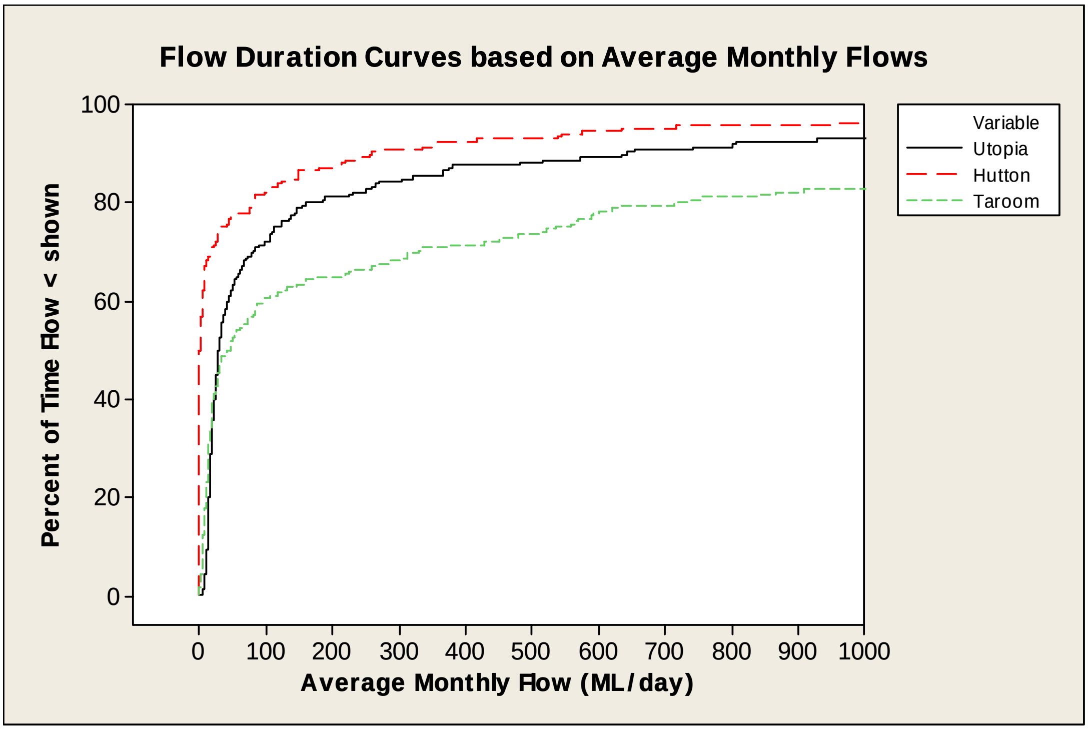


Figure 4-3 Duration Curves for Recorded Flows Upper Dawson River Catchment

4.2 Dawson River Spring Flows

Stream gaugings under baseflow conditions at the end of the 2007 dry season show there are substantial freshwater inputs to the Dawson River downstream of the Hutton Creek confluence (URS, *unpub. data*) with over 80% of the flow (Table 4-1) at Yebna Crossing coming from the shaded area in Table 4-4. According to a local land owner (Radel, pers. comm.) there are significant inflows to the Dawson River from a spring fed creek approximately 2km downstream of the Hutton Creek confluence. Discharges from the Dawson River stream banks have also been observed in this area during river health surveys (S. Anderson, *pers. comm.*). Queensland EPA (2008) provides maps of springs that support these observations (Figure 4-5).

Table 4-1 Low flow gauging and water quality Upper Dawson River, October 2007

Site	Discharge (L/s)	Discharge (ML/day)	Electrical Conductivity (µS/cm)
Dawson d/s Baffle Creek	30	2.6	1500
Hutton u/s Dawson River	7	0.6	1400
Dawson River at Yebna Crossing	210	18.1	290
Estimated Spring Flows[1] Hutton Creek Confluence to Yebna	*173*	*14.9*	*35*

Notes: [1]by mass balance calculation

Spring inflows are fresh, but it seems unlikely that their electrical conductivity (EC) is as low as calculated in Table 4-1. Background EC in the Dawson River at Dawsons Bend at Yebna is normally of the order of 250 µS/cm. This is similar to the median water quality in water bores in the Precipice and Hutton Sandstone aquifers. Nevertheless, continuous EC records have occasionally detected values as low as 57 µS/cm at Utopia (DNRW data). Presumably this reading is representative of locally fresh spring flows, but the possibility of instrument error or incorrect calibration also exists.

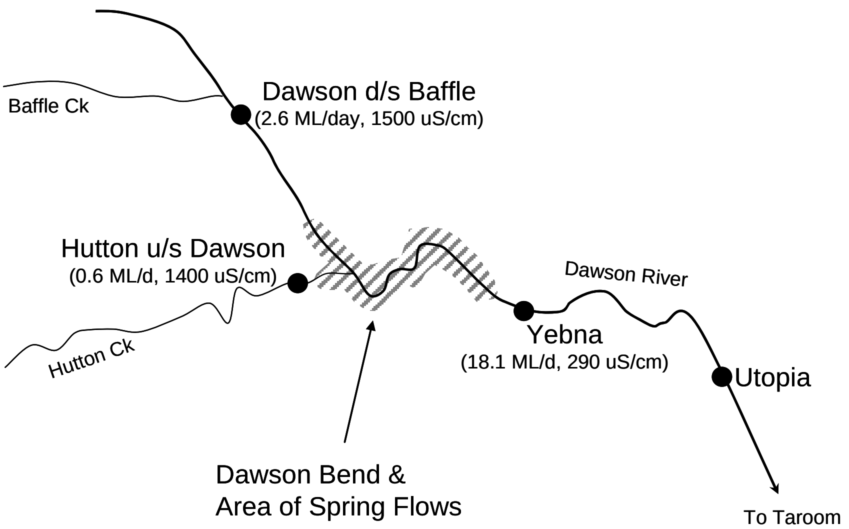


Figure 4-4 Dawson River springs area, flows and salinities, October 2007

Section 4 Existing Environment - Flow Regimes

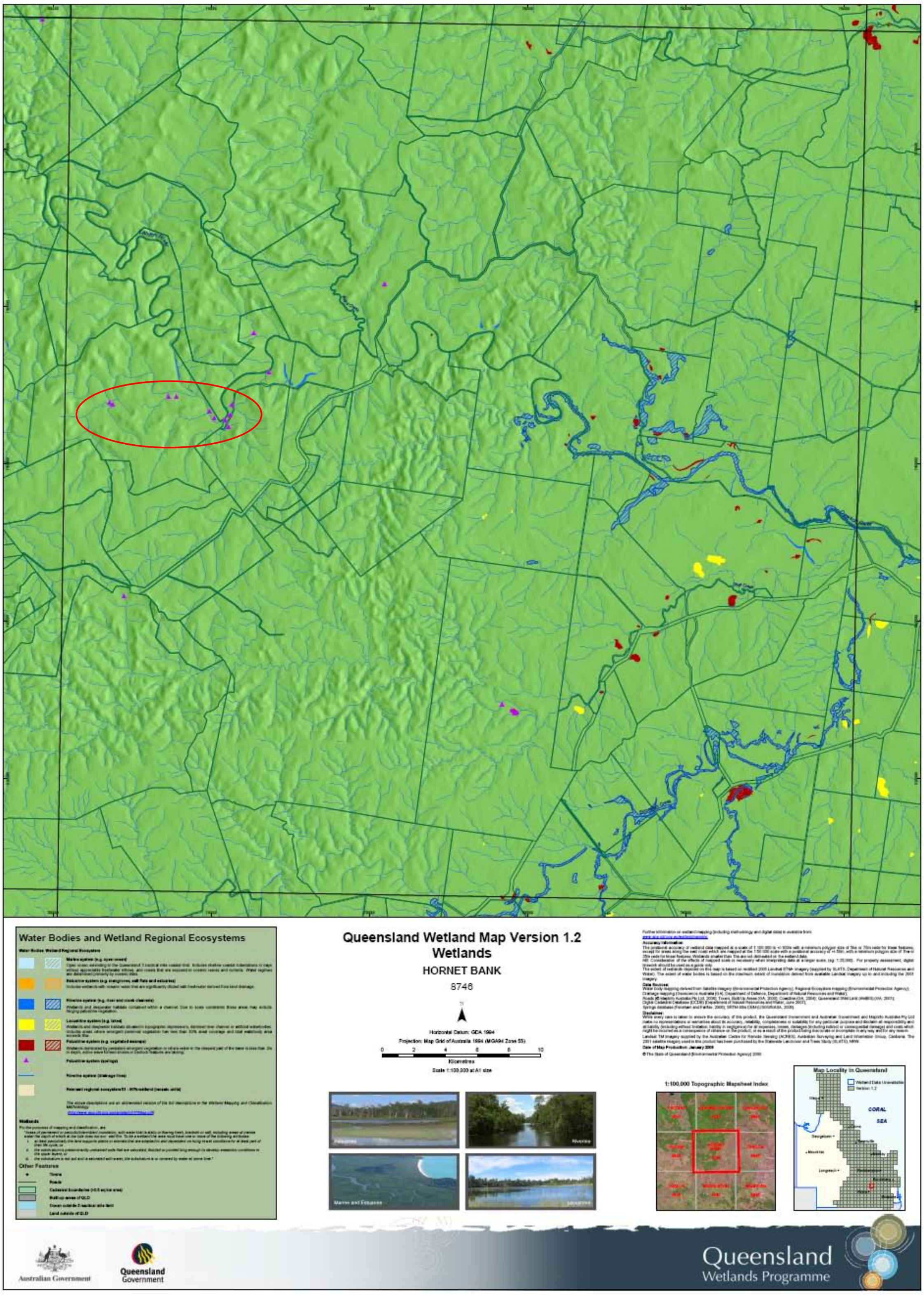


Figure 4-5 Springs in the vicinity of Dawson Bend and Hutton Creek

During March 2008 a detailed investigation was undertaken of the flows and water quality of springs discharging into the Dawson River along the reach extending Yebna Crossing upstream to the outflow of Hutton Creek to Yebna Crossing. Travel further upstream was restricted by topography.

Physical parameters (pH, EC, temperature, turbidity and DO) were measured using a Hydrolab™ MS-5 multiprobe instrument at each spring inflow and at approximately 200 m intervals along the Dawson River. Where sufficient spring flow was present water samples were collected for laboratory analysis of a range of parameters (total metals, physico-chemical parameters, major cations and anions, nutrients indicators).

Flow measurements (gaugings) were taken where possible at springs and at regular intervals along the Dawson River. Gaugings were taken using a current meter to measure velocities at points along a cross section of the stream. Corresponding width and depth measurements were taken to provide an estimate of the flow.

With respect to flow regimes the survey identified[2]:

- More than thirty springs between the outflow of Hutton Creek and Yebna Crossing (Figure 4-6). Spring discharges ranged from very small bank seepages to flows of approximately 0.5 L/s.
- Extensive cattle access was evident particularly towards Yebna Crossing.
- A number of springs were noted in the stream bed and these appear to contribute the majority of flow in the area.
- Flow at Yebna Crossing was found to be approximately 250% greater than upstream of Dawson’s Bend with the main contribution of flow occurring within 1.5 km downstream of Dawson’s Bend.
- Flow at Yebna was 171 litres/second compared with 68 litres/second measured upstream of Dawson’s Bend. Peak flow rate measured was 273 litres/second upstream of Yebna pond suggesting losses in or near the pond possibly to extractive use on the farm.
- Spring flows add significantly to the water flowing in the reach of the Dawson River downstream of Hutton Creek. It is estimated that the spring flow is approximately 17 ML/day.

The water quality of spring flows is discussed further in Section **5.3**.

[2] Raw data from Hydro Tasmania Consulting, 2008, provided in main report.

Section 4 Existing Environment - Flow Regimes

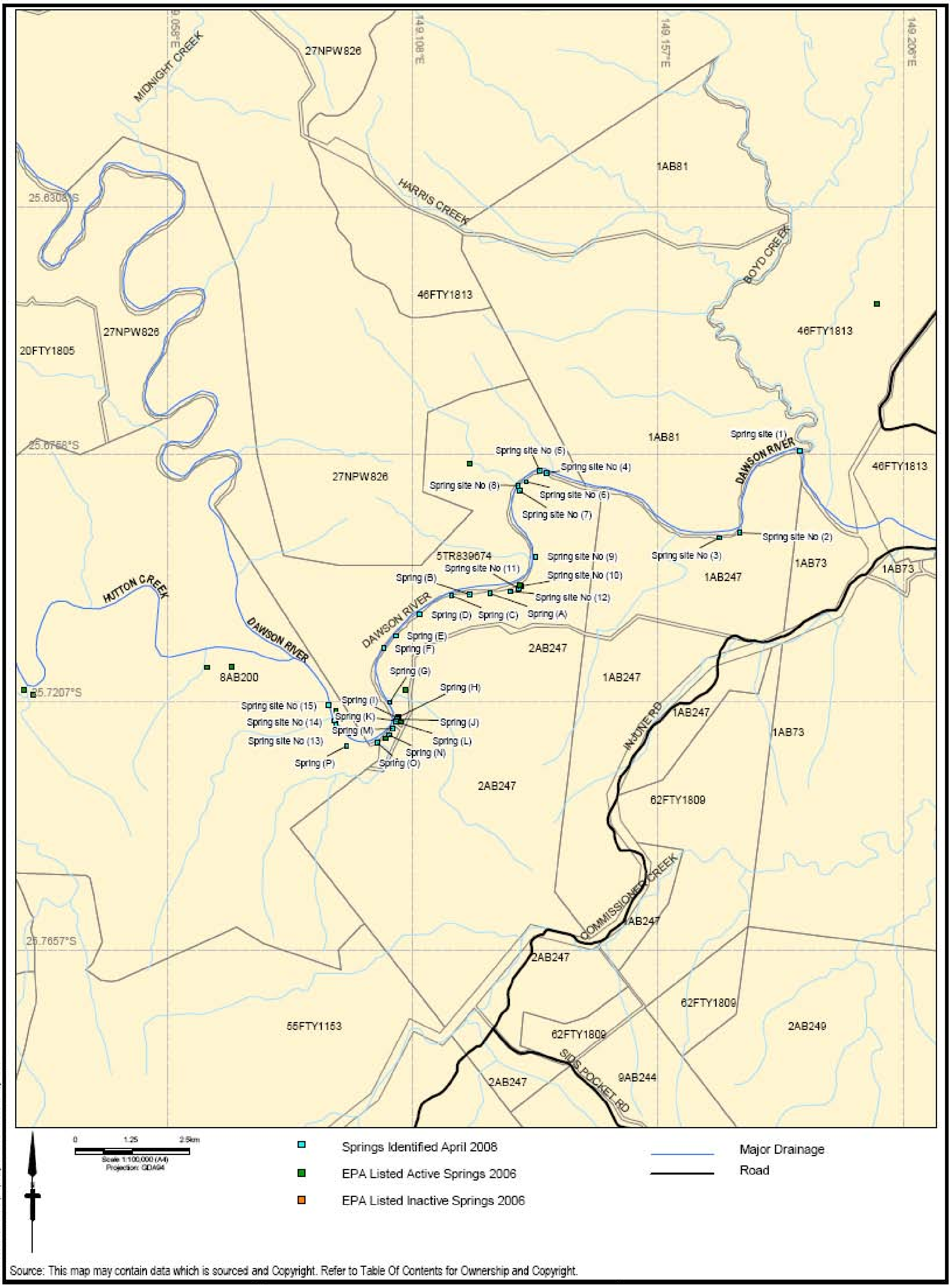


Figure 4-6 Dawson River spring locations

Existing Environment - Water Quality

5.1 Overview of General Water Quality

Summaries of all available water quality data from sites upstream and downstream of the Fairview operations are provided in Appendix A. These tables are referred to throughout this section without specific reference.

Data were derived from the following sources:

- Monitoring data provided by Santos (from 1998 to 2002);
- River Health Assessments undertaken for Santos (from 2003 to 2007);
- Department of Natural Resources and Water (DNRW); and
- Spring flow and water quality assessment undertaken on behalf of Santos (URS, 2008).

Measurements of various water quality indicators have been collected including physical parameters, cations, anions, nutrients, trace elements and biological samples. In many instance too few samples are available to provide a fully representative set of water quality data.

5.1.1 Waters upstream of associated water discharges

The Upper Baffle Creek, Upper Hutton Creek and Upper Dawson River water quality monitoring sites lie above any influence from associated water discharge. When compared with the relevant MTVs (Table 3-2) these sites are characterised by:

Low Dissolved Oxygen (DO)

Many of the reported DO values are lower than would be reasonably expected and are likely to not be representative of actual conditions. If present the very low dissolved oxygen concentrations would be expected to cause stress to in-stream fauna and possible fish kills.

High pH

Waters in the Upper Dawson catchment are typically neutral to moderately alkaline (pH~8). However, recent field sampling (URS, 2008 unpub. data) shows some of the tributaries of the Dawson River naturally have pH circa 8.5.

High Boron

Concentrations of Boron were predominantly below the relevant MTV upstream of associated discharges with the exception of two slightly elevated concentrations in Dawson waterhole and upper Baffle creek. Boron is a widespread naturally occurring trace element of igneous rocks and is commonly found in sedimentary rocks of marine origin (ANZECC & ARMCANZ, 2000).

High Zinc

Several concentrations of zinc marginally exceeding the relevant MTV were detected at sites upstream of associated water discharges. Zinc is an essential trace element that adsorbs to suspended material. Toxicity of zinc can increase with low dissolved oxygen (ANZECC & ARMCANZ, 2000). However, levels of organic matter found in most freshwater streams are generally sufficient to remove zinc toxicity. Given the amount of suspended sediment and relatively low zinc concentrations found in these streams it is unlikely that zinc would present a significant water quality issue.

High Iron Content

There were a number of very high iron concentrations observed at sites upstream of associated water discharges. Iron does not present a risk to livestock or ecosystem health at the concentrations detected. The main issues associated with high levels of iron are precipitation and biofouling resulting in blockages of irrigation equipment (ANZECC & ARMCANZ, 2000).

High Suspended Solids (TSS) and High Turbidity

The soils and slopes in the area are susceptible to erosion. This has been exacerbated by the removal of vegetation in agricultural areas, and unrestricted stock access to streams. The nature of flooding in the area is a major factor driving suspended solids transport and erosion processes.

Chlorophyll-a and nutrient enrichment

Nutrient enrichment, high turbidity, high TSS and Chlorophyll a levels at sites upstream and downstream of associated water discharges suggest that these water quality issues are likely to be due to the general erosive nature of soils and existing grazing activities in the catchment.

Other Observations

There was one observation of lead marginally exceeding the MTV. Lead is generally present in very low concentrations in natural waters and is readily adsorbed to suspended matter.

Electrical conductivity readings upstream of associated water discharges are typically in the order of 150 µS/cm, but can range from 70 to 1,800 µS/cm.

5.2 Longitudinal Changes in Dawson River Water Quality

Water quality changes along the Dawson River were examined based upon data from five sites. Table 5-1 provides a summary of water quality data from these sites. Table 5-2 provides a list of significant differences in median water quality utilising a two-sided Mann-Whitney U Test at 95% confidence level[3].

The Upper Dawson River (at Arcadia) is a small stream upstream of any associated water discharges. Wide variation in EC is evident at this site and significant deviations from MTV are evident for TSS, iron and phosphorus/phosphate. High TSS and phosphorus readings at this site may indicate the effects of locally erosive soils, land clearing and/or animal grazing.

A statistically significant decrease in median temperature ($p<0.05$) is evident between Upper Dawson River and Dawson River d/s Baffle Creek. The Upper Dawson River is characterised by wide sand beds with shallow pools compared with deeper pools, narrower channel form and dense riparian vegetation downstream of Baffle Creek. The change in median temperature is within the variation that has been observed between open and shaded

[3] This test was used as water quality data is often significantly skewed and non-normal for some parameters. An alternative test would have been to test sample averages with t-tests after transformation of the data.

areas in the Dawson River (URS, 2008 unpub, data). No other significant changes in median temperatures were identified.

A statistically significant and large increase in median EC is evident between the Upper Dawson River (215 µS/cm) and Dawson River d/s Baffle Creek (876 µS/cm), followed by a statistically significant decrease back to near the Upper Dawson River median EC at Yebna Crossing (247 µS/cm). Between Yebna Crossing and Utopia (289 µS/cm) a statistically significant but small increase in median EC is evident. No statistically significant difference in median EC is evident between Utopia and Taroom. These results suggest there is a significant increase in EC due to associated water discharges from Baffle Creek, but sufficient dilution to return salinity to background levels at Yebna Crossing. This is consistent with the discussion of spring flows in Section 4.2.

The increase in salinity between Yebna and Utopia is small and may be the result of more saline spring flows between these two sites.

Downstream sites on the Dawson River are generally more saline than headwater sites. Median salinity (EC) at Utopia is significantly higher than in the Upper Dawson River. Median total dissolved solids at Yebna Crossing are significantly higher than at Upper Dawson River.

Section 5 Existing Environment - Water Quality

Table 5-1 Longitudinal water quality in the Dawson River

Water Quality Indicator		Units	MTV	Upper Dawson River				Dawson R d/s Baffle Ck				Dawson R at Yebna Xing				Dawson R at Utopia				Dawson R at Taroom			
				Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	340	50	215	1702	12	182	876	1498	24	110	247	435	46	78	289	551	139	87	260	525	288
	pH	Stand	6.5-8.0	6.6	7	7.1	5		7.1		1	7.2	7.75	8	6	7	7.81	8.5	138	6.5	7.6	8.5	228
	Temperature	C		15.4	25.5	28	12	13	23	28	23	12	24	28	43	8	22	77	122	9	23.1	31	182
	Total dissolved solids	mg/L	1000	46	146	194	12	124	596	1019	24	75	168	296	46	58	160	317	130	60	152	306	173
	TSS	mg/L	10	52	75	125	4		32		1	2	8	142	5	0	14.5	2460	114	2	50	4900	126
Inorganic Non-Metallic Parameters	Bicarbonate Alkalinity	mg/L - CaCO3	-	28	95	151	5		130		1	87	113.5	130	6	24	134	289	130				
	Chloride	mg/L	<175	3	8	12	5		20		1	19	20.5	22	6	3	25	70	130	4	20.6	59.9	140
	Fluoride	mg/L	1	0.1	0.1	0.24	5		0.31		1	<0.1	0.13	0.23	6	0.06	0.11	0.4	126	0.08	0.13	0.7	132
	Sulphate	mg/L	400	<1	5	<10	5		<1		1	<1	7.5	<10	6	0	2	13	97	0	2	11	116
Cations	Calcium	mg/L	1000	1	6	18	5		12		1	7	10.8	17	6	5.2	17	40	130	4.3	18	44	140
	Magnesium	mg/L		1	5	6.1	5		3.5		1	4	5.5	6.2	6	1.5	6.5	15	130	1.4	5.2	11.8	140
	Potassium	mg/L		<1	6	10.7	5		7.4		1	3	3.2	6	6	2.2	4	7.7	121	2.4	5.1	7.5	130
	Sodium	mg/L	<115	3	11	22	5		59		1	27	28	33	6	7.5	32.7	112	130	7.7	28	65.8	140
Nutrients	Ammonia-Nitrogen	µg/L	20	10		590	3		93		1	<10	10	14	3	0	20.1	150	56	4.3	31.8	163	53
	Nitrate as (NO_3^-)	mg/L			128		1		305		1		<44		1	2	192	7724	81	160	1080	10000	102
	Total Phosphorous	mg/L - P	50	<10	125	1900	4		76		1	<10	40	280	5	3	55	550	59	4	157	1387	71
Trace elements	Boron	µg/L	370	<100	<100	500	5		480		1	16	<100	600	6	0	20	170	73	10	50	1000	73
	Iron	µg/L	200	4407		5100	2		2300		1	76		390	3	1	165	460	3	10	60	4800	93
	Lead	µg/L	3.4	<1		3	2		<1		2		<1		2		<1		3				
	Zinc	µg/L	8	<1		14	2		20		1	<1		<10	2	<1		<10	2	10	20	700	60

NOTES: (shaded cell) Result greater than relevant MTV

URS

Prepared for Santos Pty Ltd, 21 January 2009
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Table 5-2 Differences in median water quality along the Dawson River

Water Quality Parameter Name	Units	Upstream			Downstream			Sig	p
		Site	Median	n	Site	Median	n		
Temperature	C	**Upper Dawson River**	25.5	12	**Dawson R d/s Baffle Ck**	23	24	▼	0.018
		Dawson R d/s Baffle Ck		24	**Dawson R at Yebna Xing**		43	-	0.558
		Dawson R at Yebna Xing		43	**Dawson R at Utopia**		122	-	0.278
		Dawson R at Utopia		122	**Dawson R at Taroom**	23	182	-	0.109
EC	µS/cm at 25C	**Upper Dawson River**	215	12	**Dawson R d/s Baffle Ck**	876	24	▲	0.0002
		Dawson R d/s Baffle Ck	876	24	**Dawson R at Yebna Xing**	247	46	▼	0.0000
		Dawson R at Yebna Xing	247	46	**Dawson R at Utopia**	289	139	▲	0.012
		Dawson R at Utopia		139	**Dawson R at Taroom**	260	288	-	0.719
Total dissolved solids	Mg/L	**Upper Dawson River**	146	12	**Dawson R d/s Baffle Ck**	596	24	▲	0.0000
		Dawson R d/s Baffle Ck	596	24	**Dawson R at Yebna Xing**	168	46	▼	0.0000
		Dawson R at Yebna Xing		46	**Dawson R at Utopia**		130	-	0.234
		Dawson R at Utopia	160	130	**Dawson R at Taroom**	152	173	▲	0.007

NOTES

Medians are only shown where a statistically significant difference has been identified.

Sig indicates statistically significant difference in medians at the 95% confidence level using a Mann Whitney U Test. Mann-Whitney U Test used as tests on variance indicate possible differences.

p indicates actual level of significance e.g. p=0.05 indicates a 95% chance that the medians are the different.

▲ and ▼ indicates an increase/decrease in median values from upstream to downstream.

\- indicates no significant change from upstream to downstream.

5.3 Water Quality circa the Dawson River Springs

Between the outflow of Hutton Creek and Yebna Crossing there are discharges to the Dawson River from freshwater springs. Water quality upstream, in the vicinity of, and downstream of springs is examined for differences. Table 5-3 provides a summary of available water quality data from sites in the vicinity of the Dawson River spring flows. Table 5-4 provides a summary list of statistically significant differences in water quality parameter values between these sites utilising a two-sided Mann-Whitney U Test at 95% confidence level.

Only limited data is available to explore differences in median water quality parameters at Dawson River d/s Hutton #1, Dawson River d/s Hutton #2 and Dawson Bend. These sites are closely spaced downstream of Hutton Creek and lie in the vicinity of the Dawson River spring flows. No statistically significant differences in median water quality parameter values were identified between these sites.

Between Dawson Bend and Yebna Crossing some statistically significant changes in median water quality parameter values are evident.

- Median sodium and chloride concentrations are higher at Yebna although there is no significant difference in median electrical conductivity.
- Median pH is significantly higher at Yebna than at Dawsons Bend.
- Median concentrations of calcium are significantly lower at Yebna based upon the full datasets. However restricting the analysis to data coincident at both sites did not lead to an indication that there is a significant difference in medians. This suggests that the variability of observed data is more limited at Dawson Bend given only six samples are collected. Data at Dawson Bend is from river health sampling and is biased towards conditions at the start and end of wet season when this sampling occurs.
- Additional data is required to clearly understand the implications of these results, however, they appear consistent with the observations of spring inflows in the area.
- A comparison of surface spring water quality with the Dawson River indicates:
- Water from the surface springs has a flow weighted EC 254 µS/cm, temperature 21°C and pH 6.8.
- Surface springs exhibit higher alkalinity, major ion and fluoride concentrations than the Dawson River. Concentrations of iron and zinc are substantially higher in spring flows compared with the Dawson River and lower Hutton Creek, above the MTVs (Table 5-3).

Table 5-3 Dawson River water quality circa spring flows

	Water Quality Indicator	Units	MTV	Lower Hutton Creek				Dawson R d/s Hutton #1				Dawson R d/s Hutton #2				Dawson Bend				Dawson R at Yebna Crossing				Springs			
				Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n	Min	Med^	Max	n
Physico-Chemical	Electrical Conductivity	µS/cm at 25C	340	131	233	**1294**	16	129	265	266	6	134	249	282	5	136	251	273	6	110	247	435	46	132	301	**890**	33
	pH	Units	6.5-8.0	6.6	7.85	**8.3**	16	6.2	6.95	7.4	6	7	7.2	7.6	5	6.4	6.9	7.3	6	7.2	7.8	**8**	6	5.8	7	7.8	33
	Temp	C	na	9.7	23.2	31	15	9.3	18.4	22.5	6	13.8	21.8	25.1	5	16.7	20.2	24.6	6	12	24	28	43	12.9	19.5	26.2	33
	TDS	mg/L	1000	5	28	630	16	88	126	160	6	124	160	922	5	92	129	220	6	75	168	296	46	90	205	605	33
	TSS	mg/L	10	-	-	-	-	3	**12**	**316**	6	3	11	292	5	4	**12**	**366**	4	2	8	**142**	5	-	-	-	-
Major Ions & Alkalinity	Bicarbonate Alkalinity ($CaCO_3$)	mg/L	na	65	100	820	16	54	112	150	6	56	111	150	5	55	118	157	6	87	114	130	6	55	125	280	22
	Chloride	mg/L	175	4	18	355	16	8	12.5	16	6	8	12	14	5	9	13.5	15	6	19	20.5	22	6	13	23	166	22
	Fluoride	mg/L	1	<0.1	0.1	1.4	12	<0.1	0.2	0.21	6	<0.1	0.17	0.21	5	<0.1	0.2	0.28	6	<0.1	0.13	0.23	6	<0.1	**1.2**	**1.3**	22
	Sulphate	mg/L	400	<1	5	170	12	<1	10	<10	6	<1	10	<10	5	<1	7.5	<10	6	<1	7.5	<10	6	<1	<1	64	22
	Calcium	mg/L	1000	5	16	85	16	1	15	21	6	1	14	26	5	1	14	19	6	7	10.8	17	6	4	21	91	22
	Magnesium	mg/L	na	2	5	67	16	2	7.5	9.2	6	2	7	11	5	<1	7.7	9.2	6	4	5.5	6.2	6	1	8	28	22
	Potassium	mg/L	na	2	5	10	16	3	3	5	6	3	3	6	5	2.3	3	5	6	3	3.2	6	6	2	2	9	22
	Sodium	mg/L	115	9	21	**280**	16	15	20.5	23	6	15	20	28	5	15	21	27	6	27	28	33	6	24	28	63	22
Nutrients	Ammonia (as N)	mg/L	0.02	<0.01	0.16	**0.24**	3	<0.01	**0.02**	**0.04**	4	<0.006		<0.01	3	<0.006		<0.01	3	<0.01	0.01	0.014	3	-	-	-	-
	Nitrate as NO_3	mg/L	na	0.1	1.2	4	9		<0.04		1		<0.04		1		<0.04		1		<0.04		1	-	-	-	-
	Total Phosphorous	mg/L	0.05	<0.01	**0.095**	**0.23**	5	<0.01	**0.05**	**0.58**	6	<0.01	**0.05**	**0.68**	5	0.02	**0.05**	**0.75**	5	<0.01	0.04	**0.28**	5	-	-	-	-
Metals	Boron	µg/L	370	<0.1	0.06	**800**	12	16	100	**400**	6	15	100	**400**	5	<0.1	7	**500**	6	<0.1	8	**600**	6	<100	<100	50	22
	Iron	µg/L	200	62	**1700**	**2358**	3	60		**1400**	3	66		**950**	3	23		**1200**	3	76		**390**	3	**140**	**1090**	**14900**	22
	Lead	µg/L	3.4	<1		2	2		<1		2		<1		2		<1		2		<1		2	<1	<1	**4**	22
	Zinc	µg/L	8	<10		1.5	2	<10		**17**	2	<1		<10	2	<1		<10	2	<1		<10	2	2.5	5	**21**	22

NOTES: **BOLD** Result greater than relevant MTV

^ for the purposes of calculating the median, where results are reported as less than the LOR a value of half the LOR has been adopted

Table 5-4 Differences in median water quality Dawson Bend and Yebna Crossing

WQ parameter	Units	Dawson Bend	Yebna Crossing	p	Sig
Electrical Conductivity	µS/cm at 25C	251	247	0.113	-
pH	Stand.	6.9	7.75	0.010	▲
Total Dissolved Solids	mg/L	129	168	0.1254	-
Total Suspended Solids	mg/L	12	8	0.462	-
Sodium	mg/L	21	28	0.010	▲
Potassium	mg/L	3	3	0.472	-
Calcium	mg/L	14.0	11.0	0.423	▼*
Magnesium	mg/L	7.5	5.5	0.066	-
Alkalinity as HCO3	mg/L	118	114	0.522	-
Chloride	mg/L	13.5	20.5	0.005	▲
Fluoride	mg/L	0.19	0.13	0.689	-

NOTES:

p indicates level of significance e.g. p=0.05 indicates a 95% chance that the medians are the different.

Sig indicates direction of statistically significant change.

* restricting data sets to coincident time pairs removes the significance of this result; all other results remain the same.

5.4 Existing impacts on water quality from discharge to grade

Sites that currently receive some associated water on Hutton, Baffle and the Dawson River generally exhibit similar characteristics to upstream sites, with the following exceptions:

Fluoride

At sites downstream of current associated water discharges, fluoride was detected marginally above the MTV. Fluoride occurs naturally usually in the form of the mineral fluorspar. The main environmental impacts related to fluoride compounds are in respect of hydrogen fluoride, which immediately converts to hydrofluoric acid on contact with moisture. Under normal ranges of pH in surface waters reaction to hydrofluoric acid is very unlikely to occur. It is unlikely that the concentrations of fluoride detected would cause significant environmental harm.

Sodium

Elevated concentrations of sodium were observed in the River Health Assessments (2004 to 2007) at Baffle Creek outflow predominantly and occasionally at Upper Hutton Creek (i.e. above petroleum operations) and Hutton Creek but not at other sites downstream.

Electrical Conductivity (Salinity)

Electrical conductivity is typically elevated at those sites that receive associated water compared with upstream sites. Readings in Baffle, Hutton and Dawson Rivers ranged from approximately 150 to 1800 µS/cm.

pH

Occasional high pH readings (pH=9) have been identified during river health sampling in Baffle Creek.

5.4.1 Minor Streamlines

A number of minor streamlines exist on the escarpment amongst the existing CSG operations. These streams typically only contain water during significant rainfall events and have few refugia. They are significantly degraded due to extensive land clearing, removal of riparian vegetation and stock access. The area is highly erosive, and unlimited stock access has denuded riparian vegetation, created erosion points, and provides direct nutrient inputs (Simmons and Bristow, 2007). Streamlines generally exhibit significant bank erosion and are incised in the landscape down to bedrock with slopes significantly greater than surrounding land contours. Some small depositional areas exist, but in general terms once rock has been reached the erosion toe moves upstream.

Due to the intermittent flows, widespread removal of riparian vegetation and active erosion in these streamlines it is highly probable that the ecosystems are under significant stress. In addition to this degradation, some streamlines have received associated water discharge to grade for the last 10 – 15 years. Associated water discharges contribute continuous releases of

low dissolved oxygen, high temperature and moderate salinity water. The status of these streamlines is therefore considered heavily disturbed and this has been supported by a rapid and qualitative ecological survey (URS unpub. data 2008). Further work is planned to assess whether there is a marginal decline in streamline condition between cleared streamlines and cleared streamlines receiving associated water discharges.

A detailed quantitative study into the impacts of associated water discharge on the ecological condition of these streamlines found the addition of associated water changes the streamline environment substantially (URS unpub. data). Streamlines were investigated during the 2008 dry season, where flow was comprised entirely of associated water discharge. Water immediately below the point of discharge was found to exhibit high temperatures and pH, and low dissolved oxygen and turbidity, often dominated by algae. Dissolved oxygen and temperature tended to equilibrate within approximately 500 m. EC remained stable, and pH increased downstream of the discharge point.

Diatoms, sensitive to changes in salinity and temperature, were selected as indicators of ecological health. Diatom diversity was found to be similar between control sites and sites upstream and downstream of associated water discharge. However, a significant difference in species assemblage was observed between upstream sites or control sites, and downstream sites.

5.4.2 Baffle Creek

Two water quality sampling sites have been monitored on Baffle Creek, one upstream and one downstream of associated water discharges. The upstream site exhibits significant variations in water quality between samples possibly suggesting that data may not all come from the same site, or that sporadic contamination of the waters occurs from some upstream activity.

Comparisons of upper and lower Baffle Creek data (Table 5-5) indicate highly significant ($p<0.01$) increases in median salinity, TDS, alkalinity, chloride and sodium downstream. Significant ($p<0.05$) increases in fluoride and boron also occur downstream. Significant ($p<0.05$) decreases in median temperature and magnesium are also observed between upstream and downstream sites.

5.4.3 Hutton Creek

There is insufficient data to allow a valid statistical comparison of upstream and downstream water quality condition along Hutton Creek. However, there is sufficient data to allow a pre (1985 or before) vs post (post 1985) associated water discharge comparison of water quality in Lower Hutton Creek (Table 5-6). Mann-Whitney U tests at 9% significance level identified a significant decrease in median pH and a significant increase in median potassium concentration post associated water discharge to Hutton Creek. No other significant differences in median concentrations/values were apparent.

Table 5-5 Comparison of upstream and downstream water quality Baffle Creek

Water Quality Parameter Type	Water Quality Parameter Name	Units	MTV	Upper Baffle Creek				Lower Baffle Creek				Comparison U/S to D/S	
				Min	Med	Max	n	Min	Med	Max	n	Sig	p
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	340	67	162	1901	27	188	1260	1864	29	▲	0.003
	pH	Stand	6.5-8.0	6.6	7.25	7.8	6	6.9	8.1	8.9	5	-	0.068
	Temperature	C		14	24	32.7	25	12	20	27	23	▼	0.034
	Total dissolved solids	mg/L	1000	43	126	1293	27	128	852	1168	29	▲	0.003
	TSS	mg/L	10	6	48	49	5	10	37	76	5	-	0.835
Inorganic Non-Metallic Parameters	Bicarbonate Alkalinity	mg/L ($CaCO_3$)	-	47	72	99	6	570	694	916	6	▲	0.005
	Chloride	mg/L	<175	<0.5	7	9	6	36	56	93	6	▲	0.005
	Fluoride	mg/L	1	<0.1	0.32	0.43	6	0	1	2	6	▲	0.031
	Sulphate	mg/L	400	<1		<10	6	<1	<10	24	6	-	0.522
Cations	Calcium	mg/L	1000	<1	1	15	6	<1	1	7	6	-	0.174
	Magnesium	mg/L		1.9	4	7	6	1	2	3	6	▼	0.037
	Potassium	mg/L		4.5	6	12	6	4	6	8	6	-	0.689
	Sodium	mg/L	<115	<1	8	17	6	162	290	437	6	▲	0.005
Nutrients	Ammonia-Nitrogen	mg/L	20					0.016	-	0.12	3	NA	-
	Nitrate-Nitrogen	mg/L						<0.01	-	<0.012	1	NA	-
	Phosphorus/Phosphate	mg/L - P	50					66	185	350	5	NA	-
Trace elements	Boron 2	µg/L	370	<0.1		500	6	200	450	700	6	▲	0.025
	Iron	µg/L	200	81		1800	3	1300	-	6362	3	-	0.190
	Lead	µg/L	3.4	<1	<1		2	<1	-	8	2	NA	-
	Zinc	µg/L	8	8.3		<10	2	3	-	14	2	NA	-

Table 5-6 Comparison of upstream and downstream water quality Hutton Creek

Water Quality Parameter Type	Water Quality Parameter Name	Units	MTV	Upper Hutton Creek				Lower Hutton Creek				Comparison U/S to D/S		Lower Hutton Creek comparison pre to post					
														Pre (<=1985)		Post (>1985)		Sig	p
				Min	Med	Max	n	Min	Med	Max	n	Sig	p	Med	n	Med	n		
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	340	156		1478	2	131	233	1294	16	NA	-		10		6	-	1.000
	pH	Stand	6.5-8.0	6.6		7.9	2	6.60	7.85	8.30	16	NA	-	7.95	10	7.2	6	▼	0.045
	Temperature	C						9.7	23.2	31.0	15	NA	-		9		6	-	0.377
	Total dissolved solids	mg/L	1000	190		1139	2	5	28	630	16	NA	-		10		6	-	0.704
	TSS	mg/L	10		570		1	-	-	-	-	NA	-		10		6	-	0.129
Inorganic Non-Metallic Parameters	Bicarbonate Alkalinity	mg/L - CaCO3	-		314		1	65	100	820	16	NA	-		10		6	-	0.914
	Chloride	mg/L	<175	6		267	2	4	18	355	16	NA	-		10		6	-	0.871
	Fluoride	mg/L	1	0.1		0.31	2	<0.1	0.1	1.4	12	NA	-		8		6	-	0.273
	Sulphate	mg/L	400	<1		120	2	<1	5.0	170	12	NA	-		9		6	-	1.000
Cations	Calcium	mg/L	1000	20		91	2	5	16	85	16	NA	-		10		6	-	0.129
	Magnesium	mg/L			16		1	2	5	67	16	NA	-		10		6	-	0.588
	Potassium	mg/L			9		1	2	5	10	16	NA	-	4.7	10	7.0	6	▲	0.020
	Sodium	mg/L	<115	14		133	2	9	21	280	16	NA	-		10		6	-	0.481
Nutrients	Ammonia-Nitrogen	mg/L	20		51		1	<.01	0.16	0.24	3	NA	-						
	Nitrate (as NO_3)	mg/L			0.17		1	0.1	1.2	4.0	9	NA	-						
	Phosphorus/Phosphate	mg/L - P	50		170		1	<10	95	230	5	NA	-						
Trace elements	Boron	µg/L	370	32		<100	2	10	50	800	12	NA	-		6		6	-	0.078
	Iron	µg/L	200		1900		1	62	1700	2358	3	NA	-						
	Lead	µg/L	3.4		4.8		1	<1		2	2	NA	-						
	Zinc	µg/L	8		1.5		1	<10		1.5	2	NA	-						

Notes for Table 5-5 and Table 5-6:

(shaded)	indicates observation exceeds MTV
Sig	indicates statistically significant difference in medians at the 95% confidence level using a Mann Whitney U Test. Mann-Whitney U Test used as tests on variance indicate possible differences.
p	indicates actual level of significance e.g. p=0.05 indicates a 95% chance that the medians are the different.
▲ and ▼	indicates a significant increase/decrease in median value
-	indicates no significant change in medians
U/S to D/S	indicates change is presented as from upstream to downstream
NA	Indicates insufficient data to complete the test

5.4.4 Dawson River at Utopia

The only significant differences in pre to post associated water discharge median spot water quality are as shown in Table 5-7 (Mann-Whitney U test, 95% significance).

Table 5-7 Significant differences in median water quality - Dawson R at Utopia

WQ Parameter	Units	Median (1964 – 1985)	Median (1985 – 2007)	p	Sig
Electrical Conductivity	μS/cm at 25C	311	284	0.0090	▼
Total Dissolved Solids	mg/L	173	153	0.0019	▼
Calcium	mg/L	20.5	16.0	0.0000	▼
Magnesium	mg/L	7.50	6.00	0.0008	▼
Alkalinity as HCO3	mg/L	150	127	0.0000	▼
Chloride	mg/L	29.0	24.0	0.0017	▼
Sulphate	mg/L	3.30	1.72	0.0001	▼
Boron	μg/L	20	100	0.0024	▲

Where:

p indicates level of significance e.g. p=0.05 indicates a 95% chance that the medians are different.

Sig indicates direction of statistically significant change

5.4.5 Continuous Salinity Data

Simultaneous continuous streamflow, temperature and EC data have also been collected by DNRW at the Dawson River at Utopia Downs site for 10 years (1997 – 2007).

Mean EC is 280 +/- 140 μS/cm and median EC is 289 μS/cm suggesting little skew in the data. This is confirmed by Figure 5-1 which shows a reasonably symmetric distribution of hourly EC readings.

The range of observed EC is significant. Minimum recorded EC is 57 μS/cm and maximum is 800 μS/cm. The 90% confidence interval for the data is 163 – 396 μS/cm.

Existing Environment - Water Quality

There is evidence of a statistically significant but small reduction in spot EC pre to post associated water discharge (Table 5-7). However, the symmetry of the hourly distribution of continuous EC data and the lack of an obvious step change or trend in hourly EC time *series (*Figure 5-2) suggests this change may be due to sampling bias rather than the influence of associated water discharges.

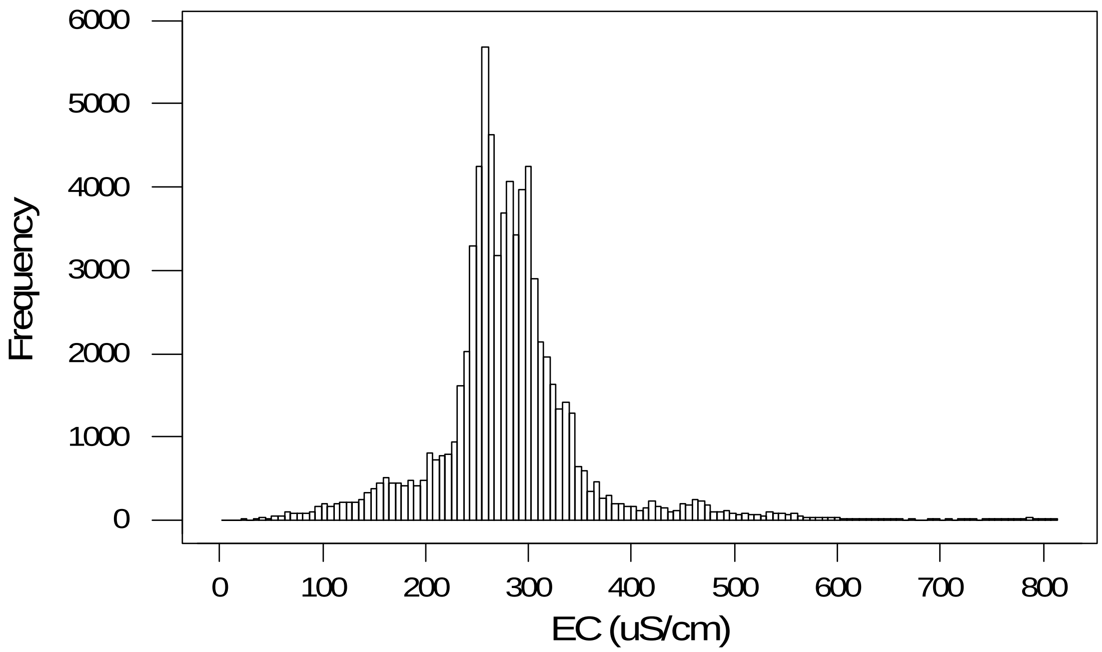


Figure 5-1 Distribution of Hourly Electrical Conductivity, Dawson R at Utopia

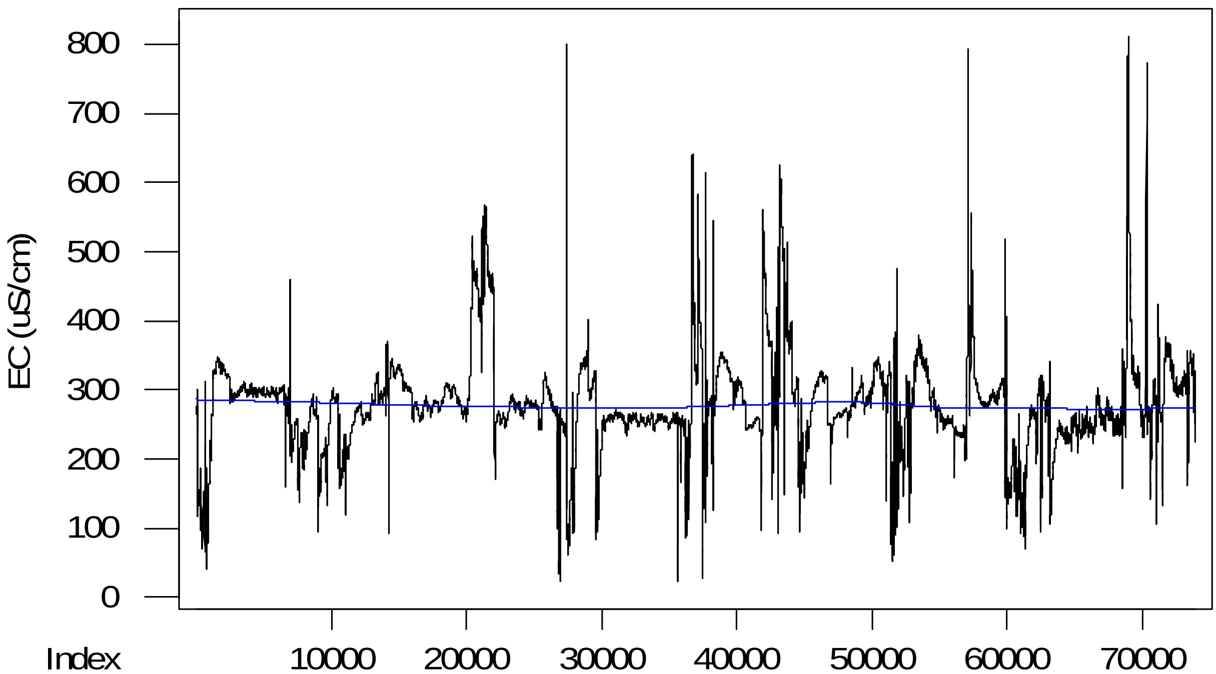


Figure 5-2 EC Time Series Record Dawson River at Utopia Downs, 2003 – 2007

Section 5 Existing Environment - Water Quality

Differences in the binomial proportions of MTV exceedances for electrical conductivity and suspended solids pre- and post-establishment of Tipperary in 1985 were examined at Utopia. The analysis showed there was no statistically significant difference in observations before or after the establishment of Tipperary for both parameters and suggests sufficient dilution exists within the river system to maintain downstream water quality at Utopia under existing associated water discharges.

Significant dilution of salinity occurs on the rising limb of hydrographs during the passage of floods and freshes; sometimes reaching as low as ~60 µS/cm. EC returns to pre-event levels over a period of 20 days or so as flows progressively becomes dominated by interflow, spring flow and/or baseflow. These behaviours are demonstrated in Figure 5-3.

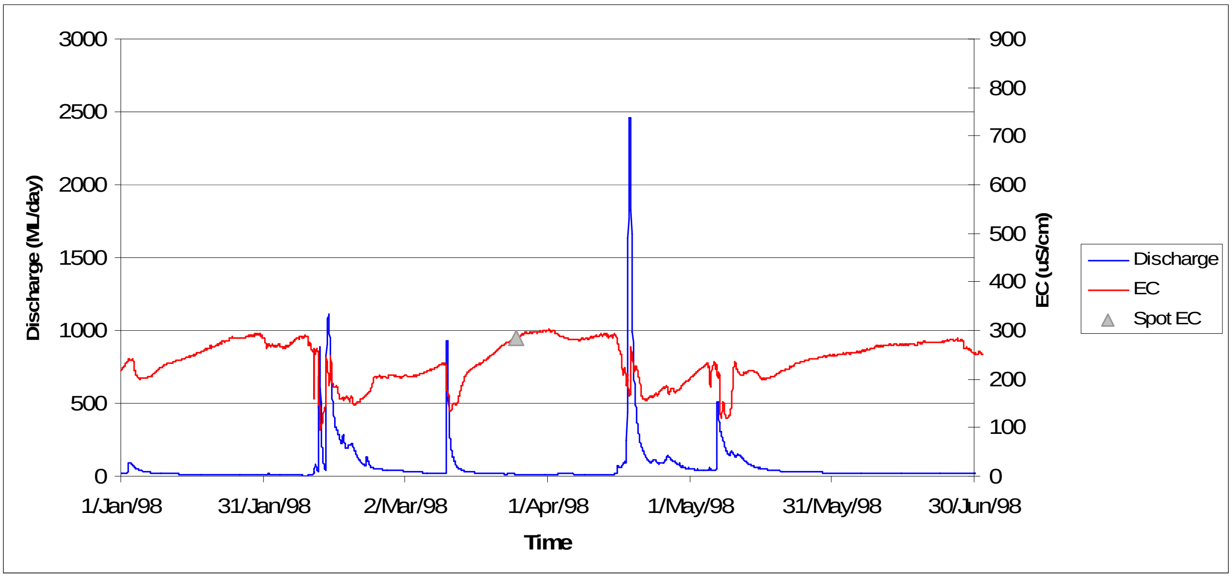


Figure 5-3 Dawson River at Utopia Downs EC and Flow Relationships

5.4.6 Continuous Water Temperature Data

There is a strong seasonal and diurnal range of temperature in the Dawson River at Utopia where a range of 7C to 34C has been observed (Figure 5-4).

In the Dawson River at Taroom a water temperature range of 8C to 26C has been observed with similar seasonal patterns to those at Utopia Downs.

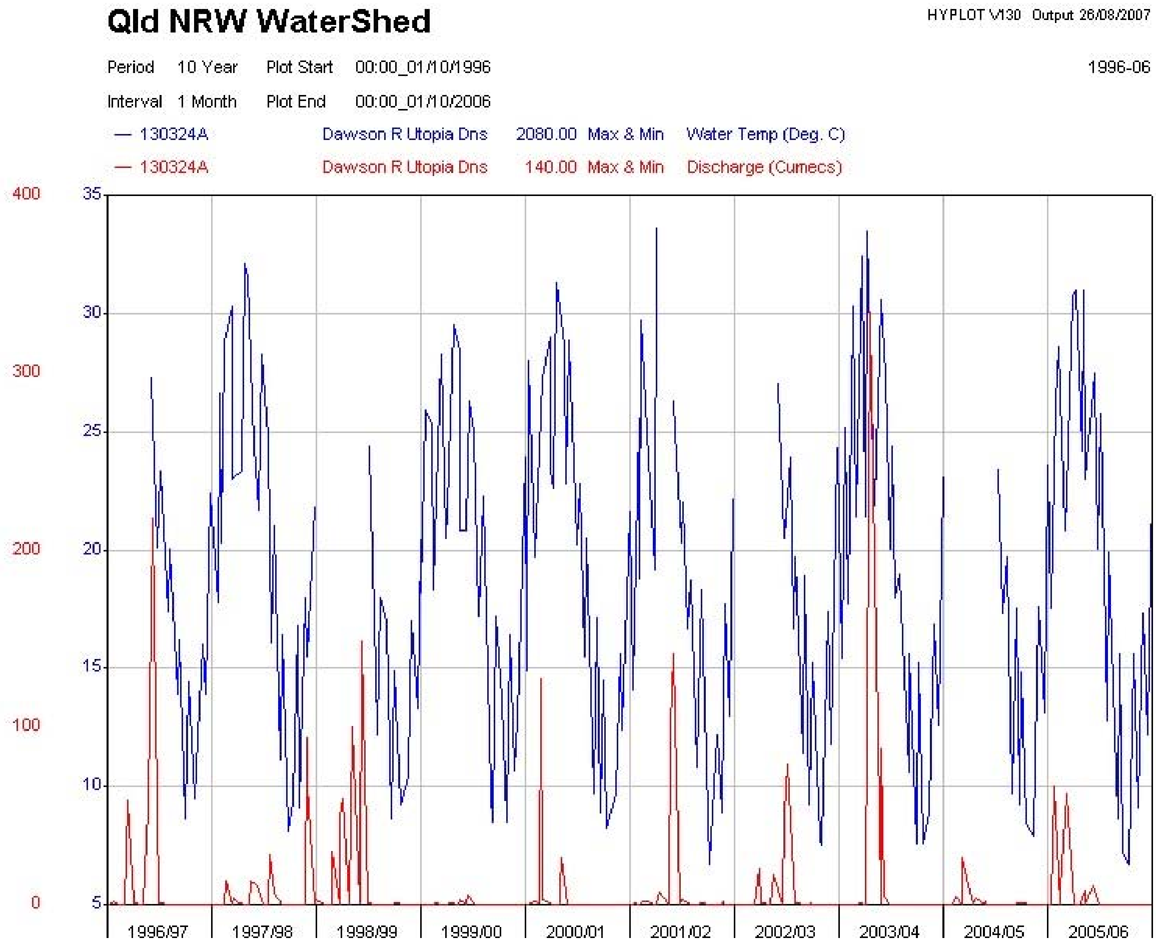


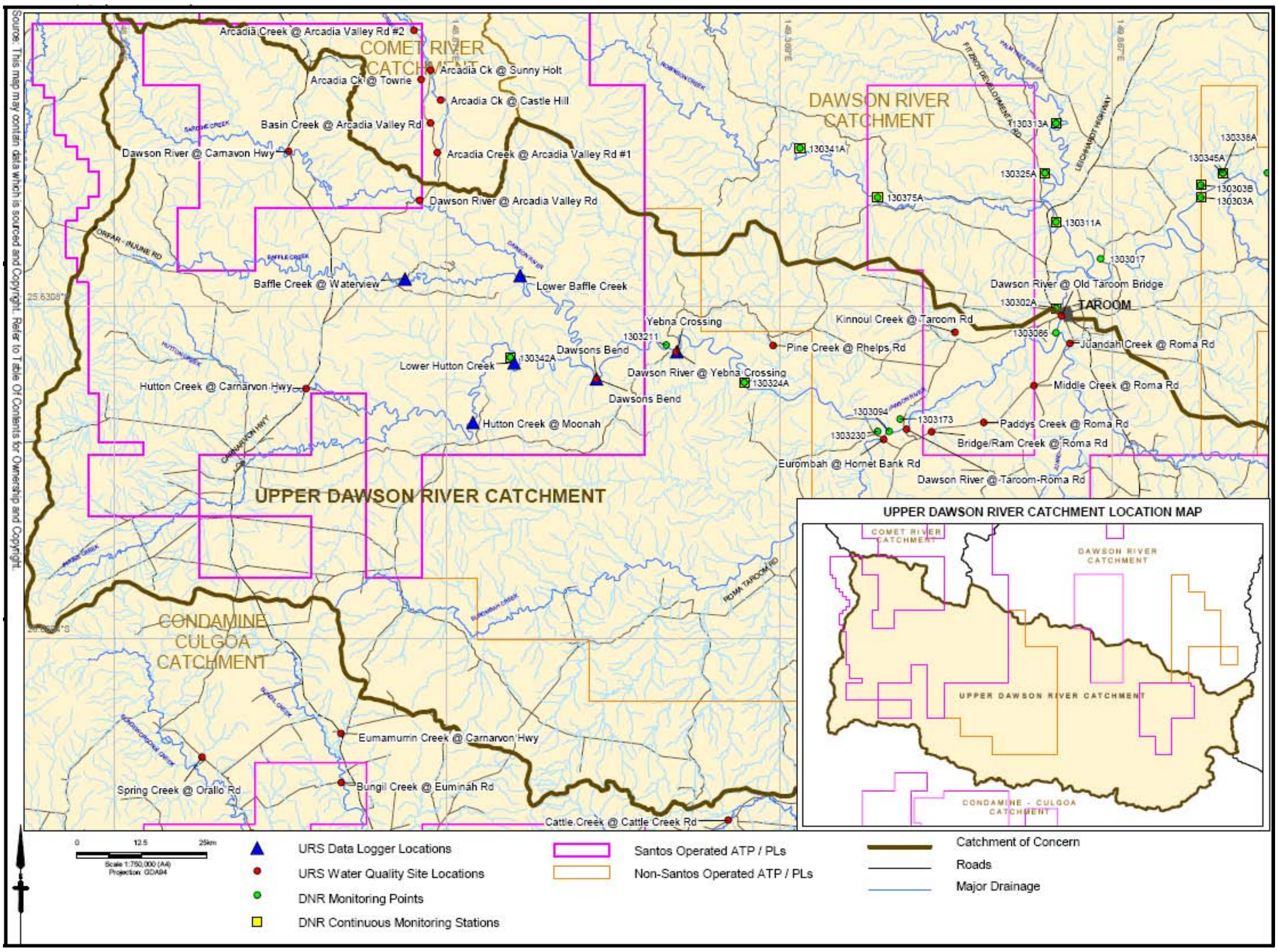
Figure 5-4 Water Temperature and Flow at Dawson River at Utopia Downs

5.4.7 Continuous Water Quality Data at Fairview

URS temporarily deployed six Hydrolab™ data loggers in Baffle and Hutton Creeks, and two locations in the Dawson River, as shown in Figure 5-5 and summarised in Table 5-8 below.

The instruments recorded continuous (1/2 – 1 hourly) measurements between June through Augsut 2008 (ongoing) of EC, pH, DO, turbidity, temperature and relative depth. Prior to initial deployment the instruments were calibrated using standardised solutions. At approximately six week intervals data sets were downloaded, the instruments cleaned, calibrated and re-deployed. Independent water quality measurements were taken for quality control purposes each time the instruments were redeployed using a TPS90FLT multi-parameter water quality instrument.

Section 5 Existing Environment - Water Quality



NB 1 cumec = 86.4 ML/day

Figure 5-5 Water Temperature and Flow at Dawson River at Utopia Downs

Table 5-8 Data Logger Site Locations

Site Name	Easting	Northing	Upstream/Downstream AW Discharge
Baffle Creek @ Waterview	681640	7168024	Upstream
Lower Baffle Creek	698965	7168306	Downstream
Hutton Creek @ Moonah	691576	7146417	Upstream
Lower Hutton Creek	697890	7155260	Downstream
Dawson's Bend	710193	7152667	Downstream
Yebna Crossing	722336	7156534	Downstream

Hutton Creek

EC concentrations in Hutton Creek downstream of associated water discharges are approximately 300µS/cm higher than recorded upstream, and show less variation during floods (Figure 5-6). Conversely pH at both sites is circumneutral, with levels at both sites within 0.5 units.

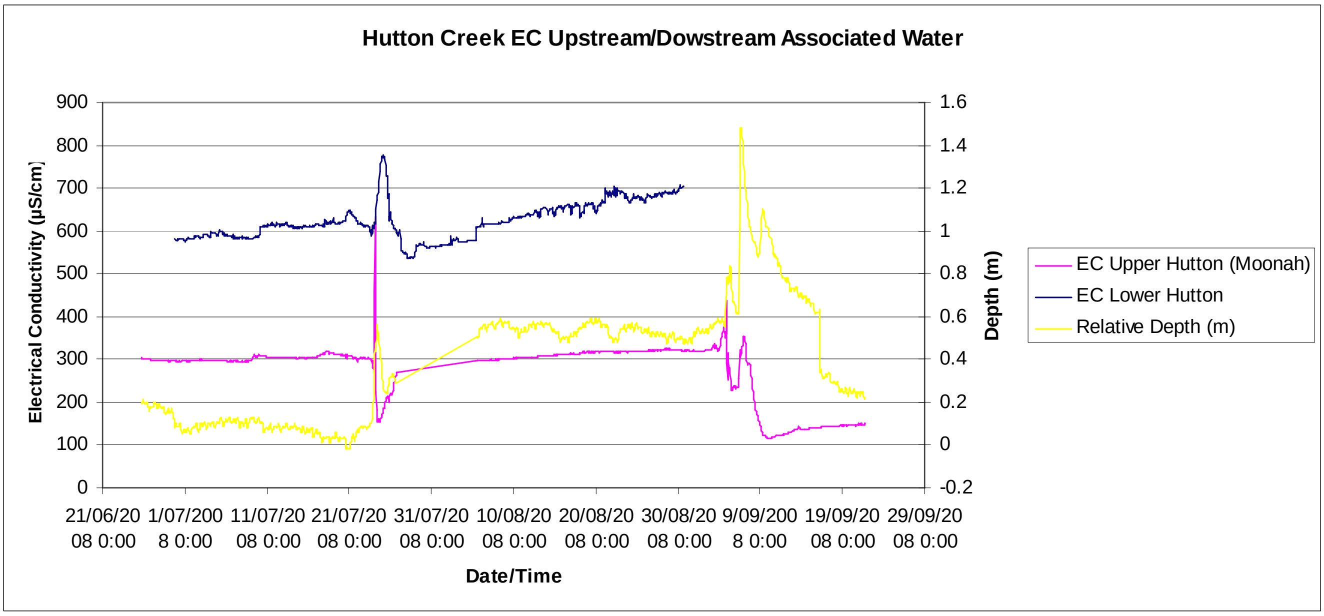


Figure 5-6 Comparison of EC levels upstream and downstream of associated water discharge in Hutton Creek, July – September 2008

Baffle Creek

Electrical conductivity and pH at a site downstream of associated water discharge (Lower Baffle Creek) are consistently higher than upstream (Baffle Creek at Waterview). Comparison of concentrations of EC and pH between the two sites are shown in Figure 5-7 below.

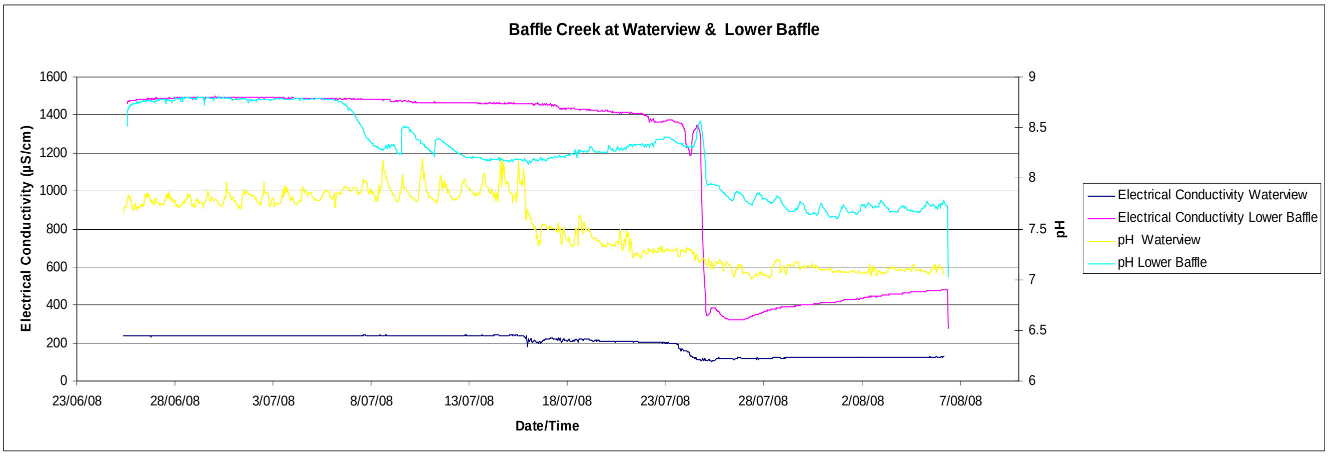
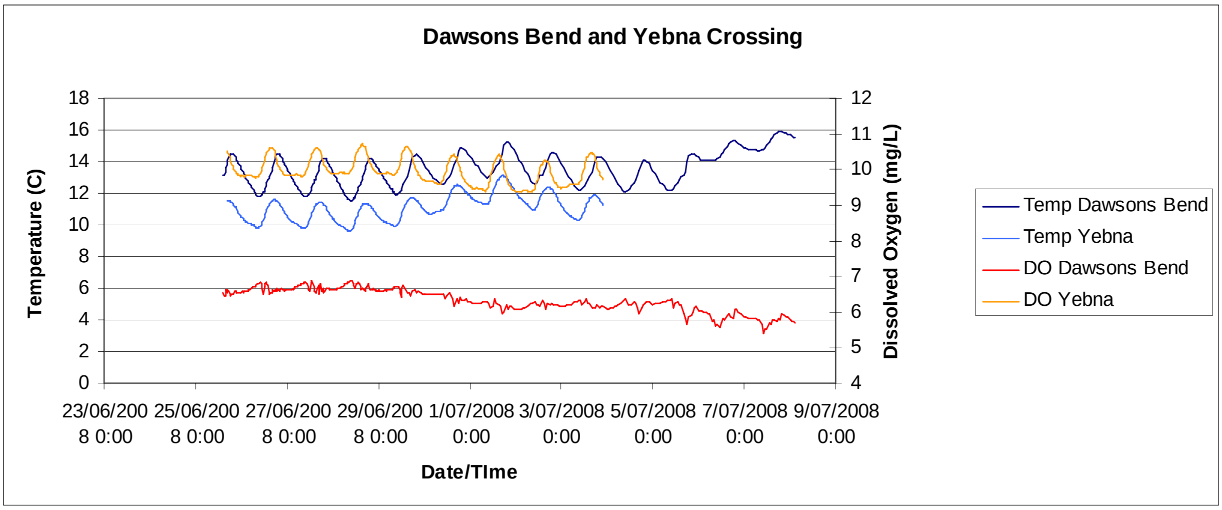


Figure 5-7 Comparison of Upstream/Downstream Baffle Creek EC and pH

Dawson River at Dawson's Bend and Yebna Crossing

Comparison of EC, pH, DO, temperature, turbidity and Eh measurements collected at Yebna Crossing and Dawsons Bend indicates:

- DO and temperature fluctuate diurnally (Figure 5-8). DO measurements at Dawson's Bend are lower and temperature is higher than at Yebna Crossing. DO generally decreases with increasing temperature, consistent with these observations. The higher temperatures recorded at Dawsons Bend may be attributed to the influence of springs, as discussed in Section 22 above.



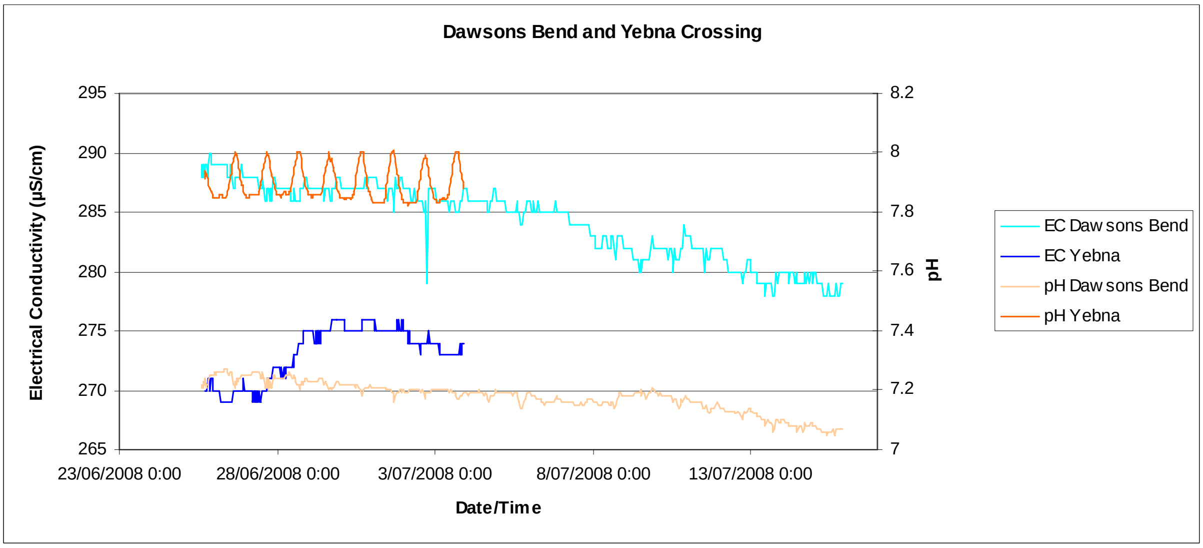


Figure 5-8 Dawson's Bend and Yebna Crossing Temperature and DO Levels

- EC is reasonably consistent at each site Figure 5-8. Although slightly higher at Dawson's Bend than at Yebna Crossing, levels are well within the expected range of variability for EC measurement.
- pH is reasonably consistent at each site, but is consistently higher at Yebna Crossing than at Dawsons Bend.
- Turbidity is variable, largely fluctuating in accordance with varying depth. An increase in turbidity is noted at both sites following a rainfall event.

5.4.8 Water Quality Profiles

Associated water has comparatively high salinity, pH and temperature when compared with the average existing surface water environments. An area of concern therefore is the potential for stratification of the water column in deeper ponded waters receiving associated water discharge. To assess for the presence of halocline (a strong vertical salinity gradient) or thermocline (temperature gradient) vertical profiles were taken at sites downstream of associated water discharges on Baffle Creek and Hutton Creek, and at Dawsons Bend on the Dawson River.

In the thalweg of each ponded area quality parameters including EC, temperature, pH, turbidity, EC, DO and redox were measured at roughly 0.1 m vertical intervals using a Hydrolab™ data logger.

A minimum of two profiles were logged at each location. The deepest profile has been graphed from each site below for comparative purposes. The trends exhibited for each indicator are generally similar for all profiles at a particular site.

Hutton Creek

Profiles collected from Hutton Creek upstream and downstream of associated water discharge are presented in Figure 5-9 below. Distinct differences are evident between the two sites. With the exception of redox potential (Eh) all parameters in the upstream site (Upper Hutton) remain relatively constant with increasing depth. In the Lower Hutton Creek site, however, DO levels decline sharply between 1-2 m depth before stabilising at less than 1 mg/L, a level likely to result in substantial impacts to the aquatic environment. Within the same depth interval EC follows an increasing trend. Eh levels do not mirror the declining DO concentrations as would be expected; the reason for this is not known. pH remains reasonably stable and temperature both show a moderate decline.

The extremely low DO levels suggest that associated water discharge is impacting the aquatic environment during periods of low to no flow. This is only the case during the dry season; periods of high flow will remove any stratification.

Existing Environment - Water Quality

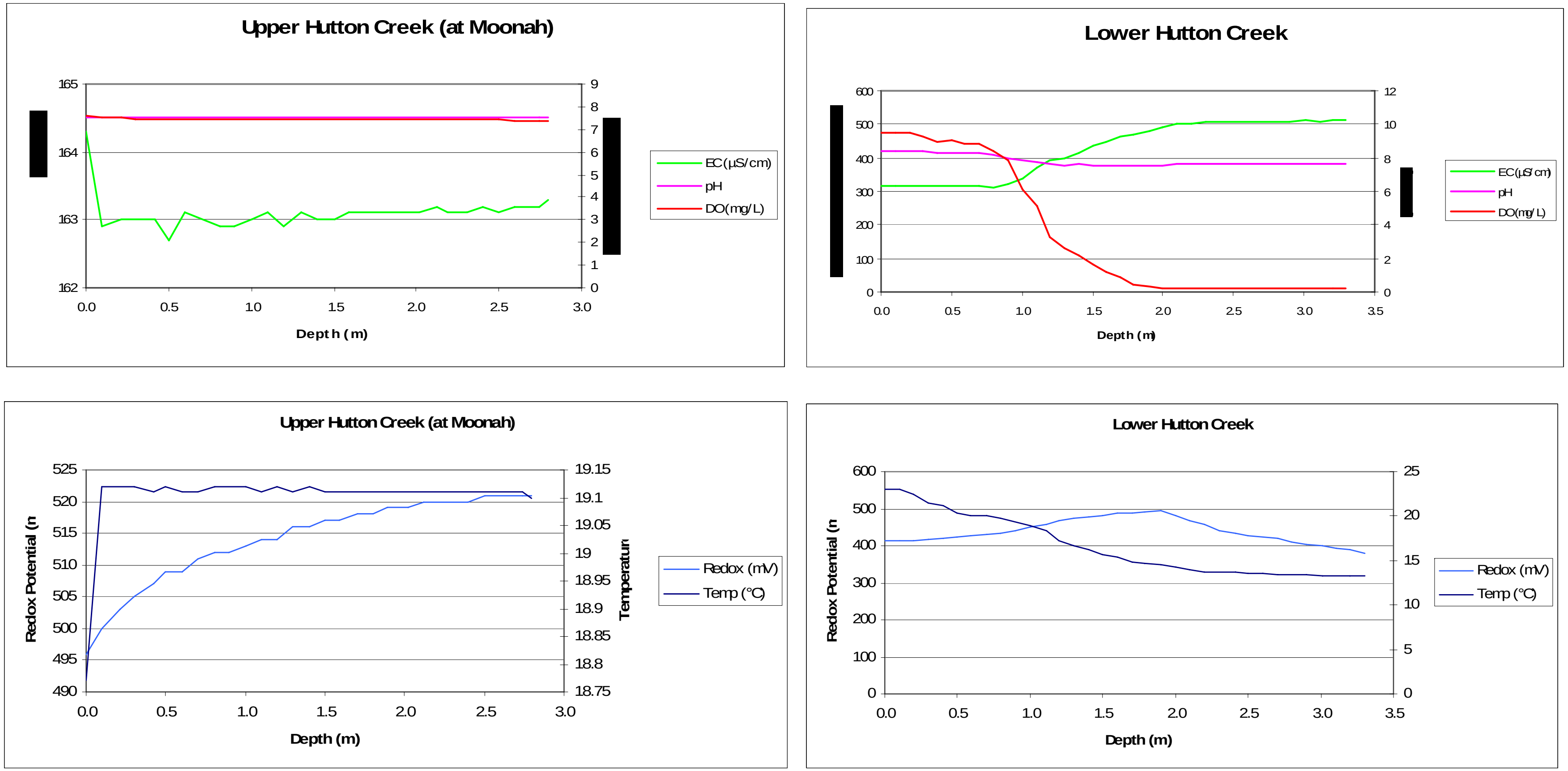
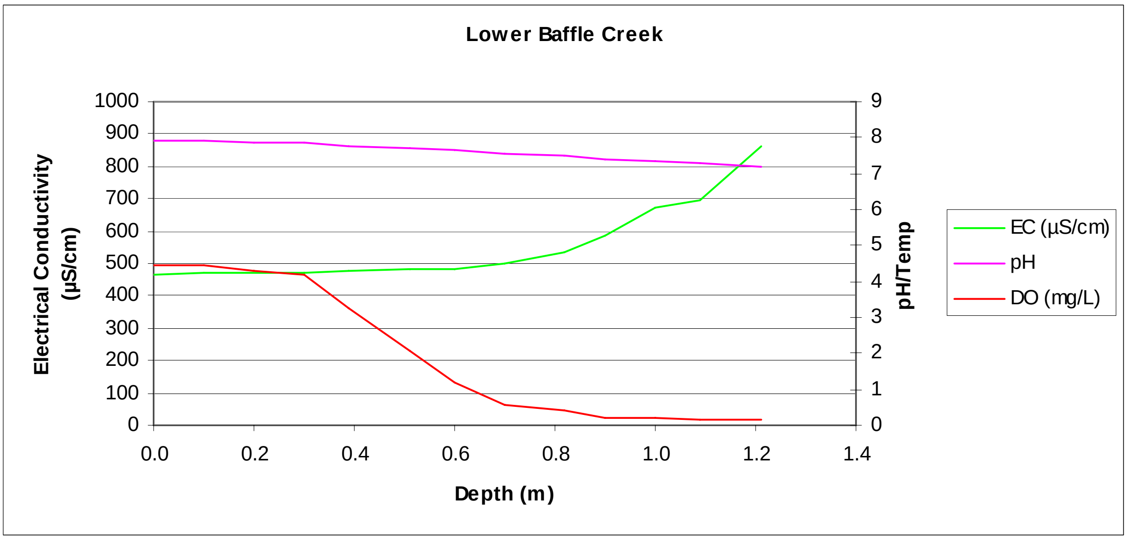


Figure 5-9 Hutton Creek vertical profiles upstream/downstream of associated water discharge

Baffle Creek

Measurement of water quality parameters through a vertical profile was undertaken in a pool located near the outflow of Baffle Creek to Dawson River. Figure 5-10 shows that EC increases with increasing depth, whereas pH and temperature shows a decreasing trend. The temperature gradient is gradual with no indication of a thermocline. More substantial increases in EC are noted from approximately 0.8 m depth. DO shows a sharp decline with depth, reaching levels that would be expected to severely affect the survival of biological communities and result in fish kills. Redox potential (Eh) also decreases with increasing depth, likely as a result of decreasing DO levels.



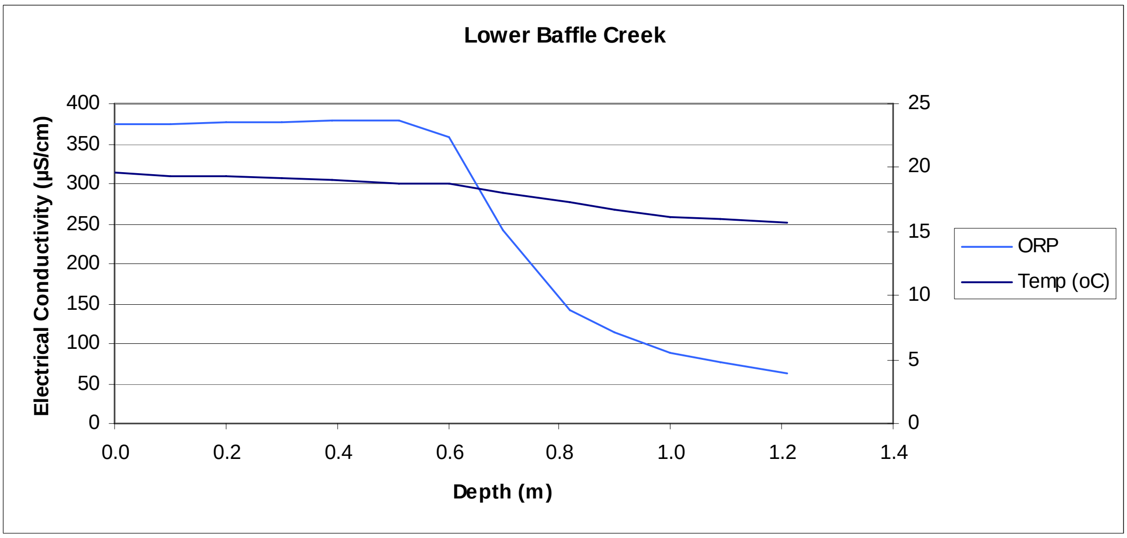
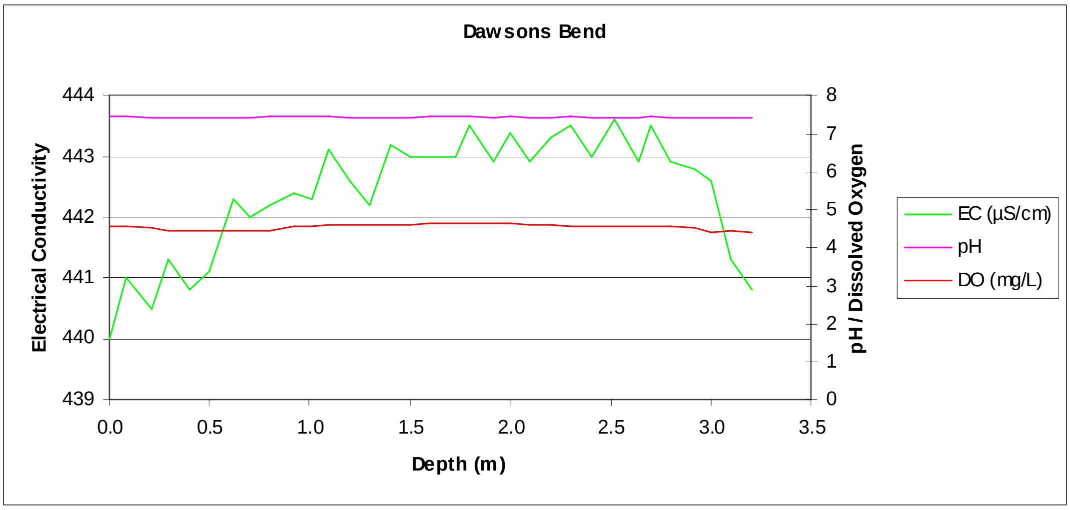


Figure 5-10 Lower Baffle Creek vertical profile

Dawsons Bend

Vertical profiles of water quality parameters taken at Dawsons Bend indicate less variability when compared with sites on Baffle and Hutton Creeks downstream of associated water discharges. Levels of EC, pH and DO remain reasonably stable. Eh and temperature show a slight increase/decrease within the range of expected natural variability (Figure 5-11).



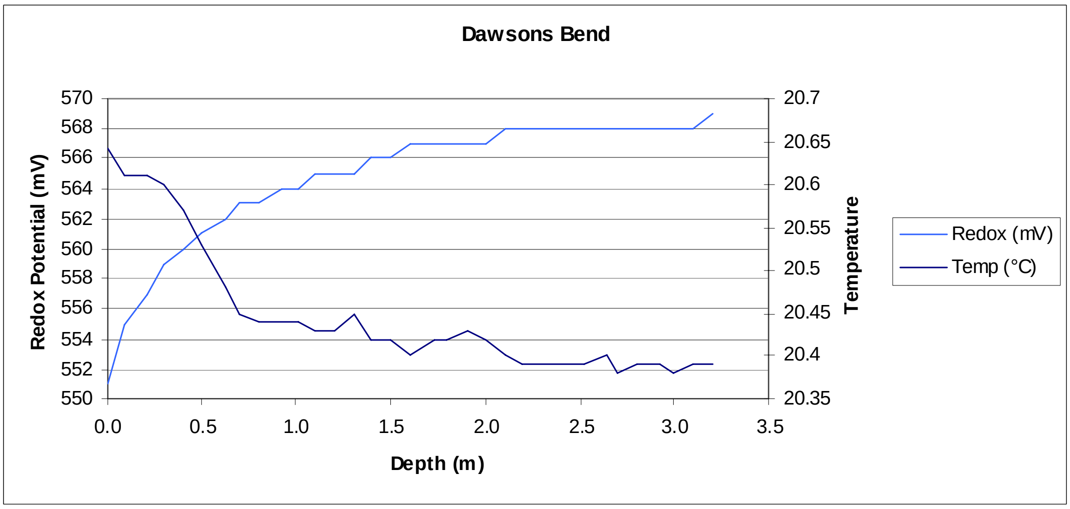


Figure 5-11 Dawson River at Dawsons Bend vertical profile

6.1 River Health of Major Streams

River health sampling has been undertaken from pool and edgewater habitats at a range of sites across the Fairview area since 2003 (EnviroTest various, Simmonds and Bristow 2007 & 2008). Sites sampled include control sites upstream of impacts, and sites down the Dawson River in an attempt to assess any longitudinal changes in river health (Figure 6-1).

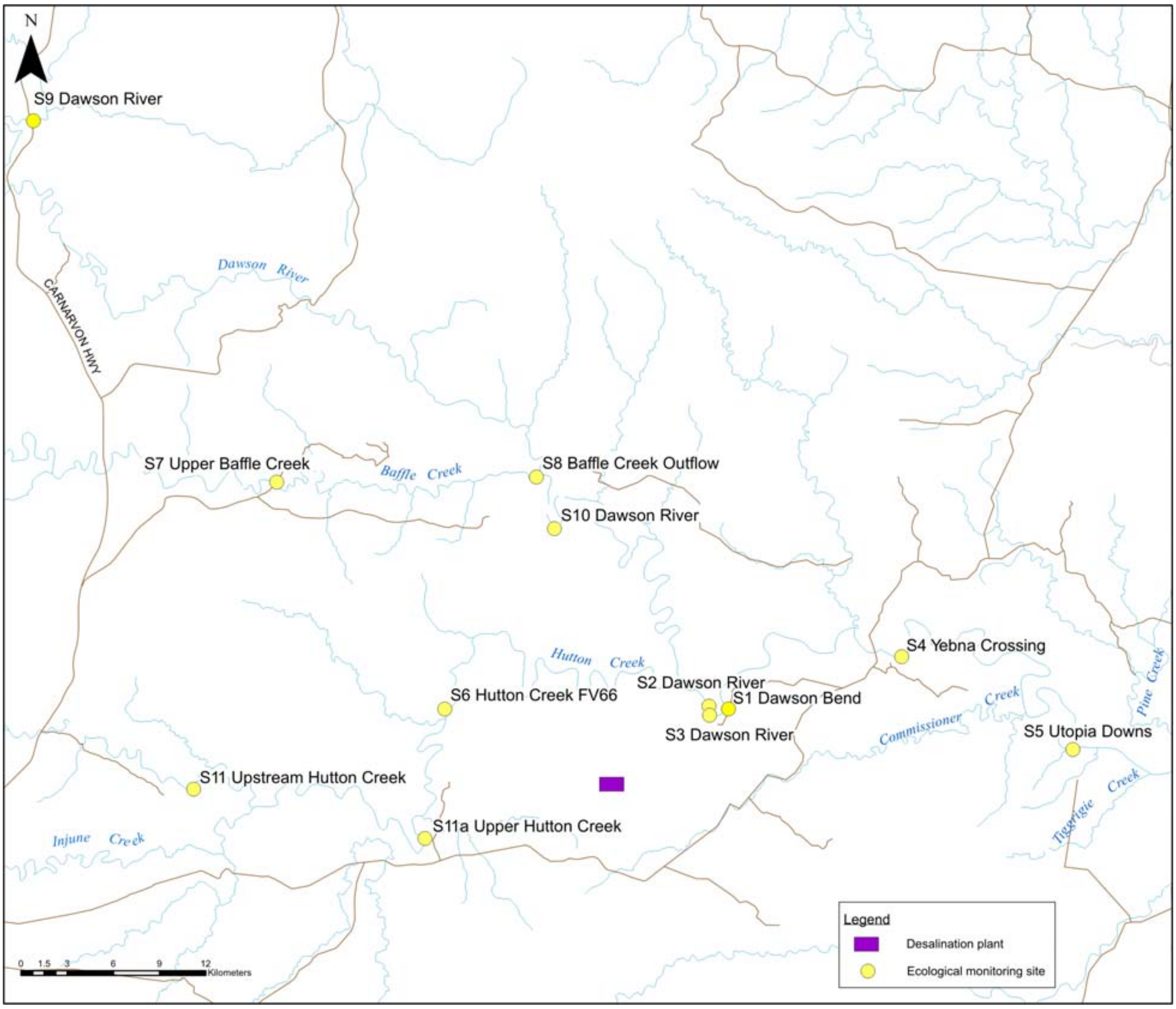


Figure 6-1 River health sampling sites at Fairview

The AusRivas macroinvertebrate and habitat sampling methodology and models developed under the National River Health Program are used. These models assign samples to various river health “bands” based on the fauna observed at a site compared with fauna predicted to be at that site based on habitat and other physical characteristics. Predictions of fauna are made on the basis of an analysis of fauna observed at ”reference condition” sites. Thus predicted fauna represent the fauna that would be expected to be at the sampling site if it were in reference condition. Models are seasonal and sampling habitat based (e.g. pools, edgewaters).

Section 6 Existing Environment - River Health

River health bands are defined in relation to reference condition as shown in Table 6-1. Calculated AusRivas bands are shown in Table 6-2.

Table 6-1 AusRivas river health bands

Band	Condition class	Description
X	Richer than reference	O/E greater than 90th percentile of reference sites
A	Equivalent to reference site	O/E within range of central 80% of reference sites
B	Below reference	O/E below 10th percentile of reference sites (same width as Band A)
C	Well below reference	O/E below Band B (same width as Band A)
D	Impoverished	O/E below Band C down to zero

Table 6-2 AusRivas model bands for spring and autumn samples Sep 03–Apr 07

Edge Habitats Site	Season Date	Spring 03 Sep-03	Autumn 04 Apr-04	Spring 04 Nov-04	Autumn 05 May-05	Spring 06 May-06	Autumn 07 Apr-07
Upstream petroleum activities							
Upper Baffle Creek		-	-	-	C	B	C
Dawson River Waterhole		-	-	-	-	-	-
Dawson River Road Crossing		-	-	-	-	B	B
Upper Hutton Creek		-	-	-	-	-	B
Downstream petroleum activities							
Baffle Creel		-	-	-	-	-	-
Baffle Creek outflow		-	C	C	C	C	B
Hutton Creek 500m upstream Dawson confluence		-	-	-	B	-	-
Hutton Creek		-	-	-	-	-	-
Hutton Creek FV66		-	C	-	C	C	C
Dawson River Hutton Creek outflow		-	-	-	-	-	C
Dawson River downstream Hutton Creek 1		-	C	B	B	C	B
Dawson River downstream Hutton Creek 2		-	-	C	B	C	B
Dawsons Bend		-	-	B	B	B	C
Yebna Crossing		-	C	C	C	B	B
Utopia Downs		-	-	-	C	C	B

Pool habitats Site	Season Date	Spring 03 Sep-03	Autumn 04 Apr-04	Spring 04 Nov-04	Autumn 05 May-05	Spring 06 May-06	Autumn 07 Apr-07
Upstream petroleum activities							
Upper Baffle Creek		C	D	B	-	C	C
Dawson River Waterhole		C	C	D	-	-	-
Dawson River Road Crossing #2		-	-	-	-	B	C
Upper Hutton Creek		C	-	-	-	-	B
Downstream petroleum activities							
Baffle Creek		C	-	-	-	-	-
Baffle Creek outflow		C	C	D	C	B	C
Hutton Creek 500m upstream Dawson confluence		-	-	-	-	-	-
Hutton Creek		C	-	-	-	-	-
Hutton Creek FV66		-	C	C	C	C	C
Dawson River Hutton Creek outflow		-	-	B	-	-	C
Dawson River downstream Hutton Creek 1		-	C	C	-	C	C
Dawson River downstream Hutton Creek 2		-	C	-	C		D
Dawsons Bend		C	C	C	C	C	B
Yebna Crossing		C	C	C	C	C	C
Utopia Downs		-	-	-	C	C	A

Single season models were used to assign sites to AusRivas bands in Table 6-2.

Band assignment varies significantly from year to year for sites both upstream and downstream of associated water discharges. Macroinvertebrate fauna are sensitive to a range of factors including changes in habitat, baseline and event based water quality, and flow conditions.

Recent advice from DNRW is that the AusRivas models for Central Queensland should not be used at this time since they have been found to be inaccurate. Additional work is being completed to update models over the next few years. Despite this warning, data was analysed using AusRivas models for comparative purposes as discussed below.

Since combined season models are usually considered more robust that individual season models the observed to expected (O/E50) ratios from each site were compared to identify any statistically significant changes in median O/E50 scores using Mann-Whitney U Tests at the 95% significance level. O/E50 scores were calculated for Spring/Autumn models for both edgewater and pool habitats.

Table 6-3 Significant O/E ratio shifts between sites

Combined Seasonal Model	Upstream Site	Downstream Site	Direction of Change
Edgewater	Baffle Creek Outflow	Dawsons Bend	▲
Pool	Hutton at FV66	Dawson at Utopia	▲
Pool	Dawson at Yebna	Dawson at Utopia	▲
Edgewater	Hutton at FV66[1]	Dawson u/s Hutton	▲
Edgewater	Hutton at FV66	Dawson at Yebna	▲

Note: 1) Hutton at FV66 is not upstream of Dawson u/s Hutton.

These results suggest that Hutton Creek at FV66 has a significantly lower river health than downstream and upstream sites on the Dawson River. There is some evidence to indicate that river health in Baffle Creek is lower than in the Dawson River, at least at Dawsons Bend. Furthermore, there is evidence to support improvement in river health between Dawson River at Yebna Crossing and Dawson River at Utopia.

Despite the limitations of the AusRivas models, and taking into account the characteristics of associated water discharges and the comparison of water quality parameters between sites in Section **Error! Reference source not found.**, it appears that there is some evidence for river health impacts arising from associated water discharges in Baffle Creek and Hutton Creek. These changes are subtle and are not reflected in general AusRivas bands. In general the data sets are minimal and the differences may simply arise from sampling variability.

Changes in O/E50 between Yebna Crossing and Utopia Downs are more likely to be associated with habitat change between the sites, or from sampling variability due to the low sample numbers.

6.2 River Health of Minor Streamlines Receiving Discharge

A number of minor streamlines exist on the escarpment amongst the existing CSG operations. These streams typically only contain water during significant rainfall events and have few refugia. They are significantly degraded due to extensive land clearing, removal of riparian vegetation and stock access. The area is highly erosive, and unlimited stock access has denuded riparian vegetation, created erosion points, and provides direct nutrient inputs (Simmons and Bristow, 2007). Streamlines generally exhibit significant bank erosion and are incised in the landscape down to bedrock with slopes significantly greater than surrounding land contours. Some small depositional areas exist, but in general terms once rock has been reached the erosion toe moves upstream.

Due to the intermittent flows, widespread removal of riparian vegetation and active erosion in these streamlines it is highly probable that the ecosystems are under significant stress. In addition to this degradation, some streamlines have received associated water discharge to grade for the last 10 – 15 years. Associated water discharges contribute continuous releases of low dissolved oxygen, high temperature and moderate salinity water. The status of these streamlines is therefore considered heavily disturbed and this has been supported by a rapid and qualitative ecological survey (URS unpub. data 2008). Further work is planned to assess whether there is a marginal decline in streamline condition between cleared streamlines and cleared streamlines receiving associated water discharges.

The nature of associated water discharges is preferential to algal or slime growth. A number of streamlines currently receiving associated water discharges contain filamentous algae and slime mats in channel. Limited impacts are evident on riparian vegetation except in some limited cases where some tree roots appear to have been drowned.

There is some evidence to suggest that the ecological impacts of associated water discharges are temporary. Where discharge has been halted, riparian vegetation and streamlines superficially appear no different to surrounding areas. Additional work is required to confirm this.

6.3 River Health of Other Minor Streamlines

General observation of other minor streamlines in agricultural areas supports the view that widespread clearing of vegetation and unrestricted stock access places the streams under significant stress. Together with the intermittent flows experienced in the area the streamlines can be categorised as heavily impacted.

Streams that maintain their riparian vegetation exhibit less erosion and a greater diversity of fauna and flora (URS unpub. qualitative data, 2008) than agricultural streams. Few water refugia are evident.

As part of an investigation into Pony Hills Water Treatment Plant permeate discharges near FV77, Simmonds and Bristow (2007b) completed a rapid ecological assessment of a minor streamline discharging to Hutton Creek. This survey was undertaken shortly after significant rainfall in the area.

The tributary rises approximately 130m above its confluence with Hutton Creek as shown in the elevation vs distance graph in Figure 6-2.

The tributary is certainly ephemeral and probably intermittent. It flows predominantly northeast and northwest before discharging into Hutton Creek approximately 8km from the proposed discharge point. Riparian vegetation is relatively intact in the vicinity of the proposed permeate discharge point near FV77, though dominated by weed species. Despite the good vegetation coverage and the presence of boulders local erosion of stream banks is evident.

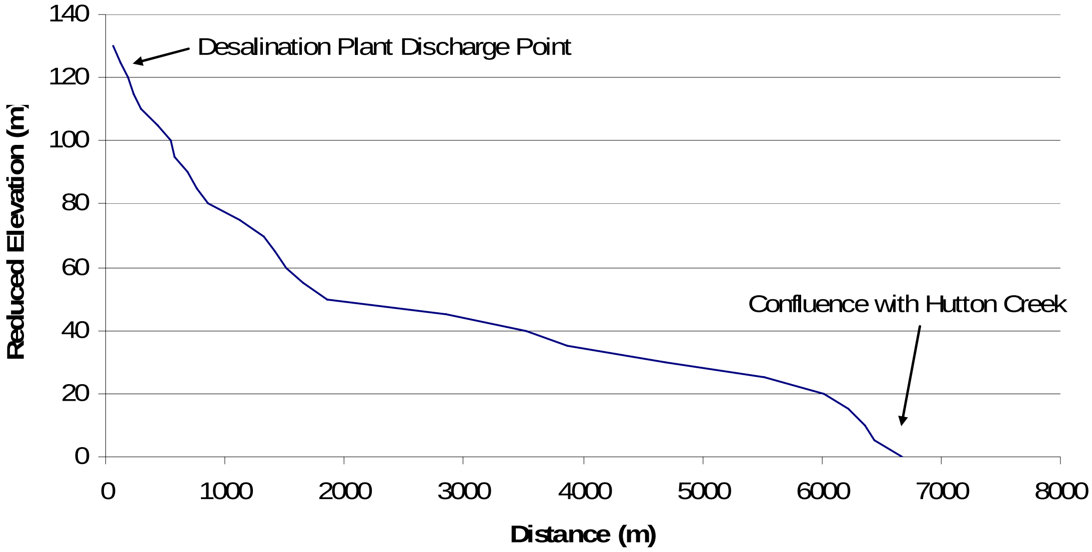


Figure 6-2 Elevation profile unnamed tributary of Hutton Creek near FV77

From the discharge point the tributary follows an incised valley to the mid-stream sections approximately 1.5 km downstream. From this point riparian and catchment vegetation has largely been cleared and the stream is subject to stock access. There is also evidence of channel works with a number of straight sections identified (S. Anderson *pers. comm.*). The reach extending from the discharge point is generally narrow (1 – 3 m), with occasional pools. The substrate ranges from silty clay, sand with cobbles, boulders and bedrock, tending to sandy cobbles and sandstone towards the Hutton Creek outflow. Stream banks are undercut and show evidence of scouring and sand deposition.

Riparian vegetation along the tributary is predominantly comprised of native and exotic grasses and other weed species, which provide some shading of the waterway. The highest density of weed species occurs in the upper reaches of the tributary. Adjacent to Hutton Creek the riparian zone broadens and the tributary feeds into a spring or billabong system dominated by wetland species.

Habitat types along the northern reaches of the tributary are limited to flat water or shallow pools, with refuges provided by fallen trees and trailing vegetation. A diverse macroinvertebrate population was observed along the northern reaches of the tributary. The spring/billabong system near the Hutton Creek outflow provides significant habitat for wetland flora and fauna. A rapid flora and fauna survey of the tributary did not identify any endangered species, though potential supporting habitats were observed (BooBook, 2007).

No rare or threatened fauna or flora were encountered, and no endangered regional ecosystems or ecological communities occur within or in close proximity to the watercourse.

Fifty-eight vertebrate species were recorded including 45 birds, 4 mammals, 4 reptiles, 4 amphibians and one fish. One scheduled threatened species was detected – the squatter pigeon listed as vulnerable under the Nature Conservation Act 1992 and Environment Protection and Biodiversity Conservation Act 1999. A small flock of white squatter pigeons was flushed from the ground in white cypress pine/eucalypt woodland beside a temporary pool at One site. Another pair of squatter pigeons was flushed from the bank of the watercourse.

Section 6 Existing Environment - River Health

Habitats within and adjoining the watercourse are suitable for populations of other rare and threatened fauna including brigalow scaly-foot, golden trailed gecko, little pied bat and large-eared bat. Targeted field surveys would be required to detect these species.

A single Herbert's rock wallaby (a locally significant species) was disturbed on a rocky slope approximately 1 km downstream of the permeate discharge point.

Two hundred and three species of plants were identified along the watercourse, of which about 30 are introduced species.

Frogs, turtles and fish were found in the spring/billabong pond adjacent to Hutton Creek. However, the steepness of the stream, and likelihood of few water refugia under dry conditions suggests the stream provides little habitat for turtles and fish.

Planned Permeate Discharges 2008/2009 — Section 7

Two desalination plants are under consideration for the Fairview Project Area:

- Pony Hills Water Treatment Plant (PHWTP) near FV77 is planned to be constructed in 2008.
- Central Desalination Plant (CDP) is proposed for 2009.

Investigations for the Pony Hills permeate discharge are complete and detailed plans have been developed for its implementation in 2008.

Investigations for Central Desalination Plant are currently being initiated.

7.1 Pony Hills Water Treatment Plant

This Section outlines the proposed discharge of treated (desalinated) associated water to grade in an unnamed tributary of Hutton Creek (Hutton Tributary) adjacent to FV77 and the potential downstream effects of this discharge on Hutton Creek and the Dawson River.

7.1.1 Hutton Tributary

The Hutton Tributary is intermittent/ephemeral, and has a small catchment area extending approximately 3.5km upstream of the permeate discharge point. Field observations made in December 2007 following significant flooding found a pool and channel system with significant water storage capacity (Simmons & Bristow, 2007b). Adjacent and well connected to Hutton Creek is a billabong or spring system.

The general environment of the tributary is described in Section 6.3.

Limited water quality data (EC, pH, temperature and DO) was also collected in December 2007 from the unnamed Hutton Tributary both at the proposed discharge point (FV77) and downstream near the confluence with Hutton Creek (Simmonds & Bristow, 2007b). The data indicates background EC in the range 354 to 533 µS/cm and pH in the range 6.8 to 7.7. This is similar to median observed levels of these parameters in Hutton Creek. Further measurements of EC in early February 2008 suggest an EC range of 450 – 510 µS/cm.

Temperatures recorded by Simmonds & Bristow (2007b) ranged from circa 22 - 31 C, and was generally lower towards the confluence with Hutton Creek. DO concentrations varied substantially (0.8 - 8.2mg/L) along the tributary.

7.1.2 Permeate Discharge

The operation of the PHWTP will involve the use of a number of chemicals including biocides and antiscalants for backwash and cleaning purposes. All water will be captured from these operations and treated. No discharge of this water is planned and it is estimated that any residual amounts of chemicals used in this process will be undetectable in permeate due to dilution and the reverse osmosis process.

Permeate is therefore likely to be clean. The predicted permeate water quality range is shown in Table 7-1 where it is compared with relevant MTV for the area. Only those water quality parameters of relevance to permeate are shown. The temperature of permeate is likely to be less than the temperature of associated water at the wells but above ambient temperatures particularly in the dry season.

Section 7 Planned Permeate Discharges 2008/2009

The salinity, pH and temperature of permeate are likely to be higher than the MTVs. The ecological risks associated with these likely exceedances are considered in the context of the existing catchment and receiving water environments in the following sections.

Table 7-1 Predicted permeate discharge quality PHWTP

Water Quality Parameter Type	Water Quality Parameter Name	Units	Min.	90th percentile	MTV	
					Value	Source
Physico-Chemical Parameters	Electrical Conductivity	µS/cm at 25C	150	500	340	
	pH	Stand	6.5	8.76	6.5-8.0	
	Temperature	C	NA	NA		
	Total dissolved solids	mg/L	100	325	1000	
	TSS	mg/L	0	0	10	
	TOC	mg/L as C	0	0		
	DOC	mg/L as C	0	0		
Inorganic Non-Metallic Parameters	Total Alkalinity	mg/L as CaCO3	40	125	20–400	QWQG
	Bicarbonate Alkalinity	mg/L as CaCO3	40	115		
	Carbonate Alkalinity	mg/L as CaCO3	0	10		
	Chloride	mg/L	30	72	175	
	Fluoride	mg/L	0	0.5	1	
	Sulphate	mg/L	0.2	0.3	400	
	Silica	mg/L as SiO_2	0.2	1.0		
Cations	Calcium	mg/L	0	0.5	1000	
	Magnesium	mg/L	0	0		
	Potassium	mg/L	0	0.6		
	Sodium	mg/L	35	107	115	
Nutrients	Ammonia-Nitrogen	mg/L	0	0.05	20#	
	Nitrate-Nitrogen	mg/L	0	0.02	0.4	
	Phosphorus/Phosphate	mg/L as P	ND	0.0004	0.05	
Trace elements	Aluminium	mg/L	0	0.05		
	Barium	mg/L	0	0.03		
	Boron	mg/L	0.1	3	370	
	Iron	µg/L	0.3	0.7	200	
	Lead	µg/L	0.3	1.7	3.4	
	Manganese	ug/L	0.05	0.1	<10 1900	QWQG* AWQG
	Zinc	µg/L	0.05	0.75	8	
	Strontium	mg/L	0.004	0.037		

NOTES:
* Guideline for aquatic aquaculture
# WQO is for Ammonia

7.1.3 Potential Impacts on Typical flows

The full flow record from Hutton Creek is compared with permeate discharges in Figure 7-1. The bankfull flood (6620 ML/day) in Hutton Creek is also shown. The bankfull flood is generally accepted as the flow that maintains channel geometry and has an Average Recurrence Interval of ~2.33 years.

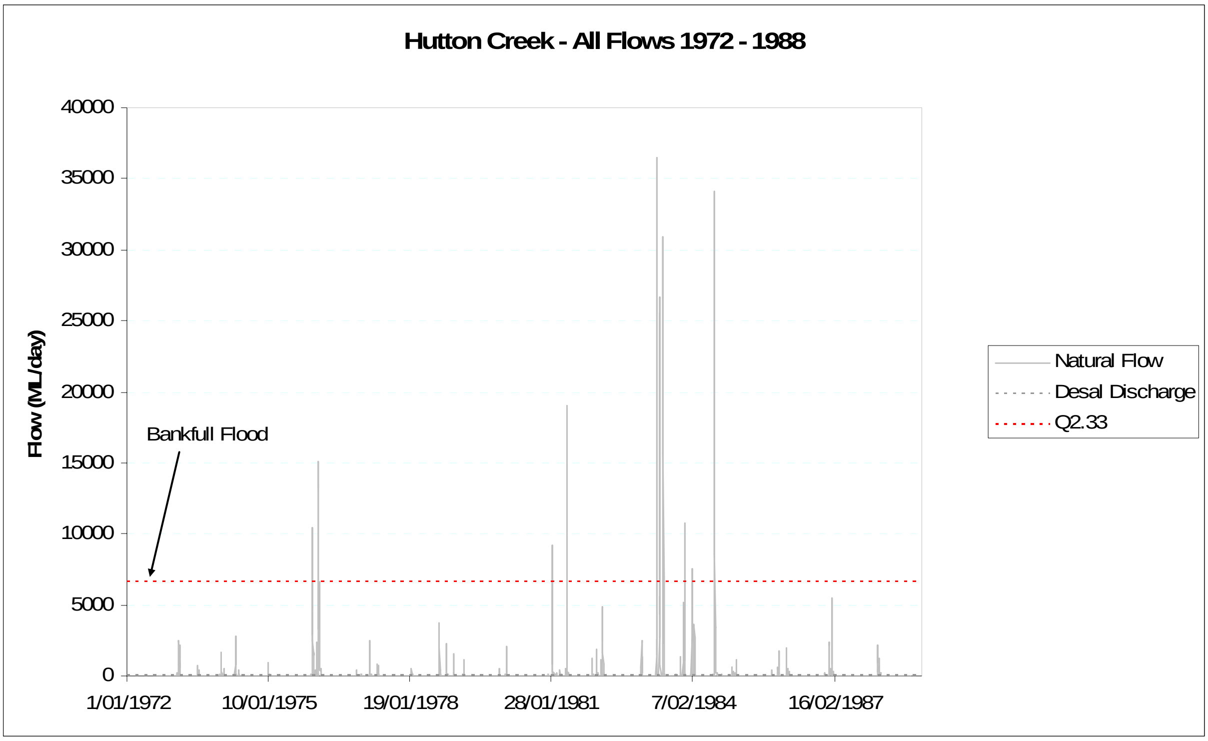


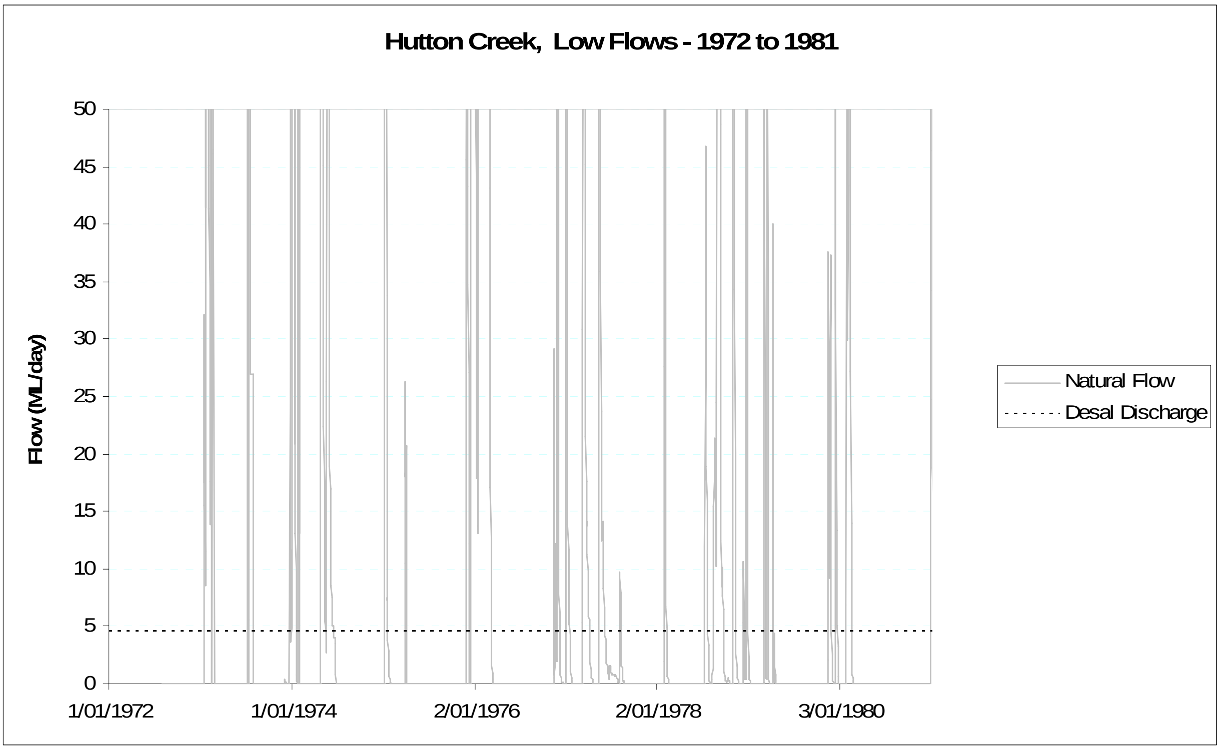
Figure 7-1 All Hutton Creek flows compared with PHWTP permeate discharge

The permeate discharge is not visible in Figure 7-1 since it is a very small percentage of the channel forming flood discharge.

To provide an improved view of the relative size of the permeate discharge to natural flows in Hutton Creek, the below figure has been split into two covering the periods 1972 – 1981 and 1982 – 1988. Furthermore any flows greater than 50 ML/day are removed from Figure 7-2 a) and b).

When flows do occur in Hutton Creek, it is likely that the permeate will be significantly diluted by the large flow volumes that occur. However, there are long periods during which the instream water quality will be significantly affected by permeate discharge. The degree of impact will be dependent upon the level of mixing that occurs instream since Hutton Creek maintains long deep pools.

Section 7 Planned Permeate Discharges 2008/2009



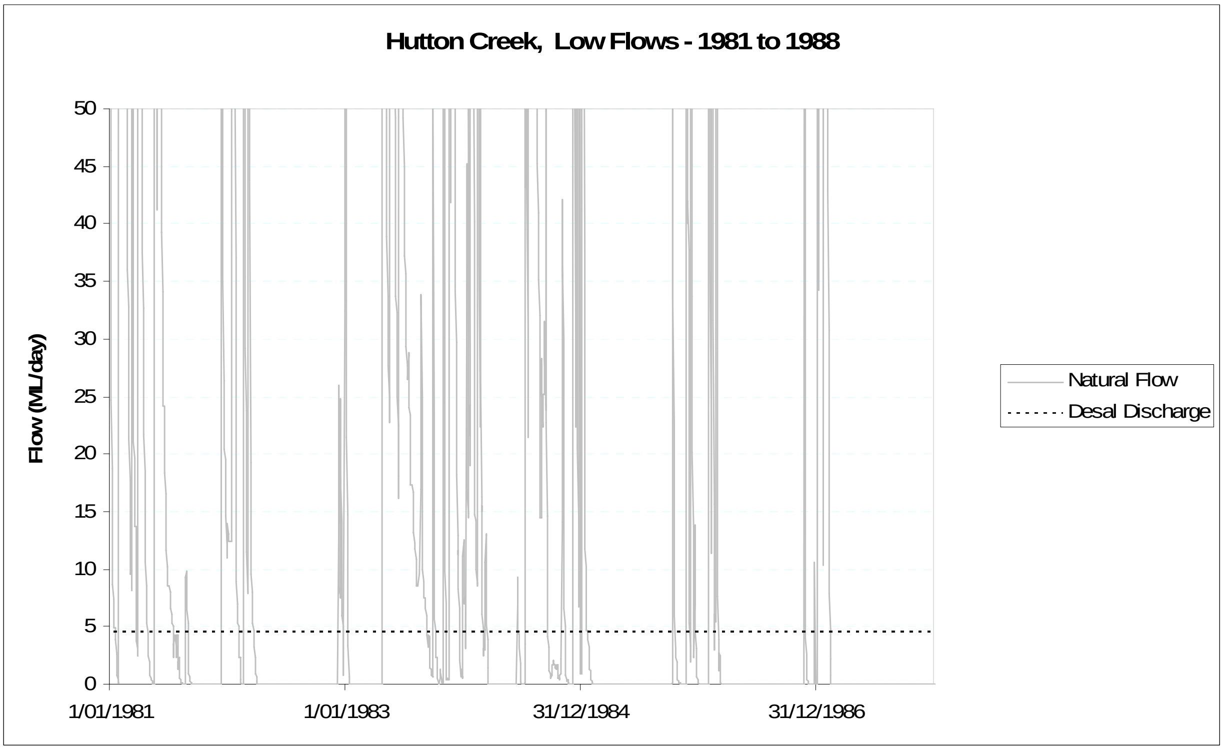


Figure 7-2 Low Hutton Creek flows compared with PHWTP permeate discharge

7.1.4 Potential Impacts on Channel Erosion

At the point of the proposed permeate discharge the unnamed Hutton Tributary has a width of approximately 20 m and a depth of approximately 1.4 m. This is more than sufficient to carry 4.5 ML/day permeate discharge within a small proportion of the stream bed. Local engineering works are planned to minimise erosion at this point.

Downstream of this point the tributary narrows but significant water storage capacity is available in scour pools and the channel system. Heavy rains lead to local flooding prior to the December 2007 field visit (Simmonds and Bristow, 2007b). There was no evidence of overbank flow even in the narrowest sections of the stream. Erosion and scour arising from the planned volumes of permeate water discharge are expected to be minimal.

Rating tables from the Hutton Creek gauging station suggest a rise in water level of approximately 100 – 150mm associated with the permeate discharge in Hutton Creek. This will simply maintain flows within the bottom of the channel since the dominant features of Hutton Creek are long wide ponds with short riffle sections between. Increased erosion is therefore considered unlikely during low flows in Hutton Creek.

At Utopia Downs on the Dawson River, DNRW rating tables suggests a rise of water level of circa 20 mm during normal flows. Once again this rise in water level will be well contained within the existing channel and no significant increase in erosion or scouring is likely.

7.1.5 Potential Impacts on Downstream Flooding

Discharges from the desalination plant will result in small rises in Hutton Creek and Dawson River as discussed in the previous section. Frequency analysis of floods in the Hutton Creek, Dawson River at Utopia and Dawson River at Taroom suggest that permeate discharge will be 0.07% and 0.03% of bankfull discharges respectively. Consideration of the cross-sections at these sites (see Figure 7-3 a and b) suggests little if any rise in natural bankfull flood levels.

7.1.6 Potential Salinity Impacts from Permeate Discharge

The predicted EC of the permeate discharge is comparable with existing EC levels in the unnamed Hutton Tributary and significantly lower than the elevated EC levels observed in Hutton Creek under low flow conditions. The proposed permeate discharge will therefore dilute salinity levels in Hutton Creek.

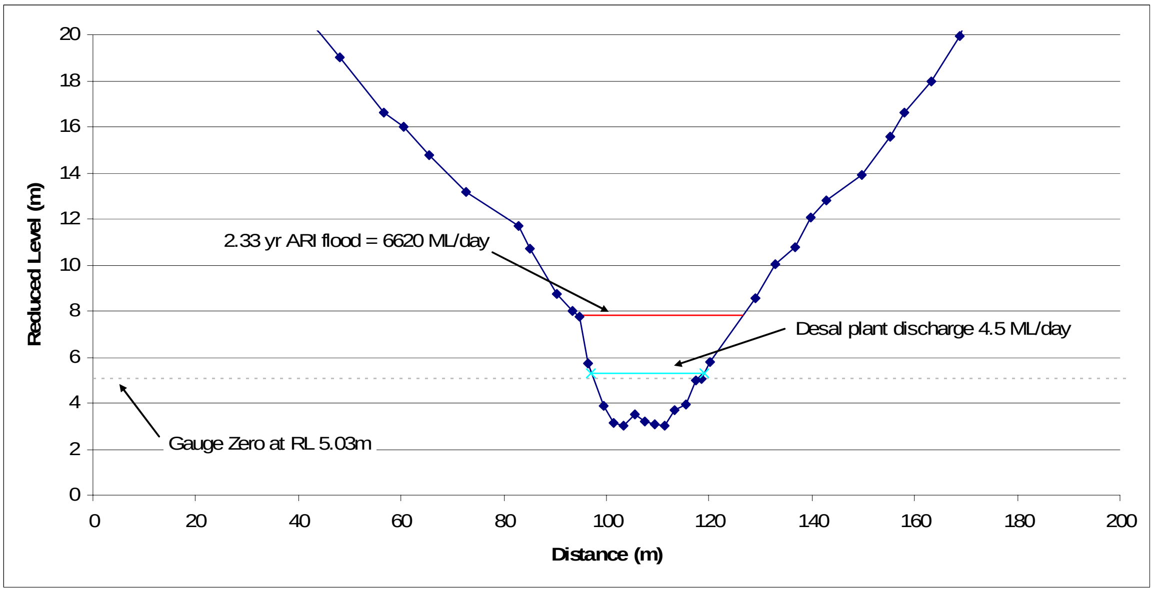
Estimated EC in Dawson River

The impacts of permeate discharges on the Dawson River EC have been estimated using a simple model that assumes complete mixing and conservation of mass. Two conservative flow conditions were considered:

- The “very low flows” condition is the minimum observed discharge during the dry season, and
- The “median November flows” condition was adopted as representative of small to medium flows.

Section 7 Planned Permeate Discharges 2008/2009

a) Hutton Creek



b) Utopia Downs

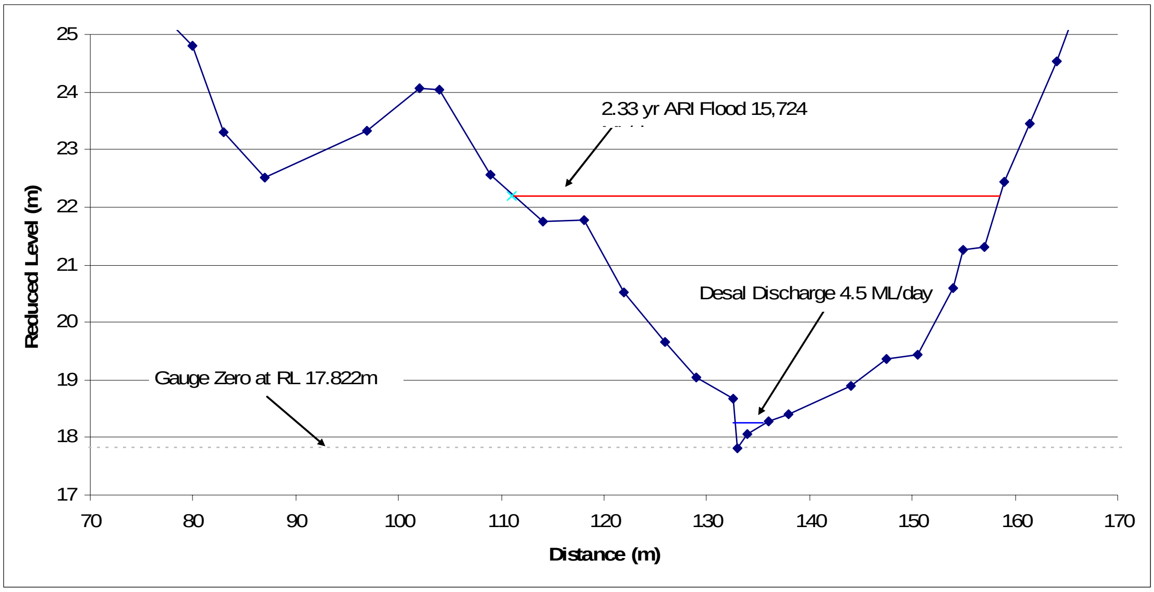


Figure 7-3 River cross-sections in Hutton Creek and Dawson River

Figure 7-4 shows the results of this modelling using various EC targets for a 4.5 ML/day permeate discharge. Under the very low flow condition, permeate discharges will potentially have a more significant effect on Dawson River EC compared with moderate flow conditions (as represented by median November flows) when little impact on Dawson River EC is likely.

Planned Permeate Discharges 2008/2009

To minimise EC impacts from the permeate it is intended to operate the plant to deliver 4.5 ML/day at 500 µS/cm which is within the observed range of EC at the discharge point in the unnamed Hutton Tributary, and below the current range of EC in Hutton Creek. A discharge with 500 µS/cm will also mean that the relevant WQO (340 µS/cm) is met within the Dawson River even under very low flows. This represents a very conservative operating scenario and very low risk of impacting on the riverine environment.

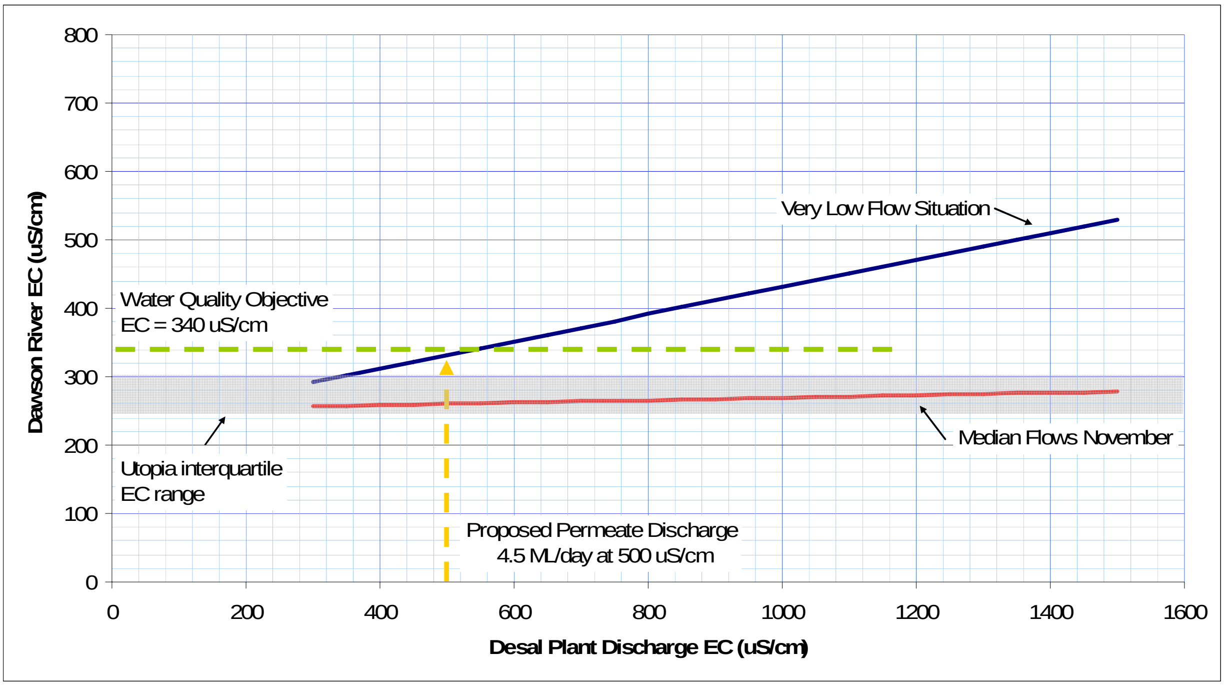


Figure 7-4 Modelled Impacts of Pony Hills Permeate Discharges

7.1.7 Potential Impacts from Permeate Discharge on Salt Loads

Annual salt loads from the Dawson River at Utopia Downs were calculated for the period 1997 - 2006 using the full length of the EC record at that site. In some years, insufficient information was available to provide a reliable estimate of annual load. Since discharge data and EC records are concurrent, a simple sum of hourly flow x salinity was used to calculate annual loads. Time weighted scaling was used to account for missing record where possible. Calculated average annual salt load is 4477 +/- 1267 tonne.

Permeate discharge of 4.5 ML/day at 500 µS/cm from Pony Hills Water Treatment plant is equivalent to an annual salt load of 558.8 tonne. This load is well within the natural variation in the catchment.

The dominant mechanism for natural salt load movement in the Dawson River is via flood events in the wet season. The increase in catchment salt load arising from the desalination plant discharge arises from a constant input in both wet and dry seasons.

During the dry season the dominant issue with permeate discharge is likely to be the concentration rather than the load.

During wet season the relative size of existing storages along the Dawson River (Glebe Weir 17,700 ML, Neville Hewitt Weir 11,300 ML) is small compared with even the median flow volume at Taroom (195,000 ML). Regular flushing of water in these storages is expected with no long term aggregation of salt in the weir pools.

Section 7 Planned Permeate Discharges 2008/2009

Given the predicted increase in salt loads is within the natural annual variability, the low level of concentration of salt discharged, and the high flow rates in the catchment it is unlikely that the increased salt load will cause any significant issues in the Dawson or Fitzroy river systems.

Table 7-2, below provides a comparison of predicted permeate water quality outputs and existing water quality observed instream. Minima, medians and maxima are shown for Hutton Creek, Dawson Bend and Yebna Crossing.

7.1.8 Other Potential Water Quality Impacts

Fluoride

Due to the proposed low concentration of fluoride in the desalination water, the discharge is predicted to dilute existing fluoride levels downstream.

Nutrients

Median ammonia concentrations in the permeate are approximately five times lower than median concentrations in Hutton Creek. The differences between maxima are within the error of measurement. Nitrate concentrations are approximately half that found in Hutton Creek, and the maximum concentration in permeate discharges is a one hundredth of that found in Hutton Creek. Consequently, nutrient concentrations are expected to improve in sites downstream of the discharge point.

Sodium

Median concentrations of Sodium in permeate water discharges will increase median concentrations in Hutton Creek but remain below guideline values. Maximum concentrations of Sodium in the permeate are well below existing observed maxima in Hutton Creek.

pH

Associated water pH is alkaline with a predicted median pH of 8.5 entering the desalination plant. Dosing with acid and other processes within the plant is expected to largely neutralise the pH of the discharge water with the expected range of pH discharged being 6.5 to 8.5 units, similar to background levels in the area. pH is expected to rapidly adjust towards local conditions on contact with soils in the balancing pond, through the proposed cooling tower, and on discharge to the unnamed Hutton Tributary. It is noted the predicted pH of the discharge water is lower than currently recorded in the unnamed Hutton Tributary, and therefore water quality within the tributary could potentially become more neutral.

Planned Permeate Discharges 2008/2009

Table 7-2 Predicted permeate quality versus existing stream water quality.

MTV	Units	Permeate		Hutton Creek				Dawson Bend				Dawson R @ Yebna Crossing			
		Min	90th%ile	Min	Med	Max	n	Min	Med	Max	n	Min	Med	Max	n
Physico-Chemical Parameters															
Electrical Conductivity	µS/cm at 25C	150	500	131	233	1294	16	136	251	273	6	110	247	435	46
pH	Stand	6.5	8.76	6.60	7.85	8.30	16	6.4	6.9	7.3	6	7.20	7.75	8.00	6
Temperature	C	NA	NA	84	150	1010	16	92	129	220	6	75	168	296	46
Total dissolved solids	mg/L	100	325	5	28	630	16	4	12	366	4	2	8	142	5
TSS	mg/L	0	0	–	–	–	–	–	–	–	–	–	–	–	–
TOC	mg/L - C	0	0	–	–	–	–	–	–	–	–	–	–	–	–
DOC	mg/L - C	0	0	6.60	7.85	8.30	16	6.4	6.9	7.3	6	7.20	7.75	8.00	6
Inorganic Non-Metallic Parameters															
Total Alkalinity	mg/L - CaCO3	40	125	–	–	–	–	–	–	–	–	–	–	–	–
Bicarbonate Alkalinity	mg/L - CaCO3	40	115	65	100	820	16	55	118	157	6	87	114	130	6
Carbonate Alkalinity	mg/L - CaCO3	0	10	–	–	–	–	–	–	–	–	–	–	–	–
Chloride	mg/L	30	72	4	18	355	16	9	14	15	6	19	21	22	6
Fluoride	mg/L	0	0.5	<0.1	0.1	1.4	12	<0.1	0.2	0.2	6	<0.1	0.2	0.2	6
Sulphate	mg/L	0.2	0.3	<1	5.0	170	12	<1	<10	<5	6	<1	<5	<10	6
Silica	mg/L - SiO2	0.2	1.0	–	–	–	–	–	–	–	–	–	–	–	–
Cations															
Calcium	mg/L	0	0.5	5	16	85	16	1	14	19	6	7	11	17	6
Magnesium	mg/L	0	0	2	5	67	16	<1	8	9	6	4	6	6	6
Potassium	mg/L	0	0.6	2	5	10	16	2	3	5	6	3	3	6	6
Sodium	mg/L	35	107	9	21	280	16	15	21	27	6	27	28	33	6
Nutrients															
Ammonia-Nitrogen	mg/L	0	0.05	<.01	0.16	0.24	3	<0.006	<0.01	<0.01	3	<0.01	<0.01	0.014	3
Nitrate-Nitrogen	mg/L	0	0.02	1	1	69	9	–	<10	–	1	<10	–	–	1
Phosphorus/ Phosphate	mg/L - P	ND	0.0004	<10	95	230	5	20	53	750	5	<10	40	280	5
Trace elements															
Aluminium	mg/L	0	0.05	–	–	–	–	–	–	–	–	–	–	–	–
Barium 2	mg/L	0	0.03	–	–	–	–	–	–	–	–	–	–	–	–
Boron 2	mg/L	0.1	3	<0.1	0.06	800	12	<0.1	257	500	6	–	–	–	–
Iron	µg/L	0.3	0.7	62	1700	2358	3	66	97	950	3	76	156	390	3
Lead	µg/L	0.3	1.7	<1		2	2	<1	–	<1	2	<1	–	<1	2
Manganese	µg/L	0.05	0.1	–	–	–	–	–	–	–	–	–	–	–	–
Zinc	µg/L	0.05	0.75	<10	–	1.5	2	<1	–	<10	2.00	<1	–	<10	2
Strontium	mg/L	0.004	0.037	–	–	–	–	–	–	–	–	–	–	–	–

Aluminium

Aluminium has not been measured in the waterways of the Upper Dawson River catchment. Modelled Aluminium 90th percentile concentrations in permeate may reach as high as 0.05 mg/L just under the AWQG trigger value for 95% protection of aquatic ecosystems (0.055 mg/L).

Strontium

Strontium has not been detected in the Upper Dawson River waterways to date.

Strontium will not be discharged in the permeate under normal conditions. However, from time to time Strontium may be sourced from associated water with a maximum predicted concentration in permeate of 0.05 mg/L. No guideline values for Strontium 2+ are available in Australia.

Natural concentrations of Strontium in the worlds groundwaters typically lie in the range 0.0001 – 0.1 mg/L (Chapman, 1998); although natural concentrations as high as 15 mg/L have been identified in drinking water extracted from some German aquifers (Behrens et al, 2001). The world average concentration for unpolluted rivers is 0.1 mg/L. This suggests that occasional Strontium discharges will not cause significant environmental harm. A working group of the German Federal Environmental Agency considered the use of Strontium salts as a tracer in groundwater investigation and recommend an upper limit of 15 mg/L is not significantly exceeded in drinking water (*ibid.*).

Temperature

Associated water has a temperature range of circa 30 – 45C. Without further treatment, permeate temperatures are likely to be close to ambient water temperatures during summer and significantly higher than ambient during winter.

High temperature discharges could pose ecological risk due to the relative constant temperature of associated water in contrast to the seasonal temperature fluctuations in streams in the area. The relative volumes of flow and almost complete mixing expected within stream means that the temperature regime in Hutton Creek may be expected to be significantly affected, while the temperatures in the Dawson River may be expected to have minimal change from current conditions due to the dominance of spring flows (the minimum 90th percentile monthly observed flow at Utopia is 211 ML/day nearly 50 times the permeate discharge).

Due to the uncertainties surrounding the rate of movement of permeate temperature back to ambient stream temperature, Santos will install cooling towers downstream of the RO plant. Cooling towers will ensure the maintenance of diurnal and seasonal temperature variations in the discharge tributary, Hutton Creek and downstream. Cooling towers will normally deliver water within 5C of wet bulb temperature.

Installation and operation of the cooling towers will be monitored. Discharge water temperatures will be monitored and compared with conditions in Hutton Creek (upstream and downstream of the tributary) and Dawson River (upstream and downstream of Hutton Creek).

7.1.9 Potential River Health Impacts from Permeate Discharge

Discharges from the proposed desalination plant may improve habitat for rock wallabies and pigeons. Changes to the billabong adjacent to Hutton Creek are likely to be minimal due to the relative size of the pond compared with flows and existing connection with Hutton Creek, The main potential ecological change is a shift in macroinvertebrate species evident in the lower reaches of the tributary due to the increased flow regime. This shift is likely to be minor.

Water quality in the tributary post permeate discharge is expected to be significantly better than at present with higher dissolved oxygen, salinity closer to background levels.

Permeate water discharge is likely to lead to a general improvement in water quality through dilution of a range of parameters. The volumes of discharge are significant under low flow conditions, but are mainly expected to lead to an improvement in available habitat as pools will remain full for longer periods and riffles between pools will contain flow. There is unlikely to be a major shift in aquatic species.

The surface waters of the Upper Dawson River are of economic, environmental and social importance. Small, low order streamlines within the Santos Production Licences are often intermittent and certainly ephemeral; and they are subject to significant erosion due to clearing and stock access. These streams do not offer significant refugia during the dry season and are considered of less value that lower order streams such as Hutton Creek, Baffle Creek and Dawson River which maintain large pools even during dry season.

7.2 Central Desalination Plant

Investigations for the potential installation and use of the Central Desalination Plant are currently underway and will be presented in detail in the 2009 EMP for the Fairview Project Area.

Using the same model for salinity as for the PHWTP and taking into account planned discharges from PHWTP and spring flows in the Dawson River it is estimated (Figure 7-5) that the permeate from the Central Desalination Plant must be no higher than 340 µS/cm in order to maintain the salinity in the Dawson River at Dawson Bend at or below the relevant WQO.

Discharges are assumed to be 15 ML/day from the CDP in this preliminary scenario.

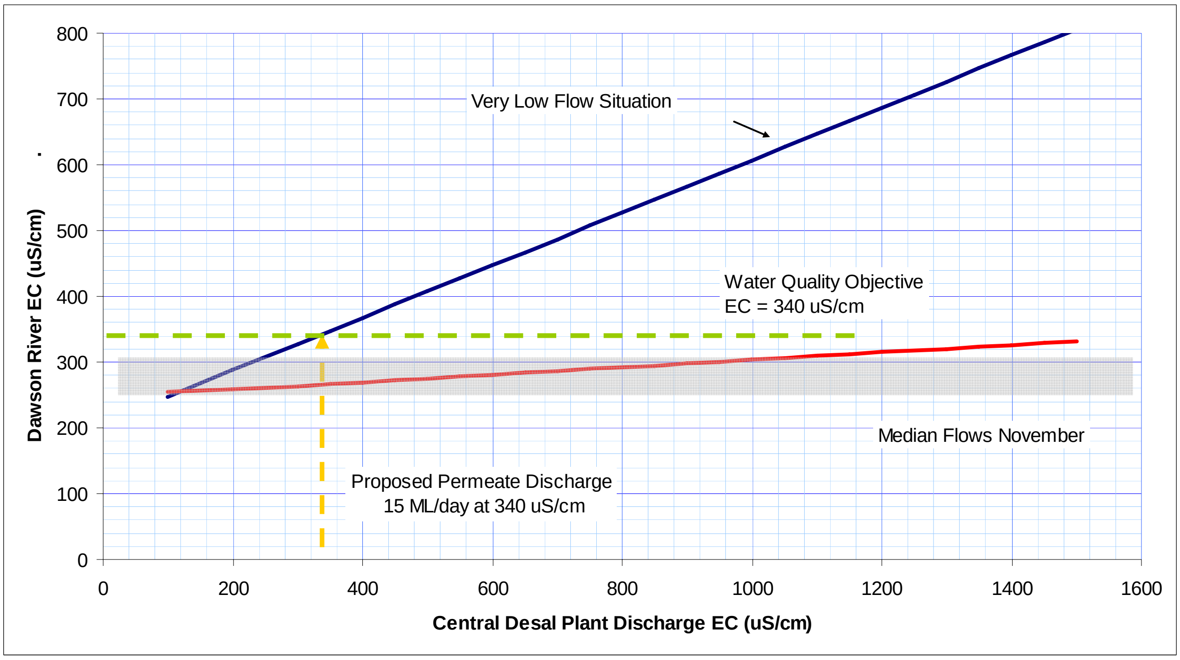


Figure 7-5 Modelled Impacts of Central Desalination Plant Permeate Discharges

Section 8 Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos Pty Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between November 2007 and January 2009 and is based on the information reviewed and conditions encountered at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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Water Quality Data Tables

Appendix A

Table A10
Upper Dawson River Spring Analytical Results
GLNG CSG Surface Water

Location	Sample ID	Date Sampled	Metals (Total)									Major Ions										Alkalinity			
			Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulfate as SO4 2-	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity
		LOR	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*1*	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
		Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
		MTV	*0.024/ 0.013*	*0.37*	*0.0002*	*0.05*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*	*1000*	*175*	*1*	*na*	*na*	*115*	*400*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
SP01	SP01_30/04/08	30/04/2008	0.002	<0.1	**0.0003**	0.001	**0.002**	**9.39**	0.002	0.002	0.01	37	46	**1.2**	10	4	43	4	4.71	4.67	0.53	<1	<1	167	167
SP01	SP01_30/04/08CHK	30/04/2008	0.002	<0.1	**0.0002**	<0.001	**0.002**	**9.42**	0.002	0.002	**0.008**	-	51	**1.2**	-	-	-	-	-	-	-	<1	<1	191	191
SP02	SP02_30/04/08	30/04/2008	0.001	<0.1	**0.0002**	0.001	**0.003**	**3.68**	0.002	0.003	**0.015**	91	166	**1.2**	28	9	63	57	10.6	9.82	3.67	<1	<1	235	235
SP02	QC01_30/04/08	30/04/2008	0.001	<0.1	**0.0002**	<0.001	**0.002**	**1.48**	0.001	0.002	**0.009**	83	52	**1.2**	24	6	55	64	8.39	8.68	1.67	<1	<1	280	280
SP03	SP03_30/04/08	30/04/2008	0.006	<0.1	**0.0002**	0.002	**0.004**	**14.9**	**0.004**	0.01	**0.017**	36	13	**1.3**	13	4	33	7	4.54	4.38	1.81	<1	<1	201	201
SP04	SP04_01/05/08	1/05/2008	0.002	<0.1	**0.0002**	<0.001	**0.002**	**4.4**	<0.001	0.001	0.01	20	28	<0.1	6	2	28	8	2.91	2.82	-	<1	<1	98	98
SP04	SP04_01/05/08CHK	1/05/2008	-	-	-	-	-	-	-	-	-	19	-	-	6	2	26	8	-	-	-	-	-	-	-
SP05	SP05_01/05/08	1/05/2008	<0.001	<0.1	0.0001	<0.001	<0.001	**0.73**	<0.001	<0.001	<0.005	4	13	**1.2**	1	2	25	<1	1.6	1.4	-	<1	<1	62	62
SP06	SP06_01/05/08	1/05/2008	<0.001	<0.1	**0.0005**	<0.001	0.001	**1.15**	<0.001	<0.001	**0.008**	4	19	**1.1**	2	2	24	<1	1.63	1.45	-	<1	<1	55	55
SP07	SP07_01/05/08	1/05/2008	<0.001	<0.1	**0.0004**	<0.001	0.011	**0.72**	<0.001	<0.001	**0.021**	4	21	**1.1**	2	2	25	<1	1.71	1.54	-	<1	<1	56	56
SP08	SP08_01/05/08	1/05/2008	<0.001	<0.1	**0.0002**	<0.001	<0.001	**0.82**	<0.001	0.006	0.007	28	46	**1.3**	8	4	45	14	4.1	4.06	0.47	<1	<1	125	125
SP09	SP09_01/05/08	1/05/2008	<0.001	<0.1	**0.0006**	<0.001	0.001	**1.09**	<0.001	<0.001	<0.005	7	23	**1.1**	3	2	28	<1	1.97	1.85	-	<1	<1	66	66
SP10	SP10_01/05/08	1/05/2008	<0.001	<0.1	0.0001	<0.001	0.001	**1.25**	<0.001	<0.001	<0.005	6	23	**1.2**	3	2	45	<1	2.73	2.54	-	<1	<1	104	104
SP10	SP10_01/05/08CHK	1/05/2008	<0.001	<0.1	**0.0002**	<0.001	0.001	**1.26**	<0.001	<0.001	<0.005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SP11	SP11_01/05/08	1/05/2008	<0.001	<0.1	**0.0002**	<0.001	<0.001	**0.41**	<0.001	<0.001	<0.005	6	24	**1.2**	3	2	44	<1	2.79	2.59	-	<1	<1	106	106
SP11	SP11_01/05/08CHK	1/05/2008	-	-	-	-	-	-	-	-	-	-	24	**1.2**	-	-	-	-	-	-	-	<1	<1	102	102
SP12	SP12_01/05/08	1/05/2008	<0.001	<0.1	**0.0002**	<0.001	<0.001	**0.45**	<0.001	<0.001	<0.005	8	26	**1.2**	3	2	39	<1	2.65	2.46	-	<1	<1	96	96
SP13	SP13_02/05/08	2/05/2008	<0.001	<0.1	**0.0002**	<0.001	<0.001	**0.8**	<0.001	<0.001	<0.005	22	21	**1.2**	12	2	27	<1	3.39	3.26	2	<1	<1	140	140
SP14	SP14_02/05/08	2/05/2008	<0.001	<0.1	**0.0003**	<0.001	<0.001	**0.78**	<0.001	<0.001	<0.005	22	21	**1.2**	12	2	27	<1	3.43	3.3	1.9	<1	<1	142	142
SP14	QC02_02/05/08	2/05/2008	<0.001	<0.1	**0.0005**	<0.001	<0.001	**0.78**	<0.001	<0.001	<0.005	22	20	**1.3**	11	2	30	<1	3.42	3.41	0.17	<1	<1	143	143
SP15	SP15_02/05/08	2/05/2008	0.001	<0.1	**0.0005**	<0.001	0.001	**1.08**	<0.001	<0.001	0.005	21	19	**1.3**	11	2	26	1	3.14	3.15	0.16	<1	<1	129	129
SP15	SP15_02/05/08CHK	2/05/2008	-	-	-	-	-	-	-	-	-	21	-	-	11	2	28	1	-	-	-	-	-	-	-

NOTES
MTV - minimum guideline trigger value
"CHK" - lab duplicate sample
"QC" - field duplicate sample
BOLD Greater than relevant MTV

Table A1
URS Water Quality Parameters Upper Dawson Catchment
GLNG CSG Surface Water

Site ID		Date/Time	Water Quality Parameters					
Number	Name	Date	Time (EST)	EC (µS/cm)	DO (mg/L)	pH	Turbidity (NTU)	Temp (oC)
			MTV	*340*		*6.5-8*	*50*	
D002	Dawson River @ Yebna Crossing	05-Mar-08	12:00	107	6.2	7.1	**270**	23.9
D002	Dawson River @ Yebna Crossing	02-Feb-08	10:35	264	5.47	6.76	**166**	25.4
D002	Dawson River @ Yebna Crossing	14-May-08	16:20	265	11.3	7.5	9	17.3
D003	Pine Creek @ Phelps Rd	05-Mar-08	-	-	-	-	-	-
D003	Pine Creek @ Phelps Rd	02-Feb-08	12:20	227.2	4	6.59	**266**	29.2
D003	Pine Creek @ Phelps Rd	13-May-08	15:45	-	-	-	-	-
D004	Dawson River @ Taroom-Roma Rd	05-Mar-08	16:40	150	6.01	7.73	**555**	23.3
D004	Dawson River @ Taroom-Roma Rd	02-Feb-08	13:36	270	5.23	6.82	**215**	27.3
D004	Dawson River @ Taroom-Roma Rd	13-May-08	10:55	**368**	9.84	7.78	14	14.6
D005	Eurombah @ Hornet Bank Rd	05-Mar-08	17:10	118	6.15	7.5	**492**	24.4
D005	Eurombah @ Hornet Bank Rd	02-Feb-08	14:15	317	5.95	7.16	**191**	28.8
D005	Eurombah @ Hornet Bank Rd	13-May-08	10:00	**340**	6.22	7.3	13	16.1
D006	Bridge/Ram Creek @ Roma Rd	05-Mar-08	16:30	192	7.43	**8.41**	**111**	28.1
D006	Bridge/Ram Creek @ Roma Rd	02-Feb-08	14:43	271	6.18	7.51	32	30.9
D006	Bridge/Ram Creek @ Roma Rd	13-May-08	11:30	-	-	-	-	-
D007	Paddys Creek @ Roma Rd	05-Mar-08	16:05	65.3	8.62	**8.41**	2	31.2
D007	Paddys Creek @ Roma Rd	02-Feb-08	14:56	232	4.57	**8.05**	**408**	30.8
D007	Paddys Creek @ Roma Rd	13-May-08	11:45	265	7.9	7.4	**240**	17.4
D008	Middle Creek @ Roma Rd	05-Mar-08	15:40	186	6.4	**8.5**	**152**	28.6
D008	Middle Creek @ Roma Rd	02-Feb-08	15:30	234	8.58	**8.34**	**54**	33.7
D008	Middle Creek @ Roma Rd	13-May-08	12:15	**488**	11.3	**8.5**	**160**	20.7
D009	Juandah Creek @ Roma Rd	05-Mar-08	15:20	120.2	2.26	7.14	**473**	28.5
D009	Juandah Creek @ Roma Rd	02-Feb-08	15:46	244	6.04	**8.06**	**163**	30.4
D009	Juandah Creek @ Roma Rd	13-May-08	12:30	218	6.36	6.8	**410**	20.5
D010	Dawson River @ Old Taroom Bridge	05-Mar-08	14:50	157.2	5.39	7.42	**427**	24.2
D010	Dawson River @ Old Taroom Bridge	02-Feb-08	16:23	225.1	4.15	6.98	**243**	27.8
D010	Dawson River @ Old Taroom Bridge	13-May-08	13:35	**420**	8.22	7.77		18.9
D011	Kinnoul Creek @ Taroom Rd	05-Mar-08	10:50	104	4.3	7.2	30	25.1
D011	Kinnoul Creek @ Taroom Rd	02-Feb-08	17:00	245	6.48	7.49	28	28.8
D011	Kinnoul Creek @ Taroom Rd	13-May-08	14:10	205	9.5	7.43	28	20.2
D012	Hutton Creek @ Carnarvon Hwy	05-Mar-08	-	-	-	-	-	-
D012	Hutton Creek @ Carnarvon Hwy	03-Feb-08	9:00	**485**	4.5	7.2	5	26.8
D012	Hutton Creek @ Carnarvon Hwy	13-May-08	9:15	260	6.7	6.98	22	14.9
D013	Dawson River @ Arcadia Valley Rd	06-Mar-08	10:00	136	-	7.1	-	-
D013	Dawson River @ Arcadia Valley Rd	03-Feb-08		222.9	6.33	7	31	25.5
D014	Dawson River @ Hornet Bank Rd	02-Feb-08	14:00	-	-	-	-	-
D015	Dawson River @ Baralaba	04-Feb-08	12:45	132	7.88	6.58	**180**	27.6
D016	Dawson River @ Carnavon Hwy	03-Feb-08		-	-	-	-	-

Notes:

MTV	minimum trigger value
BOLD	Greater than MTV
"-"	Creek dry

Table A3
Upper Dawson Catchment - Upstream Dawson River Water Quality Data
GLNG CSG Surface Water

			Physical									Cations				Anions				Nutrients & Biological					Trace Elements										Flow			
Sample Collection Point	**Sample Date**	**Time**	**Air Temp (°C)**	**Water Temp (°C)**	**pH**	**EC (µS/cm)**	**DO (mg/L)**	**DO % sat**	**TDS (mg/L)**	**TSS (mg/L)**	**Turbidity (NTU)**	**Sodium (mg/L)**	**Potassium (mg/L)**	**Calcium (mg/L)**	**Magnesium (mg/L)**	**Bicarbonate as HCO3 (mg/L)**	**Chloride (mg/L)**	**Fluoride (mg/L)**	**Sulphate (mg/L)**	**TN (µg/L)**	**TP (µg/L)**	**Ammonia (µg/L)**	**Nitrate as NO_3 (µg/L)**	**Chl-a (µg/L)**	**Arsenic (µg/L)**	**Boron (µg/L)**	**Cadmium (µg/L)**	**Chromium (µg/L)**	**Copper (µg/L)**	**Iron (µg/L)**	**Lead (µg/L)**	**Mercury (µg/L)**	**Nickel (µg/L)**	**Zinc (µg/L)**	**Level**	**Velocity**	**Physical Appearance**	**Data Source**
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*		
Dawson River - Arcadia Valley	4/05/2002																																				No Flow	S
Dawson River - Arcadia Valley	1/01/2002																																				No Flow	S
Dawson River - Arcadia Valley	1/01/2002																																				No Flow	S
Dawson River - Arcadia Valley	22/06/2001																																				No Flow	S
Dawson River - Arcadia Valley	25/05/2001																																				No Flow	S
Dawson River - Arcadia Valley	20/04/2001																																				No Flow	S
Dawson River - Arcadia Valley	8/03/2001			26		199			135																												Clear	S
Dawson River - Arcadia Valley	8/02/2001	11:00		26		285			194																												Clear	S
Dawson River - Arcadia Valley	5/01/2001	13:00		27		279			190																												Clear	S
Dawson River - Arcadia Valley	17/12/2000	14:00		25		231			157																												Clear	S
Dawson River - Arcadia Valley	18/11/2000	15:30		25		231			157																												Clear	S
Dawson River - Arcadia Valley	5/10/2000																																					S
Dawson River - Arcadia Valley	5/09/2000																																				No Water	S
Dawson River - Arcadia Valley	3/08/2000																																				No Water	S
Dawson River - Arcadia Valley	13/07/2000																																				No Flow	S
Dawson River - Arcadia Valley	15/06/2000																																				No Sample	S
Dawson River - Arcadia Valley	2/06/2000																																					S
Dawson River - Arcadia Valley	29/04/2000																																					S
Dawson River - Arcadia Valley	1/04/2000																																				Not Flowing	S
Dawson River - Arcadia Valley	2/03/2000																																				No Flow	S
Dawson River - Arcadia Valley	30/01/2000																																					S
Dawson River - Arcadia Valley	30/12/1999																																					S
Dawson River - Arcadia Valley	29/11/1999																																					S
Dawson River - Arcadia Valley	30/10/1999																																					S
Dawson River - Arcadia Valley	30/09/1999																																				Not Flowing	S
Dawson River - Arcadia Valley	29/08/1999																																				No Water	S
Dawson River - Arcadia Valley	29/07/1999																																				No Water	S
Dawson River - Arcadia Valley	1/06/1999																																				No Water	S
Dawson River - Arcadia Valley	7/05/1999																																				No Water	S
Dawson River - Arcadia Valley	5/04/1999			28		135			92																												No flow, mud hole	S
Dawson River - Arcadia Valley	6/03/1999	15:00		27		176			120																												slight flow, murky	S
Dawson River - Arcadia Valley	26/02/1999																																				No Water	S
Dawson River - Arcadia Valley	1/01/1999																																				No Flow	S
Dawson River - Arcadia Valley	21/12/1998																																				No Flow	S
Dawson River - Arcadia Valley	29/11/1998																																				No Flow	S
Upstream Dawson Waterhole	9/10/2003			26.5	7.1	170	6.80	86	109			17	11	3	3	98	8	0.1	<5							**<100**									Isolated	No flow		RH
Upstream Dawson Waterhole	22/04/04			24.9	7	273	7.90	96	156	**52**		22	6	14	5	151	12	0.1	<10	**7780**	**140**					**500**									Isolated	Low		RH
Upstream Dawson Waterhole	17/11/04			24.5	6.6	**1702**	5.70	**69**	108	**82**		3	<1	6	6	70	8	0.24	<10		**1900**	**380**				**<100**									Low-Mod	Mod		RH
Dawson Road Crossing	5/09/2006			15.4	7	50	8.61	**84**	46	**125**	**101**	3	4	1	1	28	3	0.1	4	**570**	<10	10			4	<100	<0.1	16	2	**4407**	3	<0.1	4	**14**				RH
Dawson Road Crossing	26/04/2007		19.5	18.9	6.6	159	0.81	**9**	160	**68**		11	10	18	6	95	6	0.24	<1	**3300**	**110**	**590**	128*	**8.8**	2.8	23	<1	<1	**<2**	**5100**	<1	<0.5	<3	<1				RH

NOTES

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

All samples collected upstream of existing associated water discharge

S - Santos

Water Quality Data Summary

			Physical									Cations				Anions				Nutrients				Trace Elements										Biologica	Flow			
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-a (µg/L)	Level	Velocity	Physical Appearance	Data source
		MTV	*na*	*0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1.2*	*400*	*500*	*50*	*20*		*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*		
Upper Baffle Creek	4/05/2002	15:40		21		**1585**			1078																												Clear	S
Upper Baffle Creek	1/01/2002	10:30		24		**1570**			1068																												Slight cloudy brown	S
Upper Baffle Creek	1/01/2002	10:30		24		**1570**			1068																												Slight cloudy brown	S
Upper Baffle Creek	1/01/2002	14:35		25		147			100																												Not Flowing - Yellow Brown	S
Upper Baffle Creek	1/01/2002	13:35		27		128			87																												Slight flow, muddy	S
Upper Baffle Creek	1/01/2002					97			66																												Slow Flow - Yellow Brown	S
Upper Baffle Creek	1/01/2002	13:10		29		115			78																												Slight flow, muddy	S
Upper Baffle Creek	1/01/2002	9:00		27		144			98																												Mod flow, muddy	S
Upper Baffle Creek	22/06/2001								0																												No Flow	S
Upper Baffle Creek	25/05/2001								0																												No Flow	S
Upper Baffle Creek	20/04/2001								0																												No Flow	S
Upper Baffle Creek	8/03/2001								0																												No Flow	S
Upper Baffle Creek	5/10/2000								0																													S
Upper Baffle Creek	5/09/2000								0																												No Flow	S
Upper Baffle Creek	3/08/2000								0																												No Flow	S
Upper Baffle Creek	13/07/2000	14:29		24		142			97																												Cloudy, some sediment	S
Upper Baffle Creek	15/06/2000	14:22		24		**1296**			881																												Cloudy, some sediment	S
Upper Baffle Creek	2/06/2000	10:30		19		**1901**			1293																												Slight cloudy brown	S
Upper Baffle Creek	29/04/2000	10:30		21		**1490**			1013																												Slight cloudy brown	S
Upper Baffle Creek	1/04/2000	10:30		24		**1456**			990																												Slight cloudy brown	S
Upper Baffle Creek	2/03/2000			24		**1467**			998																												Slight cloudy brown	S
Upper Baffle Creek	30/01/2000	10:30		24		**1856**			1262																												Slight cloudy brown	S
Upper Baffle Creek	30/12/1999	16:00		25		200			136																												Not Flowing	S
Upper Baffle Creek	29/11/1999	11:17		24		280			190																												Not Flowing	S
Upper Baffle Creek	30/10/1999	15:42		25		**460**			313																												Not Flowing	S
Upper Baffle Creek	30/09/1999			21		211			143																												Not Flowing	S
Upper Baffle Creek	29/07/1999			15		185			126																												No Flow	S
Upper Baffle Creek	29/07/1999			19		191			130																												Not Flowing	S
Upper Baffle Creek	1/06/1999	14:00		14		162			110																												Not Flowing	S
Upper Baffle Creek	7/05/1999	16:00		18		86			58																												Not Flowing	S
Upper Baffle Creek	5/04/1999			27		98			67																												slight flow, murky	S
Upper Baffle Creek	9/09/2003			17.5	6.8	67	8.90	94	43			6	5	1	2	54	<0.5	0.1	<5						**<100**										Mod	Low		RH
Upper Baffle Creek	21/04/2004			26.5	6.6	152	12.30	155	64	6		8	6	6	4	77	7	<.1	<10	**1350**	**60**				**500**										Low	Low		RH
Upper Baffle Creek	16/11/2004			32.7	7.8	134	8.60	119	84	**49**		<1	7	4	3	67	7	0.32	<10		**1000**	**100**			**<100**										Low	Low		RH
Upper Baffle Creek	23/05/2005				7.4	108			114	**30**		5	5	4	4	47	6	0.43	<10	**810**	**50**	**30**			**<100**				**1800**						Mod	Low		RH
Upper Baffle Creek	5/08/2006			15.8	7.1	212	9.87	99	126	**48**	**105**	17	6	11	7	99	9	0.4	3	480	**<10**	**<10**		<1	**<100**	<0.1	<1	<1	81	<1	<0.1	<1	**<10**		Mod	Low		RH
Upper Baffle Creek	22/04/2007		27.5	22.9	7.6	138	7.23	**85**	160	**49**		17	12	15	7	93	5	0.32	<1	**1100**	**<20**	**77**	318*	<1	25	<1	<1	**<2**	**750**	<1	<0.5	<3	**8.3**	**6.5**				RH
Baffle Creek	7/01/2002					**1520**			1034																												Clear	S
Baffle Creek	5/11/2001			22		**1384**			941																												Brown tinge	S
Baffle Creek	12/10/2001			22		**1484**			1009																												Brown tinge	S
Baffle Creek	29/08/2001			23		**1484**			1009																												Brown tinge	S
Baffle Creek	1/07/2001			22		**1530**			1040																												Clear, slight brown tinge	S
Baffle Creek Outflow	5/04/1999	11:50		23		**775**			527																												Slow flow - murky	S
Baffle Creek Outflow	4/05/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002								0																												Not tested	S
Baffle Creek Outflow	1/01/2002					188			128																												Slow flow - murky	S
Baffle Creek Outflow	1/01/2002	11:30		27		328			223																												Mod flow, muddy	S
Baffle Creek Outflow	22/06/2001			19		**1260**			857																												Slightly cloudy Brown	S
Baffle Creek Outflow	25/05/2001			23		**1340**			911																												Slightly cloudy Brown	S
Baffle Creek Outflow	20/04/2001			25		**1350**			918																												Slightly cloudy Brown	S
Baffle Creek Outflow	8/03/2001			26		**1459**			992																												Clear, slight brown tinge	S
Baffle Creek Outflow	5/09/2000								0																												No Sample	S
Baffle Creek Outflow	3/08/2000								0																												No Sample	S
Baffle Creek Outflow	23/07/2000								0																												No Sample	S
Baffle Creek Outflow	15/06/2000								0																												No Sample	S
Baffle Creek Outflow	1/04/2000								0																												Not Flowing	S
Baffle Creek Outflow	1/04/2000	13:00		21		**1150**			782																												Slight cloudy brown	S
Baffle Creek Outflow	1/04/2000	13:00		19		**1348**			917																												Slight cloudy brown	S
Baffle Creek Outflow	2/03/2000								0																												No Tested	S
Baffle Creek Outflow	30/01/2000	13:00		24		**1252**			851																												Slight cloudy brown	S
Baffle Creek Outflow	30/12/1999								0																												Not Flowing	S
Baffle Creek Outflow	29/11/1999	14:22		22		**860**			585																												Not Flowing	S
Baffle Creek Outflow	29/10/1999	9:24		21		**880**			598																												Not Flowing	S
Baffle Creek Outflow	30/09/1999			18		**1281**			871																												Slow Flow	S
Baffle Creek Outflow	29/07/1999			16		**867**			590																												Slow flow - murky	S
Baffle Creek Outflow	29/07/1999			13		**1233**			838																												Slow - Med. Flow	S
Baffle Creek Outflow	1/06/1999	12:13		14		**553**			376																												Slow flow - murky	S
Baffle Creek Outflow	7/05/1999	11:00		19		**621**			422																												Slow - Med. Flow	S
Baffle Creek Outflow	5/04/1999			26		**649**			441																												Slow- med flow	S
Baffle Creek Outflow	9/10/2003			19		**1444**	7.30	**79**	925			**347**	4	1	1	726	55	**2**	<5						200										Low	Low		RH
Baffle Creek Outflow	22/04/2004			20		**870**	5.10	**56**	612	**37**		**162**	5	5	3	916	36	0	<10	**3970**	**220**				**700**										Low	Low		RH
Baffle Creek Outflow	17/11/2004			23		**1403**	0.40	**5**	852	**76**		**232**	8	<1	2	623	56	1	<10	**1800**	**350**				**400**										Mod	Low		RH
Baffle Creek Outflow	21/05/2005			14		**1373**	10.10	98	1030	**10**		**349**	6	<1	2	664	68	**2**	<10	**720**	**150**	**120**			**500**				**6013**						Low	Low		RH
Baffle Creek Outflow	5/09/2006			12		**1864**	7.90	**73**	1168	**39**	**154**	**437**	6	1	2	723	93	**2**	24	**770**	**<10**	**<10**		9	**600**	<0.1	16	3	**6362**	**8**	<0.1	3	**14**		Mod	Low		RH
Baffle Creek Outflow	22/04/2007		31	19	7.8	**832**	3.01	**33**	640	**16**		**200**	6	7	3	570	40	1	<1	**1100**	**66**	16	<44*	2	360	<1	<1	<2	**1300**	<1	<0.5	<3	3	**5**				RH

BOLD Greater than minimum trigger value (refer Environmental Values Table)

MTV - minimum trigger value

Upper Baffle Creek samples upstream of existing associated water discharge

Baffle Creek & Baffle Creek Outflow samples downstream of existing associated water discharge

S - Santos

Table A5
Upper Dawson Catchment - Baffle Creek Water Quality Data
GLNG CSG Surface Water

			Physical								Cations				Anions				Nutrients				Trace Elements										Biologica		
Sample Collection Point	**Sample Date**	**Time**	**Air Temp (°C)**	**Water Temp (°C)**	**pH**	**EC (µS/cm)**	**DO (mg/L)**	**DO % sat**	**TDS (mg/L)**	**TSS (mg/L)**	**Sodium (mg/L)**	**Potassium (mg/L)**	**Calcium (mg/L)**	**Magnesium (mg/L)**	**Bicarbonate as HCO3 (mg/L)**	**Chloride (mg/L)**	**Fluoride (mg/L)**	**Sulphate (mg/L)**	**TN (µg/L)**	**TP (µg/L)**	**Ammonia (µg/L)**	**Nitrate as NO_3 (µg/L)**	**Arsenic (µg/L)**	**Boron (µg/L)**	**Cadmium (µg/L)**	**Chromium (µg/L)**	**Copper (µg/L)**	**Iron (µg/L)**	**Lead (µg/L)**	**Mercury (µg/L)**	**Nickel (µg/L)**	**Zinc (µg/L)**	**Chl-*a* (µg/L)**	**Physical Appearance**	**Data source**
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*		
Dawson Downstream Baffle	4/05/2002																																	Not tested	S
Dawson Downstream Baffle	1/01/2002																																	Not tested	S
Dawson Downstream Baffle	1/01/2002																																	Not tested	S
Dawson Downstream Baffle	22/06/2001			19		**1130**			768																									Silty cloudy Brown	S
Dawson Downstream Baffle	25/05/2001			23		**980**			666																									Silty cloudy Brown	S
Dawson Downstream Baffle	22/06/2001	11:00		24		**844**			574																									Slow flow, lt Brown	S
Dawson Downstream Baffle	22/06/2001	12:15		26		**853**			580																									Slow flow, muddy	S
Dawson Downstream Baffle	22/06/2001					182			124																									Slow flow - lt Brown	S
Dawson Downstream Baffle	22/06/2001	11:05		26		**783**			532																									Slt flow, muddy	S
Dawson Downstream Baffle	22/06/2001	11:45		27		**353**			240																									Mod flow, muddy	S
Dawson Downstream Baffle	22/06/2001			28		**673**			458																									Slow - med flow	S
Dawson Downstream Baffle	20/04/2001			24		**800**			544																									Silty cloudy Brown	S
Dawson Downstream Baffle	8/03/2001			25		288			196																									Clear, slt brown tinge	S
Dawson Downstream Baffle	5/10/2000	10:30		24		**1367**			930																									Clear, slt sediment	S
Dawson Downstream Baffle	5/09/2000	10:00		24		**1498**			1019																									Clear, slt sediment	S
Dawson Downstream Baffle	3/08/2000	10:00		20		**1358**			923																									Clear, slt sediment	S
Dawson Downstream Baffle	23/07/2000																																	No Sample	S
Dawson Downstream Baffle	15/06/2000																																	No Sample	S
Dawson Downstream Baffle	2/06/2000																																		S
Dawson Downstream Baffle	29/04/2000																																		S
Dawson Downstream Baffle	1/04/2000	1.00PM		24		**1060**			721																									Silty cloudy brown	S
Dawson Downstream Baffle	2/03/2000			24		**1152**			783																									Silty cloudy brown	S
Dawson Downstream Baffle	30/01/2000																																		S
Dawson Downstream Baffle	31/12/1999	2:30		21		**1050**			714																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	29/11/1999	15:00		22		**880**			598																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	29/10/1999	10:52		21		**910**			619																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	30/09/1999			18		**1402**			953																									Slow Flow	S
Dawson Downstream Baffle	29/07/1999			15		**872**			593																									Slow flow - murcky	S
Dawson Downstream Baffle	29/07/1999			15		**1319**			897																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	1/06/1999	11:30		13		**556**			378																									Slow flow - murcky	S
Dawson Downstream Baffle	7/05/1999	11:15		19		**664**			452																									Slow flow - Lt yellow	S
Dawson Downstream Baffle	25/4/07		24.6	19.5	**8.3**	**1296**	6.05	**67.0**	990	**99.0**	**280.0**	10	10	5.5	820	120	**1.4**	<1	**1600.0**	**90.0**	**82.0**	305*	3.4	**480.0**	<1	8.3	**<2**	**1700**	<1	<0.5	4.2	1.5	**15**		RH

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources
*by calcuation from Nitrate as N

Table A6
Upper Dawson Catchment - Hutton Creek Water Quality Data
GLNG CSG Surface Water

Sample Collection Point	Sample Date		Physical									Cations			
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)
		MTV	*na*	*0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*
Upper Hutton Creek	9/10/2003			18.8	7.9	**1478**	9.10	98	1139			**133**	9.4	91	16
Upper Hutton Creek	25/04/2007		27.7	22.5	6.6	156	4.31	**49**	190	**570**		14		20	
Hutton Creek	19/04/2004			24.4	7.2	**358**	3.60	**41**	292	**10**		27	7.0	27	7
Hutton Creek	16/11/2004			23.2	7.6	**461**	5.60	**66**	284	**36**		39	10.0	30	9
Hutton Creek	26/05/2005			9.7	7	195	9.90	88	195	**170**		18	7.0	9	4
Hutton Creek	5/08/2006			14.9	6.6	183	8.00	**78**	116	**123**	**116**	24	6.0	5	2
Hutton Creek	21/04/2007		34.3	21.3	7.1	273	3.49	**39**	220	**32**		59	7.4	12	4
Hutton Creek	8/08/1973	1450		19	**8.1**	155			96	**116**		14	5.4	11	3
Hutton Creek	15/12/1976	1317		31	7.9	**390**			198	7		30	6.8	36	7
Hutton Creek	8/09/1980	1405			**8.2**	215			122	**10**	**75**	17	4.1	16	4
Hutton Creek	25/03/1982	1405		27	8	160			97	**200**	**100**	12	4.2	12	3
Hutton Creek	16/12/1983	930		24	**8.2**	195			130	**20**	25	17	4.6	16	4
Hutton Creek	20/03/1984	1400		27	7.8	250			150	**10**	12	20	4.9	20	5
Hutton Creek	24/06/1984	1405		14	7.5	270			150	5		22	4.8	22	5
Hutton Creek	19/10/1984	1500		20	7.9	**570**			320	5		70	1.6	34	11
Hutton Creek	15/01/1985	920		24	7.8	200			120	**445**	**100**	17	5.2	15	4
Hutton Creek	20/10/1985	1025		20	**8.2**	**390**			1010	**10**	1	**175**	4.5	85	67
Hutton Creek	14/02/1988	1109		25	7.2	131			84	**630**	**100**	9	4.3	12	3

Sample Collection Point	Sample Date	Anions				Nutrients				Trace Elements										Biologica	Flow		
		Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total nitrogen (µg/L)	Total phosphorous (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-*a* (µg/L)	Level	Velocity	Data source
		na	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*	
Upper Hutton Creek	9/10/2003	314	**267**	0.1	120						<100										Isolated	No flow	RH
Upper Hutton Creek	25/04/2007		6	0.31	<1	**1800**	**170**	**51**	**168***	<1	32	**<1**	<1	**2**	**1900**	**4.8**	<0.5	6.3	1.5	**13**	-	-	RH
Hutton Creek	19/04/2004	171	28	<.1	<10	**2340**	**70**				**800**										Moderate	Low	RH
Hutton Creek	16/11/2004	190	39	0.36	<10	**1300**	**100**				<100										Low	Low	RH
Hutton Creek	26/05/2005	87	12	0.43	<10	**1330**	**230**	**240**			<100				**2358**						Low	Low	RH
Hutton Creek	5/08/2006	83	12	0.2	5	**680**	**<10**	**<10**		2	<100	<0.1	5	**<1**	62	2	<0.1	<1	**<10**		Mod	Low	RH
Hutton Creek	21/04/2007	130	20	0.31	<1	**1200**	**76**	**93**	**101***	1.6	79	**<1**	<1	**<2**	**2300**	<1	<0.5	<3	**20**	**6.6**			RH
Hutton Creek	8/08/1973	65	10	0.14																			DNRW
Hutton Creek	15/12/1976	145	37	0.5	4				**1200**														DNRW
Hutton Creek	8/09/1980	88	15	0.1	5				**4000**														DNRW
Hutton Creek	25/03/1982	77	8		5.4				**2100**														DNRW
Hutton Creek	16/12/1983	90	15		2.7				**1200**		20												DNRW
Hutton Creek	20/03/1984	110	25	0.1	6.3						20												DNRW
Hutton Creek	24/06/1984	135	19	0.1	3.3						20												DNRW
Hutton Creek	19/10/1984	185	81	0.1	12				**1100**		10												DNRW
Hutton Creek	15/01/1985	88	16	0.1	2				**1100**		20												DNRW
Hutton Creek	20/10/1985	275	**355**	0.3	170				**500**		100												DNRW
Hutton Creek	14/02/1988	65	4	0.1	2.1				**3800**		10												DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources

Table A7
Upper Dawson Catchment - Dawson Downstream Hutton Water Quality Data
GLNG CSG Surface Water

		Physical										Cations				Anions				Nutrients				Trace Elements										Biologica	Flow			
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Chl-*a* (µg/L)	Level	Velocity	Physical Appearance	Data source
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*5*	*na*	*na*		
Dawson d/s Hutton-1	23/04/2004			22.2	6.8	264	4.90	**56**	108	**66**		20	3	15	6	138	14	<.1	<10	**1050**	**190**				**400**										Moderate	Moderate		RH
Dawson d/s Hutton-1	19/11/2004			22.1	7	129	7.90	91	88	**316**		15	5	1	2	54	8	0.1	<10	**4100**	**580**				<100										Moderate	Moderate		RH
Dawson d/s Hutton-1	22/05/2005			9.3	7.4	266	13.40	116	160	3		21	3	15	8	111	14	0.21	<10	120	**<50**	<10			<100										No flow			RH
Dawson d/s Hutton-1	24/05/2005			12.4	**6**	265	8.10	**75**	143	3		21	3	16	9	113	16	0.2	<10	170	**<50**	**40**			<100										Low-Mod	Low		RH
Dawson d/s Hutton-1	5/10/2006			14.6	7.3	226	7.20	**70**	108	**15**	6	18	3	14	7	104	10	0.2	<1	60	**<10**	<10		<1	<100	<0.1	<1	<1	60	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawson d/s Hutton-1	23/04/2007		31.9	22.5	6.9	265	4.16	**49**	160	9		23	3	21	9	150	11	0.21	<1	**550**	**<20**	**30**	<44*	<1	16	<1	<1	<2		<1	<0.5	<3	**17**	<1				RH
Dawson d/s Hutton-2	23/04/2004			25.1	7.6	260	5.40	**66**	132	**20**		20	3	14	6	138	14	<.1	<10	280	**110**				**400**										Low	Moderate		RH
Dawson d/s Hutton-2	19/11/2004			22.7	7.2	134	8.00	93	922	**292**		15	6	1	2	56	8	0.08	<10	**3100**	**680**				<100										Moderate	Moderate		RH
Dawson d/s Hutton-2	24/05/2005			13.8	7	249	9.50	93	172	3		21	3	16	9	111	14	0.17	<10	190	**<50**	<10			<100				66						Low-Mod	Low		RH
Dawson d/s Hutton-2	5/10/2006			15.4	7.6	228	7.20	**71**	124	**11**	4	19	3	14	7	106	12	0.2	<1	60	**<10**	<10		<1	<100	<0.1	<1	<1	97	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawson d/s Hutton-2	23/04/2007		31.5	21.8	7	282	5.93	**68**	160	3		28	4	26	11	150	12	0.21	<1	**560**	**<20**	<6	<44*	<1	15	<1	<1	<2		<1	<0.5	<3	<1	<1				RH
Dawsons Bend	9/11/2003			19.2	6.7	258	5.10	**55**	95			27	2	14	7	157	12	0.1	<5						<100										Low	Low		RH
Dawsons Bend	20/04/2004			24.6	**6**	270	4.50	**54**	92			21	3	14	7	131	15	<.1	<10	270	**60**				**500**										Low	Low		RH
Dawsons Bend	19/11/2004			21.2	6.9	136	7.40	**84**	136	**366**		15	5	1	<1	55	9	0.17	<10	**3400**	**750**				<100										Moderate	Moderate		RH
Dawsons Bend	24/05/2005			17.9	7.1	244	8.40	89	148	4		21	3	14	9	106	15	0.21	<10	40	**<50**	<10			<100				62						Low	Mod		RH
Dawsons Bend	5/10/2006			16.7	7.3	228	7.00	**72**	122	**10**	2	21	3	13	8	102	13	0.2	<1	90	20	<10		<1	<100	<0.1	<1	<1	23	<1	<0.1	<1	**<10**		Mod	Mod		RH
Dawsons Bend	23/04/2007		23.1	24.1	6.9	273	5.03	**60**	220	**14**		22	3	19	9	130	14	0.28	<1	**540**	46	<6	<44*	<1	14	<1	<1	<2		<1	<0.5	<3	<1	<1				RH
Yebna Crossing	31/09/1999			19		**430**			292																												Slow Flow	S
Yebna Crossing	1/04/2002	15:00		22		182			124																												Slightly cloudy brown	S
Yebna Crossing	7/01/2002					244			166																												Muddy	S
Yebna Crossing	1/01/2002	15:00		25		318			216																												Very slight cloudy brown	S
Yebna Crossing	1/01/2002	15:00		25		318			216																												Very slight cloudy brown	S
Yebna Crossing	9/11/2001			21		234			159																												Clear	S
Yebna Crossing	10/10/2001					234			159																												Clear	S
Yebna Crossing	29/08/2001			22		241			164																												Clear	S
Yebna Crossing	1/07/2001			21		250			170																												Clear	S
Yebna Crossing	22/06/2001			18		215			146																												Slightly Murky	S
Yebna Crossing	25/05/2001			24		165			112																												Slightly Murky	S
Yebna Crossing	20/04/2001			24		160			109																												Slightly Murky	S
Yebna Crossing	8/03/2001			25		176			120																												Clear	S
Yebna Crossing	4/02/2001	15:00		26		186			126																												Slightly cloudy	S
Yebna Crossing	23/01/2001	14:00		25		151			103																												Slightly cloudy	S
Yebna Crossing	19/12/2000	16:00		25		249			169																												Slightly cloudy	S
Yebna Crossing	21/11/2000	13:00		26		266			181																												Clear	S
Yebna Crossing	10/10/2000	11:30		25		290			197																												Clear	S
Yebna Crossing	2/09/2000	11:00		25		297			202																												Clear	S
Yebna Crossing	3/08/2000	14:37		25		257			175																												Clear	S
Yebna Crossing	23/07/2000	14:32		25		266			181																												Clear	S
Yebna Crossing	21/06/2000	14:24		25		275			187																												Clear	S
Yebna Crossing	14/04/2000	15:00		25		241			164																												Very slight cloudy brown	S
Yebna Crossing	21/06/2000	12:30		22		305			207																												Faint Cloudy brown	S
Yebna Crossing	14/04/2000	12:30		21		279			190																												Faint Cloudy brown	S
Yebna Crossing	6/03/2000			24		**344**			234																												Very slight cloudy brown	S
Yebna Crossing	30/01/2000	12:30		25		282			192																												Very slight cloudy brown	S
Yebna Crossing	30/12/1999	10:45		20		260			177																												Flow	S
Yebna Crossing	29/11/1999	16:35		22		**380**			258																												Flow	S
Yebna Crossing	29/10/1999	16:00		23		**430**			292																												Flow	S
Yebna Crossing	29/07/1999			15		**348**			237																												Slow flow - murky	S
Yebna Crossing	29/07/1999			17		**435**			296																												Slow Flow - Clear to Yellow	S
Yebna Crossing	1/06/1999	8:00		12		245			167																												Slow flow - murky	S
Yebna Crossing	8/05/1999	9:30		18		194	4.00		132																												Mod flow - murky	S
Yebna Crossing	23/02/1999	9:50		25		110			75																												Mod flow, murky	S
Yebna Crossing	23/02/1999	10:00		28		187			127																												Mod flow, muddy	S
Yebna Crossing	23/02/1999			26		231			157																												Mod flow, muddy	S
Yebna Crossing	28/11/1998	11:30		17		286			194																												Med Flow - Brown	S
Yebna Crossing	28/11/1998	14:30		28		200			136																												Mod flow, murky	S
Yebna Crossing	28/11/1998	15:00				176			120																												Med Flow - Brown	S
Yebna Crossing	9/08/2003			19.1	7.8	214	9.50	103	89			31	3	11	5	127	19	0.1	<5						<100										Moderate	Moderate		RH
Yebna Crossing	20/04/2004			20.8	7.2	292	7.20	**81**	92	4		27	3	14	6	124	22	<.1	<10	**500**	40				**600**										Moderate	Low		RH
Yebna Crossing	18/11/2004			24.6	7.3	273	5.00	**60**	172	**142**		29	6	7	5	103	19	0.23	<10	**1100**	**280**				<100										Mod-High	Mod		RH
Yebna Crossing	25/05/2005			13	7.7	226	13.00	124	127	2		27	3	11	6	88	22	0.16	<10	50	<50	<10			<100				156						Low	Mod		RH
Yebna Crossing	5/11/2006			13.4	7.8	228	14.30	135	134	8	4	27	3	9	4	87	21	0.1	<1	30	<10	<10		<1	<100	<0.1	<1	<1	76	<1	<0.1	<1	**<10**		Mod	Mod		RH
Yebna Crossing	24/04/2007		27.4	21.6	**8**	242	9.28	107	180	**11**		33	4	17	6	130	20	0.22	<1	**500**	22	14	<44*	<1	16	<1	<1	<2	**390**	<1	<0.5	<3	<1	<1				RH

BOLD Exceeds adopted guideline value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources
*by calcuation from Nitrate as N

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400	500	50		20	700	5		371	1.4	200			8							
Dawson Taroom	31/09/1999						19		445			303																													Med Flow	S
Dawson Taroom	1/04/2002	14:00					24		96			65																													Cloudy brown	S
Dawson Taroom	1/04/2002	12:45					19		257			175																													Rapid Flow - Flood level 4.35 m, Brown	S
Dawson Taroom	1/04/2002	16:00					28		300			204																													Mod flow, muddy	S
Dawson Taroom	1/04/2002	17:00							193			131																													Rapid Flow - Brown	S
Dawson Taroom	1/04/2002	11:10					25		117			80																													Mod flow, muddy	S
Dawson Taroom	1/04/2002	11:30					27		140			95																													Mod flow, murky	S
Dawson Taroom	1/04/2002						27		258			175																													Mod flow, murky	S
Dawson Taroom	7/01/2002								216			147																													Muddy	S
Dawson Taroom	1/01/2002	16:00					24		247			168																													Clear	S
Dawson Taroom	1/01/2002	16:00					24		247			168																													Clear	S
Dawson Taroom	9/11/2001						21		242			165																													Clear	S
Dawson Taroom	10/10/2001								242			165																													Clear	S
Dawson Taroom	10/08/2001						22		214			146																													Brown tinge	S
Dawson Taroom	1/07/2001						20		234			159																													Clear	S
Dawson Taroom	22/06/2001						19		220			150																													Slightly Murky	S
Dawson Taroom	25/05/2001						24		155			105																													Slightly Murky	S
Dawson Taroom	20/04/2001						24		145			99																													Slightly Murky	S
Dawson Taroom	8/03/2001						25		118			80																													Clear	S
Dawson Taroom	5/02/2001	13:00					27		364			248																													Clear	S
Dawson Taroom	18/01/2001	10:30					26		381			259																													Clear	S
Dawson Taroom	20/12/2000	13:20					25		213			145																													Clear	S
Dawson Taroom	20/11/2000	14:00					26		268			182																													Clear	S
Dawson Taroom	2/10/2000	13:30					24		321			218																													Clear	S
Dawson Taroom	2/09/2000	13:00					24		324			220																													Clear	S
Dawson Taroom	3/08/2000	14:35					24		301			205																													Clear	S
Dawson Taroom	22/07/2000	14:33					24		297			202																													Slight cloudy, brown sediment	S
Dawson Taroom	20/06/2000	14:18					24		284			193																													Slight cloudy, brown sediment	S
Dawson Taroom	14/04/2000	16:00					24																																		Clear	S
Dawson Taroom	14/04/2000	11:45					22		410			279																													Clear	S
Dawson Taroom	14/04/2000	11:45					21		410			279																													Clear	S
Dawson Taroom	6/03/2000						23		314			214																													Clear	S
Dawson Taroom	30/01/2000	11:45					24		377			256																													Clear	S
Dawson Taroom	30/12/1999	11:30					22		340			231																													Flow	S
Dawson Taroom	29/11/1999	15:04					24		310			211																													Flow	S
Dawson Taroom	29/10/1999	14:28					24		410			279																													Flow	S
Dawson Taroom	29/07/1999						16		367			250																													Slow flow - murcky	S
Dawson Taroom	29/07/1999						17		450			306																													Slow Flow - Murky	S
Dawson Taroom	1/06/1999	9:10					14		319			217																													Mod. Flow - clear/murcky	S
Dawson Taroom	8/05/1999	11:00					19		209			142																													Moderate flow- murky	S
130302A	1/12/1963	1630	0.81	0.60	0.10			8.10	290			200			33		21.0	11.0	143	36	0.20	2.0														117.00	0.00		98	246.2		DNRW
130302A	28/05/1964	2359	0.71	0.20	0.10			8.00	244			148			36		22.0	8.0	146	32	0.60	1.0														120.00			88	245.6		DNRW
130302A	30/11/1964	1520	0.65	0.07	0.10			7.30	287			148			41		16.0	7.0	138	33	0.40															113.00	0.00		69	235.4		DNRW
130302A	7/09/1965	950	0.69	0.13	0.10			7.40	290			164			36		18.0	8.0	132	32	0.20	1.0														108.00	0.00		78	227.2		DNRW
130302A	3/02/1966	830	0.71	0.20	0.10			8.20	310						42		35.0	8.0	195	32	0.30	7.0														160.00			120	319.3		DNRW
130302A	3/02/1966	830					29																																			DNRW
130302A	14/04/1966	1430	0.84	0.23	0.10			7.80	172						22		14.0	5.0	93	12	0.15	11.0														76.00			56	157.2		DNRW
130302A	14/04/1966	1430					24																																			DNRW
130302A	11/05/1966	1645	0.69	0.18	0.10			7.60	196						22		19.0	5.0	112	14	0.10	4.0														92.00			68	176.1		DNRW
130302A	11/05/1966	1645					17																																			DNRW
130302A	25/04/1971	830	0.74	0.34	0.10			7.90	435						34		44.0	11.0	220	35	0.15															180.00	0.00		155	344.2		DNRW
130302A	25/04/1971	830	0.73	0.34			18																																			DNRW
130302A	26/08/1971	1500	0.72	0.22	0.10			7.90	390						35		32.0	10.0	189	30	0.15															155.00	0.00		121	296.2		DNRW
130302A	26/08/1971	1500	0.72	0.22			17																																			DNRW
130302A	16/09/1972	845	0.64	0.05			20																																			DNRW
130302A	14/12/1972	1615	0.65	0.02	0.10			7.70	282						30		23.0	6.0	142	24	0.20															116.00	0.00		82	225.2		DNRW
130302A	14/12/1972	1615					31																																			DNRW
130302A	13/04/1973	835	0.66	0.14	0.10			7.60	165			113	197		15	6.7	14.5	3.5	93	10	0.19						10000			90		400		7.00		76.00			51	153.2		DNRW
130302A	13/04/1973	835					21																																			DNRW
130302A	10/08/1973	1630	0.86	1.56	0.10			7.80	180			115	2		18	5.2	13.7	3.5	73	18		7.0										2100		13.00		60.00		0.2	49	141.1		DNRW
130302A	10/08/1973	1630					18																																			DNRW
130302A	5/12/1973	1630	0.70	0.22	0.10			7.80	230			134	70		18	6.1	22.0	4.7	116	16	0.17											300		10.00		96.00	0.00	0.4	74	183.8		DNRW
130302A	5/12/1973	1630					29																																			DNRW
130302A	27/03/1974	755	0.70	0.24	0.10			7.70	360			204	20		36	6.8	27.0	8.5	170	28	0.13													14.00		140.00	0.00	0.5	102	276.9		DNRW
130302A	27/03/1974	755					25																																			DNRW
130302A	24/06/1974	1700	0.78	0.52	0.10			7.60	265			152	85		28	5.5	20.0	5.3	122	24	0.15													9.00		100.00	0.00	0	72	205		DNRW
130302A	24/06/1974	1700					15																																			DNRW
130302A	19/09/1974	1710	0.69	0.21	0.10			7.80	315			175			37	3.7	18.0	7.0	146	34	0.27													3.00		120.00	0.00	0	74	246		DNRW
130302A	19/09/1974	1710					19																																			DNRW
130302A	16/10/1974	1038	0.69	0.25	0.10			7.70	290			158			31	3.3	17.0	6.0	129	30	0.17													7.00		106.00	0.00	0	67	216.5		DNRW
130302A	16/10/1974	1038	0.69	0.25			22																																			DNRW
130302A	16/12/1974	1405	0.58	0.02	0.10			7.50	310			192	31		32	6.3	19.5	6.8	136	30	0.22													30.00		112.00	0.00	0	77	230.8		DNRW
130302A	16/12/1974	1405					30																																			DNRW
130302A	7/04/1975	1610	0.85	1.60			23																																			DNRW
130302A	2/07/1975	1615	0.71	0.15			18																																			DNRW
130302A	27/08/1975	1645	0.62	0.08	0.10			7.70	267			140	14		28	3.5	14.0	5.9	125	24														2.00		103.00	0.00	0	59	200.4		DNRW
130302A	27/08/1975	1645					16																																			DNRW
130302A	14/10/1975	1630	0.59	0.03	0.10			7.90	261			140	20		31	3.3	12.0	5.7	115	26	0.10													2.00		94.00	0.00	0	53	193.1		DNRW
130302A	14/10/1975	1630					23																																			DNRW
130302A	15/10/1975	1640	0.58	0.03			24																																			DNRW
130302A	12/01/1976	1606	0.85	1.85	0.20			8.15	258			158	72		23	6.4	21.0	6.1	115	22	0.20	3.0					2400									96.00		0.8	78			DNRW
130302A	12/01/1976	1606	0.86	1.85			27																																			DNRW
130302A	13/09/1976	1542	0.64	0.16	0.10			8.50	370			201			43	3.4	24.0	7.8	165	38							200									141.00	0.00	3.2	92	284.7		DNRW
130302A	13/12/1976	1642	0.72	0.54	0.10			7.30	230			128	159		18	5.2	20.0	4.3	102	14	0.70	2.0					1700							12.00		84.00	0.00	0.1	68	168		DNRW
130302A	13/12/1976	1642					31																																			DNRW
130302A	18/04/1977	1637	0.69	0.40	0.10			8.00	310			172	27		28	5.7	24.0	7.2	120	26	0.10	5.0					700							16.00		100.00		0.7	90	217.4		DNRW
130302A	18/04/1977	1637					24																																			DNRW
130302A	28/10/1977	1210	0.60	0.12	0.10			8.20	335			174			41	3.4	13.0	7.8	142	33	0.20						200							4.00		118.00		1.1	65	241.7		DNRW
130302A	28/10/1977	1210					26																																			DNRW
130302A	12/04/1978	1428	0.62	0.21	0.10			7.90	250			149	19		21	5.0	21.0	5.8	128	18	0.20	2.5					900							11.00		106.00		0.6	76	203		DNRW
130302A	12/04/1978	1428					24																																			DNRW
130302A	28/07/1978	1124	0.69	0.48			14																																			DNRW
130302A	25/10/1978	1605	0.61	0.18			23																																			DNRW
130302A	5/01/1981	1045	1.25	2.73	0.10			7.50	200			122	1270		16	7.4	17.0	4.5	95	7	0.10	5.0					5000							13.00		78.00		0.2	61	156.8		DNRW
130302A	5/01/1981	1045					25																																			DNRW
130302A	25/03/1981	1425	0.66	0.26			26																																			DNRW
130302A	24/07/1981	1630	0.71	0.43	0.10			7.70	370			189	10	13	34	4.2	25.0	7.6	160	30	0.10	1.0					2000							6.00		132.00		0.5	94	264.4		DNRW
130302A	24/07/1981	1630					16																																			DNRW
130302A	9/09/1981	1410	1.19	1.47	0.10			7.90	160			101	50	100	13	5.3	12.0	3.1	65	11	0.10	8.0					4000							12.00		54.00		0.3	43	121.8		DNRW
130302A	9/09/1981	1410					17																																			DNRW
130302A	9/09/1981	1410	0.61	0.25	0.10			8.00	400			212	10	5	40	3.7	27.0	8.6	183	34	0.10	5.0												3.00		152.00		1.1	103	302.5		DNRW
130302A	9/10/1981	800	0.57	0.09	0.10			7.80	390			207	10	5	41	3.6	23.0	8.2	177	34	0.10	5.0					1000							3.00		146.00		0.6	91	293.5		DNRW
130302A	9/10/1981	800					21																																			DNRW
130302A	20/04/1982	1620	0.81	0.22			23																																			DNRW
130302A	9/08/1982	1645	0.79	0.14	0.10			8.50	320			170	9	2	36	3.7	21.0	6.4	140	29	0.10	3.0					400			20		20		1.00		119.00		2.7	79	242.4		DNRW
130302A	9/08/1982	1645					15																																			DNRW
130302A	2/11/1982	1105	0.70	0.02	0.10			8.10	310			170	10	8	39	3.8	15.5	6.6	140	34	0.20	1.0					600									116.00		1	66	241.2		DNRW
130302A	2/11/1982	1105					25																																			DNRW
130302A	23/03/1984	1625	0.98	0.80	0.10			7.40	355			200	20	17	33	4.9	27.0	7.3	170	25	0.10	8.3					500			20		100		14.00		140.00		0.3	98	276.5		DNRW
130302A	23/03/1984	1625					26		330																																	DNRW
130302A	20/06/1984	1600	0.85	0.25	0.10			7.40	450			250	5		51	3.9	32.0	9.7	195	42	0.10	3.7								10				7.00		161.00		0.4	120	337.8		DNRW
130302A	20/06/1984	1600					15		425																																	DNRW
130302A	29/07/1984	715	6.56	976.38	0.10			7.00	165			160	1000	100	22	6.4	9.5	3.0	95	8		4.1								40		4600	0.03	56.00		78.00		0.1	36	152.6		DNRW
130302A	29/07/1984	715					13																																			DNRW
130302A	29/07/1984	1350	6.52	1050.59	0.10			6.90	175			120	800	100	21	6.4	10.0	2.3	85	9		5.0					2300			1000		1200	1.00	19.00		70.00			34	144		DNRW
130302A	30/07/1984	855	6.43	602.20	0.10			6.50	120			120	80	100	12	6.0	8.1	2.7	60	6		3.3								20		4800	0.02	52.00		49.00			31	102.5		DNRW
130302A	31/07/1984	835	6.13	605.58	0.10			6.80	115			110	80	100	11	5.1	7.7	2.6	67	6		3.1								20		4000	0.01	44.00		55.00			30	106.1		DNRW
130302A	16/10/1984	945	0.87	0.40	0.10			8.00	425			240	5		55	2.4	26.0	8.9	185	40	0.10	9.0								10		200		6.00		154.00		1.2	102	327.8		DNRW
130302A	16/10/1984	945					24																																			DNRW
130302A	10/04/1985	840	0.81	0.16	0.10			7.80	270			160	60	63	25	5.5	22.0	5.0	140	20	0.20	2.1					600			30		390		12.00		116.00		0.5	76	221.3		DNRW
130302A	10/04/1985	840					23		250																																	DNRW
130302A	2/07/1985	1635	0.81	0.15	0.10			8.10	450			180	10	24	38	3.8	22.0	6.4	145	33	0.10						600			20		240		5.00		121.00		1	81	250.1		DNRW
130302A	2/07/1985	1635					13		284																																	DNRW

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400	500	50		20	700	5		371	1.4	200			8							
130302A	17/10/1985	1500	1.07	1.07	0.10			7.90	330			170	20	20	36	3.6	19.0	6.4	145	35	0.20	2.0					500			20		10	0.01	1.00		120.00		0.7	74	248.4		DNRW
130302A	17/10/1985	1500					23		315																																	DNRW
130302A	7/11/1985	845	0.92	0.38			23		170																																	DNRW
130302A	21/01/1986	1100	0.82	0.12	0.10			7.90	255			140	80	89	22	5.7	17.0	5.0	110	18	0.20	2.0					500			30		500	0.01	15.00		91.00		0.5	63	181.4		DNRW
130302A	21/01/1986	1100					29		134																																	DNRW
130302A	15/04/1986	1427	0.78	0.05	0.10			8.20	275			150	105	2	24	5.0	23.0	6.0	130	17	0.20	2.1								30		80		8.00		109.00		1.2	82	208.6		DNRW
130302A	15/04/1986	1427					23		275																																	DNRW
130302A	16/07/1986	1055	0.81	0.11	0.10			8.10	345			180	20	8	36	5.0	24.0	7.0	155	30	0.10									20		30		1.00		129.00		1.3	89	258.4		DNRW
130302A	16/07/1986	1055					15		363																																	DNRW
130302A	14/10/1986	1642	0.95	0.07	0.10			8.00	310			160	5	7	33	3.7	20.5	6.4	140	27	0.10									10		30		1.00		116.00		0.9	78	231.1		DNRW
130302A	14/10/1986	1642					25		300																																	DNRW
130302A	31/03/1987	1544	0.80	0.03	0.10			7.80	260			140	28		22	5.4	21.0	5.0	125	16	0.20									20		30		12.00		103.00		0.4	73	195		DNRW
130302A	31/03/1987	1544					25		246																																	DNRW
130302A	14/07/1987	1616	0.85	0.09	0.10			7.80	305			160	5	3	33	4.6	20.0	6.0	140	27	0.10									10		20		1.00		116.00		0.5	75	231.2		DNRW
130302A	14/07/1987	1616					13		361																																	DNRW
130302A	4/11/1987	1405	0.77	0.23	0.10			7.20	205			120	142	100	25	5.8	15.0	3.3	95	14	0.10						700					350		12.00		78.00		0.1	51	159.4		DNRW
130302A	4/11/1987	1405					26		208																																	DNRW
130302A	10/02/1988	833	3.29	43.20	0.10			7.10	195			110	4900	100	12	5.6	20.0	3.3	105	5	0.20	2.6					3400			20		110		11.00		86.00		0.1	64	157.1		DNRW
130302A	10/02/1988	833					23		181																																	DNRW
130302A	19/05/1988	1240	0.85	0.13	0.10			7.70	210			120	302	100	21	3.9	14.0	3.0	93	14	0.10	2.2					1400					360		14.00		77.00		0.2	47	153.2		DNRW
130302A	19/05/1988	1240					18																																			DNRW
130302A	24/09/1988	1145	0.80	0.06	0.10			7.90	250			150	60	38	29	3.2	20.0	5.2	125	23	0.10											40		3.00		104.00		0.6	71	206.1		DNRW
130302A	24/09/1988	1145					21		295																																	DNRW
130302A	12/01/1989	800	1.46	4.43	0.10			7.00	125			83	280	100	10	5.3	8.9	2.4	56	10	0.10						800					1300		19.00		46.00			32	94.2		DNRW
130302A	12/01/1989	800					26		138																																	DNRW
130302A	6/05/1989	1150	1.95	11.78	0.10			7.80	190			130	124	100	19	7.4	15.5	4.1	87	19		2.2					4700					190		12.00		72.00		0.3	56	159.4		DNRW
130302A	6/05/1989	1150							230																																	DNRW
130302A	3/09/1989	1100	0.97	0.58	0.10			7.70	325			190	100	100	35	3.5	23.0	7.3	140	38	0.10	4.4					500			40		40		8.00		115.00		0.4	88	252.2		DNRW
130302A	3/09/1989	1100							347																																	DNRW
130302A	3/12/1989	1720	1.05	1.07			29		96																																	DNRW
130302A	25/03/1990	1310	0.94	0.45	0.10			7.80	211			124	74	200	22	5.5	14.3	4.5	87	17	0.14	3.6					1900			20		70		12.20		72.00	0.01	0.3	54	156.5		DNRW
130302A	25/03/1990	1310					23		282																																	DNRW
130302A	13/07/1990	1415	1.03	0.83	0.10			8.20	394			233	36	58	44	4.5	28.1	9.2	169	38	0.13	6.0					1100			10		350		17.70		141.00	0.03	1.5	107	301.2		DNRW
130302A	13/07/1990	1415					10	8.20	423																																	DNRW
130302A	15/11/1990	805	0.84	0.13	0.10			7.90	525			295	11	8	66	5.2	33.0	11.8	221	60	0.19	3.3							0.05	30	40			6.50		182.00	0.01	1	131	401		DNRW
130302A	15/11/1990	805					25	8.30	522																																	DNRW
130302A	3/12/1990	1720	0.83	1.07				7.80	280			180	103	100	30	4.6	24.0	5.8	130	27	0.20	4.8					1700		0.15	10	20	80	0.01	16.00	10	110.00		0.5	83	230		DNRW
130302A	25/03/1991	920	0.78	0.07	0.10			7.30	241			140	57	3	22	6.4	17.9	5.4	115	16	0.17	1.9					500		0.04	40	40	20		13.20	10	94.00	0.00	0.1	66	186.3		DNRW
130302A	25/03/1991	920					24	7.90	230																																	DNRW
130302A	3/08/1991	1630	0.83	0.13	0.10			7.90	350			191	10	5	42	5.0	21.9	7.5	155	37	0.15								0.04	10				1.30		128.00	0.02	0.8	85	269.1		DNRW
130302A	3/08/1991	1630					9	8.40	303																																	DNRW
130302A	1/12/1991	1815	0.45	0.47	0.10			7.60	470			251	13	5	52	6.3	30.1	10.4	206	44	0.18						3300		0.06		20	20		2.70	10	170.00	0.01	0.5	117	353.8		DNRW
130302A	10/04/1992	853	0.83	0.12	0.10			7.60	204			123	158	200	19	4.7	17.5	4.1	102	9	0.16	1.9					1700		0.33		10	190		14.60		84.00	0.01	0.2	60	160.7		DNRW
130302A	10/04/1992	853					19		201																																	DNRW
130302A	13/08/1992	745	0.79	0.09	0.10			8.10	304			159	9		34	3.0	19.5	6.5	135	26	0.13	0.4					1000		0.01					0.50		113.00	0.03	1.1	75	227.6		DNRW
130302A	13/08/1992	745					14	7.70	310																																	DNRW
130302A	23/11/1992	1625	1.48	5.88			27	7.52	249																																	DNRW
130302A	2/07/1993	1205	0.73	0.07			14	7.40	320																																	DNRW
130302A	22/07/1993	827	0.77	0.13	0.10			7.60	335			183	12	3	37	5.6	21.5	8.2	154	28	0.14	1.8					200				10	10		4.90	10	126.00	0.01	0.4	87	256.7		DNRW
130302A	22/07/1993	827					15	7.60	325																																	DNRW
130302A	23/11/1993	1625	1.48	5.88	0.10			7.60	259			151	71	36	22	6.7	21.0	5.3	126	19	0.14	1.5					3200				20	60		11.00		103.00	0.01	0.2	74	204		DNRW
130302A	16/12/1993	1400	1.70	9.30	0.10			7.40	165			100	515	200	14	5.4	12.7	3.2	78	8	0.11	2.3					5400				40			11.00		63.00	0.01	0.1	44	128.8		DNRW
130302A	13/04/1994	1723	0.78	0.19	0.10			7.70	263			160	46	43	27	6.0	20.5	5.4	132	19	0.11	1.4					1100		0.17		30	130		15.30		109.00	0.01	0.4	73	212.7		DNRW
130302A	13/04/1994	1723					21	7.50	269																																	DNRW
130302A	31/08/1994	1535					20	8.10	313																																	DNRW
130302A	31/08/1994	1600	0.72	0.03	0.10			7.80	314			164	3	1	37	4.4	19.5	6.3	139	27	0.11	0.4					300				10			0.30		115.00	0.01	0.5	74	234.8		DNRW
130302A	31/08/1994	1600																						22.0																		DNRW
130302A	31/08/1994	1600																							0.00	33.0																DNRW
130302A	25/10/1994	845	7.20		0.10			7.20	263			154	120	200	35	4.8	15.0	4.6	113	31	0.14	1.1					1000		0.37		40	210	0.01	5.90	10	93.00		0.1	56	206.2		DNRW
130302A	25/10/1994	845																						330.0																		DNRW
130302A	25/10/1994	845																							0.18	5.0																DNRW
130302A	25/10/1994	845																										2.00														DNRW
130302A	25/10/1994	900	0.64	0.00	0.20	25	20	7.29	270	3.21																																DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30			7.65	331			179	7	2	38	6.0	20.2	6.5	151	29	0.15	0.0					560		0.00			10	0.00	4.30		124.60	0.01	0.39	77.13	251.83		DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30																			65.7																		DNRW
130302A	30/11/1994	1215	0.83	0.39	0.30		27	7.40	342																																	DNRW
130302A	16/02/1995	1253	6.00	540.00	0.20			7.14	146			88	461	200	14	5.5	10.1	2.1	62	8	0.11	2.1					4070		0.27			170	0.00	11.40		51.30	0.00	0.05	33.83	108.85		DNRW
130302A	16/02/1995	1253																						509.4																		DNRW
130302A	16/02/1995	1253																							0.16	6.7																DNRW
130302A	16/02/1995	1253																										2.00														DNRW
130302A	16/02/1995	1253	6.00	540.00	0.20		23	6.71	135																																	DNRW
130302A	28/03/1995	1730	0.78	0.26	0.30			8.04	213			133	46	78	22	5.1	17.4	5.0	110	14	0.13	1.3					1010		0.03		50	80	0.02	12.60		91.00	0.02	0.67	63.97	176.15		DNRW
130302A	28/03/1995	1730																						113.4																		DNRW
130302A	28/03/1995	1730																							0.02	35.0																DNRW
130302A	28/03/1995	1730	0.78		0.30		27	6.88	228	3.78																																DNRW
130302A	29/03/1995	1530	0.78	0.26			27	6.88	228	3.78																																DNRW
130302A	4/05/1995	1545	0.74		0.30			7.77	317			189	15	12	35	5.6	24.3	7.2	156	28	0.13	1.5					160		0.00		10		0.0	9.20	10	129.00	0.01	0.51	90.23	259.2		DNRW
130302A	4/05/1995	1545																						24.5																		DNRW
130302A	4/05/1995	1545																							0.01	7.1																DNRW
130302A	4/05/1995	1545	0.74	0.06	0.20		21	7.80	342	4.40				15																												DNRW
130302A	27/07/1995	1035	0.76	0.13	0.20		11	7.50	312	10.55				6																												DNRW
130302A	27/07/1995	1050	0.76	0.13	0.20			7.78	303			166	11	6	38	3.7	18.8	5.9	138	29	0.14	0.5							0.01		30		0.00	1.20	10	113.60	0.01	0.46	71.17	234.33		DNRW
130302A	27/07/1995	1050																						4.0																		DNRW
130302A	27/07/1995	1050																							0.00	27.4																DNRW
130302A	31/08/1995	1500	0.73	0.46	0.20			7.71	298			167	17	11	37	3.7	20.3	6.4	141	29	0.12	0.0					270		0.00		30	120	0.01	0.70		116.50	0.01	0.42	76.96	238.1		DNRW
130302A	31/08/1995	1500																						12.6																		DNRW
130302A	31/08/1995	1500																							0.00	30.3																DNRW
130302A	31/08/1995	1500	0.73	0.46	0.20	25	20	7.80	317	6.20				11																												DNRW
130302A	29/11/1995	1734	1.42	5.11	0.10			7.47	169			92	320	450	14	5.0	12.0	3.1	70	9	0.11	1.1					970		0.00		40		0.00	12.40		57.20	0.01	0.11	42.69	115.37		DNRW
130302A	29/11/1995	1734																						312.9																		DNRW
130302A	29/11/1995	1734																							0.05	67.1																DNRW
130302A	29/11/1995	1734	1.42	5.11	0.10		27	7.30	156	5.12				589																												DNRW
130302A	27/03/1996	1722	0.76	0.11	0.20			7.84	396			224	17	11	42	6.2	28.6	8.3	190	32	0.15	1.0							0.02		10	40	0.01	12.40		157.10	0.01	0.8	105.49	308.6		DNRW
130302A	27/03/1996	1722																						45.6																		DNRW
130302A	27/03/1996	1722																							0.01	43.6																DNRW
130302A	27/03/1996	1722	0.75	0.11	0.20		24	7.68	410	4.11				16																												DNRW
130302A	24/05/1996	1100	0.72		0.20			7.41	214			129	50	205	28	4.7	12.8	3.5	104	14	0.16	1.8					1300		0.00		20		0.00	10.90	10	85.60	0.00	0.14	46.33	170.84		DNRW
130302A	24/05/1996	1100																						138.2																		DNRW
130302A	24/05/1996	1100																							0.04	42.2																DNRW
130302A	24/05/1996	1100	0.82	0.31	0.20	21	15	7.30	217	6.80				216																						80.00						DNRW
130302A	19/07/1996	1130	0.76	0.14			10	7.80	317																																	DNRW
130302A	30/07/1996	1455	0.77	0.19	0.10			7.95	309			167	14	9	37	4.0	19.6	6.3	141	28	0.11	0.5							0.00			10	0.00	1.70	10	116.90	0.01	0.69	74.81	236.89		DNRW
130302A	30/07/1996	1455																						16.6																		DNRW
130302A	30/07/1996	1455																							0.00	10.2																DNRW
130302A	30/07/1996	1455	0.07	0.19	0.10		14	7.94	318	8.71				12																												DNRW
130302A	12/03/1997	700	4.06	97.00	0.10			7.01	172			111	197	327	19	7.2	10.7	2.5	84	10	0.08	2.5					1100		0.00		10	10	0.00	16.90	50	68.89	0.00	0.05	36.98	137.19		DNRW
130302A	12/03/1997	700																						696.4																		DNRW
130302A	12/03/1997	700																							0.30	163.0																DNRW
130302A	12/03/1997	700	4.06	97.00	0.10		24	6.85	172					367																												DNRW
130302A	26/03/1997	1345	0.95	1.38	0.20			7.53	304			183	57	60	30	6.6	24.9	6.5	154	20	0.13	2.0					1320		0.00		10		0.00	15.30		126.50	0.00	0.29	88.85	245.93		DNRW
130302A	26/03/1997	1345																						136.1																		DNRW
130302A	26/03/1997	1345																							0.04	61.6																DNRW
130302A	26/03/1997	1345	0.95	1.38	0.20		24	7.80	309	5.00				91																												DNRW
130302A	12/08/1997	1700	0.74	0.11	0.20		16	7.90	319	8.10																																DNRW
130302A	12/08/1997	1720	0.74	0.11	0.20			7.76	315			168	13	1	37	4.2	20.1	6.0	146	28	0.08	0.0							0.00		10		0.00	0.80		120.30	0.01	0.49	74.82	241.38		DNRW
130302A	12/08/1997	1720																						9.2																		DNRW
130302A	12/08/1997	1720																							0.01	31.8																DNRW
130302A	19/11/1997	1330	2.22	14.19	0.20	19	23	6.90	157	5.00				2800																												DNRW
130302A	19/11/1997	1340	2.22	14.19	0.20			7.16	164			102	1944	2761	23	4.6	7.8	1.7	61	14	0.11	4.8					3270		0.00		10		0.00	12.70	60	50.10	0.00	0.05	26.45	120.23		DNRW
130302A	19/11/1997	1340																						1033.3																		DNRW
130302A	19/11/1997	1340																							0.19	56.7																DNRW
130302A	27/03/1998	830	0.74	0.07	0.10			7.30	200			120	100	410	11	7.5	19.5	4.7	100	10	0.20	2.0					2300		0.05	100	50	20	0.02	9.00	20	84.00	0.00	0.1	68	160		DNRW
130302A	27/03/1998	830																						370.0																		DNRW
130302A	27/03/1998	830																							0.09	84.0																DNRW
130302A	27/03/1998	830	0.74	0.07	0.10	23	24	7.26	199	2.15				463																												DNRW
130302A	5/08/1998	730	0.76	0.15	0.20			8.10	265			140	10	10	29	4.1	16.5	5.1	120	22	0.10	2.0					500		0.05	100	50	20	0.02	1.00	20	100.00	0.00	0.9	62	200		DNRW
130302A	5/08/1998	730																						22.0																		DNRW
130302A	5/08/1998	730																							0.00	6.0																DNRW
130302A	5/08/1998	730	0.76	0.15	0.20	16	14	7.70	262	8.20				18																												DNRW
130302A	20/08/1998	1415	0.78	0.14	0.30			7.52	265			141	14	20	30	4.2	16.4	5.1	122	23	0.13	0.4					210		0.02		10	20	0.00	1.60		100.60	0.01	0.22	61.89	201.86		DNRW
130302A	20/08/1998	1415																					224.9	42.8																		DNRW
130302A	20/08/1998	1415	0.77	0.14	0.30	28	18	7.85	265	7.55				24																						105.60						DNRW
130302A	8/10/1998	1525	0.96	1.36	0.20			7.39	232			142	93	160	25	6.3	16.4	3.7	103	20	0.10	2.8					1070		0.00		20		0.00	16.50		84.34	0.00	0.14	56.13	178.1		DNRW
130302A	8/10/1998	1525																					1036.7	255.5																		DNRW
130302A	8/10/1998	1525																							0.10	10.4																DNRW
130302A	8/10/1998	1525	0.96	1.36	0.20	22	22	7.23	221	5.10				194																												DNRW

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological						Total Metals/Trace Elements							Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-a (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	na	20-80 %ile	6.5-8.0	340	na	85-110	na	10	50	115	na	1000	na	na	175	1,2	400	500	50		20	700	5		371	1.4	200			8							
130302A	18/11/1998	950	0.76	0.16	0.20			7.95	350			200	40	29	41	7.2	24.0	6.2	160	30	0.20	2.0					900		0.05	100	50	20	0.02	11.00	20	135.00	0.00	0.8	85	270		DNRW
130302A	18/11/1998	950																						120.0																		DNRW
130302A	18/11/1998	950																							0.04	11.0																DNRW
130302A	18/11/1998	950	0.76	0.16	0.20		25	7.15	401	3.30				39																												DNRW
130302A	9/02/1999	720	2.08	18.30	0.10			7.55	145			96	300	375	14	6.2	10.0	2.6	80	6	0.10	2.0					1500		0.21	100	50	290	0.02	15.00	20	66.00	0.00	0.1	35.5	120		DNRW
130302A	9/02/1999	720																						420.0																		DNRW
130302A	9/02/1999	720																							0.12	32.0																DNRW
130302A	9/02/1999	720	2.08	18.30	0.10	24	26	7.24	157	5.47				567																												DNRW
130302A	23/02/1999	1710	0.91	0.98	0.20			8.05	200			120	80	170	21	5.9	14.0	3.9	98	13	0.10	2.0					1200		0.05	100	50	70	0.02	14.00	20	82.00	0.00	0.6	51	160		DNRW
130302A	23/02/1999	1710																						230.0																		DNRW
130302A	23/02/1999	1710																							0.09	26.0																DNRW
130302A	23/02/1999	1740	0.91	0.98	0.20	32	28	7.30	232	4.40				181																												DNRW
130302A	23/02/1999	1740	0.78	0.20	0.20		13	7.40	313					32																												DNRW
130302A	9/03/1999	750	4.36	132.14	0.10			7.45	145			90	160	235	16	6.0	7.9	2.2	64	7	0.10	2.0					1500		0.23	100	50	200	0.02	17.00	20	53.00	0.00	0.1	29	110		DNRW
130302A	9/03/1999	750																						450.0																		DNRW
130302A	9/03/1999	750																							0.18	26.0																DNRW
130302A	9/03/1999	750	4.36	132.14	0.10	24	25	7.05	161	3.80				302																												DNRW
130302A	7/06/1999	1510	0.75	0.08	0.30			8.05	320			200	10	12	42	5.1	23.0	7.2	165	31	0.10	2.0					500		0.05	100	50	20	0.02	6.00	20	135.00	0.00	1.1	87	270		DNRW
130302A	7/06/1999	1510																						48.0																		DNRW
130302A	7/06/1999	1510	0.75	0.08	0.30	25	17	7.90	345	6.70				13																						116.00						DNRW
130302A	7/07/1999	1715	0.78		0.10																		336.4	33.5																		DNRW
130302A	7/07/1999	1715																							0.01	11.1																DNRW
130302A	7/07/1999	1715	0.78	0.22	0.10		14	7.50	325	8.20				32																												DNRW
130302A	13/09/1999	1350	0.74	0.11	0.30			7.93	282			161	11	5	34	4.1	18.8	6.6	142	25	0.12	0.4					340		0.00				0.00	1.10	10	117.65	0.01	0.63	74.04	232.13		DNRW
130302A	13/09/1999	1350																					286.7	42.0																		DNRW
130302A	13/09/1999	1350	0.74	0.11	0.30	27	19	7.50	293	7.80				9																						193.20						DNRW
130302A	8/12/1999	1650	0.71	0.03	0.20			7.79	321			190	9	9	41	5.5	21.0	7.8	162	31	0.16	0.0					530		0.01				0.00	3.10	30	133.44	0.01	0.58	84.47	269.09		DNRW
130302A	8/12/1999	1650																					348.8	39.4																		DNRW
130302A	8/12/1999	1650																							0.01	33.4																DNRW
130302A	8/12/1999	1650	0.71	0.03	0.20		27	7.60	337	6.92				10																												DNRW
130302A	18/02/2000	927	3.66	68.53	0.20			7.02	145			92	149	197	12	7.5	10.5	2.6	61	12	0.11	2.6					1640		0.00				0.00	13.10		50.16	0.00	0.03	36.89	110.14		DNRW
130302A	18/02/2000	927																					1221.0	562.0																		DNRW
130302A	18/02/2000	927																							0.34	14.1																DNRW
130302A	18/02/2000	927	3.66	68.53	0.20		22	7.20	133	4.10																																DNRW
130302A	22/03/2000	1520	0.89	0.84	0.20			8.16	410			221	39	37	57	6.7	18.1	6.2	185	30	0.21	1.0					1030		0.00			250	0.00	9.00	30	150.00	0.02	1.52	70.65	304.73		DNRW
130302A	22/03/2000	1520																					497.0	109.1																		DNRW
130302A	22/03/2000	1520																							0.04	21.7																DNRW
130302A	22/03/2000	1520	0.89	0.84	0.20		26	7.60	376	4.40				52																												DNRW
130302A	15/08/2000	1702	0.76		0.30			8.04	290			151	13	7	36	4.2	15.4	5.3	134	23	0.14	0.0					190		0.00				0.00	0.60		111.20	0.02	0.85	60.22	218.55		DNRW
130302A	15/08/2000	1702	0.76		0.30																		181.1	25.0																		DNRW
130302A	15/08/2000	1702	0.76		0.30																				0.01	4.3																DNRW
130302A	15/08/2000	1702	0.76	0.16	0.30		15	7.90	281	8.20				8																												DNRW
130302A	1/11/2000	815	2.00	2.09	0.20			6.96	135			88	1050	1250	15	5.3	7.6	2.0	55	8	0.10	2.8					5000		1.23			510	0.00	15.20		45.00	0.00	0.03	27.19	100.55		DNRW
130302A	1/11/2000	815	2.00		0.20																		3220.0	664.0																		DNRW
130302A	1/11/2000	815	2.00		0.20																				0.16	32.6																DNRW
130302A	1/11/2000	815	2.00	2.09	0.20		19	6.70	126	6.60																																DNRW
130302A	15/11/2000	1510	1.09	2.45	0.30			7.60	140			91	220	345	13	4.3	9.3	2.7	72	6	0.10	2.0					1400		0.05	100	50	490	0.02	18.00	700	59.00	0.00	1	35	110		DNRW
130302A	15/11/2000	1510	1.09		0.30																		1300.0	320.0																		DNRW
130302A	15/11/2000	1510	1.09		0.30																				0.09	66.0																DNRW
130302A	15/11/2000	1510	1.09	2.45	0.30		23	7.00	140	5.50				365																												DNRW
130302A	27/02/2001	1657	0.74	0.10	0.20		29	6.60	160	3.30				120																												DNRW
130302A	27/02/2001	1715	0.74	0.09	0.20			7.40	160			98	30	115	13	5.1	12.0	3.5	86	7	0.10	2.0					800		0.17	100	50	320	0.02	14.00	20	71.00	0.00	1	44	130		DNRW
130302A	27/02/2001	1715	0.74		0.20																		740.0	190.0																		DNRW
130302A	27/02/2001	1715	0.74		0.20																				0.07	37.0																DNRW
130302A	27/02/2001	1715	0.74		0.20		29	6.60	160	3.30				120																												DNRW
130302A	7/06/2001	1340	0.69	0.02	0.30			7.95	220			120	10	11	18	5.3	17.0	5.1	115	11	0.10	2.0					500		0.05	100	50	20	0.02	9.00	20	94.00	0.00	0.5	63	170		DNRW
130302A	7/06/2001	1340																					510.0	50.0																		DNRW
130302A	7/06/2001	1340	0.69	0.02	0.30	29	18	7.50	220	6.30				12																						99.00						DNRW
130302A	17/07/2001	1555	0.71	0.04	0.20			7.80	290			150	10	6	28	5.8	18.5	6.3	135	23	0.10	2.0					500		0.05	100	50	20	0.02	3.00	20	110.00	0.00	0.5	72	220		DNRW
130302A	17/07/2001	1555																					370.0	30.0																		DNRW
130302A	17/07/2001	1555																							0.01	10.0																DNRW
130302A	17/07/2001	1555																										7														DNRW
130302A	17/07/2001	1555	0.71	0.04	0.20		14	7.70	289	7.30				84																												DNRW
130302A	9/10/2001	1335	0.62	0.30	0.30			7.76	310			161	11	4	34	4.3	18.9	6.2	140	27	0.14	0.0							0.00	30			0.00	1.50	10	115.70	0.01	0.46	72.65	230.84		DNRW
130302A	9/10/2001	1335																					339.6	31.1																		DNRW
130302A	9/10/2001	1335	0.62	0.30	0.30		19	7.70	311	6.10				7																						112.40						DNRW
130302A	5/12/2001	1610	0.86	0.49			29	7.30	193	4.10																																DNRW
130302A	5/12/2001	1620	0.86	0.49	0.20			7.45	195			120	650	890	24	4.9	11.0	2.8	85	11	0.10	4.0					2500		0.24	200	30	170	0.03	15.00	30	70.00	0.00	0.1	39	150		DNRW
130302A	5/12/2001	1620																					1700.0	370.0																		DNRW
130302A	5/12/2001	1620																							0.15	59.0																DNRW
130302A	5/12/2001	1620	0.71	0.49	0.20		29	7.30	193	4.10				914																												DNRW
130302A	18/02/2002	1750	2.77	47.37	0.30			7.10	135			84	1100	1750	12	4.4	9.9	2.5	68	5	0.10	3.0					3600		0.05	100	30	10	0.03	10.00	40	56.00	0.00	0.1	35	110		DNRW
130302A	18/02/2002	1750																					2100.0	640.0																		DNRW
130302A	18/02/2002	1750																							0.05	29.0																DNRW
130302A	18/02/2002	1750	2.77	47.37	0.30		27	7.20	148	3.50				1170																												DNRW
130302A	19/02/2002	748	3.45	47.73	0.30		27	7.10	89	3.00				882																												DNRW
130302A	19/02/2002	1210	3.45	47.73	0.30			6.95	110			76	550	860	11	4.7	7.0	2.1	55	5	0.10	4.0					2700		0.05	800	30	10	0.03	13.00	40	45.00	0.00	0	26	92		DNRW
130302A	19/02/2002	1210																					1700.0	690.0																		DNRW
130302A	19/02/2002	1210																							0.11	24.0																DNRW
130302A	20/02/2002	910	2.92	29.43	0.30			6.95	87			60	340	580	8	4.1	5.3	1.7	45	4	0.10	2.0					1500		0.05	700	30	10	0.03	11.00	40	37.00	0.00	0	20	71		DNRW
130302A	20/02/2002	910																					1200.0	420.0																		DNRW
130302A	20/02/2002	910																							0.08	34.0																DNRW
130302A	20/02/2002	910	2.92	29.43	0.30		26	7.00	90	3.60				513																												DNRW
130302A	12/03/2002	1545	0.95	1.66	0.20			7.55	190			110	90	225	19	4.3	12.5	3.7	90	9	0.10	2.0					1600		0.13	100	30	140	0.03	12.00	10	74.00	0.00	0.2	46	140		DNRW
130302A	12/03/2002	1545																					700.0	140.0																		DNRW
130302A	12/03/2002	1545																							0.05	33.0																DNRW
130302A	12/03/2002	1545	0.95	1.66	0.20		26	7.30	185	8.00				214																												DNRW
130302A	12/03/2002	1620	0.95	1.63	0.20		26	7.30	185	8.00																																DNRW
130302A	7/05/2002	1455	0.68	0.91	0.10			7.73	268			152	35	114	36	4.6	15.2	4.3	137	13	0.16	1.1					1090		0.01	50		40	0.01	9.90		112.60	0.01	0.4	55.61	211.69		DNRW
130302A	7/05/2002	1455																					614.8	152.3																		DNRW
130302A	7/05/2002	1455	0.67	0.91	0.10	28	20	7.30	265	3.60				113																												DNRW
130302A	8/07/2002	1600	0.75	0.12	0.40			7.85	250			130	10	30	28	4.1	14.5	4.5	110	21	0.10	2.0					500		0.05	100	30	70	0.03	5.00	10	91.00	0.00	0.4	55	180		DNRW
130302A	8/07/2002	1600																					300.0	44.0																		DNRW
130302A	8/07/2002	1600																							0.01	11.0																DNRW
130302A	8/07/2002	1600	0.75		0.40		11	7.90	241	9.90				28																												DNRW
130302A	8/10/2002	745	0.69		0.10			7.40	245			130	50	140	28	5.3	14.5	3.9	110	17	0.20	2.0					900		0.07	100	30	110	0.03	7.00	40	92.00	0.00	0.2	52	180		DNRW
130302A	8/10/2002	745																					830.0	220.0																		DNRW
130302A	19/11/2002	1545	0.74	0.56	0.20			7.60	345			190	220	250	53	6.4	14.0	4.0	165	24	0.20	2.0					1600		0.05	200	30	110	0.03	7.00	10	135.00	0.00	0.4	52	270		DNRW
130302A	19/11/2002	1545																					280.0	1200.0																		DNRW
130302A	19/11/2002	1545																							0.09	56.0																DNRW
130302A	19/11/2002	1545	0.84	0.56	0.20	33	25	7.40	342	2.90				373																												DNRW
130302A	18/03/2003	1630	0.77		0.20			7.60	200			120	150	260	23	5.2	12.0	3.6	105	7	0.20	2.0					1500		0.05	100	30	10	0.03	11.00	10	87.00	0.00	0.2	45.5	160		DNRW
130302A	18/03/2003	1630																					900.0	290.0																		DNRW
130302A	18/03/2003	1630																							0.03	36.0																DNRW
130302A	18/03/2003	1630	0.77		0.20		30	7.20	171	3.60				261																												DNRW
130302A	15/05/2003	1500	0.78		0.20			7.57	210			122	78	255	24	4.2	13.0	3.6	104	11	0.12	0.8					1310		0.05		10	100	0.01	12.81		85.77	0.01	0.21	47.33	162.41		DNRW
130302A	15/05/2003	1500																					789.5	189.0																		DNRW
130302A	15/05/2003	1500	0.78		0.20	24	20	7.40	221	4.80																										228.00						DNRW
130302A	18/06/2003	1723	0.75		0.20			7.85	248			144	20	45	29	4.5	16.5	4.8	122	18	0.12	1.0					260		0.04	100	10	60	0.03	9.99	10	101.17	0.01	0.47	60.98	196.71		DNRW
130302A	18/06/2003	1723	0.75		0.20																		371.6	44.7																		DNRW
130302A	18/06/2003	1723	0.75		0.20																				0.01	10.2																DNRW
130302A	18/06/2003	1723	0.75		0.20		14	7.30	255	6.50				45																												DNRW
130302A	9/09/2003	1635	0.75	0.12	0.10			8.10	280			150	10	14	32	3.9	16.0	5.2	130	22	0.10	2.0					500		0.05	200	30	10	0.03	1.00	10	110.00	0.00	0.9	61	210		DNRW
130302A	9/09/2003	1635	0.75		0.10																		200.0	20.0																		DNRW
130302A	9/09/2003	1635	0.75		0.10																				0.01	8.0																DNRW
130302A	9/09/2003	1650	0.75	0.12	0.20		19	8.10	279	7.50				16																												DNRW
130302A	28/10/2003	810	0.70		0.20			7.60	305			160	20	12	34	4.8	19.0	6.1	150	24	0.20	2.0					500		0.05	100	30	10	0.03	1.00	10	125.00	0.00	0.3	72	240		DNRW
130302A	28/10/2003	810	0.70		0.20																		330.0	42.0																		DNRW
130302A	28/10/2003	810	0.70		0.20	27	23	7.70	313	3.10				12																						135.00						DNRW
130302A	13/01/2004	1530	0.83		0.10			7.20	155			98	1300	2000	17	5.0	10.0	2.0	78	6	0.20	4.0					2600		0.05	100	30	20	0.03	14.00	50	64.00	0.00	0.1	33	120		DNRW
130302A	13/01/2004	1530	0.83		0.10																		2300.0	850.0																		DNRW
130302A	13/01/2004	1530	0.83		0.10																				0.23	73.0																DNRW
130302A	13/01/2004	1530	0.83		0.10		27	6.90	154	2.20				2000																												DNRW
130302A	13/01/2004	1535	0.83	0.59			27	6.90	154	2.10				2000																												DNRW
130302A	11/05/2004	1545	0.76		0.10			7.80	385			210	10	22	49	5.6	21.5	6.7	185	30	0.20	2.0					500		0.05	100	30	20	0.03	10.00	10	150.00	0.00	0.7	81	300		DNRW
130302A	11/05/2004	1545	0.76		0.10																		350.0	41.0																		DNRW
130302A	11/05/2004	1545	0.76		0.10																				0.01	9.0																DNRW
130302A	11/05/2004	1545	0.76		0.10		19	7.60	382	5.60				22																												DNRW
130302A	22/05/2004	1050	999.99		0.20			7.85	380			210	20	13	46	5.0	21.0	7.0	180	31	0.20	2.0					500		0.05	100	30	10	0.03	6.00	10	150.00	0.00	0.8	82	290		DNRW
130302A	22/05/2004	1050	999.99		0.20																		210.0	29.0																		DNRW
130302A	22/05/2004	1050	999.99		0.20	24	16	7.90	378	7.20				16																						157.60						DNRW
130302A	25/10/2004	1515	0.77		0.10			7.78	342			180	19	14	41	5.0	19.0	6.5	157	28	0.10	1.0					500		0.05	30	30	10	0.03	2.00	10	130.00	0.00	0.7	74	258		DNRW
130302A	25/10/2004	1515	0.77		0.10																		380.0	40.0																		DNRW
130302A	25/10/2004	1515	0.77		0.10																				0.01	4.7																DNRW
130302A	25/10/2004	1515	0.77		0.10		27	7.50	346	5.00				14																												DNRW
130302A	28/10/2004	730	1.48		0.30			7.18	218			127	1760	2790	24	6.9	13.0	3.3	101	11	0.10	3.9					2200		0.05	60	30	10	0.03	13.00	30	83.00	0.00	0.1	45	165		DNRW

Water Quality Data Summary

						Physical									Cations/Anions								Nutrients & Biological							Total Metals/Trace Elements						Alkalinity						
Sample Collection Point	Sample Date	Time	Stream Water Level (m)	Stream Discharge (Cumecs)	Dist. below Water Surface	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS mg/L	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Total N (µg/L)	Total P (µg/L)	Total React P sol (mg/L)	Ammonia (µg/L)	Nitrate as NO3 (ug/L)	Chl-*a* (µg/L)	Aluminium as Al soluble (mg/L)	Boron (µg/L)	Copper (µg/L)	Iron (µg/L)	Manganese as Mn soluble (mg/L)	Silica as SiO2 sol (mg/L)	Zinc (µg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide as OH (mg/L)	Carbonate as CO3 (mg/L)	Hardness as CaCO3 (mg/L)	Total Diss. Ions (mg/L)	Physical Appearance	Data source
					MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*		*20*	*700*	*5*		*371*	*1.4*	*200*			*8*							
130302A	28/10/2004	730	1.48		0.30																		**3807.5**	**1387.1**																		DNRW
130302A	28/10/2004	730	1.48		0.30																				0.16	**41.4**																DNRW
130302A	28/10/2004	730	1.48		0.30		20	7.20	215	3.20				**2000**																												DNRW
130302A	16/11/2004	1200	1.62		0.30			7.48	201			123	**766**	**976**	20	5.7	15.0	3.6	99	12	0.10	1.7					**3100**		0.10	40	30	80	0.03	12.00	**20**	82.00	0.00	0.2	53	161		DNRW
130302A	16/11/2004	1200	1.62		0.30																		**1549.4**	**417.9**																		DNRW
130302A	16/11/2004	1200	1.62		0.30	33	26	7.60	145	4.00				**800**																						87.00						DNRW
130302A	16/03/2005	820	0.69		0.10			7.74	**388**			227	**40**	**59**	59	6.8	18.0	5.1	213	22	0.20	1.0					**1000**		0.05	80	30	10	0.03	9.00	**10**	176.00	0.00	0.6	65	326		DNRW
130302A	16/03/2005	820	0.70		0.10																		**639.0**	**157.0**																		DNRW
130302A	16/03/2005	820	0.70		0.10																				0.05	**35.0**																DNRW
130302A	16/03/2005	820	0.70		0.10		25	7.60	**386**	2.10				**62**																												DNRW
130302A	7/07/2005	1730	0.89		0.00			7.57	204			120	**310**	**389**	26	4.3	9.3	3.0	92	15	0.10	2.3					**2000**		0.05	50	30	10	0.03	12.00	**60**	76.00	0.00	0.2	35	154		DNRW
130302A	7/07/2005	1730	0.90		0.00																		**1037.0**	**197.0**																		DNRW
130302A	7/07/2005	1730	0.90		0.00																				0.09	**49.0**																DNRW
130302A	7/07/2005	1730					15	7.50	205	8.10				**380**																												DNRW
130302A	24/10/2005	1700	3.20		0.10			7.10	118			77	**1340**	**1830**	17	4.2	4.3	1.4	58	6	0.20	1.5					**3800**		0.05	70	30	10	0.03	10.00	**80**	48.00	0.00	0	17	97		DNRW
130302A	24/10/2005	1700	3.20		0.10																		**2052.0**	**411.0**																		DNRW
130302A	24/10/2005	1700			0.10		24	7.00	92	7.00				**999**																												DNRW
130302A	15/11/2005	1520	0.89		0.20			7.48	193			115	**149**	**262**	19	5.0	13.0	3.9	97	12	0.10	1.2					**1200**		0.05	30	30	10	0.03	12.00	**10**	80.00	0.00	0.1	49	152		DNRW
130302A	15/11/2005	1520	0.00		0.00																		**880.0**	**168.0**																		DNRW
130302A	15/11/2005	1520	0.00		0.00																				0.03	**27.1**																DNRW
130302A	15/11/2005	1520					27	7.20	194	5.30																																DNRW
130302A	12/12/2005	1730			0.30			7.39	161			99	**716**	**759**	14	6.0	12.0	2.7	82	6	0.10	1.9					**2300**		0.05	50	30	50	0.03	14.00	**80**	68.00	0.00	0.1	41	127		DNRW
130302A	12/12/2005	1730			0.30																		**1328.2**	**449.5**																		DNRW
130302A	14/12/2005	1730			0.30	34	30	7.40	136	6.40				**660**																												DNRW
130302A	7/02/2006	1505	0.00		0.10			7.40	234			136	**44**	**86**	22	6.9	17.0	4.1	120	10	0.10	1.0					**1000**		0.05	40	30	140	0.03	17.00	**10**	98.00	0.00	0.2	58	180		DNRW
130302A	7/02/2006	1505	0.72		0.10																		**757.7**	**233.6**																		DNRW
130302A	7/02/2006	1505	0.72		0.10																				0.10	**20.9**																DNRW
130302A	7/02/2006	1505			0.10		29	7.40	246	2.00				**87**																												DNRW
130302A	5/05/2006	810	0.68		0.10			7.37	199			118	**32**	**52**	18	5.6	15.0	3.9	110	8	0.20	1.0					500		0.05	30	30	60	0.03	12.00	**20**	90.00	0.00	0.1	54	162		DNRW
130302A	5/05/2006	810			0.10																		**540.0**	**130.0**																		DNRW
130302A	5/05/2006	810			0.10																				0.03	**41.7**																DNRW
130302A	5/05/2006	810			0.10		16	7.30	182	2.10				**54**																												DNRW
130302A	23/08/2006	705	0.68		0.20			7.77	292			154	9	6	33	5.7	18.0	5.2	134	25	0.10	1.0					500		0.05	60	30	10	0.03	1.00	**20**	111.00	0.00	0.4	67	222		DNRW
130302A	23/08/2006	705	0.68		0.20		15	7.60	297					8																												DNRW
130302A	10/11/2006	1640			0.10			7.37	179			105	**916**	**1480**	17	5.6	13.0	2.8	85	10	0.13	3.0					**3000**		0.05	70	30	60	0.03	9.00	**60**	70.00	0.00	0.1	44	139		DNRW
130302A	10/11/2006	1640			0.10																		**2370.0**	**519.0**																		DNRW
130302A	10/11/2006	1640			0.10	26	25	7.30	166	8.20				**905**																												DNRW
130302A	14/11/2006	810	1.72		0.10	22	26	7.50	259	7.50				**230**																												DNRW
130302A	30/11/2006	945						7.52	**358**			200	**78**	**106**	40	6.3	23.0	6.2	172	23	0.20	2.3					**1300**		0.05	40	30	10	0.01	12.00	**10**	142.00	0.00	0.3	82	275		DNRW
130302A	30/11/2006	945																					**731.7**	**110.3**																		DNRW
130302A	30/11/2006	945																							0.01	**22.6**																DNRW
130302A	30/11/2006	945	0.72		0.10		26	7.50	**361**					**121**																												DNRW
130302A	20/03/2007	1600			0.10			7.38	131			89	**700**	**1090**	17	4.8	9.5	2.0	70	5	0.12	3.2					**1900**		0.11	140	30	100	0.01	11.00	**100**	58.00	0.00	0.1	32	114		DNRW
130302A	20/03/2007	1600																					**1870.0**	**605.0**																		DNRW
130302A	20/03/2007	1600			0.10	31	26	7.30	122	9.60				**999**																												DNRW
130302A	21/03/2007	1220	0.94		0.20			7.35	137			86	**648**	**1010**	13	5.7	9.7	2.1	70	5	0.12	2.4					**2700**		0.08	50	30	70	0.01	11.00	**30**	58.00	0.00	0.1	33	111		DNRW
130302A	21/03/2007	1220																					**1445.1**	**356.3**																		DNRW
130302A	21/03/2007	1220																							0.13	**51.7**																DNRW
130302A	21/03/2007	1220	0.95		0.20		26	7.00	137	4.50				**900**																												DNRW
130302A	6/05/2007	830		0.00	0.60			7.40	220			127	**86**	**106**	17	6.7	18.0	4.2	117	7	0.15	1.4					**900**		0.05	30	30	40	0.01	13.00	**10**	96.00	0.00	0.2	63	173		DNRW
130302A	6/05/2007	830																					**583.6**	**184.5**																		DNRW
130302A	8/05/2007	1130			0.10			7.46	195			120	**119**	**255**	16	6.3	16.0	3.7	108	8	0.14	2.4					**700**		0.07	50	30	110	0.01	13.00	**30**	89.00	0.00	0.2	56	162		DNRW
130302A	8/05/2007	1130																					**777.7**	**187.6**																		DNRW
130302A	8/05/2007	1130			0.10		20	7.20	182	8.00																																DNRW
130302A	3/07/2007	1645			0.20			7.63	216			121	**131**	**275**	21	4.6	15.0	4.3	102	15	0.12	1.4					**1400**		0.06	30	30	90	0.01	8.00	**20**	84.00	0.00	0.2	54	164		DNRW
130302A	3/07/2007	1645			0.20																		**587.5**	**127.4**																		DNRW
130302A	3/07/2007	1645																							0.04	**34.7**																DNRW
130302A	3/07/2007	1645	0.93		0.20		12	7.60	215	10.20				**290**																												DNRW
130302A	25/09/2007	1500																				1.0								40	30	10	0.01		**10**		0.00					DNRW
130302A	25/09/2007	1500			0.20	34	20	7.70	320	8.30				28																												DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNRW - Department of Natural Resources and Water

Table A9
Upper Dawson Catchment - Dawson River at Utopia Downs
GLNG CSG Surface Water

		Physical										Cations				Anions				Nutrients & Biological					Trace Elements										Flow		
Sample Collection Point	Sample Date	Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-*a* (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity	Data source
		MTV	*na*	*20-80 %ile*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*	*500*	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*	
Utopia	25/05/2005			12	7.2	233	11.30	103	154	9		28	3	12	6	91	22	0.15	<10	70	**<50**	**<10**				<100	-	-	-	165					Low-mod	Mod	RH
Utopia	5/11/2006			12.3	7.9	223	14.20	132	136	**10**	4	29	4	11	4	91	21	0.1	1	100	**<10**	**<10**			<1	<100	<0.1	<1	<1	1	<1	<0.1	<1	**<10**	Mod	Mod	RH
Utopia	24/04/2007		29.8	19.8	7.6	286	8.08	89	200	**12**		37	6	22	7	150	23	0.22	<1	**680**	34	18	<44*	<1	<1	20	<1	<1	<2	**460**	<1	<0.5	<3	**<1**			RH
Utopia	20/11/1964	2359			7.7	310			174			47		19	9	156	40	0.2	2				55														DNRW
Utopia	2/02/1966	2359			7.4	288			161			35		20	7	140	30	0.1																			DNRW
Utopia	6/10/1966	2359			**8**	270			162			39		14	9	136	32	0.15	1																		DNRW
Utopia	11/08/1968	1510			7.6	273			170			40		20	6	137	28		9																		DNRW
Utopia	8/06/1970	1307			7.7	290			173			38		24	5	154	30	0.15																			DNRW
Utopia	24/04/1971	1310		19	**8**	**390**			212			32		40	9	195	35	0.1																			DNRW
Utopia	25/08/1971	1445		17	7.8	320			180			32		20	15	159	35	0.1																			DNRW
Utopia	25/11/1971	1000		24	**8**	**360**			102			44		34	4	178	36	0.2																			DNRW
Utopia	10/05/1972	800		18	**8**	270			167			40		17	8	146	30	0.25																			DNRW
Utopia	15/09/1972	1330		18																																	DNRW
Utopia	14/04/1973	1730		23	**8.2**	310			187	**13**		32	5	27	8	163	70	0.2								20											DNRW
Utopia	11/08/1973	1200		17	**8.1**	200			122			21	5	15	5	87	20																				DNRW
Utopia	5/12/1973	1100		27	**8.3**	270			161	**20**		24	5	23	7	131	26	0.16																			DNRW
Utopia	27/03/1974	1030		27	7.8	**355**			203			40	5	25	8	164	32	0.13																			DNRW
Utopia	26/06/1974	1215		15	7.7	300			178	**42**		34	4	21	7	139	31	0.13																			DNRW
Utopia	18/09/1974	1530		17	7.6	335			199	**54**		36	4	21	9	149	34	0.27																			DNRW
Utopia	16/12/1974	1730		27	7.5	330			171	9		35	5	20	8	158	14	0.16																			DNRW
Utopia	8/04/1975	1000		21.5																																	DNRW
Utopia	5/07/1975	1055		16	**8**	262			145	**33**		27	3	16	6	115	22	0.1																			DNRW
Utopia	17/10/1975	1300		26	7.6	311			165	**11**		32	4	16	7	140	26	0.2																			DNRW
Utopia	3/06/1976	1350		16	**8.1**	**430**			239			42	4	35	9	186	40	0.2	5				55														DNRW
Utopia	14/09/1976	1231		16	**8.3**	**375**			211	5		43	4	28	8	167	37	0.2					55														DNRW
Utopia	14/12/1976	1632		29	**8.2**	**360**			198	**11**		28	6	34	8	165	26	0.4	2				331														DNRW
Utopia	20/04/1977	1347		22	**8.2**	**385**			212	7		39	5	28	9	153	36		5				193														DNRW
Utopia	25/10/1977	937		24	**8.2**	325			181			35	4	21	8	150	28	0.1					166														DNRW
Utopia	11/04/1978	1305		77	**8**	280			164	**15**		30	4	19	7	142	26	0.1	2				83														DNRW
Utopia	24/10/1978	1154		21																																	DNRW
Utopia	11/11/1980	1505		29	7.8	330			172			34	4	18	8	150	24	0.1	1				138														DNRW
Utopia	18/12/1980	1200		29	7.6	320			170			31	4	19	9	148	25	0.1	1				55														DNRW
Utopia	4/02/1981	1440		18	7.6	78			77	**500**		8	4	5	2	24	3	0.1	6				**7724**														DNRW
Utopia	4/02/1981	1440			7.4	90			62	**500**		8	4	6	2	38	4	0.1	4				**1379**														DNRW
Utopia	5/02/1981	945		18	7.5	117			75	**500**		10	5	8	2	47	6	0.1	4				**1931**														DNRW
Utopia	8/02/1981	725			7.3	116			83	**100**		9	4	8	2	44	6	0.1	13				**1931**														DNRW
Utopia	24/03/1981	1755			**8.1**	285			144	**10**	16	24	5	21	7	133	20	0.1	1																		DNRW
Utopia	24/03/1981	1755		27																																	DNRW
Utopia	4/06/1981	1010		16	7.3	86			58	**200**	680	8	3	5	2	26	6	0.1	7				**1103**														DNRW
Utopia	23/07/1981	1640			**8.2**	**370**			195	**10**	10	37	4	25	8	155	31	0.1	2																		DNRW
Utopia	10/11/1981	915		24	**8.5**	**360**			200	**10**		33	4	24	8	150	27	0.2	13				276														DNRW
Utopia	25/03/1982	850		22	**8**	290			160	**50**	100	24	4	20	6	135	20	0.1	4				276														DNRW
Utopia	12/08/1982	1130		14	**8.1**	300			170	9	2	35	3	19	7	140	27	0.1	3				110														DNRW
Utopia	3/11/1982	1545		25	7.8	330			190	**10**	13	37	5	21	8	165	30	0.2	1				110														DNRW
Utopia	16/02/1983	1730		28																																	DNRW
Utopia	15/12/1983	800		24	**8.1**	320			190	**25**	72	31	4	24	7	145	28	0.1	3.3				138														DNRW
Utopia	24/03/1984	1045		26	7.3	290			220	5	3	37	4	28	9	175	33	0.1	7							30											DNRW
Utopia	23/06/1984	1210		12	7.8	330			200	5		41	3	25	8	150	36	0.1	2.5																		DNRW
Utopia	18/10/1984	1140		20	**8.3**	**480**			280	5		56	5	31	10	200	55	0.1	4.5				138			10											DNRW
Utopia	13/04/1985	1345		23	7.5	**350**			200	**10**	3	41	3	23	7	165	36	0.1								20											DNRW
Utopia	5/07/1985	1425			**8.1**	**340**			180	5	6	37	3	20	7	150	33	0.1																			DNRW
Utopia	18/10/1985	1330		22	7	90			77	**330**	100	9	3	8	2	50	8	0.1	2				138			10											DNRW
Utopia	22/01/1986	1714		30	**8**	292			160	5	5	33	5	19	7	140	26	0.2					331			20											DNRW
Utopia	18/07/1986	1440		16	**8.4**	238			160	**25**	9	32	3	19	7	130	26	0.1																			DNRW
Utopia	17/10/1986	1643		25	**8**	301			160	**10**	13	32	3	19	7	140	27	0.1					690														DNRW
Utopia	9/01/1987	1807		28	7.7	152			95	**2460**	100	11	5	13	3	72	7	0.1	2.6				**1324**														DNRW
Utopia	3/04/1987	930		23	7.9	288			160	**10**	7	32	4	20	6	140	26	0.1								20											DNRW
Utopia	17/07/1987	1530		11	**8.1**	314			150	**19**	9	31	3	17	6	125	22	0.1																			DNRW
Utopia	6/11/1987	1720		21	7.3	273			150	**44**	34	29	5	17	6	120	22	0.2																			DNRW
Utopia	12/02/1988	1645		28	7.3	142			97	**730**	100	12	5	11	4	69	9	0.1					524			10											DNRW
Utopia	17/05/1988	1452		18	7.5	250			130	**48**	38	26	3	16	5	115	21	0.1																			DNRW
Utopia	26/09/1988	1430		24	**8.1**	274			150	**12**	6	29	4	18	7	125	25	0.1																			DNRW
Utopia	12/01/1989	1437		27	7.1	175			89	**125**	100	10	5	13	3	73	9	0.1																			DNRW
Utopia	7/05/1989	852			7.8	308			150	**81**	80	24	6	19	6	105	27		3.2				**2152**														DNRW
Utopia	2/09/1989	1613			7.9	**434**			250	**10**	11	46	3	31	10	180	54	0.1	5							50											DNRW
Utopia	3/12/1989	1440		30	**8.5**	**405**			230	**76**	59	43	4	28	8	155	48	0.2	4				331			100			0.02								DNRW
Utopia	24/03/1990	1115		22	**8.1**	320			179	**47**	45	33	4	20	7	133	32	0.16	2.8				166			30											DNRW
Utopia	13/07/1990	1145		11	**8.2**	**475**			260		32	51	4	31	11	182	46	0.16	7				386			20											DNRW
Utopia	15/11/1990	1330		26	7.6	**498**			270	2		58	4	31	11	200	52	0.16	3.4							40			0.03								DNRW
Utopia	23/03/1991	915		22	7.8	**380**			217	4	5	47	5	24	8	167	44	0.19								30			0.03								DNRW
Utopia	3/08/1991	1405		8	**8**	303			176	**16**	4	37	3	19	7	141	33	0.13	2.8							20			0.04								DNRW
Utopia	29/11/1991	1340		27	7.5	294			182	4	3	41	4	17	8	143	32	0.16	0.6										0.03								DNRW
Utopia	12/04/1992	1003		17	7.6	302			158	**11**	3	33	3	19	7	135	26	0.14																			DNRW
Utopia	12/08/1992	1120		12	**8.3**	240			151	**11**	1	33	2	16	7	124	25	0.13	0.7				55														DNRW
Utopia	2/12/1992	1405		26	**8.1**	310			167	9	5	34	4	17	8	136	25	0.12	0.3				221						0.01								DNRW
Utopia	24/03/1993	1015		21.1	7.7	284			153	**11**	7	37	4	14	7	121	26	0.14					55						0.02								DNRW
Utopia	21/07/1993	915		14.2	7.9	249			137	**23**	15	30	3	15	6	115	20	0.12	0.6				28														DNRW
Utopia	24/11/1993	1455			7.6	190			110	**230**	100	15	4	13	4	79	19	0.1	2				**938**			100			0.05								DNRW
Utopia	24/11/1993	1455		24.6	7.75	163																															DNRW
Utopia	16/12/1993	1300			7.65	165			99	**290**	100	15	4	11	4	76	12	0.1	2				**1048**			100			0.05								DNRW
Utopia	13/04/1994	940		15.7	7.9	294			168	8	4	33	4	19	6	134	28	0.1	0.6				110						0.01								DNRW
Utopia	31/08/1994	1330		17.4	**8**	278			147	4	3	33	3	15	7	126	23	0.11	0.7		20	17															DNRW
Utopia	23/09/1994	1420		16.2	7.8	294			155	3		34	4	16	7	134	26	0.12			27	**20**							0.02								DNRW
Utopia	30/11/1994	920		24.3	7.79	312			170	**19**	9.8	31	4	20	9	150	22	0.14	0		**73**		149			0			0								DNRW
Utopia	11/01/1995	1250		27.4	7.25	182			110	**400**	100	18	5	12	4	76	14	0.2	2		**260**	**150**	**1434**			100			0.05								DNRW
Utopia	10/02/1995	919		25.1	7.18	95	6.21		65	**1220**	200	9	4	7	2	42	7	0.11	1.29		**487**	**30**	**1131**			0			0								DNRW
Utopia	9/03/1995	1539			7.58	185			114	**124**	200	18	4	13	4	85	17	0.1	1.8		**191**	**49**	414			0			0.01								DNRW

Water Quality Data Summary

Sample Collection Point	Sample Date		Physical									Cations				Anions			
		Time	Air Temp (°C)	Water Temp (°C)	pH	EC (µS/cm)	DO (mg/L)	DO % sat	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate as HCO3 (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)
		MTV	*na*	*0-80 %il*	*6.5-8.0*	*340*	*na*	*85-110*	*na*	*10*	*50*	*115*	*na*	*1000*	*na*	*na*	*175*	*1,2*	*400*
Utopia	29/03/1995	900		22.6	**8.31**	321	6.75		180	8	8.9	37	4	21	7	142	28	0.13	1.08
Utopia	4/05/1995	1000			7.56	303			163	4	4.5	35	4	18	6	131	28	0.12	1.02
Utopia	7/06/1995	1100			7.91	296			158	**10**	3.3	32	4	17	6	125	28	0.12	0.78
Utopia	5/07/1995	845		9	7.95	292	10.85		159	**11**	7.9	33	3	16	7	132	27	0.11	0.47
Utopia	26/07/1995	1530		10.4	7.81	292	11.48		163	0	9.74	37	3	17	6	133	28	0.14	0.63
Utopia	31/08/1995	900		15.7	7.84	297	7.96		159	9	7.11	34	3	18	7	132	27	0.12	0.56
Utopia	5/10/1995	1330		20.9	7.92	289	8.24		153	9	7.24	31	4	16	7	127	25	0.14	0
Utopia	2/11/1995	1300			7.24	192			113	**196**		21	4	11	4	89	17	0.13	1.64
Utopia	28/11/1995	1315		27	7.57	195	6.13		113	**208**	340	19	4	13	4	82	18	0.11	2.04
Utopia	8/01/1996	750		25.4	7.94	262	6.53		117	**92**	143	20	3	15	5	117	5	0.11	0.9
Utopia	1/02/1996	1120		28.1	7.35	218	5.82		132	**235**	371	22	5	15	5	99	18	0.11	1.9
Utopia	4/03/1996	1432		24.1	7.81	**403**	9.66		224	**14**	17.1	45	5	27	8	182	35	0.13	0.9
Utopia	27/03/1996	1021		21.9	7.96	**391**	6.64		211	**11**	12.8	44	4	24	8	174	35	0.14	0.54
Utopia	9/05/1996	1540			7.48	203			123	**124**		29	4	10	3	97	16	0.15	1.9
Utopia	4/06/1996	1450		15.9	7.78	303	9.90		169	8	22.2	35	5	18	6	135	27	0.1	0.79
Utopia	3/07/1996	1530		10.9	7.98	307	11.38		166	9	11	35	3	18	7	135	27	0.1	0
Utopia	30/07/1996	950		12.3	7.86	289	9.20		156	**20**	14	34	3	17	6	127	26	0.06	0.38
Utopia	4/12/1996	925		26.1	7.98	338	3.50		189	**20**	18	43	5	18	8	153	28	0.15	0
Utopia	25/03/1997	925		20.8	7.56	312	6.76		179	**30**	54	33	5	21	7	145	23	0.12	1.33
Utopia	13/08/1997	1230		12.2	7.75	299			160	**10**		35	3	17	6	135	26	0.1	2
Utopia	21/11/1997	1030	28.6	22.6	7.8	260	6.20		150	**800**	1120	45	5	8	2	130	11	0.2	2
Utopia	25/03/1998	1230	31.9	25.9	7.75	285	7.90		160	**10**	16.1	28	6	21	6	140	21	0.1	2
Utopia	25/03/1998	1250		25.9	7.8	285	7.90				16								
Utopia	23/07/1998	1315	16.3	12.9	7.59	258	10.30		140	**15**	26	30	3	15	6	119	22	0.12	0.37
Utopia	8/10/1998	800	14.7	18.4	7.96	240	7.40		155	**34**	79	28	5	18	5	115	24	0.1	1.56
Utopia	24/02/1999	1330			**8.1**	230			140	**40**	60	25	5	16	5	115	16	0.1	2
Utopia	24/02/1999	1400	22.5	23.2	7.8	272	7.00				72.3								
Utopia	8/03/1999	1500		26.7	7.45	129	6.20		79	**160**	294	11	6	8	2	58	4	0.1	2
Utopia	6/07/1999	1232		11.6	7.3	261	9.80				12								
Utopia	6/07/1999	1500		11.8	**8.28**	262	9.80		152	4	12	32	3	16	7	127	24	0.11	0.38
Utopia	8/12/1999	1215		24.5	**8.16**	**396**	7.40		234	6	8	63	5	16	7	207	29	0.21	0
Utopia	28/02/2000	805																	
Utopia	22/03/2000	1025		24	**8.1**	248	6.90		146	**37**	86	32	5	13	5	117	20	0.15	1.04
Utopia	16/08/2000	1620		13.3	**8.26**	284	11.20		142	**14**	10	31	3	14	6	124	22	0.13	0
Utopia	15/11/2000	859		22.4	7.75	164	6.90		100	**150**	257	20	4	9	3	84	11	0.1	2
Utopia	28/02/2001	1205		26.3	7.85	249	6.60		140	**10**	13	26	4	15	5	120	18	0.1	2
Utopia	18/07/2001	1138		10.3	**8.1**	259	10.40		140	**10**	6	28	3	14	6	120	23	0.1	2
Utopia	5/12/2001	1330		28.2	**8.1**	335	7.20		190	**20**	27	39	4	19	10	160	24	0.2	2
Utopia	20/02/2002	1105		26.5	7.3	130	6.50		82	**240**	308	14	4	7	3	62	7	0.1	3
Utopia	9/07/2002	1255		8.3	**8.1**	273	11.00		150	**20**	12	36	3	14	6	125	24	0.1	2
Utopia	20/11/2002	825		21.9	7.95	291	4.60		160	**20**	16	36	4	15	7	135	25	0.2	2
Utopia	18/03/2003	1115		23.4	**8.1**	261	7.40		150	**30**	47	31	5	16	5	130	18	0.2	2
Utopia	18/06/2003	1455		11	7.97	266	9.50		149	**10**	11	32	3	16	6	122	23	0.11	0.65
Utopia	9/09/2003	1440			**8.25**	275			150	**10**	11	33	3	15	6	130	23	0.1	2
Utopia	9/09/2003	1448		17.1		278	9.60				13								
Utopia	13/01/2004	1245		29.3	7.7	304	5.50		170	**40**	28	43	5	13	6	145	25	0.2	2
Utopia	12/05/2004	1250		14.4	**8.1**	291	9.60		160	**10**	9	35	3	16	6	135	25	0.1	2
Utopia	26/10/2004	1215		25.3	7.76	302	4.70		160	**12**	8	36	4	15	7	139	24	0.1	1
Utopia	15/03/2005	1130		24.2	7.83	270	6.10		147	**14**	17	33	5	14	5	129	24	0.1	1
Utopia	6/07/2005	1415		13.5	**8.14**	**551**	9.50		317	**136**	311	112	4	6	3	289	32	0.3	1
Utopia	16/11/2005	1008		23.3	7.57	167	8.60		109	**345**	444	19	4	11	3	85	14	0.1	2
Utopia	7/02/2006	1030			7.09	161			91	**207**	344	14	8	9	3	68	9	0.1	1
Utopia	8/02/2006	1030		26.1	7.1	158					350								
Utopia	4/05/2006	1540		15.5	7.99	222	9.40		131	**16**	19	27	4	13	5	114	21	0.1	1
Utopia	22/08/2006	1230		14.6	7.98	297			141	**27**	8	32	3	14	6	120	23	0.1	1
Utopia	29/11/2006	1025		26.1	7.8	**350**					87								
Utopia	20/03/2007	1040		22.2	7.4	196	4.30				195								
Utopia	3/07/2007	1426		11.3	7.4	**427**	10.00				364								

Sample Collection Point	Sample Date	Nutrients & Biological					Trace Elements										Flow		Data source
		TN (µg/L)	TP (µg/L)	Ammonia (µg/L)	Nitrate as NO_3 (µg/L)	Chl-*a* (µg/L)	Arsenic (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Iron (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Level	Velocity	
		500	*50*	*20*	*700*	*5*	*24/13*	*370*	*0.2*	*50*	*1.4*	*200*	*3.4*	*0.6*	*11*	*8*	*na*	*na*	
Utopia	29/03/1995		34	**20**	121			0			0.05								DNRW
Utopia	4/05/1995		40	7				0			0.02								DNRW
Utopia	7/06/1995		28	**27**	408			0			0.01								DNRW
Utopia	5/07/1995		21	9				0			0.02								DNRW
Utopia	26/07/1995		3	**38**				0			0.02								DNRW
Utopia	31/08/1995		17	**21**	36			0			0.05								DNRW
Utopia	5/10/1995		15	**26**				0			0.02								DNRW
Utopia	2/11/1995		**158**	**25**	519			0			0.07								DNRW
Utopia	28/11/1995		**184**	**58**	433			0			0.01								DNRW
Utopia	8/01/1996		**114**	**41**	339			0			0.04								DNRW
Utopia	1/02/1996		**193**	**20**	**772**			0			0								DNRW
Utopia	4/03/1996		**59**	**30**				0			0.02								DNRW
Utopia	27/03/1996		42	**27**				0			0.01								DNRW
Utopia	9/05/1996		**138**	**24**	359			0			0.02								DNRW
Utopia	4/06/1996		32	**25**	251			0			0.01								DNRW
Utopia	3/07/1996		20	14				0			0.05								DNRW
Utopia	30/07/1996		29	20				0			0								DNRW
Utopia	4/12/1996		**59**	**57**	193			0			0								DNRW
Utopia	25/03/1997		**92**	**37**	276			0			0.01								DNRW
Utopia	13/08/1997		10	0	138			100			0.05								DNRW
Utopia	21/11/1997		**550**	**31**	662			100			0.05								DNRW
Utopia	25/03/1998		**70**	**87**	138			100			0.05								DNRW
Utopia	25/03/1998																		DNRW
Utopia	23/07/1998		30	12	66			0			0								DNRW
Utopia	8/10/1998	**573**	**118**	6	190			0			0.01								DNRW
Utopia	24/02/1999		**130**	5	193			100			0.05								DNRW
Utopia	24/02/1999																		DNRW
Utopia	8/03/1999		**330**	**20**	414			100			0.05								DNRW
Utopia	6/07/1999																		DNRW
Utopia	6/07/1999	105	22	4				0			0								DNRW
Utopia	8/12/1999	301	**79**	**55**	138			100			0								DNRW
Utopia	28/02/2000	**873**	**126**																DNRW
Utopia	22/03/2000	434	**98**	**21**	406			0			0								DNRW
Utopia	16/08/2000	147	27	10	47			0			0								DNRW
Utopia	15/11/2000	**990**	**250**	**23**	524			100			0.05								DNRW
Utopia	28/02/2001	320	**80**	8	138			100			0.05								DNRW
Utopia	18/07/2001	110	20		138			100			0.05								DNRW
Utopia	5/12/2001	320	**55**	14	138			20			0.03								DNRW
Utopia	20/02/2002	**1200**	**340**	**24**	497			100			0.03								DNRW
Utopia	9/07/2002	100	19	4	138			100			0.03								DNRW
Utopia	20/11/2002	290	**59**	17	138			20			0.03								DNRW
Utopia	18/03/2003	330	48	14	138			100			0.03								DNRW
Utopia	18/06/2003	104	13	3	138			100			0.03								DNRW
Utopia	9/09/2003	150	21	3	138			100			0.03								DNRW
Utopia	9/09/2003																		DNRW
Utopia	13/01/2004	310	**64**	**26**	138			100			0.03								DNRW
Utopia	12/05/2004	130	23	6	138			100			0.03								DNRW
Utopia	26/10/2004	244	43	7	138			30			0.03								DNRW
Utopia	15/03/2005	312	41	11	138			40			0.03								DNRW
Utopia	6/07/2005	**929**	**118**	**51**	524			170			0.03								DNRW
Utopia	16/11/2005	**1030**	**230**	**25**	441			80			0.03								DNRW
Utopia	7/02/2006				**745**			30			0.03								DNRW
Utopia	8/02/2006	**1637**	**265**	**48**															DNRW
Utopia	4/05/2006	164	34	6	138			20			0.03								DNRW
Utopia	22/08/2006				138			70			0.03								DNRW
Utopia	29/11/2006	**596**	**109**	**55**															DNRW
Utopia	20/03/2007																		DNRW
Utopia	3/07/2007																		DNRW

BOLD Greater than minimum trigger value (refer Environmental Values Table)
MTV - minimum trigger value
Samples collected downstream of existing associated water discharge points
S - Santos
RH - River Health Report
DNR - Department of Natural Resources

Table A2
Upper Dawson Catchment - URS Surface Water Analytical Results
GLNG CSG Surface Water

Location	Sample ID	Date Sampled	Analyte	Physico-Chemical Parameters				Metals (Total)									Nutrients				Major Ions										Alkalinity			
			Sample Type	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Organic Carbon	Suspended Solids (SS)	Arsenic	Boron	Cadmium	Chromium	Copper	Iron	Lead	Nickel	Zinc	Nitrate and Nitrite (as N)	Total Kjeldahl Nitrogen as N	Total Phosphorus as P	Total Nitrogen as N	Calcium	Chloride	Fluoride	Magnesium	Potassium	Sodium	Sulphate	Total Anions	Total Cations	Ionic Balance	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate as CaCO3	Total Alkalinity (as $CaCO_3$)
			Units	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/l*	*meq/l*	*%*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
			LOR	*2*	*5*	*1*	*1*	*0.001*	*0.1*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.001*	*0.001*	*0.005*	*0.01*	*0.1*	*0.01*	*0.1*	*1*	*1*	*0.1*	*1*	*1*	*1*	*1*	*0.01*	*0.01*	*0.01*	*1*	*1*	*1*	*1*
			MTV	*na*	*na*	*na*	*10*	*0.024/0.013*	*0.37*	*0.0002*	*0.05*	*0.0014*	*0.2*	*0.0034*	*0.011*	*0.008*	*na*	*na*	*0.05*	*0.5*	*1000*	*175*	*1*	*na*	*na*	*115*	*400*	*na*	*na*	*na*	*na*	*na*	*na*	*na*
D002	D002_05/03/08	5/03/2008	PS	-	31	8	**152**	0.002	<0.1	**0.0002**	0.004	**0.005**	-	**0.004**	0.004	**0.016**	**0.141**	1	**0.2**	**1.1**	12	8	0.1	4	6	20	2	1.74	1.9	-	<1	<1	73	73
D002	D002_05/03/08CHK	5/03/2008	LD	-	-	-	**146**	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	4	5	22	2	-	-	-	-	-	-	-
D002	D002_13/05/08	13/05/2008	PS	<5	1	-	3	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.67**	<0.001	<0.001	<0.005	<0.01	0.4	0.02	0.4	19	25	0.1	7	3		31	2.93	2.97	-	-	-	-	-
D004	D004_05/03/08	5/03/2008	PS	-	47	10	**152**	0.002	<0.1	0.0001	0.006	**0.008**	-	**0.007**	0.008	**0.031**	**0.174**	0.9	**0.19**	**1.1**	18	16	0.1	5	6	28	2	2.54	2.68	-	<1	<1	102	102
D004	D004_05/03/08CHK	5/03/2008	LD	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D004	QC02_05/3/08	5/03/2008	FD	-	49	<1	**290**	0.003	<0.1	0.0018	0.009	**0.008**	-	**0.007**	0.008	**0.04**	**0.149**	1.4	**0.19**	**1.6**	16	15	0.1	4	5	28	2	2.51	2.52	-	-	-	102	102
D004	D004_13/05/08	13/05/2008	PS	49	2	-	8	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.4**	<0.001	<0.001	<0.005	<0.01	0.1	0.03	0.1	27	35	<0.1	9	4		43	3.94	4.02	1.05	-	-	-	-
D004	D004_13/05/08CHK	13/05/2008	LD	-	2	-	-	-	-	-	-	-	-	-	-	-	**0.012**	-	-	-	28	-	-	9	4		49	-	-	-	-	-	-	-
D005	D005_05/03/08	5/03/2008	PS	-	44	<1	**270**	0.002	0.1	**0.0007**	0.003	**0.009**	-	**0.005**	0.005	**0.028**	**0.28**	0.8	**0.21**	**1.1**	16	9	0.1	3	6	20	2	1.93	2.05	-	<1	<1	82	82
D005	D005_13/05/08	13/05/2008	PS	<5	7	-	5	<0.001	0.08	<0.0001	<0.001	<0.001	**0.23**	<0.001	0.001	<0.005	<0.01	0.8	**0.05**	**0.8**	35	19	0.2	6	6		33	3.69	3.83	1.82	-	-	-	-
D007	D007_05/03/08	5/03/2008	PS	-	54	<1	**74**	0.002	<0.1	<0.0001	0.003	**0.007**	-	0.003	0.004	**0.02**	<0.01	1.8	**0.56**	**1.8**	13	8	0.1	2	9	20	2	1.84	1.95	-	<1	<1	78	78
D007	D007_13/05/08	13/05/2008	PS	28	9	-	**119**	0.002	0.05	<0.0001	0.002	**0.002**	**2.91**	0.001	0.002	<0.005	**0.012**	1.2	**0.22**	**1.2**	24	14	0.4	5	9		25	2.88	2.92	-	-	-	-	-
D007	D007_13/05/08CHK	13/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.2**	-	-	14	0.3	-	-		-	-	-	-	-	-	-	-
D009	D009_05/03/08	5/03/2008	PS	-	49	<1	**214**	0.004	<0.1	**0.0002**	0.005	**0.01**	-	**0.006**	0.007	**0.034**	**0.353**	1.7	**0.42**	**2.1**	12	6	0.1	2	8	23	3	1.89	2	-	<1	<1	83	83
D009	D009_13/05/08	13/05/2008	PS	16	7	-	**122**	0.002	<0.05	<0.0001	0.005	**0.007**	**9.62**	**0.005**	0.006	**0.025**	**0.177**	1.4	**0.37**	**1.6**	17	9	0.2	4	7		26	2.23	2.41	-	-	-	-	-
D009	D009_13/05/08CHK	13/05/2008	LD	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-								-	-	-	-
D010	D010_05/03/08	5/03/2008	PS	-	42	<1	**260**	0.002	<0.1	**0.0002**	0.005	**0.007**	-	**0.006**	0.005	**0.025**	**0.182**	1.3	**0.17**	**1.5**	13	16	0.2	3	6	35	2	2.53	2.63	-	<1	<1	102	102
D010	D010_05/03/08CHK	5/03/2008	LD	-	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	0.2	-	-	-	-	-	-	-	<1	<1	102	102
D010	D010_13/05/08	13/05/2008	PS	<5	3	-	6	<0.001	<0.05	<0.0001	<0.001	<0.001	**0.28**	<0.001	<0.001	<0.005	<0.01	0.3	<0.01	0.3	28	39	0.2	10	5		49	4.34	4.45	1.18	-	-	-	-
D011	D011_05/03/08	5/03/2008	PS	-	82	<1	**26**	0.002	<0.1	<0.0001	<0.001	**0.003**		<0.001	0.002	<0.005	**0.015**	1	**0.3**	**1**	14	1	<0.1	3	8	17	1	1.74	1.91	-	<1	<1	84	84
D011	D011_13/05/08	13/05/2008	PS	8	7	-	**21**	0.001	0.05	**0.0005**	<0.001	**0.003**	**0.81**	<0.001	0.001	<0.005	<0.01	0.7	**0.09**	**0.7**	21	<1	0.1	4	7		16	2.02	2.22	-	-	-	-	-
D012	D012_14/05/08	14/05/2008	PS	45	10	-	**13**	<0.001	<0.05	0.0001	<0.001	**0.003**	**0.21**	<0.001	0.002	<0.005	<0.01	0.9	**0.07**	**0.9**	26	12	0.2	7	8		26	3.09	3.2	1.69	-	-	-	-
D012	D012_14/05/08CHK	14/05/2008	LD	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	-	-	-	25	-	0.1	7	7		25	-	-	-	-	-	-	-

NOTES

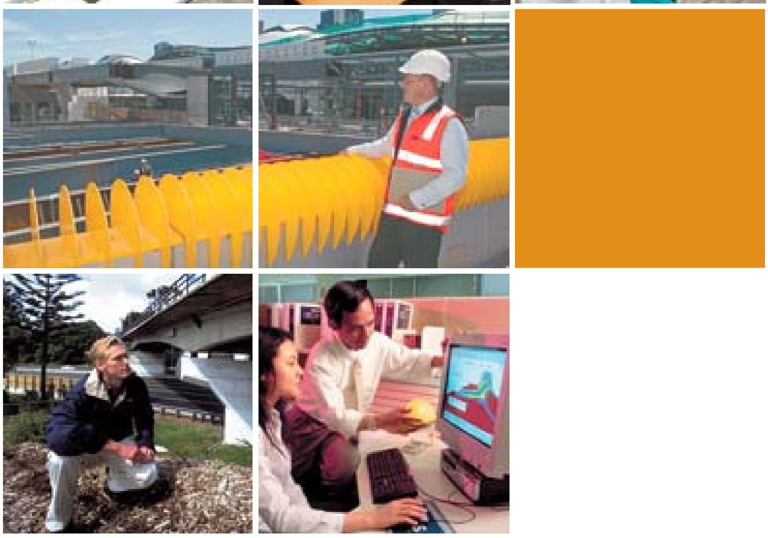
MTV - minimum trigger value
BOLD greater than MTV
PS - Primary Sample
LD - Lab Duplicate
FD - Field Duplicate Sample

Review of Aquatic Weeds

Appendix G

R E P O R T

GLNG CSG Surface Water - Aquatic Weeds



Prepared for

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21st January 2009

43270896

Table of Contents

Appendices

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Date: 21 January 2009
Reference: Appendix G – Aquatic Weeds
Status: Final

Introduction Section 1

Santos Ltd (Santos) is undertaking an expansion of its coal seam gas (CSG) operations in Queensland with a view to exporting extracted methane to international markets. The Gladstone Liquid Natural Gas (GLNG) project involves the expansion of gas fields across the northern Condamine-Balonne, Upper Dawson River and Comet-Brown River catchments. Extracted gas will then be piped to an export facility to be developed on Curtis Island, Gladstone.

A by-product from CSG operations is extracted groundwater, termed associated water. Santos is considering a range of options for the management of associated water, one of which includes discharge to local water bodies (discharge to grade). Santos engaged URS Australia Pty Ltd (URS) to undertake a detailed study into the potential adverse affects on aquatic ecosystems should this management option be utilized.

One of the areas of concern highlighted at an inter-departmental risk assessment workshop is the potential for aquatic weed infestation due to the introduction of associated water to previously ephemeral streamlines.

This report provides a review of existing and potential aquatic weeds in the Maranoa-Balonne catchment, upper Dawson River catchment, and Comet River catchment. A qualitative assessment of the risk of increased weed infestation due to the discharge of associated water is made.

Section 2 Background

2.1 Available Literature on Weeds and Associated Water

Bergquist *et al.* (2007) recently reported an investigation of non-native species richness in CSG fields compared with control sites and found increased richness associated with combined primary disturbances (including the development of well pads, roads, pipelines, dams and discharges) and combined "secondary disturbances" (i.e. subplots established adjacent to primary disturbance sites). Statistical comparisons are made between control sites and discharge areas that indicate non-native species richness is higher in the latter. However, it is probable that this is an incorrect conclusion since control sites include areas which are not drainage lines and which are shown to have significantly different native and non-native species richness and soil chemistry.

Nevertheless, Stearns *et al.* (2005) using data from the same experimental arrangement as Bergquist *et al.* (2007) did compare the vegetation in one control gully with vegetation in another gully subject to associated water discharge. They found that there was a significant difference in both native species richness (lower) and non-native species richness (higher) compared with the control. No significant differences were found between salt tolerant species between the gullies suggesting that primary reasons for the observed difference in species richness might be disturbance associated with CSG production or the application of water. Although Stearns *et al.* (2005) suggest their results are not conclusive, there is certainly some evidence that vegetation in gullies subjected to associated water are prone to non-native vegetation invasion.

As water is a limiting resource in vegetation population establishment, the addition of water into formerly dry streams has been noted to have the potential to alter species composition and cover, and to maintain source populations for exotic species (Bergquist *et al.*, 2006).

Both of the above studies were completed in the Powder River Basin, Wyoming USA. The watercourses studied are largely ephemeral and land uses are similar to the GLNG project catchments in central QLD. Limited data suggests that the streams are possibly less incised and shallower than streams in Queensland.

Disturbed sites in the Powder River Basin study also demonstrated significantly greater soil salinity than control sites. These differences in soil salinity could result in changes in vegetation composition and an increase in non-native plants. Recent studies of streamlines receiving associated water discharge at Fairview (URS *unpub,* 2008) revealed similar differences in soil salinity and sodium concentrations upstream and downstream of associated water discharge points. However, concentrations of other major cations including calcium, magnesium, and potassium found at Fairview, both at control and receiving sites, are substantially lower than found in Wyoming.

Repeated application of sodic associated water for irrigation has been found to lead to the accumulation of sodium and salt in the soil profile and lead to degradation in the soil structure particularly for fine grain soils (Ganjegunte *et al.*, 2005 and 2008). The effects of degradation include increased surface crusting, reduced infiltration and reduced hydraulic conductivity (Park and O'Conner, 1980 cited in Ganjegunte *et al.*, 2005).

Theoretically, the discharge of associated waters with high sodium absorption ratio (SAR) could potentially impact the integrity of surface soils in the beds and banks of stream. However, the effects of leaching during floods could be a mitigating factor.

If localised areas of increased salinity and soil SAR are created then reduced permeability and increased pH may result in long-term affects on vegetation, including the death of riparian vegetation (State of Montana, 2002). This could potentially create additional habitat for the establishment of hardier weed species, though this is likely to apply only to terrestrial species.

The available literature tends to focus on the spread of noxious species associated with field and pipeline construction activities, rather than through discharge of associated water to grade. Long distance transport of weeds via drilling equipment and vehicles, soil disturbance due to bore, pipeline and road construction, and the creation of preferential distribution pathways through roads and pipelines are all mechanisms of concern.

2.2 State and National Weed Classification

Under the *Land Protection (Pest and Stock Route Management) Act 2002* there are three classes of declared plants:

- Class 1: "not commonly present or established in the State; and has the potential to cause an adverse economic, environmental or social impact in the State…"; and
- Class 2 or 3: "is established in the State; and is causing, or has the potential to cause, an adverse economic, environmental or social impact in the State…".

Class 2 and 3 pests are differentiated based on the significants of the impact or potential impact, the area affected or likely to be affected, and the likely or extant spread of the plant.

Landholders are required by law to keep their land free of Class 1 pests, are required to try and keep land free of Class 2 pests.

Weeds may also be classified as Weeds of National Significance (WONS) under the *National Weeds Strategy*[1]*,*(NWS). The NWS was endorsed in 1998 by Australian governments to provide a strategic approach to weed management including the prevention of new problems, reduction in existing impacts, and provision of a framework and capacity for ongoing management within Australia.

Twenty WONs were identified through an evaluation process considering invasiveness, impacts, potential for spread and socio-economic and environmental values[2].

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[1] National Weeds Strategy is currently being reviewed and is to be renamed the Australian Weed Strategy (http://www.weeds.org.au/nws.htm, viewed 9 September 2008)

[2] Note the Department of Environment, Water, Heritage and the Arts *Weeds of National Significance (WONS)* webpage (http://www.weeds.gov.au/weeds/lists/wons.html), states 20 WONS identified, but lists 21 species.

Section 3 Information Sources

To ascertain the current and potential distribution of aquatic weeds across the catchments encompassing the GLNG field development, a web-based search of key Australian weed databases was undertaken:

- Weeds Australia (http://www.weeds.org.au/). Provides information and distribution (potential and current) maps of aquatic weed species by NRM region.
- Department of Primary Industries and Fisheries (DPIF):
  - *Annual pest distribution maps* (http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/4790_9824_ENA_HTML.htm). DPIF produces grid-based annual distribution maps for known pest species. Predictive maps are also generated from modelling programs indicating where weeds are likely to occur, based on preferred climatic conditions. Annual surveys were carried out, with data report from 2003- to 2007. A grid framework is utilised and the distribution and density of each weed is rated by survey participants (local government, DPI&F officers and others with local knowledge). Class 1 and 2 pests are rated on a 16.67km^2 grid, and Class 3 pests on a 50km2 grid. Species are assessed based on the occurrence (presence/absence/unknown), distribution (localised/widespread) and density (occasional/common/abundant).
  - *Predictive weed maps* (http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/4790_9838_ENA_HTML.htm): Predictive models have been developed using CLIMEX and CLIMATE programs to estimate potential weed distributions across Queensland. Global climate data sets are used which include distribution in the country of origin as well as any naturalised distribution. The models do not include soil preferences or other ecological parameters.
- Department of the Environment, Water, Heritage and the Arts, *Weeds of National Significance*, (http://www.weeds.gov.au/index.html). Provides information on weeds classified as Weeds of National Significance (WONS).

The following organisations were then contacted to confirm which, if any, aquatic weeds were known to have established in the region:

- Central Highlands Regional Council: Susan Walters, Rural Lands Officer, Springsure,
- DPIF Biosecurity: Graham Hardwick, Principal Land Protection Officer, Invasive Plants and Animals; and Duncan Swan, Senior Land Projection Officer

The findings from reviews and discussions are discussed in Section 4.1.

4.1 Historical and Current Aquatic Weed Distribution

Five aquatic weeds and one terrestrial weed (with a preference for floodplain and riparian environments) were found to have previously been identified in one or more areas either in, or in the vicinity of the GLNG field development. These include one Class 1 (Alligator Weed), four Class 2 (Hymenachne, Salvinia, Water Lettuce and Water Hyacinth), and one undeclared (Lippia) species.

It should be noted that the predicted associated water volumes for discharge are insignificant compared with natural flood events, and the addition of associated water to streams is unlikely to impact on the flood plain environment. Therefore it is unlikely that dispersal of terrestrial weeds such as Parthenium, which is transported by floodwaters but does not establish in the riparian environment, will be increased.

Consultation with the abovementioned authorities indicated the following:

- Although not an aquatic weed, Lippia (*Phyla canescens*) is known to exist in the Condamine-Balonne region and is prevalent in flood plain environments.
- *Hymenachne amplexicaulis* has been recorded in the Comet-Brown River catchment in tributaries draining into the lower Dawson River.
- There are no known aquatic weed species recorded to date in the Upper Dawson.
- In the Condamine catchment the following aquatic weeds have been recorded: Hymenachne (*Hymenachne amplexicaulis*) at Thallon and Chinchilla, Salvinia (*Salvinia spp*.) at Miles, Water Hyacinth (*Eichhornia* crassipes) at Meandarra, and Water Lettuce (Pistia stratiotes) Dumaresq River (Texas, Border Rivers catchment).

Review of the DPIF distribution maps supports the above. In addition the following should be noted:

- The most prevalent weed in the region, Lippia, is not classified as an aquatic weed. However, it has been detected extensively across the Condamine-Balonne, Upper Dawson and Comet-Brown catchments. It is well adapted to floodplain and riparian environments with heavy clay soils, and can be dispersed by floodwater.
- There appear to be limited detections of aquatic weeds in the Upper Dawson catchment.
- Outbreaks in the Comet River catchment have generally been in the vicinity of Emerald and to the east of the catchment (Lippia, Salvinia), with the exception of the presence of Hymenache in southern Arcadia.
- Salvinia and Water Hyacinth outbreaks have occurred at locations more than 100 km east and south east of Roma.
- Alligator Weed was detected in the vicinity and to the south of Roma in 2005, but has not been detected since.

A search of the *Weeds Australia Database* for Water Plants by NRM region returned 20 species for Maranoa-Balonne and 21 species for Fitzroy. However, with the exception of Water Lettuce, none of these weeds are listed as having current distribution in the GLNG field area. Some are shown as potential distribution (nine species), but actual distributions were geographically far removed. For the remainder of these weeds, the current and potential distribution areas fall well outside the areas of concern for the GLNG field. The maps generated in this database are very coarse, covering the whole of Australia. It is therefore considered appropriate to focus on the more detailed information provided by DPIF.Table 4-1 provides a summary of potential and existing aquatic weeds across the GLNG field area. The distribution of each species from 2006-2007, based on DPI mapping, is presented in Appendix A.

Table 4-1 Aquatic Weed Mapping and Distribution

Common Name	Scientific Name	Distribution[1]			Years Mapped
		Roma	Upper Dawson	Comet	
Alligator Weed	*Alternanthera philoxeroides*	Occasional/Localised occurrences detected in Roma and to the south in 2005. Not detected since.	Not detected	Not detected	2003 to 2007
Hymenachne	*Hymenachne amplexicaulis*	Not detected	Not detected	Occasional/Localised, Emerald, southern Arcadia 2005-2007. Outbreaks recorded at Thallon and Chinchilla (east of Comet catchment)	2003 to 2007
Lippia	*Phyla canescens*	Occasional/Localised across much of Condamine-Balone catchment around Roma in 2007. Well established in Condamine, Border Rivers, Maranoa-Balonne and Warrego-Paroo catchments	Occasional/Localised around much of Upper Dawson catchment in 2007	Occasional/Localised around Emerald to the east in 2007	2007
Salvinia	*Salvinia species*	Common localised, detected at Miles (approx. 140km due east of Roma) 2005-2007	Not detected	Occasional/Localised due east and north east of Comet catchment 2003-2007	2003 to 2007
Water Lettuce	*Pistia stratiotes*	Occasional/Localised due east of Roma. Outbreak to the south of Roma at NSW border.	Not detected	Occasional/localised in 2006 approx. 100km to the east of the Comet River	2003 to 2006
Water Hyacinth	*Eichhornia crassipes*	Detected at Meandarra (approximately 140km south east of Roma), Occasional/Localised detected in Roma and to the south 2003-2006	Not detected	Not detected	2003 to 2006

NOTES
[1]From DPI distribution maps 2003-2007. Refers to Density/Distribution
[2]Weed of National Significance

4.2 Potential Distribution

As discussed in Section 3, DPIF produces predictive distribution maps for declared weed species. Models are used to predict the suitability of differing climates across Queensland for growth of each species (CLIMEX model). Climate suitability ranges from *Unsuitable*, *Marginal*, *Suitable* to *Highly Suitable*. Predictive maps have been generated for a limited number of aquatic weed species in the GLNG project area:

- Alligator Weed – *Marginal* for all, area of *Suitable* to west of Arcadia and upper Dawson River
- Water Lettuce – *Suitable* around Roma, becoming *Highly Suitable* extending to the north of Emerald
- Salvinia – *Unsuitable* around Roma, ranging from *Marginal* to *Highly Suitable* around Comet.
- Water Hyacinth – predominantly *Suitable*, ranging to *Highly Suitable* extending to far north of Comet

- Cabomba – *Highly Suitable* for whole region. However, it should be noted that Cabomba has only been detected in coastal regions of QLD and not in the vicinity of the field area.
- Water Milfoil (*Myriophyllum spciatum*)– *high-very high suitability* climate match, however has not been detected in the vicinity of the field area.

4.3 Dispersal Mechanisms and Habitat Preferences

Details of characteristics, dispersal mechanisms and habitat preferences for each species are presented in Table 4-2. Generally each species disperses downstream via flood events, and across catchments through human activities, bird and animal movement.

The primary potential impacts of discharging associated water to grade are associated with increased salinity, temperature, and pH, and increased or changed flow regimes. When considering the tolerance to these parameters of each identified aquatic weed species the following is noted:

- Alligator Weed and Salvinia are salinity tolerant.
- All species are able to survive in, or adjacent to continuously flowing water.

No information was available regarding pH tolerances.

Section 4 Results

Table 4-2 Aquatic Weed Characteristics

Common Name	Scientific Name	Description	Characteristics & Impacts	Reproduction and Dispersal	Habitat preferences	QLD Declaration	WON[2]
Alligator Weed	*Alternanthera philoxeroides*	South American perennial plant. Hollow stems, dark green leaves arranged on opposite pairs along stem with distinct midrib, no leaf stalk, white paper-like ball-shaped flowers carried on short stalks.	Restricts water flow, damages irrigation equipment, increases water loss, reduces water quality, creates favourable habitat for mosquitoes, hinders recreational activities, replaces native plans, causes death of native submerged water plants and fish.	Flowers midsummer to March, but viable seed not recorded in Australia. Spreads through vegetative reproduction. Movement between river catchments most commonly due to human activities and animals. Regrowth occurs quickly from stems or underground rhizomes. Spread downstream when fragmented (by floods, or mechanical/chemical control).	Can tolerate 10% sea-strength salinity or up to 30% salinity in flowing brackish water, optimal growth in fresh water with high nutrient level. Temperature affects growth, with peak growth occurring in summer. Can establish on land and survive extremely dry periods. Stems lose leaves in winter, severe frost kills stems but regrowth occurs quickly	Class 1	Yes
Hymenachne	*Hymenachne amplexicaulis*	Robust rhizomatous perennial grass, up to 2.5m high. Erect and pithy stems, leaf blades 10-45cm long and 3 cm wide. Spike-like cylindrical flower heads 20-40cm long.	Originally from South/Central America. Released in Queensland in 1988 as ponded pasture for cattle. Infestations can affect drains, lagoons, wetlands, creeks and rivers, interfere with irrigation, infrastructure and aquatic habitats. Can increase flooding by reducing capacity of drainage channels, physical barrier for aquatic/semi-aquatic species	Seed dispersal by water movement (flooding), mud attached to animals and migratory aquatic birds. Seeds require contact with moist-water-logged soil for 48 hours before germination can take place. Seed also survives in water and germinates when water levels recede during the dry season. In QLD generally flowers between April and June, triggered when day length decreases to less than 12 hours. Hymenachne reproduces from both seed and broken stem fragments. It produces large numbers of viable seeds, germinates easily (graziers have reported good germination by throwing seeds into ponds). Can spread easily with stem fragments (minimum two nodes) planted in mud/shallow water.	Thrives best on clay soils that are inundated during the wet season rains but dry out to some extent in the dry season (subsoil must remain moist). Can only withstand short periods of drought. Can withstand up to 40 weeks flooding by growing above floodwaters. Flourishes in sediment and nutrient-rich water, does not tolerate brackish water or shade. Found mainly in low-lying areas along the edges of permanent water.	Class 2	Yes
Lippia	*Phyla canescens*	Summer-growing broadleaf perennial herb with thick, woody taproot which enables it to establish and persist in	Serious environmental and pastoral weed in Murray-Darling river system, poses serious threat to protected wetland areas,	Grows vegetatively, spread by floodwater, seed dispersal, vehicle, birds/livestock. Spread appears to be related to flood events. Also capable of	Well adapted to floodplain environments, prefers heavy clay soils.	Not declared	No

Common Name	Scientific Name	Description	Characteristics & Impacts	Reproduction and Dispersal	Habitat preferences	QLD Declaration	WON[2]
		poorly structures soils common to the riparian areas and floodplains of the MDB. Leaves occur in pairs at stem nodes, 1-3cm long, blunt serrated edge towards tip tapering to short stem, grey-ish green stems and leaves; white, cream, pinkish or pale lilac small tubular flowers, founded 1-1.5mm fruits	dense carpet-like spread prevents growth of other riparian vegetation resulting in soil erosion that decreases bank stability and degrades overall waterway health, aggressive weed which outcompetes pasture	spreading on high grounds and in areas not affected by floodwaters. Drought and frost tolerant. Can survive long periods of inundation. Readily establishes on bare ground.			
Salvinia	*Salvinia species*	Free-floating, mat-forming perennial, small spongy paired green leaves, leaf surfaces covered with long, stiff water-repellent hairs, as plant matures leaves thicken and fold mid-rib, young leaves oval, about 12mm across and lie flat on water, roots trail from each pair of young leaves.	Found in isolated water bodies from North QLD to NSW border, west to Mt Isa. Often survives for a short time after being stranded by receding waters. Can completely cover wetlands and lakes, excluding fish and invertebrates but haven for mosquitoes. Collects debris during flooding, increases water loss, degrades water quality, recreational impacts, damages irrigation equipment.	Native to south-eastern Brazil, first reported in Australia near Sydney in 1952 and in QLD from 1953. Does not produce fertile spores, believed to be sterile hybrid. Reproduces by fragmentation, little growth in winter. Under optimal conditions can double in volume in 2-3 days. Dispersed in floodwaters and through human activities (including boats). It has been intentionally spread throughout the world as an ornamental pond/aquarium plant.	Nutrient rich, slow moving streams or still ponds, high temperatures (20-30^{o}C, can survive up to 43^{o}C), can survive being frozen but little growth in winter. In nutrient rich water with optimal temperature capable of doubling in area in <5days. Can survive salinities up to one tenth sea water (approx 3.5 ppt).	Class 2	Yes
Water Lettuce	*Pistia stratiotes*	Free-floating aquatic weed. Spongy perennial, fan-shaped leaves covered with hairs. Fibrous roots up to 80cm long, small green flowers.	Forms dense mats covering rivers and dams. Restricts water flow and increases loss, interferes with irrigation/stock watering, can damage wildlife habitat, promote mosquito breeding. Impacts swimming, recreation and fishing.	Originally from Asia, now naturalised in NT. Spread by vegetative reproduction and seeds.	Prefers stationary/slow-moving streams, frost sensitive, can tolerate polluted water. Can survive long periods in damp situations.	Class 2	
Water Hyacinth	*Eichhornia crassipes*	Floating waterweed with a fibrous root system. Round, dark green leaves up to 5cm diameter. Spongy bulbous	Forms dense mats that causes waterway obstruction, depleted oxygen, habitat destruction, increased water loss, harbours	Grows from seed and through vegetative reproduction. Seeds, dispersed by water, may germinate within days or may remain dormant for	Prefers fresh, static or slow-flowing nutrient rich water. Tolerates annual temperature of approx. 21 to 27°C, estimated pH of 5.0 to 7.5. Leaves	Class 2	No

Section 4 Results

Common Name	Scientific Name	Description	Characteristics & Impacts	Reproduction and Dispersal	Habitat preferences	QLD Declaration	WON[2]
		leaf stalks, light purple flowers with darker blue/purple and yellow centre.	mosquitoes, health and safety risk, interference with irrigation/stock watering, damage to structures. Biological control has been effective in some regions, particularly in tropical areas. Particularly important it is prevented from entering Murray-Darling Basin (MDB).	up to 15 or more years. Mainly increases in density by daughter plants produced on stolons. Flowering during summer. Stolons can be broken off and drift in water or by wind movement to form new colonies. Infestations can break up into 'rafts' that drift with winds and currents. Seeds/stolons also dispersed by birds, in mud/sediments, boats and discarded pond refuse.	are killed by frost, and plants cannot tolerate water temperatures >34°C.		

NOTES
[1]From DPI distribution maps 2003-2007. Refers to Density/Distribution
[2]Weed of National Significance

A prima facie case for increased weed distribution due to 1) CSG development disturbance of land, and 2) the discharge of water into dry environments has been made overseas.

There is limited information available regarding the distribution of aquatic weeds across the GLNG project field area. Nevertheless, it appears that there are few weed species observed at present.

- Aquatic weeds are not known to be currently established in the Upper Dawson Catchment.
- Aquatic weed species are more prevalent in the Comet River and Upper Balonne River catchments but are generally located away from the proposed field development areas.
- An exception is the terrestrial weed, Lippia, which is found across all catchments and can establish in riparian environments.

A wide variety of dispersal mechanisms are currently available. This suggests the introduction of associated water discharge to streamlines is unlikely to be the primary mechanism facilitating distribution of aquatic weeds. Increased vehicle and machinery movement associated with the construction of the gas field and pipeline is more likely to increase dispersal opportunities but these activities are carefully managed to avoid weed spread.

Flowing water is a primary mechanism of dispersal but normally associated with the large natural seasonal floods in the region. Since associated water volumes are insignificant compared with these natural events it appears unlikely that discharge of associated water will increase the likelihood of dispersal of aquatic weeds, or of terrestrial weeds that establish in the flood plain environment. It is important that any discharges do not significantly alter the frequency of flooding, and are kept at a level that avoids erosion in channel.

The introduction of water to previously ephemeral streams may create a favourable habitat for the establishment of aquatic weed species and provide opportunities for changes in species composition. However, the chemistry of associated water is likely to preclude significant weed or native plant growth if untreated.

It is also apparent that there is limited macrophyte growth instream at the present time despite high temperatures and nutrient concentrations. It is likely that the natural turbidity of waters in the area acts to limit the growth of instream vegetation by reducing light availability and trapping nutrients on clay particles.

The current limited distribution of weed species is the most important barrier to infestation in the region. Together with the low light environment instream, it appears unlikely that weed infestations will be significantly altered by associated water discharges.

Section 6 Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 12 October 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between October 2007 and January 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

References

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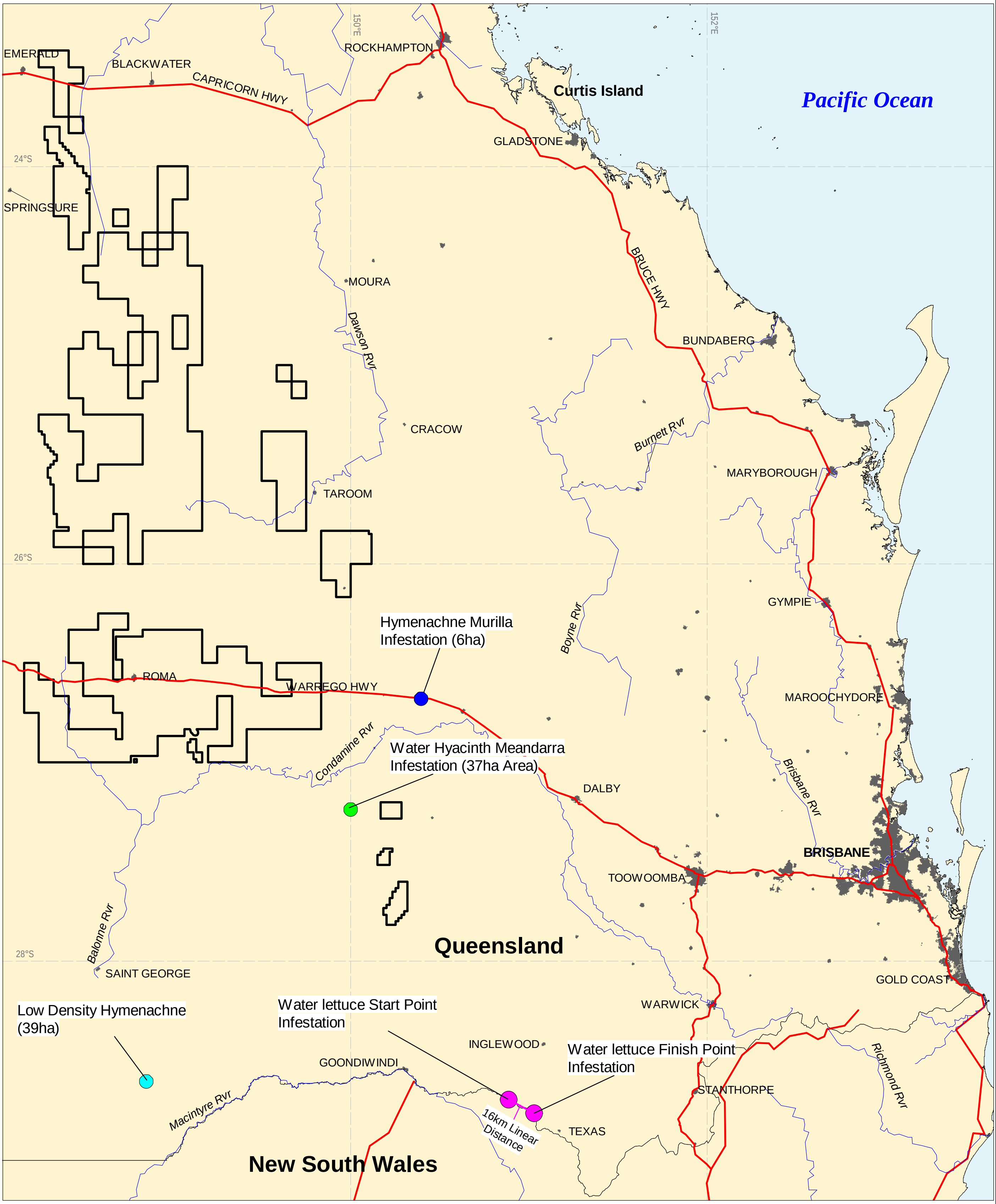
Aquatic Weed Distributions

Appendix A



N W E S

0 50 100km

Scale: 1:3 000 000 (A4)
Datum : GDA94

Major Road	Water lettuce Infestation
Major Drainage	Water Hyacinth Meandarra Infestation
CSG Fields	Hymenachne Murilla Infestation
	Low Density Hymenachne Infestation

Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownerstip and Copyright.

Client: LNG

URS

Project: GLNG GAS FIELD DEVELOPMENT ASSOCIATED WATER DISCHARGE STUDY

Title: AQUATIC WEEDS

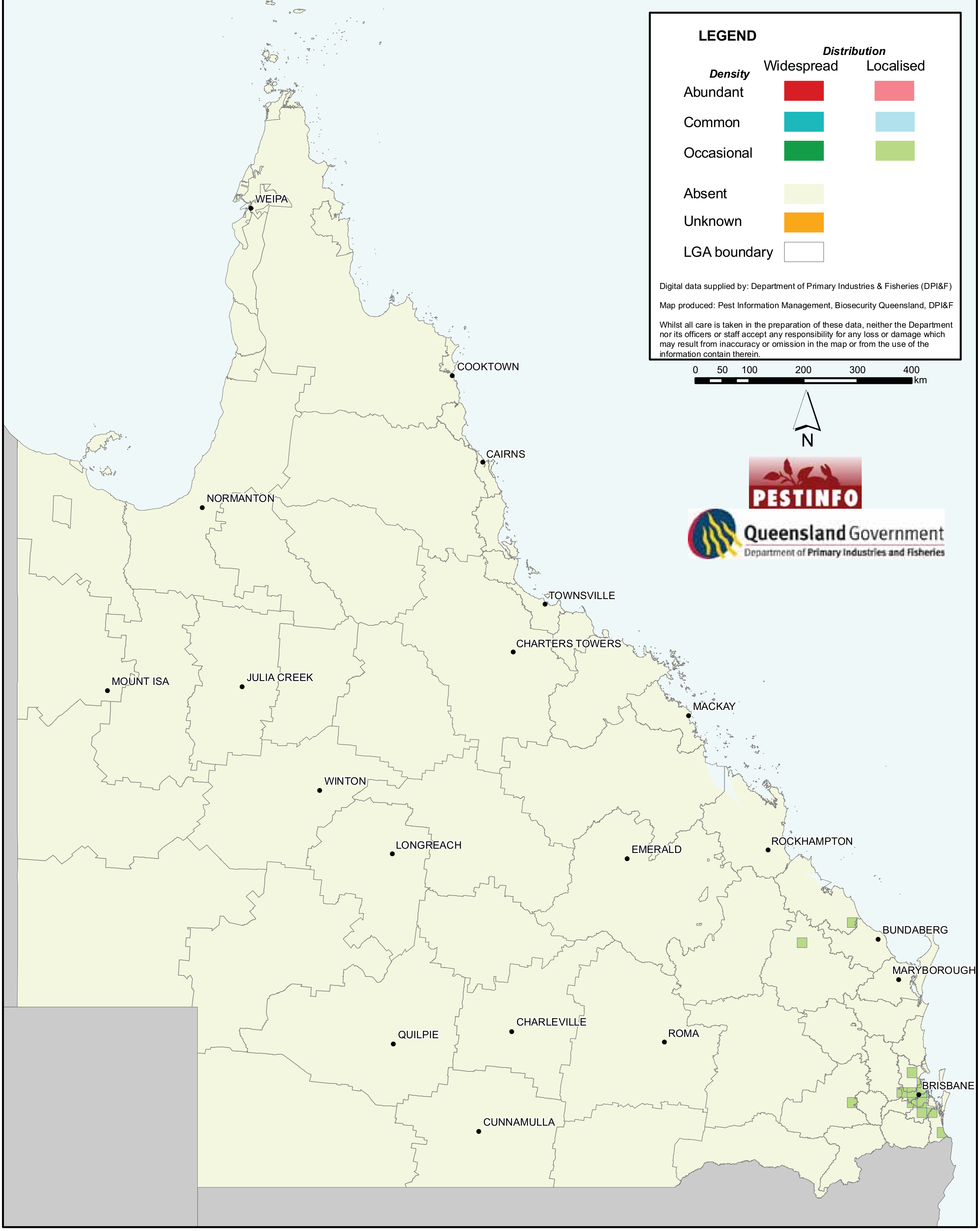
Draft

Drawn: CA	Approved: JB	Date: 23-01-2009	Figure: 1	Rev:B
Job No: 4262 6220	File No: 42626220-g-539.wor			A4

ALLIGATOR WEED

(Alternanthera philoxeroides)

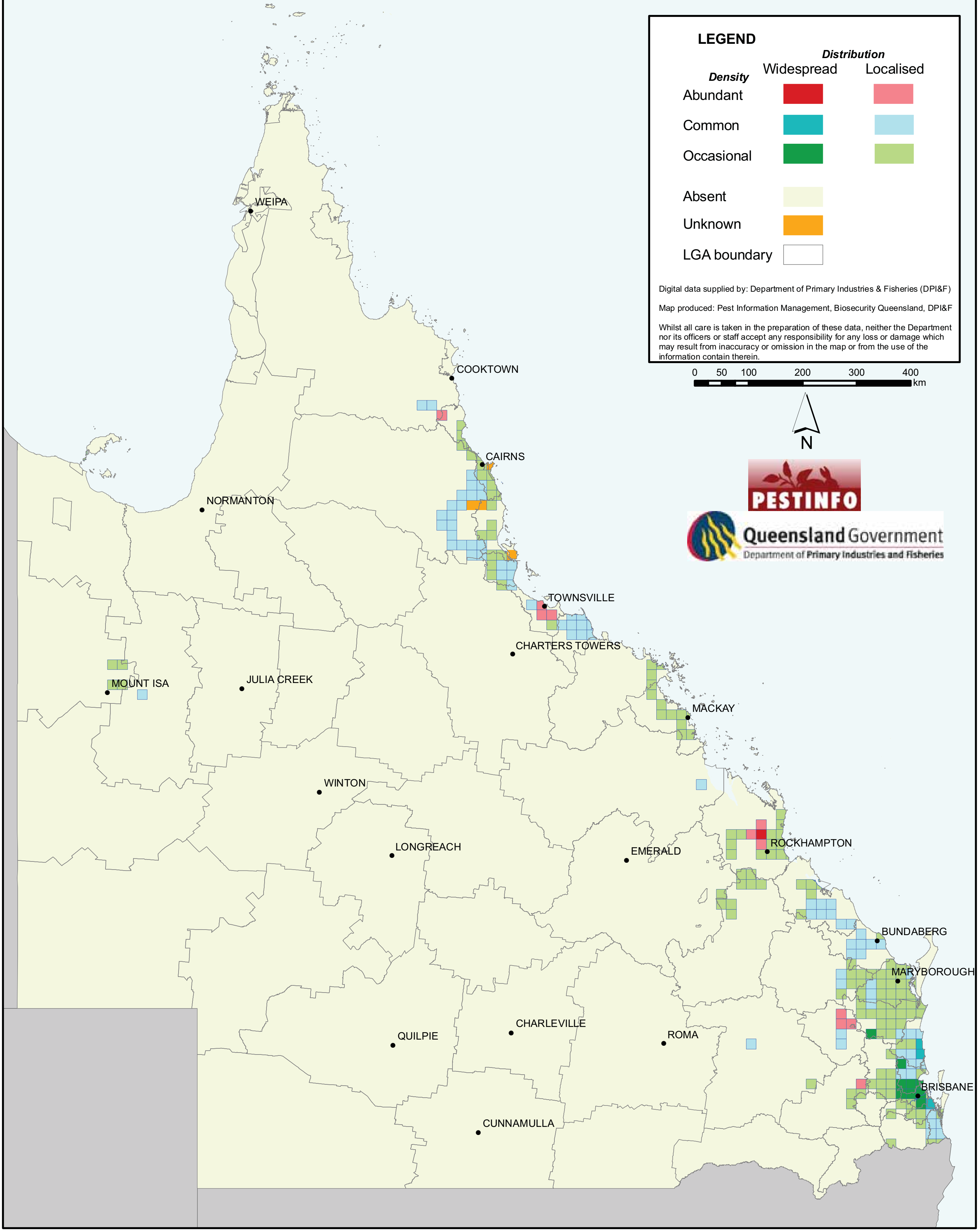
QUEENSLAND DISTRIBUTION 2007



SALVINIA

(Salvinia molesta)

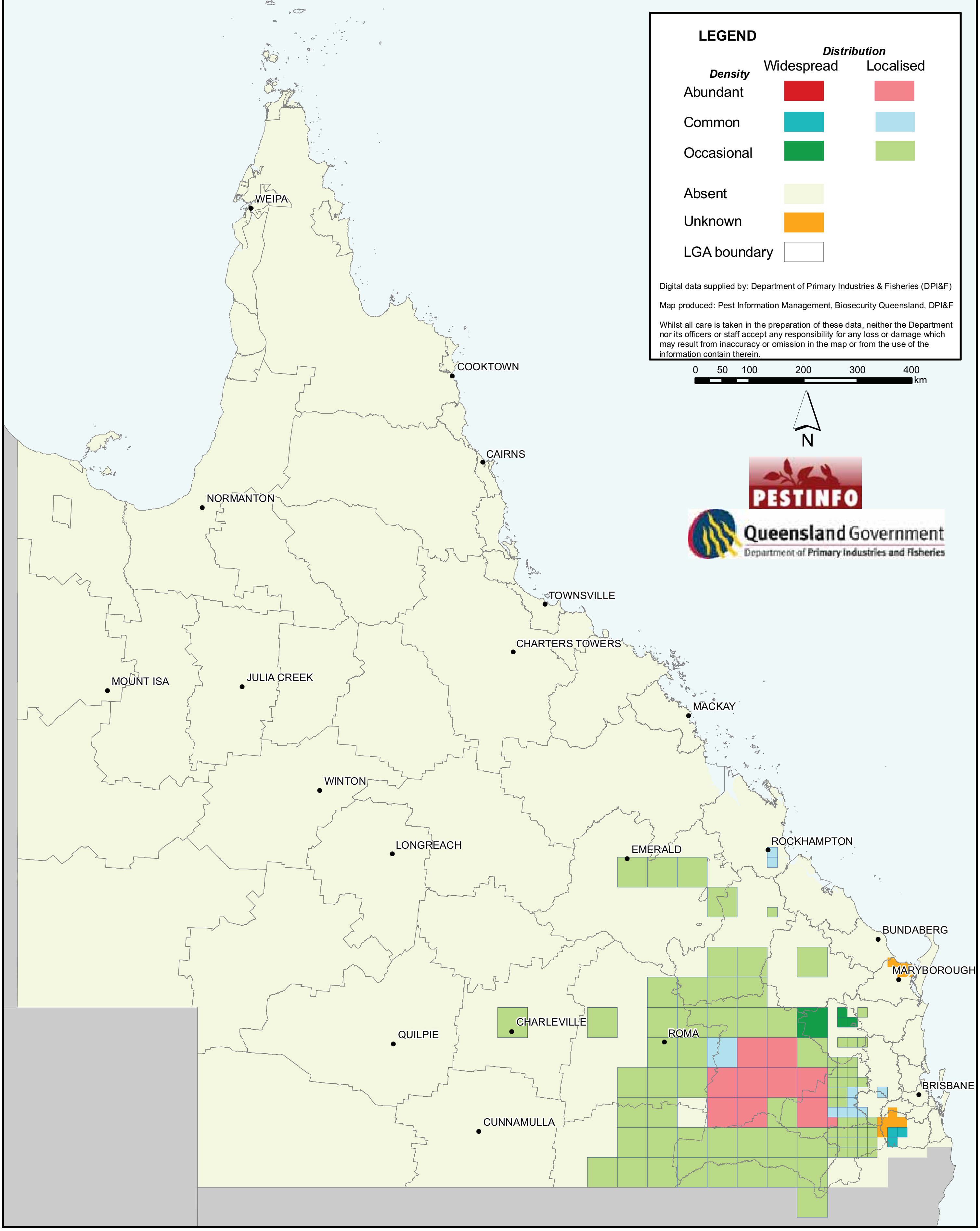
QUEENSLAND DISTRIBUTION 2007



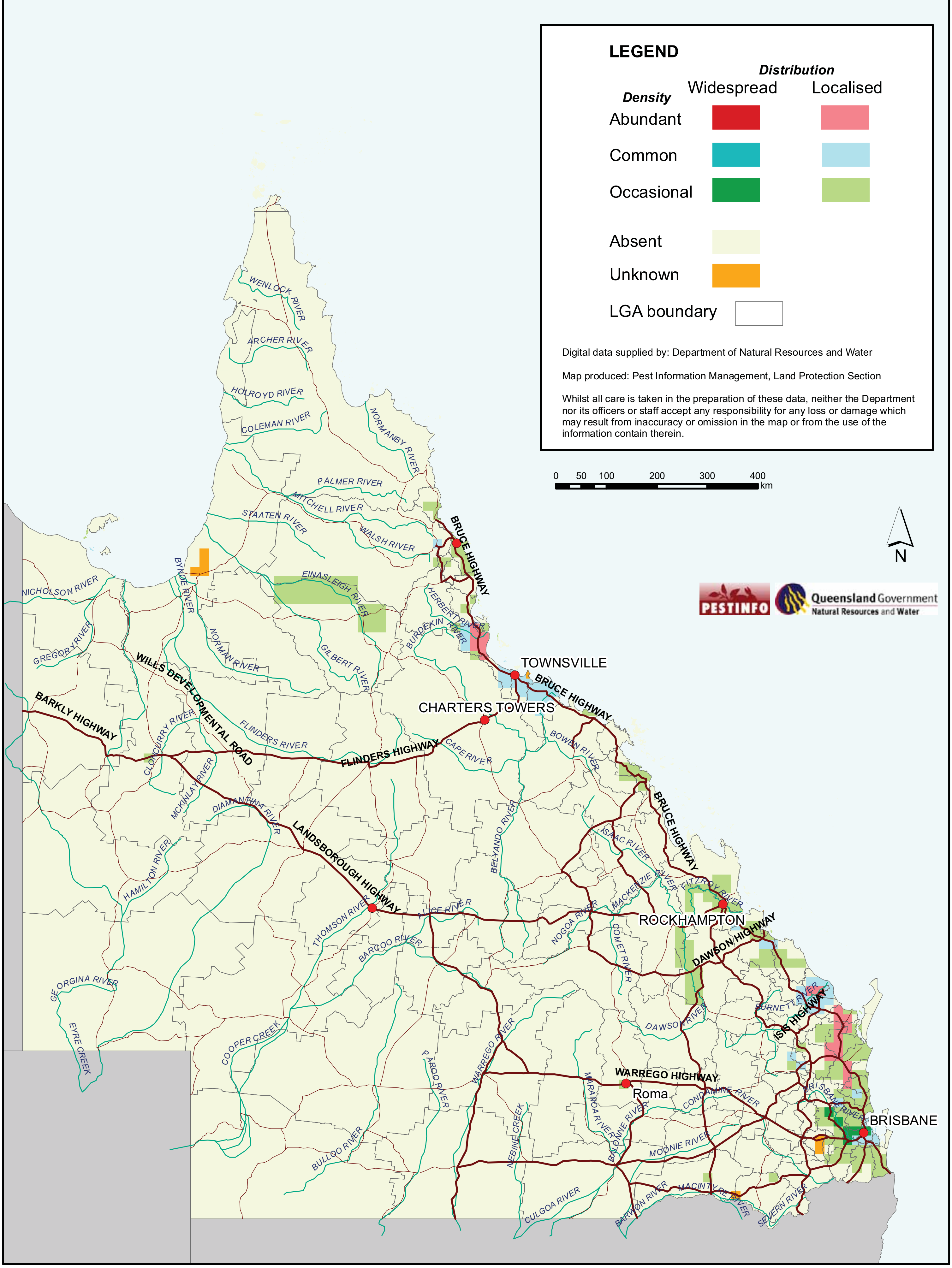
LIPPIA

(Phyla canescens)

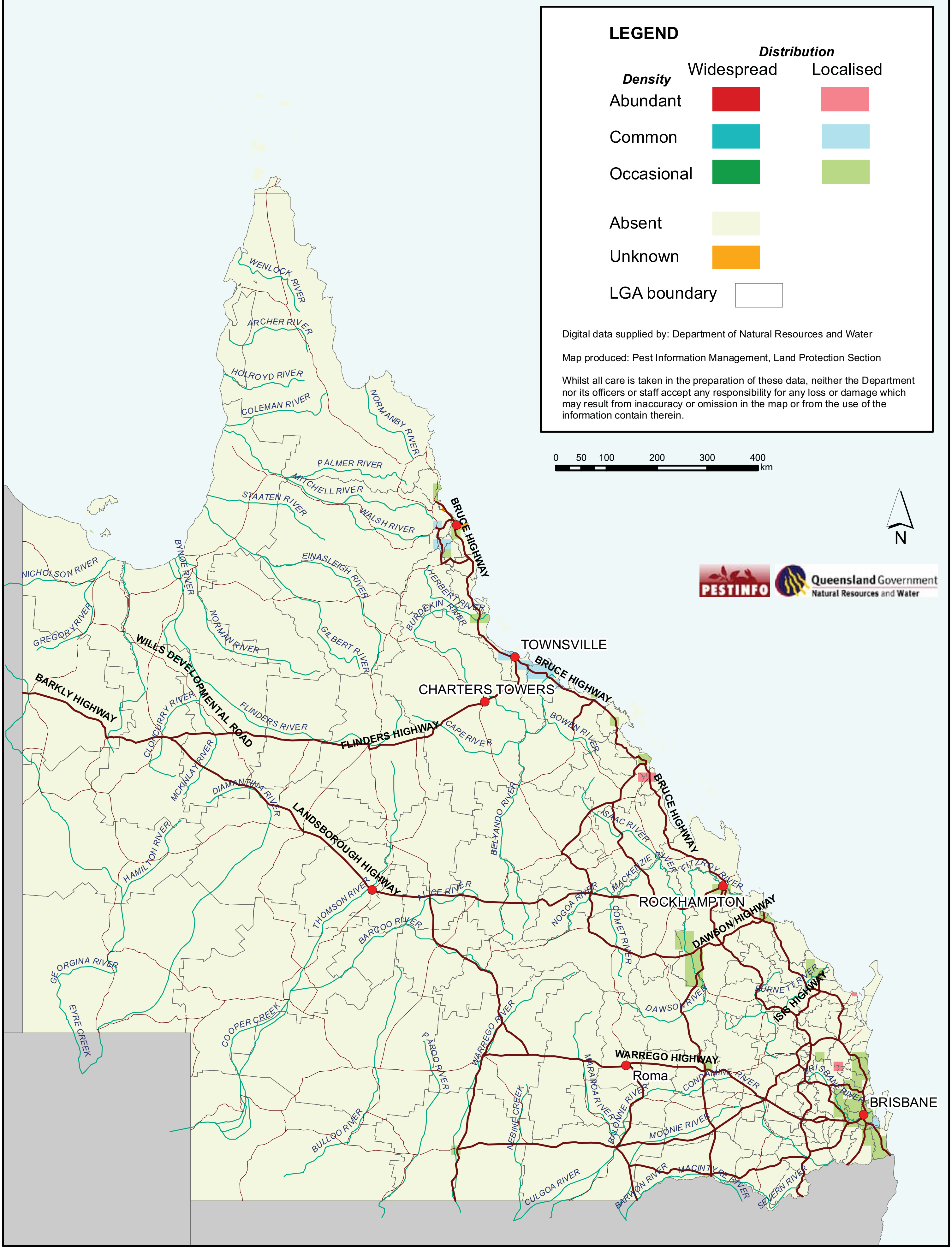
QUEENSLAND DISTRIBUTION 2007



WATER HYACINTH DISTRIBUTION 2006 QUEENSLAND



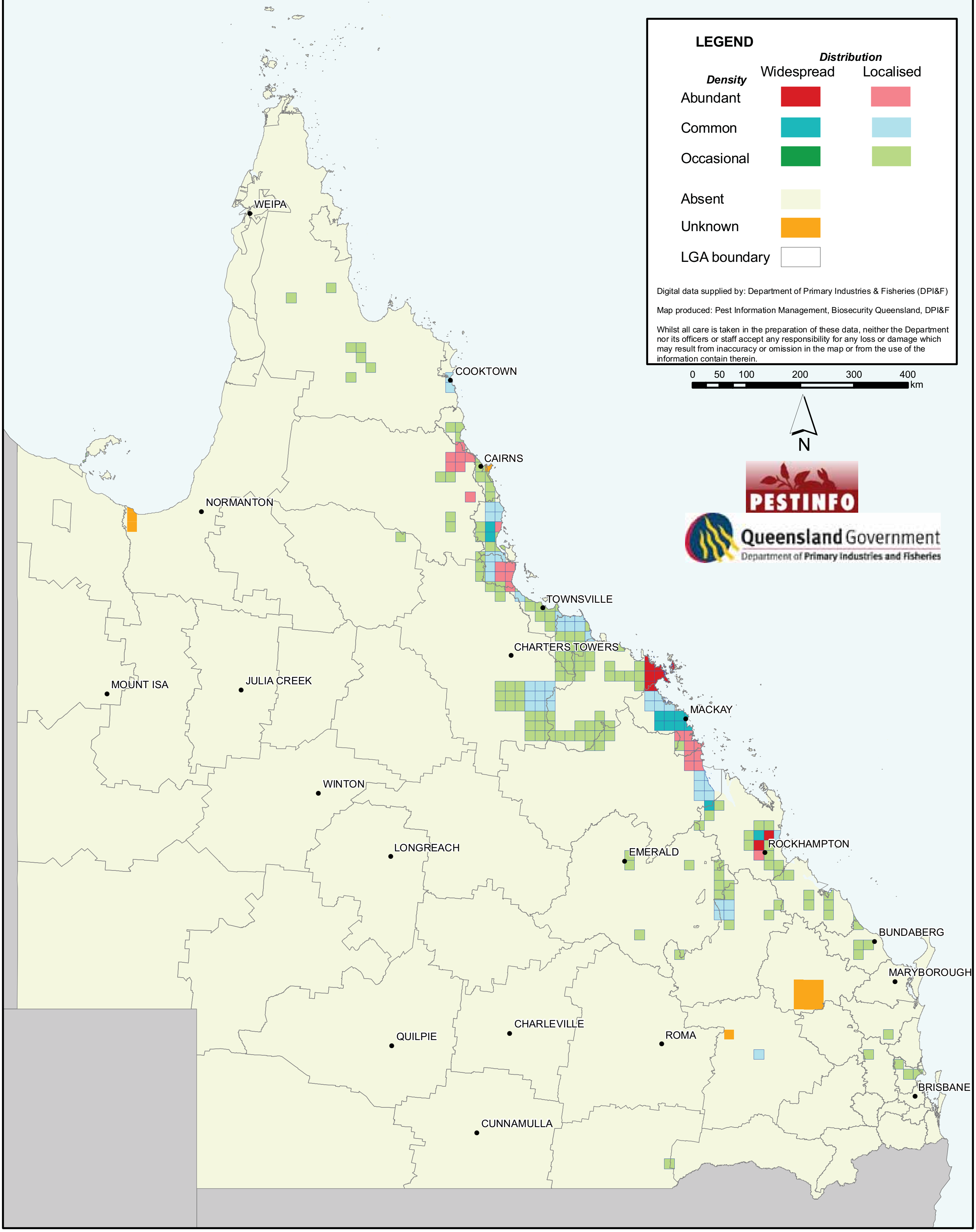
WATER LETTUCE DISTRIBUTION 2006
QUEENSLAND



HYMENACHNE

(Hymennache amplexicaulis)

QUEENSLAND DISTRIBUTION 2007

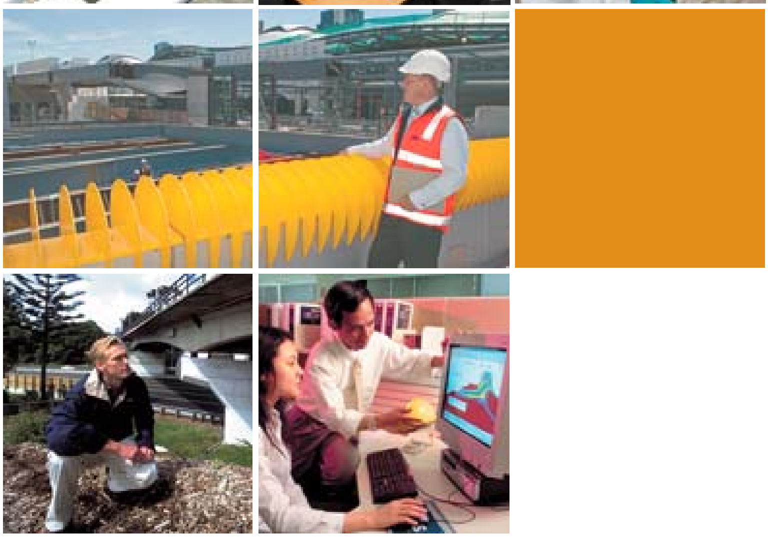


Potential for Erosion

Appendix H

R E P O R T

Potential for Erosion Arising from GLNG Associated Water Discharges



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David Fuller
Senior Principal

Date: 21 January 2009
Reference: 43270896
Status: FINAL

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Tables & Figures

Tables

Figures

1.1 Aim

URS undertook a desktop analysis to assess the potential for erosion arising from discharge of associated water into streamlines of the Upper Dawson, the Condamine-Balonne, and the Comet-Brown River catchments.

The aim of the analysis was to utilise existing data and approximate methods to conservatively quantify average flow velocities that could then be compared to velocities that initiate erosion in the sandy - clay and silt soils typical of these catchments (~0.3 – 0.5 m/s).

1.2 Approach

Two methods were used to assess velocities and depths of flow in each stream. For each method it was assumed that the discharge of associated water occurs when there is no other flow in channel. The peak field discharge has been assumed unless otherwise specified (i.e. in some cases the associated water is assumed to be split between different streams). No infiltration or transmission losses are assumed.

Stream Gauging Data

Limited stream cross-sections and rating curve data are available from stream gauging stations in the catchments.

Cross-sectional and discharge information was sourced from stream gauging stations and used to estimate flow velocities and depths. Field visits indicate that these sites have similar cross-sections to other points along the streams. However, they will have different discharge characteristics than other parts of the stream due to downstream hydraulic controls (e.g. weirs, natural bars).

Cross sections at the following sites were taken to assess any potential local scouring:

- Two sites in the Upper Dawson River Catchment: Dawson River at Utopia Downs (130324A) and Hutton Creek at Fairview (130342A);
- Two sites in the Condamine-Balonne Catchment: Bungil Creek at Tabers (422210) and Yuleba (422219A) at Forestry Station.
- One site in the Comet River Catchment: Brown River at Lake Brown (130502B).

Hydraulic Calculations

Manning's equation (*) was independently used to estimate depths and velocities assuming a conservative roughness coefficient, bed slope equivalent to average catchment slope, and cross-section as per the relevant gauging station.

$$V = \frac{1}{n} R^{2/3} S^{-1/2} \qquad (*)$$

Where V = velocity, n is a roughness coefficient, R = hydraulic radius and S = slope of the water surface.

For the purposes of this study a conservative roughness coefficient was utilised for all sites (n = 0.025) and the slope of the water surface was assumed to be equal to the average slope of the surrounding topography. Hydraulic radius was calculated from the cross-sections from the relevant gauging stations assuming these to be representative of an arbitrary point in the catchment.

Section 2 Results

2.1 Upper Dawson River Catchment

The assumed maximum peak associated water discharge is 52.5 ML/day.

2.1.1 Case 1 – Discharge to Hutton Creek

It is assumed all discharge passes through the Hutton Creek at the Fairview gauging station. Figure 2-1 shows the water level for peak discharge in this cross-section. The flow is maintained within the thalweg with an average velocity 0.015 m/s.

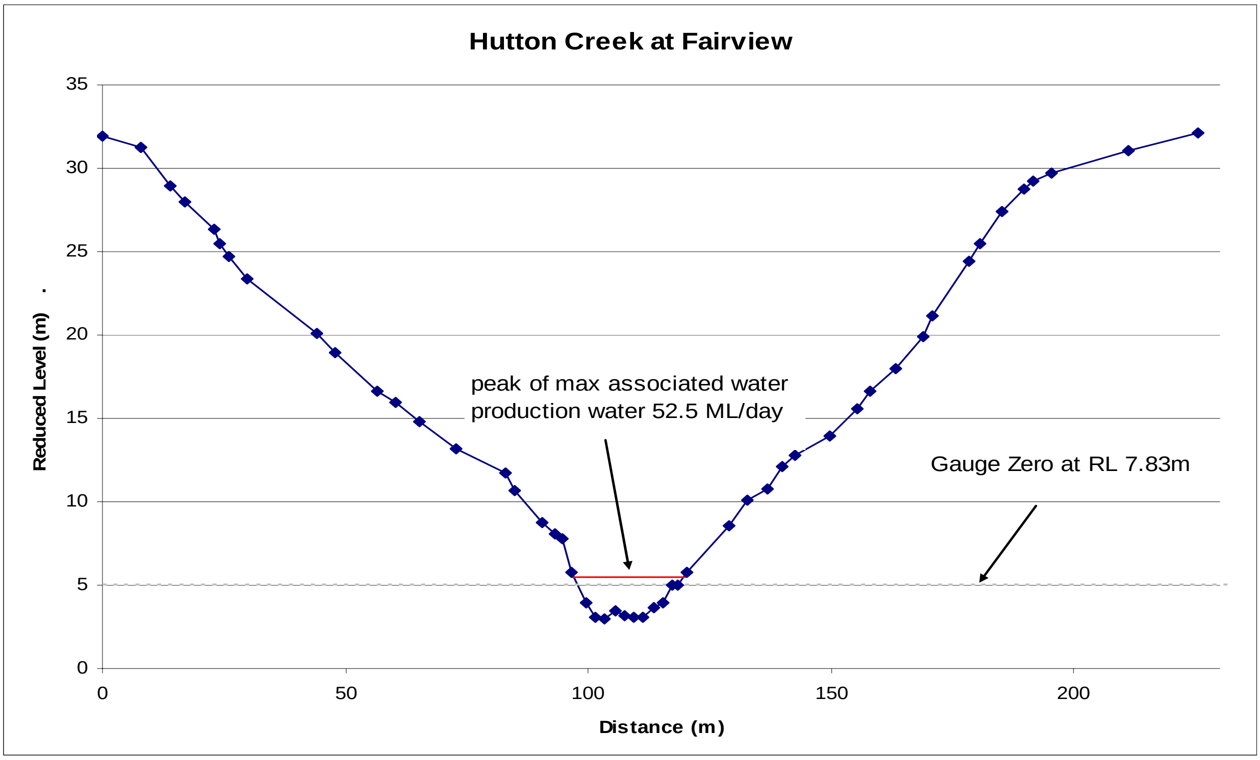

Figure 2-1 Cross Section of Hutton Creek at Fairview

Application of Manning's Equation provides an estimated average velocity = 0.031 m/s.

2.1.2 Case 2 – Discharge to Dawson River

It is assumed that all flow travels down the Dawson River to Utopia without losses. Figure 2-2 shows that flow is maintained within the thalweg, and from the rating curve an average velocity of 0.167 m/s is estimated.

Use of Manning's Equation provides an estimated velocity = 0.0005 m/s.

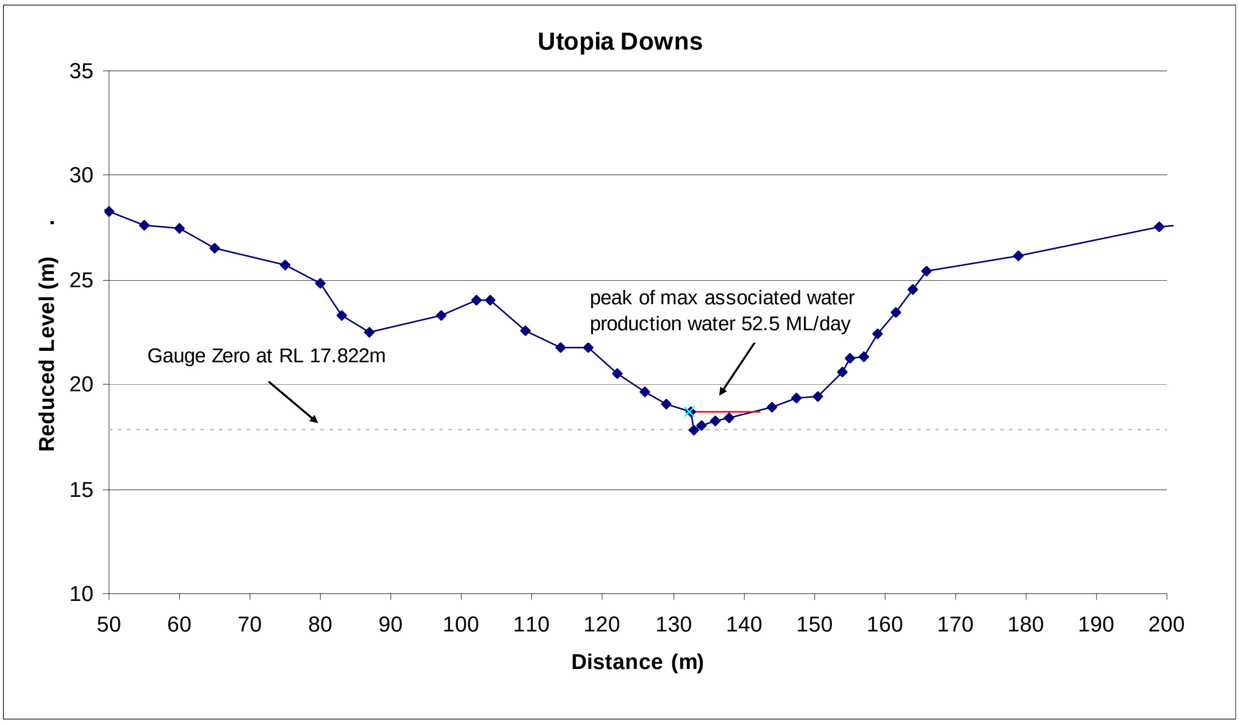

Figure 2-2 Cross Section of Dawson River at Utopia Downs

2.2 Roma-Condamine River Catchment

The peak associated water generation rate is estimated to be 20.0 ML/d.

2.2.1 Case 1 – Concentrated Discharge to Bungil Creek

Bungil Creek is significantly disturbed and has demonstrated elevated salinity compared with other streams in the region. It is assumed in this scenario that the full field generation of associated water is concentrated and discharged down Bungil Creek. Thus the assumed discharge to the creek is 20 ML/day.

Figure 2-3 shows that flow is maintained within the thalweg, and from the rating curve an average velocity of 0.078 m/s is estimated.

Use of Manning's Equation provides an estimated velocity = 0.0006 m/s.

2.2.2 Case 2 – Distributed Discharge to Three Streams

An alternative is that water is concentrated from each portion of the Roma Field and discharged to three local streams. Assuming that water is generated uniformly across the field it is assumed that each of the three major streams will receive approximately 33% of the peak discharge rate. That is, 6 ML/day.

Figure 2-4 shows that flow is maintained within the thalweg, and from the rating curve an average velocity of 0.008 m/s is estimated.

Use of Manning's Equation provides an estimated velocity = 0.002m/s.

Section 2 Results

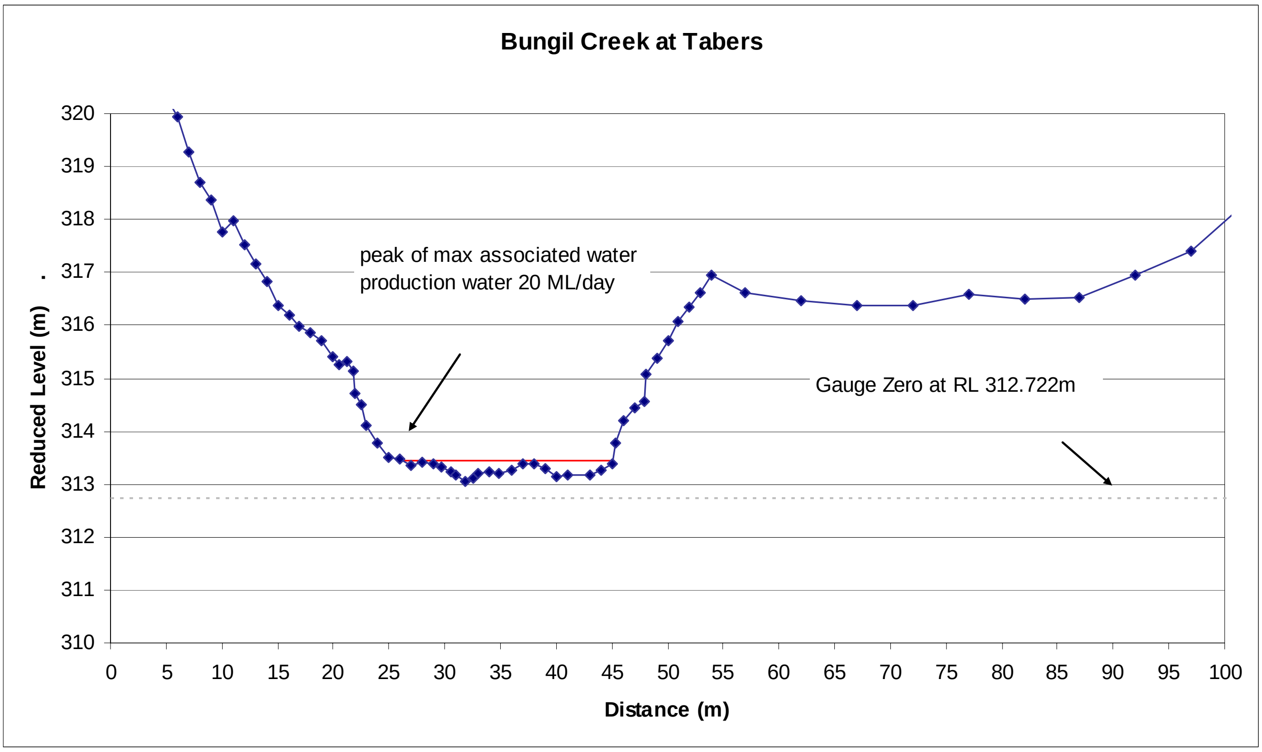

Figure 2-3 Cross Section of Bungil Creek at Tabers

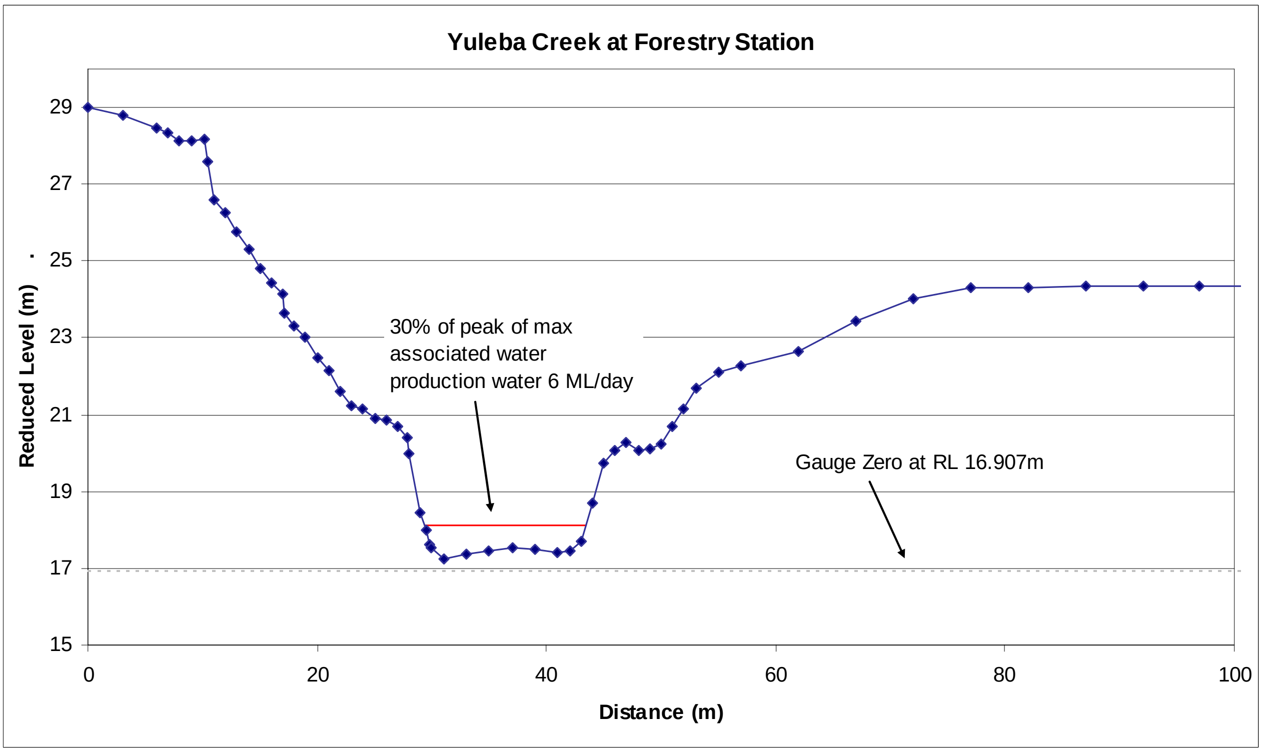

Figure 2-4 Cross Section of Yuleba Creek at Forestry Station

2.3 Comet River Catchment

Maximum associated water production in Arcadia is estimated to be 27.4 ML/d.

It is assumed in this scenario that the water is generated evenly across the entire catchment and that discharge is concentrated and discharged to three points, one in the upper catchment (discussed below), one near Rolleston and the other near Emerald.

The most recent rating curve for the site Brown River at Lake Brown was used to determine the water level in the cross section at 30% of the peak discharge. Figure 2-5 shows that the discharge is maintained within the thalweg and it is estimated that the average velocity is 0.006 m/s.

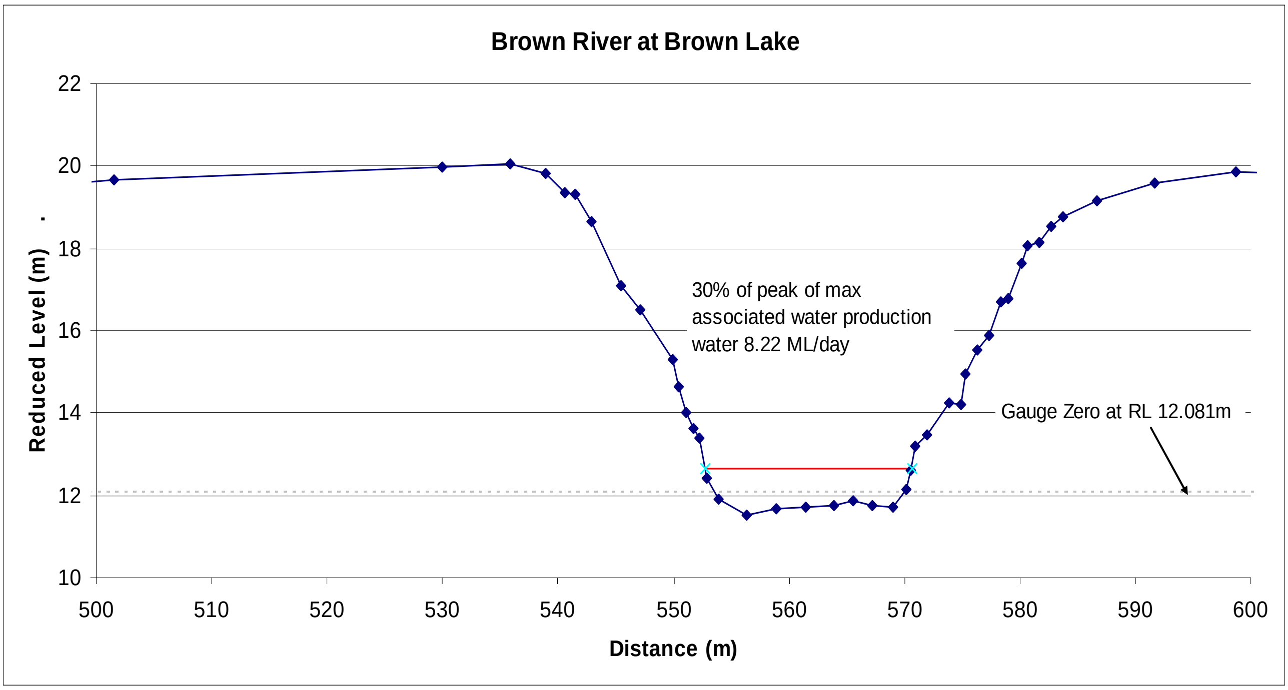

Figure 2-5 Cross Section of Brown River at Brown Lake

Application of Manning's Equation provides an alternative estimate of mean velocity as 0.008m/s.

Section 3 Discussion and Conclusion

Velocities of associated water flows are typically less than 0.1 m/s except in the case of the Dawson River at Utopia where 0.19 m/s was estimated (Table 3-1). Compared with the estimated velocity for inception of erosion (0.3 – 0.5 m/s) all of these velocities are small.

Table 3-1 Estimated Velocities and Depths

Catchment	Site Name	Site No	Discharge (ML/day)	Gauge Height (m)	Area (m2)	Velocity (m/s)	Mannings Velocity (m/s)
Upper Dawson	Hutton at Fairview	130342A	52.5	0.45	40.29	0.015	0.031
	Dawson at Utopia	130324A	52.5	0.9	3.63	0.167	0.0005
Condamine - Balonne	Bungil at Tabors	444210A	20	0.71	2.94	0.078	0.0006
	Yuleba at Forest	422219A	6	1.2	8.94	0.008	0.002
Comet-Brown	Brown at Lake Brown	130502B	8.22	0.58	15.73	0.006	0.008

Data in Table 3-1 was compared to average velocities under flooding conditions. The highest gauge data was obtained from the NRW WaterShed site to calculate the velocities (Table 3-2) under flood conditions.

Table 3-2 Estimated velocities and depths under flood conditions

Catchment	Site Name	Site No	Discharge (ML/day)	Gauge Height (m)	Area (m2)	Flood flow velocities (m/s)
Upper Dawson	Hutton at Fairview	130342A	45,606	9.70	79.9	2.98
	Dawson at Utopia	130324A	87,696	12.82	553.2	0.86
Condamine - Balonne	Bungil at Tabors	444210A	72,817	7.87	470.7	1.79
	Yuleba at Forest	422219A	29,516	9.92	1182.0	0.62
Comet-Brown	Brown at Lake Brown	130502B	31,505	7.53	114.5	3.25

The flood flow velocities shown in Table 3-2 are well above the estimated velocity for inception of erosion (0.3 – 0.5 m/s). Compared to the discharge under flood conditions, additional discharges of associated water are minimum. It is also noted that most of these streams are ephemeral and the flood behaviour is rapid and large. The small proportion of the stream channel occupied by associated water discharges is unlikely to significantly reduce flood carrying capacity and hence unlikely to alter the frequency of flood events and associated erosion.

It is concluded that there is little risk of any additional scouring and erosion occurring as a result of associated water discharges.

Limitations | Section 4

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 12 October 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

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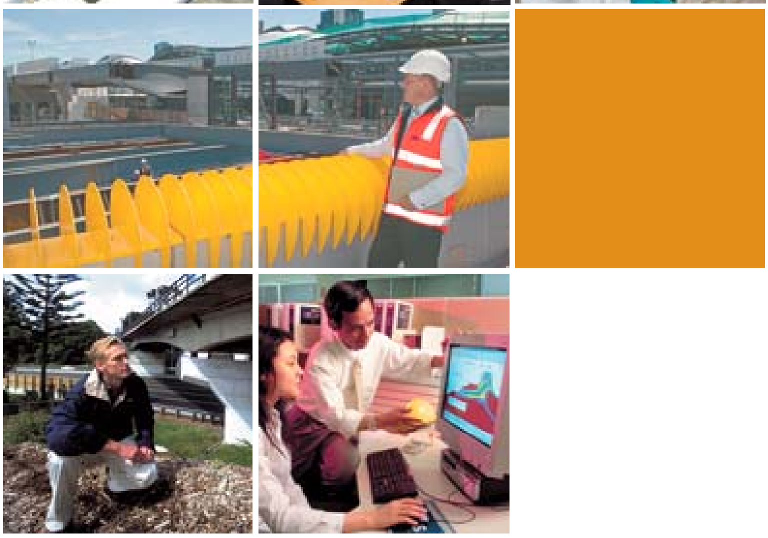
Modelling of Flows, Temperature and Salinity – Upper Dawson River

Appendix I

REPORT

Hydrologic Modelling of Dawson River Catchment



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Date:	21 January 2009
Reference:	Hydrologic Modelling of Dawson River Catchment
Status:	FINAL

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Appendices

Introduction Section 1

Associated water is typically a by-product of Coal Seam Gas (CSG) development and its management is an integral aspect of the Gladstone Liquid Natural Gas (GLNG) project. Santos is considering a range of water management options including evaporation, stock watering, discharge to grade, treatment, injection, irrigation, and beneficial reuse. However, the focus of this report is on discharge to grade and potential changes in hydrology, salinity and temperature that may arise instream under a range of scenarios. This information will be used within an ecological risk assessment framework to assess risks to environmental values identified in the study area.

Study Area

The area of study includes three catchments: Upper Dawson River, Comet River, and minor tributaries of the Upper Balonne River in Condamine-Culgoa. The Upper Dawson River and Comet River catchments drain to the Fitzroy Basin and ultimately to the Great Barrier Reef Lagoon. The Balonne River is part of the Murray-Darling Basin ultimately discharging via Lake Alexandrina to the Gulf of St Vincent in South Australia.

The catchments are in various states of CSG production, appraisal or development.

This report focuses on the Upper Dawson River catchment from its headwaters to Taroom (**Error! Reference source not found.**).

Modelling Approach

Hydrologic modelling is needed to assess the impacts of discharges on the local and regional environment. The model will be used to assess impacts of CSG production on flow regime, temperature and salinity concentration.

Various options are available to model the hydrology and water quality of the catchment. The two main candidates considered were IQQM (Integrated Quantity and Quality Model) and E2 both of which are utilised in Queensland. E2 was chosen as the main modelling platform for flow and salinity. Due to E2 salinity modelling limitations, an empirical algorithm was ultimately developed to model salinity. Likewise, E2 does not provide the capability to model temperature. For temperature modelling, the US EPA's QUAL2K model was chosen.

Report Structure

The report presents the calibration of hydrologic and salinity models in the first two chapters. Various associated water management scenarios are then formulated and modelled. Results are presented in the final chapter.

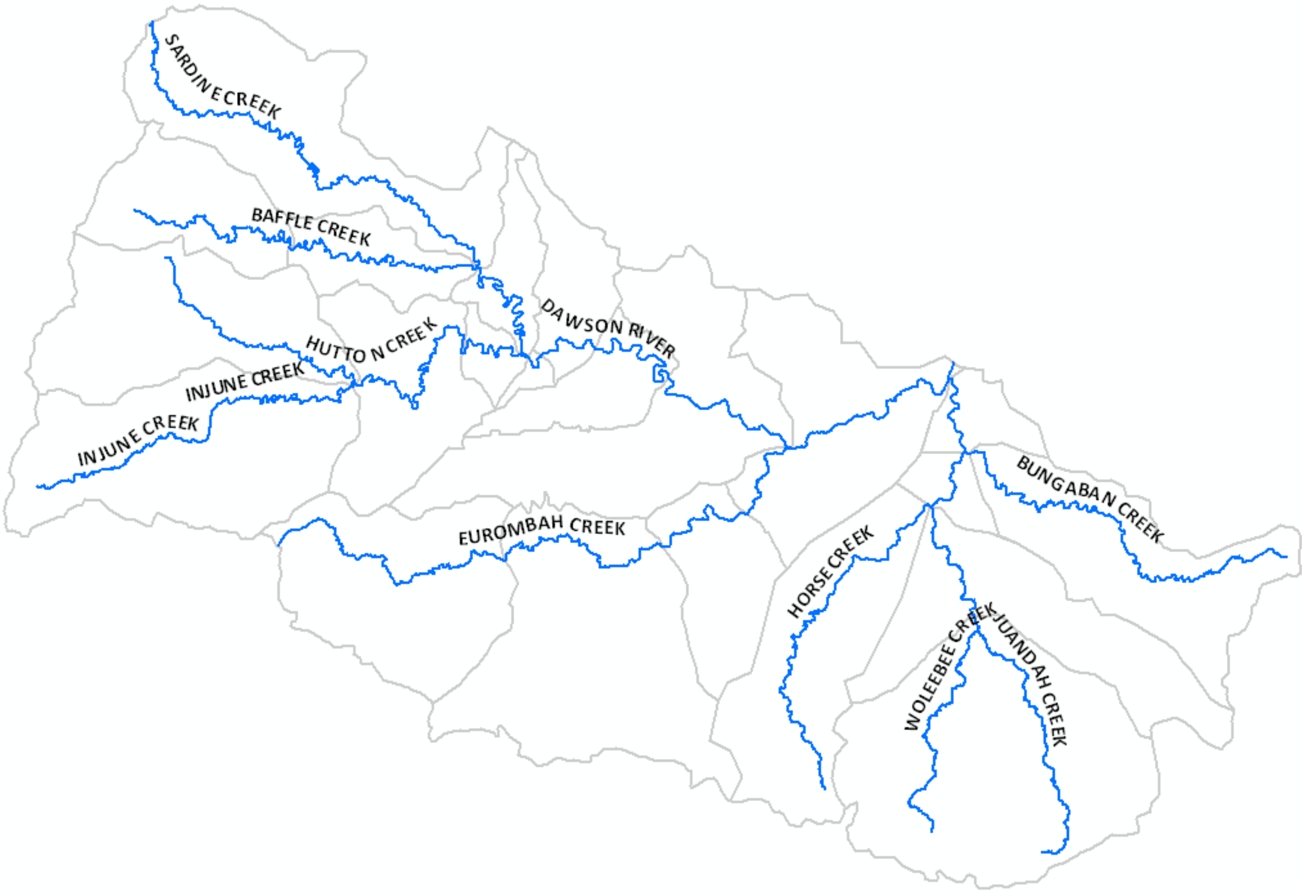

Figure 1-1 Major Streams in the Dawson River Catchment

Modelling Objectives

The modelling objectives are:

- Develop calibrated models of flow, temperature and salinity;
- Create a flow model that is consistent with models currently used in Queensland (IQQM and E2) to enable later assessment of regional effects;
- Investigate alternative associated water discharge options;
- Identify the range, frequency, and extent of flow, temperature and salinity impacts from discharge of associated water to grade; and
- Provide information to support ecological risk assessment.

3.1 Background

The basic architecture of the E2 modelling framework consists of a subcatchment-node-link system, as described in Appendix A. Alternative water balance models can be selected for use within E2. For this project the Australian Water Balance Model (AWBM) was selected as the rainfall-runoff model since it is widely used and was originally developed in Queensland. A daily time step was utilised for modelling. The AWBM model utilises eight model parameters representing three conceptual water stores with area representation, surface and baseflow recession constants, and a baseflow index. Further explanation of the AWBM model and its parameters are provided in Appendix A.

3.2 Model Assumptions

3.2.1 Subcatchment Delineation

The model structure is based on key subcatchments to allow broad scale assessment of water management options. The Dawson River catchment (15,541 sq km) was subdivided into 22 subcatchments based on major stream confluences and particular areas of interest, such as stream gauge locations. A node exists at the outlet of each subcatchment. Additional inputs or outputs can be applied at each node. The 22 delineated subcatchments (the nodes are not shown to improve legibility) along with the stream gauges are presented below in Figure 3-1.

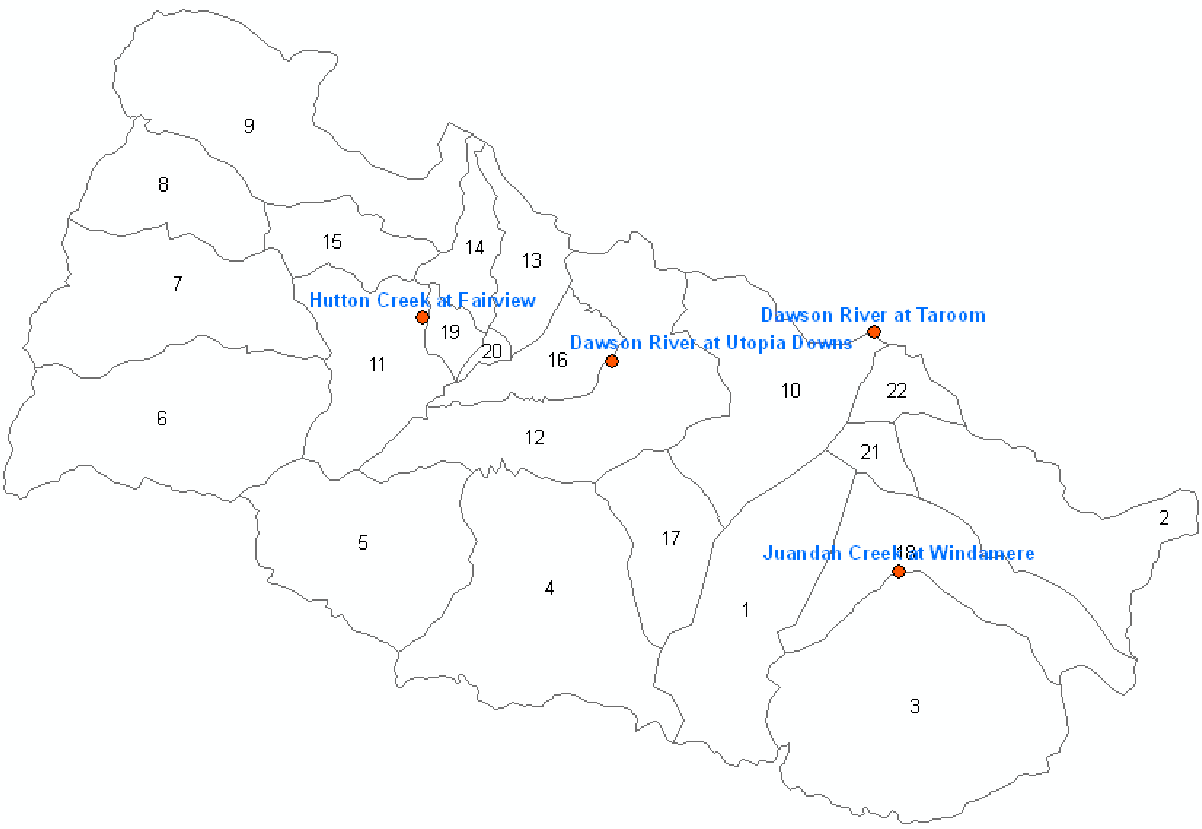

Figure 3-1 Subcatchment Delineation and Stream Gauge Locations

3.2.2 Network Creation

A GIS shapefile was used to represent the subcatchments, and the stream network was drawn in manually within E2. While catchment area is calculated within E2 for the purpose of runoff generation, there is no explicit spatial representation of the stream network. The E2 flow path network is shown in Figure 3-2.

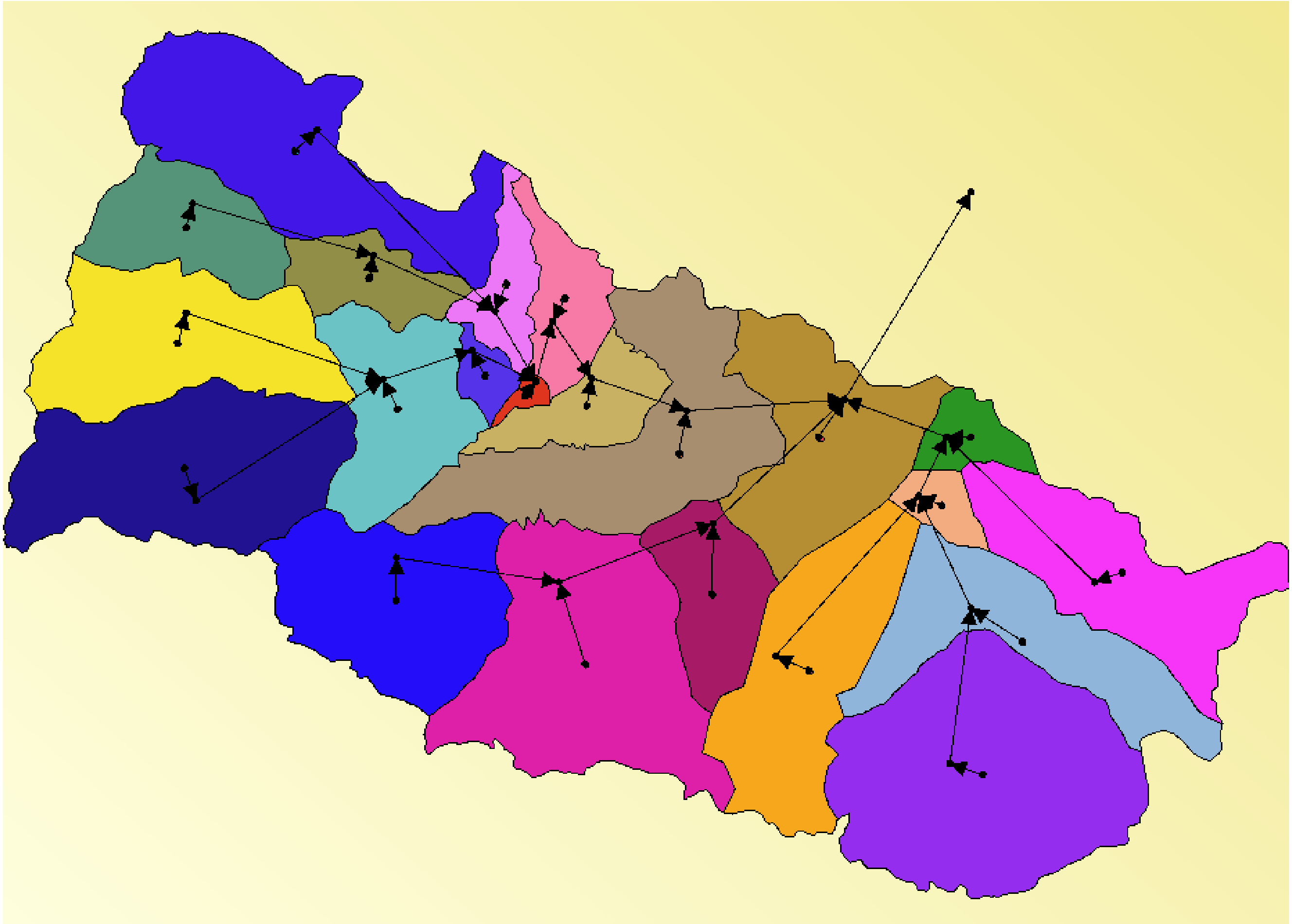

Figure 3-2 E2 Subcatchment Network

3.2.3 Flow Routing

The Dawson catchment is a large catchment (15,541 sq km). Runoff from the furthermost reaches can take considerable time before it is recorded at the Taroom outlet on Dawson River. E2 offers several routing methods to delay the flow through the links. These range from simple lag flow where flow is delayed with no change to the shape, to more sophisticated routing methods which can smooth the flow of the hydrograph accounting for catchment and reach storage effects. In the development of the Dawson River catchment, two methods of routing were selected: General Lag and Laurenson non-linear routing.

General Lag works by transposing the hydrograph by a length of time with no other changes in shape occurring. The required input for general lag is solely the amount of time in days to transpose the hydrograph.

Laurenson non-linear routing is more sophisticated and requires the input of two factors;

$$S(Q) = K \times Q^m$$

Where:

K = a dimensional empirical factor which acts as a storage delay parameter. Although K is empirical factor it should be thought of as a storage delay and thus in seconds; and

m = a dimensionless empirical exponent, measure of the non-linearity of the model.

3.2.4 Simulations

E2 has the ability to have multiple model simulations active at any one time. This allows for easy comparison to be made between the modelled and observed data. For each location where observed data was available, a separate model was constructed in order to compare E2 modelled results with observed flow measurements. At the approximate location in the E2 model of the observation gauge, the observed flow data was assigned to an outlet node of a subcatchment.

3.3 Model Calibration

Since there is limited surface flow data for many locations, and the project operates across multiple scales, it is expected that modelling will need to progress from broad calibration to more accurate calibration over time. For initial calibration, the same AWBM parameters were applied across many of the subcatchments. The main reason for this was a lack of information that could inform separate parameterisation as well as to reduce the potential degrees of freedom during calibration.

A separate model was created using the same AWBM parameters throughout the entire catchment. This model did not produce results sufficiently representative of the gauge data. Therefore, variation in the AWBM parameters is considered necessary in a catchment the size of the Dawson River catchment.

3.3.1 Objective Function

The selection of an appropriate objective function is an important part in validating the model performance. The choice of function is dependent on the model's application. In this case the end purpose of the model is to estimate in-stream salinity levels. These levels are dependent on stream flow and consequently comparison of actual and modelled stream flow is of greatest importance. Boughton (2005) notes that in the common case of water yield analysis, the most common validation of model performance is a comparison of calculated and actual monthly totals of runoff. Early studies used the coefficient of determination (r^2) as a measure of agreement. However, it is becoming increasingly common to now use the Nash-Sutcliffe coefficient of efficiency (CE) where CE is:

$$CE = 1 - \sum_{t=1}^{T} (Q_0^t - Q_m^t)^2 / \sum_{t=1}^{T} (Q_0^t - \overline{Q_0})^2$$

Where:

T = total time modelled

Q_0^t = Observed flow at time t;

Q_m^t = Modelled flow at time t; and

$\overline{Q_0}$ = Mean observed flow.

The value of CE lies between 1.0 (a perfect fit) and -∞ where a value of less than 0 would indicate that the mean value of the observed time series would have been a better predictor than the model (Krause, Boyle and Blase, 2005). A model producing a CE value over 0.7 is considered a reasonable representation of the physical world on a daily time step. Calibration in E2 gives values for both r^2 and CE; these are the only efficiency criteria calculated.

3.3.2 Calibration Tools

E2 contains a calibration tool for flow and constituents based on either subcatchments or links. As explained in Appendix A, the iterative calibration process is clunky and cumbersome given the number of links and nodes, each with 8 adjustable AWBM parameters. After an initial run, the automatic calibration was not sufficiently quick or accurate enough. Therefore, further calibration was accomplished using manual adjustment and regional application of AWBM parameters across the catchment.

The Rainfall Runoff Library (RRL) was also considered and trialled for model calibration but determined too simplistic for a study area as large as the Dawson catchment (see Appendix A for further explanation).

3.3.3 Calibration Period

As described in the data compilation section of Appendix A, rainfall input files from 1975 to 2006 were developed representing 32 years of data, which were available for the calibration process. A strategic method was developed for the calibration of the E2 model. Initial attempts at calibration were focused on ensuring accuracy of the lowest flow events as the model was primarily designed to model salinity, which is at its highest concentration during low flow events. Once a satisfactory level of calibration was achieved the calibration turned to ensuring that the high flow peaks, the total yearly runoff and the shape of the hydrograph were well represented.

The AWBM contains storages that are initially empty when the model starts. A warm up period is often required during calibration or validation so that the stores can reach a representative value. This can be done in one of two ways. One method is to exclude the warm up period from the objective function calibration and validation periods; this is not possible in E2 but can be done in RRL. Another way is to ensure the model calibration and validation period follows a period of low or zero precipitation so that it can be assumed that moisture stores are empty.

While calibrating the model over the entire range of data available is the only way to optimise the results, little indication of the models robustness can be gauged (i.e. how well it performs outside of the calibration period). It was initially intended to exclude some of the available data from the calibration period to allow for a period of model validation; however, due to the difficulties in calibrating the model it was decided to include as much of the data as possible in the calibration period.

3.4 Results and Interpretation

For meaningful modelling of salinity, a well calibrated runoff model is required. A model producing a CE value over 0.7 is considered a reasonable representation and was the target when calibrating E2. A structured modelling approach was undertaken where the headwater subcatchments with stream gauges were modelled first. Once these areas were satisfactorily calibrated, the subcatchments upstream of the next gauging station were calibrated. This was repeated down the catchment, until all subcatchments upstream of the final gauge on Dawson River were calibrated. Thereby a model was developed with four sets of AWBM parameters;

- Subcatchments upstream and immediately downstream of Juandah Creek;
- Subcatchments upstream of Hutton Creek at Fairview;
- Between Hutton Creek at Fairview and Dawson River at Utopia Downs; and

- Between Utopia Downs and Taroom on the Dawson River.

The largest difficulty encountered in the refinement of the E2 model was ensuring that small rainfall events were not causing excessive runoff. This was deemed a high priority due to the ephemeral nature of the streams in the Dawson River catchment for much of the year. To reduce the noise associated with these smaller rainfall events, it was required to set the capacity of the three stores in the AWBM model at or near the maximum advisable levels. Larger than typical AWBM soil capacity parameters were used to simulate catchment storages such as pools of standing water. This assumption was confirmed following consultation with URS employees familiar with the Dawson catchment. These storages retard small rainfall events resulting in little to no runoff being recorded on the downstream gauging stations. However, larger rainfall events inundate the pools and significant runoff is measured at the stream gauge stations.

Increasing the storage capacities to better reflect the ephemeral nature of the streams resulted in difficulty matching peaks in high rainfall events and producing the total aggregated runoff being generated by the catchment. As has been mentioned previously, AWBM has three parameters intended to determine the rate at which the base flow store is depleted: BFI, K_{base} and K_{surf}. To ensure that flow remained in the system and that large runoff events were being captured, the parameters were set such that little of store is depleted over time (except through evaporation). Initially these parameters were set to null, however they were increased to between 0.4 and 0.5 to smooth the shape of the falling limb of the hydrograph.

The third challenge faced by the modelling team was matching the timing of the peaks of runoff events as well as the recession curve following the event. Initially it was attempted to calibrate the routing on a subcatchment-by-subcatchment basis, allocating a value based on the probable length of the stream within the reach. It was found that the routing times were typically short, with routing times ranging between 12 and 24 hours. This arises from the fine delineation of the subcatchments. Two routing regimes adopted. For the subcatchments upstream of Hutton Creek a simple lagged flow equivalent to 0.5 days was found to best represent the data. For all the catchments downstream of Hutton Creek the more sophisticated Laurenson non-linear routing was adopted. Initially some variability in the parameters was trialled for catchments upstream and downstream of Utopia Downs, however after much trialling a single set of parameters were applied with a delay of 1.5 days (129600 seconds), and a measure of the non-linearity of 0.8 (as recommended in Australian Rainfall and Runoff).

A summary of the calibrated AWBM parameters used in the final calibration are presented in Table 3-1 and the calibrated routing values are presented in Table 3-2.

Table 3-1 Summary of Final AWBM Calibration Parameters

AWBM Parameters	Subcatchments			
	In the region of Juandah Creek	Upstream of Hutton Creek	Between Hutton Creek and Utopia Downs	Between Utopia Downs and Taroom
A1	0.134	0.134	0.134	0.134
A2	0.433	0.433	0.433	0.433
BFI	0.4	0	0.35	0
C1	30	50	50	35
C2	70	125	170	120
C3	150	200	250	250
Kbase	1	0	1	0
Ksurf	0.3	0.5	0.45	0.4

Table 3-2 Summary of Routing Parameters

Lag Flow	Subcatchments Upstream of Hutton Creek	Laurenson Parameters	Subcatchments		
			In the region of Juandah Creek	Between Hutton Creek and Utopia Downs	Between Utopia Downs and Taroom
Time (Days)	0.5	**K (seconds)**	129600	129600	129600
		m	0.8	0.8	0.8

The end result of the calibration was a thoroughly developed model producing a Nash-Sutcliff criterion of 0.72, with a net volume difference of 3.75% between the E2 model and the observed runoff over 26 years of observed flow available at Taroom on the Dawson River. Hydrographs and a scatter plot displaying the observed and E2 modelled runoff at the Taroom gauging station are shown in Figure 3-3, Figure 3-4 and Figure 3-5 for the periods 1980 to 2004 and 1989 to 1992 (to more clearly illustrate the models general performance) respectively.

Overall the results produced in E2 are fairly representative to those observed at the stream gauge stations. The cease to flow, low and medium flow events mirror observed behaviour. The rising and falling limbs, peak, and timing of modelled hydrographs match observed records. Many of the largest high flow peaks have not been successfully matched. These events could be attained; however, it resulted in poorer calibration of the low flow events by introducing significant noise. It was felt that as the flow model was built with a desire to model salinity, which is critical in low flow events, that matching cease to flow and low flow events were a higher priority. It is believed that the lack of peaks is due to the averaging of the rainfall data over multiple gauges and the necessity of using gauges outside of the subcatchment. The result of these necessities has resulted in input files with much of the peakiness removed from the data making it impossible to perfectly match the observed records. Further, all input data was on a daily time step, which reduces the ability to model flash floods which occur over a much shorter time step (minutes to hours).

The E2 flow model was confirmed by an external independent peer reviewer (Appendix A).

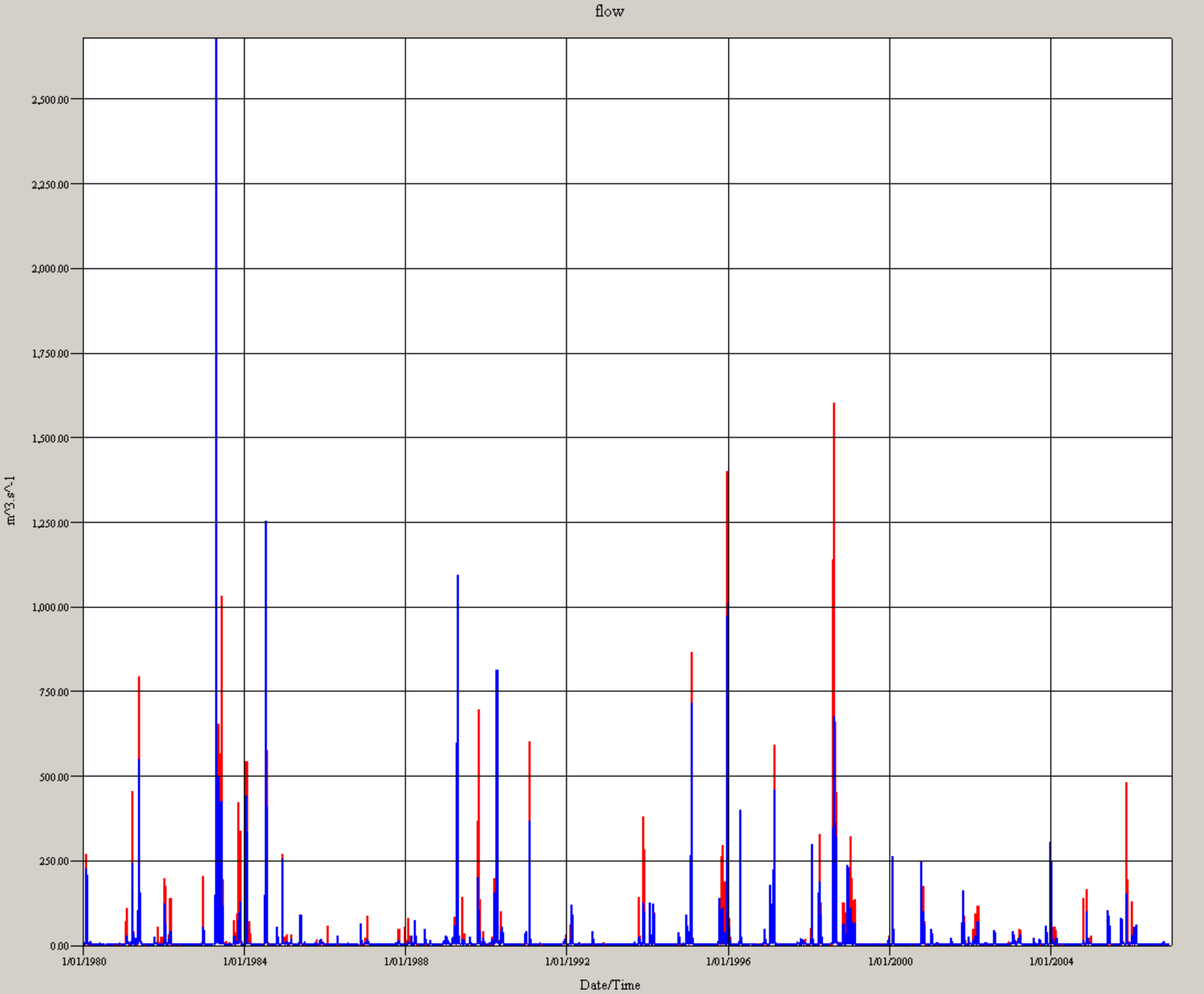

Figure 3-3 Hydrograph of E2 Modelled (Blue) and Observed (Red) Runoff 1980 to 2004

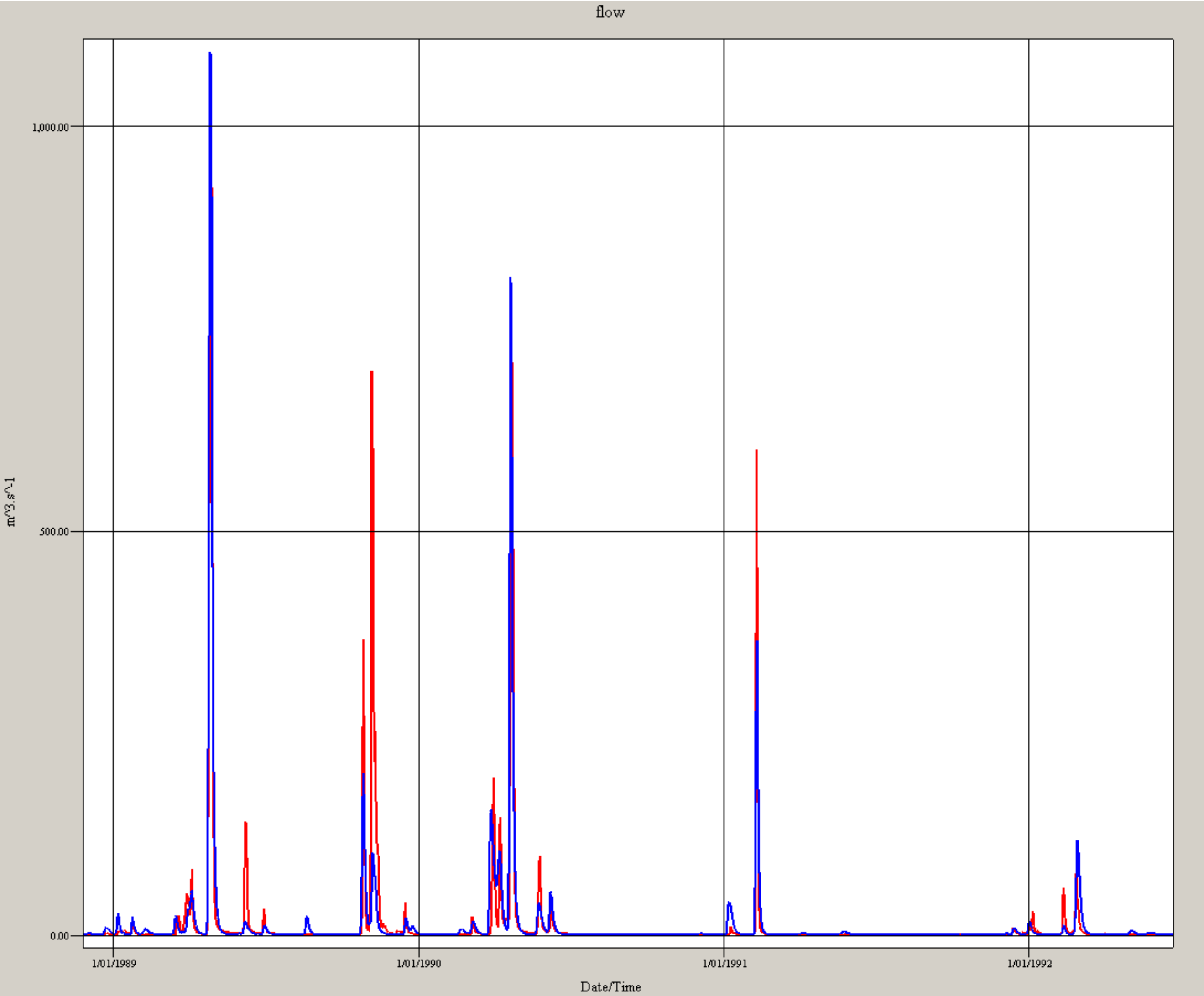

Figure 3-4 Hydrograph of E2 Modelled (Blue) and Observed (Red) Runoff 1989 to 1992

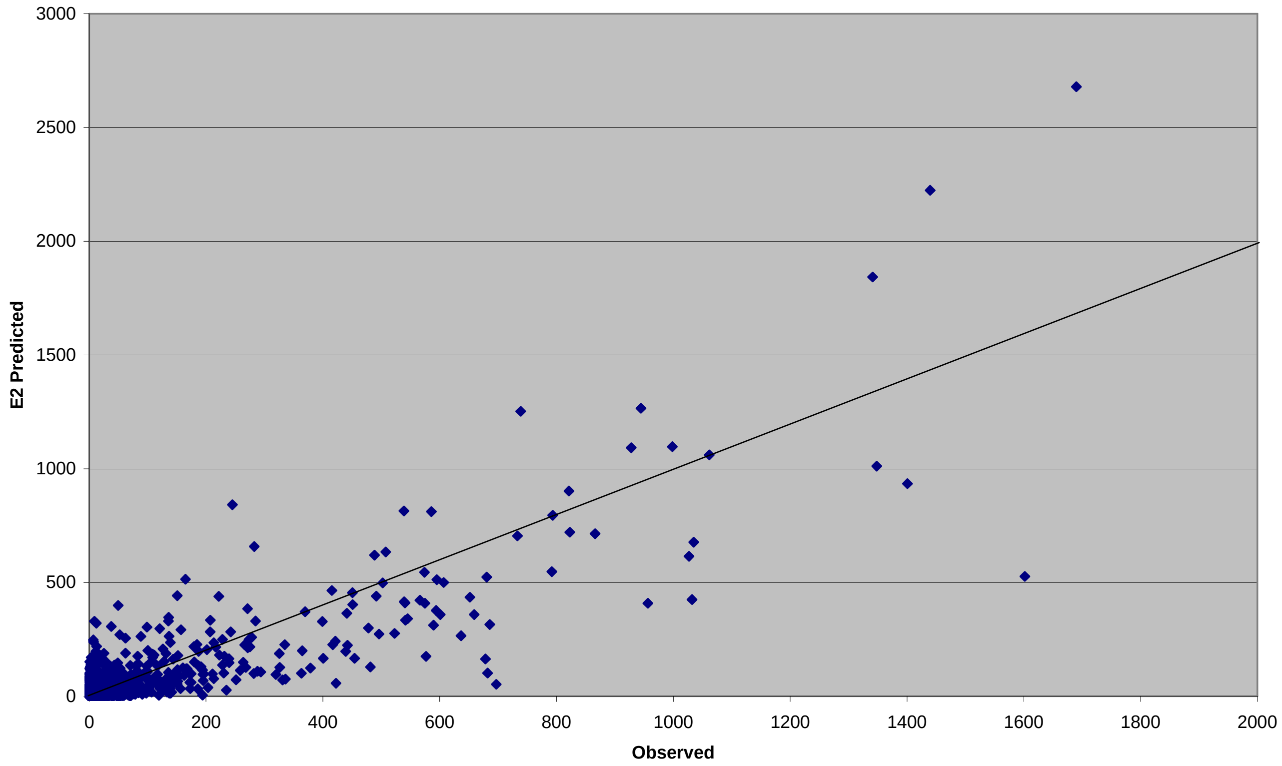

Figure 3-5 Scatter Plot of E2 Modelled and Observed Runoff 1980 to 2004

4.1 Background

Associated water is typically a by-product of Coal Seam Gas (CSG) development and its management is an integral aspect of the Gladstone Liquid Natural Gas (GLNG) project. Associated water discharge to natural streamlines (typically unnamed drainage lines and depressions) and downstream receiving waters (named creeks and rivers) may have benefits. For example, increases in flow may assist environmental flows and improve water supply security. Other impacts may include introducing unseasonal flow regimes, reducing habitat availability, increasing surface water salinity, or changing temperature regimes. To reduce the salinity concentration of their associated water, Santos plans to install a desalination plant adjacent to a tributary of Hutton Creek. The plant will use reverse osmosis to desalinate associated water from Coal Seam Gas production. At 75% efficiency, the plant is designed to deliver 4.5 ML/day of permeate to the tributary on construction. The brine stream will be injected to the Timbury Hills Formation.

The temperature of associated water is in the range 24 – 43 C. The permeate is expected to be discharged at a temperature of 40 °C to a point on the tributary approximately 6 km upstream of Hutton Creek. The point of entry to Hutton Creek is a long pool which itself is approximately 6 km upstream of the confluence of Hutton Creek and the Dawson River.

In and around the confluence of these two streams there is strong evidence for a regional groundwater discharge. Flows in the Dawson River are permanent perhaps 4 or 5 km upstream of the confluence. Similarly in Hutton Creek flows are thought to be permanent approximately 4km upstream of the confluence.

The purpose of this modelling report is to estimate the likely distance downstream before water temperatures become indistinguishable from background.

A range of scenarios are considered to quantify the degree of uncertainty in the results.

4.2 Modelling

Water temperatures were modelled in the Dawson River using QUAL2K, a one-dimensional river and stream quality model produced by the United States of America's Environmental Protection Agency (USA EPA). The program achieves a high level of sophistication, and capacity to model stream quality by considering the many variables that affect water quality in river streams. For the calculation of heat dissipation from a thermal input into a stream, the heat budget and temperature are modelled using known or interpolated meteorological data.

QUAL2K simulates water quality by varying;

- Stream background flow, temperature, and water quality;
- Point and diffuse pollutant source inputs (volume, temperature and quality);
- Reach conditions, including width, slope and roughness;
- Air and dew point temperature;
- Wind speed; and
- Cloud and shade cover.

4.2.1 Modelling Objectives

To gauge the year round temperature impacts on the Dawson River, six river flow scenarios were developed under two seasonal conditions:

Wet Season (November to March)

- Ephemeral (cease to flow) stream conditions, discharge at source;
- Spring flow, pipe and discharge into spring flows along the Dawson River;
- Wet season base flow, discharge at source;

Dry Season (April to October)

- Ephemeral (cease to flow) stream conditions, discharge at source;
- Spring flow, pipe and discharge into springs; and
- Dry season base flow, discharge at source;

During large runoff events the associated water would be diluted to a level indistinguishable from natural flow, therefore it was decided to only model the cease to flow and base flow conditions. In addition to the six weather scenarios, two pollutant flow rates under two temperature states were investigated;

Current Production Levels

- Direct discharge - 4.5ML/d discharged at 40 °C;
- Store and release - 4.5ML/d discharged at 5 °C above background water temperature;

Future Production Levels

- Direct discharge - 19.5ML/d discharged at 40 °C; and
- Store and release - 19.5ML/d discharged at 5 °C above background water temperature

These scenarios were developed to represent the current production with direct discharge, and current production levels with the discharge being stored and cooled prior to release into Hutton Creek. Further scenarios representing a 15ML/d increase in production under both direct discharge to grade and store and release conditions were developed.

4.2.2 Model Data

Model parameters are described in Appendix B and summarized in Table 4-1.

Table 4-1 Summary of Model Parameters

				Night 12am to 5am		Morning to Midday 5am to 1pm		Midday to Evening 1pm to 12am		
	Flow State	Flow (ML/d)	Water Temp	Air Temp	Dew Temp	Air Temp	Dew Temp	Air Temp	Dew Temp	Wind Speed (m/s)
Wet Season	Ephemeral	0	27	17.7	17	25.2	15.6	30.9	13.5	2.8
	Spring Flow	17.28	22.1	17.7	17	25.2	15.6	30.9	13.5	2.8
	Base Flow	50	27	17.7	17	25.2	15.6	30.9	13.5	2.8
Dry Season	Ephemeral	0	17	7.5	7.5	16	8.4	23.1	5.9	2.6
	Spring Flow	17.28	22.1	7.5	7.5	16	8.4	23.1	5.9	2.6
	Base Flow	25	17	7.5	7.5	16	8.4	23.1	5.9	2.6

4.2.3 Model Assumptions

In the development of the model, the following assumptions about climatic conditions and stream interactions were made:

- Immediate mixing of the pollutant into the main body of Dawson River, assuming complete flow and temperature mixing at the point of injection;
- The associated water temperature was assumed to be a constant 40°C, unvarying throughout the day or year. Similarly, in the store and release scenarios, associated water is discharged at exactly 5°C over the Hutton Creek background levels; and
- Spring waters flowed at a constant discharge and temperature; therefore no seasonality in these parameters was used in the model.

4.3 Results and Interpretation

As was previously mentioned, the QUAL2K models were run for both varying climatic data and varying associated water discharges and temperatures. In all, 24 scenarios were developed, each with a combination of the aforementioned climatic and associated water parameters. These parameters as well as the mixed stream conditions are presented in Table 4-2.

Table 4-2 Temperature Model Scenarios

Season	Scenario	Santos Discharge (ML/d)	Hutton Creek Flow (ML/d)	Mixed Flow (ML/d)	Santos Discharge Temperature	Hutton Creek Temperature	Mixed Temperature
Wet Season	1	4.5	0	4.5	40	27	40.0
	2	4.5	50	54.5	40	27	28.1
	3	19.5	0	19.5	40	27	40.0
	4	19.5	50	69.5	40	27	30.6
	5	4.5	0	4.5	32	27	32.0
	6	4.5	50	54.5	32	27	27.4
	7	19.5	0	19.5	32	27	32.0
	8	19.5	50	69.5	32	27	28.4
Dry Season	9	4.5	0	4.5	40	17	40.0
	10	4.5	25	29.5	40	17	20.5
	11	19.5	0	19.5	40	17	40.0
	12	19.5	25	44.5	40	17	27.1
	13	4.5	0	4.5	22	17	22.0
	14	4.5	25	29.5	22	17	17.8
	15	19.5	0	19.5	22	17	22.0
	16	19.5	25	44.5	22	17	19.2
Wet Season Spring Flow	17	4.5	17.3	21.78	40	22	25.7
	18	19.5	17.3	36.78	40	22	31.5
	19	4.5	17.3	21.78	27	22	23.0
	20	19.5	17.3	36.78	27	22	24.7
Dry Season Spring Flow	21	4.5	17.3	21.78	40	22	25.7
	22	19.5	17.3	36.78	40	22	31.5
	23	4.5	17.3	21.78	27	22	23.0
	24	19.5	17.3	36.78	27	22	24.7

By applying the above scenarios to the QUAL2K mode, the magnitude and length of the heat plume were calculated. The results of all simulations are shown in Figure 4-1. It was decided to not measure the length of the plume until complete normalisation as this took considerably longer due to the nature of regression curves. For Scenarios 1 to 16, the length of the plume was recorded until the temperature normalised at one of two states. These were 0.5 and 1.0°C above the background temperature. These states were selected as they represent the level of natural daily fluctuation of the water temperature in Hutton Creek.

For Scenarios 17 to 24 (the spring flow models), the plume length was recorded until the temperature was normalised to the spring flow temperature (22.1°C) or the background temperature of Hutton Creek, whichever was higher.

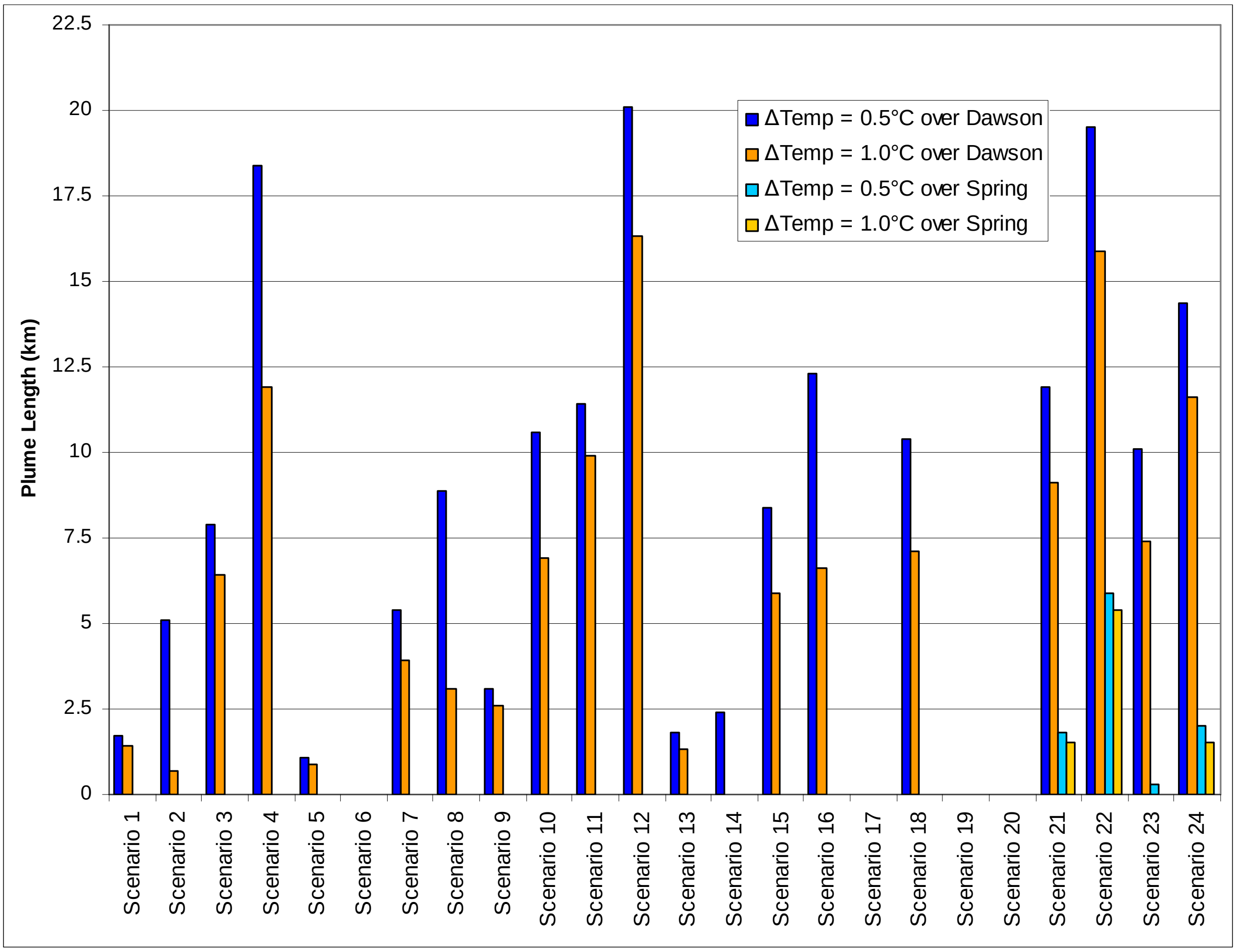

Figure 4-1 Length of Temperature Plume in Hutton Creek

As can be seen from Figure 4-1, very few scenarios could be considered acceptable. Typically, using the same associated water conditions, the plume length during the wet season was found to be notably less than the dry season equivalent. This is due to both the greater base flows and the notably higher background temperature of the stream during the wet season.

Six (non-spring flow) scenarios produce a plume with a change in temperature of 1.0°C above the background temperature with a plume length of less than 1.5km. These scenarios were 1, 2, 5, 6, 13, and 14. All of these scenarios involve the discharge of a maximum of 4.5ML per day. The minimum plume produced under the increased production models was in excess of 3.1km. Only one set of associated water parameters provides satisfactory results independent on seasonality and the conditions in Hutton Creek. These parameters are current discharge levels (4.5ML/d) stored and released at 5°C higher than background temperatures. These parameters are used in scenarios 5, 6, 13 and 14.

Generally the spring flow scenarios were found to perform far better then the discharge at source scenarios, particularly when the plume is measured till normalisation with the spring flow temperature. Under this criterion all except one of the scenarios were found to have effectively normalised within the first 2km from the associated water being introduced to the stream.

Despite cooling the associated water to 5°C higher than background, a release of 19.5ML/d is likely to cause a rise in temperature in the stream for several km when discharged at the source. To reduce the plume length two options are feasible, increase the detention time before release thus allowing the temperature to further drop, the alternative being piping the associated water and discharging at a location with a suitable spring flow or higher flow.

5.1 Background

Associated water is produced as a necessary by-product of Coal Seam Gas (CSG) production. Associated water has a moderate salinity[1]. The discharge of this associated water into nearby streams prompted the creation of a model to evaluate potential impacts of this elevated salt concentration. Salinity modelling was intended to represent the current conditions, as well as the discharge associated with additional wells to begin pumping in the future, and various management scenarios as described in Section 6.2.

The original plan was to model salinity in conjunction with flow using E2; however, many limitations rendered E2 unfit for this purpose (Appendix C). These limitations prompted URS to develop a simple empirical algorithm to produce representative salinity modelling results.

5.2 Modelling

5.2.1 Model Objectives

The above-mentioned limitations within E2 prompted URS to build a simple algorithm in Excel to produce representative salinity modelling results. The objectives of the algorithm were:

- To apply a simple algorithm consistently across Fairview, Roma, and Arcadia study locations;
- To produce conservative salinities (equal to or minimally higher than observed), attempting to replicate pulses or surges when salinity may be particularly of concern;
- To duplicate current conditions whilst also accommodating additional discharge and salinity from CSG production wells and treatment plants;
- To span the date extent of available flow data, thus extrapolating unknown salt concentrations; and
- To produce a user-friendly interface to evaluate various water management scenarios as described in Section 6.3.

5.2.2 Model Data

The basic salinity model was created based on stream flow and observed salinities. Where available, observed flow data was sourced from the Department of Natural Resources and Water (NRW) stream gauges for the extent of record. In areas with no stream gauges, E2 modelled flows were used. In Fairview, flow data was used from two gauges: Dawson River at Taroom (1980-2007) and Dawson River at Utopia (1975-2007). Continuous electrical conductivity data was sourced at the same two gauges for the extent of record (1993-2007 at Taroom and 1997-2007 at Utopia) with additional NRW water quality spot data over a longer time period. All collected electrical conductivity data was compared to modelled salinities to refine the empirical models, which span the time extent of the flow record.

[1] Salinity is typically measured as TDS or indirectly using electrical conductivity (EC) measured at a standard temperature (typically 25°C). A linear relationship exists between EC (measured in µS/cm) and TDS (mg/L) for the range of salinities discussed in this report.

5.2.3 Model Assumptions

An empirical algorithm was developed to replicate observed salt concentration trends. The model is based on a minimum and maximum salt concentration with fluctuation based on flow levels. This is similar to the high flow/low flow concentration model embedded in E2 with additional flexibility to account for the transition between high and low flow salinities.

When the flow is zero, the salt concentration is assumed to be zero. When flow equals or exceeds a selected high flow, the model resets to the minimum salt concentration. Salinity is expected to decrease in high flow and increase in low flow. The amount of daily incremental change in salinity was determined based on the rates of increase and decrease of observed salinity such that the final algorithm best fits the observed salinity curve.

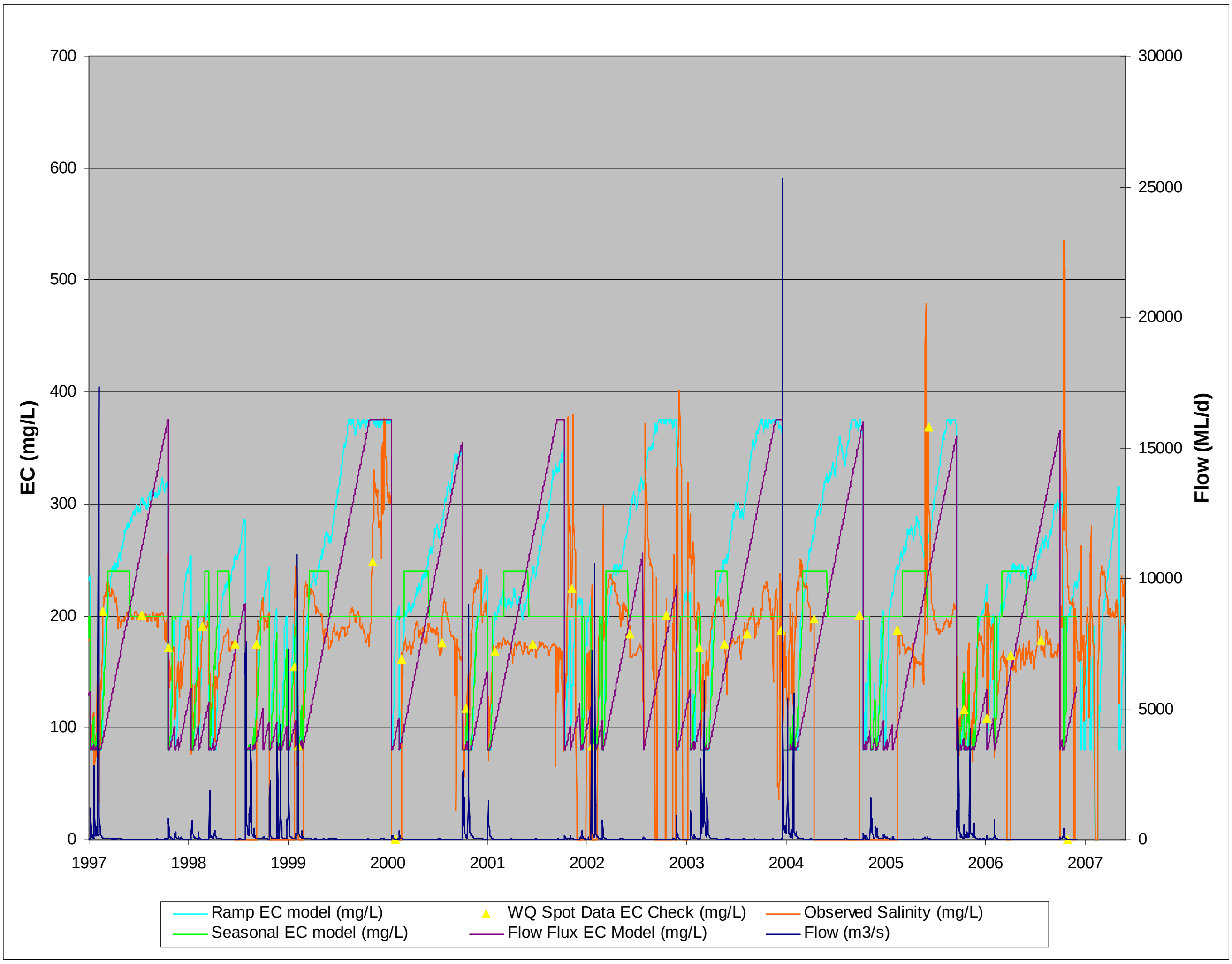

Figure 5-1 Trialled Salinity Modelling Sophistications at Utopia

Starting with a simple algorithm, three different modelling sophistications were trialled including (1) introduction of seasonality, (2) a ramp from a first maximum concentration to a second peak concentration, and (3) salinity responsive to flow flux. The modelling sophistications are described in Appendix C. Comparison of the three modelling sophistications resulted in selection of the ramp approach being used for all salinity model simulations. The ramp approach sufficiently captures the seasonal surges between March and June at Utopia, and the difference in salinity prediction from the flow flux approach was negligible and the complication was deemed unnecessary and less defensible.

When additional discharge and salinity was introduced from CSG production wells and treatment plants, proportional mixing was assumed to preserve the mass balance. Results of salinity modelling are presented in the next section.

6.1 Background

Santos proposes to manage associated water from the Fairview Project Area in accordance with the EPA operational policy (Anon., 2007) whilst recognising the current volumes, quality, and impact of the existing associated water discharge. Associated water discharge has occurred at the site over the last 14 years. Santos Group of companies commenced operatorship of the site in 2005.

Santos recognises that water is a precious commodity and essential for the well being of the local community both now and into the future. After carefully considering the levels of existing and proposed development within the Fairview Project Area, the imperatives of the international gas industry, and the desires of the local community, Santos has proposed a mix of associated water management options.

It is recognised that the proposed options need to be reviewed within an adaptive management framework that takes into account government initiatives in regional water management and development, changing economics of the gas and water markets, opportunities for regional development, and improved knowledge and science underpinning the extraction and use of associated water. Santos is committed to this regular review as part of its planning processes.

Significant volumes of associated water will be generated over the development life of the Fairview Project Area. Management options include injection, onsite reuse, stock watering, irrigation, desalination and discharge, and direct discharge.

6.2 Scenarios

To explore the boundaries of any potential impacts of associated water discharge, it is necessary to define modelling scenarios. It is prudent to explore the potential for different points and quantities of discharge within each field as this will provide improved decision making and option analysis. Results can also feed back directly into the overall risk analysis.

It was determined useful to consider three points on each associated water production curve (minimum predicted water production and maximum predicted water production) for each modelling run. The three points identified are 1/3 peak production, 2/3 peak production and peak production. That is, for each point on the curve we will assume a constant flow from the CSG field over the full modelling period and compare the results with a no discharge scenario. This means that six different flows (1/3 min peak, 2/3 min peak, 3/3 min peak, 1/3 max peak, 2/3 max peak, and 3/3 max peak) will be combined with existing flows to assess the impacts for each scenario identified.

In Fairview, the following four scenarios were considered, after consultation with Santos:

- Option 1: Existing discharge to grade + desalination at Pony Hills + additional untreated discharge to grade;
- Option 2: Existing discharge to grade + desalination at Pony Hills + additional desalination at Central Treatment Plant;
- Option 3: Existing discharge to grade + desalination at Pony Hills only (all other water assumed to irrigation)
- Option 4: Piping discharge to catchment outlet at Taroom, with existing discharge to grade + desalination at Pony Hills + additional untreated discharge to grade;

6.3 Modelling

6.3.1 Model Parameters

Flow weighted salt concentration was calculated for the various scenarios from the following equation.

$$C_{mixed} = \frac{Q_1 \times c_1 + Q_2 \times c_2 + Q_3 \times c_3 + Q_4 \times c_4}{Q_1 + Q_2 + Q_3 + Q_4}$$

Where Q_1 / c_1 = observed flow / modelled salinity in Dawson River at Taroom;

Q_2 / c_2 = direct discharge to grade from CSG well production / salinity of direct discharge;

Q_3 / c_3 = discharge from Pony Hills desalination / salinity of desalination discharge; and

Q_4 / c_4 = varies by scenario as additional direct discharge (Option 1), discharge from Central Treatment Plant (Option 2), or piped to Taroom (Option 4) / associated salinity of each option.

In Option 3, irrigation is a direct removal of CSG discharge, which occurs on the plateau where associated water is generated; it is expected that there is zero runoff.

Modelled salt concentration was based on the ramp salinity Model, as described in Section 5.2.3, and detailed below.

If $Q_t = 0$

$c_t = 0$

If $Q_t > Q_{HIGH}$

$c_t = c_{MIN}$

If $Q_t > Q_{t-1}$ (rising limb)

$c_t = c_{t-1} - c_{DECREASE}$

If $Q_t < Q_{t-1}$ *AND* $c_t < c_{RAMP}$

$c_t = c_{t-1} + c_{IBR}$

If $Q_t < Q_{t-1}$ *AND* $c_t > c_{RAMP}$

$c_t = c_{t-1} + c_{IAR}$

Where Q_t = Flow at timestep t;

Q_{HIGH} = high flow trigger parameter;

c_t = salt concentration at timestep t;

c_{MIN} = minimum salt concentration;

c_{RAMP} = salt concentration at which the rate of increase changes;

$c_{DECREASE}$ = rate of salt concentration decrease;

c_{IBR} = rate of salt concentration increase below ramp (IBR); and

c_{IAR} = rate of salt concentration increase above ramp (IAR).

6.3.2 Model Data

Discharge input was extracted from the Fairview minimum and maximum associated water production curves at the peak levels as well as 1/3 and 2/3 of peak levels. The peak of the maximum associated water production curve is 52.5 ML/d, resulting in 1/3 peak of 17.5 ML/d and 2/3 peak of 35 ML/d. Similarly, the peak of the minimum associated water production curve is 27.5 ML/d, resulting in 1/3 peak of 9.2 ML/d and 2/3 peak of 18.3 ML/d.

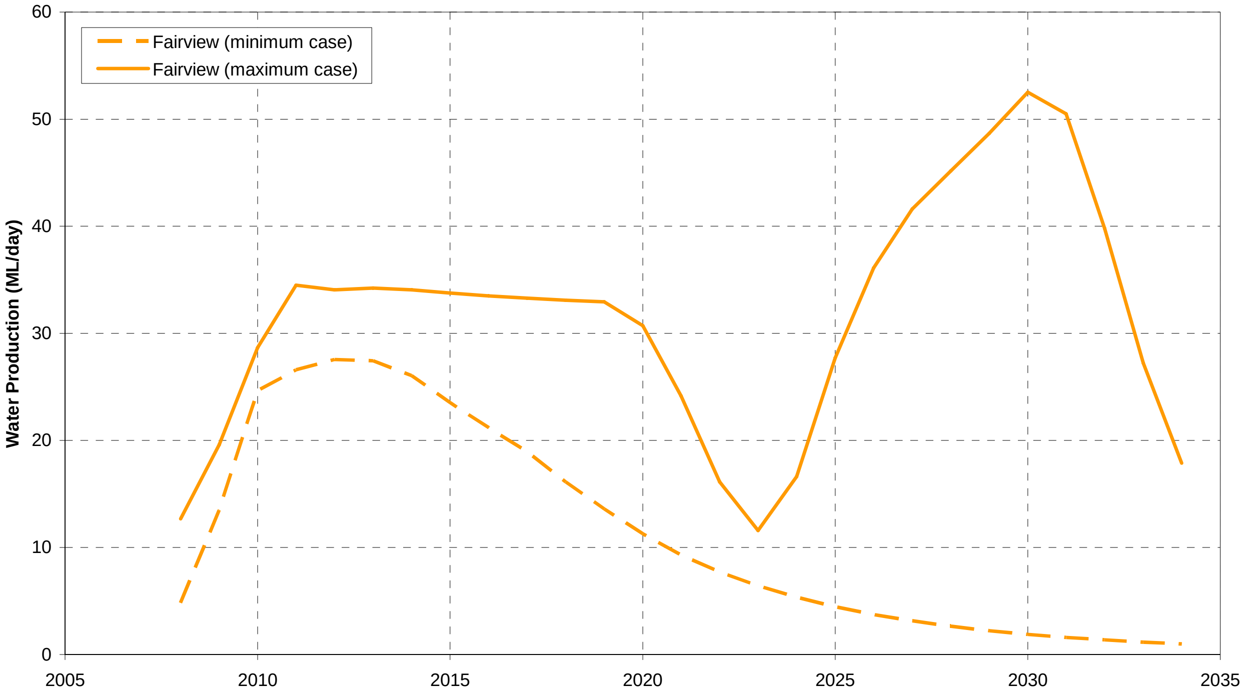

Figure 6-1 Future Predicted Associated Water Production in Fairview

In all scenarios, direct discharge was estimated at 4.5 ML/d, Pony Hills desalination discharge was estimated at 4.5 ML/d, and the remaining portion was calculated as the difference between those two fixed discharges and the target discharge levels (three points along the water production curves). The remaining portion was discharged to grade in Option 1, discharged from the Central Treatment Plant in Option 2, and piped to Taroom in Option 4. In Option 3 (irrigation), no additional water was discharged to Dawson River.

The model was developed to always include a direct discharge of 4.5 ML/d. The Fairview production field is located upstream of the Hutton Creek gauging station, the most upstream observed record. Therefore, between 1994 and 2007, the potential exists to double count associated water discharge, as the portion routed to Dawson River is inherently included in stream gauge flow measurements. To avoid duplication of flow, associated water from CSG production was deducted from the gauge flow measurements during this time period.

Of the associated water discharged in the treated scenarios, the discharge volume was reduced by 25% of the input volume. This assumption corresponds to the expected losses from the desalination treatment process as brine.

Associated water is sampled regularly from each production well and analysed for a number of water quality parameters. Based on comprehensive sampling from 56 producing wells in the Fairview project area over the period 2005 to 2007, the average Electrical Conductivity (EC) of CSG associated water was 1,998 µS/cm (TDS 1,338 mg/L. EC was estimated at 500 µS/cm (TDS 335 mg/L) for Pony Hills permeate discharge, 340 µS/cm (228 mg/L) for Central Treatment Plant permeate, and 0 µS/cm introduced to the stream from irrigation.

Table 6-1 Discharge (ML/d) for Fairview Development Scenarios

Scenario	Predicted Production	Direct Discharge	Pony Hills	Additional Discharge to Grade	Central Treatment Plant	Irrigation	Piping	Discharged to Dawson River
Option 1: Existing discharge to grade + desalination at Pony Hills + additional untreated discharge to grade								
1.1	17.5 (1/3 max)	4.5	4.5	7.0	-	-	-	16
1.2	35 (2/3 max)	4.5	4.5	24.5	-	-	-	33.5
1.3	52.5 (3/3 max)	4.5	4.5	42.0	-	-	-	51
1.4	9.2 (1/3 min)	4.5	3.5	0	-	-	-	8
1.5	18.3 (2/3 min)	4.5	4.5	7.8	-	-	-	16.8
1.6	27.5 (3/3 min)	4.5	4.5	17.0	-	-	-	26
Option 2: Existing discharge to grade + desalination at Pony Hills + additional desalination at Central Treatment Plant								
2.1	17.5	4.5	4.5	-	5.3	-	-	14.3
2.2	35	4.5	4.5	-	18.4	-	-	27.4
2.3	52.5	4.5	4.5	-	31.5	-	-	40.5
2.4	9.2	4.5	3.5	-	0	-	-	8
2.5	18.3	4.5	4.5	-	5.9	-	-	14.9
2.6	27.5	4.5	4.5	-	12.8	-	-	21.8
Option 3: Existing discharge to grade + desalination at Pony Hills only (all other water assumed to irrigation)								
3.1	17.5	4.5	4.5	-	-	0	-	9
3.2	35	4.5	4.5	-	-	0	-	9
3.3	52.5	4.5	4.5	-	-	0	-	9
3.4	9.2	4.5	3.5	-	-	0	-	8
3.5	18.3	4.5	4.5	-	-	0	-	9
3.6	27.5	4.5	4.5	-	-	0	-	9
Option 4: Piping discharge to Taroom – discharge to grade + desalination at Pony Hills								
4.1	17.5	4.5	4.5	-	-	-	7.0	16
4.2	35	4.5	4.5	-	-	-	24.5	33.5
4.3	52.5	4.5	4.5	-	-	-	42.0	51
4.4	9.2	4.5	3.5	-	-	-	0	8
4.5	18.3	4.5	4.5	-	-	-	7.8	16.8
4.6	27.5	4.5	4.5	-	-	-	17.0	26

Table 6-2 Salt Input (mg/L) for Fairview Options

Option	Direct Discharge	Pony Hills	Additional Discharge to Grade	Central Treatment Plant	Irrigation	Piping
1	1339	335	1339	-	-	-
2	1339	335	-	228	-	-
3	1339	335	-	-	0	-
4	1339	335	-	-	-	1339

6.4 Model Development and Parameters

To assess the impact of associated water discharge to the Dawson River system, two salinity models were developed to simulate the natural condition of the river at their respective locations. Two models were created to represent two possible locations for point source input of associated water: Utopia Downs and Taroom on the Dawson River.

At the Utopia Downs gauging station, 10 years of continuous (with gaps) EC data has been collected between 1997 and 2007. The salinity model was calibrated to best fit the observed records. The stream flow, calibrated salinity model, and observed continuous and spot records are shown in Figure 6-2 and

Figure 6-3. The salinity model is conservative overall, tending to overestimate the salinity in the system. This was necessary to allow the model to reach the peaks in the observed records. The salinity model was applied over the available date range of flow data from 1975 to 2007 to extend the period over which the scenarios can be assessed.

Similarly, 14 years of continuous (with gaps) EC data has been collected between 1993 and 2007 at the Taroom gauging station on the Dawson River. The salinity model was developed between 1993 and 2007 using the observed continuous EC record, then checked against spot records dating back to 1981. The calibrated salinity model successfully matches the rises and falls as well as the seasonal peaks between April and June. The stream flow, calibrated salinity model, and the observed continuous and spot records are shown in Figure 6-4 and

Figure 6-5. Typically, the model is conservative, tending to overestimate the salinity in the system. This was necessary to allow the model to reach the peaks in the observed records. The salinity model was applied over the available date range of flow data from 1980 to 2007 to extend the period over which the scenarios can be assessed.

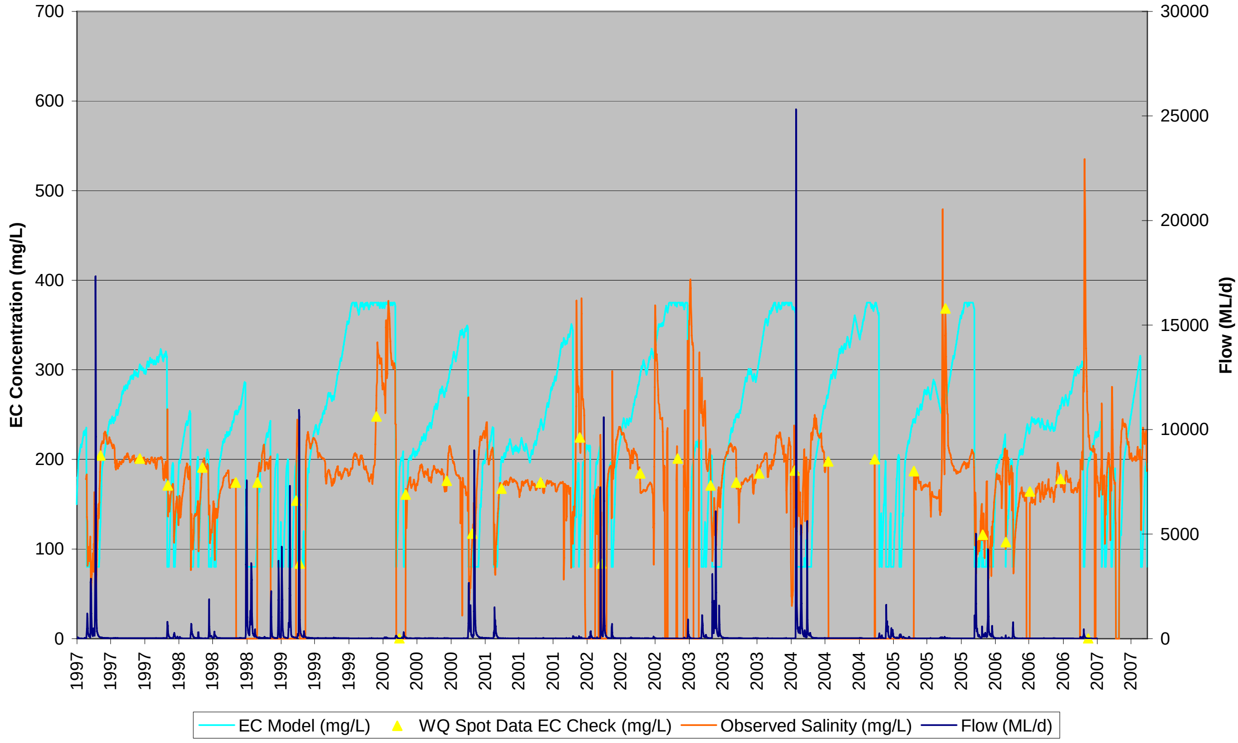

Figure 6-2 Utopia Downs Salinity Model - 1997 to 2007

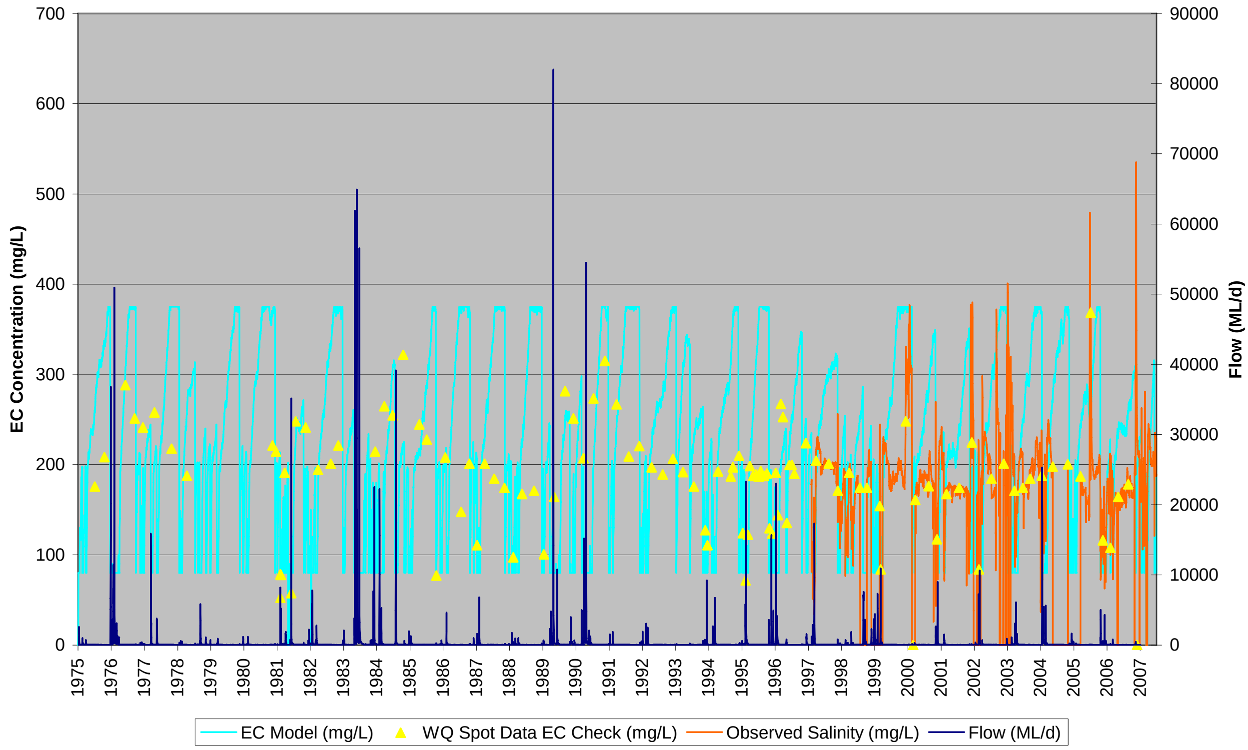

Figure 6-3 Utopia Downs Salinity Model – 1975 to 2007

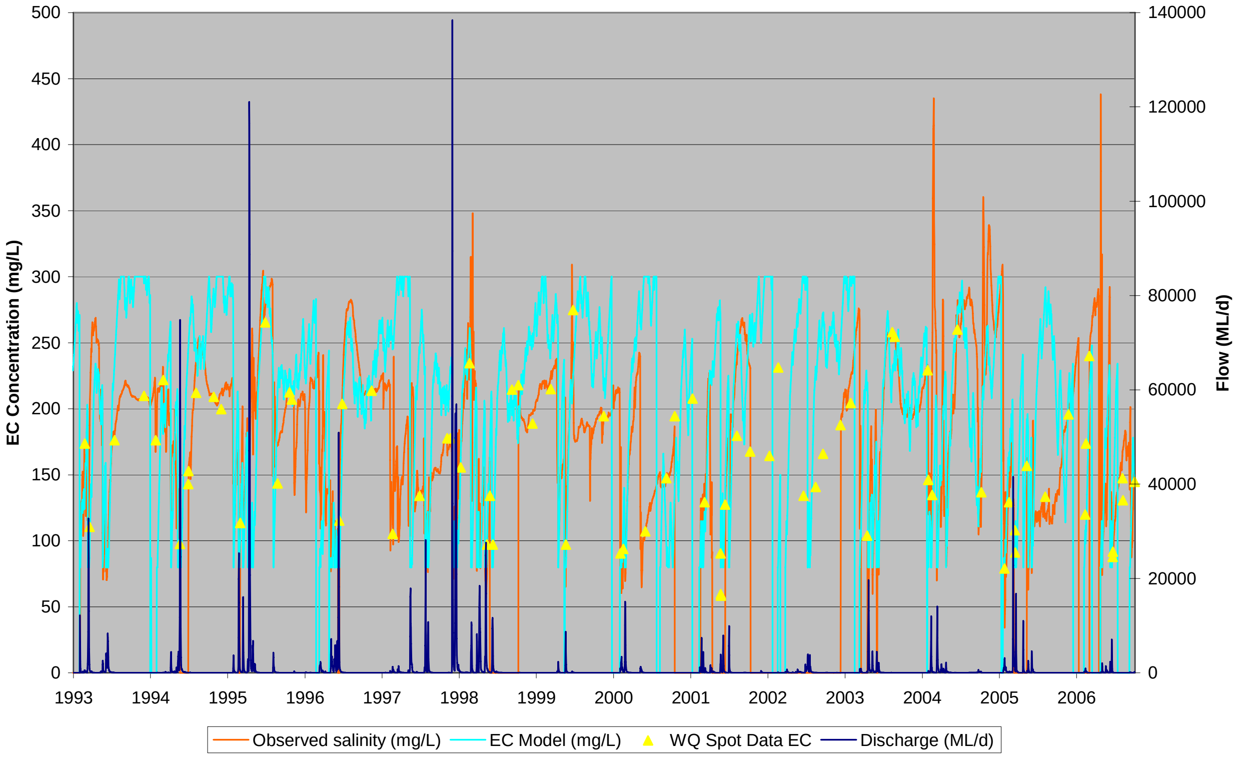

Figure 6-4 Taroom Salinity Model - 1993 to 2007

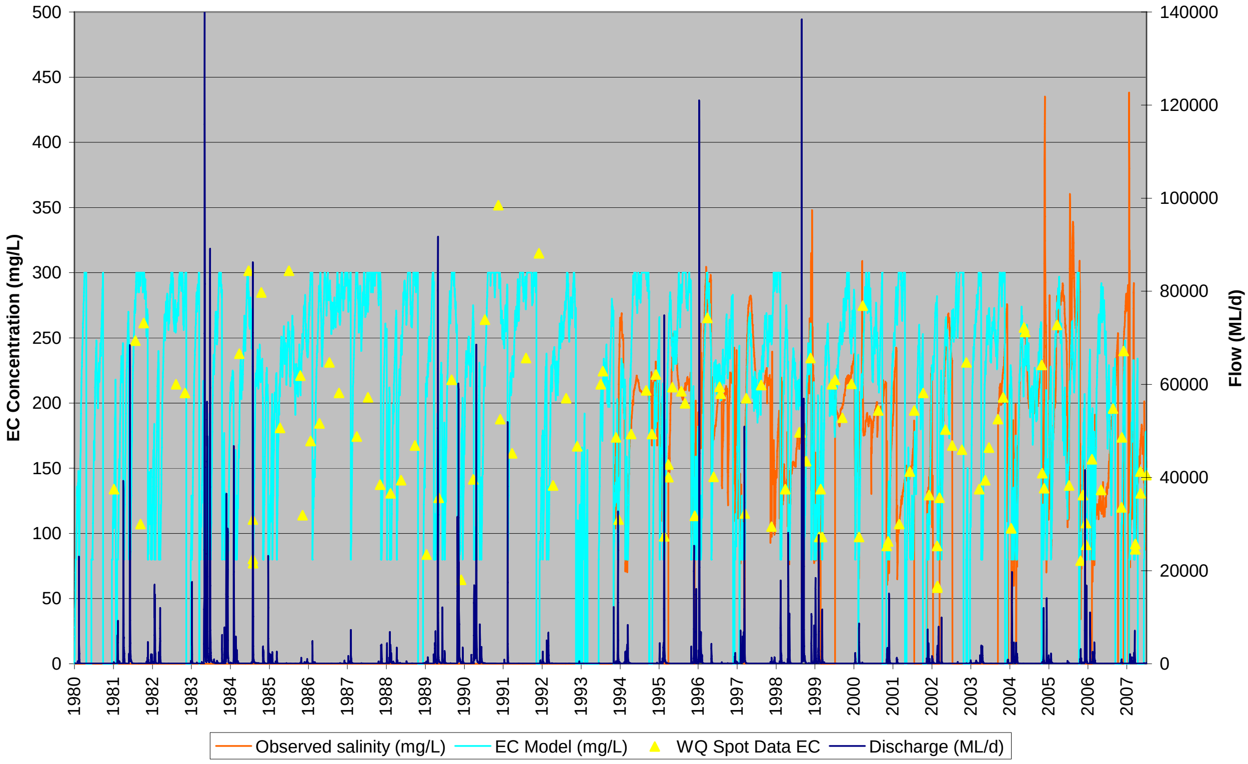

Figure 6-5 Taroom Salinity Model - 1980 to 2007

The parameters used in the salinity model for Utopia and Taroom are presented in Table 6-3 below.

Table 6-3 Dawson Salinity Model Parameters

salinity Ramp Model Parameter	Scenarios 1, 2, 3 (Utopia)	Scenario 4 (Taroom)	Units
High Flow salinity Reset to Minimum Concentration	100	2000	ML/d
Max Concentration	375	300	mg/L
Minimum Concentration	80	80	mg/L
Ramp Change Concentration	200	215	mg/L
Flow Decreases - salinity Increase - Below salinity Ramp by:	10	7	mg/L per day
Flow Decreases - salinity Increase - Above salinity Ramp by:	2	3	mg/L per day
Flow Increase - salinity Decrease by:	1.5	5	mg/L per day

6.5 Results and Interpretation

To assess the environmental impacts on the Dawson River as a result of future associated water production, 24 models were developed in accordance with the scenarios and parameters defined in Table 6-1. A statistical overview of the modelled results of each scenario is presented in Table 6-4 and graphically in Figure 6-6. The results show:

- **Minimum** salt concentration of the mixed stream (during large runoff events);
- **Average** salt concentration;
- **Maximum** salt concentration (typically the concentration of the associated water);
- 25% of days the mixed stream salt concentration is equal to or less than **Lower Quartile**;
- 50% of days the mixed stream salt concentration is equal to or less than **Median**;
- 75% of days the mixed stream salt concentration is equal to or less than **Upper Quartile**; and
- **95th Percentile** representing the value that 95% of the stream salt records are below.

Associated Water Management Scenarios — Section 6

Table 6-4 Summary of Scenarios - Mixed Stream Salt Concentrations (mg/L)

	Future Production (ML/d)	Statistics			Quartile			95th Percentile
		Min	Average	Max	Lower	Median	Upper	
Utopia Salinity Model	**-**	**0**	**231**	**375**	**150**	**233**	**312**	**375**
1.1	17.5	80	**576**	1056	425	636	747	908
1.2	35.0	80	**776**	1204	635	874	977	1109
1.3	52.5	81	**877**	1250	767	992	1079	1182
1.4	9.2	80	**426**	900	297	460	556	704
1.5	18.3	80	**591**	1070	436	653	764	925
1.6	27.5	80	**710**	1165	559	795	904	1052
2.1	17.5	80	**374**	612	292	418	481	549
2.2	35.0	80	**320**	428	279	361	398	417
2.3	52.5	80	**294**	370	271	330	354	366
2.4	9.2	80	**426**	900	297	460	556	704
2.5	18.3	80	**370**	596	291	414	475	538
2.6	27.5	80	**338**	480	284	381	425	457
3.1	17.5	80	**418**	837	298	455	545	676
3.2	35.0	80	**418**	837	298	455	545	676
3.3	52.5	80	**418**	837	298	455	545	676
3.4	9.2	80	**426**	900	297	460	556	704
3.5	18.3	80	**418**	837	298	455	545	676
3.6	27.5	80	**418**	837	298	455	545	676
Taroom Salinity Model	**-**	**0**	**168**	**300**	**80**	**209**	**260**	**300**
4.1	17.5	80	**701**	1056	410	774	1039	1056
4.2	35.0	80	**866**	1204	601	1009	1195	1204
4.3	52.5	80	**940**	1250	726	1106	1244	1250
4.4	9.2	60	**556**	898	309	562	868	898
4.5	18.3	80	**714**	1070	420	792	1053	1070
4.6	27.5	80	**815**	1165	530	938	1154	1165

The Dawson River at Utopia Downs and Taroom has been observed to be ephemeral under certain times of the year. Further, the base flow within the stream is often very low, in the order of a few ML/day. During periods of no flow, the only flow in the stream is the associated water discharge, thereby resulting in a salt concentration in the system equal to that of the production water. This has been found to skew the average and quartiles towards higher salt concentration.

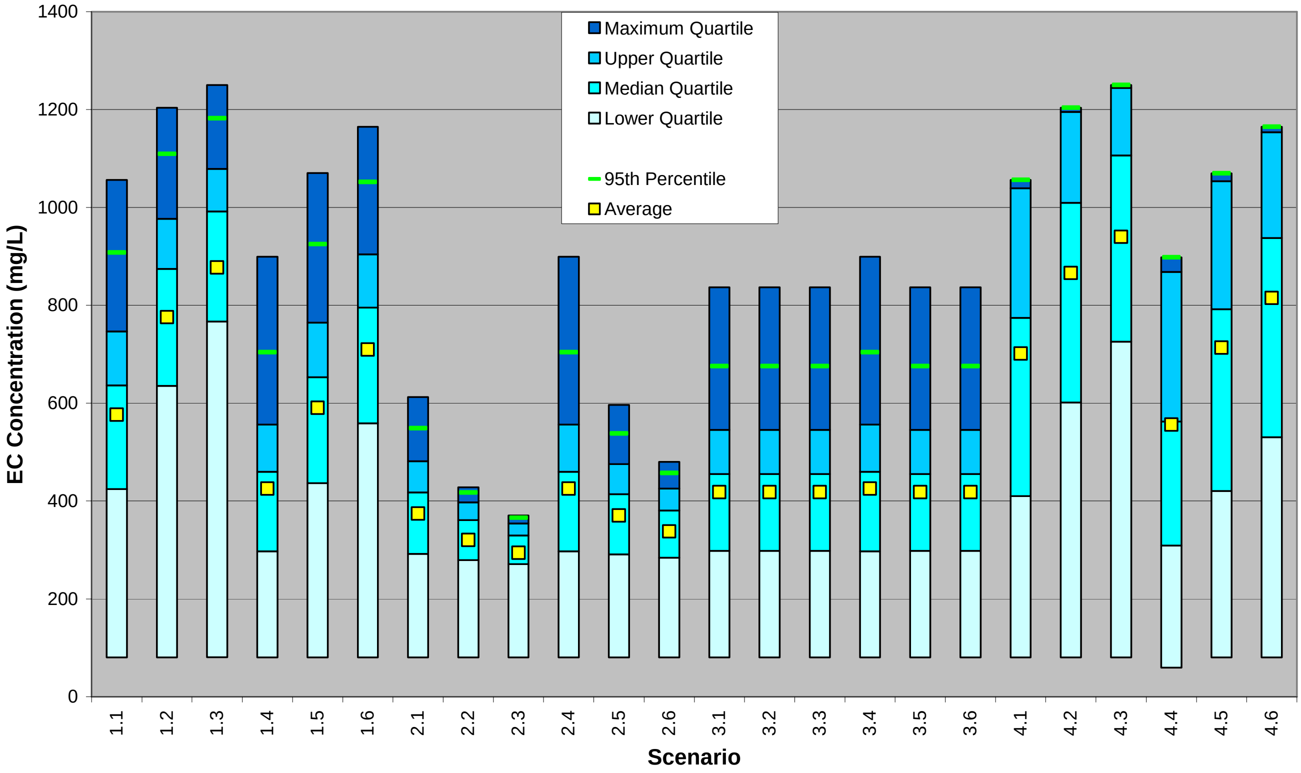

Figure 6-6 Summary of Scenarios - Mixed Salt Concentration in Dawson River

6.5.1 Scenario 1 – Additional Direct Discharge to Grade

Of the predicted discharge, all scenarios assume 4.5 ML/d will continue to be discharged to grade and 6.0 ML/d will be directed to Pony Hills Desalination Plant. A 25% volume reduction is anticipated due to treatment; thus output from Pony Hills is 4.5 ML/d. The allocation of the remainder of produced associated water varies by scenario. In Scenario 1, the remaining associated water is discharged to grade untreated at Utopia Downs. For each scenario, a figure displays the current conditions and the range of predicted salt concentrations based on future CSG production. Figure 6-7 shows the Utopia salinity model representing natural stream conditions, in addition to the salinity model based on minimum (9.2 ML/d) and maximum (52.5 ML/d) predicted future production.

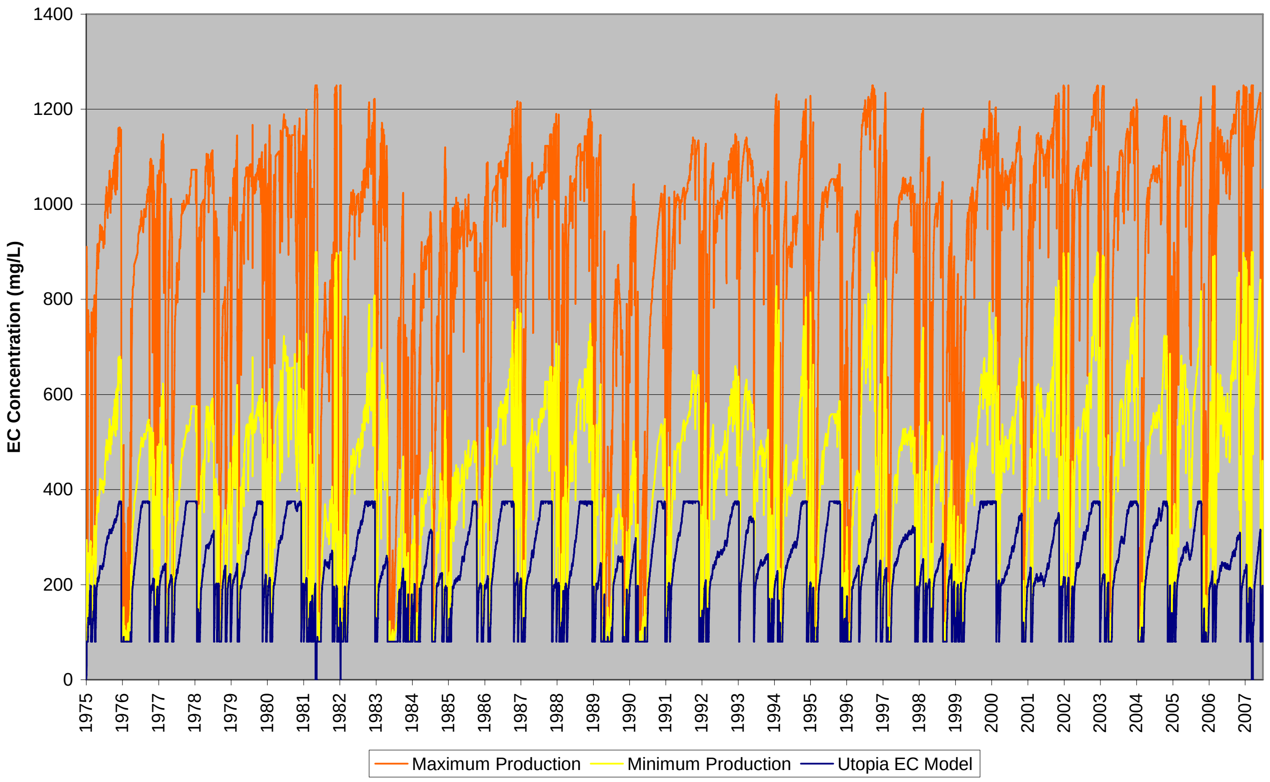

Figure 6-7 Scenario 1 - Mixed Stream salinity Concentration – Future Projected Production

6.5.2 Scenario 2 – Central Treatment Plant

Scenario 2 represents treating any additional discharge at a new central treatment plant. The additional discharge is equal to the predicted production minus the 4.5 ML/d already discharged to grade and 6.0 ML/d directed to Pony Hills Treatment Plant. Figure 6-8 shows the Utopia salinity model (natural stream conditions), in addition to the minimum (9.2 ML/d) and the maximum (52.5 ML/d) predicted future production. This represents the current and likely range of future production within Fairview. Of interest is that, as more associated water is being produced, the mixed stream salt concentration tends to match natural stream conditions. This is due to the significantly reduced salt concentration of water treated at the Central Treatment Plant (228 mg/L as compared to 1339 mg/L of water that is directly discharged). As the ratio of treated to untreated water becomes greater, the mixed stream salt concentration tends towards the treated concentration, and therefore natural background levels.

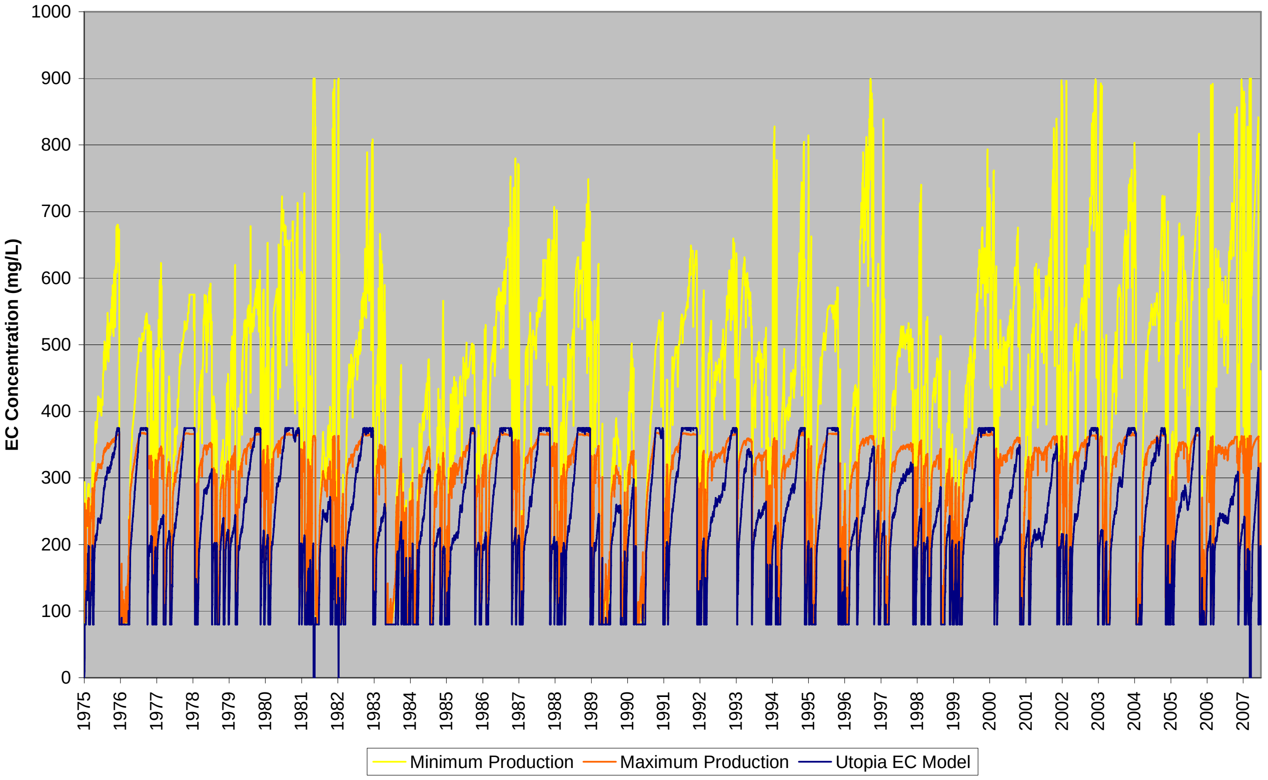

Figure 6-8 Scenario 2 - Mixed Stream Salt Concentration – Future Projected Production

6.5.3 Scenario 3 – Additional Future Production to Irrigation

Scenario 3 represents directing additional discharge to irrigation. The additional discharge is equal to the predicted production minus the 4.5 ML/d already discharged to grade and 6.0 ML/d directed to Pony Hills Treatment Plant. Figure 6-9 shows the Utopia salinity model (natural stream conditions), in addition to the minimum (9.2 ML/d) and the maximum (52.5 ML/d) predicted future production. This represents the current and likely range of future production within Fairfield. As no additional flow is being released into the Dawson River at Utopia Downs, the modelled scenarios overlap. The increase in salt concentration is representative of 4.5 ML per day being discharged directly to grade and a further 4.5 ML per day being discharged from the Pony Hills treatment plant.

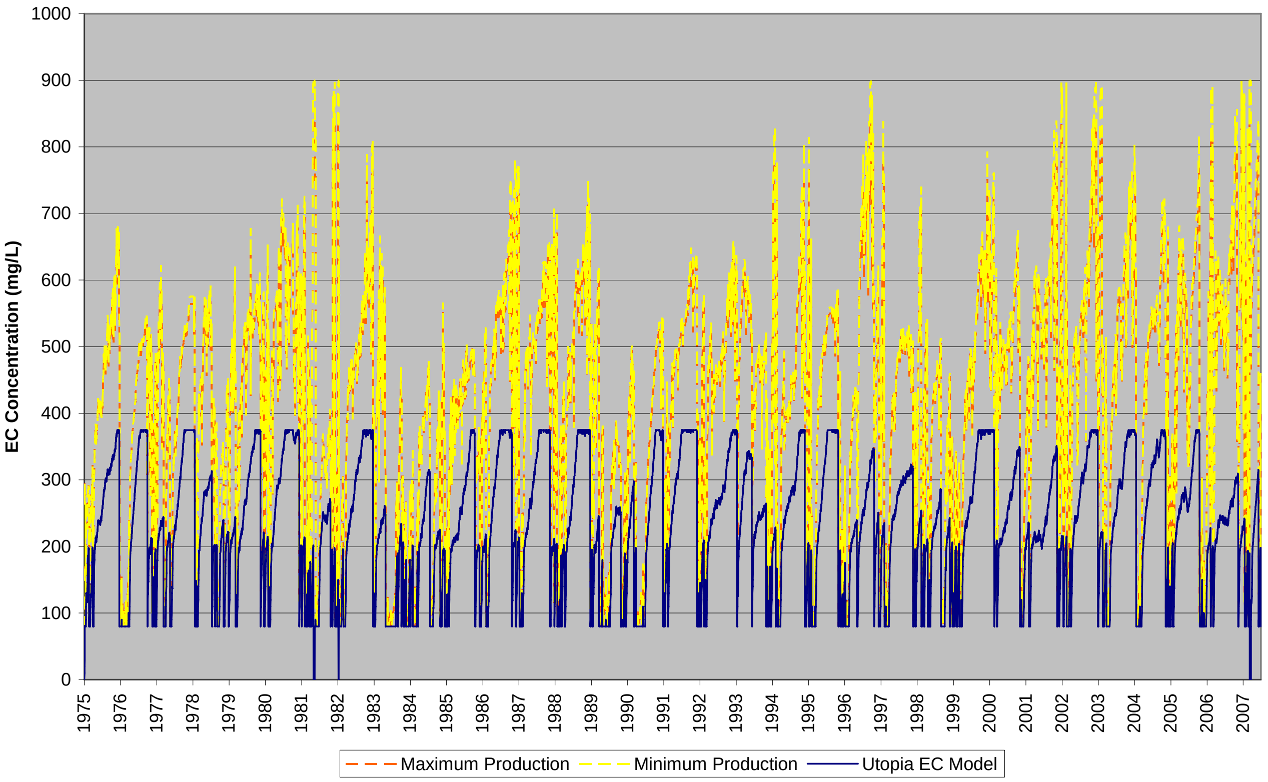

Figure 6-9 Scenario 3 - Mixed Stream Salt Concentration – Future Projected Production

6.5.4 Scenario 4 – Additional Direct Discharge to Grade at Taroom

Scenario 4 represents piping untreated associated water to Taroom for discharge. The additional discharge is equal to the predicted production minus the 4.5 ML/d already discharged to grade and 6.0 ML/d directed to Pony Hills Treatment Plant. Piped water is untreated and remains at the salt concentration of associated water as it is produced and therefore behaves similarly to Scenario 1. The primary difference is that water is discharged at Taroom in Scenario 4 and to Utopia Downs in Scenario 1. Figure 6-10 shows the Taroom salinity model (natural stream conditions), in addition to the minimum (9.2 ML per day) and the maximum (52.5 ML per day) future production. This represents the current and likely range of future production within Fairfield.

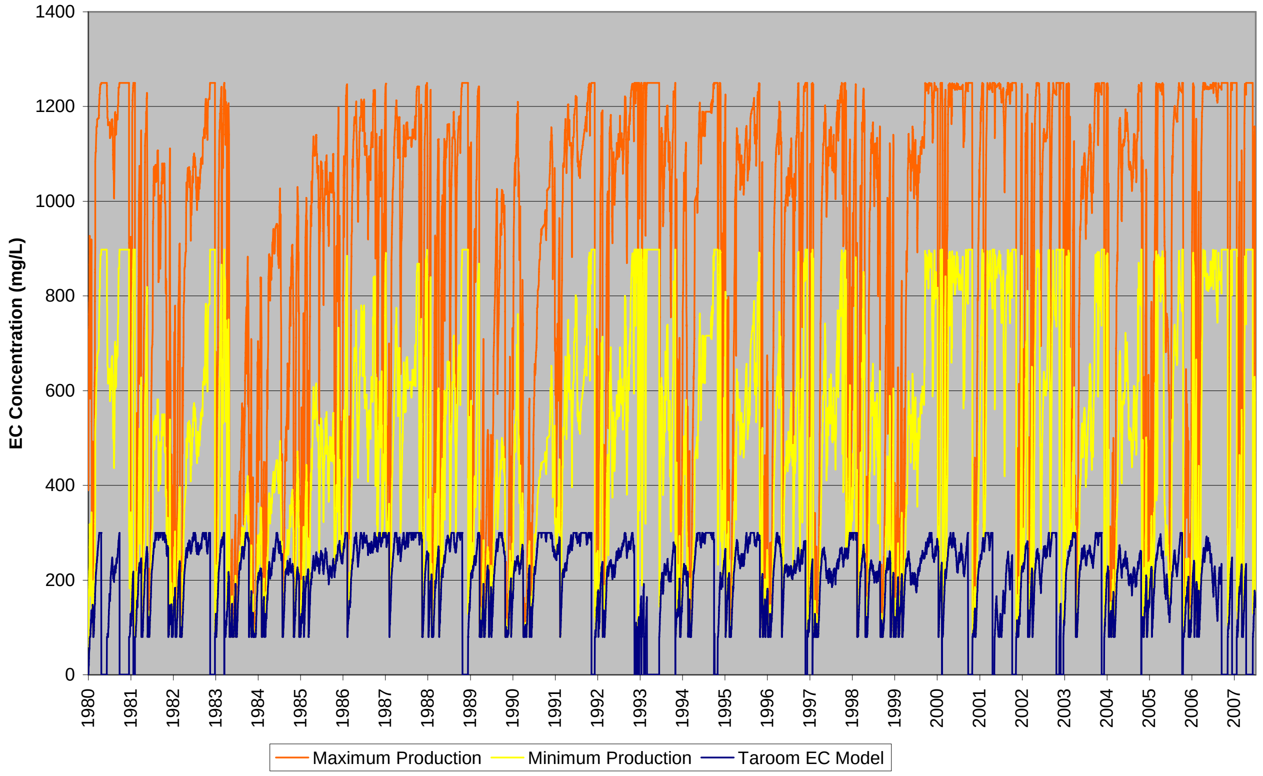

Figure 6-10 Scenario 1 - Mixed Stream Salt Concentration – Future Projected Production

Flows

A rainfall-runoff model has been developed for the Upper Dawson River catchment (and Fairview Field) within the limits of the available data. The model is representative of the observed stream gauging records and allows prediction of the most important flow regimes (zero, low and medium flows) required to assess changes in salinity and flow arising from potential discharges of associated water. Many of the high flow events have not been successfully matched. Attempts to model these peak flows further lead to poor fits in the lower flows. It is likely that the reason for this inability to balance high and low flow modelling is associated with poor representation of rainfalls across the catchment due to limited gauge records. However, impacts of regional groundwater discharges into the Dawson River may also have an some effect on the model parameterisation.

An independent development of the model in an alternative modelling package found similar modelling limitations and confirmed the work performed by URS.

Under-estimates of peak flows will generally produce conservative estimates of dilution (and hence higher salinities under flood events) than would be observed in reality.

Salinity

Modelling shows that discharge of untreated associated water to streams around Fairview or to the Dawson River at Taroom will increase the salinity once the assimilative capacity is exceeded. The spring inflows at Dawson's Bend provide significant "freshwater" inflows especially from the bed of the River.

For the Pony Hills Treatment Plant, permeate discharge treated up to 500 uS/cm will be assimilated into the existing flow regime downstream of the springs at Dawson's Bend, with a very high certainty of achieving the regional water quality objectives for the river at that point. However, as volumes of associated water discharge increase under the proposed Central Water Treatment Plant the assimilative capacity of the stream is exceeded unless higher levels of desalinisation are adopted.

Temperature

Modelling of instream temperatures also shows the persistence of a temperature effect downstream is related to the volumes of discharge and the relative temperature of the discharge compared with the ambient environment.

Under low flow scenarios and temperature maintained within +5^{o}C of ambient conditions the persistence of a 1^{o}C temperature difference would be at worst case 2.5 km downstream, but most scenarios indicate that temperatures will equalise within 1 km. Where associated water is released at ~40^{o}C, the distance required before temperatures return to within 1^{o}C of ambient are up to 10 km in dry season and 5 km in wet season.

Under high flow scenarios and temperature maintained within +5^{o}C of ambient, the persistence of a 1^{o}C temperature difference instream would be at worst case 12.5 km in dry season and ~9 km in wet season.

The significant spring flows entering the Dawson River circa Dawson's Bend also offer significant ameliorating effect on temperatures. Modelling suggests that even if the water temperature of associated water is not reduced below 40^{o}C when discharged, the spring flows will reduce the plume length to ~1.5 – 2 km. With temperatures of associated water maintained within 5^{o}C of ambient the plume length is reduced to less than 1 km.

Results generated in this report will be considered as part of the overall risk assessment of discharging associated water to grade.

Limitations Section 8

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 12 October 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between October 2007 and January 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Flow Model Development

Appendix A

E2 Background

The basic architecture of the E2 modelling framework consists of a subcatchment-node-link system based on two previous software packages, the Environmental Management Support System (EMSS) and the Integrated Quality and Quantity Model (IQQM). E2 allows for the generation of flow and materials in subcatchments and then onto a node where they are routed and possibly processed along a link.

Within E2 sub-catchments are broken up into 'functional units' that represent areas of similar behaviour or response. These can be various combinations of land use or cover such as forestry or grazing, management techniques or even position in the landscape such as ridge, floodplain, etc. Each FU can then have various models describing processes of runoff generation, constituent generation and filtering.

A.1.1 Australian Water Balance Model (AWBM)

The Australian Water Balance Model (AWBM) is a catchment water balance model capable of relating rainfall and evaporation to runoff on an hourly or daily time step. It has a total of eight parameters with the model containing three conceptual stores (C1-C3) with area representation (A1 - A3 summing to 100% of the total area) plus surface and baseflow recession constants and a baseflow index. The relative sensitivity of each parameter can vary depending on the value of the others; however the model is generally most sensitive to the recession constants and baseflow index (Argent *et al,* 2007a). Figure A-1 shows a conceptual diagram of the model and Table A-1 details the AWBM parameters and their default settings.

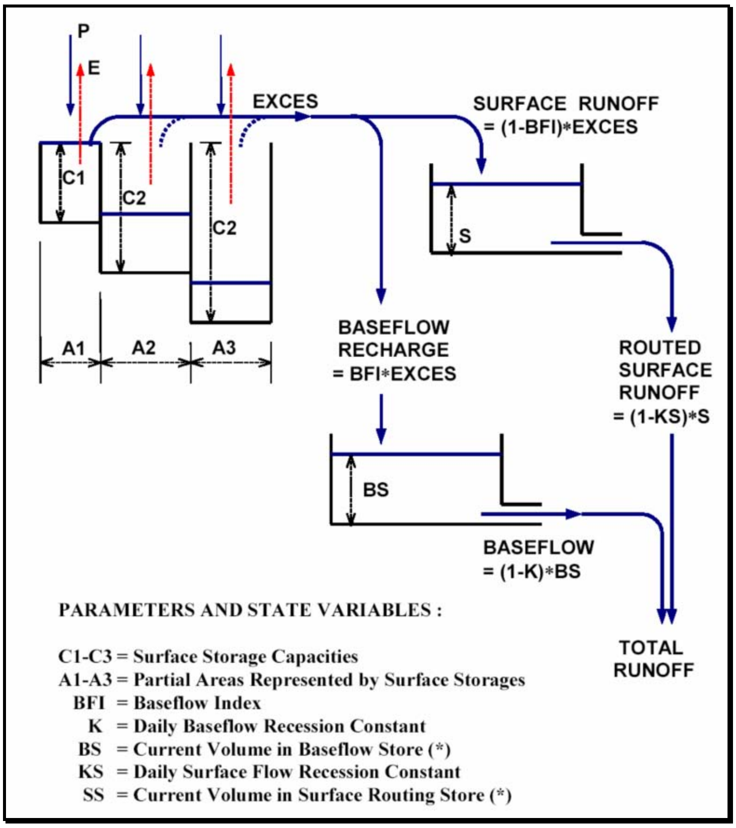

Figure A-1 Australian Water Balance Model (AWBM)

Table A-1 Definition of AWBM parameters and their default values

Parameter	Definition	Units	Max	Min	Default value
Base flow index (BFI)	The ratio of baseflow to total flow in the stream flow	none	1.0	0	0.35
Daily surface flow recession constant (KS)	Determines the rate at which the surface flow runoff store is depleted	Day^{-1}	1.0	0	0.35
Daily base flow recession constant (BS)	Determines the rate at which the base flow store is depleted	Day^{-1}	1.0	0	0.95
A1	Partial area of surface store 1	None	1.0	0	0.134
A2	Partial area of surface store 2	None	1.0	0	0.433
C1	Capacity of surface store 1	mm	50	0	7
C1	Capacity of surface store 1	mm	200	0	50
C1	Capacity of surface store 1	mm	500	0	150

(Source: Based on Argent *et al*, 2007a)

The model works by calculating the water balance for each partial store independently of the others at the desired time step. The water balance is calculated as:

$Store_n = Store_n + Rain – Evaporation$ (where n = 1-3)

When the amount of moisture in the store exceeds its capacity, runoff occurs. Part of the runoff can then be used to recharge the baseflow. This is calculated as:

Baseflow recharge = BFI x Rainfall Excess

The remainder of the excess then becomes surface runoff. The baseflow store is then depleted at a rate of:

Baseflow depletion= $(1.0 - K_{base})$ x Baseflow store

(Where K_{base} is the daily baseflow recession constant)

In larger catchments flows often arrive from different areas at different times and it may be necessary to attenuate some flows. This is achieved in the model by a surface store whereby the discharge is controlled by the daily surface flow recession constant (K_{surf}):

Surface flow routing = $(1.0-K_{surf})$ x Surface store

Changing the values of the two recession constants allows the shape of the flood hydrograph to be altered. Higher values of both constants give slower recessions and hence longer falling limbs. Therefore they can be used to simulate different catchment conditions. The value of BFI also dictates how much of the rainfall excess is directed to either runoff or baseflow. This is important in allowing the model to capture different types of geology and catchment morphology.

A.1.2 Network Creation

E2 accepts a variety of spatial data to determine the catchment network and land use. Digital elevation models (DEM) can be used to automatically generate the subcatchment network required for the modelling process. However, Rob Argent (an E2 developer) advised against use of DEMs for this process since data preprocessing to connect gaps, identify stream flow direction, and fill pits can be extremely time intensive and could be especially problematic when dealing with the highly ephemeral nature of the stream network in the study area. For this reason, the use of GIS shape files was used to represent the subcatchments and the stream network was drawn in manually within E2. This means that while catchment area is calculated within E2 for the purpose of runoff generation, there is no explicit spatial representation of the stream network.

A.2 Data Collation and Preparation

Construction of the E2 model required the following data:

- **Subcatchments** were delineated based on major stream confluences and areas of interest using ArcGIS. Subcatchments were first converted into a raster, then an ascii grid file for entry into E2, which recognizes its spatial reference. The stream network was manually drawn on top of the subcatchments using non-spatially referenced links and nodes.
- **Functional units** must be identified upon initial construction of the E2 model and cannot be altered thereafter. Functional units are typically based on **land use** and associated hydrologic behaviour. Based on land use data obtained from Queensland DNRW, the land is predominantly grazing. With no data to distinguish behavioural differences across the Dawson catchment, land use was determined to not be influential or required in model development. Therefore, the model uses only a single functional unit covering all areas.
- One of the challenges encountered in building the E2 model was loading the input **rainfall** files into the model. Initially the model was developed using SILO gridded rainfall data. Daily gridded rainfall files (0.25 degree cell size which is approximately 28km x 28 km) were purchased from SILO through BOM. Daily files were available from April 1997 through mid-February 2008. URS utilized a 10 year calibration period from April 1997 through March 2007 with subsequent months providing a validation period. The publicly released version of E2 is unable to process the gridded files directly. Therefore URS created an automated process to convert all grids to Lambert Conformal Conic projection, then calculate zonal statistics (an area weighted average) over all cells within a given subcatchment to produce an input rainfall file for each subcatchment containing a time series of daily rainfall. The input rainfall file was in space delineated text (.sdt) format in the form 'year month day value'.

  During the calibration of the Dawson River catchment model it was found that significant variations existed between the gridded rainfall input and observed discharge at the gauges, which prompted a more thorough investigation into the accuracy of the input rainfall data. A comparison was made between gridded rainfall data and point data from rainfall stations located within Dawson catchment. Despite both data sets being sourced from the Bureau of Meteorology, there were major differences in the quantities and distribution of rainfall. It was decided to construct a new E2 model replacing the gridded rainfall input with the point data rainfall.

  A total of 48 gauges around Dawson catchment were used to generate a rainfall input file for each subcatchment. Rainfall gauge data was available for its entire operational life. Many of the gauges had records extending back to 1900 or even earlier. However, it was decided to model the time period from

January 1975 to December 2006.The decision to model over this time period was two fold, to maximise the number of data points available (most gauges did not become operational till mid-last century or later) and to ensure that modern measuring procedures were undertaken. Where multiple gauges were available within a single subcatchment, the rainfall observed at these gauges was averaged to produce a single rainfall input for the catchment. Where no gauges existed within the subcatchment, rainfall data from the nearest gauges were used. Where there were missing days for a given gauge, data was infilled from adjacent gauges.

The results from E2 were exported into Excel to compare (1) E2 model with point rainfall input, (2) E2 model with SILO rainfall input, and (3) E2 model with observed discharge at the lower Dawson River gauge. Basic findings were that with minimal preliminary calibration, hydrographs are generally better aligned with point rainfall input rather than SILO rainfall input, with the E2 model better matching the peaks and rise and fall. The overall conclusion is that the point rainfall data better reflects the discharge data at Dawson than the SILO gridded data. It was therefore decided to continue the modelling and calibration using the point rainfall data as inputs. However, there are still limitations in the quality of the hydrologic model due to the averaging of the rainfall data over multiple gauges, the necessity of using gauges outside of the subcatchment and due to many of the rainfall records being incomplete.

- A single **evaporation** input file was applied across the entire catchment based on the nearest recording station at Taroom with gaps filled by data from the next nearest stations.
- Continuous daily or hourly **discharge** data was available for four stream gauging stations in the Dawson catchment. The gauge names, IDs and years of data used in the development of the model are as follows:
  - Dawson River at Taroom (130302A) – 1/1/1980 to 31/12/2006
  - Dawson River at Utopia Downs (130324A) – 1/1/1975 to 31/12/2006
  - Hutton Creek at Fairview (130342A) – 1/1/1975 to 29/9/1988
  - Juandah Creek at Windamere (130344A) – 1/1/1975 to 31/12/2006

  Some of this data was initially presented in an hourly time step and occasionally multiple daily spot times. The processing of this data into a daily timestep required specific VBA looping macros in Excel. Discharge data was used to calibrate the water balance model. Two of the gauges within the Dawson catchment was complete over the 32 years of rainfall input being applied, these were Dawson River at Utopia Downs and Juandah Creek at Windamere.
- Continuous daily or hourly EC data was also available from two NRW stream gauging stations. These included the two gauging stations located on the Dawson River (Utopia Downs and Taroom). Other various spot monitoring water quality samples from NRW and URS sampling were used in combination with the continuous data to the salinity model. EC values were converted into salt concentration (mg/L) as follows:

  EC (µS) x 0.67 = salinity (mg/L) (NRW fact sheet: *Measuring salinity,* 2007)

URS has also been engaged in a program of water quality monitoring within the study area for this and other related studies. This data will be used to further refine the models next year. Background EC levels were based on various borehole data in the study area.

A.3 Model Calibration

A.3.1 E2 Calibration Tools

E2 contains a separate calibration tool that can be used to calibrate separate aspects of the model. Four types of calibration tool are available:

- Subcatchment flow – to calibrate the water balance models
- Link flow – to calibrate flow routing
- Subcatchment constituent – to calibrate constituent generation and filter models
- Link constituent – to calibrate the in-stream constituent models

Within the calibration process, the catchment may be cropped to allow calibration of sub areas such as groups of subcatchments. This is intended to allow different parts of the catchment to be calibrated separately based on the location of gauges, dams etc.

Unfortunately, the calibration tool within E2 is manually very intensive, requiring upwards of hundreds of parameters to be assigned before the automatic processors take over. For example, the Dawson River catchment with 44 subcatchments (22 main subcatchments plus the 22 small nodes necessary for discharge injection) with one functional unit and the 8 AWBM parameters would require 352 separate manual inputs (44x1x8=352). Further, after an initial run it was found that the automatic calibration was not sufficiently quick or accurate enough. A manual approach to calibration was taken for the final refinement of the E2 model.

A.3.2 Rainfall Runoff Library (RRL)

After an initial attempt to calibrate the water balance in E2 yielded poor results, research indicated that some additional software might provide a more detailed set of tools for calibration. The Rainfall Runoff Library (RRL), also available from the CRC for Catchment Hydrology as part of the catchment modelling toolkit (www.toolkit.net.au/rrl), was utilised. The software contains 5 different Rainfall-Runoff models (including the AWBM) along with 8 calibration optimisers and 10 objective functions. Unlike E2, the use of the calibration optimisers largely automates the process so that many calibration iterations can be run without the need to constantly input parameter values.

The model differs from E2 in that it is a lumped model (it has only a single surface) and therefore is not able to model spatial variation in catchment characteristics such as changes in rainfall or runoff characteristics, or able to account for lag. It is therefore most useful on smaller catchments without upstream inflows. Reference is often made in literature of the advantages of water balance model calibration in the RRL due to its advanced functionality (e.g. Xu and Argent, 2005).

Because RRL is a lumped model, it only requires a single rainfall file as well as an evaporation record and an observed flow record for calibration. Catchment area is also required. The rainfall file initially used was simply created by averaging the existing rainfall files. Because RRL only allows headwater catchments to be modelled (an observed flow cannot be assigned as an input to a subcatchment), its usefulness is limited to providing an initial starting point on which to begin further refinement.

The choice of calibration optimiser came down to the best performing one - the shuffled complex evolution (SCE-UA). The objective function was again the Nash-Sutcliffe coefficient of efficiency (CE). The initial results were far more promising than default parameters in E2. The combination of the calibration optimiser to run several hundred iterations plus the ability to manually adjust the parameters with real-time results quickly enabled CE to be achieved on a daily time step.

Attempts to calibrate the Juandah Creek catchment using the RRL auto calibration feature yielded a CE result of 0.623. However, typically the modelled runoff was found to be under predicting during large runoff events, missing many of the smaller events and introduced many false positives. Using RRL, the AWBM parameters were manual manipulated to calibrate the catchment using visual cues. This reduced the mathematical objective CE function to 0.609. The rainfall-runoff model was improved such that cease to flow and low flow, the critical flow regimes for salinity modelling, better matched the observed records. Further, the high flows were better aligned, however little to no improvement could be achieved for medium level runoff events without introducing additional low flow noise. A comparison between the observed flow at Juandah Creek and the modelled flow is shown in Figure A-1.

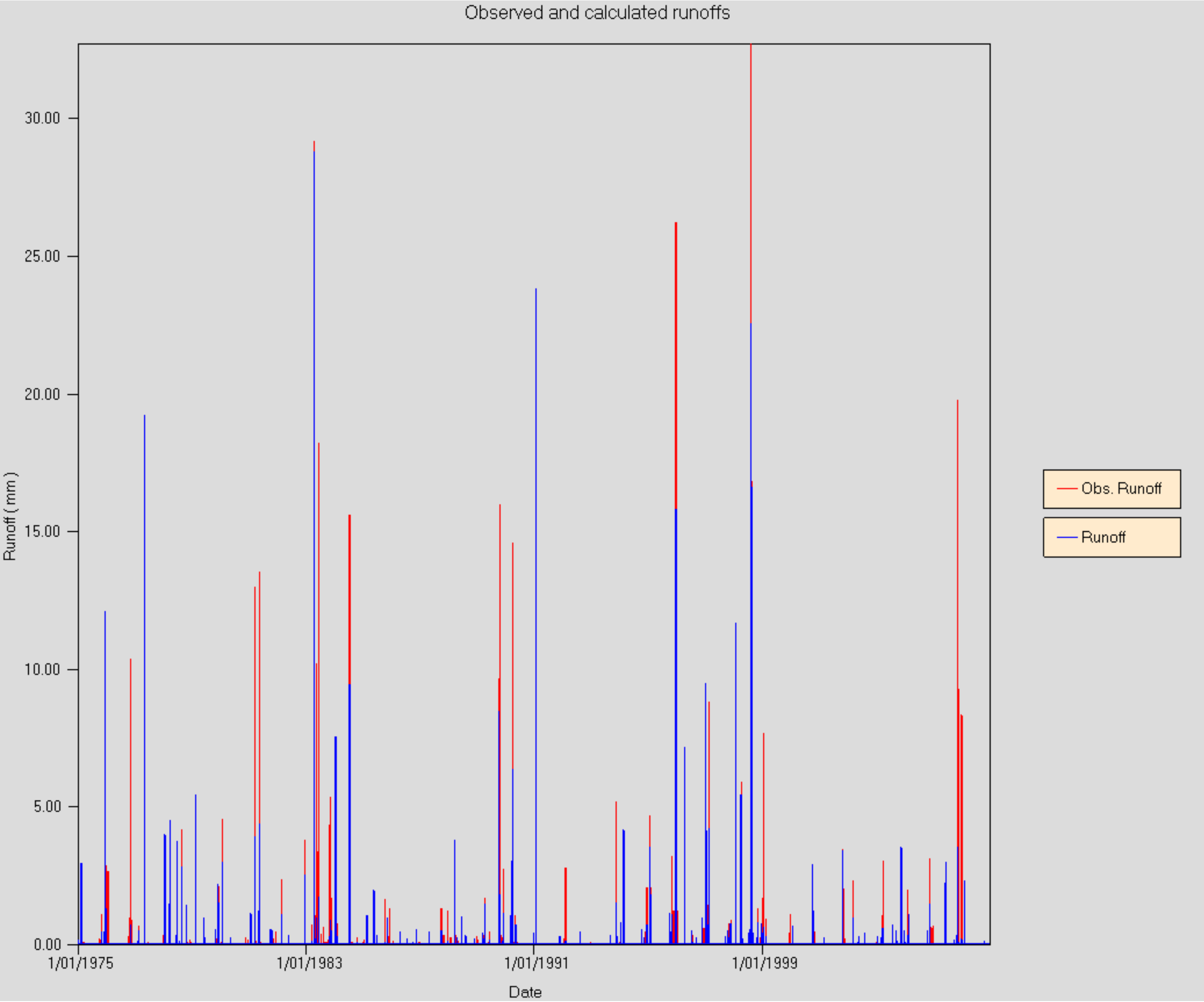

Figure A-2 RRL Flow Calibration at Juandah Creek

Unfortunately, no other gauging station with Dawson River catchment could be considered a headwater. The gauge with the second least catchment area was Hutton Creek catchment consisting of approximately 2870 sq km and considerable routing, which resulted in the RRL model producing poor results. It was decided to abandon the RRL for any further calibration and instead use AWBM parameters for Juandah Creek as a starting point and do all the refinements in the more sophisticated model in E2.

A.4 Quality Assurance of E2 Flow Modelling Package

Early in the model development significant discrepancies between observed and modelled flow in the Dawson catchment created uncertainty regarding the capabilities of the designed E2 models to replicate current conditions in the Dawson River catchment. Subconsultants from HydroTasmania were contracted to replicate the Dawson hydrologic model using Kisters Modelling Hydstra software which they've used extensively to model approximately 70 catchments around Tasmania.

The comparative exercise proved interesting and useful. First, it was observed that a key parameter in Hydstra model calibration is the upper limit on baseflow, while E2 does not provide a variable for adjusting or limiting baseflow, thus seemingly allowing for infinite groundwater storage. Secondly, Hydstra is able to apply seasonality on soil stores, whereas E2 parameters are limited to a single number, applied throughout the entire time series.

In a comparison between E2 and Hydstra models created with identical parameters, the models produced very similar results for a single subcatchment (same peaks, same capture of events, slightly different recession curves). However, when complexity was added in modelling the entire Dawson catchment (22 subcatchments), discrepancies became more apparent, suggesting that E2 fell short of accurately representing channel routing.

They came to the same conclusion, namely that the model can be calibrated well for individual events but the parameters remain event-specific; they also achieved similar degrees of model fit and obtained similar parameter values for the AWBM.

Both models severely underestimated flow volume for many events, which prompted a more thorough investigation of the input rainfall data. Even if the peaks could be matched with rising and falling limbs, it would be impossible to "create" additional volume. With dogged differences between rainfall and observed discharge at the Taroom gauge, it is difficult to fathom model replication of observed conditions.

It should be noted that both Dawson models were produced using SILO rainfall data which was later proved to be of questionable quality, showing surprising differences from the point rainfall data also sourced from BOM. E2 models were reconstructed using point rainfall gauge data, which resulted in a much better calibration. A Hydstra model utilising point rainfall gauge data was never built.

B.1 Model Data

Flow data collected from a stream gauge on Dawson River at Hutton Creek provided historic flow rates. The gauge at Hutton Creek has no facilities for recording water quality of the stream. Therefore it was necessary to source water quality data from a nearby stream gauging station. The closest gauge with a continuous record of stream temperature was found to be a gauge on Dawson River located at Taroom.

To ascertain the winter and summer water temperatures regimes, the available data was sorted by month, then amalgamated by season before being averaged. The data was graphed and the averages plotted. From investigation it was found that whilst fluctuation in water temperature existed during individual months, the seasonal temperatures remain largely constant. During wet season months the water temperature averaged 27°C, whilst during the dry season the temperature variation was greater, averaging 17°C.

Over the course of a day, the stream temperature was found to fluctuate on average by 1°C. The historic stream temperature at Hutton Creek and the average wet and dry season temperatures are shown in Figure B-1.

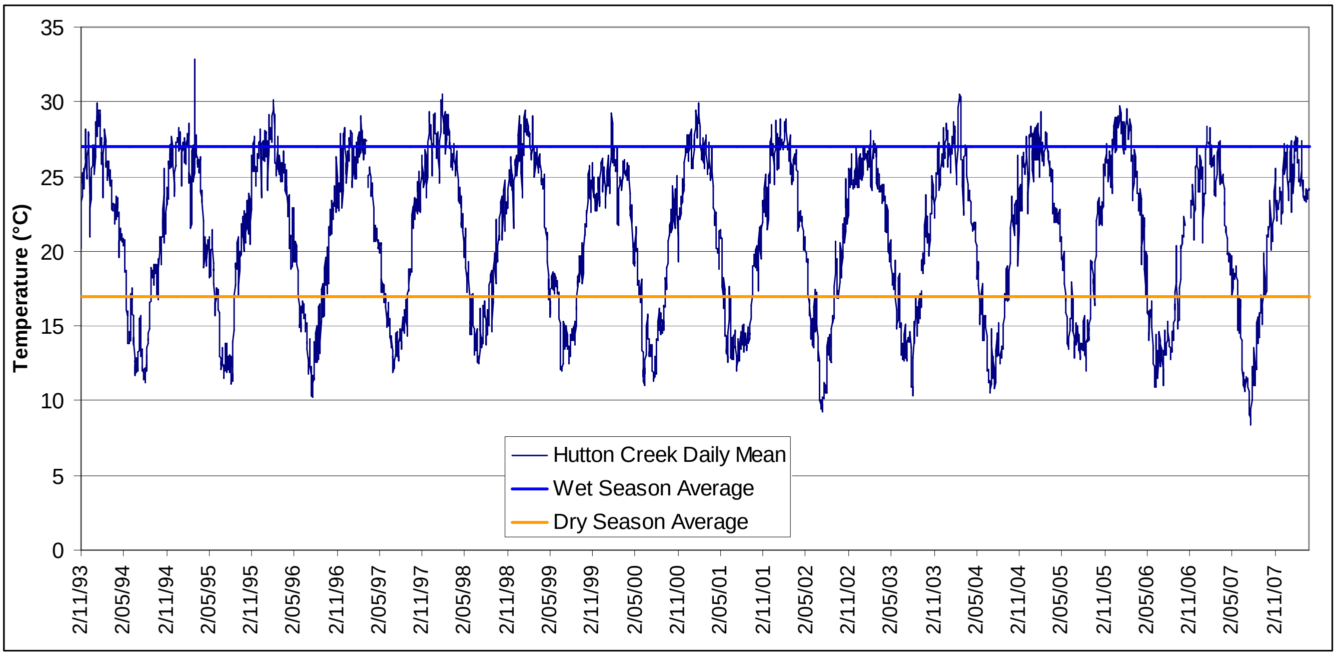

Figure B-1 Historic Stream Temperatures at Hutton Creek

Unlike stream temperature, the flow rate in Hutton Creek was found to be highly variable. For most of the wet and dry season, Hutton Creek ceases to flow. Further, flow in the creek was found to be highly variable. As previously discussed, low flow (base flow) will be critical as less volume will result in less dilution of the mixed temperature stream.

To find the base flow in Hutton Creek, several steps were required. Initially the flow data was filtered by seasonality, then sorted by flow. The sorted and filtered data was plotted in a graph and presented in Figure B-2. The axis of Figure B-2 has been reduced to highlight the transition between base flows and high flow/freshes. From inspection of Figure B-2 the wet season has an average base flow of 50ML/d, whilst the dry season has on average half the flow at 25ML/d.

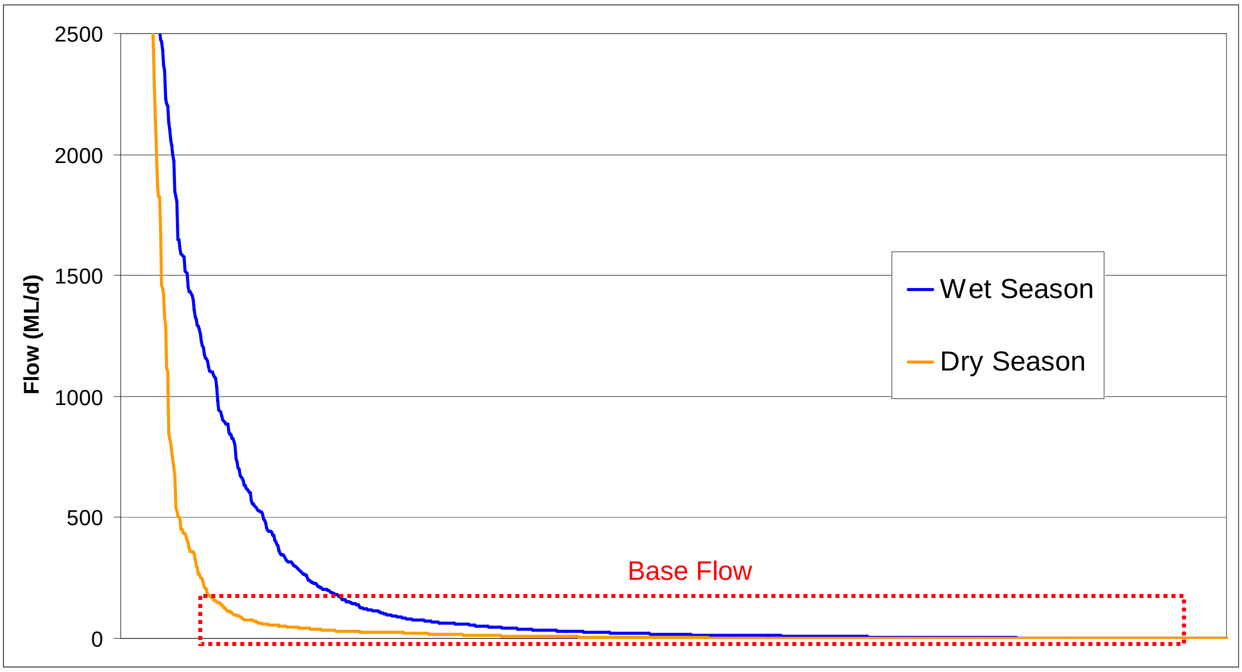

Figure B-2 Filtered and Sorted Historic Flow in Hutton Creek

In addition to stream flow and temperature data, QUAL2K requires the input of air and dew point temperature, wind speed, and other rate constants associated with temperature loss from the system. This data was taken, where available, from historic data recorded at the Injune post office weather station with Injune being the closest weather station to the Hutton Creek. The historic data was sourced from the Australian Bureau of Meteorology climate data online website. QUAL2K allows different parameters to be set on an hourly basis to allow for changes in weather over a day. To account for this variability three time zones were developed for the model;

- Morning to Midday (5am-1pm), using historic average data recorded at 9am;
- Midday to Evening (1pm-12am), using 3pm data; and
- Night (12am-5am), using data corresponding to the coldest period of the day, i.e. average daily minimum temperature.

C.1 E2 Limitations

The original plan was to model salinity in conjunction with flow using E2; however, many limitations rendered E2 unfit for this purpose. Event Mean Concentration/Dry Weather Concentration (EMC/DWC) was identified as an appropriate constituent model to capture high salinity in low flow and low salinity in high flows. The initial approach to apply the EMC/DWC model to the existing stream network was inadequate due to the fact that the model type is intrinsically linked to the Rainfall-Runoff model applied to each functional unit. This means that predicted salt concentration would be dependent on the amount of runoff generated by the water balance model. While this is acceptable for the purpose of generating background EC levels, it would not be appropriate for the purpose of modelling fixed discharges from CSG wells.

Innovative design was used to trick E2 into correctly modelling fixed discharges from the CSG wells. Ultimately, an additional catchment of nominal area (less than one square kilometre) was added within each subcatchment. This was necessary to create a node upon which to apply input flow and salt concentration representing well discharge. This node was part of the link and node network, but served only as an input to the catchment within which it resided. All wells within the subcatchment were modelled by a single node.

The second incongruity was in the logic of the EMC/DWC model itself, which is linked to three parameters of the AWBM Rainfall-Runoff model (BFI, Kbase, and Ksurf) rather than flow. If all flow is directed to Kbase, E2 flatlines at the DWC concentration. Similarly, if all flow is directed to Ksurf, E2 flatlines at the EMC concentration. If the flow is split between equal Kbase and Ksurf using the BFI parameter, E2 flatlines at an average of the EMC and DWC concentrations. Where Kbase and Ksurf differentiate from each other, E2 fluctuates inconsistently with flow and observed salt concentrations.

A third complication is that E2 calibration of salinity requires adjustment of AWBM parameters, which would inherently alter the calibration of flow. Preliminary calibration efforts without regard to the effect on flow suggested that E2 would not effectively align to observed data. Overall, E2 modelling of salinity was neither representative nor defendable.

A comparison of the observed and E2 modelled salt concentration at the Comet River at AMTD 17.2km gauging station (Comet River Catchment) is shown in Figure C-1.

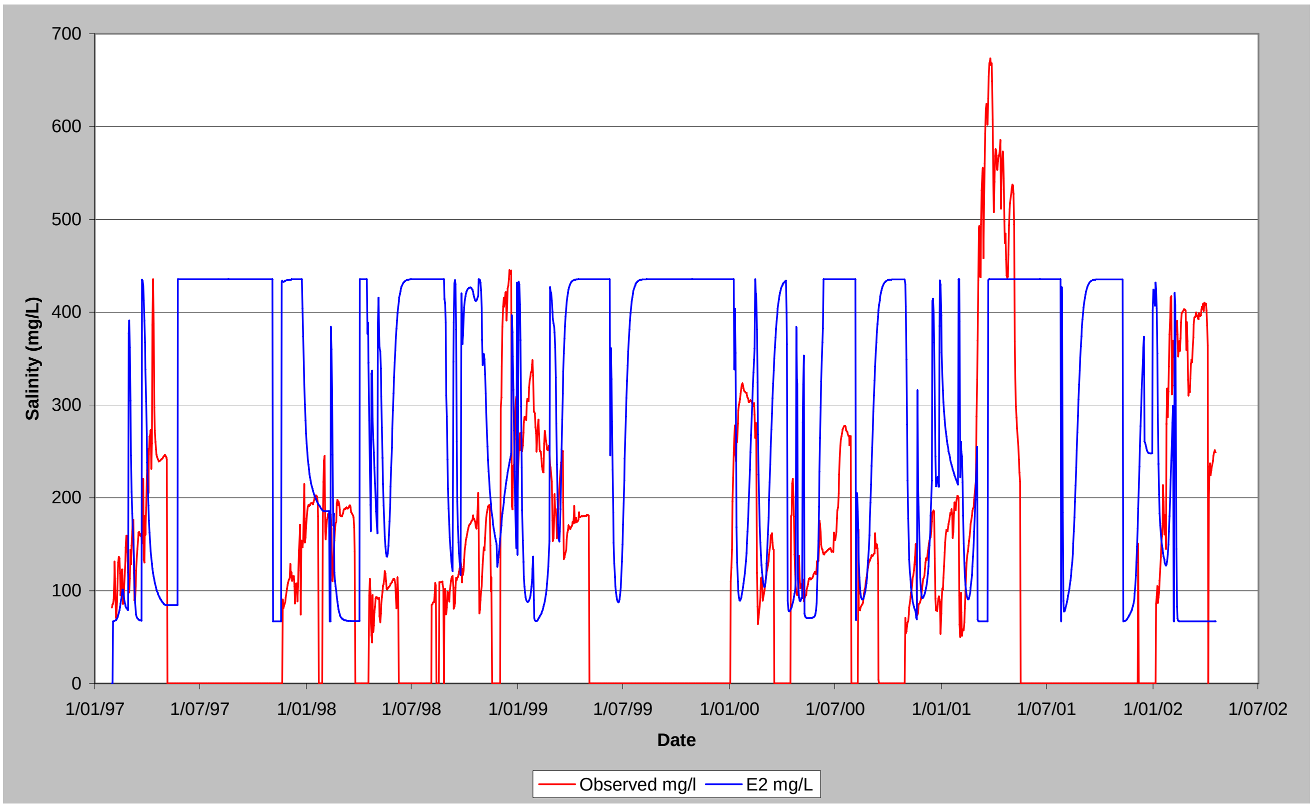

Figure C-1 (blue) and Observed Salinity (red) at Comet River

C.2 Model Sophistications

A basic empirical algorithm was developed to replicate observed salinity trends. When the flow is zero, the salt concentration is assumed to be zero. The model is based on a minimum and maximum salt concentration with fluctuation based on flow levels. When flow equals or exceeds a selected high flow, the model triggers reset to the minimum salt concentration. Salinity is expected to decrease in high flow and increase in low flow. The amount of daily incremental change in salinity was determined based on the rates of increase and decrease of observed salinity such that the final algorithm best fits the observed salinity curve.

Starting with a simple algorithm, three different modelling sophistications were trialled including (1) introduction of seasonality, (2) a ramp from a first maximum concentration to a second peak concentration, and (3) salinity responsive to flow flux.

Seasonality was noticed to be particularly relevant for Taroom, where many of the surges in salinity occur annually during a three month period from March to June. A simple extension of the basic algorithm allows the salinity to be capped at a higher maximum during these months. Seasonality appeared less relevant at Utopia and other stream gauges. Seasonal salinity model parameters (Table C-1) include three flow levels at low, medium, and high flow. An incremental increase is applied to salinity between low and medium flow while an incremental decrease is applied to salinity between medium and high flow.

The ramp approach appeared to apply more consistently across gauges, and is based on the premise that for decreasing flow, one incremental increase rate is applied up to a preset ‘ramp change concentration’ followed by a second incremental increase rate applied above the ‘ramp change concentration’ (Table C-2). A third incremental rate applies when flow increases, thus reducing the salinity by a fixed amount each day. This method tends to overestimate salinity over extended time periods (conservative) while capturing more of the spikes in salinity.

The flow flux sophistication was an attempt to make salinity estimates more sensitive to changes in flow. The flow flux salinity model parameters (Table C-3) also include three flow levels at low, medium, and high flow. Below the low flow level, salinity was incrementally increased at a set rate. Between low and medium flow, salinity was incrementally increased when the flow dropped from the previous time step, while it was incrementally decreased when the flow increased. Between medium and high flow, salinity was incrementally decreased at a set rate.

Table C-1 Seasonal Salinity Model Parameters

Max Concentration (Jul-Mar)	200	mg/L
Max Concentration (Apr-June)	250	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	345	ML/d
Medium Flow	170	ML/d
Low Flow	25	ML/d
Salinity Decrease between medium and high flow	1	mg/L per day
Salinity Increase between low and medium flow	5	mg/L per day

Table C-2 Ramp Salinity Model Parameters

Max Concentration	375	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	100	ML/d
Ramp Change Concentration	200	mg/L
Flow Decreases - Salinity Increase - Below salinity Ramp by:	10	mg/L per day
Flow Decreases - Salinity Increase - Above salinity Ramp by:	2	mg/L per day
Flow Increases - Salinity Decrease by:	1.5	mg/L per day

Table C-3 Flow Flux Salinity Model Parameters

Max Concentration	375	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	500	ML/d
Medium Flow	200	ML/d
Low Flow	80	ML/d
Between medium and high flow - salinity decrease by:	50	mg/L per day
Below low flow - Salinity increase by:	1.2	mg/L per day
Between low and medium flow - flow decrease - Salinity increase by:	10	mg/L per day
Between low and medium flow - flow increase - Salinity decrease by:	1	mg/L per day

Modelling of Flows, Temperature and Salinity – Condamine-Balonne

Appendix J

REPORT

Hydrologic Modelling of Ballonne-Condamine Catchment

Prepared for

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Date:	21 January 2009
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Status:	Final

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Introduction Section 1

Associated water is typically a by-product of Coal Seam Gas (CSG) development and its management is an integral aspect of the Gladstone Liquid Natural Gas (GLNG) project. Santos is considering a range of water management options including evaporation, stock watering, discharge to grade, treatment, injection, irrigation, and beneficial reuse. However, the focus of this report is on discharge to grade and potential changes in hydrology and salinity that may arise instream under a range of scenarios. This information will be used within an ecological risk assessment framework to assess risks to environmental values identified in the study area.

The report focuses on the technical aspects of model development and prediction and does not draw conclusions on the impacts of CSG development or alternative preferred management options.

Study Area

The area of study includes three catchments: Upper Dawson River, Comet River, and minor tributaries of the Upper Balonne River. The Upper Dawson River and Comet River catchments drain to the Fitzroy Basin and ultimately to the Great Barrier Reef Lagoon. The Balonne River is part of the Murray-Darling Basin ultimately discharging via Lake Alexandrina to the Gulf of St Vincent in South Australia.

The catchments are in various states of CSG production, appraisal or development.

This report focuses on the Santos licensed areas within the Balonne-Condamine catchment (Figure 1-1).

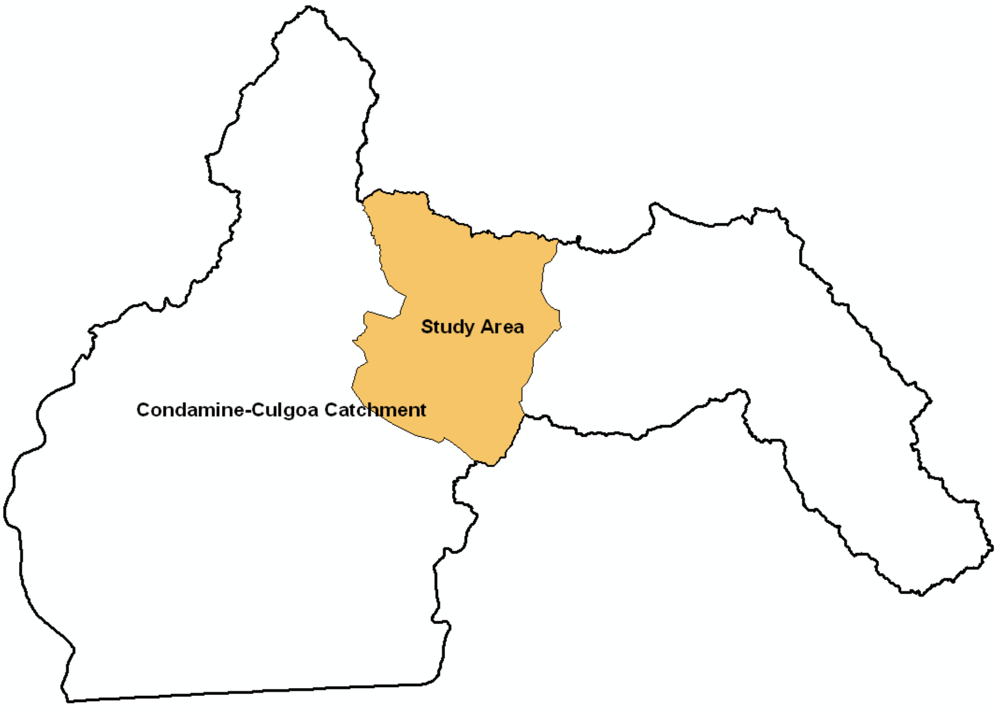


Figure 1-1 Balonne-Condamine Catchment and Study Area Location

Major streams within the catchment are Bungil Creek, Wallumbilla Creek, and Yuleba Creek feeding into the Balonne River (Figure 1-2).

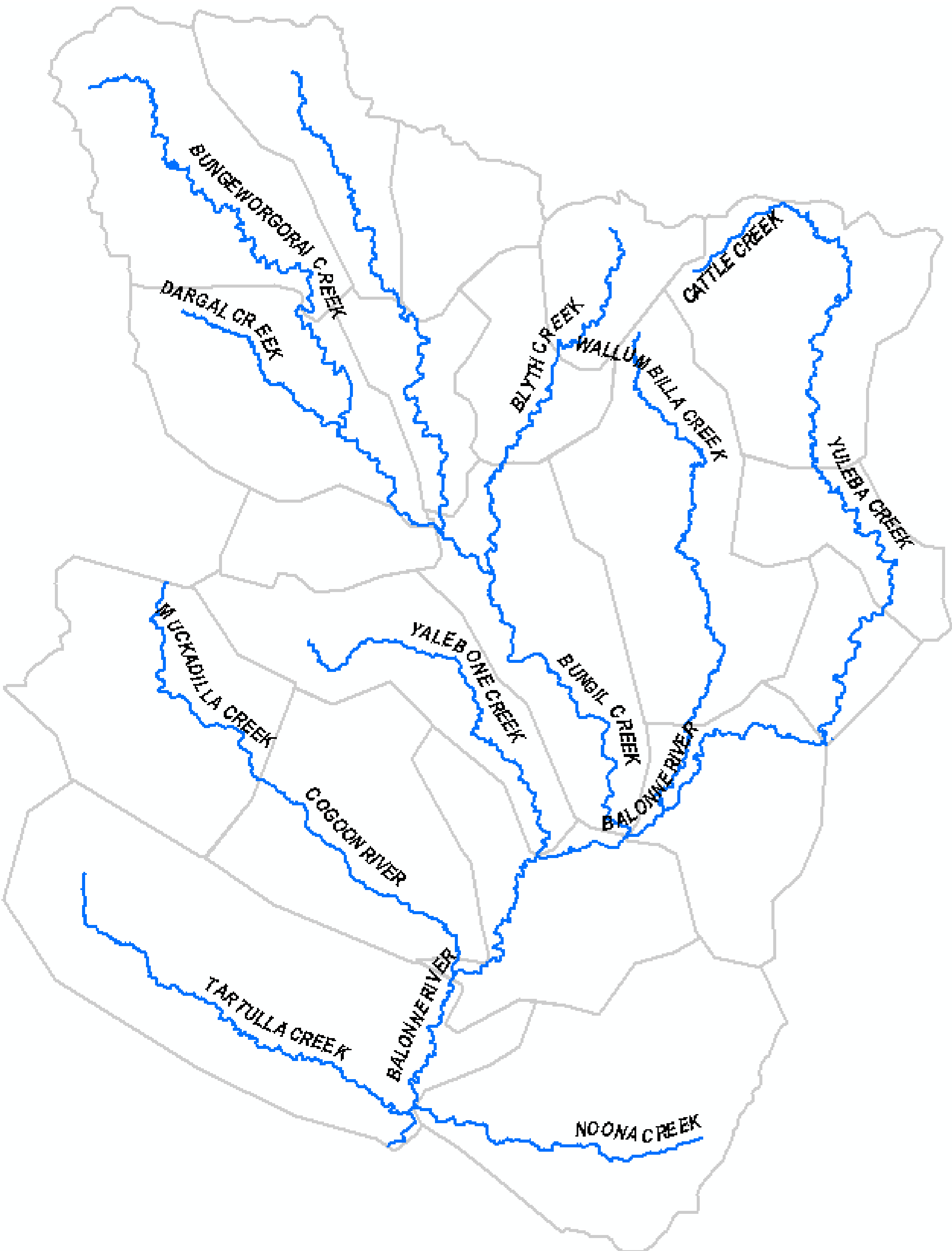


Figure 1-2 Major Streams within Balonne-Condamine Study Area

Introduction

Section 1

Modelling Approach

Hydrologic modelling is needed to assess the impacts of discharges on the local and regional environment. The model will be used to assess impacts of CSG production on flow regime and salinity concentration.

Various options are available to model the hydrology and water quality of the catchment. The two main candidates considered were IQQM (Integrated Quantity and Quality Model) and E2 both of which are utilised in Queensland. E2 was chosen as the main modelling platform for flow and salinity. Due to E2 salinity modelling limitations, an empirical algorithm was ultimately developed to model salinity.

Report Structure

The report presents the calibration of hydrologic and salinity models in the first two chapters. Various associated water management scenarios are then formulated and modelled. Results are presented in the final chapter.

Modelling Objectives

The modelling objectives are:

- Develop calibrated models of flow and salinity;
- Create a flow model that is consistent with models currently used in Queensland (IQQM and E2) to enable later assessment of regional effects;
- Investigate alternative associated water management options;
- Identify the range, frequency, and extent of flow and salinity impacts from discharge of associated water to grade; and
- Provide information to support ecological risk assessment.

3.1 Background

The basic architecture of the E2 modelling framework consists of a subcatchment-node-link system, as described in Appendix A. Alternative water balance models can be selected for use within E2. For this project the Australian Water Balance Model (AWBM) was selected as the rainfall-runoff model since it is widely used and was originally developed in Queensland. A daily time step was utilised for modelling. The AWBM model utilises eight model parameters representing three conceptual water stores with area representation, surface and baseflow recession constants, and a baseflow index. Further explanation of the AWBM model and its parameters are provided in Appendix A.

3.2 Model Assumptions

3.2.1 Subcatchment Delineation

The initial model structure is based on key subcatchments to allow broad-scale assessment of water management options. The entire Balonne-Condamine catchment measures 135,848 sq km, while the Santos study area represents a fraction of the total area (approximately 16,810 sq km). The Balonne-Condamine River upstream of Santos production and exploration areas is heavily regulated. Creating a model of these areas would be impossible without intimate details of each regulated structure and its operational rules.

A model was therefore built that only includes the Santos licensed areas. Results from this model may be used as input to regional DNRW models to assess regional scale impacts if required.

The model is subdivided into 20 subcatchments based on major stream confluences and particular areas of interest, such as stream gauge locations. A node exists at the outlet of each subcatchment. Additional inputs or outputs can be applied at each node. The 20 delineated subcatchments (the nodes are not shown to improve legibility) along with the stream gauges are presented in Figure 3-1.

3.2.2 Network Creation

A GIS shape file was used to represent the subcatchments, and the stream network was drawn in manually within E2. While catchment area is calculated within E2 for the purpose of runoff generation, there is no explicit spatial representation of the stream network. The E2 flow path network is shown in Figure 3-2.

3.2.3 Flow Routing

The Balonne-Condamine catchment is spatially a large catchment (135,848 sq km in total). Runoff from the furthermost reaches can take considerable time before it is recorded at the gauging stations on the Balonne-Condamine River. E2 offers several routing methods to transfer the flow through the links. These range from simple lag flow where flow is delayed with no change to the shape, to more sophisticated routing methods which can smooth the flow of the hydrograph accounting for catchment and reach storage effects. In the development of the Balonne-Condamine catchment, Laurenson non-linear routing was adopted. Laurenson non-linear routing requires the input of two factors;

$$S(Q) = KQ^m$$

Where;

S = storage in the reach for a given flow Q

K = a dimensional empirical factor which acts as a storage delay parameter. Although K is empirical factor it should be thought of as a storage delay and thus in seconds; and

m = a dimensionless empirical exponent, measure of the non-linearity of the model.

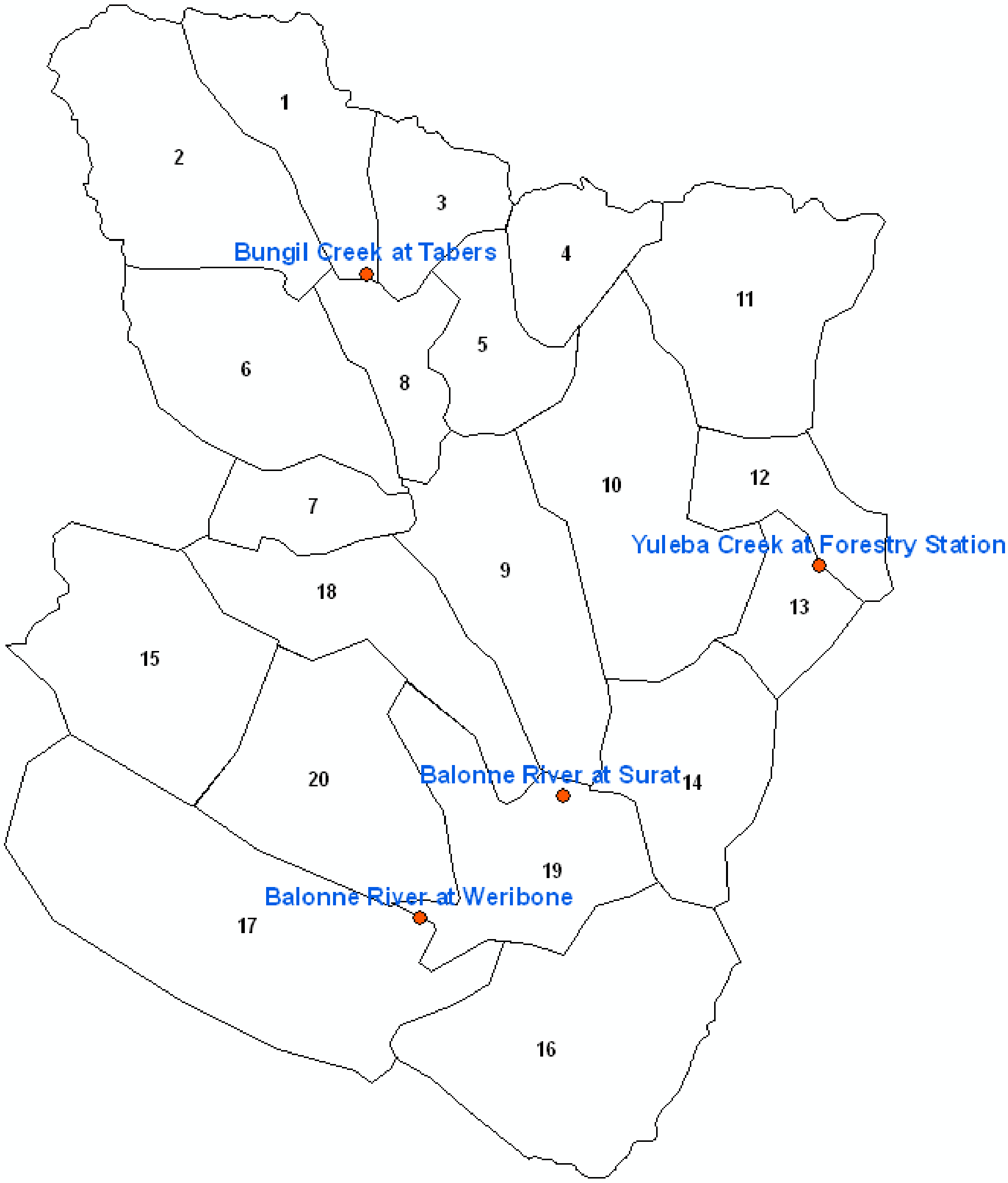


Figure 3-1 Subcatchment Delineation and Stream Gauge Locations

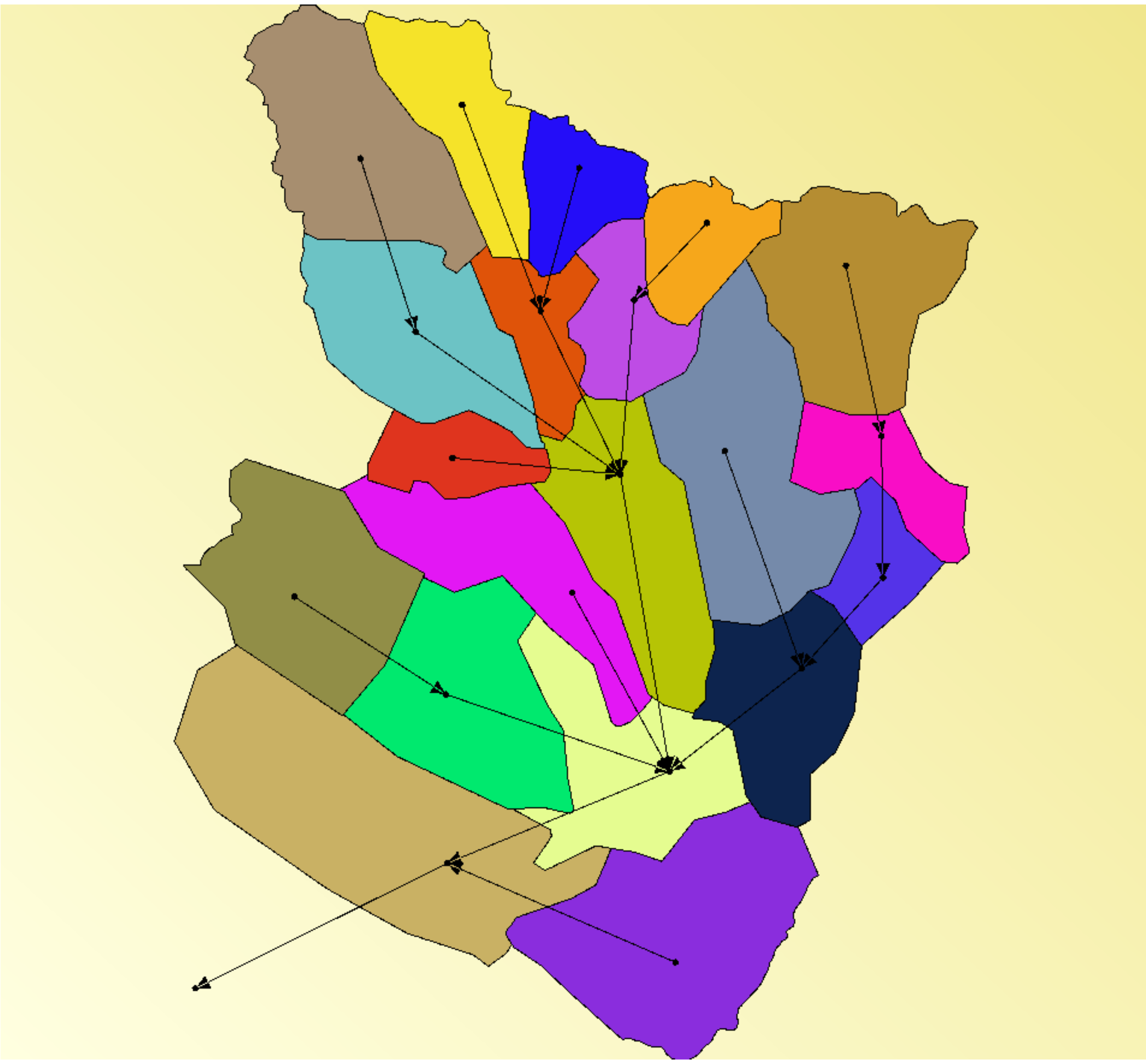


Figure 3-2 E2 Subcatchment Network

3.2.4 Simulations

E2 has the ability to have multiple model simulations active at any one time. This allows for easy comparison to be made between the modelled and observed data. For each location where observed data was available a separate model was constructed in order to compare E2 modelled results with observed flow measurements. At the approximate location in the E2 model of the observation gauge, the observed flow data was assigned to an outlet node of a subcatchment.

3.3 Model Calibration

Since there is limited surface flow data for many locations, and the project operates across multiple scales, it is expected that modelling will need to progress from broad calibration to more accurate calibration over time. For initial calibration, the same AWBM parameters were applied across many of the subcatchments. The main reason for this was a lack of information that could inform separate parameterisation as well as to reduce the potential degrees of freedom during calibration.

Modelling results from the Upper Dawson and Comet River catchments also initially used the same AWBM parameters throughout the entire catchment. Models did not produce results sufficiently representative of the observed gauge data. Therefore, it is expected that variation in the AWBM parameters is also necessary in the Balonne-Condamine catchment.

3.3.1 Objective Function

The selection of an appropriate objective function is an important part in validating the model performance. The choice of function is dependent on the models application and in this case the end purpose of the model is to estimate in-stream salinity levels. These levels are dependent on stream flow and consequently comparison of actual and modelled stream flow is of greatest importance. Boughton (2005) notes that in the common case of water yield analysis the most common validation of model performance is a comparison of calculated and actual monthly totals of runoff. Early studies used the coefficient of determination (r^2) as a measure of agreement however it is becoming increasingly common to now use the Nash-Sutcliffe coefficient of efficiency (CE) where CE is:

$$CE = 1 - \sum_{t=1}^{T}(Q_0^t - Q_m^t)^2 / \sum_{t=1}^{T}(Q_0^t - \overline{Q_0})^2$$

Where:

T = total time modelled

Q_0^t = Observed flow at time t;

Q_m^t = Modelled flow at time t; and

$\overline{Q_0}$ = Mean observed flow.

The value of CE lies between 1.0 (a perfect fit) and -∞ where a value of less than 0 would indicate that the mean value of the observed time series would have been a better predictor than the model (Krause, Boyle and Blase, 2005). A model producing a CE value over 0.7 is considered a reasonable representation of the physical world. Calibration in E2 gives values for both r^2 and CE; these are the only efficiency criteria calculated.

3.3.2 Calibration Tools

E2 contains a calibration tool for flow and constituents based on either subcatchments or links. As explained in Appendix A, the iterative calibration process is cumbersome given the number of links and nodes, each with 8 adjustable AWBM parameters. Automatic calibration was not found to be sufficiently quick nor accurate. Therefore, further calibration was accomplished using manual adjustment and regional application of AWBM parameters across the catchment.

The Rainfall Runoff Library (RRL) was also considered and trialled for model calibration but determined too simplistic for a study area as large as the Balonne-Condamine catchment and insufficient to capture surface flow routing (see Appendix A for further explanation).

3.3.3 Calibration Period

As described in the data compilation section of Appendix A, rainfall input files from 1975 to 2006 were developed representing 32 years of data, which were available for the calibration process. A strategic method was developed for the calibration of the E2 model. Initial attempts at calibration were focused on ensuring accuracy of the lowest flow events as the model was primarily designed to model salinity, which is at its highest concentration during low flow events. Once a satisfactory level of calibration was achieved the calibration turned to ensuring that the high flow peaks, the total yearly runoff and the shape of the hydrograph were well represented.

The AWBM model contains storages that are initially empty when the model starts. A warm up period is often required during calibration or validation so that the stores can reach a representative value. This can be done in one of two ways. One method is to exclude the warm up period from the objective function calibration and validation periods (Argent *et al,* 2007b); this is not possible in E2 but can be done in RRL. Another way is to ensure the model calibration/validation period follows a period of low or zero precipitation so that it can be assumed that moisture stores are empty.

While calibrating the model over the entire range of data available is the only way to optimise the results, little indication of the models robustness can be gauged (Argent *et al,* 2007b) i.e. how well it performs outside of the calibration period. It was initially intended to exclude some of the available data from the calibration period to allow for a period of model validation; however, due to the difficulties in calibrating the model it was decided to include as much of the data as possible in the calibration period.

3.4 Results and Interpretation

For meaningful modelling of salinity, a well calibrated runoff model is required. A model producing a CE value over 0.7 (on a daily timestep) is considered a reasonable representation and was the target when calibrating E2. Due to the difficulty with calibrating the Bungil Creek model with the gauge data it was decided to focus modelling attention to modelling the Yuleba Creek catchment. Once this was achieved to a satisfactory level the AWBM parameters found to best fit this subcatchment would be applied throughout the greater Balonne-Condamine catchment. Further, due to suspect stream data prior to 1994, it was decided to calibrate the model using only data collected after this period.

The largest difficulty encountered in the refinement of the E2 model was ensuring that small rainfall events were not causing excessive runoff. This was deemed a high priority due to the ephemeral nature of the streams in the Balonne-Condamine catchment for much of the year. To reduce the noise associated with these smaller rainfall events, it was required to set the capacity of the three stores in the AWBM model at or near the maximum advisable levels. Larger than typical AWBM soil capacity parameters were used to simulate catchment storages such as pools of standing water. This assumption was confirmed following consultation with URS employees familiar with the Balonne-Condamine catchment. These storages retard small rainfall events resulting in little to no runoff being recorded on the downstream gauging stations. However, larger rainfall events inundate the pools and significant runoff is measured at the stream gauge stations.

Increasing the storage capacities to better reflect the ephemeral nature of the streams resulted in difficulty matching peaks in high rainfall events and producing the total aggregated runoff being generated by the catchment. As has been mentioned previously, AWBM has three parameters intended to determine the rate at which the base flow store is depleted: BFI, K_{base} and K_{surf}. To ensure that flow remained in the system and that large runoff events were being captured, the parameters were set such that little of the store is depleted over time through discharge to the creek (evaporative losses from the store were maintained). Initially these parameters were set to nill. However they were increased to 0.4 to improve the shape of the falling limb of the hydrograph and better fit the observed records.

The third challenge faced by the modelling team was matching the timing of the peaks of runoff events as well as the recession curve following the event. It was found that the routing times were typically short, with routing times ranging between 12 and 24 hours. This arises from the fine delineation of the subcatchments. For all subcatchments, Laurenson non-linear routing was adopted. After much trialling a single set of parameters were applied with a delay of 1.5 days (129600 seconds) and a measure of the non-linearity of 0.75.

A summary of the calibrated AWBM parameters used in the final calibration are presented in Table 3-1 and the calibrated routing values are presented in Table 3-1.

Table 3-1 - Summary of Final AWBM Calibration Parameters

AWBM Parameters	Yuleba Creek Subcatchments
A1	0.134
A2	0.433
BFI	0
C1	50
C2	90
C3	200
Kbase	0
Ksurf	0.4

Table 3-2 - Summary of Routing Parameters

Laurenson Parameters	Yuleba Creek Subcatchments
K (seconds)	129600
m	0.75

The end result of the calibration was a well developed model of the subcatchments upstream of the Yuleba Creek gauging station, which was producing a Nash-Sutcliff criterion of 0.75, with a net volume difference between the E2 model and the observed runoff of 0.40%. These calibration results were achieved over 13 years of observed flow records, between 1994 and 2006. Records prior to this data were not used due to concerns over the quality of the data. A hydrograph and scatter plot showing the observed and E2 modelled runoff for the period 1994 to 2006 at the Yuleba Creek gauging station are shown in Figure 3-3 and Figure 3-4.

Overall the results produced in E2 are very similar to those observed at the stream gauge stations. The cease to flow, low and medium flow events are all accurately mirroring the observed behaviour as is the general shape of the hydrograph with falling limbs being accurately represented. Flows between 30 and 50 m^3 per second were not as successfully modelled. These events could be attained however it resulted in poorer calibration of the lower flow events by introducing significant noise. It was felt that as the flow model was built with a desire to model salinity, which is critical in low flow events, that matching cease to flow and low flow events were a higher priority.

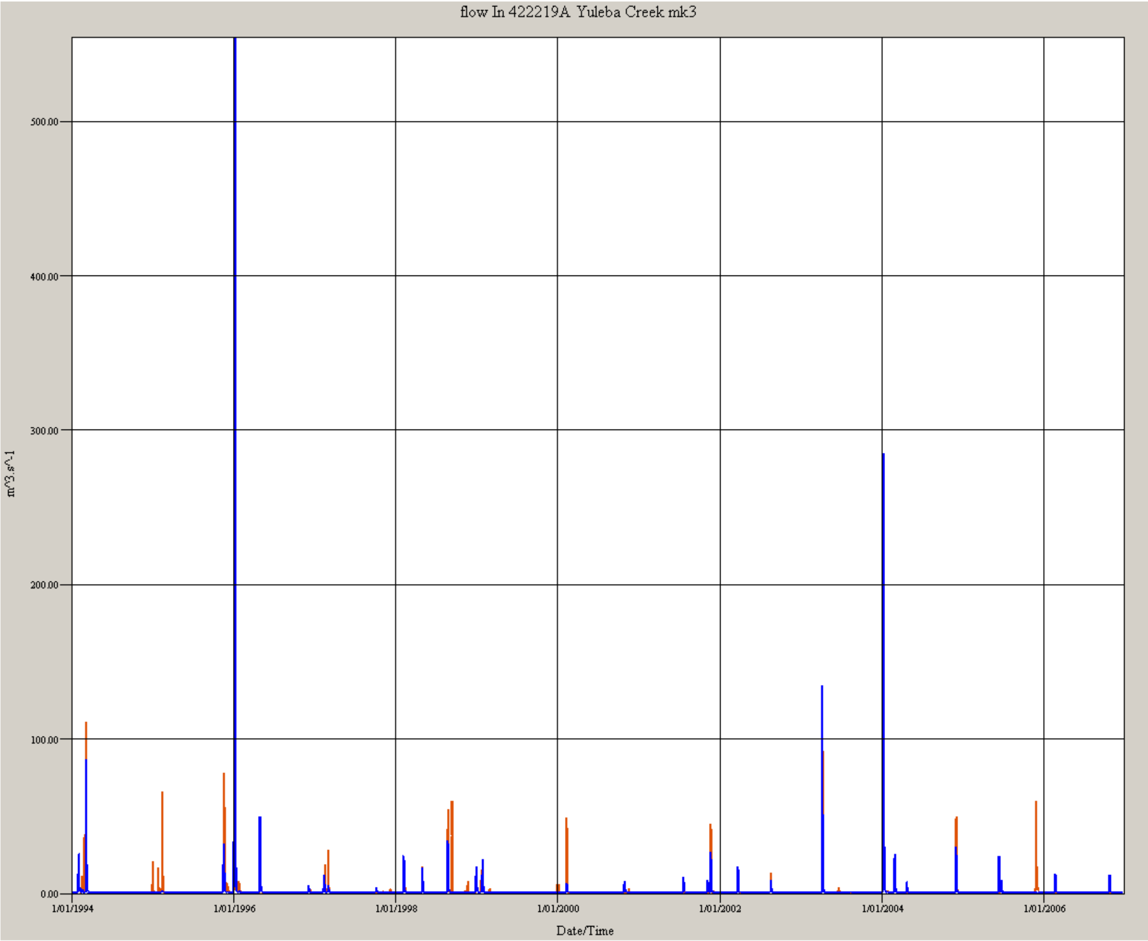


Figure 3-3 Hydrograph of E2 Modelled (Blue) and Observed (Red) Runoff 1994 to 2006

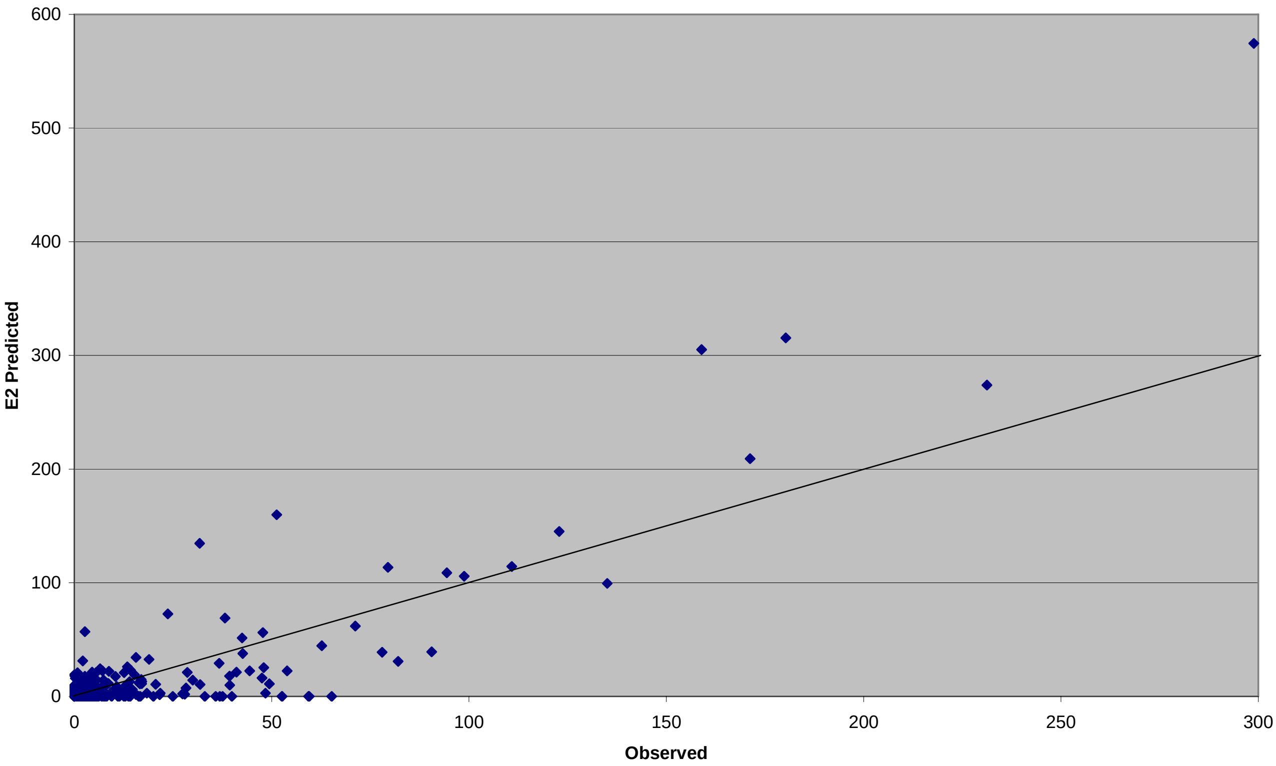


Figure 3-4 Scatter Plot of E2 Modelled and Observed Runoff 1994 to 2006

4.1 Background

Associated water is produced as a necessary by-product of Coal Seam Gas (CSG) production. Associated water has a moderate salinity[1]. The discharge of this associated water into nearby streams prompted the creation of a model to evaluate potential changes in instream salinity. Salinity modelling was intended to represent the current conditions, as well as the discharge associated with additional wells to begin pumping in the future. Various management scenarios as described in Section 5.2.

The original plan was to model salinity in conjunction with flow using E2; however, many limitations rendered E2 unfit for this purpose (Appendix C). These limitations prompted URS to develop a simple empirical algorithm to reflect observed salinity variations and generate representative modelling results.

4.2 Modelling

4.2.1 Model Objectives

The above-mentioned limitations within E2 prompted URS to build a simple algorithm in Excel to produce representative salinity modelling results. The objectives of the algorithm were:

- To apply a simple algorithm consistently across Fairview, Roma, and Arcadia study locations;
- To produce conservative salinity estimates (equal to or minimally higher than observed), attempting to replicate pulses or surges when salinity may be particularly of concern;
- To duplicate current conditions whilst also accommodating additional discharge and salinity from CSG production wells and treatment plants;
- To span the date extent of available flow data, thus extrapolating unknown salinitys; and
- To produce a user-friendly interface to evaluate various water management scenarios as described in Section 5.3.

4.2.2 Model Data

The basic salinity model was created based on continuous stream flow data and observed spot EC readings converted to TDS concentrations. Where available, observed flow data was sourced from the Department of Natural Resources and Water (NRW) stream gauges for the extent of record. In areas with no stream gauges, E2 modelled flows were used. In the Balonne-Condamine catchment, flow data was used to simulate four discharge locations;

- Bungil Creek (1975-2006 using E2 modelled flow);
- Wallumbilla Creek (1975-2006 using E2 modelled flow);
- Yuleba Creek (1975-2006 using E2 modelled flow); and

---

[1] Salinity is typically measured as TDS or indirectly using electrical conductivity (EC) measured at a standard temperature (typically 25 ^{o}C). A linear relationship exists between EC (measured in µS/cm) and TDS (mg/L) for the range of salinities discussed in this report.

- Balonne-Condamine River at Surat (1969-2007 using scaled flow from Weribone).

E2 flow data was necessary in Bungil, Wallumbilla and Yuleba Creek. Records exist for both Bungil and Yuleba. However these were of limited length and of questionable quality (see Section 3 for details). Only 5 years of flow at Surat gauging station were available. E2 flow was compared to this 5 year period, however due to the spatial variation in the catchment, and the regulated Balonne-Condamine River the E2 model was not representative of the observed data. Therefore to extend the observation record it was required to simulate flow at Surat. To achieve this goal, scaled flow at the nearest gauging station (Weribone on the Balonne River) was used. The Weribone gauge, being lower down the catchment has greater runoff than at Surat, it was thus necessary to scale the flow to better represent flow at Surat. A reduction of flow by 20% was deemed most appropriate.

Continuous EC data was unavailable at any of the gauging stations. Therefore, only NRW spot water quality data was available for calibration purposes.

4.2.3 Model Assumptions

The basis for the empirical salinity algorithm used for the Condamine-Balonne catchments is the model developed for the Dawson River using observed EC records from the Utopia gauging station. This model was also found to be sufficiently simple but complex enough to model salinity behaviour in the Comet River catchment. The basic model is described below.

The model is based on a minimum and maximum salt concentrations with fluctuation based on flow levels. This is similar to the high flow/low flow modelling algorithm used in E2 but allowance has been made for transition between flow states to reflect observed behaviour. When the flow is zero, salinity is assumed to be zero. When flow equals or exceeds a selected high flow, the model is reset to the minimum salt concentration. Salinity is expected to decrease in high flow and increase in low flow. The amount of daily incremental change in salt concentration was determined based on the rates of increase and decrease of observed salinity such that the final algorithm best fits the observed salinity curve.

Starting with a simple algorithm, three different modelling sophistications were trialled including (1) introduction of seasonality, (2) a ramp from a first maximum salt concentration to a second peak salt concentration, and (3) salt responsive to flow flux (Figure 4-1). The modelling sophistications are described in Appendix B. Comparison of the three modelling sophistications resulted in selection of the ramp approach being used for all salinity model simulations. The ramp approach sufficiently captures the seasonal surges between March and June. The difference in salinity prediction using the flow flux approach was negligible and the complication was deemed unnecessary and less defensible.

The model was customised for the Condamine-Balonne catchments by adjusting the model parameters to fit observed the spot salinity data.

When additional discharge and salt is introduced from CSG production wells and treatment plants, full mixing is assumed and mass balance preserved.

Results of salinity modelling are provided in Section 5.

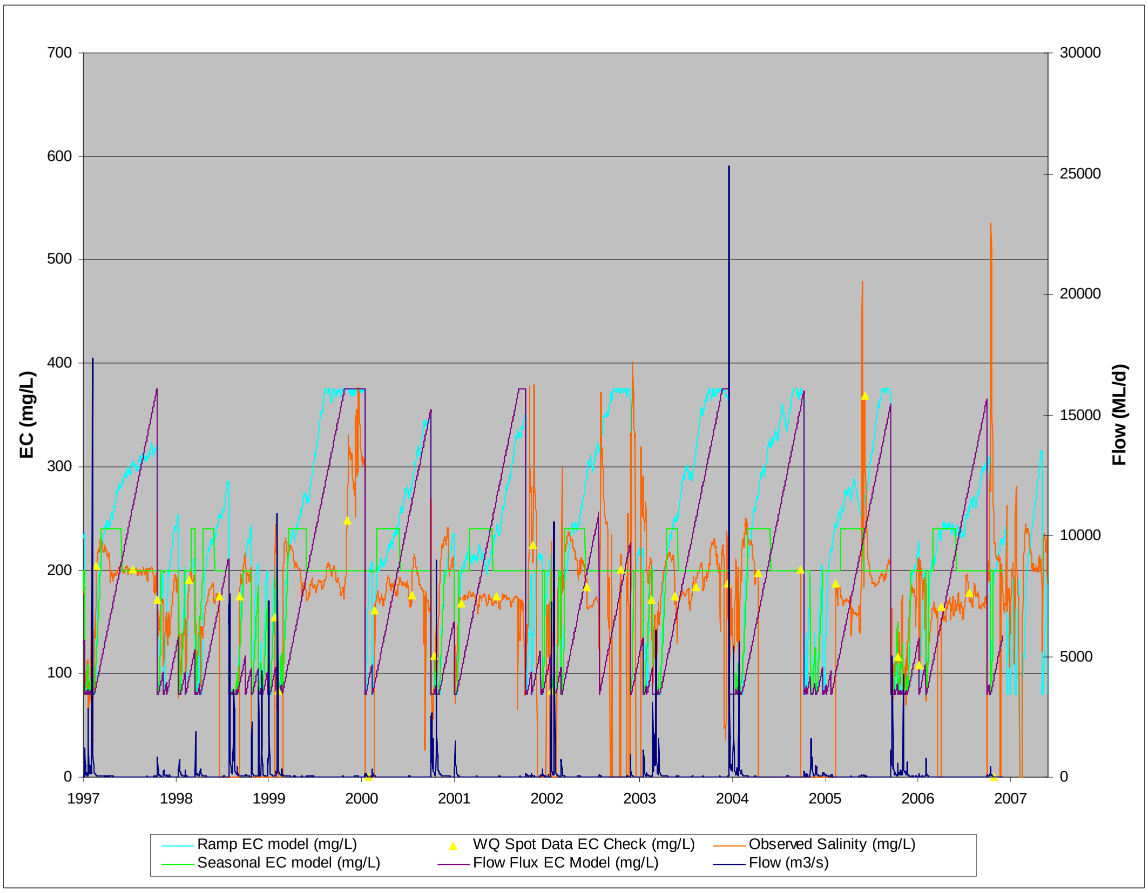


Figure 4-1 Trialled Salinity Modelling Sophistications at Utopia

5.1 Background

Santos recognises that water is a precious commodity and essential for the well being of the local community both now and into the future. After carefully considering the levels of existing and proposed development within the Roma Project Area, the imperatives of the international gas industry, and the desires of the local community, Santos has proposed a mix of associated water management options.

It is recognised that the proposed options need to be reviewed within an adaptive management framework that takes into account government initiatives in regional water management and development, changing economics of the gas and water markets, opportunities for regional development, and improved knowledge and science underpinning the extraction and use of associated water. Santos is committed to this regular review as part of its planning processes.

Significant volumes of associated water will be generated over the development life of the Roma Project Area. Management options include injection, onsite reuse, stock watering, irrigation, desalination and discharge, and direct discharge.

5.2 Scenarios

To explore the boundaries of any potential impacts of associated water discharge, it is necessary to define modelling scenarios. It is prudent to explore the potential for different points and quantities of discharge within each field as this will provide improved decision making and option analysis. Results can also feed back directly into the overall risk analysis.

It was determined useful to consider three points on each associated water production curve (minimum predicted water production and maximum predicted water production) for each modelling run. The three points identified are 1/3 peak production, 2/3 peak production and peak production. That is, for each point on the curve we will assume a constant flow from the CSG field over the full modelling period and compare the results with a no discharge scenario. This means that six different flows (1/3 min peak, 2/3 min peak, 3/3 min peak, 1/3 max peak, 2/3 max peak, and 3/3 max peak) will be combined with existing flows to assess the impacts for each scenario identified.

In Roma, six scenarios were considered after consultation with Santos. Scenarios were selected with a view to minimising the potential ecological impacts of discharging associated water to grade. There are pros and cons with each scenario. For example discharging all water to a single point minimises the environmental footprint, but increases the level of impact in the chosen stream. Conversely distributing the discharge across three creeks results in a wider footprint but increases the water supply security for a wider population downstream. Scenarios modelled include:

- Option 1: Untreated discharge into three points in the catchment allocated one third of water production each with the three points located in Yuleba, Bungil and Wallumbilla Creeks;
- Option 2: Untreated total production released at Bungil Creek;
- Option 3: Untreated total production released at Surat Weir via a pipeline;
- Option 4: Treated discharge into the same three points in the catchment, each allocated one third of water production;
- Option 5: Treated total production released at Bungil Creek; and

- Option 6: Treated total production released at Surat Weir via a pipeline.

5.3 Modelling

5.3.1 User Interface to Model

Flow weighted salt concentration was calculated for the various scenarios from the following equation.

$$C_{mixed} = \frac{Q_1 \times c_1 + Q_2 \times c_2 + Q_3 \times c_3}{Q_1 + Q_2 + Q_3}$$ Equation 10-1

Where Q_1 / c_1 = modelled or observed flow / modelled salt concentration in the receiving stream;

Q_2 / c_2 = direct discharge to grade from CSG well production / salt concentration of direct discharge; and

Q_3 / c_3 = treated discharge from desalination plant / salt concentration of permeate discharge.

Modelled salt concentration was based on the ramp salinity model, as described in Section 4.2.3, and detailed below.

If $Q_t = 0$

$c_t = 0$

If $Q_t > Q_{HIGH}$

$c_t = c_{MIN}$

If $Q_t > Q_{t-1}$ (rising limb)

$c_t = c_{t-1} - c_{DECREASE}$

If $Q_t < Q_{t-1}$ *AND* $c_t < c_{RAMP}$

$c_t = c_{t-1} + c_{IBR}$

If $Q_t < Q_{t-1}$ *AND* $c_t > c_{RAMP}$

$c_t = c_{t-1} + c_{IAR}$

Where Q_t = Flow at timestep t;

Q_{HIGH} = high flow trigger parameter;

c_t = salt concentration at timestep t;

c_{MIN} = minimum salt concentration;

c_{RAMP} = salt concentration at which the rate of increase changes;

$c_{DECREASE}$ = rate of salt concentration decrease;

c_{IBR} = rate of salt concentration increase below ramp (IBR); and

c_{IAR} = rate of salt concentration increase above ramp (IAR).

5.3.2 Model Data

Discharge input was extracted from the Roma minimum and maximum associated water production curves at the peak levels as well as 1/3 and 2/3 of peak levels. The peak of the maximum associated water production curve is 20.0 ML/d, resulting in 1/3 peak of 6.7 ML/d and 2/3 peak of 13.3 ML/d. Similarly, the peak of the minimum associated water production curve is 11.5 ML/d, resulting in 1/3 peak of 3.8 ML/d and 2/3 peak of 7.7 ML/d.

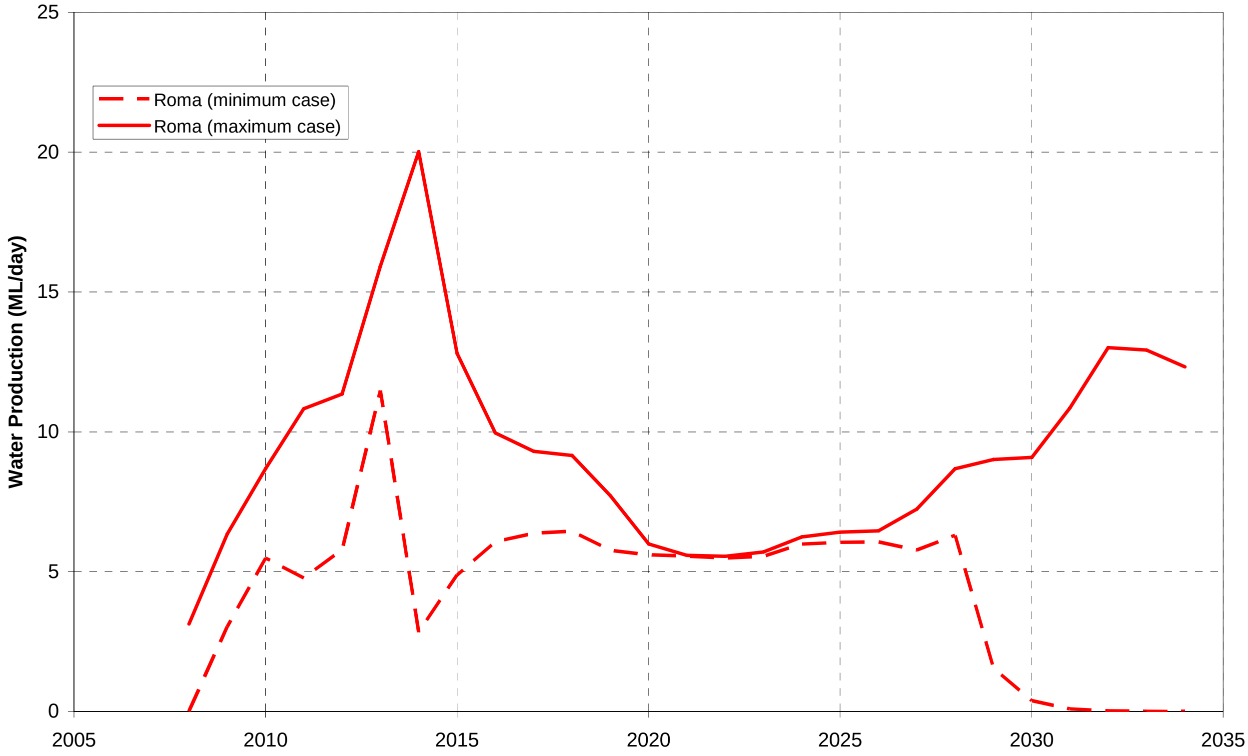


Figure 5-1 Future Predicted Associated Water Production in Roma

In all scenarios, flow was directly discharged to grade in either a completely treated or untreated state. No case assumed mixing of untreated and treated associated water prior to release into the streams.

Of the associated water discharged in the treated scenarios, the discharge volume was reduced by 25% of the input volume. This assumption corresponds to the expected losses from the desalination treatment process as brine.

Associated water is sampled regularly from each production well and analysed for a number of water quality parameters. Based on comprehensive sampling of 52 production wells within Roma project area between 2006 and 2007, the average electrical conductivity of CSG associated water was 3,438 µS/cm (TDS 2,303 mg/L).

For treated discharge scenarios an electrical conductivity of 290 µS/cm (TDS 194 mg/L) was adopted, based on background surface water salinity levels across the catchment. The target treated electrical conductivity corresponds to the mean electrical conductivity in Yuleba and Bungil Creeks derived from 166 spot samples.

Table 5-1 Flow (ML/d) for Roma Scenarios

Scenario	Predicted Production	Direct Discharge	Direct Discharge per Location	Treated Discharge[1]	Treated Discharge per Location	Total Discharge to Streams
Scenario 1: Untreated discharge into three points in the catchment allocated 1/3 of water production each with the three points located in Bungil, Wallumbilla and Yuleba Creek						
1.1	6.7 (1/3 max)	6.7	2.2	-	-	6.7
1.2	13.3 (2/3 max)	13.3	4.4	-	-	13.3
1.3	20.0 (3/3 max)	20.0	6.7	-	-	20.0
1.4	3.8 (1/3 min)	3.8	1.3	-	-	3.8
1.5	7.7 (2/3 min)	7.7	2.6	-	-	7.7
1.6	11.5 (3/3 min)	11.5	3.8	-	-	11.5
Scenario 2: Untreated total production released at Bungil Creek						
2.1	6.7	6.7	6.7	-	-	6.7
2.2	13.3	13.3	13.3	-	-	13.3
2.3	20.0	20.0	20.0	-	-	20.0
2.4	3.8	3.8	3.8	-	-	3.8
2.5	7.7	7.7	7.7	-	-	7.7
2.6	11.5	11.5	11.5	-	-	11.5
Scenario 3: Untreated total production released at Surat Weir via a pipeline						
3.1	6.7	6.7	6.7	-	-	6.7
3.2	13.3	13.3	13.3	-	-	13.3
3.3	20.0	20.0	20.0	-	-	20.0
3.4	3.8	3.8	3.8	-	-	3.8
3.5	7.7	7.7	7.7	-	-	7.7
3.6	11.5	11.5	11.5	-	-	11.5
Scenario 4: Treated discharge into the same three points in the catchment as Scenario 1, each allocated 1/3 of water production;						
4.1	6.7	-	-	5.0	1.7	5.0
4.2	13.3	-	-	10.0	3.3	10.0
4.3	20.0	-	-	15.0	5.0	15.0
4.4	3.8	-	-	2.9	1.0	2.9
4.5	7.7	-	-	5.8	1.9	5.8
4.6	11.5	-	-	8.6	2.9	8.6
Scenario 5: Treated total production released at Bungil Creek						
5.1	6.7	-	-	5.0	5.0	5.0
5.2	13.3	-	-	10.0	10.0	10.0
5.3	20.0	-	-	15.0	15.0	15.0
5.4	3.8	-	-	2.9	2.9	2.9
5.5	7.7	-	-	5.8	5.8	5.8
5.6	11.5	-	-	8.6	8.6	8.6

Scenario	Predicted Production	Direct Discharge	Direct Discharge per Location	Treated Discharge[1]	Treated Discharge per Location	Total Discharge to Streams
Scenario 6: Treated total production released at Surat Weir via a pipeline						
6.1	6.7	-	-	5.0	5.0	5.0
6.2	13.3	-	-	10.0	10.0	10.0
6.3	20.0	-	-	15.0	15.0	15.0
6.4	3.8	-	-	2.9	2.9	2.9
6.5	7.7	-	-	5.8	5.8	5.8
6.6	11.5	-	-	8.6	8.6	8.6

[1]Treated discharge accounts for a 25% reduction in discharge volume due to desalination process

Table 5-2 Input Salt (mg/L) for Roma Scenarios

Scenario	Direct Discharge	Treated Discharge
1	2303	-
2	2303	-
3	2303	-
4	-	194
5	-	194
6	-	194

5.4 Model Development and Parameters

To assess the impacts of associated water discharged to the Balonne-Condamine catchment, four salinity models were to simulate the natural condition of the river at their respective locations. The four models were created to represent four possible locations for point source discharge of associated water to Bungil Creek, Wallumbilla Creek, Yuleba Creek, and at Surat Weir on the Balonne River.

No continuous water quality apparatus measuring stream salinity has operated at any of the four gauging stations. Therefore the calibration of the salinity model was dependant on URS and NRW spot data measurements. Parameters used in the Dawson and Comet catchment salinity models were used as a starting point for calibration of the Roma models. Parameters were then adjusted to achieve the best calibration possible given the limited spot data set. Overall the model appears to reasonably match the spot data. Without a significant increase in spot or continuous electrical conductivity data, further model calibration is not feasible. The stream flow, calibrated salinity ramp model, and the spot observed records are shown in Figure 5-2, Figure 5-3, Figure 5-4 and Figure 5-5 for Bungil Creek, Wallumbilla Creek, Yuleba Creek and Surat Weir respectively.

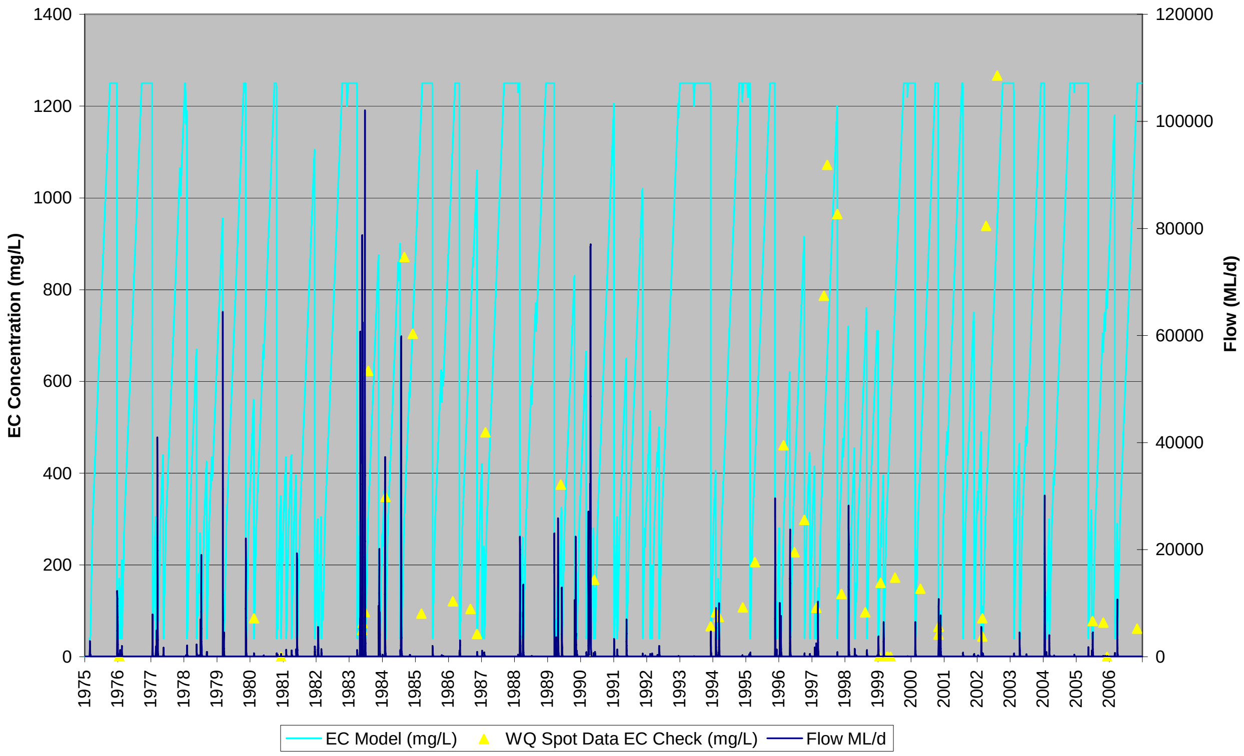


Figure 5-2 Bungil Creek Salinity Model - 1975 to 2006

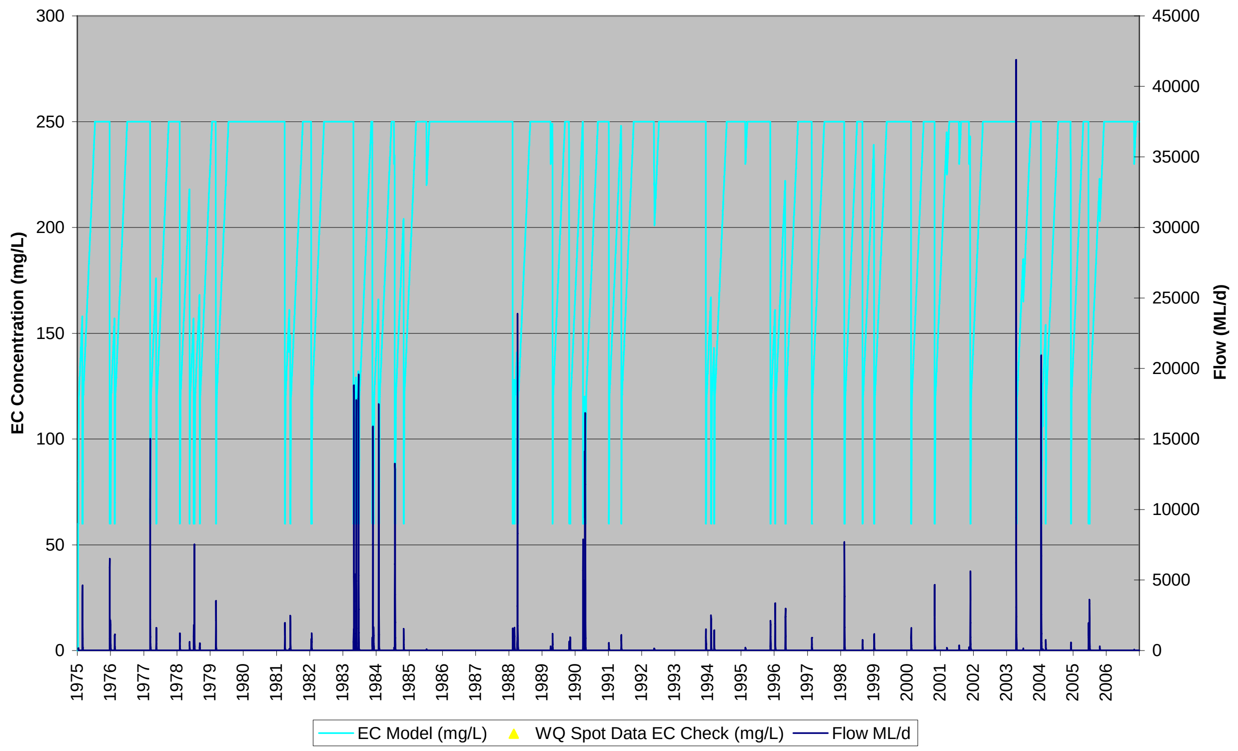


Figure 5-3 Wallumbilla Creek Salinity Model - 1975 to 2006

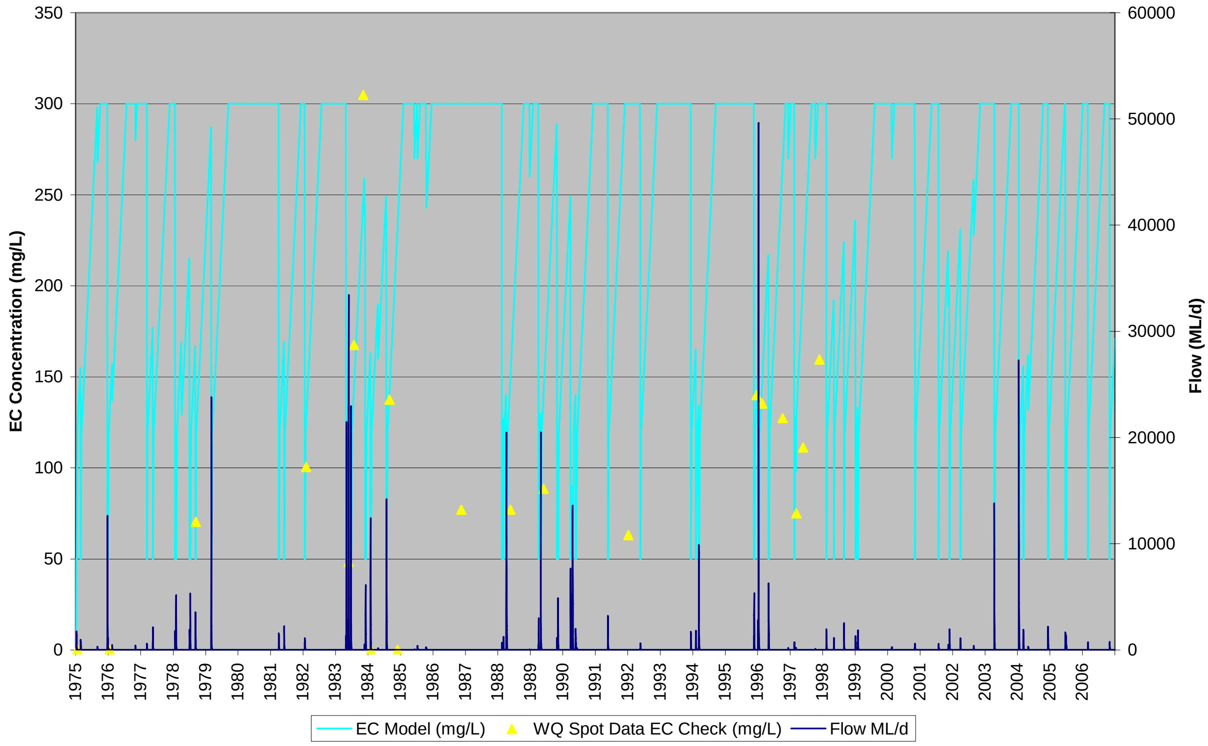


Figure 5-4 Yuleba Creek Salinity Model - 1975 to 2006

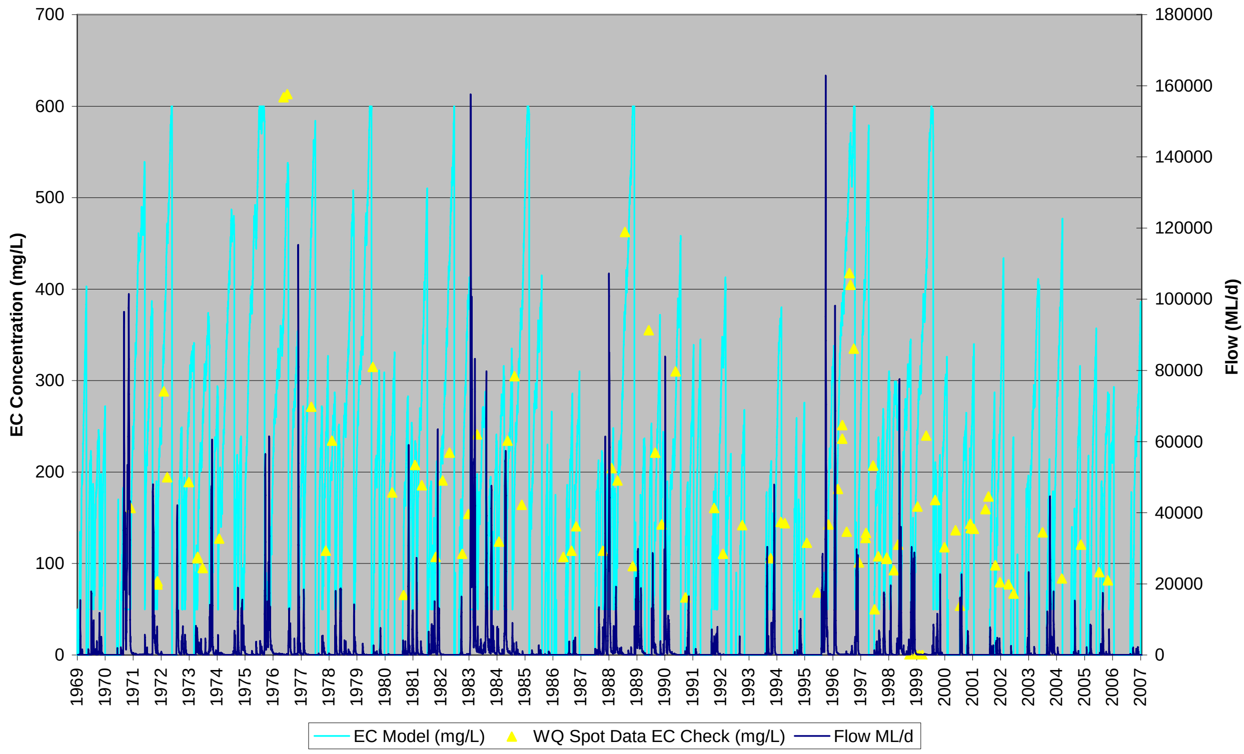


Figure 5-5 Surat Weir Salinity Model - 1969 to 2007

Associated Water Management Scenarios

The parameters used in the salinity model for Bungil, Wallumbilla and Yuleba Creeks and Surat Weir are presented in Table 5-3.

Table 5-3 Roma Salinity Model Parameters

Ramp Model Parameter	Bungil	Wallumbilla	Yuleba	Surat Weir	Units
High Flow Salinity Reset to Minimum Concentration	500	500	500	5000	ML/d
Maximum Concentration	1250	250	300	600	mg/L
Minimum Concentration	40	60	50	50	mg/L
Ramp Change Concentration	300	130	130	180	mg/L
Flow Decreases - Salinity Increase - Below Salinity Ramp by:	10	10	10	10	mg/L/day
Flow Decreases - Salinity Increase - Above Salinity Ramp by:	5	1	1	4	mg/L/day
Flow Increase - Salinity Decrease by:	10	10	10	5	mg/L/day

5.5 Results and Interpretation

To assess the environmental impacts on streams in the Roma field area as a result of future associated water production, 60 models were developed in accordance with the scenarios and parameters defined in Table 5-1. A statistical overview of the natural salinity models is shown in Table 5-4. A statistical overview of the modelled results of each of the various scenarios is presented in Table 5-5 and graphically in Figure 5-6. The results show:

- **Minimum** salt concentration of the mixed stream (during the large runoff events);
- **Average** salt concentration;
- **Maximum** salt concentration (typically the concentration of the associated water);
- 25% of days the mixed stream salt concentration is equal to or less than **Lower Quartile**;
- 50% of days the mixed stream salt concentration is equal to or less than **Median**;
- 75% of days the mixed stream salt concentration is equal to or less than **Upper Quartile**; and
- **95th Percentile** representing the value that 95% of the stream salinity records are below.

Table 5-4 Summary of Scenarios - Mixed Stream Salinity (mg/L)

Salinity Model	Future Production (ML/d)	Statistics			Quartile			95th Percentile
		Min	Average	Max	Lower	Median	Upper	
Bungil	-	0	647	1250	305	595	1040	1250
Wallumbilla	-	0	214	250	178	250	250	250
Yuleba	-	0	232	300	168	259	300	300
Surat Weir	-	0	176	600	50	170	274	483

Associated Water Management Scenarios

Table 5-5 Summary of Scenarios - Mixed Stream Salt Concentrations (mg/L)

Scenario	Future Production (ML/d)	Statistics			Quartile			95th Percentile
		Min	Average	Max	Lower	Median	Upper	
1.1 Bungil	2.2	40	1801	2303	1510	2280	2302	2303
1.2 Bungil	4.4	40	1861	2303	1798	2291	2303	2303
1.3 Bungil	6.7	40	1894	2303	1933	2295	2303	2303
1.4 Bungil	1.3	40	1749	2303	1285	2262	2302	2303
1.5 Bungil	2.6	40	1813	2303	1571	2283	2303	2303
1.6 Bungil	3.8	40	1849	2303	1741	2290	2303	2303
1.1 Wallumbilla	2.2	60	2126	2303	2299	2303	2303	2303
1.2 Wallumbilla	4.4	60	2148	2303	2301	2303	2303	2303
1.3 Wallumbilla	6.7	60	2159	2303	2302	2303	2303	2303
1.4 Wallumbilla	1.3	60	2106	2303	2295	2303	2303	2303
1.5 Wallumbilla	2.6	60	2131	2303	2299	2303	2303	2303
1.6 Wallumbilla	3.8	60	2143	2303	2301	2303	2303	2303
1.1 Yuleba	2.2	50	2045	2303	2269	2303	2303	2303
1.2 Yuleba	4.4	50	2078	2303	2286	2303	2303	2303
1.3 Yuleba	6.7	50	2096	2303	2292	2303	2303	2303
1.4 Yuleba	1.3	50	2016	2303	2244	2302	2303	2303
1.5 Yuleba	2.6	50	2052	2303	2273	2303	2303	2303
1.6 Yuleba	3.8	50	2072	2303	2283	2303	2303	2303
2.1 Bungil	6.7	40	1900	2303	1956	2296	2303	2303
2.2 Bungil	13.3	40	1953	2303	2111	2300	2303	2303
2.3 Bungil	20.0	40	1981	2303	2170	2301	2303	2303
2.4 Bungil	3.8	40	1855	2303	1769	2291	2303	2303
2.5 Bungil	7.7	40	1911	2303	1993	2297	2303	2303
2.6 Bungil	11.5	40	1942	2303	2083	2299	2303	2303
3.1 Surat	6.7	50	966	2303	216	520	2264	2303
3.2 Surat	13.3	50	1046	2303	247	649	2284	2303
3.3 Surat	20.0	50	1101	2303	273	765	2290	2303
3.4 Surat	3.8	50	915	2303	200	442	2237	2303
3.5 Surat	7.7	50	980	2303	221	542	2269	2303
3.6 Surat	11.5	50	1027	2303	239	617	2281	2303
4.1 Bungil	2.2	40	214	1235	194	196	206	402
4.2 Bungil	4.4	40	208	1230	194	195	201	350
4.3 Bungil	6.7	40	204	1225	194	195	199	317
4.4 Bungil	1.3	40	221	1237	195	197	213	445
4.5 Bungil	2.6	40	213	1234	194	196	205	389
4.6 Bungil	3.8	40	209	1231	194	195	202	363
4.1 Wallumbilla	2.2	60	188	240	194	194	194	194
4.2 Wallumbilla	4.4	60	188	240	194	194	194	194

Scenario	Future Production (ML/d)	Statistics			Quartile			95th Percentile
		Min	Average	Max	Lower	Median	Upper	
4.3 Wallumbilla	6.7	60	189	239	194	194	194	194
4.4 Wallumbilla	1.3	60	187	240	194	194	194	194
4.5 Wallumbilla	2.6	60	188	240	194	194	194	194
4.6 Wallumbilla	3.8	60	188	240	194	194	194	194
4.1 Yuleba	2.2	50	186	290	194	194	194	195
4.2 Yuleba	4.4	50	186	289	194	194	194	195
4.3 Yuleba	6.7	50	187	289	194	194	194	195
4.4 Yuleba	1.3	50	185	290	194	194	194	196
4.5 Yuleba	2.6	50	186	290	194	194	194	195
4.6 Yuleba	3.8	50	186	289	194	194	194	195
5.1 Bungil	6.7	40	204	1225	194	195	198	312
5.2 Bungil	13.3	40	200	1210	194	195	196	270
5.3 Bungil	20.0	40	198	1196	194	194	196	252
5.4 Bungil	3.8	40	209	1231	194	195	201	355
5.5 Bungil	7.7	40	203	1223	194	195	198	302
5.6 Bungil	11.5	40	201	1214	194	195	197	277
6.1 Surat Weir	6.7	50	209	598	170	194	247	418
6.2 Surat Weir	13.3	50	205	596	170	194	241	389
6.3 Surat Weir	20.0	50	202	594	171	194	236	375
6.4 Surat Weir	3.8	50	212	599	170	194	252	436
6.5 Surat Weir	7.7	50	208	598	170	194	246	413
6.6 Surat Weir	11.5	50	206	596	170	194	242	395

In scenarios 1 and 4, the three creeks are parallel with each creek allocated one third of the flow. Since each creek flows directly to the Balonne-Condamine River, no flow is assumed to interact between streams.

All four discharge locations are ephemeral at certain times of the year. Further, the base flow within the stream is often very low, in the order of a few ML per day. During periods of no flow, the only flow in the stream is the associated water discharge, thereby resulting in a salt concentration in the system equal to that of the production water. This has been found to skew the average and quartiles towards higher salt concentrations during untreated scenarios.

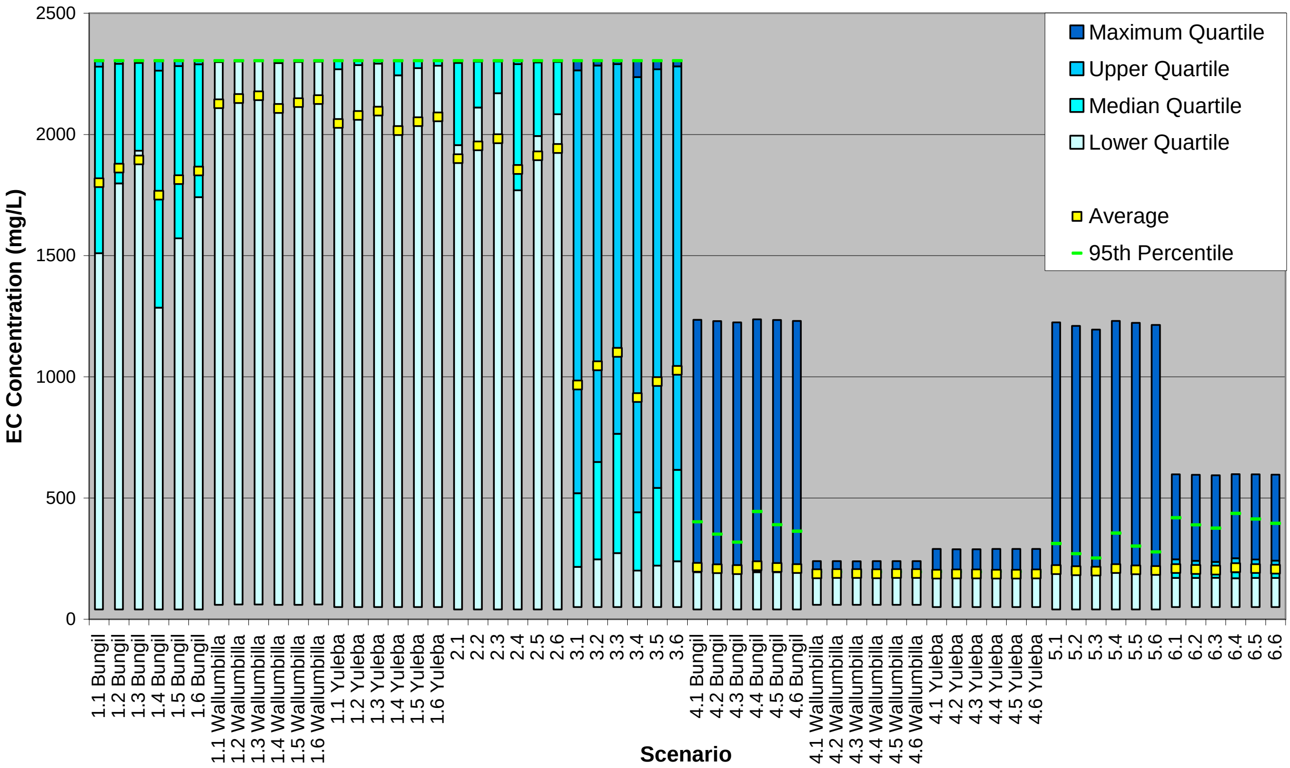


Figure 5-6 Summary of Scenarios - Mixed Salt Concentration in Roma Catchment

5.5.1 Scenario 1 – Untreated Direct Discharge to Three Locations

Scenario 1 represents discharging untreated associated water at three points within the Roma catchment. The three locations selected were Bungil, Wallumbilla and Yuleba Creeks. Figure 5-7, Figure 5-8 and Figure 5-9 show the three salinity models in natural stream conditions, in addition to the minimum (3.8 ML/d) and the maximum (20.0 ML/d) predicted future production. This represents the current and likely range of future production within the Balonne-Condamine River catchment.

All three streams are completely ephemeral or experience very low flow, and at many times, the only flow present in the stream is the associated water. Therefore, at all locations, the salinity in the stream is often equal to the associated water concentration (2303 mg/L). Further, at all locations, little variation existed between the maximum and minimum future production scenarios. Once the streams receive a non-trivial volume of associated water, the salinity in the mixed stream will not be significantly altered by further increases of associated water.

Due to the higher flow and natural background salinity in Bungil Creek, the effect of introducing untreated associated water to the stream is significant, but less than in Wallumbilla and Yuleba Creeks. The addition of associated water to Wallumbilla and Yuleba Creeks results in a much more drastic increase in salt concentration from natural conditions.

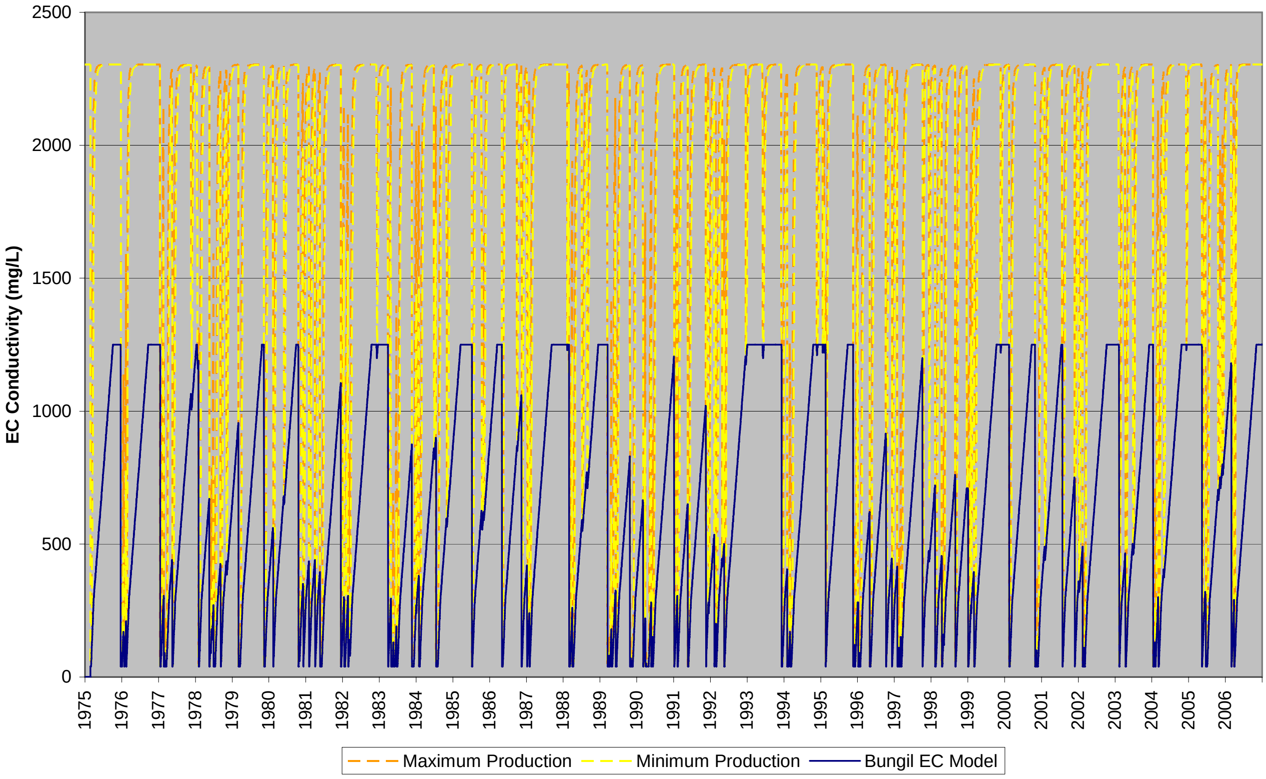


Figure 5-7 Scenario 1 – Untreated Discharge – Bungil Creek

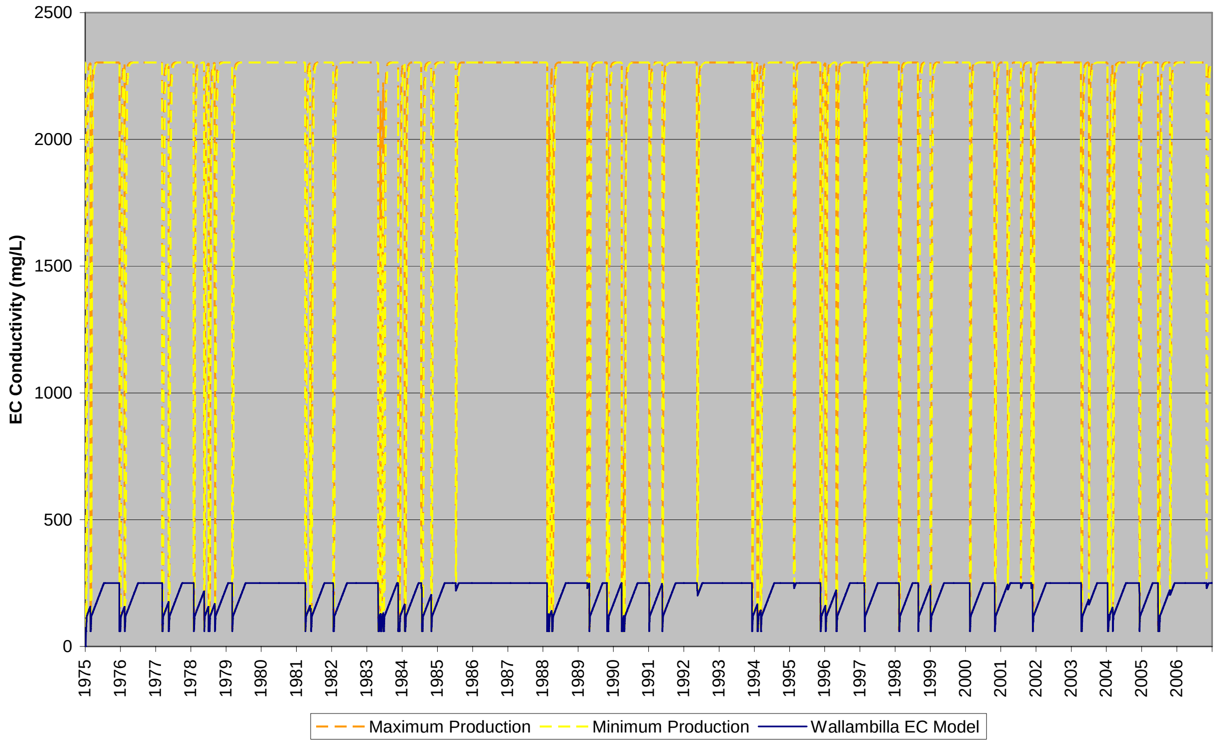


Figure 5-8 Scenario 1 – Untreated Discharge – Wallumbilla Creek

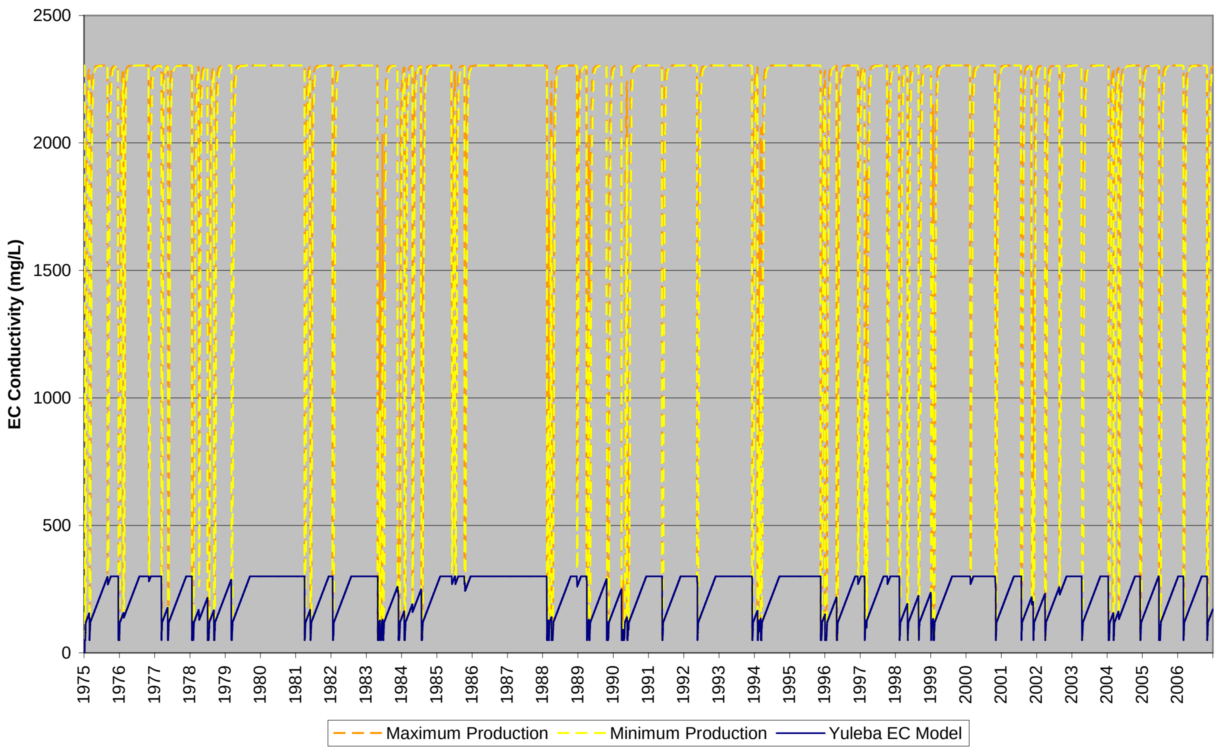


Figure 5-9 Scenario 1 – Untreated Discharge – Yuleba Creek

5.5.2 Scenario 2 – Untreated Direct Discharge to Bungil Creek

During analysis of Scenario 1 it was found that due to its comparatively high flow and higher than normal background levels of salt in the stream, Bungil Creek would be the preferred stream to receive untreated associated water. Scenario 2 represents discharging untreated production water along Bungil Creek. Figure 5-10, shows the Bungil Creek salinity model (natural stream conditions), in addition to the minimum (3.8 ML/d) and the maximum (20.0 ML/d) predicted future production. This represents the current and likely range of future production within Balonne-Condamine River catchment.

Overall the results show the same findings as were found in Scenario 1. Little variation exists between the maximum and minimum discharge levels. During low and cease to flow conditions of the stream, the salinity in the mixed stream tends to the levels of the associated water.

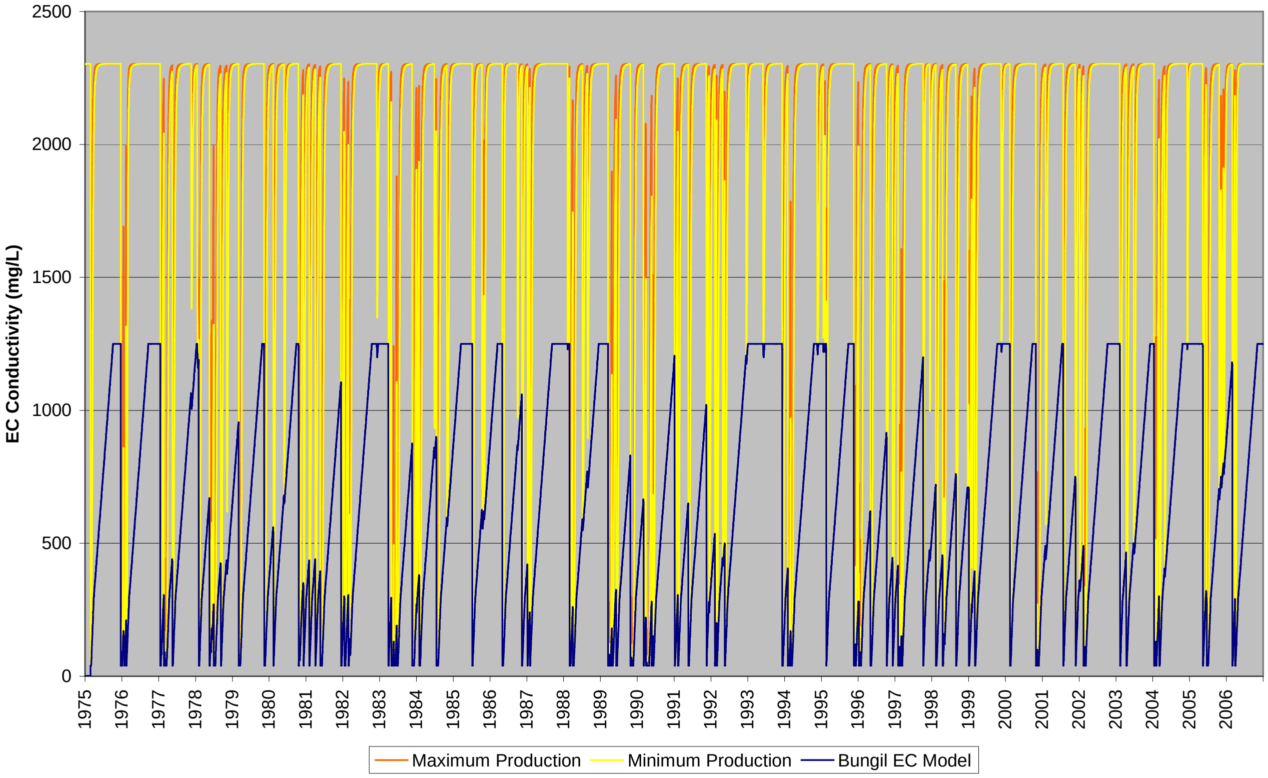


Figure 5-10 Scenario 2 – Untreated Direct Discharge to Bungil Creek

5.5.3 Scenario 3 – Untreated Piped Discharge to Surat Weir

Scenario 4 represents piping untreated associated water to Surat Weir on the Balonne-Condamine River for discharge. Figure 5-11 shows the Surat Weir salinity model (natural stream conditions), in addition to the minimum (3.8 ML/d) and the maximum (20.0 ML/d) predicted future production. This represents the current and likely range of future production within the Roma catchment.

The modelling performed at Surat Weir exhibited notable variability between the maximum and minimum future production scenarios. During periods of flow, the minimum future production was found to have far less impact on the natural stream condition than the peak production scenario. The median salt concentration under minimum associated water discharge was found to be 442 mg/L, and 765 mg/L under maximum discharge. At Surat Weir on the Balonne River, the river consistently becomes ephemeral, resulting in the associated water comprising the bulk of the flow. During these periods, the salinity of the stream will be dominated by the salt concentration of the associated water.

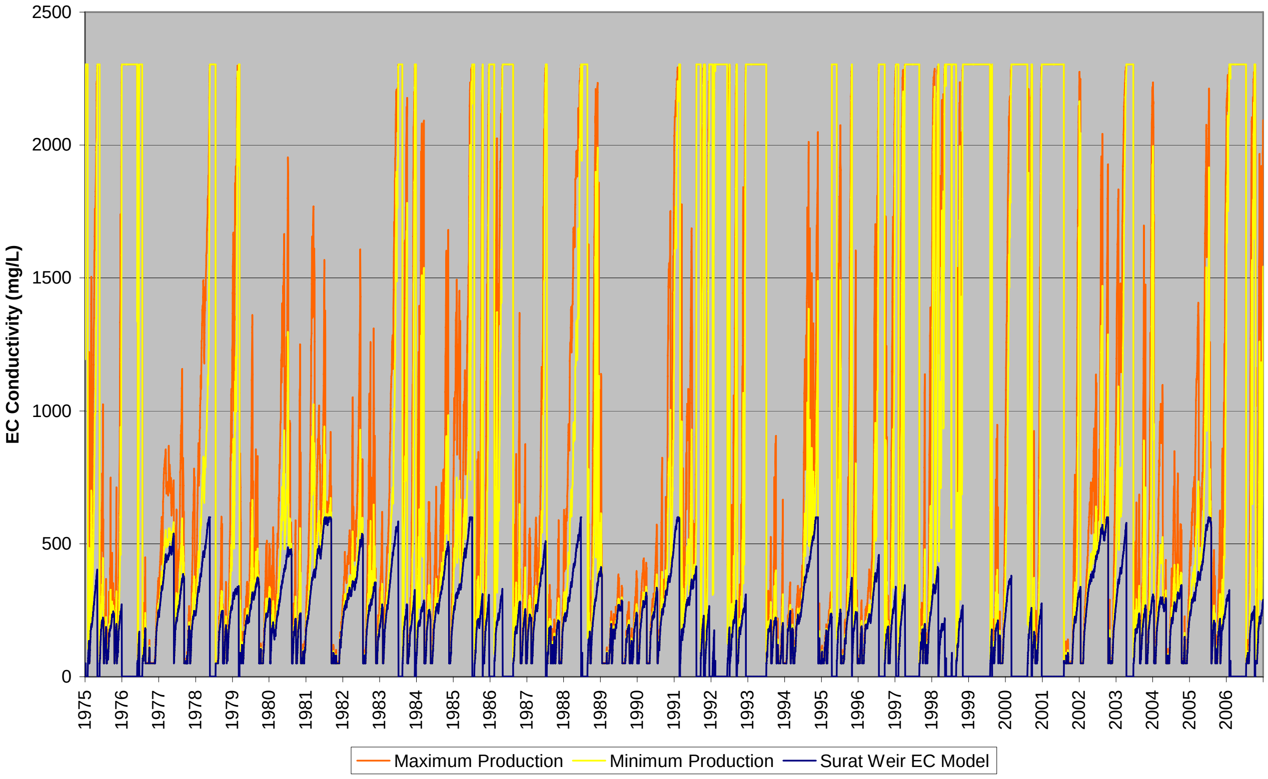


Figure 5-11 Scenario 3 – Untreated Piped Discharge to Surat Weir

5.5.4 Scenario 4 – Treated Direct Discharge to Three Locations

Scenario 4 represents discharging treated associated water at three points within the Roma catchment. The three locations selected were Bungil, Wallumbilla and Yuleba Creek. Figure 5-12, Figure 5-13 and Figure 5-14 shows the three salinity models in natural stream conditions, in addition to the minimum (3.8 ML/d) and the maximum (20.0 ML/d) predicted future production. This represents the current and likely range of future production within the Balonne-Condamine River catchment.

The volume of the discharge was reduced by 25%. This represents the volume of brine generated in the desalination process.

All three streams are ephemeral. At many times the only flow present in the stream is the associated water. Therefore, at all locations, the salinity in the stream is equal to the water quality of the treated associated water (194 mg/L).

All three creeks exhibit similar patterns. When the streams have ceased to flow, the salt concentration is constant and equivalent to the salinity of the treated associated water. Further, the greater the volume of treated production water, the greater the tendency of the mixed streamflow salt concentration to move towards the treated water quality level. This results in the mixed streams salt concentration not peaking during dry periods prior to ceasing to flow. Further the mixed stream salt concentration would increase during large runoff events; typically these events had very dilute concentrations of salt in the stream.

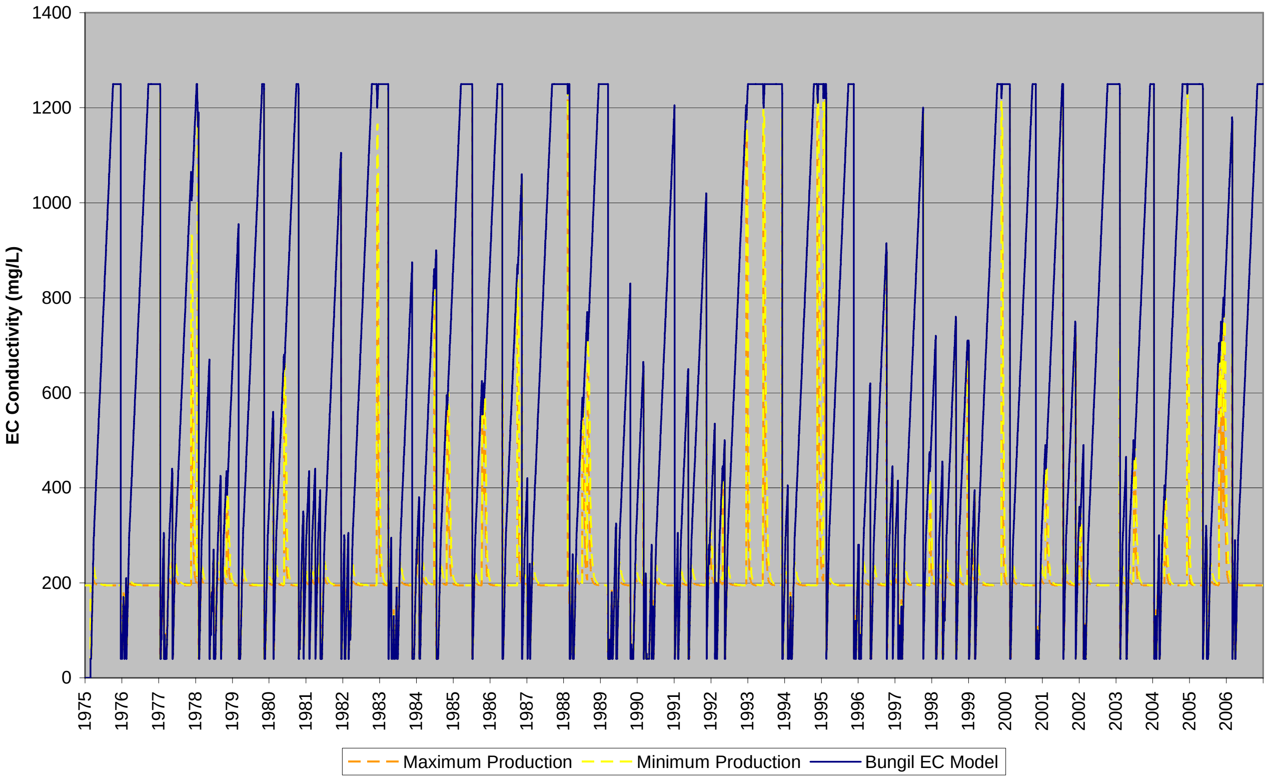


Figure 5-12 Scenario 4 – Treated Discharge at Bungil Creek

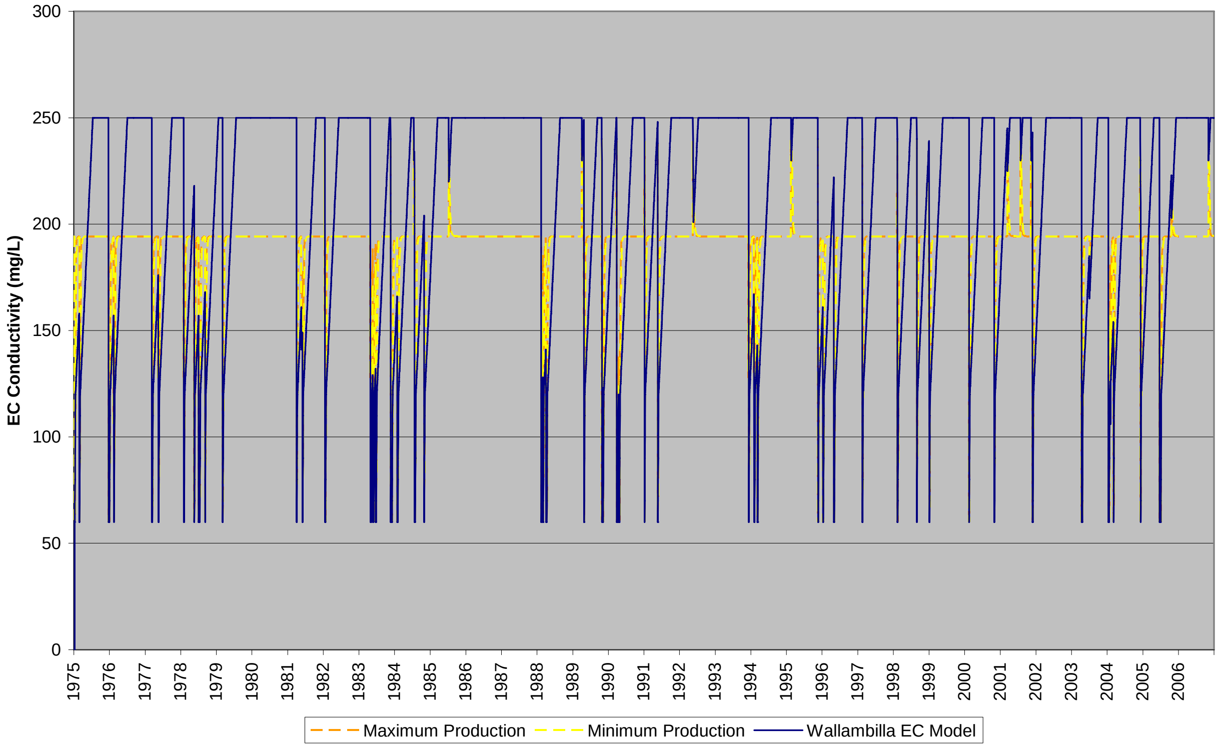


Figure 5-13 Scenario 4 – Treated Discharge at Wallumbilla Creek

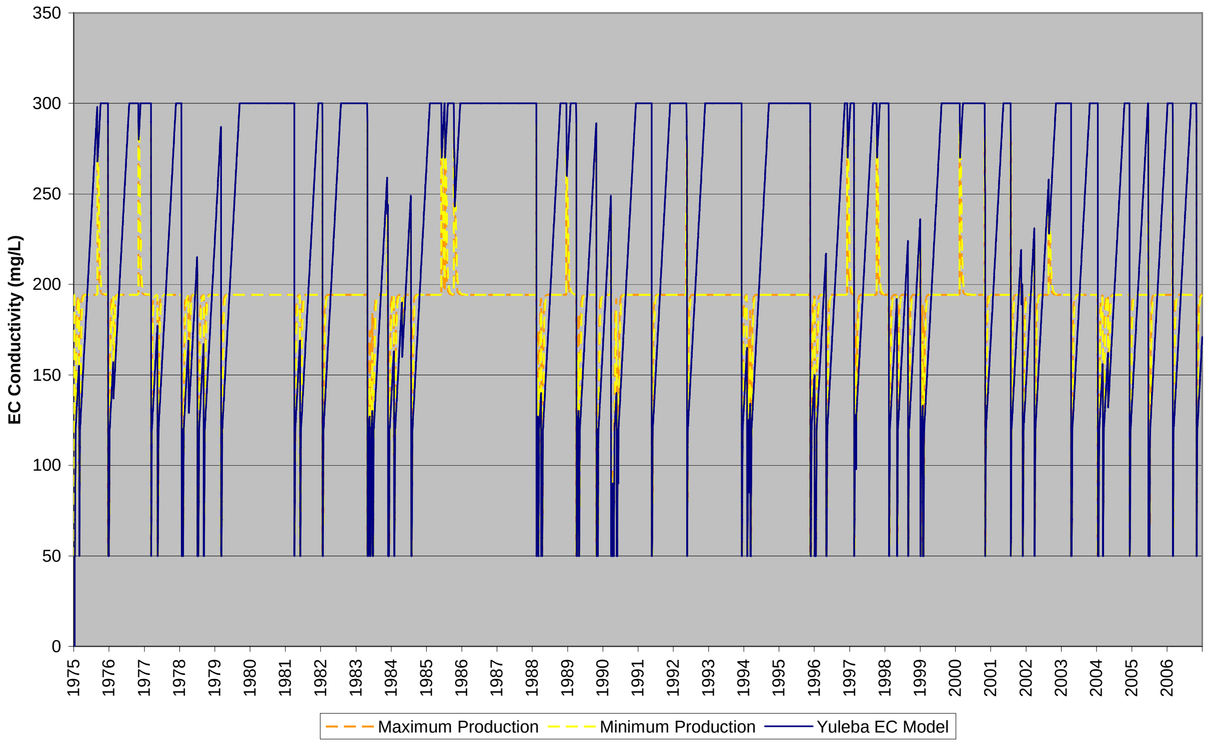


Figure 5-14 Scenario 4 – Treated Discharge at Yuleba Creek

5.5.5 Scenario 5 – Treated Direct Discharge to Bungil Creek

Scenario 4 represents treating the associated water prior to being released along Bungil Creek. Figure 5-15 shows the Bungil Creek salinity model (natural stream conditions), in addition to the minimum (3.8 ML/d) and the maximum (20.0 ML/d) predicted future production. This represents the current and likely range of future production within the Roma catchment.

The volume of the discharge was reduced by 25%. This represents the volume of brine generated in the desalination process.

All three streams are ephemeral. At many times the only flow present in the stream is the associated water. Therefore, at all locations, the salinity in the stream is equal to the treated associated water concentration (194 mg/L).

When the stream has ceased to flow the salinity stabilises at the target salinity of the treated associated water. Further, the greater the volume of treated production water, the greater the tendency of the mixed stream to skew towards the treated water quality level. This results in the mixed streams salt concentration not peaking during dry periods prior to ceasing to flow, and increasing the salinity during large runoff events that typically had very dilute concentrations of salt in the stream.

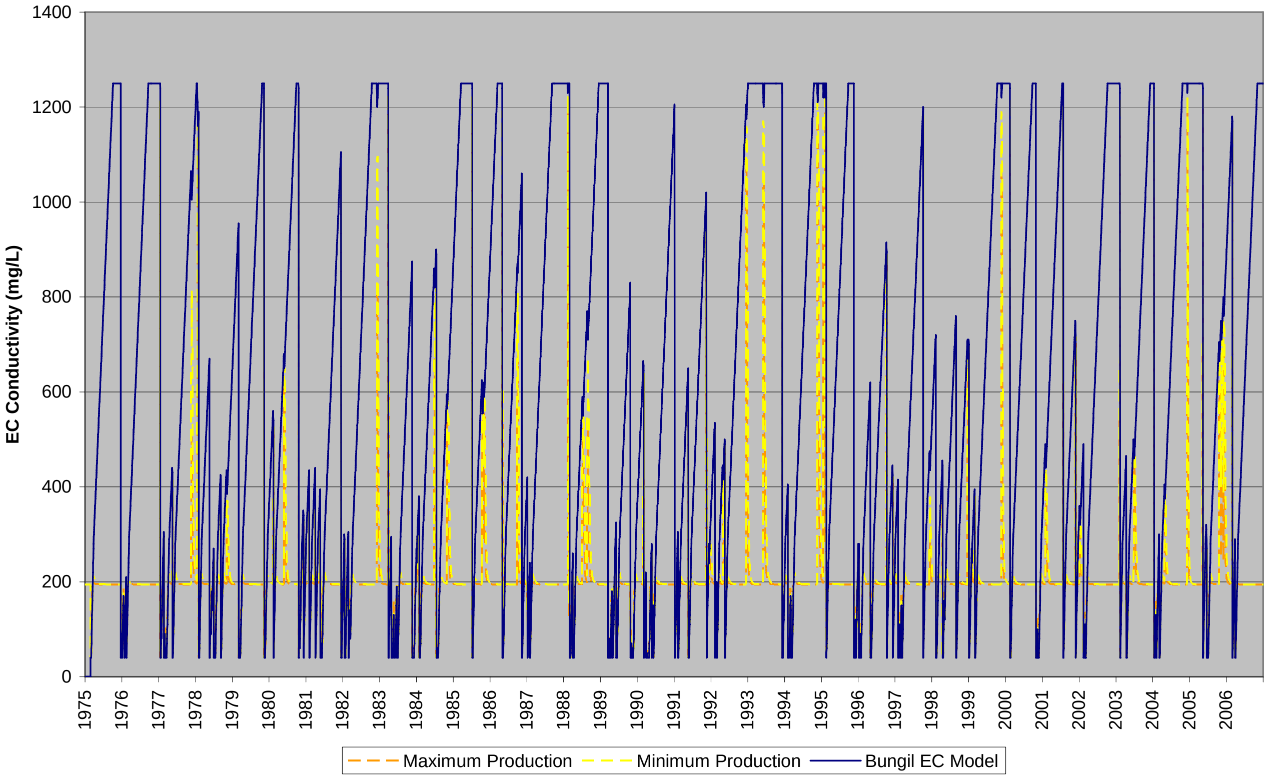


Figure 5-15 Scenario 5 – Treated Discharge at Bungil Creek

5.5.6 Scenario 6 – Treated Piped Discharge to Surat Weir

Scenario 6 represents piping treated associated water to Surat Weir on the Balonne River for release. Figure 5-16 shows the Surat Weir salinity model in natural stream conditions, in addition to the minimum (3.8 ML/d) and the maximum (20.0 ML/d) predicted future production. This represents the current and likely range of future production within Comet River catchment.

The volume of the discharge was reduced by 25%. This represents the volume of brine generated in the desalination process.

Unlike Scenario 5 (treated discharge at Bungil Creek), little variation was found between the natural salt concentration and the level in the mixed stream. The Balonne River upstream of Surat Weir is occasionally ephemeral; at many times the only flow present in the stream is the associated water. This results in the salinity in the stream equating to the treated associated water concentration (194 mg/L). As was found in Scenarios 4 and 5, as the volume of treated production water applied to the stream increases, the greater the tendency of the mixed stream to skew towards the treated water quality level. This results in the mixed streams salt concentration not peaking as high during dry periods prior to ceasing to flow. However, unlike Scenarios 4 and 5, there was found to be little increase in salinity during large runoff events that typically have very dilute concentrations of salt in the stream.

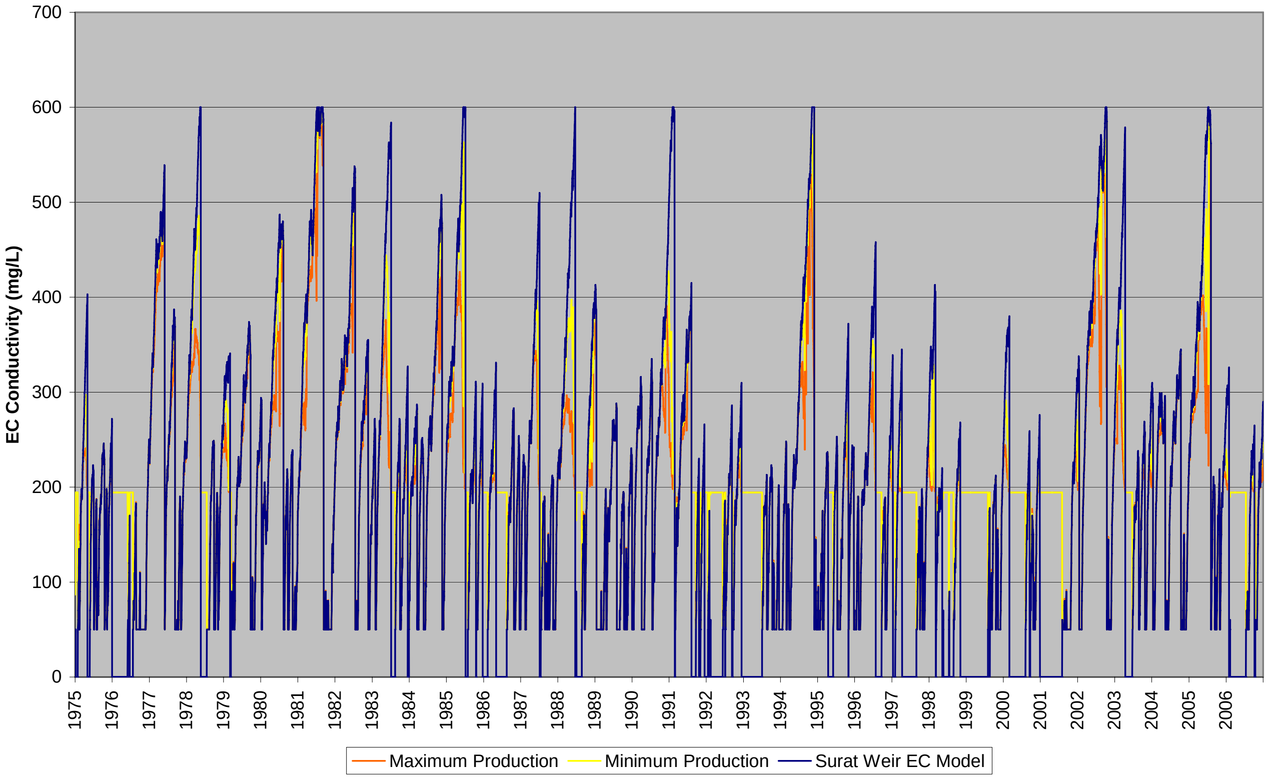


Figure 5-16 Scenario 6 – Treated Piped Discharge at Surat Weir

Conclusion Section 6

A rainfall-runoff model has been developed for subcatchments of the Balonne-Condamine catchment relevant to the Roma Field CSG development. The model allows prediction of the most important flow regimes needed to assess changes in salinity and flow arising from potential discharges of associated water. However, the accuracy of the model is limited by the available data.

The flow model is calibrated within the limits of the data available. Additional streamflow data is required for confirmation of the calibration used.

The salinity model utilised for the Balonne-Condamine subcatchments is the same as that adopted for the Dawson and Comet river catchments. The model is relatively simple and empirical, but sufficiently complex to explain the majority of the observed variation in salinity in these regions. Model parameters were adjusted to reflect observed spot EC records from the study area.

The flow and salinity models are sufficient to allow consideration of a range of associated water management scenarios. Only basic scenarios have been investigated at this time, but scenarios involving storage and release or other more complex management options can be investigated in future using these models.

Sixty model scenarios were run using four models representing alternative discharge locations. The results indicate that untreated discharge at any location will significantly alter the salt concentration in the receiving waters. Discharge to the ephemeral creek systems (Yuleba, Bungil and Wallumbilla) will effectively mean there is no reduction in salinity of associated water during the dry season since there is no water for dilution under low flow conditions.

Discharge to the Surat Weir was also investigated. It is known that the Balonne River also ceases to flow, but the weir is a man-made structure that has increased the duration and extent of streambed wetting at Surat and therefore offers the potential for discharge without affecting the low flow hydrology as much as in the above mentioned creek systems.

Results generated in this report will be considered as part of the overall risk assessment of discharging associated water to grade.

Limitations Section 7

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 10 July 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared in September 2008 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Flow Model Development

Appendix A

A.1 E2 Background

The basic architecture of the E2 modelling framework consists of a subcatchment-node-link system based on two previous software packages, the Environmental Management Support System (EMSS) and the Integrated Quality and Quantity Model (IQQM). E2 allows for the generation of flow and materials in subcatchments and then onto a node where they are routed and possibly processed along a link.

Within E2 sub-catchments are broken up into 'functional units' that represent areas of similar behaviour or response. These can be various combinations of land use or cover such as forestry or grazing, management techniques or even position in the landscape such as ridge, floodplain, etc. Each FU can then have various models describing processes of runoff generation, constituent generation and filtering.

A.1.1 Australian Water Balance Model (AWBM)

The Australian Water Balance Model (AWBM) is a catchment water balance model capable of relating rainfall and evaporation to runoff on an hourly or daily time step. It has a total of eight parameters with the model containing three conceptual stores (C1-C3) with area representation (A1 - A3 summing to 100% of the total area) plus surface and baseflow recession constants and a baseflow index. The relative sensitivity of each parameter can vary depending on the value of the others; however the model is generally most sensitive to the recession constants and baseflow index (Argent *et al,* 2007a). Figure A-1 shows a conceptual diagram of the model and Table A-1 details the AWBM parameters and their default settings.

Figure A-1 Australian Water Balance Model (AWBM)

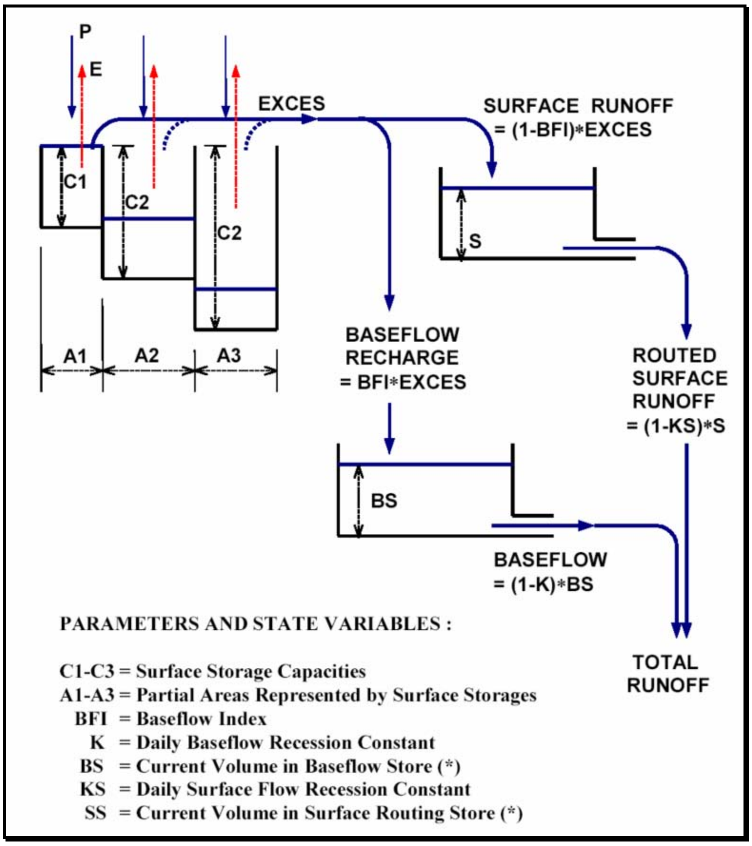


Table A-1 Definition of AWBM parameters and their default values

Parameter	Definition	Units	Max	Min	Default value
Base flow index (BFI)	The ratio of baseflow to total flow in the stream flow	none	1.0	0	0.35
Daily surface flow recession constant (KS)	Determines the rate at which the surface flow runoff store is depleted	Day^{-1}	1.0	0	0.35
Daily base flow recession constant (BS)	Determines the rate at which the base flow store is depleted	Day^{-1}	1.0	0	0.95
A1	Partial area of surface store 1	None	1.0	0	0.134
A2	Partial area of surface store 2	None	1.0	0	0.433
C1	Capacity of surface store 1	mm	50	0	7
C1	Capacity of surface store 1	mm	200	0	50
C1	Capacity of surface store 1	mm	500	0	150

(Source: Based on Argent *et al*, 2007a)

The model works by calculating the water balance for each partial store independently of the others at the desired time step. The water balance is calculated as:

$Store_n = Store_n + Rain – Evaporation$ (where n = 1-3)

When the amount of moisture in the store exceeds its capacity, runoff occurs. Part of the runoff can then be used to recharge the baseflow. This is calculated as:

Baseflow recharge = BFI x Rainfall Excess

The remainder of the excess then becomes surface runoff. The baseflow store is then depleted at a rate of:

Baseflow depletion= (1.0 - K_{base}) x Baseflow store

(Where K_{base} is the daily baseflow recession constant)

In larger catchments flows often arrive from different areas at different times and it may be necessary to attenuate some flows. This is achieved in the model by a surface store whereby the discharge is controlled by the daily surface flow recession constant (K_{surf}):

Surface flow routing = (1.0-K_{surf}) x Surface store

Changing the values of the two recession constants allows the shape of the flood hydrograph to be altered. Higher values of both constants give slower recessions and hence longer falling limbs. Therefore they can be used to simulate different catchment conditions. The value of BFI also dictates how much of the rainfall excess is directed to either runoff or baseflow. This is important in allowing the model to capture different types of geology and catchment morphology.

A.1.2 Network Creation

E2 accepts a variety of spatial data to determine the catchment network and land use. Digital elevation models (DEM) can be used to automatically generate the subcatchment network required for the modelling process. However, Rob Argent (an E2 developer) advised against use of DEMs for this process since data preprocessing to connect gaps, identify stream flow direction, and fill pits can be extremely time intensive and could be especially problematic when dealing with the highly ephemeral nature of the stream network in the study area.

For this reason, the use of GIS shape files was used to represent the subcatchments and the stream network was drawn in manually within E2. This means that while catchment area is calculated within E2 for the purpose of runoff generation, there is no explicit spatial representation of the stream network.

A.2 Data Collation and Preparation

Construction of the E2 model required the following data:

- **Subcatchments** were delineated based on major stream confluences and areas of interest using ArcGIS. Subcatchments were first converted into a raster, then an ascii grid file for entry into E2, which recognizes its spatial reference. The stream network was manually drawn on top of the subcatchments using non-spatially referenced links and nodes.

- **Functional units** must be identified upon initial construction of the E2 model and cannot be altered thereafter. Functional units are typically based on **land use** and associated hydrologic behaviour. Based on land use data obtained from Queensland DNRW, the land is predominantly grazing. With no data to distinguish behavioural differences across the Comet catchment, land use was determined to not be influential or required in model development. Therefore, the model uses only a single functional unit covering all areas.

- One of the challenges encountered in building the E2 model was loading the input **rainfall** files into the model. Initially the Comet and Dawson River catchment models were developed using SILO gridded rainfall data. Daily gridded rainfall files (0.25 degree cell size which is approximately 28km x 28 km) were purchased from SILO through BOM. Daily files were available from April 1997 through mid-February 2008. URS utilized a 10 year calibration period from April 1997 through March 2007 with subsequent months providing a validation period. The publicly released version of E2 is unable to process the gridded files directly. Therefore URS created an automated process to convert all grids to Lambert Conformal Conic projection, then calculate zonal statistics (an area weighted average) over all cells within a given subcatchment to produce an input rainfall file for each subcatchment containing a time series of daily rainfall. The input rainfall file was in space delineated text (.sdt) format in the form 'year month day value'.

  During the calibration of the Comet and Dawson River catchment models it was found that significant variations existed between the gridded rainfall input and observed discharge at the gauges, which prompted a more thorough investigation into the accuracy of the input rainfall data. A comparison was made between gridded rainfall data and point data from rainfall stations located within the respective catchments. Despite both data sets being sourced from the Bureau of Meteorology, the differences in rainfall were drastic. It was decided to construct a new E2 model replacing the gridded rainfall input with the point data rainfall.

  Approximately 100 rain gauging stations within and around the Comet and Dawson River catchments were used to generate rainfall input files for each subcatchment. Where multiple gauges were available within a single subcatchment, the rainfall observed at these gauges was averaged to produce a single rainfall input for the catchment. Where no gauges existed within the subcatchment, rainfall data from the nearest gauges were used. Where there were missing days for a given gauge, data was infilled from adjacent gauges.

  The results from E2 were exported into Excel to compare (1) E2 model with point rainfall input, (2) E2 model with SILO rainfall input, and (3) E2 model with observed discharges at the lower Comet and Dawson River catchments river gauges respectively. Basic findings were that with minimal preliminary calibration, hydrographs were generally better aligned with point rainfall input rather than SILO rainfall input, with the E2 model better matching the peaks and rise and fall. The overall conclusion is that the point rainfall data better reflects the discharge data at Comet and Dawson River catchments than the SILO gridded data.

It was therefore decided to develop the Balonne-Condamine catchment model using the point rainfall data as inputs. In all 53 rainfall gauges around Balonne-Condamine were used to generate a rainfall input file for each subcatchment. However, as was found modelling the neighbouring catchments, there are still limitations in the quality of the hydrologic model due to the averaging of the rainfall data over multiple gauges, the necessity of using gauges outside of the subcatchment and due to many of the rainfall records being incomplete.

- A single **evaporation** input file was applied across the entire catchment based on the recording station at Roma Airport with gaps filled by data from the next nearest stations.
- In the entire Balonne-Condamine catchment there exists records for 103 continuous **discharge** gauging stations, however many are no longer operational. Four gauging stations are present with records between 1975 and 2006 within the areas Santos has been granted exploration or production licences. Upstream of the study areas, the Balonne-Condamine River system is heavily regulated. It is therefore not possible to accurately model natural stream flow along the Balonne River using the observed records due to the regulation of the river system caused by the dams. This limited the available data to gauges at to two locations. The gauge names, IDs and years of data used in the development of the E2 model are as follows:
  - Yuleba Creek at Forestry Station (422219A) – 1/1/1975 to 31/12/2006
  - Bungil Creek at Tabers (422210A) – 1/1/1975 to 31/12/2006

  Some of this data was initially presented in an hourly time step and occasionally multiple daily spot times. The processing of this data into a daily time step required specific VBA looping macros in Excel. Discharge data was used to calibrate the water balance model. Neither of the gauges records were complete over the 32 years of rainfall input being applied. Gaps in the data ranged from several days to many months. E2 does not allow for gaps in the input data nor gap indicators. Gaps spanning a single day were infilled by interpolation to create a continuous record which could be used in E2. During longer periods of gaps where interpolation is infeasible, it was decided to infill the records with zeros and to disregard these periods during calibration.
- Continuous daily or hourly electrical conductivity data was not available from any NRW stream gauging station within the study area of the Balonne-Condamine catchment. Therefore salinity modelling is dependant on the various spot monitoring water quality samples from NRW and URS sampling. Electrical conducitivites were converted into salt concentration (mg/L) using a conversion factor of:

  EC (µS) x 0.67 = salinity (mg/L) (NRW fact sheet: *Measuring salinity,* 2007)

URS has also been engaged in a program of water quality monitoring within the study area for this and other related studies. This data will be used to further refine the models next year. Background salinity levels were based on various borehole data in the study area.

A.3 Model Calibration

A.3.1 E2 Calibration Tools

E2 contains a separate calibration tool that can be used to calibrate separate aspects of the model. Four types of calibration tool are available:

- Subcatchment flow – to calibrate the water balance models
- Link flow – to calibrate flow routing
- Subcatchment constituent – to calibrate constituent generation and filter models
- Link constituent – to calibrate the in-stream constituent models

Within the calibration process, the catchment may be cropped to allow calibration of sub areas such as groups of subcatchments. This is intended to allow different parts of the catchment to be calibrated separately based on the location of gauges, dams etc.

Unfortunately, the calibration tool within E2 is manually very intensive, requiring upwards of hundreds of parameters to be assigned before the automatic processors take over. For example the Balonne-Condamine catchment with 40 subcatchments (20 main subcatchments plus the 20 small nodes necessary for discharge injection) with one functional unit and the 8 AWBM parameters would require 320 separate manual inputs (40x1x8=320). Further, after an initial run it was found that the automatic calibration was not sufficiently quick or accurate enough. A manual approach to calibration was taken for the final refinement of the E2 model.

A.3.2 Rainfall Runoff Library (RRL)

After an initial attempt to calibrate the water balance in E2 yielded poor results, research indicated that some additional software might provide a more detailed set of tools for calibration. The Rainfall Runoff Library (RRL), also available from the CRC for Catchment Hydrology as part of the catchment modelling toolkit (www.toolkit.net.au/rrl), was utilised. The software contains 5 different Rainfall-Runoff models (including the AWBM) along with 8 calibration optimisers and 10 objective functions. Unlike E2, the use of the calibration optimisers largely automates the process so that many calibration iterations can be run without the need to constantly input parameter values.

The model differs from E2 in that it is a lumped model (it has only a single surface) and therefore is not able to model spatial variation in catchment characteristics such as changes in rainfall or runoff characteristics, or able to account for lag. It is therefore most useful on smaller catchments without upstream inflows. Reference is often made in literature of the advantages of water balance model calibration in the RRL due to its advanced functionality (e.g. Xu and Argent, 2005).

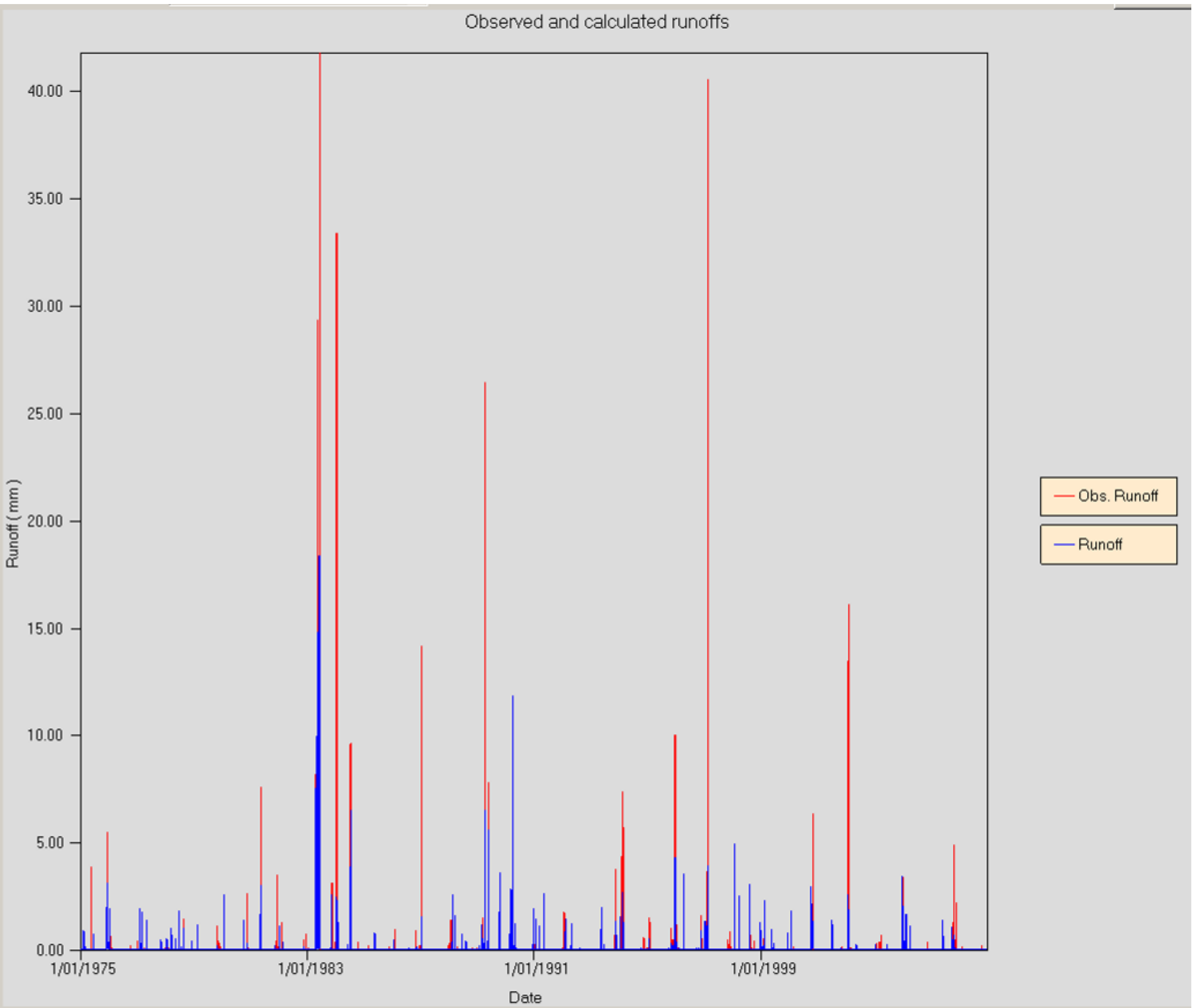
Because RRL is a lumped model, it only requires a single rainfall file as well as an evaporation record and an observed flow record for calibration. Catchment area is also required. The rainfall file initially used was simply created by averaging the existing rainfall files. Because RRL only allows headwater catchments to be modelled (an observed flow cannot be assigned as an input to a subcatchment), its usefulness is limited to providing an initial starting point on which to begin further refinement.

The choice of calibration optimiser came down to the best performing one - the shuffled complex evolution (SCE-UA). The objective function was again the Nash-Sutcliffe coefficient of efficiency (CE). The initial results were far more promising than default parameters in E2. The combination of the calibration optimiser to run several hundred iterations plus the ability to manually adjust the parameters with real-time results quickly enabled CE to be achieved on a daily time step.

Both continuous stream gauge locations (Bungil and Yuleba Creek) are stream headwaters and can therefore be modelled in RRL. However, Yuleba Creek with twice the catchment area of Bungil Creek (Bungil Creek at Tabers ((710 km^2)) and Yuleba Creek at Forestry Station ((1,475 km^2))) is less suitable due to the extra surface water routing. Due to its higher suitability, initial attempts were focused on the Bungil Creek catchment.

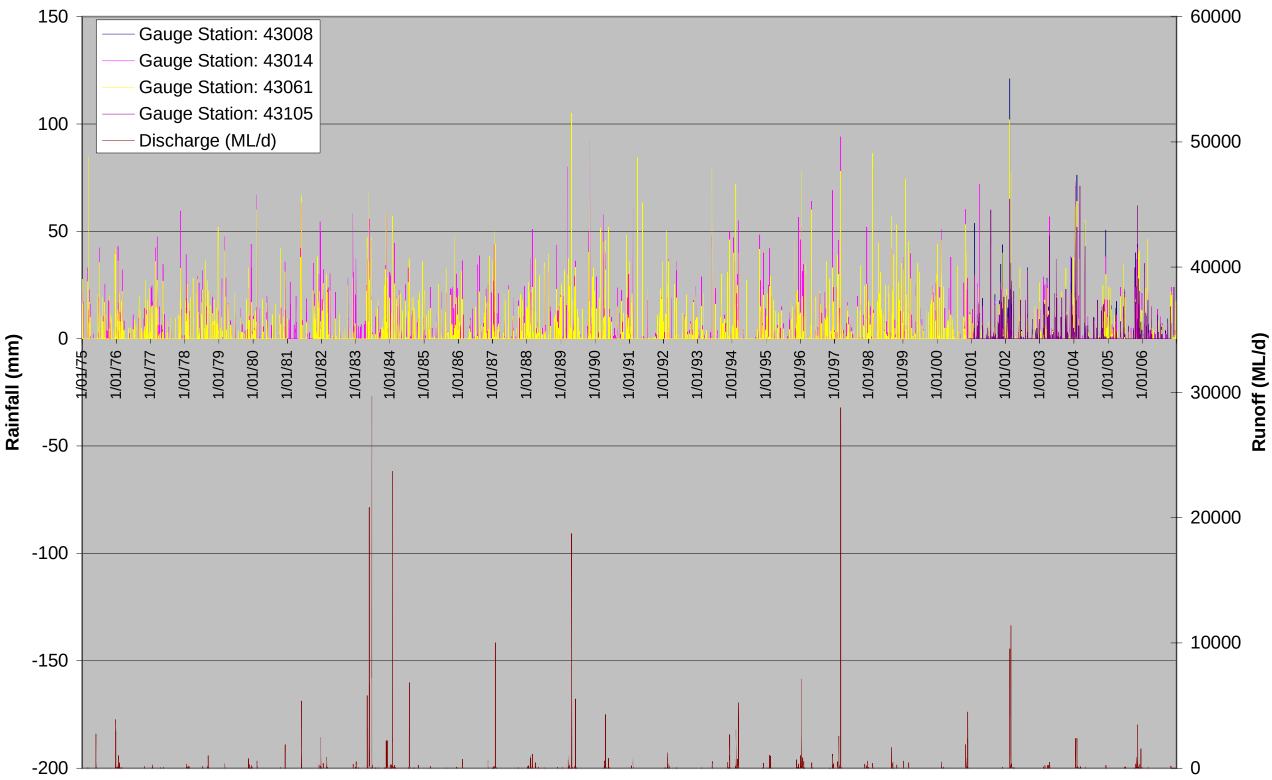
Attempts to calibrate the Bungil Creek catchment using the RRL auto calibration feature yielded poor results. Typically the modelled runoff was found to be under predicting during large runoff events, missing many of the smaller events and introduced many false positives. Replacing the RRL calibrated parameters with typical AWBM values that were used in the successful calibration of both Dawson and Comet catchment did not improve the correlation between the modelled and the observed runoff. A comparison between the observed flow at Bungil Creek and the modelled flow is show in Figure A-1.

Figure A-2 RRL Flow Auto-Calibration at Bungil Creek



Due to the poor calibration at Bungil Creek, attention was turned to the rainfall data. Knowing the issues caused by using SILO rainfall data, a comparison of the rainfall gauges nearest Bungil Creek catchment and the runoff recorded at the catchment outlet was undertaken. Of the nearest four rainfall gauges, there was found little correlation between the rainfall events and the volume of runoff generated, casting doubt on the accuracy of the Bungil Creek runoff gauge. The comparison between rainfall and runoff is shown in Figure A-2, note that rainfall and runoff are shown on separate axis to isolate it from the noise in the rainfall gauges. Due to the dispersed nature of the rain gauging stations, only one of the rainfall gauges used in the development of the Bungil Creek rainfall input file was located within the catchment. Further, this gauge was non-operational until 2001. However, the other three gauges were located close to, but outside of the catchment. This could account for the poor calibration, yet all four of the gauges report similar timing and magnitude of rainfall events. In addition when the model was run using only rainfall and runoff data since 2001 there was no significant increase in calibration results. There was a slight increase in CE, however this was to be expected when modelling specific events, and certainly were not indicative of using only the rainfall gauge within the catchment proper.

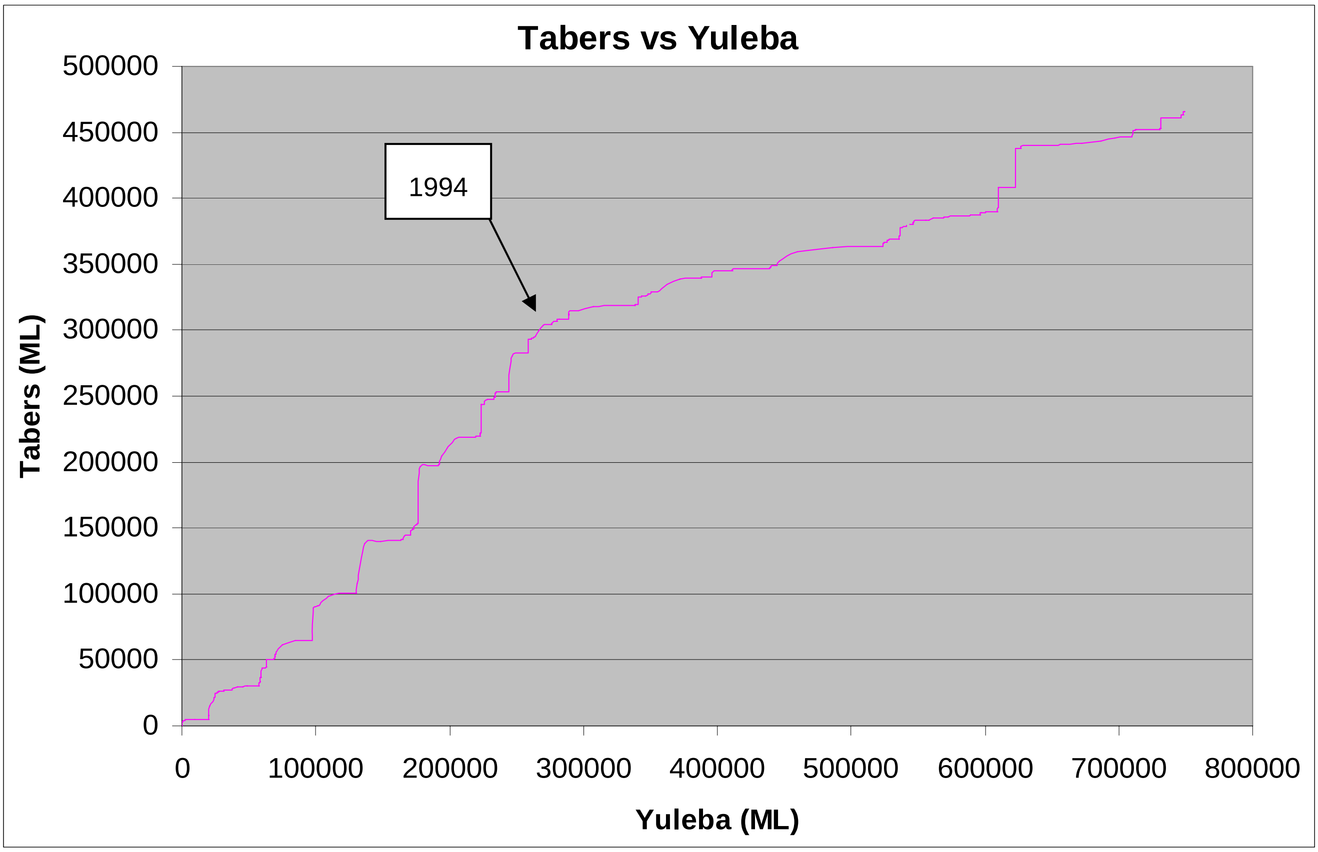
Figure A-3 Rainfall Gauge Data vs Runoff at Bungil Creek



Due to the uncertainty and suspect nature of the Bungil Creek discharge data, it was decided to focus attention towards Yuleba Creek in the hopes of applying the AWBM parameters for Yuleba Creek throughout the Balonne-Condamine catchment. Whilst investigating possible explanations for the poor calibration at Bungil Creek a cumulative mass graph comparing Bungil and Yuleba Creek discharge was created, shown in Figure A-3. From inspection of Figure A-3, a noticeable change in slope of the cumulative mass graph occurs during 1994. This often indicates a change in the way with which the discharge measurements were taken. A change is often implemented if an error is recognised in the rating curves used to convert depth of flow in a stream with discharge. To identify which gauging stations rating curve was modified it was necessary to produce cumulative mass graphs comparing Yuleba and Bungil Creek against discharge from the Utopia Downs gauge in the Dawson catchment. By inspecting the different graphs it was found that Yuleba was the gauge that had a modified rating curve.

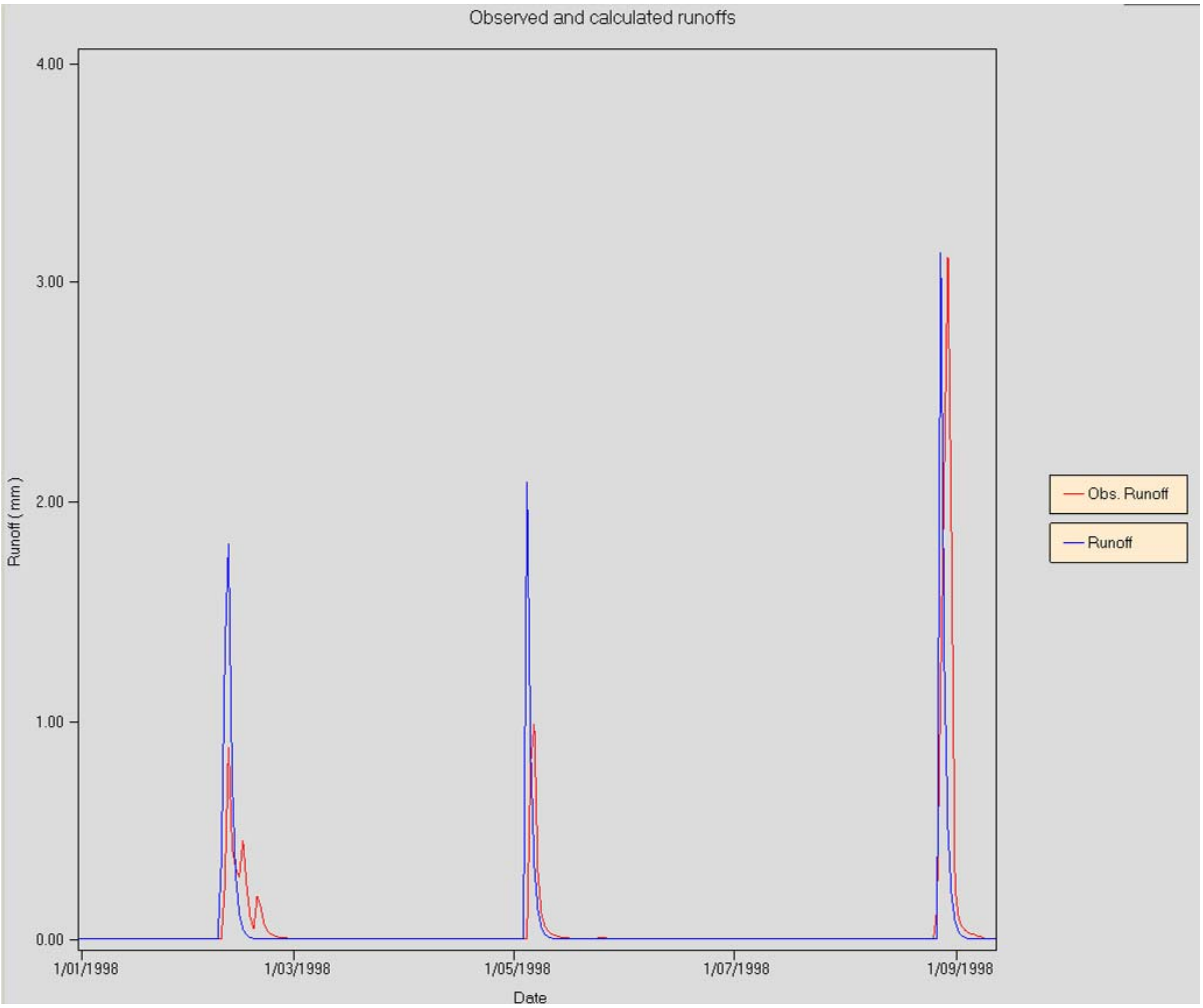
Within RRL, AWBM parameters that were found to be typical within the Dawson catchment were applied to the Yuleba Creek model. Running these parameters over the complete 32 years of data produced a CE of 0.363. When the same parameters are run over the period 1/1/1975 to 31/12/1993 a CE of -0.07 was produced. Finally the model was run over the period 1/1/1994 to 31/12/2006 (i.e. after the change in slope) the model resulted in a CE of 0.677. Therefore it was decided to use stream flow data from Yuleba from 1994 onwards due to its better fit with typical AWBM parameters used in the Dawson and Comet catchments. Further, as AWBM parameter were found be closely aligned with those in Dawson and Comet, and within those catchments the parameters were found to be relatively uniform, provided some confidence in applying one set of parameters throughout the Balonne-Condamine catchment.

Figure A-4 Cumulative Mass Graph



Modifying the AWBM parameters within RRL produced a slightly higher CE value, however through visual inspection of specific events, it was found that the events were consistently predicted earlier than they were observed. This observation signified that the RRL was inadequate of achieving better calibration due to its lack of routing options. A sample of the RRL Yuleba Creek results showing the models lack of routing is shown in Figure A-4. Further modelling of the Yuleba Creek catchments was undertaken in E2 so that more advanced routing of the flow could be achieved.

Figure A-5 Yuleba Creek Specific Event RRL Runoff Results



A.3 Quality Assurance of E2 Flow Modelling Package

Model development for the three catchments in this study began with the Dawson River catchment, which was used as a pilot study area before developing the E2 models for the Comet River and Balonne-Condamine catchments. Early in the model development, significant discrepancies between observed and modelled flow in the Dawson catchment created uncertainty regarding the capabilities of the designed E2 models to replicate current conditions in the Dawson River catchment. Subconsultants from HydroTasmania were contracted to replicate the Dawson hydrologic model using Kisters Modelling Hydstra software which they've used extensively to model approximately 70 catchments around Tasmania.

The comparative exercise proved interesting and useful. First, it was observed that a key parameter in Hydstra model calibration is the upper limit on baseflow, while E2 does not provide a variable for adjusting or limiting baseflow, thus seemingly allowing for infinite groundwater storage. Secondly, Hydstra is able to apply seasonality on soil stores, whereas E2 parameters are limited to a single number, applied throughout the entire time series.

In a comparison between E2 and Hydstra models created with identical parameters, the models produced very similar results for a single subcatchment (same peaks, same capture of events, slightly different recession curves). However, when complexity was added in modelling the entire Dawson catchment (22 subcatchments), discrepancies became more apparent, suggesting that E2 fell short of accurately representing channel routing.

They came to the same conclusion, namely that the model can be calibrated well for individual events but the parameters remain event-specific; they also achieved similar degrees of model fit and obtained similar parameter values for the AWBM.

Both models severely underestimated flow volume for many events, which prompted a more thorough investigation of the input rainfall data. Even if the peaks could be matched with rising and falling limbs, it would be impossible to “create” additional volume. With dogged differences between rainfall and observed discharge at the Taroom gauge, it is difficult to fathom model replication of observed conditions.

It should be noted that both Dawson models were produced using SILO rainfall data which was later proved to be of questionable quality, showing surprising differences from the point rainfall data also sourced from BOM. E2 models were reconstructed using point rainfall gauge data, which resulted in a much better calibration. A Hydstra model utilising point rainfall gauge data was never built.

Salinity Model Development

Appendix B

Salinity Model Development — Appendix B

B.1 E2 Limitations

The original plan was to model salinity in conjunction with flow using E2; however, many limitations rendered E2 unfit for this purpose. Event Mean Concentration/Dry Weather Concentration (EMC/DWC) was identified as an appropriate constituent model to capture high salinity in low flow and low salinity in high flows. The initial approach to apply the EMC/DWC model to the existing stream network was inadequate due to the fact that the model type is intrinsically linked to the Rainfall-Runoff model applied to each functional unit. This means that predicted salt concentration would be dependent on the amount of runoff generated by the water balance model. While this is acceptable for the purpose of generating background salinity levels, it would not be appropriate for the purpose of modelling fixed discharges from CSG wells.

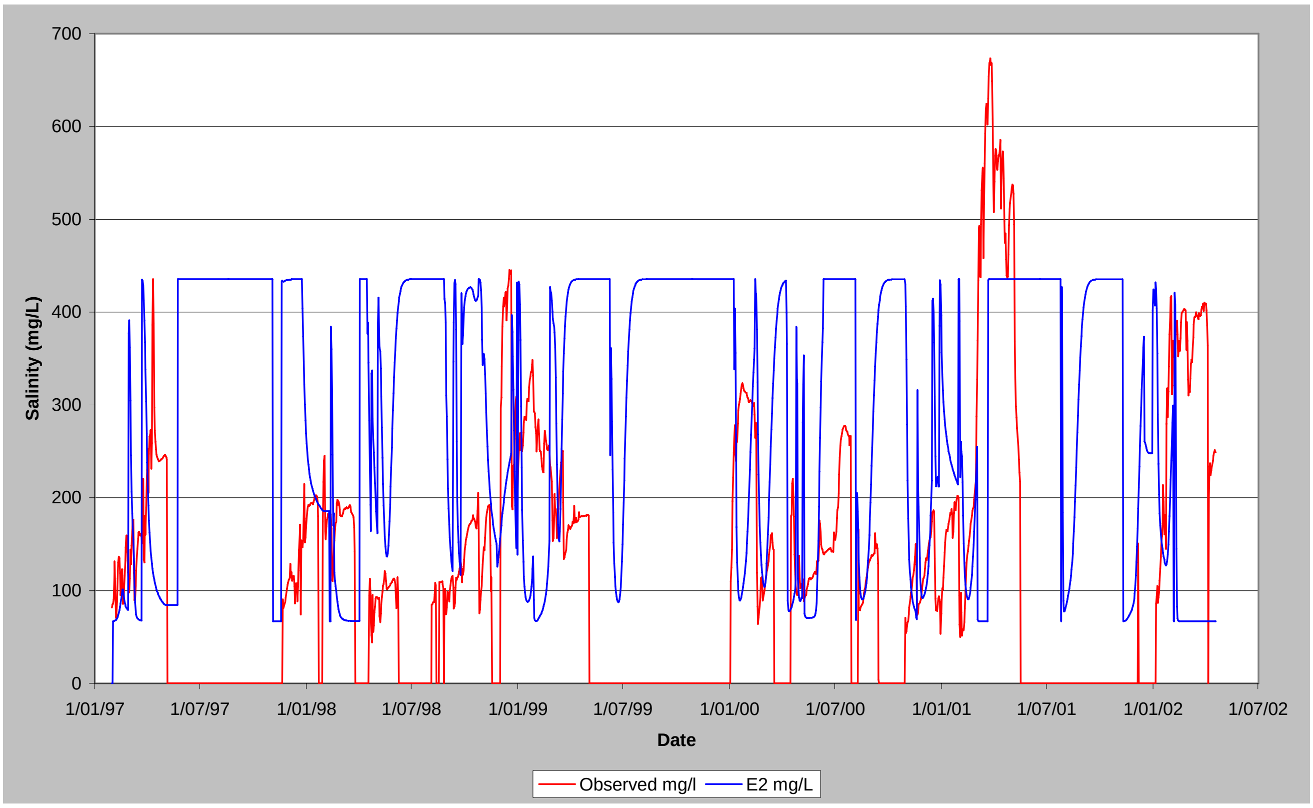
Innovative design was used to trick E2 into correctly modelling fixed discharges from the CSG wells. Ultimately, an additional catchment of nominal area (less than one square kilometre) was added within each subcatchment. This was necessary to create a node upon which to apply input flow and salt concentration representing well discharge. This node was part of the link and node network, but served only as an input to the catchment within which it resided. All wells within the subcatchment were modelled by a single node.

The second incongruity was in the logic of the EMC/DWC model itself, which is linked to three parameters of the AWBM Rainfall-Runoff model (BFI, Kbase, and Ksurf) rather than flow. If all flow is directed to Kbase, E2 flatlines at the DWC concentration. Similarly, if all flow is directed to Ksurf, E2 flatlines at the EMC concentration. If the flow is split between equal Kbase and Ksurf using the BFI parameter, E2 flatlines at an average of the EMC and DWC concentrations. Where Kbase and Ksurf differentiate from each other, E2 fluctuates inconsistently with flow and observed salt concentrations.

A third complication is that E2 calibration of salinity requires adjustment of AWBM parameters, which would inherently alter the calibration of flow. Preliminary calibration efforts without regard to the effect on flow suggested that E2 would not effectively align to observed data. Overall, E2 modelling of salinity was neither representative nor defendable.

A comparison of the observed and E2 modelled salt concentration at the Comet River at AMTD 17.2km gauging station (Comet River Catchment) is shown in Figure B-1.

Figure B-1 E2 (blue) and Observed Salinity (red) at Comet River



B.2 Model Sophistications

A basic empirical algorithm was developed to replicate observed salt concentration trends. When the flow is zero, the salt concentration is assumed to be zero. The model is based on a minimum and maximum salt concentration with fluctuation based on flow levels. When flow equals or exceeds a selected high flow, the model triggers reset to the minimum salt concentration. Salinity is expected to decrease in high flow and increase in low flow. The amount of daily incremental change in salinity was determined based on the rates of increase and decrease of observed salinity such that the final algorithm best fits the observed salinity curve.

Starting with a simple algorithm, three different modelling sophistications were trialled including (1) introduction of seasonality, (2) a ramp from a first maximum concentration to a second peak concentration, and (3) salinity responsive to flow flux.

Seasonality was noticed to be particularly relevant for Taroom, where many of the surges in salt concentration occur annually during a three month period from March to June. A simple extension of the basic algorithm allows the salt concentration to be capped at a higher maximum during these months. Seasonality appeared less relevant at Utopia and other stream gauges. Seasonal salinity model parameters (Table B-1) include three flow levels at low, medium, and high flow. An incremental increase is applied to salinity between low and medium flow while an incremental decrease is applied to salinity between medium and high flow.

The ramp approach appeared to apply more consistently across gauges, and is based on the premise that for decreasing flow, one incremental increase rate is applied up to a preset 'ramp change concentration' followed by a second incremental increase rate applied above the 'ramp change concentration' (Table B-2). A third incremental rate applies when flow increases, thus reducing the salt concentration by a fixed amount each day. This method tends to overestimate salinity over extended time periods (conservative) while capturing more of the spikes in salt concentration.

The flow flux sophistication was an attempt to make salinity estimates more sensitive to changes in flow. The flow flux salinity model parameters (Table B-3) also include three flow levels at low, medium, and high flow. Below the low flow level, salt concentration was incrementally increased at a set rate. Between low and medium flow, salt concentration was incrementally increased when the flow dropped from the previous time step, while it was incrementally decreased when the flow increased. Between medium and high flow, salt concentration was incrementally decreased at a set rate.

Table B-1 Seasonal Salinity Model Parameters

Max Concentration (Jul-Mar)	200	mg/L
Max Concentration (Apr-June)	250	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	345	ML/d
Medium Flow	170	ML/d
Low Flow	25	ML/d
Salinity Decrease between medium and high flow	1	mg/L per day
Salinity Increase between low and medium flow	5	mg/L per day

Table B-2 Ramp Salinity Model Parameters

Max Concentration	375	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	100	ML/d
Ramp Change Concentration	200	mg/L
Flow Decreases - Salinity Increase - Below Salinity Ramp by:	10	mg/L per day
Flow Decreases - Salinity Increase - Above Salinity Ramp by:	2	mg/L per day
Flow Increases - Salinity Decrease by:	1.5	mg/L per day

Table B-3 Flow Flux Salinity Model Parameters

Max Concentration	375	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	500	ML/d
Medium Flow	200	ML/d
Low Flow	80	ML/d
Between medium and high flow - Salinity decrease by:	50	mg/L per day
Below low flow - Salinity increase by:	1.2	mg/L per day
Between low and medium flow - flow decrease - Salinity increase by:	10	mg/L per day
Between low and medium flow - flow increase - Salinity decrease by:	1	mg/L per day

Modelling of Flows, Temperature and Salinity – Comet-Brown River

Appendix K

REPORT

Hydrologic Modelling of Comet River Catchment

Prepared for

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21st January 2009

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Date:	21 January 2009
Reference:	Hydrologic Modelling of Comet River Catchment
Status:	Final

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Appendices

Introduction Section 1

Associated water is typically a by-product of Coal Seam Gas (CSG) development and its management is an integral aspect of the Gladstone Liquid Natural Gas (GLNG) project. Santos is considering a range of water management options including evaporation, stock watering, discharge to grade, treatment, injection, irrigation, and beneficial reuse. However, the focus of this report is on discharge to grade and potential changes in flows and salinity that may arise instream under a range of associated water discharge scenarios. This information will be used within an ecological risk assessment framework to assess risks to environmental values identified in the study area.

Study Area

The area of study includes three catchments: Upper Dawson River, Comet River, and minor tributaries of the Upper Balonne River. The Upper Dawson River and Comet River catchments drain to the Fitzroy Basin and ultimately to the Great Barrier Reef Lagoon. The Balonne River is part of the Murray-Darling Basin ultimately discharging via Lake Alexandrina to the Gulf of St Vincent in South Australia.

The catchments are in various states of CSG production, appraisal or development.

This report focuses on the Comet River catchment from its headwaters to its outlet (**Error! Reference source not found.**).

Modelling Approach

Hydrologic modelling is needed to assess the impacts of discharges on the local and regional environment. The model will be used to assess impacts of CSG production on flow regime and salinity concentration.

Various options are available to model the hydrology and water quality of the catchment. The two main candidates considered were IQQM (Integrated Quantity and Quality Model) and E2 both of which are utilised in Queensland. E2 was chosen as the main modelling platform for flow and salinity. Due to E2 salinity modelling limitations, an empirical algorithm was ultimately developed to model salinity.

Report Structure

The report presents the calibration of hydrologic and salinity models in the first two chapters. Various associated water management scenarios are then formulated and modelled. Results are presented in the final chapter.

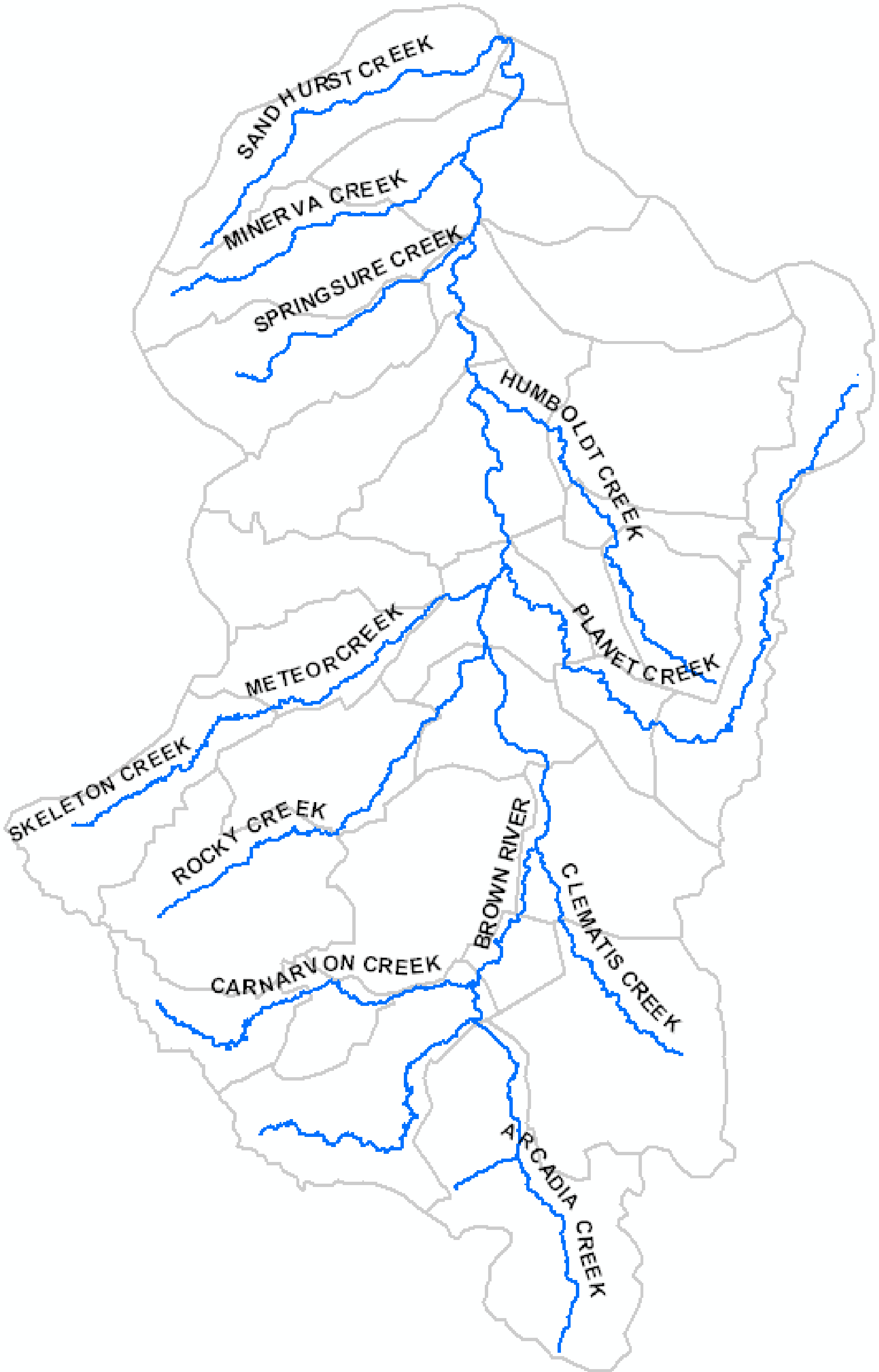

Figure 1-1 Major Streams in the Comet River Catchment

Modelling Objectives — Section 2

The modelling objectives are:

- Develop calibrated models of flow and salinity;
- Create a flow model that is consistent with models currently used in Queensland (IQQM and E2) to enable later assessment of regional effects;
- Investigate alternative associated water discharge options;
- Identify the range, frequency, and extent of flow and salinity impacts from discharge of associated water to grade; and
- Provide information to support ecological risk assessment.

3.1 Background

The basic architecture of the E2 modelling framework consists of a subcatchment-node-link system, as described in Appendix A. Alternative water balance models can be selected for use within E2. For this project the Australian Water Balance Model (AWBM) was selected as the rainfall-runoff model since it is widely used and was originally developed in Queensland. A daily time step was utilised for modelling. The AWBM model utilises eight model parameters representing three conceptual water stores with area representation, surface and baseflow recession constants, and a baseflow index. Further explanation of the AWBM model and its parameters are provided in Appendix A.

3.2 Model Assumptions

3.2.1 Subcatchment Delineation

The initial model structure is based on key subcatchments to allow broad-scale assessment of water management options. The Comet River catchment (16,457 sq km) was subdivided into 31 subcatchments based on major stream confluences and particular areas of interest, such as stream gauge locations. A node exists at the outlet of each subcatchment. Additional inputs or outputs can be applied at each node. The 31 delineated subcatchments (the nodes are not shown to improve legibility) along with the stream gauges are presented in Figure 3-1.

3.2.2 Network Creation

A GIS shapefile was used to represent the subcatchments, and the stream network was drawn in manually within E2. While catchment area is calculated within E2 for the purpose of runoff generation, there is no explicit spatial representation of the stream network. The E2 flow path network is shown in Figure 3-2.

3.2.3 Flow Routing

The Comet catchment is a large catchment (16,457 sq km). Runoff from the furthermost reaches can take considerable time before it is recorded at the outlet of Comet River. E2 offers several routing methods to transfer the flow through the links. These range from simple lag flow where flow is delayed with no change to the shape, to more sophisticated routing methods which can smooth the flow of the hydrograph accounting for catchment and reach storage effects. In the development of the Comet catchment, the method of routing selected was Muskingum without losses.

The method requires the input of two factors, K and X in Muskingum Equation;

$$S = K[X \times I + (1 - X) \times O]$$

Where:

I = inflow rate;

O = outflow rate;

K = the Muskingum delay parameter, units are seconds and represents the delay of flow; and

X = the Muskingum attenuation parameter, which determines the relative weighting of inflow and outflow from the reach

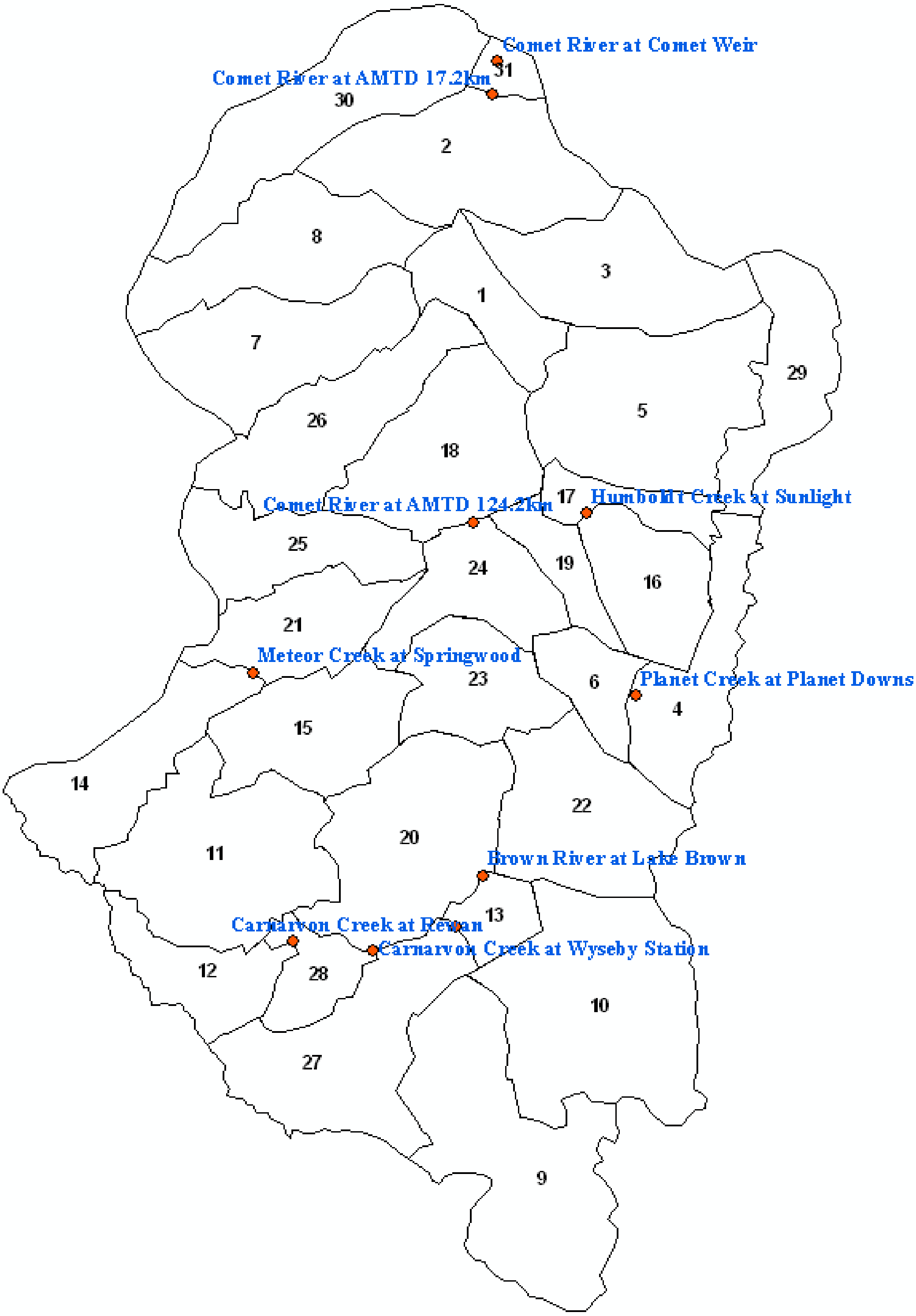

Figure 3-1 Subcatchment Delineation and Stream Gauge Locations

Figure 3-2 E2 Subcatchment Network

3.2.4 Simulations

E2 has the ability to have multiple model simulations active at any one time. This allows for easy comparison to be made between the modelled and observed data. For each location where observed data was available a separate model was constructed in order to compare E2 modelled results with observed flow measurements. At the approximate location in the E2 model of the observation gauge, the observed flow data was assigned to an outlet node of a subcatchment.

3.3 Model Calibration

Since there is limited surface flow data for many locations, and the project operates across multiple scales, it is expected that modelling will need to progress from broad calibration to more accurate calibration over time. For initial calibration, the same AWBM parameters were applied across many of the subcatchments. The main reason for this was a lack of information that could inform separate parameterisation as well as to reduce the potential degrees of freedom during calibration.

A separate model was created using the same AWBM parameters throughout the entire catchment. This model did not produce results sufficiently representative of the gauge data. Therefore, variation in the AWBM parameters is considered necessary in a catchment the size of the Comet River catchment.

3.3.1 Objective Function

The selection of an appropriate objective function is an important part in validating the model performance. The choice of function is dependent on the models application and in this case the end purpose of the model is to estimate in-stream salinity levels. These levels are dependent on stream flow and consequently comparison of actual and modelled stream flow is of greatest importance. Boughton (2005) notes that in the common case of water yield analysis the most common validation of model performance is a comparison of calculated and actual monthly totals of runoff. Early studies used the coefficient of determination (r^2) as a measure of agreement however it is becoming increasingly common to now use the Nash-Sutcliffe coefficient of efficiency (CE) where CE is:

$$CE = 1 - \sum_{t=1}^{T} (Q_0^t - Q_m^t)^2 / \sum_{t=1}^{T} (Q_0^t - \overline{Q_0})^2$$

Where:

T = total time modelled

Q_0^t = Observed flow at time t;

Q_m^t = Modelled flow at time t; and

$\overline{Q_0}$ = Mean observed flow.

The value of CE lies between 1.0 (a perfect fit) and -∞ where a value of less than 0 would indicate that the mean value of the observed time series would have been a better predictor than the model (Krause, Boyle and Blase, 2005). A model producing a CE value over 0.7 is considered a reasonable representation of the physical world. Calibration in E2 gives values for both r^2 and CE; these are the only efficiency criteria calculated.

3.3.2 Calibration Tools

E2 contains a calibration tool for flow and constituents based on either subcatchments or links. As explained in Appendix A, the iterative calibration process is cumbersome given the number of links and nodes, each with 8 adjustable AWBM parameters. Automatic calibration was not found to be sufficiently quick or accurate. Therefore, further calibration was accomplished using manual adjustment and regional application of AWBM parameters across the catchment.

The Rainfall Runoff Library (RRL) was also considered and trialled for model calibration but determined too simplistic for a study area as large as the Comet River catchment (see Appendix A for further explanation).

3.3.3 Calibration Period

As described in the data compilation section of Appendix A, rainfall input files from 1974 to 2006 were developed representing 33 years of data, which were available for the calibration process. A strategic method was developed for the calibration of the E2 model. Initial attempts at calibration were focused on ensuring accuracy of the lowest flow events as the model was primarily designed to model salinity, which is at its highest concentration during low flow events. Once a satisfactory level of calibration was achieved the calibration turned to ensuring that high flow peaks, the total yearly runoff and the shape of the hydrograph were well represented.

The AWBM contains storages that are initially empty when the model starts. A warm up period is often required during calibration or validation so that the stores can reach a representative value. This can be done in one of two ways. One method is to exclude the warm up period from the objective function calibration and validation periods (Argent *et al,* 2007b); this is not possible in E2 but can be done in RRL. Another way is to ensure the model calibration/validation period follows a period of low or zero precipitation so that it can be assumed that moisture stores are empty.

While calibrating the model over the entire range of data available is the only way to optimise the results, little indication of the models robustness can be gauged (Argent *et al,* 2007b) i.e. how well it performs outside of the calibration period. It was initially intended to exclude some of the available data from the calibration period to allow for a period of model validation; however, due to the difficulties in calibrating the model it was decided to include as much of the data as possible in the calibration period.

3.4 Results and Interpretation

For meaningful modelling of salinity, a well calibrated runoff model is required. A model producing a CE value over 0.7 is considered a reasonable representation and was the target when calibrating E2. A structured modelling approach was undertaken where the headwater subcatchments with stream gauges were modelled first. Once these areas were satisfactorily calibrated the subcatchments upstream of the next gauging station were calibrated. This was repeated down the catchment, until all subcatchments upstream of the final gauge on Comet River were calibrated.

The largest difficulty encountered in the refinement of the E2 model was ensuring that small rainfall events were not causing excessive runoff. This was deemed a high priority due to the ephemeral nature of the streams in the Comet River catchment for much of the year. To reduce the noise associated with these smaller rainfall events, it was required to set the capacity of the three stores in the AWBM model at or near the maximum advisable levels. Larger than typical AWBM soil capacity parameters were used to simulate catchment storages such as pools of standing water. This assumption was confirmed following consultation with URS employees familiar with the Comet catchment. These storages retard small rainfall events resulting in little to no runoff being recorded on the downstream gauging stations. However, larger rainfall events inundate the pools and significant runoff is measured at the stream gauge stations.

Increasing the storage capacities to better reflect the ephemeral nature of the streams resulted in difficulty matching peaks in high rainfall events and producing the total aggregated runoff being generated by the catchment. As has been mentioned previously, AWBM has three parameters intended to determine the rate at which the base flow store is depleted: BFI, K_{base} and K_{surf}. To ensure that flow remained in the system and that large runoff events were being captured, the parameters were often set such that neither store is depleted over time (except through evaporation), i.e. K_{base} and K_{surf} were set to null.

The third challenge faced by the modelling team was matching the timing of the peaks of runoff events as well as the recession curve following the event. Initially it was attempted to calibrate the routing on a subcatchment-by-subcatchment basis, allocating a value based on the probable length of the stream within the reach. It was found that the routing times were typically short, with routing times ranging between 12 and 24 hours. This arises from the fine delineation of the subcatchments. A single value was applied to the final model of 19.5 hours (70,000 seconds), a time that represented the mean routing time over the entire catchment.

A summary of the calibrated AWBM parameters used in the final calibration are presented in Table 3-1 and the calibrated routing values are presented in Table 3-2.

Table 3-1 Summary of Final AWBM Calibration Parameters

AWBM Parameters	Subcatchments (Refer to Figure 3-1 for subcatchments relative location)						
	9 & 27	13	12	28	11, 14, 15	4, 6, 10, 20, 21, 22, 23, 24, 25, 29	1, 2, 3, 5, 7, 8, 16, 17, 18, 19, 26
A1	0.134	0.134	0.134	0.134	0.134	0.134	0.134
A2	0.433	0.433	0.433	0.433	0.433	0.433	0.433
BFI	0	0	0	0.745	0	0	0.247
C1	50	50	45	50	50	50	40
C2	155	200	150	130	120	190	50
C3	300	500	300	250	180	390	90
Kbase	0	0	0	0.55	0	0	0
Ksurf	0	1	0	1	0	0	1

Table 3-2 - Summary of Routing Parameters

Muskingum Parameter	Estimate
K (Seconds)	70000
X (Unitless)	0

The end result of the calibration was a thoroughly developed model producing a Nash-Sutcliff coefficient of efficiency of 0.73, with a net volume difference of 0.2% between the E2 model and the observed rainfall over 31 years of observed flow available from the Comet River at AMTD 17.2km gauge. Hydrographs and a scatter plot displaying the observed and E2 modelled runoff at the Comet River at AMTD 17.2km gauging station are shown in Figure 3-3, Figure 3-4 and Figure 3-5 for the periods 1974 to 2004 and 1976 to 1979 respectively.

The E2 flow model was confirmed by an external independent peer reviewer (Appendix A).

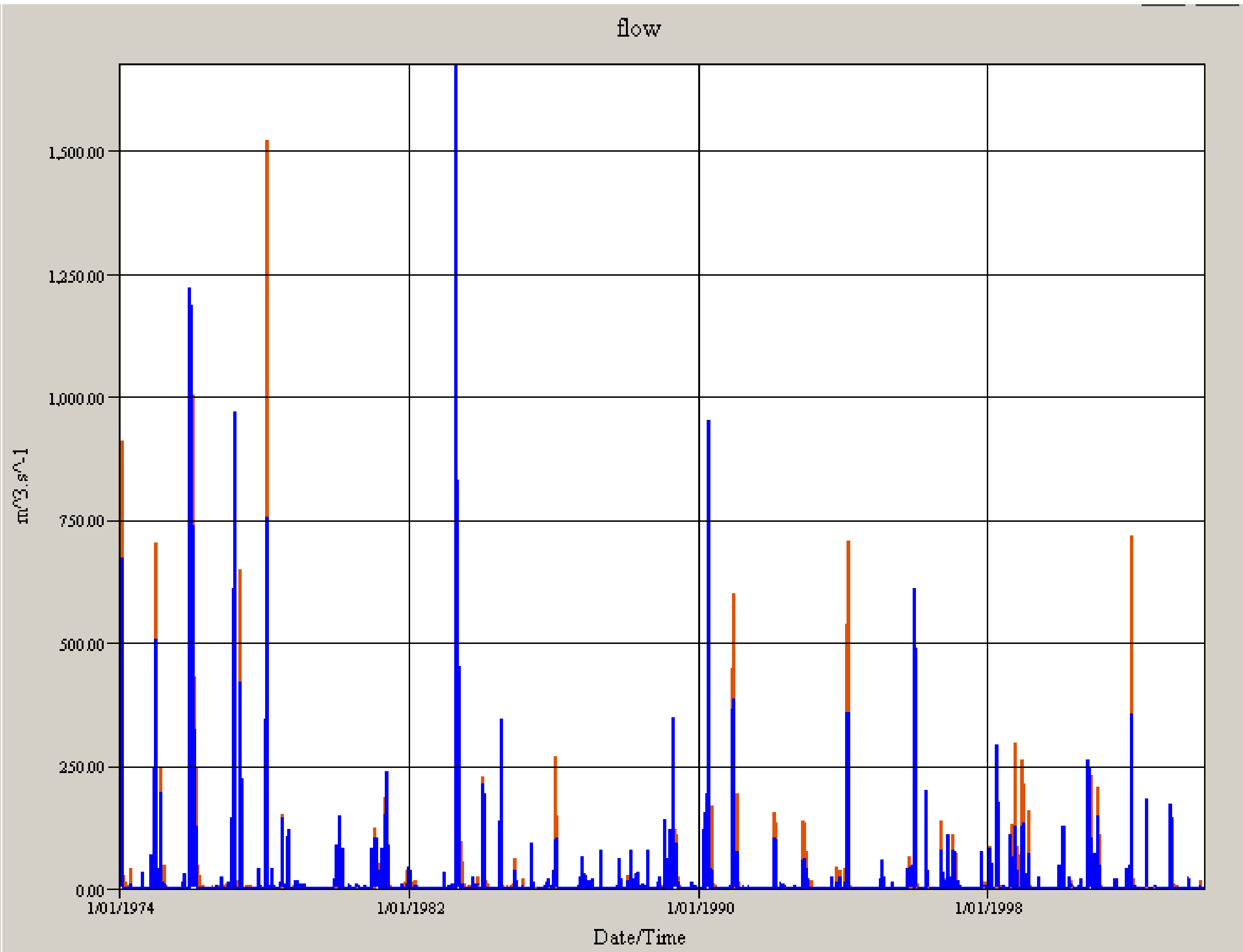

Figure 3-3 – Hydrograph of E2 Modelled (Blue) and Observed (Red) Runoff (1974-2004)

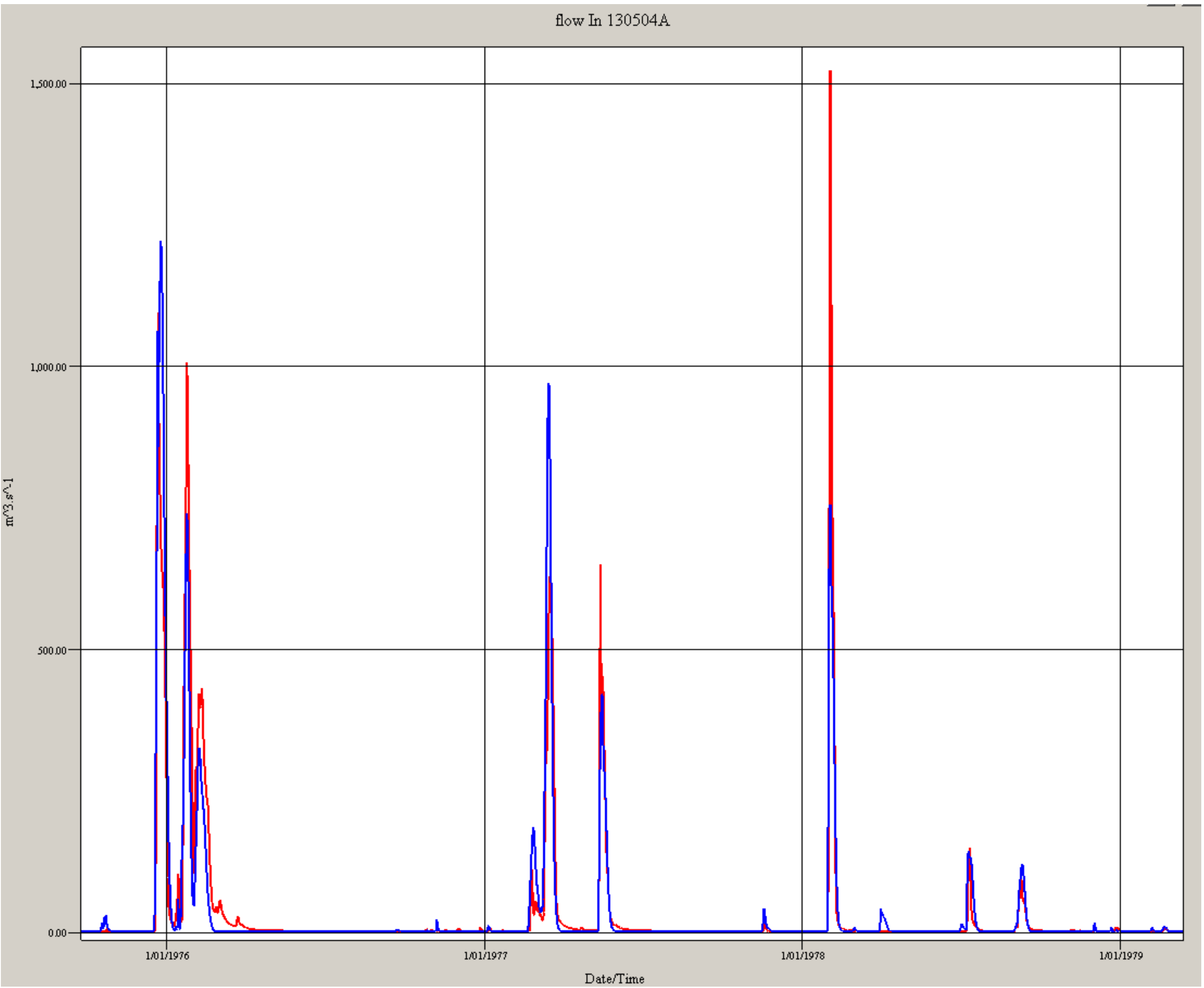

Figure 3-4 – Hydrograph of E2 Modelled (Blue) and Observed (Red) Runoff (1976-1979)

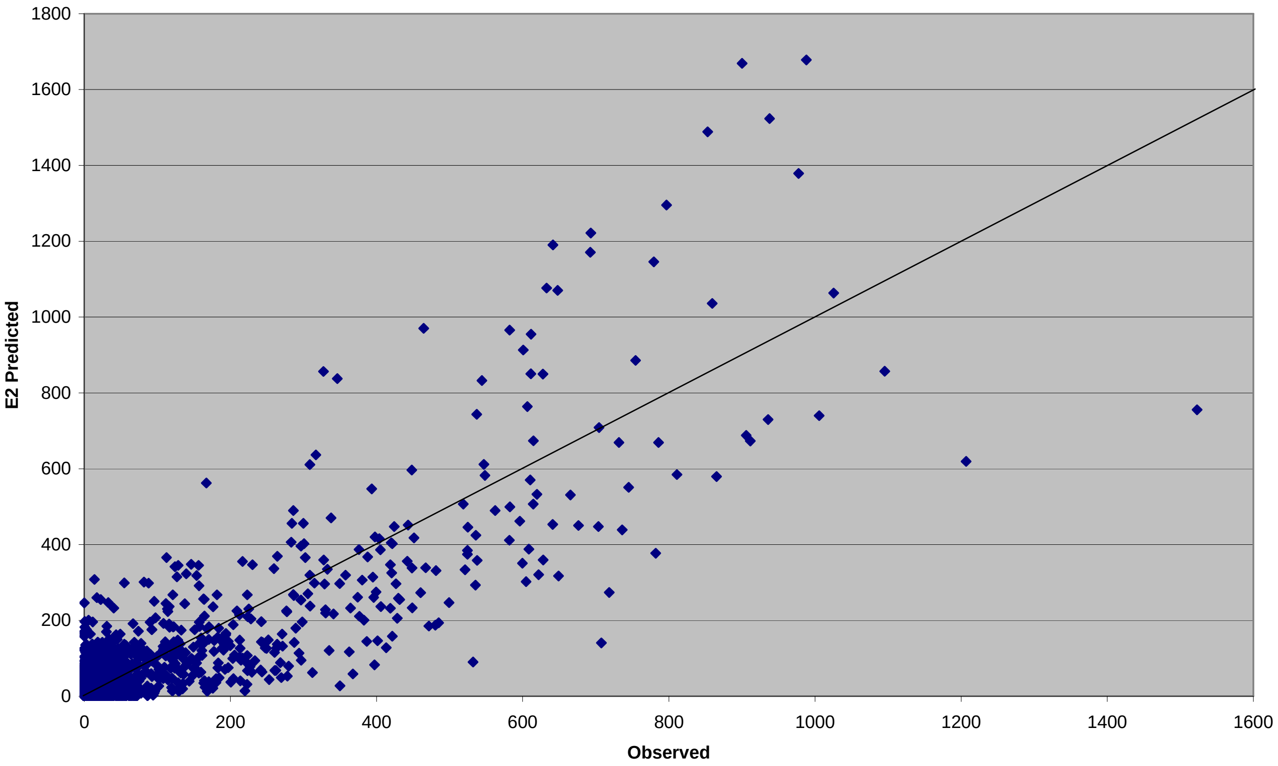

Figure 3-5 – Scatter Plot of E2 Modelled and Observed Runoff (1974-2004)

4.1 Background

Associated water is produced as a necessary by-product of Coal Seam Gas (CSG) production. Associated water has a moderate salinity[1]. The discharge of this associated water into nearby streams prompted the creation of a model to evaluate potential impacts of this elevated salt concentration. Salinity modelling was intended to represent the current conditions, as well as the discharge associated with additional wells to begin pumping in the future, and various management scenarios as described in Section 5.2.

The original plan was to model salinity in conjunction with flow using E2; however, many limitations rendered E2 unfit for this purpose (Appendix C). These limitations prompted URS to develop a simple empirical algorithm to produce representative salinity modelling results.

4.2 Modelling

4.2.1 Model Objectives

The above-mentioned limitations within E2 prompted URS to build a simple algorithm in Excel to produce representative salinity modelling results. The objectives of the algorithm were:

- To apply a simple algorithm consistently across Fairview, Roma, and Arcadia study locations;
- To produce conservative salinity estimates (equal to or minimally higher than observed), attempting to replicate pulses or surges when salinity may be particularly of concern;
- To duplicate current conditions whilst also accommodating additional discharge and salinity from CSG production wells and treatment plants;
- To span the date extent of available flow data, thus extrapolating unknown salt concentrations; and
- To produce a user-friendly interface to evaluate various water management scenarios as described in Section .

4.2.2 Model Data

The basic salinity model was created based on stream flow and observed EC. Where available, observed flow data was sourced from the Department of Natural Resources and Water (NRW) stream gauges for the extent of record. In areas with no stream gauges, E2 modelled flows were used. In the Comet catchment, flow data was used to simulate three discharge locations;

- Comet River at AMTD 17.2km (1974-2004), representing the catchment outlet;
- Comet River at AMTD 124.2km (1974-2007), representing Rolleston; and
- Brown River at Arcadia (1974-1993) and Brown River at Lake Brown (1993-2006) were amalgamated with a scaling factor to represent discharge at Arcadia.

[1] Salinity is typically measured as TDS or indirectly using electrical conductivity (EC) measured at a standard temperature (typically 25 ^{o}C). A linear relationship exists between EC (measured in µS/cm) and TDS (mg/L) for the range of salinities discussed in this report.

Continuous EC data was sourced from the two gauges on the Comet River for the extent of record (1997-2000 at Rolleston and 1997-2002 at the catchment outlet) with additional NRW water quality spot data over a longer time period. Only spot water quality data was available at Arcadia. All collected salinity data was compared to modelled salinity to refine the empirical models, which span the time extent of the flow record.

4.2.3 Model Assumptions

An empirical algorithm was developed to replicate observed salt concentration records. The model is based on a minimum and maximum salt concentration with fluctuation based on flow levels. This is similar to the high flow/low flow concentration model embedded in E2 with additional flexibility to account for the transition between high and low flow salinities.

When the flow is zero, the salt concentration is assumed to be zero. When flow equals or exceeds a selected high flow, the model resets to the minimum salt concentration. Salinity is expected to decrease in high flow and increase in low flow. The amount of daily incremental change in salinity was determined based on the rates of increase and decrease of observed salinity such that the final algorithm best fits the observed salinity curve.

Starting with a simple algorithm, three different modelling sophistications were trialled including (1) introduction of seasonality, (2) a ramp from a first maximum concentration to a second peak concentration, and (3) salinity responsive to flow flux (Figure 4-1). The modelling sophistications are described in Appendix B. Comparison of the three modelling sophistications resulted in selection of the ramp approach being used for all salinity model simulations. The ramp approach sufficiently captures the seasonal surges between March and June at Taroom, and the difference in salinity prediction from the flow flux approach was negligible and the complication was deemed unnecessary and less defensible.

When additional discharge and salinity was introduced from CSG production wells and treatment plants, straight mixing was assumed within a mass balance.

Results of salinity modelling are included in the next section of Associated Water Management Scenarios.

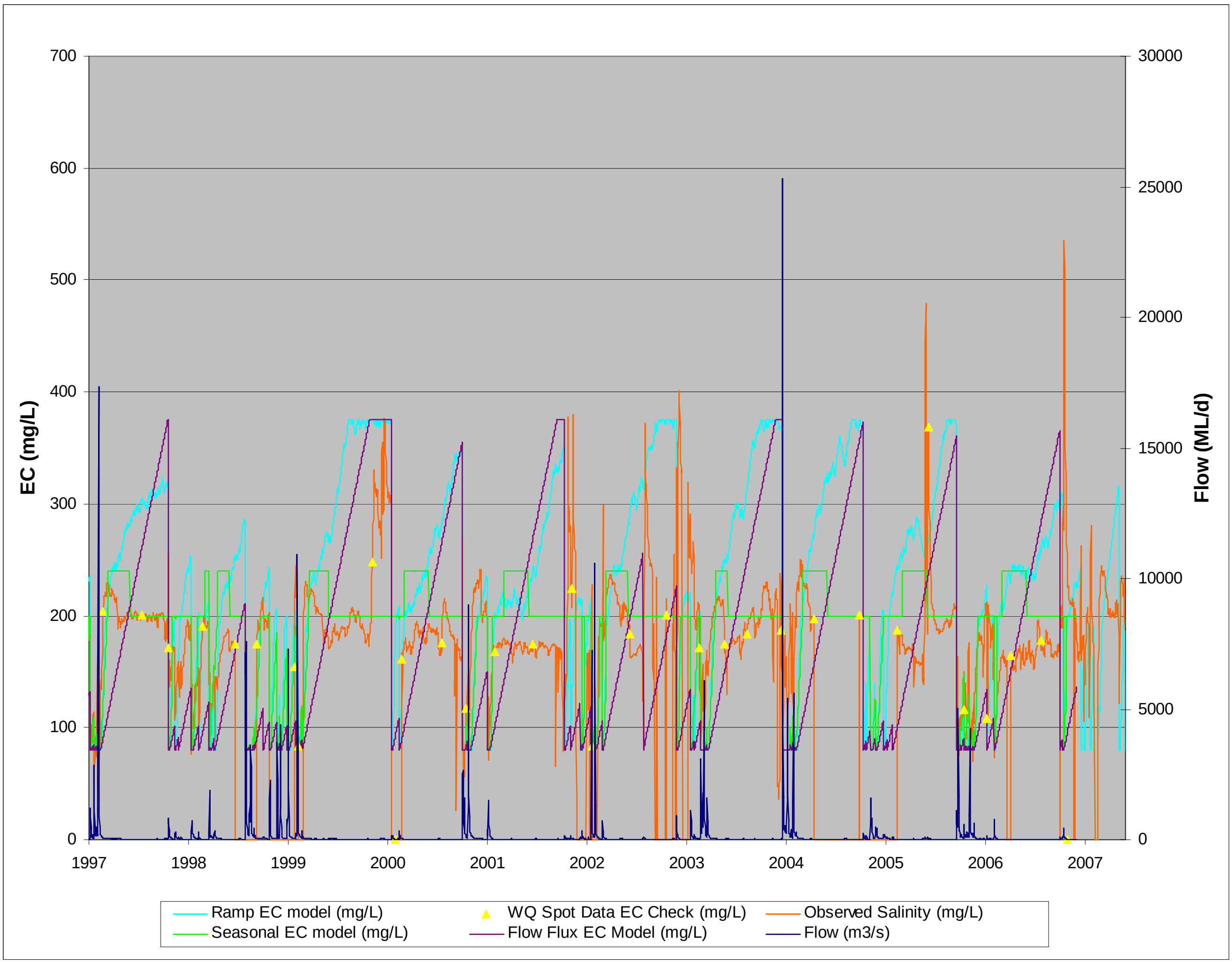

Figure 4-1 Trialled Salinity Modelling Sophistications at Utopia

5.1 Background

Santos recognises that water is a precious commodity and essential for the well being of the local community both now and into the future. After carefully considering the levels of existing and proposed development within the Arcadia Project Area, the imperatives of the international gas industry, and the desires of the local community, Santos has proposed a mix of associated water management options.

It is recognised that the proposed options need to be reviewed within an adaptive management framework that takes into account government initiatives in regional water management and development, changing economics of the gas and water markets, opportunities for regional development, and improved knowledge and science underpinning the extraction and use of associated water. Santos is committed to this regular review as part of its planning processes.

Significant volumes of associated water will be generated over the development life of the Arcadia Project Area. Management options include injection, onsite reuse, stock watering, irrigation, desalination and discharge, and direct discharge.

5.2 Scenarios

To explore the boundaries of any potential impacts of associated water discharge, it is necessary to define modelling scenarios. It is prudent to explore the potential for different points and quantities of discharge within each field as this will provide improved decision making and option analysis. Results can also feed back directly into the overall risk analysis.

It was determined useful to consider three points on each associated water production curve (minimum predicted water production and maximum predicted water production) for each modelling run. The three points identified are 1/3 peak production, 2/3 peak production and peak production. That is, for each point on the curve a constant flow was assumed from the CSG field over the full modelling period and compared with the results of a no discharge scenario. This means that six different flows (1/3 min peak, 2/3 min peak, 3/3 min peak, 1/3 max peak, 2/3 max peak, and 3/3 max peak) were combined with existing flows to assess the impacts for each scenario identified.

In Arcadia, the following four scenarios were considered after consultation with Santos:

- Option 1: Untreated associated water discharge into three points in the catchment allocated one-third of water production each with the three points located in Arcadia, around Rolleston, and at the catchment outlet;
- Option 2: Treated CSG discharge into the same three points in the catchment, each allocated one-third of water production;
- Option 3: Untreated total CSG discharge released at Rolleston via a pipeline; and
- Option 4: Treated total CSG discharge released at Rolleston via a pipeline.
- Modelling

5.2.1 Model Parameters

Flow weighted salt concentration was calculated for the various scenarios from the following equation.

$$C_{mixed} = \frac{Q_1 \times c_1 + Q_2 \times c_2 + Q_3 \times c_3}{Q_1 + Q_2 + Q_3}$$

Where Q_1 / c_1 = observed flow / modelled salt concentration in the receiving stream;

Q_2 / c_2 = direct discharge to grade from CSG well production / salt concentration of direct discharge; and

Q_3 / c_3 = treated discharge from desalination plant / salt concentration of desalination discharge.

Modelled salt concentration was based on the ramp Salinity Model, as described in Section 4.2.3, and detailed below.

If $Q_t = 0$

$c_t = 0$

If $Q_t > Q_{HIGH}$

$c_t = c_{MIN}$

If $Q_t > Q_{t-1}$ (rising limb)

$c_t = c_{t-1} - c_{DECREASE}$

If $Q_t < Q_{t-1}$ *AND* $c_t < c_{RAMP}$

$c_t = c_{t-1} + c_{IBR}$

If $Q_t < Q_{t-1}$ *AND* $c_t > c_{RAMP}$

$c_t = c_{t-1} + c_{IAR}$

Where Q_t = Flow at timestep t;

Q_{HIGH} = high flow trigger parameter;

c_t = salt concentration at timestep t;

c_{MIN} = minimum salt concentration;

c_{RAMP} = salt concentration at which the rate of increase changes;

$c_{DECREASE}$ = rate of salt concentration decrease;

c_{IBR} = rate of salt concentration increase below ramp (IBR); and

c_{IAR} = rate of salt concentration increase above ramp (IAR).

5.2.2 Model Data

Discharge input was extracted from the Arcadia minimum and maximum associated water production curves at the peak levels as well as 1/3 and 2/3 of peak levels. The peak of the maximum associated water production curve is 27.4 ML/d, resulting in 1/3 peak of 9.1 ML/d and 2/3 peak of 18.3 ML/d. Similarly, the peak of the minimum associated water production curve is 1.4 ML/d, resulting in 1/3 peak of 0.5 ML/d and 2/3 peak of 0.9 ML/d (Table 5-1).

Figure 5-1 Future Predicted Associated Water Production in Arcadia

In all scenarios, flow was direct discharge in either a completely treated or untreated state. No case assumed a mixing of untreated and treated associated water prior to release into the streams.

Of the associated water discharged in the treated scenarios, the discharge volume was reduced by 25% of the input volume. This assumption corresponds to the expected losses from the desalination treatment process as brine.

No salinity data was available for associated water within the Arcadia Field. However, based on comprehensive sampling from 56 producing wells in the Fairview project area over the period 2005 to 2007, the average Electrical Conductivity (EC) of associated water was 1,998 µS/cm (TDS 1,338 mg/L). From sampling of 52 production wells within Roma project area between 2006 and 2007, the average EC was 3,438 µS/cm (TDS 2,303 mg/L). Conservatively, it was decided to adopt the salinity of the Roma Field in modelling untreated associated water discharges in Arcadia.

For treated discharge scenarios a target permeate EC of 280 µS/cm (TDS 188 mg/L) was assumed based on replicating the mean background surface water salinity within the Comet River based on 194 spot samples and limited continuous EC data.

Associated Water Management Scenarios

Table 5-1 Flow (ML/d) for Arcadia Scenarios

Scenario	Predicted Production	Direct Discharge	Direct Discharge per Location	Treated Discharge	Treated Discharge per Location	Discharged to Comet River
Scenario 1: Untreated discharge into three points in the catchment allocated 1/3 of water production each with the three points located in Arcadia, around Rolleston, and at the catchment outlet						
1.1	9.1 (1/3 max)	9.1	3.0	-	-	9.1
1.2	18.3 (2/3 max)	18.3	6.1	-	-	18.3
1.3	27.4 (3/3 max)	27.4	9.1	-	-	27.4
1.4	0.5 (1/3 min)	0.5	0.2	-	-	0.5
1.5	0.9 (2/3 min)	0.9	0.3	-	-	0.9
1.6	1.4 (3/3 min)	1.4	0.5	-	-	1.4
Scenario 2: Treated discharge into the same three points in the catchment, each allocated 1/3 of water production						
2.1	9.1	-	-	6.9	2.3	6.9
2.2	18.3	-	-	13.7	4.6	13.7
2.3	27.4	-	-	20.6	6.9	20.6
2.4	0.5	-	-	0.4	0.1	0.4
2.5	0.9	-	-	0.7	0.2	0.7
2.6	1.4	-	-	1.1	0.4	1.1
Scenario 3: Untreated total production released at Rolleston via a pipeline						
3.1	9.1	9.1	9.1	-	-	9.1
3.2	18.3	18.3	18.3	-	-	18.3
3.3	27.4	27.4	27.4	-	-	27.4
3.4	0.5	0.5	0.5	-	-	0.5
3.5	0.9	0.9	0.9	-	-	0.9
3.6	1.4	1.4	1.4	-	-	1.4
Scenario 4: Treated total production released at Rolleston via a pipeline						
4.1	9.1	-	-	6.9	6.9	6.9
4.2	18.3	-	-	13.7	13.7	13.7
4.3	27.4	-	-	20.6	20.6	20.6
4.4	0.5	-	-	0.4	0.4	0.4
4.5	0.9	-	-	0.7	0.7	0.7
4.6	1.4	-	-	1.1	1.1	1.1

Table 5-2 Salt Input (mg/L) for Arcadia Scenarios

Scenario	Direct Discharge	Treated Discharge
1	2303	-
2	-	188
3	2303	-
4	-	188

5.3 Model Development and Parameters

To assess the impacts of associated water discharged to the Comet River system, three salinity models were developed to simulate the natural condition of the river at their respective locations. The three models were created to represent three possible locations for point source input of associated water. The locations selected were Arcadia, Rolleston, and the catchment outlet on the Comet River.

At the catchment outlet gauging station, 5 years of continuous (with gaps) EC data has been collected between 1997 and 2002. The salinity model was calibrated to best fit the observed records. The stream flow, calibrated salinity model, and continuous and spot records at the catchment outlet are shown in Figure 5-2 and Figure 5-3. The salinity model is conservative overall, tending to overestimate the salinity in the system. This was necessary to allow the model to reach the peaks in the observed records. The salinity model was applied over the available data range of flow data from 1974 to 2004 to extend the period over which the scenarios can be assessed.

Similarly, 3 years of continuous (with gaps) EC data has been collected between 1997 and 2000 at the Rolleston gauging station on the Comet River. The salinity model was developed between 1997 and 2000 using the observed continuous EC record, then verified by checking against spot records going back to 1974. It was noticed that the model was not reaching the higher salinity measurements in the spot data over this period. The model was recalibrated to better reach the peaks without sacrificing calibration during the continuous record. The stream flow, calibrated salinity model, and the continuous and spot observed records at Rolleston are shown in Figure 5-4 and Figure 5-5.

Lastly, the Arcadia salinity model was developed. No continuous water quality apparatus has operated at the Arcadia gauging station for any useful length of time, and the limited data available is of highly questionable quality. Therefore the calibration of the salinity model was dependant on 40 NRW spot data measurements. Parameters used in the Rolleston salinity model were used as a basis for the Arcadia model. High flow salinity reset to minimum concentration and the maximum concentration were adjusted to achieve a calibration to the spot data measurements. Overall the model appears to match the spot data on the majority of occasions. Without a significant increase in spot data or a continuous EC record, the model is calibrated within the limits of the available data. The stream flow, calibrated salinity model, and the spot observed records for Arcadia are shown in Figure 5-6.

Associated Water Management Scenarios

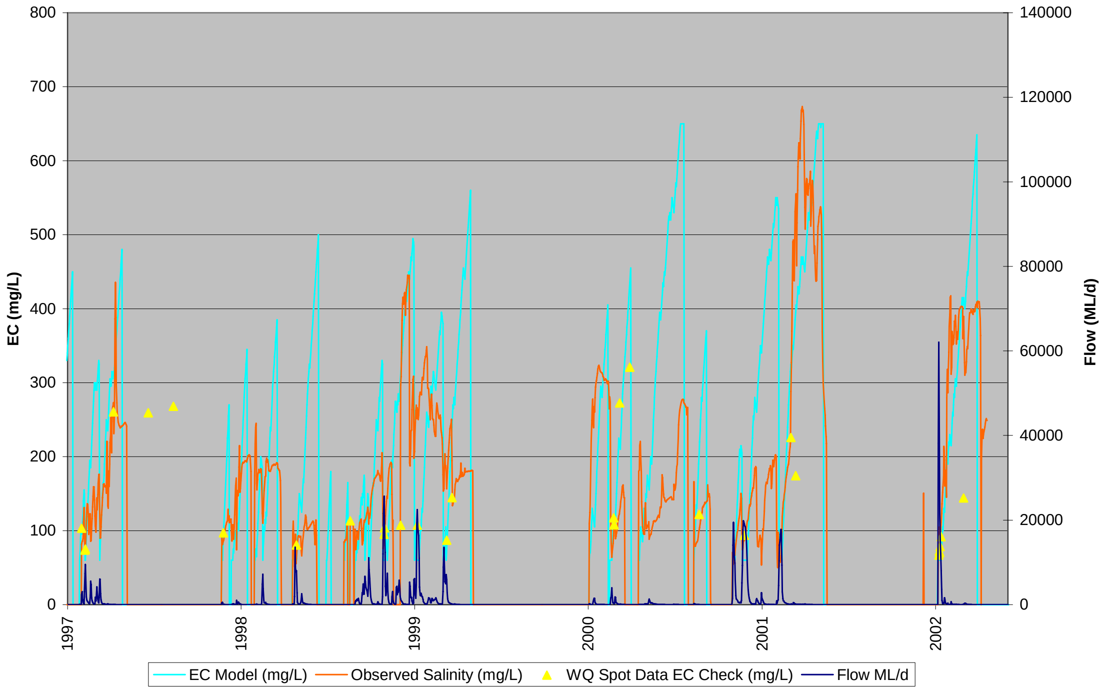

Figure 5-2 Catchment Outlet Salinity Model - 1997 to 2002

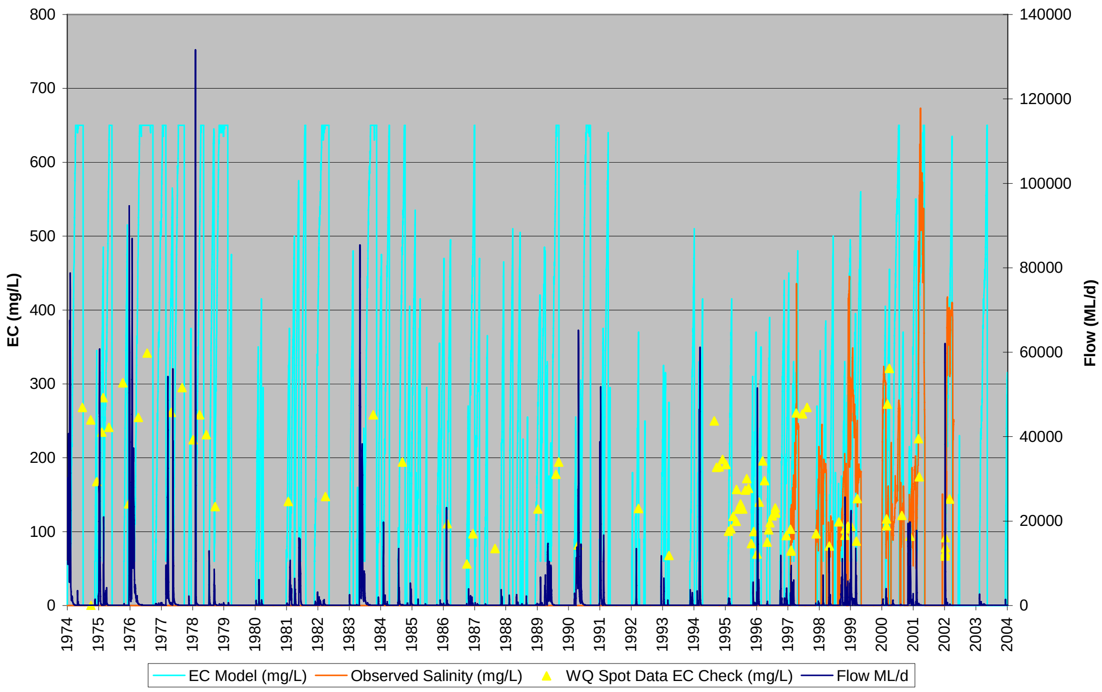

Figure 5-3 Catchment Outlet Salinity Model – 1975 to 2004

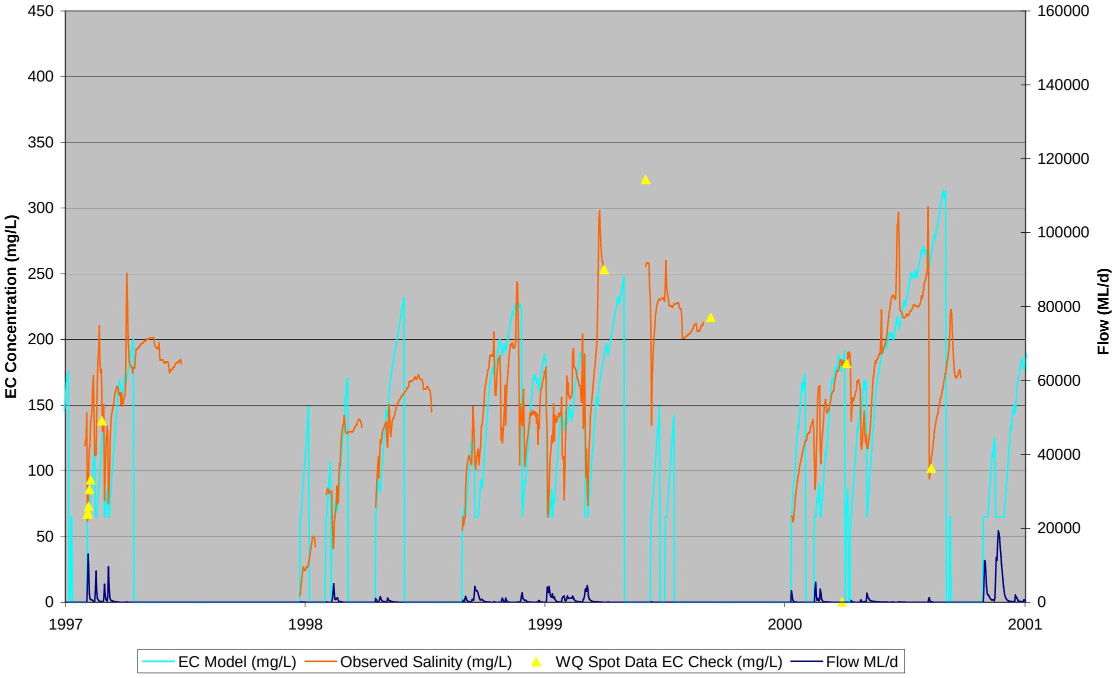

Figure 5-4 Rolleston Salinity Model - 1997 to 2001

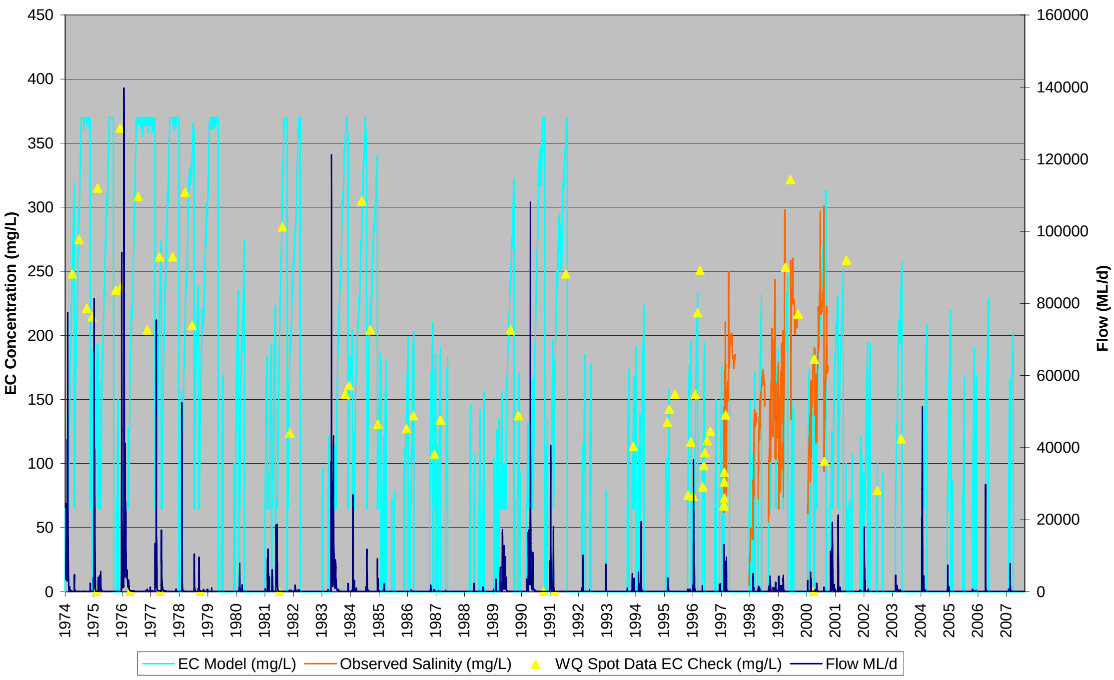

Figure 5-5 Rolleston Salinity Model - 1974 to 2007

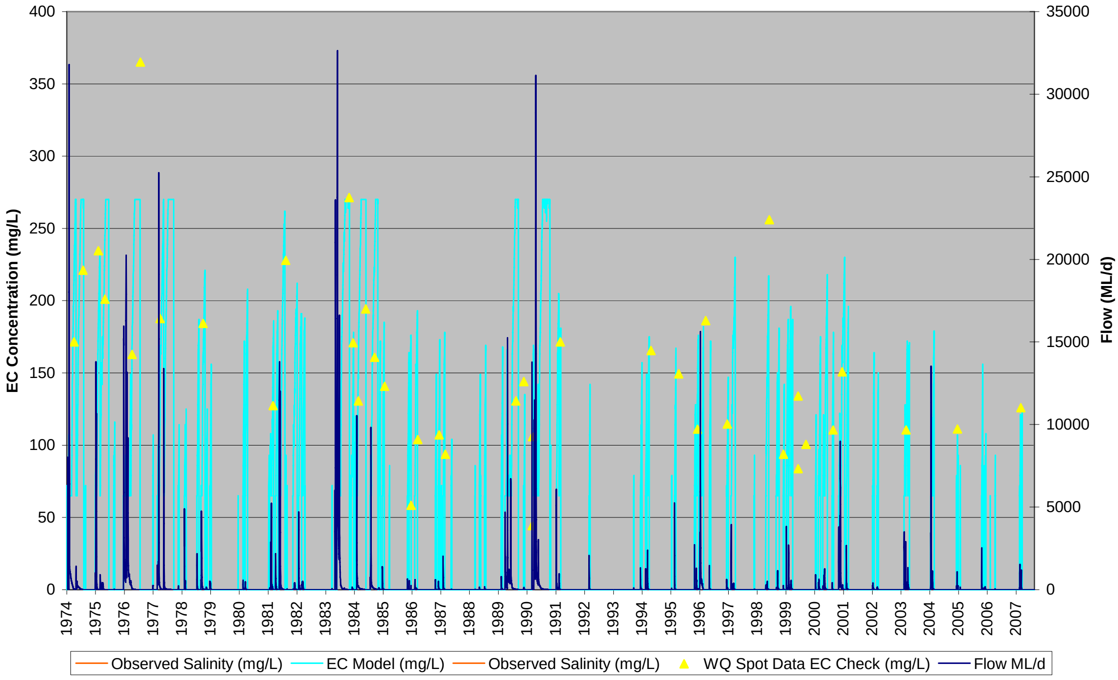

Figure 5-6 Arcadia Salinity Model - 1974 to 2007

The parameters used in the salinity model for Arcadia, Rolleston and the catchment outlet are presented in Table 5-3 below.

Table 5-3 Comet Salinity Model Parameters

Ramp Model Parameter	Outlet Scenarios 1 & 2	Rolleston Scenarios 1, 2, 3 & 4	Arcadia Scenarios 1 & 2	Units
High Flow Salinity Reset to Minimum Concentration	6000	2000	500	ML/d
Max Concentration	650	370	270	mg/L
Minimum Concentration	60	65	65	mg/L
Ramp Change Concentration	300	170	170	mg/L
Flow Decreases - Salinity Increase - Below Salinity Ramp by:	15	7	7	mg/L/day
Flow Decreases - Salinity Increase - Above Salinity Ramp by:	10	3	3	mg/L/day
Flow Increase - Salinity Decrease by:	5	3	3	mg/L/day

5.4 Results and Interpretation

To assess the environmental impacts on the Comet River as a result of future associated water production, the three regional models were later customized to evaluate 48 scenarios, in accordance with the scenarios and parameters defined in Table 5-3. A statistical overview of the modelled natural stream conditions are presented in Table 5-4. A statistical overview of the modelled results of each scenario is presented in Table 5-5 and graphically in Figure 5-7. The results show:

- **Minimum** salt concentration of the mixed stream (during large runoff events);
- **Average** salt concentration;
- **Maximum** salt concentration (typically the concentration of the associated water).
- 25% of days the mixed stream salt concentration is equal to or less than **Lower Quartile**;
- 50% of days the mixed stream salt concentration is equal to or less than **Median**;
- 75% of days the mixed stream salt concentration is equal to or less than **Upper Quartile**; and
- **95th Percentile** representing the value that 95% of the stream salinity records (as mg/L) are below.

Table 5-4 Modelled Natural Stream Salinity (mg/L)

Scenario	Statistics				Quartile			95th Percentile
	Min	Average	Average (no flow excluded)	Max	Lower	Median	Upper	
Arcadia Salinity Model	0	41	**146**	270	0	0	65	242
Rolleston Salinity Model	0	94	**194**	370	0	0	174	367
Outlet Salinity Model	0	126	**323**	673	0	105	188	405

All three discharge locations are dry at certain times of the year. This is apparent in the quartiles showing Arcadia and Rolleston having ceased to flow greater than 50% of days of record. The outlet flows for a greater proportion of the year due to the greater catchment area, however there are still ‘no flow’ periods for at least 25% of model period. Further, the base flow within the streams is often very low, in the order of a few ML/day. This has been found to skew the average and quartiles towards low salinity. The average of the salinity model only including days with recorded flow has been included in Table 5-4 for comparison.

Table 5-5 Summary of Scenarios - Mixed Stream Salt concentrations (mg/L)

Scenario	Future Production (ML/d)	Statistics			Quartile			95th Percentile
		Min	Average	Max	Lower	Median	Upper	
Scenario 1: Untreated discharge into three points in the catchment allocated 1/3 of water production each with the three points located in Arcadia, around Rolleston, and at the catchment outlet								
1.1 Arcadia	3.0	65	**1827**	2303	1807	2303	2303	2303
1.2 Arcadia	6.1	65	**1865**	2303	2022	2303	2303	2303
1.3 Arcadia	9.1	66	**1891**	2303	2107	2303	2303	2303
1.4 Arcadia	0.2	65	**1729**	2303	486	2303	2303	2303
1.5 Arcadia	0.3	65	**1744**	2303	720	2303	2303	2303
1.6 Arcadia	0.5	65	**1755**	2303	899	2303	2303	2303
1.1 Rolleston	6.1	4	**1560**	2303	521	2303	2303	2303
1.2 Rolleston	12.2	7	**1633**	2303	725	2303	2303	2303
1.3 Rolleston	18.3	11	**1679**	2303	887	2303	2303	2303
1.4 Rolleston	0.3	0	**1361**	2303	235	2303	2303	2303
1.5 Rolleston	0.6	0	**1392**	2303	261	2303	2303	2303
1.6 Rolleston	0.9	1	**1415**	2303	284	2303	2303	2303
1.1 Outlet	9.1	1	**1566**	2303	635	2303	2303	2303
1.2 Outlet	18.3	2	**1631**	2303	797	2303	2303	2303
1.3 Outlet	27.4	3	**1674**	2303	923	2303	2303	2303
1.4 Outlet	0.5	0	**1411**	2303	360	2303	2303	2303
1.5 Outlet	0.9	0	**1433**	2303	387	2303	2303	2303
1.6 Outlet	1.4	0	**1449**	2303	408	2303	2303	2303
Scenario 2: Treated discharge into the same three points in the catchment, each allocated 1/3 of water production								
2.1 Arcadia	3.0	0	**176**	267	188	188	188	207
2.2 Arcadia	6.1	1	**176**	266	188	188	188	201
2.3 Arcadia	9.1	1	**176**	266	188	188	188	198
2.4 Arcadia	0.2	0	**176**	270	188	188	188	236
2.5 Arcadia	0.3	0	**176**	270	188	188	188	230
2.6 Arcadia	0.5	0	**176**	269	188	188	188	224
2.1 Rolleston	6.1	0	**184**	367	186	188	188	300
2.2 Rolleston	12.2	0	**183**	364	187	188	188	281
2.3 Rolleston	18.3	0	**182**	363	187	188	188	270
2.4 Rolleston	0.3	0	**189**	370	183	188	188	351
2.5 Rolleston	0.6	0	**188**	370	183	188	188	344
2.6 Rolleston	0.9	0	**188**	370	184	188	188	339
2.1 Outlet	9.1	0	**230**	648	188	188	234	543
2.2 Outlet	18.3	0	**223**	647	188	188	212	508
2.3 Outlet	27.4	0	**223**	645	188	188	226	503
2.4 Outlet	0.5	0	**243**	650	188	188	245	633
2.5 Outlet	0.9	0	**241**	650	188	188	240	622

Scenario	Future Production (ML/d)	Statistics			Quartile			95th Percentile
		Min	Average	Max	Lower	Median	Upper	
2.6 Outlet	1.4	0	**239**	650	188	188	238	612
Scenario 3: Untreated total production released at Rolleston via a pipeline								
3.1 Rolleston	9.1	3	**1601**	2303	630	2303	2303	2303
3.2 Rolleston	18.3	5	**1679**	2303	887	2303	2303	2303
3.3 Rolleston	27.4	8	**1727**	2303	1079	2303	2303	2303
3.4 Rolleston	0.5	0	**1378**	2303	248	2303	2303	2303
3.5 Rolleston	0.9	0	**1414**	2303	284	2303	2303	2303
3.6 Rolleston	1.4	0	**1439**	2303	313	2303	2303	2303
Scenario 4: Treated total production released at Rolleston via a pipeline								
4.1 Rolleston	9.1	0	**184**	366	187	188	188	289
4.2 Rolleston	18.3	0	**182**	363	187	188	188	270
4.3 Rolleston	27.4	0	**181**	361	187	188	188	257
4.4 Rolleston	0.5	0	**189**	370	183	188	188	348
4.5 Rolleston	0.9	0	**188**	370	184	188	188	339
4.6 Rolleston	1.4	0	**187**	369	184	188	188	332

Scenarios were based on each stream directly receiving one third of the flow; however, the streams are in series and the most upstream discharge will inherently be included in downstream analysis. As a result the flow was aggregated down the catchments such that; Arcadia received 1/3 of the water production, Rolleston received 2/3, and 100% of the associated water discharge is present in the stream at the outlet. Losses from evaporation or seepage were assumed to be negligible.

As noted above, all three discharge locations are ephemeral under certain times of the year. Further, the base flow within the stream is often very low, in the order of a few ML/day. During periods of no flow, the only flow in the stream is the associated water discharge, thereby resulting in an salt concentration in the system equal to that of the production water. This has been found to skew the average and quartiles towards higher salt concentrations.

Associated Water Management Scenarios

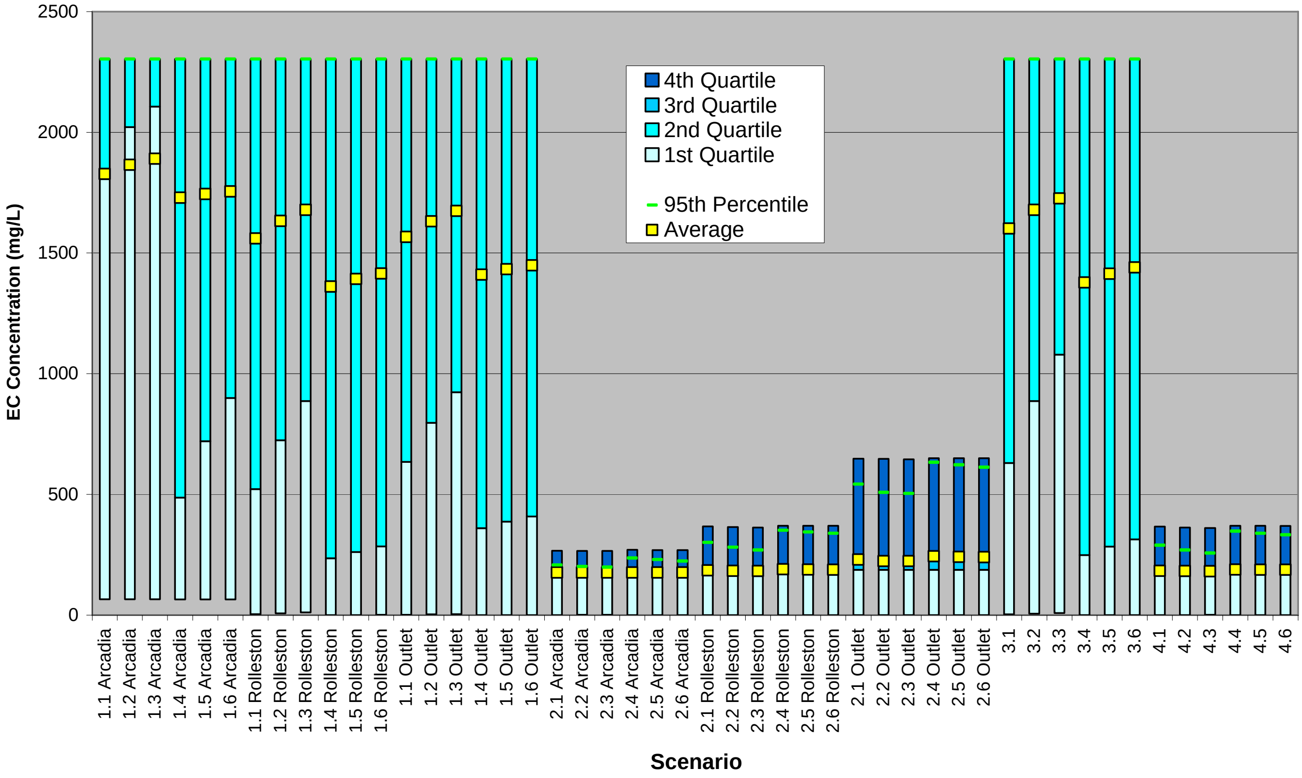

Figure 5-7 Summary of Scenarios - Mixed Salt concentration in Dawson River

5.4.1 Scenario 1 – Untreated Direct Discharge

Scenario 1 represents discharging untreated associated water at three points within the Comet catchment. The three locations selected were Arcadia on the Brown River, Rolleston on the Comet River and at the catchment outlet. Figure 5-8, Figure 5-9 and Figure 5-10 show the three salinity models in natural stream conditions, in addition to the minimum (0.5 ML/d) and the maximum (27.4 ML/d) predicted future production. This represents the current and likely range of future production within the Comet River catchment.

All three streams are ephemeral during much of the year, resulting in the only flow present in the stream being the associated water. Therefore, at all locations, the salinity in the stream is often flat lined at the salt concentration of the associated water (2303 mg/L). Arcadia exhibited the largest overall difference in salinity between the natural model and the production scenarios. This is due to Arcadia having both the lowest natural background salinity level, and the lowest flow of the three locations. However, increasing the level of discharge in Arcadia had little effect on the overall salinity in the system, as any discharge would have the same effect when the river has ceased to flow.

The modelling at Rolleston and at the catchment outlet both exhibited greater variability between the maximum and minimum future production scenarios. The difference is greatest during the period 1974 to 1984. During this time period, the minimum future production was found to have far less impact on the natural stream condition than the peak production scenario.

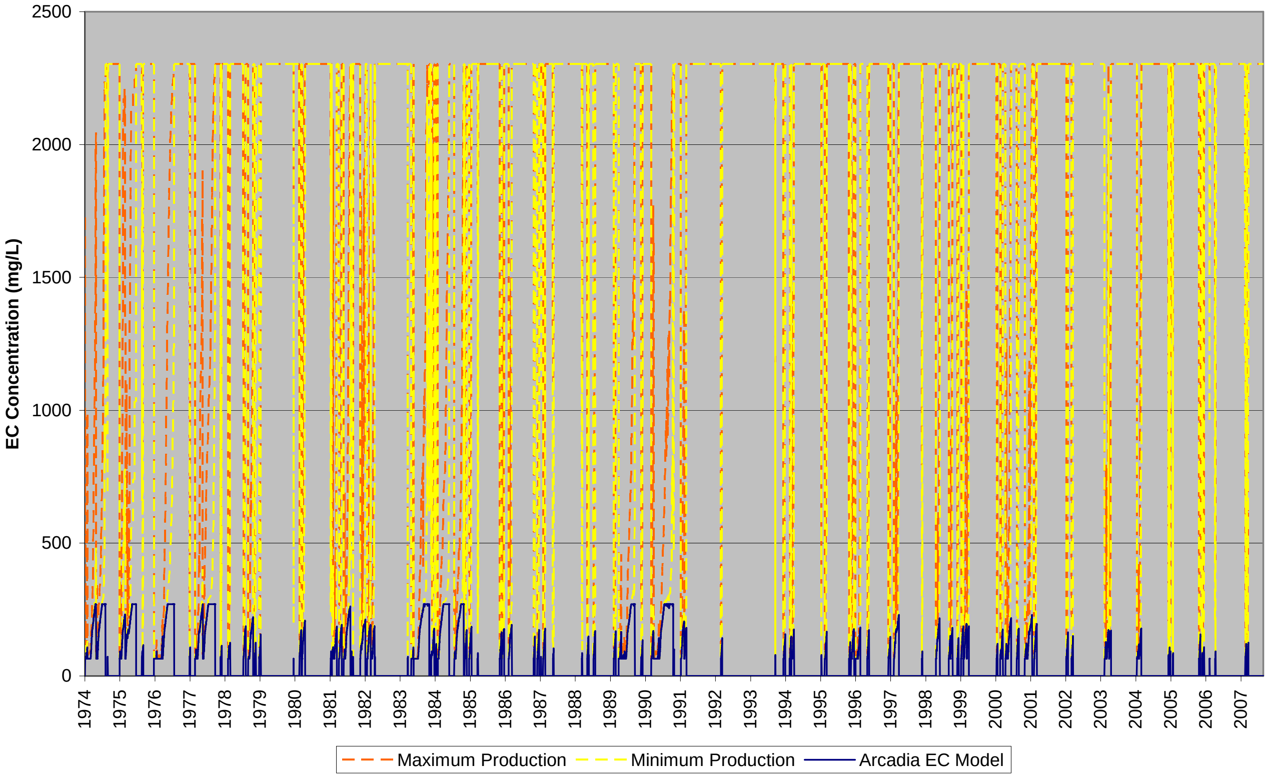

Figure 5-8 Scenario 1 – Untreated Discharge – Arcadia

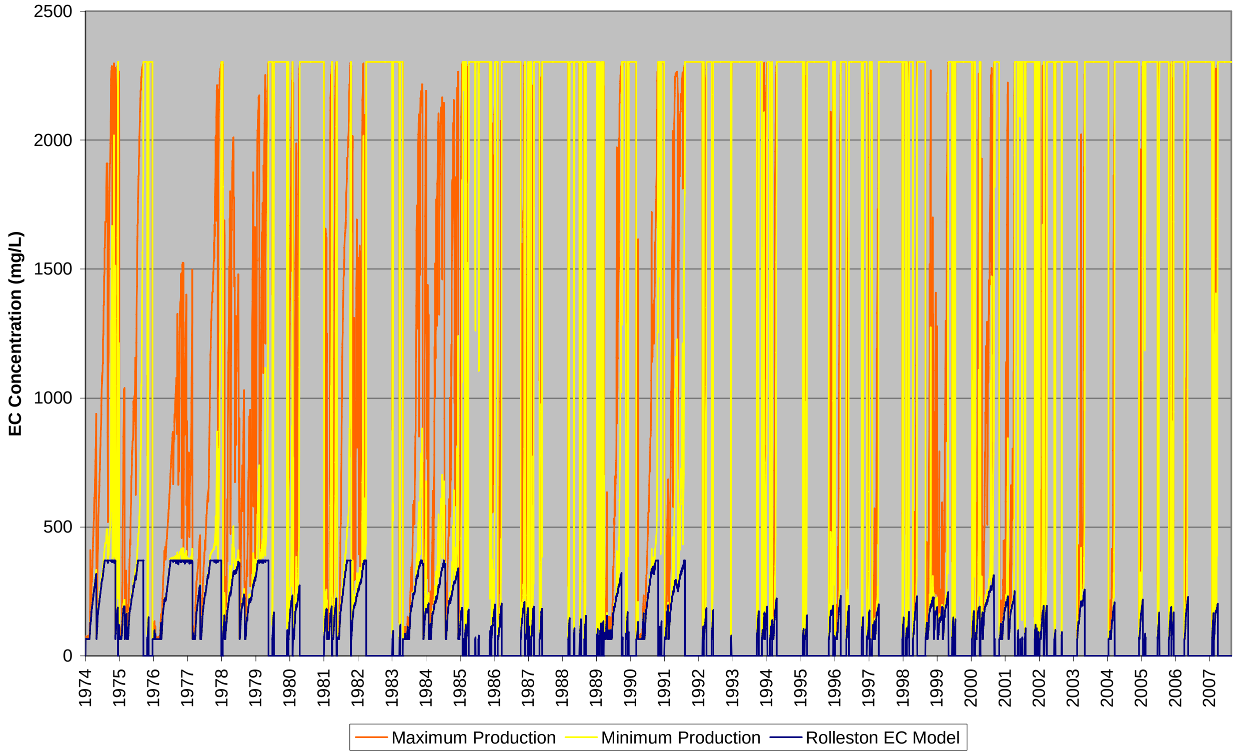

Figure 5-9 Scenario 1 – Untreated Discharge - Rolleston

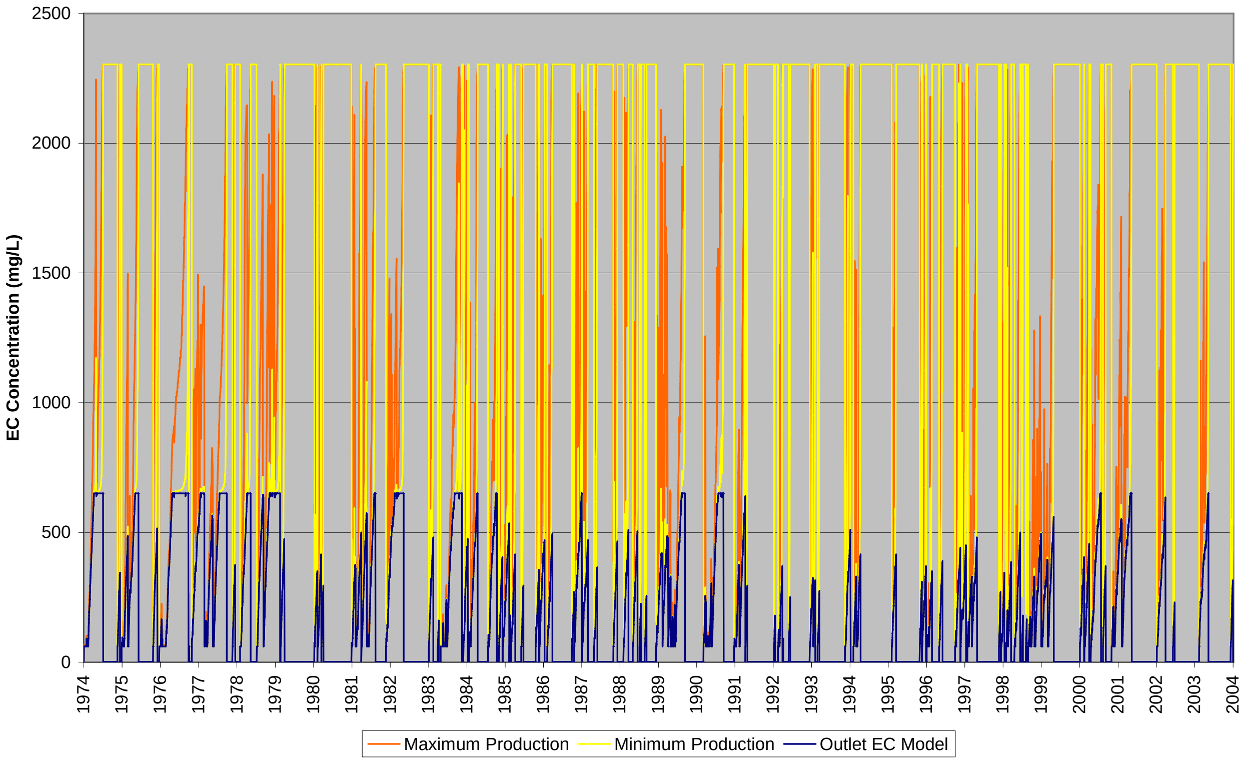

Figure 5-10 Scenario 1 – Untreated Discharge – Catchment Outlet

5.4.2 Scenario 2 – Treated Discharge

Scenario 2 represents directing and discharging treated production water at three points within the Comet catchment. The three locations selected were Arcadia on the Brown River, Rolleston on the Comet River and at the catchment outlet. Figure 5-11, Figure 5-12 and Figure 5-13 show the three salinity models in natural stream conditions, in addition to the minimum (0.5 ML/d) and the maximum (27.4 ML/d) predicted future production. This represents the current and likely range of future production within Comet River catchment.

All three streams are ephemeral during much of the year, resulting in the only flow present in the stream being the associated water. Therefore, at all locations, the salinity in the stream is often equivalent to the salinity of the permeate stream (TDS 188 mg/L).

All three locations exhibit similar correlations between the natural and associated water scenarios. When the stream has ceased to flow, the salinity is equivalent to the mean natural background salinity level, which is the target salinity of the treated associated water. The greater the volume of treated production water, the greater the tendency of the mixed stream to skew towards the treated water quality level. This results in the mixed stream's salt concentration not peaking during dry periods prior to ceasing to flow, and increasing the salinity during large runoff events that typically had very dilute concentrations of salt in the stream.

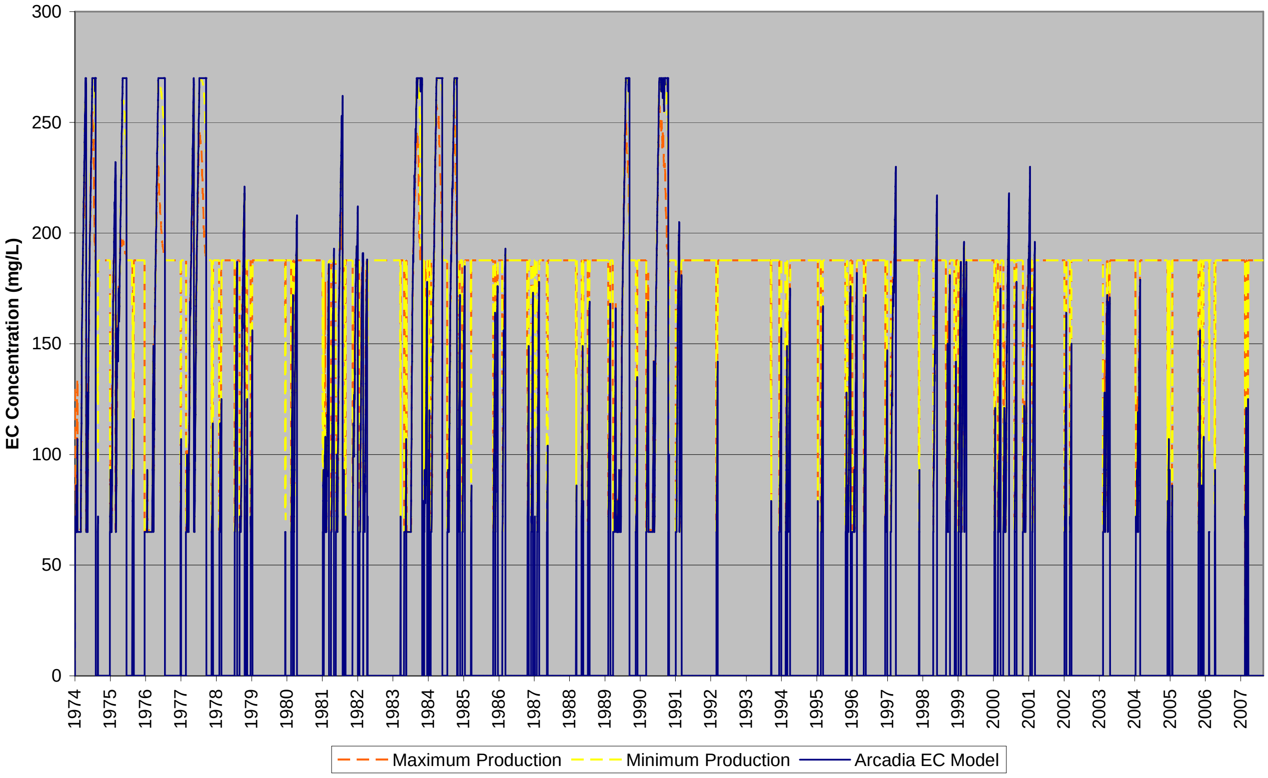

Figure 5-11 Scenario 2 – Treated Discharge – Arcadia

Associated Water Management Scenarios

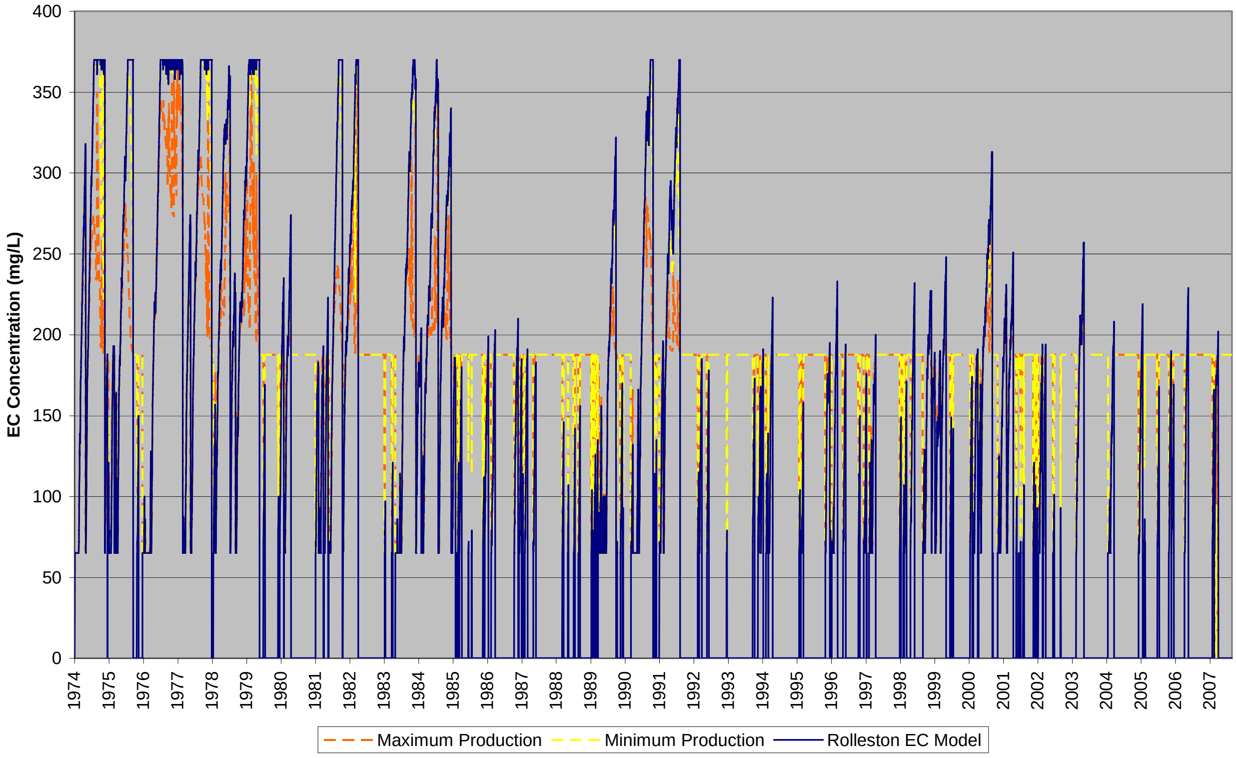

Figure 5-12 Scenario 2 – Treated Discharge - Rolleston

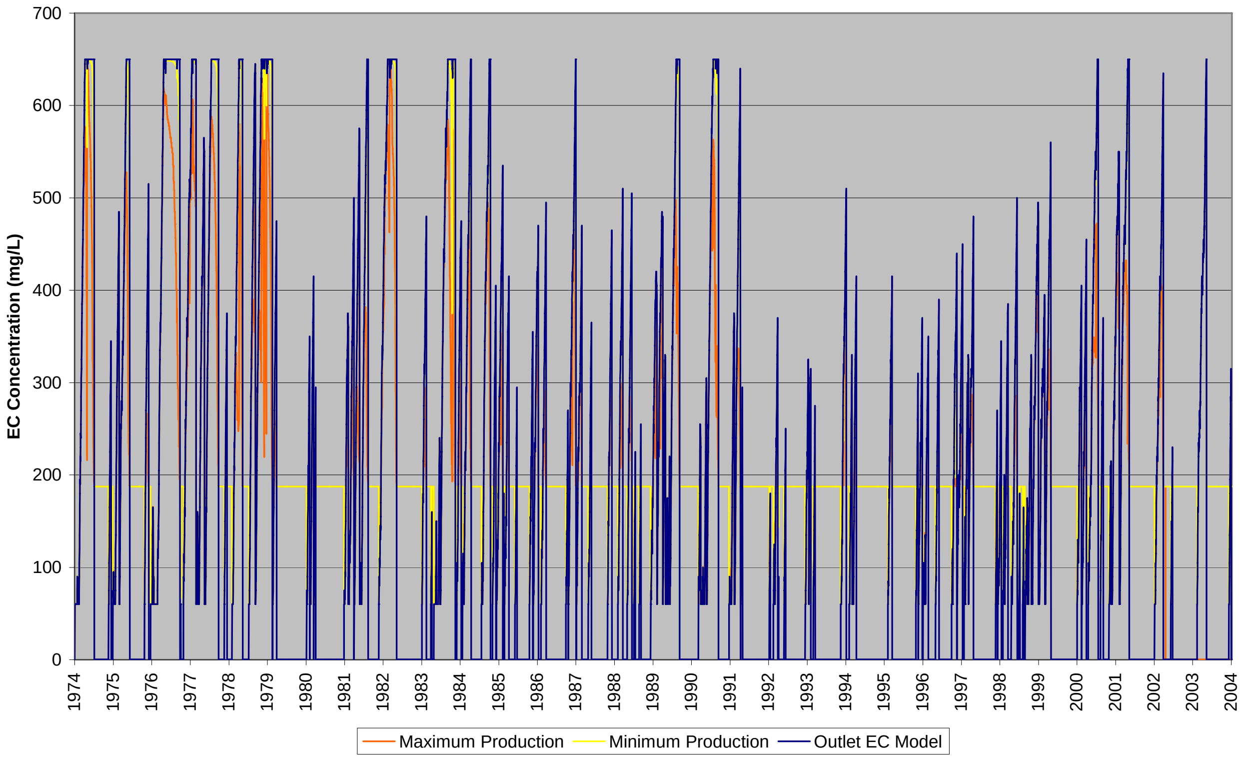

Figure 5-13 Scenario 2 – Treated Discharge – Catchment Outlet

5.4.3 Scenario 3 – Piped Untreated Discharge at Rolleston

Scenario 4 represents piping untreated associated water to Rolleston for discharge. Figure 5-14 shows the Rolleston salinity model in natural stream conditions, in addition to the minimum (0.5 ML/d) and the maximum (27.4 ML/d) predicted future production. This represents the current and likely range of predicted future production within the Comet River Catchment.

The modelling at Rolleston exhibited variability between the maximum and minimum future production scenarios. The difference is greatest during the period 1974 to 1984. During this time period, the minimum future production was found to have far less impact on the natural stream condition than the peak production scenario. However, there exists little difference between Scenario 1 and Scenario 3 when comparing maximum production at Rolleston despite effectively adding 50% more discharge.

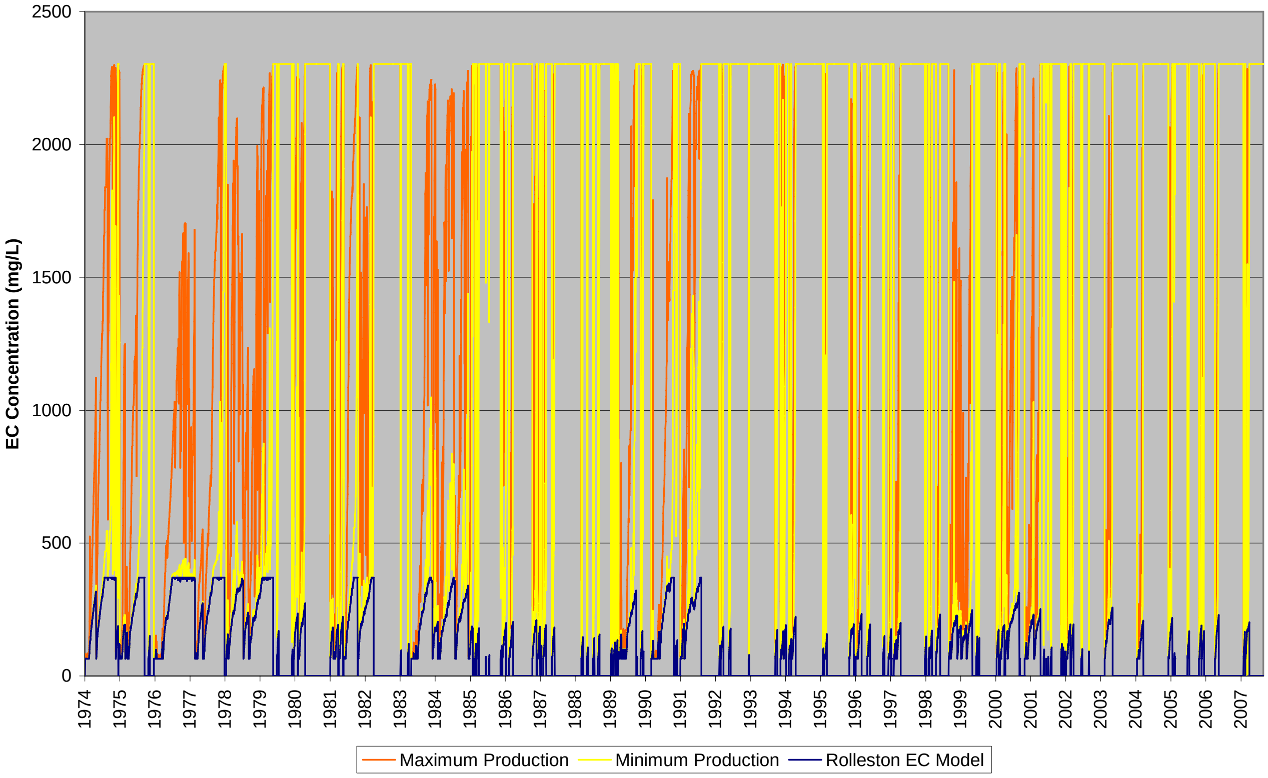

Figure 5-14 Scenario 3 – Untreated Discharge at Rolleston

5.4.4 Scenario 4 – Piped Treated Discharge at Rolleston

Scenario 4 represents piping treated associated water to Rolleston before release. Figure 5-15 shows the Rolleston salinity model in natural stream conditions, in addition to the minimum (0.5 ML/day) and the maximum (27.4ML/d) predicted future production. This represents the current and likely range of future production within Comet River catchment.

The Comet River at Rolleston is ephemeral during the greater portion of the year, resulting in the only flow present in the stream being the associated water. Therefore, at all locations, the salinity in the stream is equal to the treated associated water concentration (188 mg/L).

When the stream has ceased to flow, the salinity is equivalent to the mean natural background salinity level, which is the target salinity of the treated associated water. Further, the greater the volume of treated production water, the greater the tendency of the mixed stream to skew towards the treated water quality level. This results in the mixed streams salt concentration not peaking during dry periods prior to ceasing to flow, and increasing the salinity during large runoff events that typically had very dilute concentrations of salt in the stream.

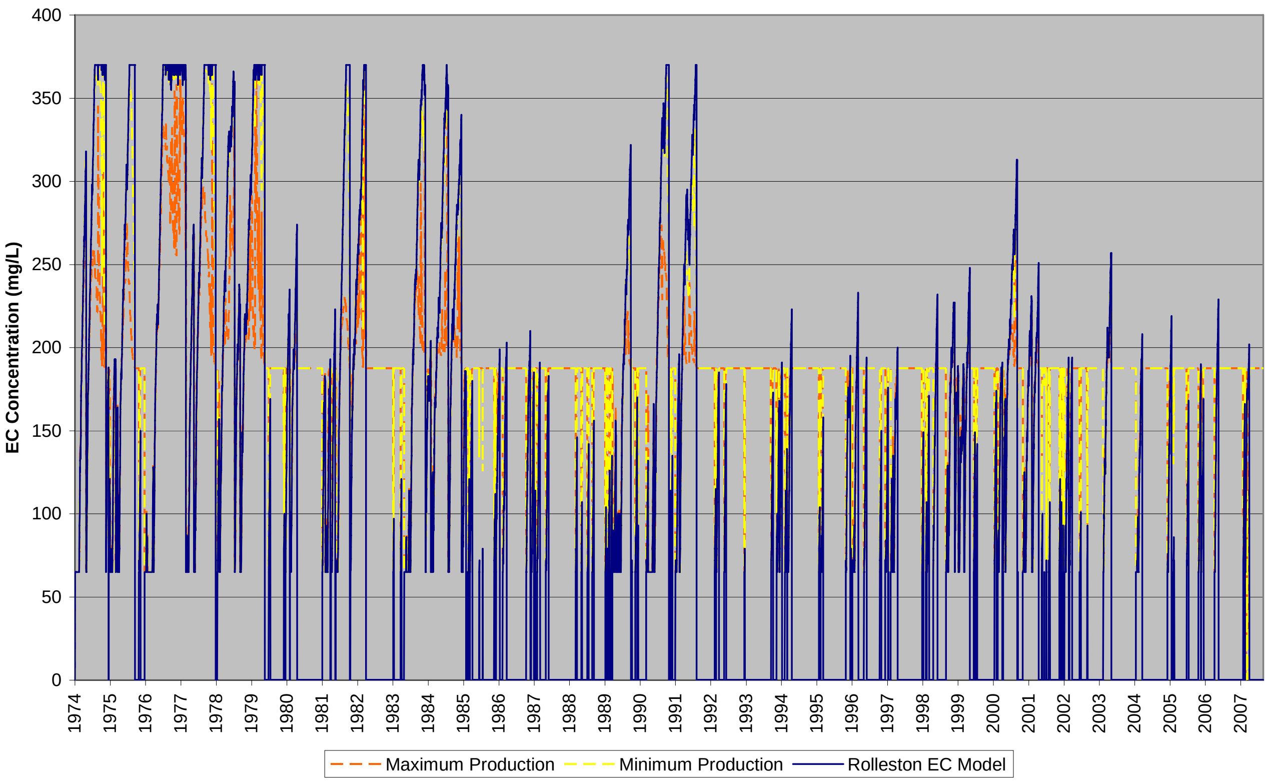

Figure 5-15 Scenario 4 – Treated Discharge at Rolleston

Conclusion Section 6

A rainfall-runoff model has been developed for the Comet River catchment (and Arcadia Field) within the limits of the available data. The model is representative of the observed stream gauging records and allows prediction of the most important flow regimes (zero, low and medium flows) required to assess changes in salinity and flow arising from potential discharges of associated water. Larger flows are less accurately represented with the E2 model with flow peaks generally lower than observed. Matching of peak flows was a lower priority in model fit runs since salinity will typically be diluted under these flows. Under-estimates of peak flows will generally produce conservative dilution for consideration in developing management options.

Modelling shows that discharge of associated water will dominate salinities in the low to moderate flow regime of the Comet River. Thus untreated discharges to grade will only be partially diluted under many flow conditions and not diluted under zero natural flows. Similarly, treated discharges (permeate) will also dominate the salinity regime, with no dilution under zero flows in dry season and some dilution at other times.

Results generated in this report will be considered as part of the overall risk assessment of discharging associated water to grade.

Limitations Section 7

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Santos and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 12 October 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between October 2007 and January 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility f or any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

A.1 E2 Background

The basic architecture of the E2 modelling framework consists of a subcatchment-node-link system based on two previous software packages, the Environmental Management Support System (EMSS) and the Integrated Quality and Quantity Model (IQQM). E2 allows for the generation of flow and materials in subcatchments and then onto a node where they are routed and possibly processed along a link.

Within E2 sub-catchments are broken up into ‘functional units’ that represent areas of similar behaviour or response. These can be various combinations of land use or cover such as forestry or grazing, management techniques or even position in the landscape such as ridge, floodplain, etc. Each FU can then have various models describing processes of runoff generation, constituent generation and filtering.

A.1.1 Australian Water Balance Model (AWBM)

The Australian Water Balance Model (AWBM) is a catchment water balance model capable of relating rainfall and evaporation to runoff on an hourly or daily time step. It has a total of eight parameters with the model containing three conceptual stores (C1-C3) with area representation (A1 - A3 summing to 100% of the total area) plus surface and baseflow recession constants and a baseflow index. The relative sensitivity of each parameter can vary depending on the value of the others; however the model is generally most sensitive to the recession constants and baseflow index (Argent *et al,* 2007a). Figure A-1 shows a conceptual diagram of the model and Table A-1 details the AWBM parameters and their default settings.

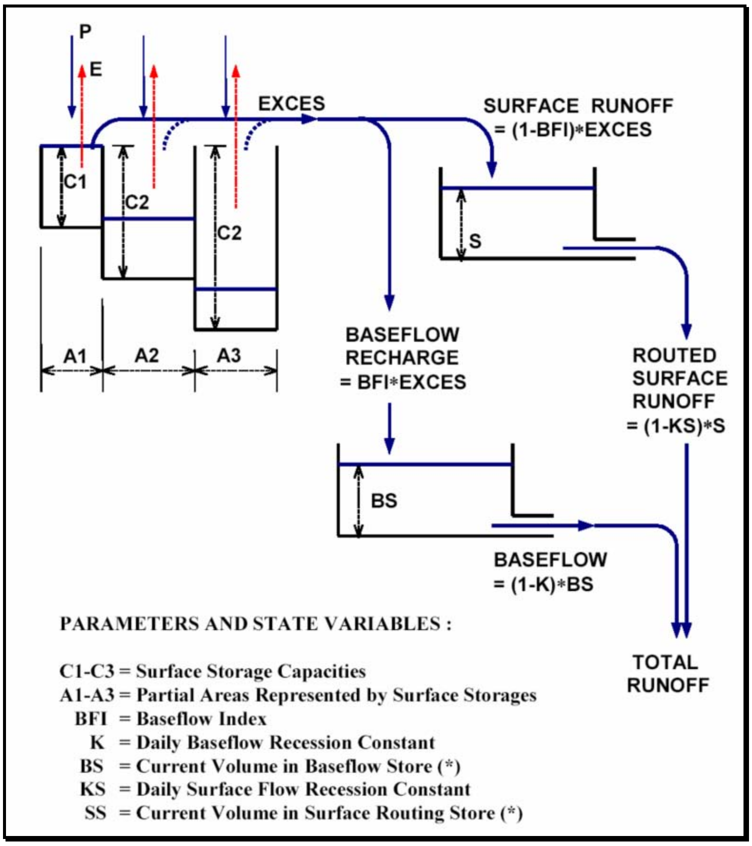

Figure A-1 Australian Water Balance Model (AWBM)

Table A-1 Definition of AWBM parameters and their default values

Parameter	Definition	Units	Max	Min	Default value
Base flow index (BFI)	The ratio of baseflow to total flow in the stream flow	none	1.0	0	0.35
Daily surface flow recession constant (KS)	Determines the rate at which the surface flow runoff store is depleted	Day^{-1}	1.0	0	0.35
Daily base flow recession constant (BS)	Determines the rate at which the base flow store is depleted	Day^{-1}	1.0	0	0.95
A1	Partial area of surface store 1	None	1.0	0	0.134
A2	Partial area of surface store 2	None	1.0	0	0.433
C1	Capacity of surface store 1	mm	50	0	7
C1	Capacity of surface store 1	mm	200	0	50
C1	Capacity of surface store 1	mm	500	0	150

(Source: Based on Argent *et al*, 2007a)

The model works by calculating the water balance for each partial store independently of the others at the desired time step. The water balance is calculated as:

$Store_n = Store_n + Rain – Evaporation$ (where n = 1-3)

When the amount of moisture in the store exceeds its capacity, runoff occurs. Part of the runoff can then be used to recharge the baseflow. This is calculated as:

Baseflow recharge = BFI x Rainfall Excess

The remainder of the excess then becomes surface runoff. The baseflow store is then depleted at a rate of:

Baseflow depletion= (1.0 - K_{base}) x Baseflow store

(Where K_{base} is the daily baseflow recession constant)

In larger catchments flows often arrive from different areas at different times and it may be necessary to attenuate some flows. This is achieved in the model by a surface store whereby the discharge is controlled by the daily surface flow recession constant (K_{surf}):

Surface flow routing = (1.0-K_{surf}) x Surface store

Changing the values of the two recession constants allows the shape of the flood hydrograph to be altered. Higher values of both constants give slower recessions and hence longer falling limbs. Therefore they can be used to simulate different catchment conditions. The value of BFI also dictates how much of the rainfall excess is directed to either runoff or baseflow. This is important in allowing the model to capture different types of geology and catchment morphology.

A.1.2 Network Creation

E2 accepts a variety of spatial data to determine the catchment network and land use. Digital elevation models (DEM) can be used to automatically generate the subcatchment network required for the modelling process. However, Rob Argent (an E2 developer) advised against use of DEMs for this process since data preprocessing to connect gaps, identify stream flow direction, and fill pits can be extremely time intensive and could be especially problematic when dealing with the highly ephemeral nature of the stream network in the study area.

For this reason, the use of GIS shape files was used to represent the subcatchments and the stream network was drawn in manually within E2. This means that while catchment area is calculated within E2 for the purpose of runoff generation, there is no explicit spatial representation of the stream network.

A.2 Data Collation and Preparation

Construction of the E2 model required the following data:

- **Subcatchments** were delineated based on major stream confluences and areas of interest using ArcGIS. Subcatchments were first converted into a raster, then an ascii grid file for entry into E2, which recognizes its spatial reference. The stream network was manually drawn on top of the subcatchments using non-spatially referenced links and nodes.
- **Functional units** must be identified upon initial construction of the E2 model and cannot be altered thereafter. Functional units are typically based on **land use** and associated hydrologic behaviour. Based on land use data obtained from Queensland DNRW, the land is predominantly grazing. With no data to distinguish behavioural differences across the Comet catchment, land use was determined to not be influential or required in model development. Therefore, the model uses only a single functional unit covering all areas.
- One of the challenges encountered in building the E2 model was loading the input **rainfall** files into the model. Initially the model was developed using SILO gridded rainfall data. Daily gridded rainfall files (0.25 degree cell size which is approximately 28km x 28 km) were purchased from SILO through BOM. Daily files were available from April 1997 through mid-February 2008. URS utilized a 10 year calibration period from April 1997 through March 2007 with subsequent months providing a validation period. The publicly released version of E2 is unable to process the gridded files directly. Therefore URS created an automated process to convert all grids to Lambert Conformal Conic projection, then calculate zonal statistics (an area weighted average) over all cells within a given subcatchment to produce an input rainfall file for each subcatchment containing a time series of daily rainfall. The input rainfall file was in space delineated text (.sdt) format in the form 'year month day value'.

  During the calibration of the Comet River catchment model it was found that significant variations existed between the gridded rainfall input and observed discharge at the gauges, which prompted a more thorough investigation into the accuracy of the input rainfall data. A comparison was made between gridded rainfall data and point data from rainfall stations located within Comet catchment. Despite both data sets being sourced from the Bureau of Meteorology, the rainfall differences were drastic. It was decided to construct a new E2 model replacing the gridded rainfall input with the point data rainfall.

  A total of 53 gauges around Comet catchment were used to generate a rainfall input file for each subcatchment. Rainfall gauge data was available for its entire operational life. Many of the gauges had records extending back to 1900 or even earlier. However, it was decided to model the time period from January 1974 to December 2006.The decision to model over this time period was two fold, to maximise the number of data points available (most gauges did not become operational till mid-last century) and to ensure that modern measuring procedures were undertaken. Where multiple gauges were available within a single catchment, the rainfall observed at these gauges was averaged to produce a single rainfall input for the catchment. Where no gauges existed within the catchment, rainfall data from the nearest gauges were used. Where there were missing days for a given gauge, data was infilled from adjacent gauges.

  The results from E2 were exported into Excel to compare (1) E2 model with point rainfall input, (2) E2 model with SILO rainfall input, and (3) E2 model with observed discharge at the lower Comet River gauge. Basic findings were that with minimal preliminary calibration, hydrographs are generally better aligned with point rainfall input rather than SILO rainfall input, with the E2 model better matching the peaks and rise and fall. The overall conclusion is that the point rainfall data better reflects the discharge data at Comet than the SILO gridded data. It was therefore decided to continue the modelling and calibration using the point rainfall data as inputs. However, there are still limitations in the quality of the hydrologic model due to the averaging of the rainfall data over multiple gauges, the necessity of using gauges outside of the subcatchment and due to many of the rainfall records being incomplete.

- A single **evaporation** input file was applied across the entire catchment. As BOM does not operate a device capable of measuring evaporation within the Comet catchment the input file was built using an amalgamation of the nearest recording stations including Emerald, Taroom and Brigalow Research Station.

- Continuous daily or hourly **discharge** data was available for ten stream gauging stations in the Comet catchment. Due to the close proximity of two of the gauges only one was utilised whilst the other was used for verification purposes. The gauge names, IDs and years of data used in the development of the model are as follows;

  – Brown River at Arcadia (130502A) – 1/1/1974 to 19/3/1993
  – Brown River at Lake Brown (130502B) – 20/12/1984 to 31/12/2006
  – Carnavon Creek at Wyseby Station (130503A) – 1/1/1974 to 30/6/1988
  – Carnavon Creek at Rewan (130509A) – 30/5/1985 to 31/12/2006
  – Comet River at AMTD 17.2km (130504A) – 1/1/1974 to 7/1/2004
  – Comet River at AMTD 124.2km (130506A) – 1/1/1974 to 31/12/2006
  – Humboldt Creek at Sunlight (130505A) – 1/1/1974 to 1/10/1988
  – Planet Creek at Planet Downs (130507A) – 1/1/1974 to 21/3/1993
  – Meteor Creek at Springwood (130508A) – 1/1/1974 to 2/11/1988

  Some of this data was initially presented in an hourly time step and occasionally multiple daily spot times. The processing of this data into a daily time step required specific VBA looping macros in Excel. Discharge data was used to calibrate the water balance model. Only the gauge located on Comet River at AMTD 124.2km was complete over the 33 years of rainfall input being applied.

- Continuous daily or hourly electrical conductivity (EC) data was also available from the three NRW stream gauging stations. These included the two gauging stations located on Comet River and the gauge located on the Brown River at Lake Brown. In addition to being of questionable quality, the length of data records were also of concern with gauges ranging from 6 months of continuous data with the longest running gauge producing 5 years of sporadic readings. Upon closer inspection of the gauge data, it was apparent that only one gauge was producing data that was both recorded over a sufficient length of time and of a suitable quality for calibration purposes. Fortunately the gauge producing useable data was located on Comet River at AMTD 17.2km, the outlet gauge leaving the catchment. Other various spot monitoring water quality samples from NRW and URS sampling were used in combination with the continuous data to calibrate the salinity model. Electrical conductivity was first converted into a salt concentration (mg/L) using a conversion factor of:

  EC (µS) x 0.67 = salinity (mg/L)   (NRW fact sheet: *Measuring salinity,* 2007)

URS has also been engaged in a program of water quality monitoring within the study area for this and other related studies. This data will be used to further refine the models next year. Background salinity levels were based on various borehole data in the study area.

A.3 Model Calibration

A.3.1 E2 Calibration Tools

E2 contains a separate calibration tool that can be used to calibrate separate aspects of the model. Four types of calibration tool are available:

- Subcatchment flow – to calibrate the water balance models
- Link flow – to calibrate flow routing
- Subcatchment constituent – to calibrate constituent generation and filter models
- Link constituent – to calibrate the in-stream constituent models

Within the calibration process, the catchment may be cropped to allow calibration of sub areas such as groups of subcatchments. This is intended to allow different parts of the catchment to be calibrated separately based on the location of gauges, dams etc.

Unfortunately, the calibration tool within E2 is manually very intensive, requiring upwards of hundreds of parameters to be assigned before the automatic processors take over. For example the Comet catchment with 62 subcatchments (31 main subcatchments plus the 31 small nodes necessary for discharge injection) with one functional unit and the 8 AWBM parameters would require 496 separate manual inputs (62x1x8=496). Further, after an initial run it was found that the automatic calibration was not sufficiently quick or accurate enough. A manual approach to calibration was taken for the final refinement of the E2 model.

A.3.2 Rainfall Runoff Library (RRL)

After an initial attempt to calibrate the water balance in E2 yielded poor results, research indicated that some additional software might provide a more detailed set of tools for calibration. The Rainfall Runoff Library (RRL), also available from the CRC for Catchment Hydrology as part of the catchment modelling toolkit (www.toolkit.net.au/rrl), was utilised. The software contains 5 different Rainfall-Runoff models (including the AWBM) along with 8 calibration optimisers and 10 objective functions. Unlike E2, the use of the calibration optimisers largely automates the process so that many calibration iterations can be run without the need to constantly input parameter values.

The model differs from E2 in that it is a lumped model (it has only a single surface) and therefore is not able to model spatial variation in catchment characteristics such as changes in rainfall or runoff characteristics, or able to account for lag. It is therefore most useful on smaller catchments without upstream inflows. Reference is often made in literature of the advantages of water balance model calibration in the RRL due to its advanced functionality (e.g. Xu and Argent, 2005).

Because RRL is a lumped model, it only requires a single rainfall file as well as an evaporation record and an observed flow record for calibration. Catchment area is also required. The rainfall file initially used was simply created by averaging the existing rainfall files. Because RRL only allows headwater catchments to be modelled (an observed flow cannot be assigned as an input to a subcatchment), its usefulness is limited to providing an initial starting point on which to begin further refinement.

The choice of calibration optimiser came down to the best performing one - the shuffled complex evolution (SCE-UA). The objective function was again the Nash-Sutcliffe coefficient of efficiency (CE). The initial results were far more promising than default parameters in E2. The combination of the calibration optimiser to run several hundred iterations plus the ability to manually adjust the parameters with real-time results quickly enabled CE to be achieved on a daily time step. A summary of the CE results are summarised in Table A-1.

Table A-2 RRL Calibrated Results at Headwater Locations

Gauge Location	Nash-Sutcliff Criterion
Carnavon Creek at Rewan (130509A)	0.508
Humboldt Creek at Sunlight (130505A)	0.857
Planet Creek at Planet Downs (130507A)	0.482
Meteor Creek at Springwood (130508A)	0.462

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A.4 Quality Assurance of E2 Flow Modelling Package

Model development for the three catchments in this study began with the Dawson River catchment, which was used as a pilot study area before developing the E2 model for the Comet River catchment. Early in the model development, significant discrepancies between observed and modelled flow in the Dawson catchment created uncertainty regarding the capabilities of the designed E2 models to replicate current conditions in the Dawson River catchment. Subconsultants from HydroTasmania were contracted to replicate the Dawson hydrologic model using Kisters Modelling Hydstra software which they've used extensively to model approximately 70 catchments around Tasmania.

The comparative exercise proved interesting and useful. First, it was observed that a key parameter in Hydstra model calibration is the upper limit on baseflow, while E2 does not provide a variable for adjusting or limiting baseflow, thus seemingly allowing for infinite groundwater storage. Secondly, Hydstra is able to apply seasonality on soil stores, whereas E2 parameters are limited to a single number, applied throughout the entire time series.

In a comparison between E2 and Hydstra models created with identical parameters, the models produced very similar results for a single subcatchment (same peaks, same capture of events, slightly different recession curves). However, when complexity was added in modelling the entire Dawson catchment (22 subcatchments), discrepancies became more apparent, suggesting that E2 fell short of accurately representing channel routing.

They came to the same conclusion, namely that the model can be calibrated well for individual events but the parameters remain event-specific; they also achieved similar degrees of model fit and obtained similar parameter values for the AWBM.

Both models severely underestimated flow volume for many events, which prompted a more thorough investigation of the input rainfall data. Even if the peaks could be matched with rising and falling limbs, it would be impossible to “create” additional volume. With dogged differences between rainfall and observed discharge at the Taroom gauge, it is difficult to fathom model replication of observed conditions.

It should be noted that both Dawson models were produced using SILO rainfall data which was later proved to be of questionable quality, showing surprising differences from the point rainfall data also sourced from BOM. E2 models were reconstructed using point rainfall gauge data, which resulted in a much better calibration. A Hydstra model utilising point rainfall gauge data was never built.

Salinity Model Development Appendix B

B.1 E2 Limitations

The original plan was to model salinity in conjunction with flow using E2; however, many limitations rendered E2 unfit for this purpose. Event Mean Concentration/Dry Weather Concentration (EMC/DWC) was identified as an appropriate constituent model to capture high salinity in low flow and low salinity in high flows. The initial approach to apply the EMC/DWC model to the existing stream network was inadequate due to the fact that the model type is intrinsically linked to the Rainfall-Runoff model applied to each functional unit. This means that predicted salt concentration would be dependent on the amount of runoff generated by the water balance model. While this is acceptable for the purpose of generating background salinity levels, it would not be appropriate for the purpose of modelling fixed discharges from CSG wells.

Innovative design was used to trick E2 into correctly modelling fixed discharges from the CSG wells. Ultimately, an additional catchment of nominal area (less than one square kilometre) was added within each subcatchment. This was necessary to create a node upon which to apply input flow and salt concentration representing well discharge. This node was part of the link and node network, but served only as an input to the catchment within which it resided. All wells within the subcatchment were modelled by a single node.

The second incongruity was in the logic of the EMC/DWC model itself, which is linked to three parameters of the AWBM Rainfall-Runoff model (BFI, Kbase, and Ksurf) rather than flow. If all flow is directed to Kbase, E2 flatlines at the DWC concentration. Similarly, if all flow is directed to Ksurf, E2 flatlines at the EMC concentration. If the flow is split between equal Kbase and Ksurf using the BFI parameter, E2 flatlines at an average of the EMC and DWC concentrations. Where Kbase and Ksurf differentiate from each other, E2 fluctuates inconsistently with flow and observed salt concentrations.

A third complication is that E2 calibration of salinity requires adjustment of AWBM parameters, which would inherently alter the calibration of flow. Preliminary calibration efforts without regard to the effect on flow suggested that E2 would not effectively align to observed data. Overall, E2 modelling of salinity was neither representative nor defendable.

A comparison of the observed and E2 modelled salt concentration at the Comet River at AMTD 17.2km gauging station (Comet River Catchment) is shown in Figure B-1.

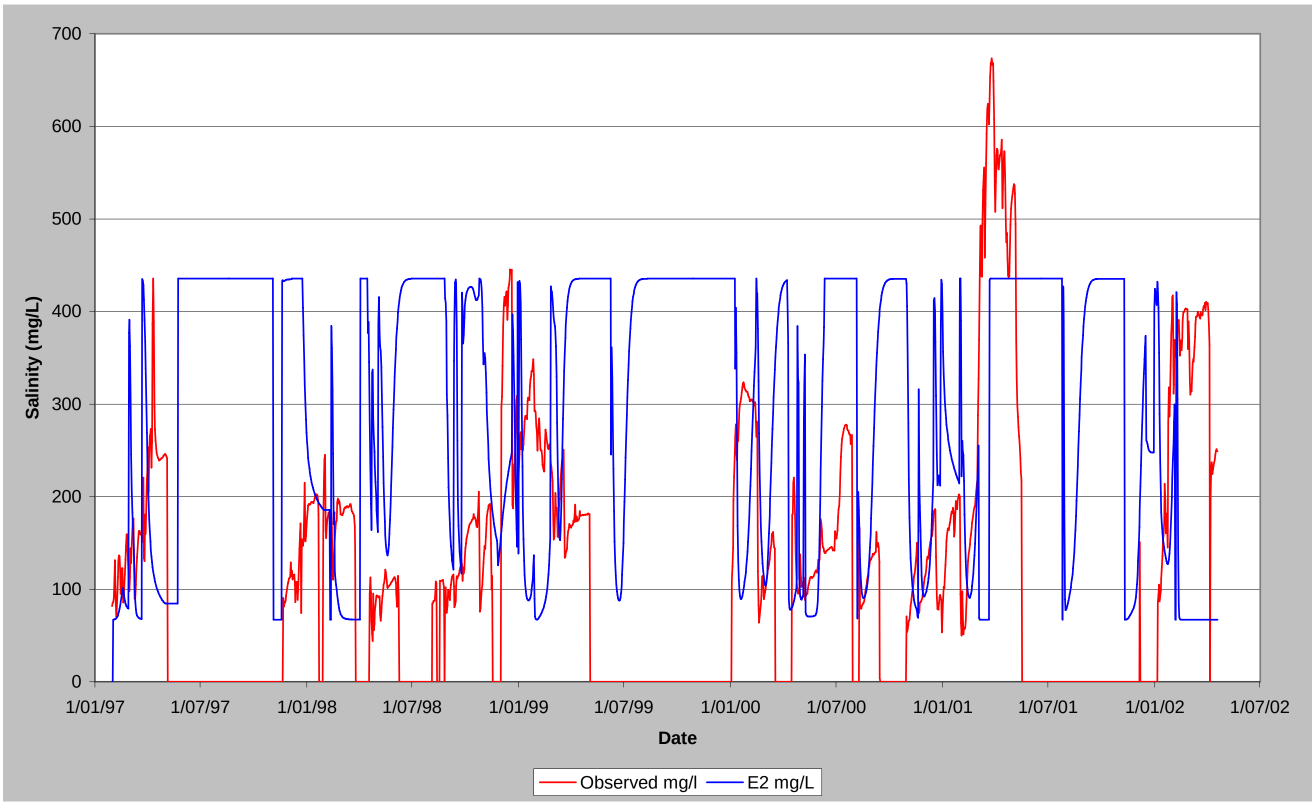

Figure B-1 E2 (blue) and Observed Salinity (red) at Comet River

B.2 Model Sophistications

A basic empirical algorithm was developed to replicate observed salt concentration trends. When the flow is zero, the salt concentration is assumed to be zero. The model is based on a minimum and maximum salt concentration with fluctuation based on flow levels. When flow equals or exceeds a selected high flow, the model triggers reset to the minimum salt concentration. Salinity is expected to decrease in high flow and increase in low flow. The amount of daily incremental change in salinity was determined based on the rates of increase and decrease of observed salinity such that the final algorithm best fits the observed salinity curve.

Starting with a simple algorithm, three different modelling sophistications were trialled including (1) introduction of seasonality, (2) a ramp from a first maximum concentration to a second peak concentration, and (3) salinity responsive to flow flux.

Seasonality was noticed to be particularly relevant for Taroom, where many of the surges in salt concentration occur annually during a three month period from March to June. A simple extension of the basic algorithm allows the salt concentration to be capped at a higher maximum during these months. Seasonality appeared less relevant at Utopia and other stream gauges. Seasonal salinity model parameters (Table B-1) include three flow levels at low, medium, and high flow. An incremental increase is applied to salinity between low and medium flow while an incremental decrease is applied to salinity between medium and high flow.

The ramp approach appeared to apply more consistently across gauges, and is based on the premise that for decreasing flow, one incremental increase rate is applied up to a preset ‘ramp change concentration’ followed by a second incremental increase rate applied above the ‘ramp change concentration’ (Table B-2). A third incremental rate applies when flow increases, thus reducing the salt concentration by a fixed amount each day. This method tends to overestimate salinity over extended time periods (conservative) while capturing more of the spikes in salt concentration.

The flow flux sophistication was an attempt to make salinity estimates more sensitive to changes in flow. The flow flux salinity model parameters (Table B-3) also include three flow levels at low, medium, and high flow. Below the low flow level, salt concentration was incrementally increased at a set rate. Between low and medium flow, salt concentration was incrementally increased when the flow dropped from the previous time step, while it was incrementally decreased when the flow increased. Between medium and high flow, salt concentration was incrementally decreased at a set rate.

Table B-1 Seasonal Salinity Model Parameters

Max Concentration (Jul-Mar)	200	mg/L
Max Concentration (Apr-June)	250	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	345	ML/d
Medium Flow	170	ML/d
Low Flow	25	ML/d
Salinity Decrease between medium and high flow	1	mg/L/day
Salinity Increase between low and medium flow	5	mg/L/day

Table B-2 Ramp Salinity Model Parameters

Max Concentration	375	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	100	ML/d
Ramp Change Concentration	200	mg/L
Flow Decreases - Salinity Increase - Below Salinity Ramp by:	10	mg/L/day
Flow Decreases - Salinity Increase - Above Salinity Ramp by:	2	mg/L/day
Flow Increases - Salinity Decrease by:	1.5	mg/L/day

Table B-3 Flow Flux Salinity Model Parameters

Max Concentration	375	mg/L
Minimum Concentration	80	mg/L
High Flow Salinity Reset to Minimum Concentration	500	ML/d
Medium Flow	200	ML/d
Low Flow	80	ML/d
Between medium and high flow - Salinity decrease by:	50	mg/L/day
Below low flow - Salinity increase by:	1.2	mg/L/day
Between low and medium flow - flow decrease - Salinity increase by:	10	mg/L/day
Between low and medium flow - flow increase - Salinity decrease by:	1	mg/L/day