8 WATER RESOURCES AND WATER QUALITY

8.1 Introduction

This Chapter addresses the hydrologic regime of the Dawson River, and the hydrogeology resources and water quality that may be affected by any component of the construction or operation of the Glebe Option. Each major environmental value is presented separately and reviewed with respect to both construction and operation phases.

8.2 Methodology

The primary sources of information for surface and groundwater components are existing databases and models held by State government agencies, while, for surface water quality, the existing catchment data was supplemented by SunWater data specific to the Glebe Weir site and by further seasonal field data collected for the Glebe Option.

8.3 Surface Water

8.3.1.1 General

This section addresses the following surface water aspects of the Glebe Option:

- a description of the stream flow, flooding and the existing water users in the Dawson River and greater Fitzroy River basin;
- a description of the potential hydrological impacts and mitigation measures for the raising of Glebe Weir; and
- a specific assessment of the hydrological impacts during construction.

WJV require up to 8,500 ML/yr of high priority allocation for the operation of the Wandoan Coal Mine. In order to determine the viability of supplying this quantity of water from the Glebe Weir raising, SunWater has undertaken a range of hydrological modelling scenarios. These utilised the NRW IQQM model to determine the impacts of extracting additional volumes from the raised weir.

The modelling scenarios have revealed that the weir raising alone is capable of generating an additional 6,500 ML of high priority yield with no impact to existing users within the Dawson Valley Water Supply Scheme, or to the Environmental Flow Objectives (EFOs) established under the Fitzroy Basin Resource Operations Plan (ROP) (NRW, 2006b). As this volume is insufficient to meet the Project's needs, additional modelling scenarios were performed to determine the viability of purchasing existing allocations and transferring them into the weir in order to increase the weir's yield. Through this modelling, SunWater has determined that the 2,000 ML shortfall could be obtained by purchasing 3,210 ML of existing, predominantly unutilised, Medium A priority allocation from the Theodore section of the Scheme and converting this to high priority allocation through amendment of the ROP. This would fulfill the shortfall of 2,000 ML of high priority yield required by the Project. 3,210 ML represents 5.7% of the total existing medium priority allocations from the Dawson scheme.

8.3.2 Description of Environmental Values

8.3.2.1 Drainage Characteristics

The major drainage features of the Fitzroy River basin, in which Glebe Weir is located, are shown in Figure 8-1. The Fitzroy River has a catchment area of about 142,900 km^2 that drains via several major tributaries including the Dawson, Nogoa, Comet, Mackenzie, Isaac and Connors Rivers. It drains into the Pacific Ocean near Rockhampton on the Central Queensland Coast. The Fitzroy River is the second largest catchment in Australia and is the largest in Queensland.

Glebe Weir is located at the southern end of the Fitzroy Basin on the Dawson River at AMTD 326.2 km approximately 30 km downstream from the township of Taroom. The Dawson River represents some 35% of the overall Fitzroy River catchment area. The catchment area of the Dawson River to Glebe Weir is 23,180 km^2, which is some 45% of the total Dawson River catchment to its confluence with the Fitzroy River and 16% of the

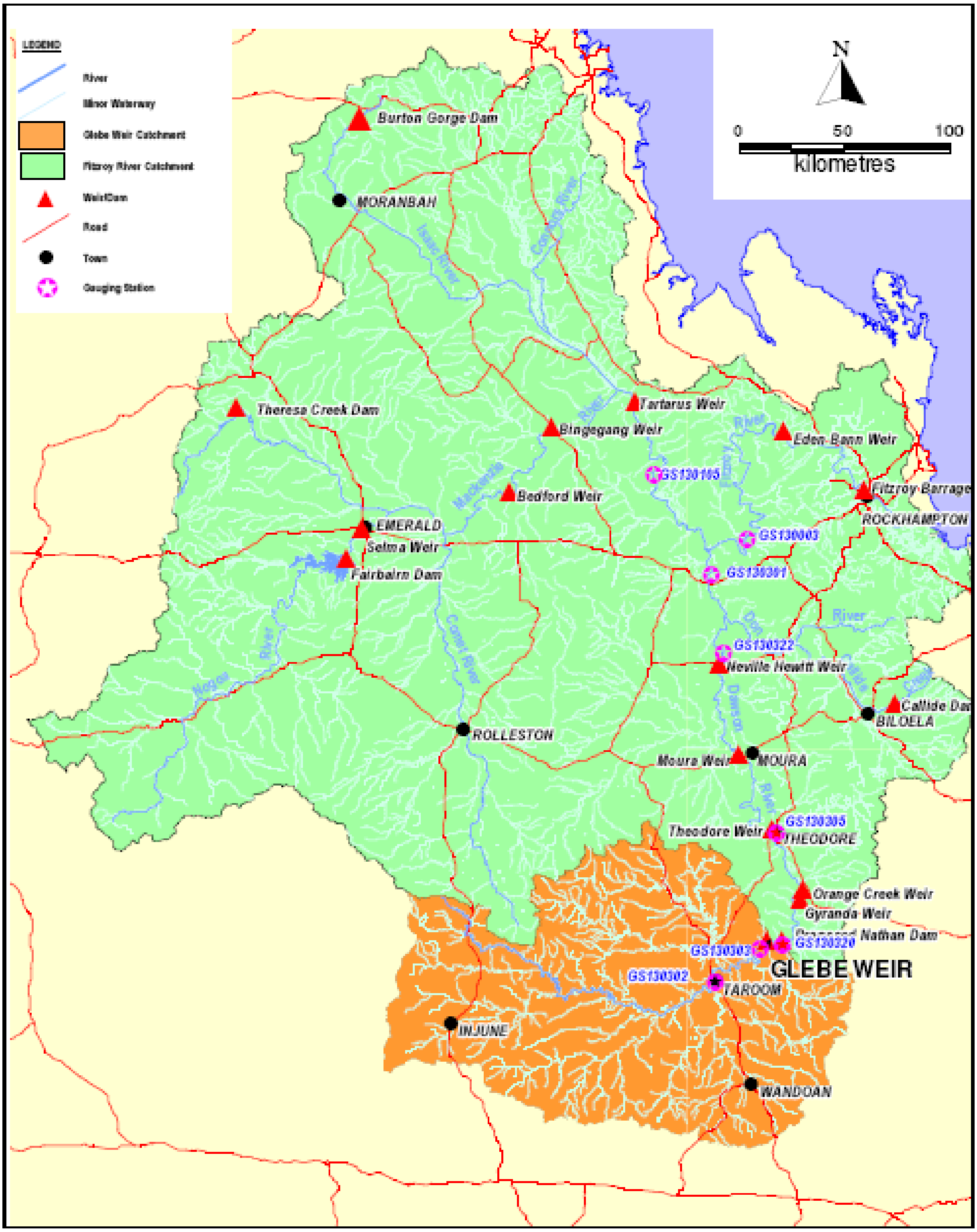

Figure 8-1 Fitzroy River drainage characteristics

total Fitzroy River catchment area. Several minor tributaries drain into the Dawson River upstream of Glebe Weir, the largest of which are Juandah Creek, Palm Tree Creek, Eurombah Creek and Hutton Creek. Several minor tributaries drain directly into the Glebe Weir pool. Details of these catchments are given in Table 8-1.

Table 8-1. Catchments draining into the Glebe Weir pool

Catchment	Catchment Area (km^2)
Double Stable Yard Creek and Scrubby Creek	49.7
Bentley Creek	347.9
Binghi Creek	56.8
Spring Gully / Boggomoss Creek	109.6
Cockatoo Creek	1029.5

- Stream Flow

Summary stream gauging data for the sites between Taroom and Nathan Gorge indicated in Figure 8-1 are given in Table 8-2.

From Table 8-2 the following key matters can be discerned.

- above the Glebe Weir impoundment, the Dawson River is not truly perennial;
- at “The Glebe” recorder station 130303A from the period 1919-1956 although the Dawson River was not completely perennial, it recorded perennial flow for the months of February, March, April, July, August, September, and November; and
- at recorded station 130320A at Nathan Gorge, over the period 1954-1986 there were recorded periods during which the Dawson River was not perennial at this location, however the presence of Glebe Weir from November 1971, would be expected to have impacted on downstream flows since that time.

The greater persistence of flows in the Dawson River at the site of “The Glebe” compared to site 130302A at Taroom may be most easily explained in terms of the greater catchment area at “the Glebe” however discharge from the Hutton Sandstone may also play a small role that cannot be quantitatively discerned from the available hydrographic record.

Table 8-2. Relevant NRW stream gauging locations along the Dawson River.

Gauging Station Number	Gauging Station name	Period of record	Stream Discharge Volume in Megalitres												
130302A	Dawson River at Taroom	1911-2006	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Mean	54,037	95,121	35,781	26,672	26,705	16,361	15,197	7,426	8,560	9,343	26,593	45,777
			Max	489,488	1,443,045	598,098	366,353	1,001,295	380,786	364,752	323,333	334,543	226,720	431,466	596,399
			Min	79	86	0	0	0	0	0	0	10	0	0	42
130303A	Dawson River at The Glebe	1919-1956	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Mean	84,823	202,993	82,128	54,158	44,310	20,311	41,503	12,237	2,068	23,177	36,486	65,023
			Max	698,038	2,566,152	1,304,077	824,552	878,954	310,731	863,006	194,059	12,007	313,905	590,951	1,128,667
			Min	0	300	26	15	0	0	120	202	105	16	1	0
130303B	Dawson River at Glebe Recorder	1956 (?)-1984	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Mean	69,887	167,389	60,578	38,072	56,199	26,780	25,275	7,907	3,292	14,758	26,616	69,770
			Max	698,038	2,566,152	1,304,077	824,552	1,816,918	630,738	863,006	194,059	105,282	313,905	590,951	1,128,667
			Min	0	0	0	0	0	0	0	0	0	0	0	0
130338A	Dawson River at Glebe Weir Headwater	1983-2002	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Mean	44,974	50,014	19,544	46,424	100,437	34,439	13,231	23,879	34,711	5,714	37,341	31,609
			Max	656,595	204,853	193,386	373,237	1,612,121	602,122	212,748	292,970	648,458	53,106	248,830	157,410
			Min	0	0	0	0	0	0	0	0	0	0	0	0
130345A	Dawson River at Glebe Weir Tailwater	1982-2002	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Mean	49,394	54,515	21,382	45,446	98,690	32,593	12,800	25,873	35,748	7,016	39,075	32,368
			Max	656,556	235,312	198,262	404,854	1,657,402	593,219	206,013	293,075	653,099	58,134	254,909	164,782
			Min	1,315	352	0	0	0	0	0	0	0	0	0	0
130320A	Dawson River at Nathan Gorge	1954-1986	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Mean	73,740	223,818	29,881	29,691	138,056	65,097	26,506	15,375	10,145	6,171	17,513	81,706
			Max	630,505	2,531,932	202,223	513,092	2,111,480	700,018	200,656	222,395	178,747	59,825	123,343	898,259
			Min	82	45	0	0	0	0	0	0	0	33	36	109

The mean minimum and maximum annual flows at stream gauging stations throughout the Fitzroy Basin are shown in Table 8-3. The recorded annual flow volumes at the various Glebe Weir stations over the period of record are shown in Figure 8-2. The locations of these gauging stations are shown in Figure 8-1. The following observations can be made with respect to the results in Table 8-1 and Figure 8-2:

- the Dawson River is characterised by extended periods of no to low flow. Several of the Dawson River stations have recorded no flow for periods over 12 months;
- the mean annual flow at the Dawson River gauging stations is directly proportional to catchment area;
- the recorded annual flow volumes at Glebe Weir vary considerably. There are several very wet years, particularly during the 1950s, and several years with no or very low runoff;
- the mean and maximum annual flow at the downstream end of the Dawson River at Boolburra is about 22% to 23% of the mean and maximum annual flow in the Fitzroy River at Riversleigh. The catchment area to Boolburra is about 38% of the Riversleigh catchment area, which suggests that the Dawson River catchment contributes less runoff than the Mackenzie River catchment.

Table 8-3. Fitzroy River recorded flow statistics, October to September Water Year.

Gauging Station		AMTD (km)	Catchment area (km^2)	Period of Record	Mean Annual Flow (ML)	Minimum Annual Flow (ML)	Maximum Annual Flow (ML)
Number	Name						
Dawson River							
130302	Taroom	384.6	15,846	1911-2006	358,915	2,939	2,880,781
130303[a]	Glebe	330.1	21,881	1919-2002	514,539	0	4,528,166
130305	Theodore	230.1	27,330	1924-2002	621,274	0	4,727,754
130322[b]	Beckers	71.0	40,500	1924 -2006	928,144	495	5,730,730
130301	Boolburra	16.1	49,293	1910-1978	1,065,362	0	5,533,933
Mackenzie River							
130105	Coolmaringa	376	76,645	1971–2006	3,526,744	200,460	19,741,356
Fitzroy River							
130003	Riversleigh	276	131,385	1922-2006	4,724,362	96,120	23,874,301

[a] includes 130303a (1919-1956), 130303b (1956-1983) and 130338 (1983-2002)
[b] includes 130304 (1924-1961) and 130322 (1964 – 2006)

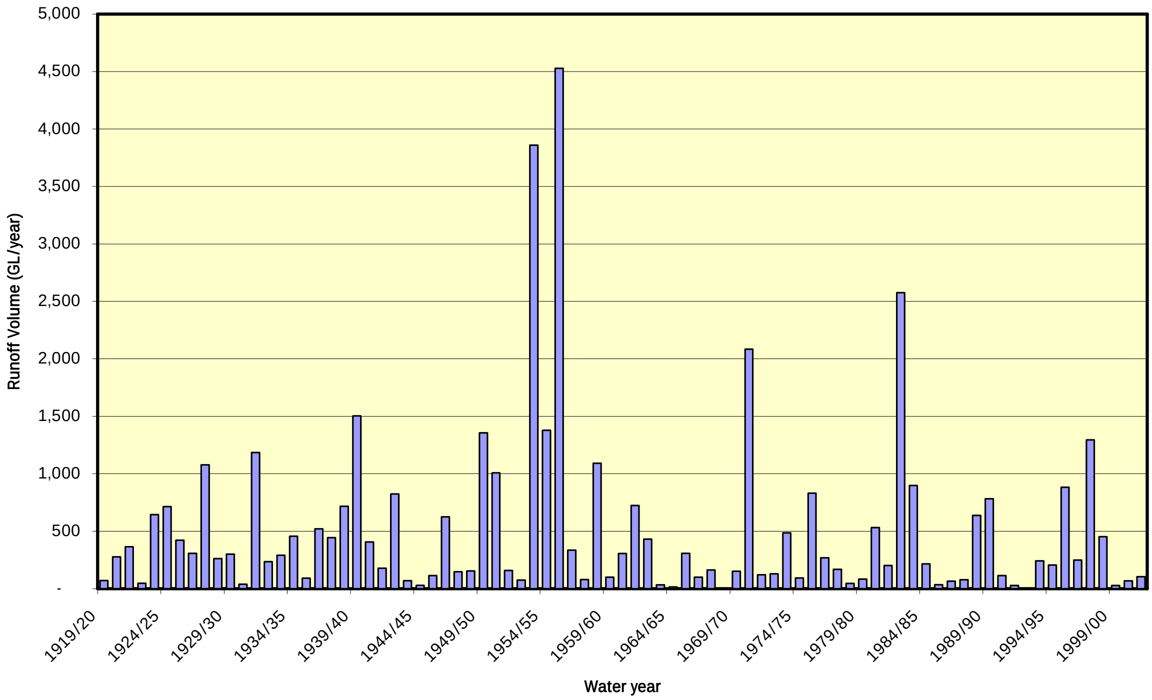

Figure 8-2 Recorded annual flow volumes at Glebe Weir,
GS130303a (1919-1956), GS130303b (1956-1983) and GS130338 (1983-2002)

- Flood Behaviour

Stream flows have been recorded at the various Glebe Weir gauges (Station Nos 130303a&b, 130338) since October 1919. The highest recorded flow (4,610 m^3/s), occurred in February 1956 when the river reached a height of 17.75 m gauge height (GH). Large floods have also occurred in February 1954 (16.61 mGH), May 1955 (15.44 mGH) and May 1983 (15.36 mGH). These large floods occurred over periods of weeks and had flood volumes in excess of a million megalitres (ML). Given that the storage capacity of Glebe Weir is only 17,700 ML, downstream flood levels for medium to large floods are generally unaffected by the existing weir. For frequent floods, the impact of the weir is more significant. However, the weir has historically been at or near full for more than 50% of the time and is overtopped more than 30% of the time. This suggests that the impact of the weir on minor (frequent) floods is limited to the first flush of the season.

Given the relatively low impact of the weir during floods (300 mm at bank full), a flood study at the weir has not been undertaken. However, design flood discharges at the proposed Nathan Gorge damsite, located some 11 river kilometres downstream of the Glebe Weir have been estimated by SunWater in April 2008 for flood events ranging from the 5 year Average Recurrence Interval (ARI) to the Probable Maximum Flood (PMF). These design flood estimates are summarised in Table 8-4 and are expected to be representative of design flood discharges at Glebe Weir. The critical storm duration associated with these design floods varied between 24 hours (1 day) and 120 hours (5 days). These design discharges are shown in Table 8-4. Based upon the flood frequency analysis undertaken by SunWater, the 1956 flood, by far the largest on record, has a calculated ARI plotting position of between 100 and 150 years.

Table 8-4. Design flood discharges, Dawson River at Nathan Gorge (NRW, 1997).

Flow Event	Peak Discharge (m^3/s)
5 Yr ARI	1,430
10 Yr ARI	1,900
20 Yr ARI	2,530
50 Yr ARI	3,050
100 Yr ARI	3,590
1,000 Year ARI	5,160
10,000 Year ARI	9,160
PMF	25,300

8.3.2.2 Existing Water Resource Development

□ Water Resource Planning

The water resource component of the Glebe Option will be assessed under the *Water Act 2000*and its subordinate legislation, the *Water Resource (Fitzroy Basin) Plan 1999* (WRP) (NRW, 1999). The WRP establishes the framework for sustainably managing water and water allocations in the basin. The framework establishes management strategies that deal with:

- environmental flow objectives (EFOs);
- Water Allocation and Security Objectives (WASOs);
- water and ecosystem monitoring requirements, and
- requirements for implementing the strategies.

The WRP specifies the use of the Fitzroy Integrated Quantity and Quality Model (IQQM) developed by NRW over the period 1 January 1900 to 31 December 1995 to assess the impact of water resource development within the catchment. IQQM is a hydrologic modelling tool developed by the New South Wales Department of Water and Energy for use in planning and evaluating water resource management policies at the river basin scale. It is a generalised hydrological simulation package (model) which can be applied to regulated and unregulated streams and is used here to address water quantity issues. The model is structured for investigating and resolving water sharing issues between different groups of users, including the environment (Podger, 2004). A Resource Operations Plan (ROP) (NRW, 2006a) has been developed that provides details on the operating rules of the various storages in the basin to assist with the compliance with the WRP.

NRW have initiated a review of the Fitzroy Basin WRP which aims to develop a new plan and associated supporting materials such as IQQM models by 2009. As a consequence it is possible that alternate operational and environmental strategies may be developed.

- Water Supply Schemes and Water Management Areas

Water supply schemes include those parts of the water resource plan area that contain individual water entitlements that are supplied water (supplemented) using in-stream storage infrastructure. The resource operation plan contains the rules for how the infrastructure operator must operate the infrastructure and it also contains the water sharing rules for the supply of water to the holders of supplemented water entitlements.

Water management areas includes those parts of the water resource plan area that contain water entitlements that rely on opportunity based river flows (such as waterharvesting), these water entitlements are referred to as unsupplemented water entitlements, as water supplies are not delivered from in-stream storage infrastructure.

The plan area can have overlapping water supply scheme and water management area sections of the river system. This is possible as the unsupplemented water take can only occur when water supply in the river is in excess of water being supplied from in-stream infrastructure.

There are supplemented and unsupplemented water entitlements in the Fitzroy Basin. The supplemented allocation holders are delivered water from the various impoundments in the valley. The locations of these schemes are shown in Figure 8-3. The supplemented water supply schemes in the Fitzroy Basin include:

- Dawson Valley Water Supply Scheme;
- Nogoa Mackenzie Water Supply Scheme;
- Lower Fitzroy Water Supply Scheme; and
- Fitzroy Barrage Water Supply Scheme.

Glebe Weir and the proposed additional allocation to supply the Wandoan Coal Mine form part of the Dawson Valley Water Supply Scheme. The Dawson Valley Water Supply Scheme is operated by SunWater under a Resource Operations Licence (ROL) issued by NRW.

The unsupplemented water entitlement holders opportunistically pump water when there is flow in the river. The unsupplemented water management areas in the Fitzroy Basin include:

- Dawson Valley Water Supply Area;
- Nogoa Mackenzie Water Supply Area; and
- Lower Fitzroy Water Supply area.

Dawson Valley Water Management Area is divided into two unsupplemented water management areas (WMAs). WMA1 represents water harvesting on the Dawson River from AMTD 453.5km downstream to the Nathan Gorge and WMA2 represents water harvesting on the Dawson River below Nathan Gorge. The locations of the unsupplemented water management areas are shown in Figure 8-4. NRW are responsible for ensuring that the unsupplemented areas comply with the WRP.

The Glebe Weir Raising and supply of water to the Wandoan Coal mine only potentially impacts on the Dawson Valley Supplemented Water Supply Scheme and the Dawson Valley Unsupplemented Water Management Area. The remaining supplemented and unsupplemented schemes are not discussed further in this chapter.

- Dawson Valley Water Supply Infrastructure

Summary details of the existing water resource infrastructure in the Dawson Valley Water Supply Scheme are shown in Table 8-5. The locations of this infrastructure are shown in Figure 8-1. These storages are managed by SunWater in accordance with its ROL.

Table 8-5 Summary details of existing water resource infrastructure, Dawson Valley Water Supply Scheme.

Structure	Dawson River Location (AMTD km)	Full Supply Volume (ML)	Dead Storage Volume (ML)	Length of River Inundated (km)	Fish Transfer System
Glebe Weir	326.2	17,700	430	30.3	Nil
Gyranda Weir	284.5	16,500	2,120	35.5	Nil
Orange Creek Weir	270.7	6,140	2,320	13.8	Nil
Theodore Weir	228.5	4,760	750	16.0	Nil
Moura Off Stream Storage	156.9	2,820	140	NA	NA
Moura Weir	150.2	7,700	600	12.6	Vertical Slot Fishway
Neville Hewitt Weir	82.7	11,300	2,120	30.3	Fish Lock

NA not applicable

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Figure 8-3 Fitzroy Basin Supplemented Water Supply Schemes

Figure 8-4 Fitzroy Basin Unsupplemented Water Supply Areas

□ Water Use

The total volumetric limits of the supplemented allocations and unsupplemented water entitlements in the Fitzroy Basin are shown in Table 8-6. The supplemented allocations are separated into high, medium A and medium priority, which reflects the level of security of supply for the different types of allocations. A high priority allocation will generally have close to 100% reliability of supply, whereas the medium and medium A priority allocations will have a lower reliability that is determined, amongst other things, on the amount of water available within the various storages over and above the requirements for the high priority users. The WJV will require a high priority allocation from Glebe Weir.

Table 8-6 Fitzroy Basin Supplemented Allocations and Unsupplemented Water Entitlements

<table>
<tr><th rowspan="2">Water Supply Scheme</th><th colspan="3">Nominal Volume of Supplemented Allocation (ML/yr)</th><th rowspan="2">Unsupplemented Total Volumetric Limit (ML/yr)</th></tr>
<tr><th>High</th><th>Medium A</th><th>Medium</th></tr>
<tr><td>Dawson</td><td>5,579</td><td>19,456</td><td>36,902</td><td>NA</td></tr>
<tr><td>Nogoa Mackenzie</td><td>44,398</td><td>0</td><td>190,925</td><td>60,720</td></tr>
<tr><td>Lower Fitzroy</td><td>25,520</td><td>0</td><td>3,101</td><td rowspan="2">46,000*</td></tr>
<tr><td>Fitzroy Barrage</td><td>50,000</td><td>0</td><td>12,335</td></tr>
</table>

*Lower Fitzroy Water Supply Area

Throughout the year, the ROL holder (SunWater) issues an ‘announced allocation’ expressed as a percentage of the total volumetric limit, which in effect puts a ceiling on the amount that each water allocation holder can extract from the river. The announced allocation formula provides for an announced allocation differential of up to 20% for medium A priority water allocations over medium priority water allocations in the upper Dawson sub-scheme. This is consistent with arrangements previously in place for supplies from the channel systems in the Dawson scheme (NRW, 2006a).

A total volumetric limit for the unsupplemented water entitlements in the Dawson Valley Water Supply Area has not been determined in the ROP due to the uncertainties associated with the proposed Nathan Dam. The WRP includes provisions for the construction of the proposed Nathan Dam. However, the operation details for Nathan Dam are not available because it has not yet been approved or constructed. Therefore, water harvesting (unsupplemented) entitlements have not been converted to water allocations in the Dawson Water Management Area because the performance of these entitlements can not be determined.

□ Dawson Valley Water Supply Scheme

The Dawson Valley Water Supply Scheme is divided in to two sub-schemes. The upper Dawson sub-scheme includes Glebe, Gyranda, Orange Creek, Theodore and Moura Weirs and the Moura off stream storage, while the lower Dawson sub-scheme includes Neville Hewitt Weir. The two sub-schemes operate independently as the lower sub-scheme achieves higher reliabilities than the upper sub-scheme without being supplemented from the upper storages. The upper Dawson sub-scheme storages are operated in harmony to maximise efficiencies and to minimise transmission losses in the system.

At present, the majority of the demand in the upper Dawson sub-scheme is associated with the irrigation of agricultural crops such as cotton. The cotton water year commences about September and is completed by about March. Water is released from Glebe Weir from about July to top up the downstream storages prior to the start of the cotton irrigation season. A range of rules has been developed for the weirs to ensure the water is available at the closest weir to the water demand to minimise transmission losses and reduce water ordering times. Water is then released from Glebe Weir on an ‘as needed’ basis to top up the downstream storages throughout the irrigation season until the weir is empty. If no additional runoff is received, Glebe Weir can run out of water prior to the end of the irrigation season.

There are three allocation holders that extract water directly from Glebe Weir and none between Glebe Weir and the next downstream storage (Gyranda Weir) that are affected by this operating strategy. The relative impact of this operating strategy on these allocation holders is not significant. However, it is understood that these farmers are compensated for the reduced opportunity to pump during the dry periods through reduced allocation charges.

- Impact of Existing Development on Dawson River Stream Flows

The simulated mean annual stream flows at three gauging stations downstream of Glebe Weir for pre-development and full entitlement modelling conditions are shown in Table 8-7. The locations of these gauging stations are shown in Figure 8-1. The stream flows were obtained from the NRW IQQM model results over the period 1 October 1900 to 30 September 1995. The full entitlement flows represent the simulated flows (NRW’s DAW31b.s36), which basically represents the river flows that would have occurred over the 94 year period had the existing infrastructure been in place and the existing allocation holders extracted their full allocation of water over this period. As not all allocations are fully activated, full entitlement modelling represents the worst case scenario rather than the current use conditions. The pre-development flows represent the conditions in the river with no infrastructure and no water extractions.

The results show that the existing infrastructure and water entitlements reduce mean annual flows in the Dawson River by up to 11%. The reduction in flows at Nathan Gorge is less significant at 4%, which indicates that most of the water infrastructure and water use is located downstream of Nathan Gorge.

Table 8-7 Dawson River mean annual stream flows, pre-development and full entitlement (WRP) conditions

Gauging Station		AMTD (km)	Catchment area (km^2)	Mean Annual Discharge Volume (ML)		Percent Reduction
Number	Name			Pre-Development	WRP	
130322	Beckers	71.0	40,500	1,011,900	895,700	11
130305	Theodore	230.1	27,330	664,900	589,600	11
130320	Nathan Gorge	307.2	23,300	571,500	548,700	4

8.3.2.3 WASOs and EFOs

The Fitzroy basin WRP outlines the objectives that must be met by Resource Operations Licence (ROL) holders such as SunWater who hold the ROL for the Dawson Valley Water Supply Scheme (WSS). The main objectives of the WRP are the Water Allocation Security Objectives (WASOs) and the Environmental Flow Objectives (EFOs). WASOs are expressed as a reliability, i.e. 'The water allocation security performance indicator for supplemented water supplies within an existing or future water supply scheme is defined as the median of the simulated monthly reliabilities for water allocations of a particular priority group within that water supply scheme'. EFOs are expressed as a range of statistics based on seasonal, medium and high flows and post winter flow events to provide for environmental water requirements for natural ecosystems in the plan area.

The WASOs and EFOs for the Fitzroy Basin are detailed in Schedule 2 and 3 of the WRP. Although the WRP outlines a number of objectives for the Fitzroy Basin, not all are applicable to the assessment of the Wandoan Coal Mine water supply. This chapter highlights the essential WASOs and EFOs relevant to this study.

- Water Allocation Security Objectives

The WASOs outlined in Schedule 3 of the WRP are relevant to all medium and high priority users on the Upper and Lower Dawson Valley Water Supply Schemes. These are summarised in Table 8-8.

Table 8-8 Fitzroy Basin Water Allocation Security Objectives

Priority Group	Mandatory Median Monthly Reliability (%)	Upper Bound target Median Monthly Reliability (Optional) (%)
High	≥ 95	≥ 100
Medium	≥ 82	≥ 88

- Environmental Flow Objectives

The three environmental flow reporting locations mentioned in Schedule 2 of the WRP that are impacted by the proposed changes to the Dawson Valley Water Supply Scheme are shown in Table 8-9. The environmental flow objectives at the relevant reporting nodes are detailed in Table 8-10, Table 8-11 and Table 8-12. The locations of these reporting nodes are shown in Figure 8-1.

Table 8-9 Dawson River Reporting Locations

WRP Node No.	Station Name	Station Number
2	Dawson River at Beckers	GS 130322
4	Dawson River at Theodore	GS 130305
5	Dawson River at Nathan Gorge	GS 130320

The Fitzroy WRP identifies seasonal base flows as a non-mandatory objective. The seasonal objective relates to the percentage of time at particular seasons of the year that a specific base flow occurs. The base flow for a given node is the estimated flow at that node that has been assessed as being required to optimise the available wetted habitat in the low flow section of the river.

The seasonal base flow objectives (SBF) described in Table 8-10 require that for a watercourse within Dawson Valley WSS, SBF performance indicators at the reporting nodes should be between 0.8 to 1.2 times the values given in Table 8-10. The SBF performance indicator is defined as the proportion of time (expressed as a percentage) for each of the three seasons (Jan–Apr, May–Aug and Sep–Dec) during which the base flow is equalled or exceeded for the corresponding season over the simulation period.

Table 8-10 Seasonal Base Flow Objectives at EFO nodes for Dawson Valley WSS.

Node	Location	Base Flow (ML/d)	Seasonal Base Flow Performance indicator values (based on the pre-development flow pattern).		
			Jan-April (%)	May-Aug (%)	Sep-Dec (%)
2	Dawson River at Beckers	86	67	29	35
4	Dawson River at Theodore	78	64	27	36
5	Dawson River at Nathan Gorge	45	62	27	35

The Fitzroy WRP also requires that the first post winter flow (FPWF) event mimics the pre-development flow pattern as it passes through storages in the system. For an event to be considered a FPWF it must satisfy a range of criteria including that it occurs between 15 September and 10 April, has a minimum length of 21 days, and meets particular flow and volume requirements at various locations throughout the Fitzroy Basin. The specific objectives are described in the Table 8-11.

Table 8-11 Mandatory First Post Winter Flow (FPWF) Event objectives for reporting nodes in Table 8-11.

Performance Indicator for FPWF objective	Units	Mandatory Values
Number of first post-winter flows	% of FPWF events in the simulation expressed as % of number of post-winter flow years¥.	≥ 80%
Number of flows within 2 weeks of predevelopment event	% of FPWF events in the simulation expressed as % of number of post-winter flow years¥.	≥ 50%
Number of flows within 4 weeks of predevelopment event	% of FPWF events in the simulation expressed as % of number of post-winter flow years¥.	≥ 70%
Flow Duration 2 times base flow for 4 day tolerance	% of 2-times base flow events in the simulation expressed as % of number of post-winter flow years¥.	≥ 70%
Flow Duration 5 times base flow for 4 day tolerance	% of 5-times base flow events in the simulation expressed as % of number of post-winter flow years¥.	≥ 70%
Average peak flow	% of flow for the Pre development event.	≥ 70%

¥ - means a year in the simulation period in which a first post-winter flow event happens for the pre-development flow pattern.

The medium to high flow objectives cover a range of statistics that reflect estuarine and river health. The medium to high flow event objectives are only relevant to Node 2 (Dawson River at Beckers) and are as follows:

- the medium to high flow performance indicators must be better than or equal to the corresponding planned development limits in Table 8-12; and
- the medium to high flow performance indicators should be better than the corresponding environmental flow limits shown in Table 8-12.

With the exception of the fish species diversity statistic, the performance indicators planned development limits and environmental flow limits in Table 8-12 are expressed in terms of the percentage of the pre-development flow pattern performance indicator.

Table 8-12 Mandatory and Non mandatory Medium to High Flow Event Objectives for Node 2 (Dawson River at Beckers).

Performance Indicator for medium to high flow objective	Environmental flow limits (%) – (Non mandatory Targets)	Planned development limits (%) – (Mandatory Targets)
Mean Annual Flow	≥ 74	≥ 69
Median Annual Flow	≥ 50	≥ 50
Floodplain Zone Statistics	≥ 70	≥ 69
Upper Riparian Zone Statistic or Bank Full Statistic	≥ 85	≥ 80
In-channel Riparian Zone Statistic	≥ 75	≥ 75
Channel Morphology Statistic	≥ 65	≥ 60
Fish Species Diversity Statistic (APFD)	≤ 3	≤ 3

8.3.3 Potential Impacts and Mitigation Measures

□ General

The potential hydrological impacts of raising Glebe Weir and supplying the additional high priority demand to Wandoan Coal are as follows:

- potential increase in erosion downstream of the dam due to rapid inflation and deflation of the rubber dam;
- increase the extent of flooding upstream of the weir;
- impact on WASOs for downstream water entitlements; and
- impact on downstream EFOs.

A discussion of the above impacts and proposed mitigation measures is given below.

8.3.3.1 Flooding and Erosion Impacts and Mitigation Measures

The raised Glebe Weir inundation area at the full supply level of 172.9 m AHD extends some 31 river kilometres upstream of the raised weir. The inundation area is generally confined to the main channel of the Dawson River with some overbank areas inundated along the minor waterways that drain into the impoundment, namely Binghi Creek and Boggomoss Creek to the north and Cockatoo Creek to the south.

The Wandoan Coal Mine high priority demand will change the storage level behaviour of Glebe Weir. Under the current operating strategy, water is released from the weir on a regular basis to top up the downstream storages and, therefore, the water level can fluctuate significantly throughout the year. The high priority demand for

Wandoan Coal Mine will require sufficient water to be stored at the weir to supply the mine through extended dry periods. Therefore, the weir will be full to near full more frequently and the water level fluctuations will reduce. This change in operating strategy will improve the opportunity to pump for the three allocation holders located on Glebe Weir pool.

The proposed inflatable rubber dam (membrane) to raise Glebe Weir could potentially increase flood levels upstream of the dam and erosion downstream of the dam if not operated correctly. Inflatable rubber dams consist of a fabric reinforced rubber membrane that can be inflated with air. The membranes can be set to inflate and deflate automatically based on the upstream water level. When fully deflated, the crest of the new weir will be only 0.14 m above the existing weir crest level. Therefore, if the membranes are fully deflated, then the increase in upstream flood levels will be about 0.14 m at the weir structure decreasing upstream with backwater profile such that the effect would be negligible at the upstream limit of the storage.

If the membrane is not deflated during a flood event, then premature overbank flooding would occur as some 2 m depth of the waterway will be unavailable to carry the flood flows. In addition, if the membrane is deflated too early or too quickly on the rising limb of the flood then the rapid release of the stored water may cause erosion in the downstream channel. If the membrane is inflated too quickly on the falling limb of the flood hydrograph, then the rapid draw down of downstream flows may cause the saturated river banks to collapse and potentially strand fish in pools.

Operating rules will be developed for the proposed weir to mitigate these impacts. The general concept of the proposed operating rules will be as follows:

- the central 55.2 m section of the membrane will commence deflation when the water level is 0.15 m above the weir crest (flow rate = 25 m^3/s);
- the membrane will be deflated to ensure that the rate of the downstream water level rise is consistent with historical flood event water level rises;
- the membrane will be inflated to ensure that the rate of downstream water level fall is consistent with historical flood event water level falls; and
- the membrane will be inflated to maximise the storage volume at the completion of the flow event while still being consistent with the Fitzroy WRP EFOs.

In addition, a fail safe mechanism will be included so that the rubber dam will always deflate when the storage level reaches a set headwater level to ensure that no additional overbank flooding occurs. Under the above operating rules, the weir upgrade will not significantly impact on upstream flood levels or downstream erosion. Further hydraulic analysis will be undertaken during detailed design to develop operating rules to mitigate any flood and erosion impacts of the raised weir.

The utilisation of inflatable rubber dams to increase the storage capacity of water impoundments is a relatively common practice throughout the world, with this technology having been successfully utilised by SunWater for a series of other raising projects in Queensland such as Bedford Weir on the Mackenzie River, Claude Wharton Weir on the Burnett River, Dumbleton Weir on the Pioneer River, and Koombooloomba Dam on the Tully River.

Note that the existing weir and the proposed raised weir are effectively drowned when upstream flood flows reach the crest level of the proposed left and right bank levees (172.5 m AHD). That is, the water level downstream of the weir is within about 0.3 m of the upstream water level at this level. This water level was reached in five of the years between 1982 and 2002 at the Glebe Weir Headwater gauge (GS 130338a), or approximately once every four years.

8.3.3.2 WASO's and EFO's

SunWater used the Fitzroy WRP IQQM model (NRW's Daw31b.s36) to assess the impact of the raised weir and a range of new high priority demand scenarios on the Dawson River EFOs and WASOs. To comply with the WRP objectives, changes to the existing medium priority entitlements and environmental flow release rules from the various weirs were necessary. The objective of the changes was to ensure all mandatory WRP EFOs and WASOs were met, in addition to ensuring the performance of the existing high and medium priority water entitlements were no worse than under the existing WRP conditions case. The purpose of this last requirement was to alleviate the concerns existing users may have about the impact of raising the weir and the additional demand. A summary of the changes made to the WRP IQQM model for each demand scenario to achieve these objectives is given in Table 8-13.

Table 8-13 Summary of environmental flow release rule changes

Operational Changes from Existing WRP	Existing WRP Condition (EO case)	Additional Glebe Weir Demand (ML/yr)		
		6,500	7,000	8,500
Pre-requisite purchase and conversion of Medium Priority from Theodore channel.	-	None	980 ML	3210 ML
System Reserve (Upper Dawson/Lower Dawson)	Reserve as Transmission and Operating loss.	Upper Dawson: System Reserve for months between Jan-Dec is 3000 ML.	Lower Dawson: 10 ML reduced from Jan, 100 ML reduced from Feb-April, 100 ML reduced from May-Sept and 50 ML reduced from Oct-Dec as compared to Existing WRP (EO) case.	
Local Supply Volume (LSV) for Gyranda Weir	3700 ML	4400 ML	4100 ML	4100 ML
LSV for Theodore Weir	3140 ML	3525 ML	3525 ML	3525 ML
Nominal Operating Volume (NOV) for Gyranda Weir	4100 ML	4410 ML	NA	NA
Seasonal Base Flow (SBF) Release trigger from Neville Hewitt Weir	NA	SBF release trigger increased from 70 ML/d to 80 ML/d.	NA	NA
Environmental First Post Winter Flow (FPWF)	No Environmental Flow Release	Environmental Flow Release Strategy	Environmental Flow Release Strategy	Environmental Flow Release Strategy

Operational Changes from Existing WRP	Existing WRP Condition (EO case)	Additional Glebe Weir Demand (ML/yr)		
		6,500	7,000	8,500
Release Strategy for Glebe and Theodore	Strategy for Glebe and Theodore.	based on inflows and storage volume	based on inflows and storage volume	based on inflows and storage volume

Each of the changes listed in Table 8-13 is described below:

- for each scenario except the 6,500 ML/yr demand scenario, some pre-requisite purchase and conversion of existing medium priority allocation from the Theodore reach of the Dawson River was necessary to eliminate the adverse effects on the reliabilities of supply to existing users. For the 7,000 ML/yr demand scenario, 980 ML/yr of medium priority allocation need to be purchased. That is, 980 ML of medium priority allocation is required to secure an additional 500 ML/yr of high priority water at Glebe Weir. For the 8,500 ML/yr demand scenario, 3,210 ML/yr of medium priority allocation needs to be purchased.
- the system reserve refers to the amount of water to be stored in the system including losses to protect the reliability of supply to the existing high and medium priority users within the scheme. The system reserve parameters are outlined in the Fitzroy ROP.
- the local supply volume (LSV) for Gyranda and Theodore Weirs is a mechanism that protects the supply to users located either on-pond or within that particular reach of the river from downstream storage demands. It prevents the downstream storages from ordering if the upstream storage is below a certain level. For further detail on this issue, refer to the Fitzroy ROP Section 4.1E.
- the nominal operating volume (NOV) for Gyranda Weir is a mechanism by which releases must be made from the relevant upstream storage to maintain the water level in Gyranda at its nominal operating level, unless the water level in the upstream storage is below its local supply volume.
- seasonal Base Flow (SBF) release trigger for Neville Hewitt Weir is a release that is based on inflows to Neville Hewitt Weir to meet SBF environmental objective. This adjustment was made for the 6,500 ML/yr demand scenario to protect the existing medium priority reliabilities in the Lower Dawson.
- environmental flow release strategies were developed for Glebe and/or Theodore Weirs for each demand scenario based on hardwired files. Inflow based strategies were derived as they have the best chance of mimicking natural flow regimes. The term 'hardwired' refers to the use of a 'flag' file created outside IQQM specifying commencement and cessation dates for the FPWF releases for the simulation period. This is currently the preferred approach by NRW for this Water Supply Scheme.

□ Compliance with WASOs

The modelled reliabilities for the high and medium priority users in the Dawson Valley Water Supply Scheme for the existing Fitzroy WRP scenario and the three new demand scenarios from Glebe Weir are provided in Table 8-14 and Table 8-15. For the high priority allocations in the Upper Dawson sub-scheme, median monthly reliabilities are shown for all high priority users with and without the new high priority demand for the WJV to show the impact on the existing users.

The following is of note:

- the comparison of the results against the WRP target values shows that all three demand scenarios satisfy the mandatory WASOs for the Dawson River Water Supply Scheme;
- the proposed upgrade does not impact on the high or medium priority reliabilities in Lower Dawson sub-scheme;
- the reliability of the existing high priority users in the Upper Dawson sub-scheme remain at 100%. A lower reliability is given to the proposed Wandoan Coal high priority allocation to ensure the existing high priority users are not affected; and
- the reliability of the median priority users in the Upper Dawson sub-scheme improves from 83% to 84-85% for each scenario.

Table 8-14 High Priority WASOs for Upper and Lower Dawson

Mandatory Water Allocation Security Objectives	WRP Target Reliability (%)	Model Reliability (%)
Fitzroy WRP (Existing Conditions)		
UPPER DAWSON		
Median Monthly Reliability (Excluding new HP node)	NA	NA
Median Monthly Reliability (Including new HP node)	≥ 95	100
LOWER DAWSON		
Median Monthly Reliability	≥ 95	100
6,500ML/yr Demand Scenario		
UPPER DAWSON		
Median Monthly Reliability (Excluding new HP node)	NA	100
Median Monthly Reliability (Including new HP node)	≥ 95	97
LOWER DAWSON		
Median Monthly Reliability	≥ 95	100
7,000 ML/yr Demand Scenario		
UPPER DAWSON		
Median Monthly Reliability (Excluding new HP node)	NA	100
Median Monthly Reliability (Including new HP node)	≥ 95	97
LOWER DAWSON		
Median Monthly Reliability	≥ 95	100
8,500ML/yr Demand Scenario		
UPPER DAWSON		
Median Monthly Reliability (Excluding new HP node)	NA	100
Median Monthly Reliability (Including new HP node)	≥ 95	97
LOWER DAWSON		

Mandatory Water Allocation Security Objectives	WRP Target Reliability (%)	Model Reliability (%)
Median Monthly Reliability	≥ 95	100

Table 8-15 Mandatory Medium Priority WASOs for Upper and Lower Dawson

Mandatory Water Allocation Security Objectives	WRP Target Reliability (%)	Model Reliability (%)
Fitzroy WRP (Existing Conditions)		
UPPER DAWSON		
Median Monthly Reliability	82-88	83
LOWER DAWSON		
Median Monthly Reliability	82-88	90
6,500ML/yr Demand Scenario		
UPPER DAWSON		
Median Monthly Reliability	82-88	84
LOWER DAWSON		
Median Monthly Reliability	82-88	90
7,000ML/yr Demand Scenario		
UPPER DAWSON		
Median Monthly Reliability	82-88	85
LOWER DAWSON		
Median Monthly Reliability	82-88	90
8,500ML/yr Demand Scenario		
UPPER DAWSON		
Median Monthly Reliability	82-88	84
LOWER DAWSON		
Median Monthly Reliability	82-88	90

8.3.3.3 Unsupplemented Water Users

The Fitzroy WRP also specifies WASOs for some unsupplemented water users. It is recalled that the Dawson River is divided into two unsupplemented water management areas (WMA); WMA1 representing water harvesting on the Dawson River from AMTD 453.5km to the Nathan Gorge and WMA2 representing water harvesting on the Dawson River below Nathan Gorge. WMA1 users remain unaffected in all scenarios considered as the new development is downstream of WMA1. The WRP does not specify WASOs for unsupplemented water users in WMA2. However, the performance of some WMA2 users will be adversely affected by the modelled scenarios when compared against the existing Fitzroy WRP case. Typically this means a missed water harvesting opportunity by a maximum of up to one day per year. If this water supply alternative is adopted, the Proponent will

Table 8-16 Comparison of Unsupplemented Water Performance Indicators.

IQQM Node (Water users on Dawson River below Nathan Gorge)	Number of Pumping Days Fitzroy WRP Scenario			Number of days by which water harvesting (WH) opportunity is missed when compared to Fitzroy WRP Scenario								
				6,500ML/yr Demand Scenario			7,000ML/yr Demand Scenario			8,500ML/yr Demand Scenario		
	30%ile Year	50%ile Year	75%ile Year	30%ile Year	50%ile Year	75%ile Year	30%ile Year	50%ile Year	75%ile Year	30%ile Year	50%ile Year	75%ile Year
18	20	17	6	0	1	0	0	1	0	0	1	0
28	40	32	16	0	0	0	0	0	0	0	0	0
29	8	8	2	0	0	0	0	0	0	0	0	1
37	22	19	14	0	0	0	0	0	0	0	1	0
38	20	17	9	0	0	0	0	0	0	0	0	1
48	14	8	4	0	0	0	0	0	0	0	0	0
57	47	36	29	0	0	0	0	0	0	0	0	0
85	73	68	60	0	0	0	0	0	0	0	0	0
101	22	18	10	0	0	0	0	0	0	0	1	1
104	21	17	11	0	0	1	0	0	1	0	0	1
107	20	17	8	0	0	0	0	0	0	0	0	1
112	20	17	6	0	0	0	0	0	0	0	0	0
115	21	17	12	1	0	1	0	0	1	1	0	1
117	21	18	9	1	0	0	1	0	0	1	1	0
118	20	16	7	0	0	1	0	0	0	0	0	1
119	19	16	7	0	1	1	0	1	1	0	1	1
120	19	16	5	0	0	0	0	0	0	0	0	0
121	19	15	5	0	0	1	0	0	0	0	0	1
122	20	16	10	0	0	1	0	0	0	0	0	1
123	22	20	17	0	1	0	0	0	0	0	1	0
124	21	18	14	0	0	1	0	0	1	0	0	1
126	103	103	103	0	0	0	0	0	0	0	0	0
131	21	18	12	0	0	1	0	0	1	0	1	1
132	21	16	10	1	0	0	1	0	0	1	0	1
254	21	18	12	0	0	1	0	0	1	0	1	1
255	20	16	10	0	0	0	0	0	0	0	0	0
288	14	14	14	0	0	0	0	0	0	0	0	0

discuss compensation arrangements with impacted water harvesters for the estimated missed opportunity. This variance from the existing Fitzroy WRP case for each modelled demand scenario is given in Table 8-16.

- Compliance with EFOs

The non mandatory and mandatory EFO results are shown in Table 8-17 to Table 8-19 respectively, at the reporting nodes specified in Table 8-9 for the Fitzroy WRP and the three modelled demand scenarios from Glebe Weir. The results show that all environmental flow statistics meet mandatory requirements. However, there are several non mandatory seasonal base flow performance indicator objectives that are not met. Note that the existing Fitzroy WRP also does not meet these non mandatory objectives under full entitlement modelling.

Table 8-17 Non Mandatory Seasonal Base Flow Objectives Results

Node	Location	Seasonal Base Flow Performance Indicator objective Target (Non mandatory)	Seasonal Base Flow Performance Indicator Objective		
			Jan-April	May-Aug	Sep-Dec
Fitzroy WRP (Existing Conditions)					
2	Dawson River at Beckers	0.8-1.2	0.8	0.8	0.7
4	Dawson River at Theodore	0.8-1.2	0.8	0.9	0.9
5	Dawson River at Nathan Gorge	0.8-1.2	0.9	0.9	1.21
6,500 ML/yr Demand Scenario					
2	Dawson River at Beckers	0.8-1.2	0.8	0.8	0.7
4	Dawson River at Theodore	0.8-1.2	0.7	0.8	0.7
5	Dawson River at Nathan Gorge	0.8-1.2	0.9	0.8	1.2
7,000 ML/yr Demand Scenario					
2	Dawson River at Beckers	0.8-1.2	0.8	0.8	0.7
4	Dawson River at Theodore	0.8-1.2	0.7	0.8	0.7
5	Dawson River at Nathan Gorge	0.8-1.2	0.8	0.8	1.1
8,500 ML/yr Demand Scenario					
2	Dawson River at Beckers	0.8-1.2	0.8	0.8	0.7
4	Dawson River at Theodore	0.8-1.2	0.7	0.8	0.8
5	Dawson River at Nathan Gorge	0.8-1.2	0.8	0.8	1.1

Does Not Achieve Non-mandatory Target

Note that the three new demand scenarios include an environmental release from Glebe Weir based on a hardwired file generated for pre-development first post winter flow (FPWF) pattern at node 5 (Nathan Gorge), Glebe Weir inflows and storage volume. As directed by NRW, a post winter release strategy was also developed for Theodore Weir to improve the performance of WRP Node 4 (Theodore) FPWF statistics based on Theodore Weir inflows, storage volume and a hardwired file generated for Gyranda Weir pre-development FPWF pattern.

Table 8-18 Mandatory First Post-Winter Flow Event Performance Indicators.

Performance Indicator for FPWF objective	Mandatory Values	Node 2 (Beckers)	Node 4 (Theodore)	Node 5 (Nathan)
Fitzroy WRP (Existing Conditions)				
Number of first post-winter flows	≥ 80%	92%	89%	92%
Number of flows within 2 weeks of predevelopment event	≥ 50%	73%	66%	71%
Number of flows within 4 weeks of predevelopment event	≥ 70%	81%	70%	73%
Average peak flow	≥ 70%	85%	81%	90%
Flow Duration 2 times base flow for 4 day tolerance	≥ 70%	87%	87%	92%
Flow Duration 5 times base flow for 4 day tolerance	≥ 70%	80%	84%	91%
6,500 ML/yr Demand Scenario				
Number of first post-winter flows	≥ 80%	92%	87%	91%
Number of flows within 2 weeks of predevelopment event	≥ 50%	72%	67%	69%
Number of flows within 4 weeks of predevelopment event	≥ 70%	81%	71%	71%
Average peak flow	≥ 70%	85%	77%	89%
Flow Duration 2 times base flow for 4 day tolerance	≥ 70%	88%	87%	91%
Flow Duration 5 times base flow for 4 day tolerance	≥ 70%	82%	85%	89%
7,000 ML/yr Demand Scenario				
Number of first post-winter flows	≥ 80%	92%	85%	91%
Number of flows within 2 weeks of predevelopment event	≥ 50%	72%	67%	69%
Number of flows within 4 weeks of predevelopment event	≥ 70%	81%	71%	71%
Average peak flow	≥ 70%	85%	77%	87%
Flow Duration 2 times base flow for 4 day tolerance	≥ 70%	88%	85%	91%
Flow Duration 5 times base flow for 4 day tolerance	≥ 70%	81%	84%	90%
8,500 ML/yr Demand Scenario				
Number of first post-winter flows	≥ 80%	92%	85%	90%
Number of flows within 2 weeks of predevelopment event	≥ 50%	72%	67%	69%
Number of flows within 4 weeks of predevelopment event	≥ 70%	81%	71%	71%
Average peak flow	≥ 70%	85%	76%	86%
Flow Duration 2 times base flow for 4 day tolerance	≥ 70%	88%	84%	90%
Flow Duration 5 times base flow for 4 day tolerance	≥ 70%	81%	84%	88%

Table 8-19 Mandatory and non mandatory medium to high flow event objectives for Node 2 (Beckers)

Performance Indicator for Medium to High Flow Objective	Mandatory Targets (Planned Development Limits) for Node 2	Non-mandatory Targets (Environmental Flow Limits) for Node 2	Existing WRP	Demand Scenario (ML/yr)		
				6,500	7,000	8500
Mean Annual Flow	≥ 69%	≥ 74	89%	88%	88%	88%
Median Annual Flow	≥ 50%	≥ 50	80%	79%	79%	79%
Floodplain zone statistics	≥ 69%	≥ 70	84%	84%	84%	84%
Upper Riparian zone statistic or Bank full statistic	≥ 80%	≥ 85	91%	91%	91%	91%
In-channel riparian zone statistic	≥ 75%	≥ 75	86%	85%	85%	85%
Channel Morphology statistic	≥ 60%	≥ 65	81%	85%	83%	83%
Fish Species Diversity Statistic (APFD)	≤ 3	≤ 3	1	1	1	1

8.3.3.4 Flow Regime

Simulated daily flow duration curves at the three reporting locations given in Table 8-9 for pre-development and the existing conditions Fitzroy WRP, as well as the new 6,500 ML/yr, 7,000 ML/yr and 8,500 ML/yr Glebe Weir demand scenarios are shown in Figure 8-5, Figure 8-6 and Figure 8-7. The flow duration curves represent the percentage of time the flow is equal to or exceeds a particular discharge during the simulation period. Flow duration curves provide an indication of the variations in daily flows over an extended period of time. They also enable a comparison of the changes in flow regime due to the different demand scenarios. The changes in mean annual flow at the three reporting nodes for the different modelled scenarios are given in Table 8-20. The results indicate the following:

- the pre-development flow is significantly different to all of the development scenarios. However, the differences between each of the development scenarios are generally minor;
- at Beckers, the flow duration curves of the four development scenarios are very similar except for some minor variations in frequency between the 10 ML/d and 100 ML/d flow range;
- at Theodore, the frequency of flows greater than 100 ML/d is generally unchanged. However, the three Glebe Weir demand development scenarios would reduce the number of days there are flows less than 100 ML/d when compared to the existing Fitzroy WRP scenario.
- at Nathan Gorge, the difference between the flow duration curves for pre-development and the four development scenarios is not significant for flows greater than about 15 ML/d. However, the existing Fitzroy WRP and proposed Glebe Weir demand scenarios have a significant impact relative to pre-development flows less than 15 ML/d.

- when compared to the Existing Fitzroy WRP conditions, the three Glebe Weir demand scenarios reduce mean annual flows by about 0.5% at Beckers, 1% at Theodore and 1.5% at Nathan Gorge. For the larger demand scenarios, the reduction in flow is minimised by the proposed acquisition of medium priority water from the system.

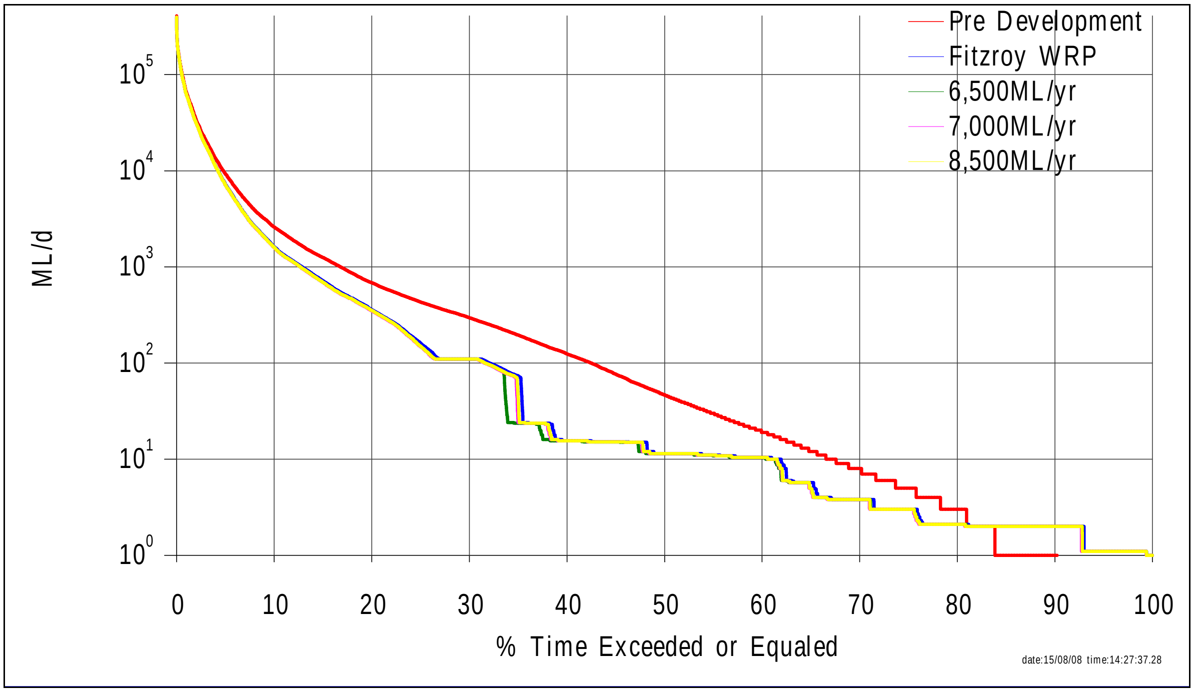

Figure 8-5 Daily Flow Duration Curves for Dawson River at Beckers (node 2), Pre-development and Development Scenarios

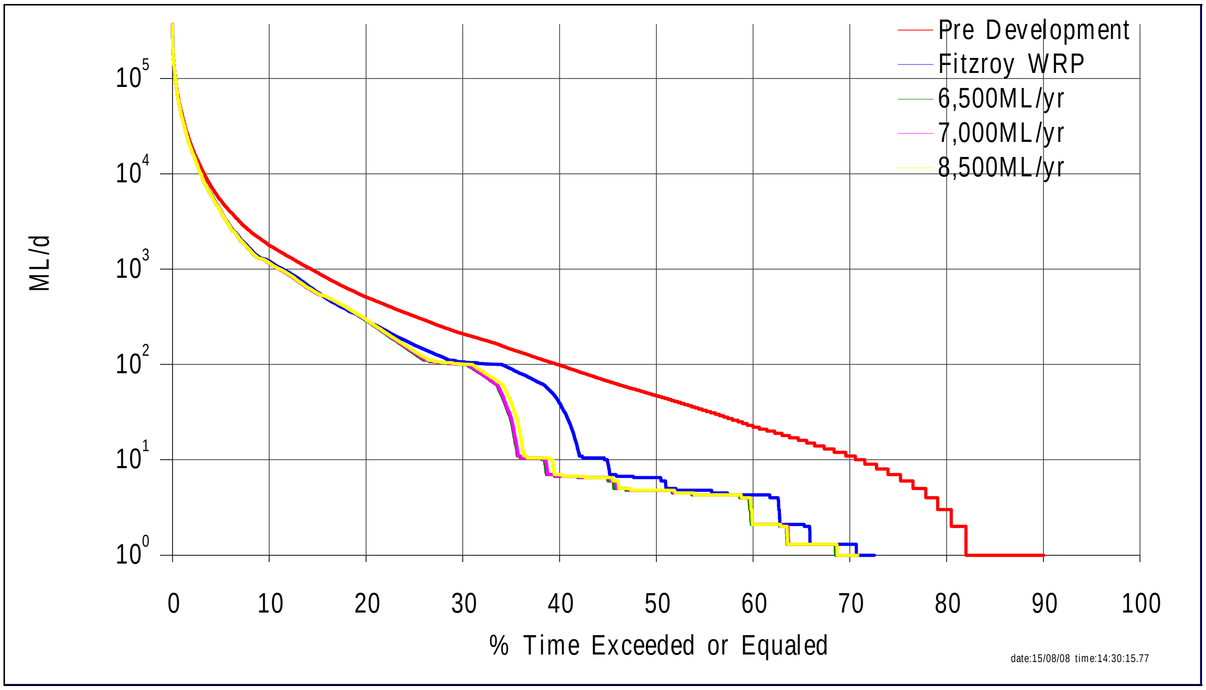

Figure 8-5 Daily Flow Duration Curves for Dawson River at Theodore (node 4), Pre-development and Development Scenarios

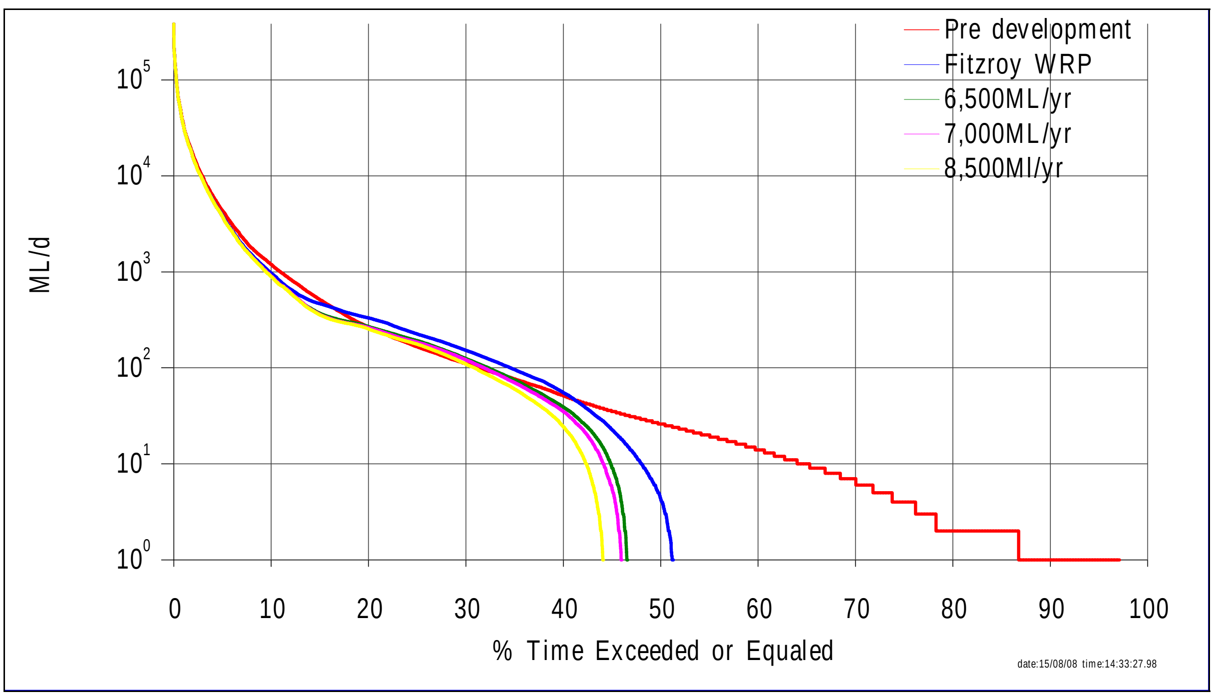

Figure 8-7 Daily Flow Duration Curves for Dawson River at Nathan Gorge (node 5), Predevelopment and Development Scenarios

Table 8-20 Dawson River mean annual flows, pre-development and various development scenarios

Gauging Station		Mean Annual Discharge Volume (ML)				
Number	Name	Pre-Development	Existing Fitzroy WRP	Glebe Weir Demand Scenarios (ML/yr)		
				6,500	7,000	8,500
130322	Beckers	1,011,900	895,700	891,000	891,000	891,700
130305	Theodore	664,900	589,600	583,300	583,500	584,300
130320	Nathan Gorge	571,500	548,700	540,800	540,200	538,800

- Construction Stage Hydrological Impacts

The construction of the raised Glebe Weir is not likely to significantly impact on the hydrologic flow regime of the Dawson River. There will be a temporary loss of available storage volume due to the removal of the existing concrete spillway weir crest. This temporary loss of storage could impact on the reliability of supply for some downstream users, particularly if construction occurs during a Dawson River flow event. The construction of the concrete spillway weir crest is programmed to occur during the drier months (See Section 2 for indicative work schedule) to reduce the potential for this to occur. In addition, the current operating strategy of releasing water in July to top up the downstream storages prior to the commencement of the cotton irrigation season may need to change to draw down the storage sufficiently for construction. This change is not expected to be significant, if it is needed at all.

8.3.3.5 Summary of Findings

- Flooding and Erosion Impacts and Mitigation Measures

The raised Glebe Weir inundation area is generally confined to the main channel of the Dawson River with some overbank areas inundated along the minor waterways that drain into the impoundment, namely Binghi Creek and Boggomoss Creek to the north and Cockatoo Creek to the south.

The WJV high priority demand will change the storage level behaviour of Glebe Weir. The weir will be full to near full more frequently and the water level fluctuations will reduce to ensure there is sufficient water to supply the WJV through extended dry periods.

Operating rules will be developed for the inflatable rubber dam proposed to raise Glebe weir to minimise the impact on flooding and erosion. The general concept of the proposed operating rules will be as follows:

- the weir will commence deflation when the water level is 0.15 m above the crest of the new weir to minimise upstream flooding;
- the weir will be deflated to ensure that the rate of the downstream water level rise is consistent with historical flood event water level rises to reduce downstream erosion;
- the weir will be inflated to ensure that the rate of downstream water level fall is consistent with historical flood event water level falls to reduce downstream bank slumping; and
- the weir will be inflated to maximise the storage volume at the completion of the flow event while still being consistent with the Fitzroy WRP EFOs.

In addition, a fail safe mechanism will be included so that the rubber dam will always deflate when the storage level reaches a set headwater level to ensure that no additional overbank flooding occurs. Under the above operating rules, the proposed weir upgrade will not significantly impact on upstream flood levels or downstream erosion.

□ Dawson River WASO and EFO Impacts and Mitigation Measures

Modelling has been undertaken to assess the hydrological impact of three demand scenarios (6,500 ML/yr, 7,000 ML/yr and 8,500 Ml/yr) to supply water to the Project from a raised Glebe Weir on the Dawson River. A range of management strategies has been developed to mitigate the impact of the additional high priority demand from a raised Glebe Weir on Dawson River WASOs and EFOs outlined in the Fitzroy WRP. These management strategies include:

- the pre-requisite purchase and retirement of medium priority water from the Theodore reach of the Dawson River:
- changes to the environmental flow release rules from the downstream weirs; and
- changes to the system reserve.

The results of the modelling show that:

- for the 6,500 ML/yr demand scenario, there is no requirement to purchase any medium priority water to meet the WASOs and EFOs. However, 980 ML of medium priority water has to be purchased for the 7,000 ML/yr demand scenario and 3,210 ML of medium priority water has to be purchased for the 8,500 ML demand scenario (The availability of medium priority water allocations for purchase along the Dawson River has not been explored in this study).
- under the above management strategies, the mandatory water allocation security objectives (WASOs), which represent the rights of the existing water entitlement holders, and all mandatory environmental flow objectives (EFO) outlined in the Fitzroy WRP are met for all three demand scenarios;
- the differences between current WRP statistics and those achieved by all scenarios, is in the order of a few percent.
- some non mandatory EFOs are not met for any of the three demand scenarios as well as for the existing WRP development conditions. The deviations are quantitatively small and some statistics show similar small improvements.
- the three Glebe Weir demand scenarios impact some unsupplemented users below Nathan Gorge by reducing the available number of days they can harvest water each year by a maximum of up to one day. There is no specific performance objective for these allocations. If this water supply alternative is adopted, the Proponent will discuss compensation arrangements with impacted water harvesters for the estimated missed opportunity.
- when compared to the existing Fitzroy WRP conditions, the three Glebe Weir demand scenarios will reduce mean annual flows by about 0.5% at Beckers, 1% at Theodore and 1.5% at Nathan Gorge (the three EFO reporting locations for the Dawson Valley Water Supply Scheme.
- low flows at Nathan Gorge are significantly reduced by the existing weir and this effect will increase with each development scenario.

□ Construction Stage Impacts

The construction of the raised Glebe Weir is not likely to significantly impact on hydrologic flow regime of the Dawson River. There will be a temporary loss of storage volume due to the removal of the existing concrete spillway weir crest, which could temporarily impact on the reliability of supply for some downstream users. It is proposed to program the works on the concrete spillway weir crest during the drier months, which would reduce the potential for this to occur. In addition, the current operating strategy of releasing water in July to top up the downstream storages prior to the commencement of the cotton irrigation season may need to change to draw down the storage sufficiently for construction. This change is not expected to be significant, if it is needed at all.

8.4 Groundwater

8.4.1 Description of Existing Environmental Values

8.4.1.1 Overview of geological reporting

A detailed description of the geological characteristics of the study area is presented in Section 6.2.3. Nevertheless, it is appropriate to include the general sequence of sediments in the study area and this is shown in Table 8-21 and Table 8-22.

Table 8-21 Summary of relevant geological units on Taroom 1:250,000 Scale Sheet (modified after Forbes, 1968).

Age	Formation name	Geological mapping symbol	Lithology	Thickness (m)	Depositional environment
Cainozoic	Alluvium	Qa	Alluvium		
Cainozoic	Undifferentiated soil and sand	Cz	Soil, sand		
Middle Jurassic	Birkhead Formation	Jmb	Calcareous labile and sublabile lithic sandstone, siltstone, shale, carbonaceous shale and coal	At least 152	Paludal
Lower - Middle Jurassic	Hutton Sandstone	Jlh	Argillaceous sublabile and quartzose sandstone, minor mudstone, rare pebble conglomerate beds	122 - 183	Fluvial or lacustrine
	Evergreen Formation	Jle	Labile and sublabile sandstone, mudstone, shale, coal	137 - 168	Lacustrine, shallow-water marine at top
	Evergreen Formation - Oolite Member	Jlo	Pelletal or oolitic limestone, chamositic when fresh, chamositic mudstone, sandstone	1.5 - 9.1	Shallow-water marine
Lower Jurassic	Evergreen Formation - Westgrove Ironstone Member	Jlw	Concretionary ironstone, oolitic or pelletal in places, chamositic when fresh, chamositic mudstone	1.5 - 9.1	Shallow-water marine
	Evergreen Formation - Boxvale Sandstone Member	Jlb	Quartzose sandstone, siltstone, coal	9 - 43	Fluvial or lacustrine; possibly shallow water marine at top
	Precipice Sandstone	Jlp	Cross-bedded quartzose sandstone, sublabile lithic sandstone, siltstone	46 - 91	Fluvial

Table 8-22 Summary of relevant geological units on Taroom 1:250,000 Scale Sheet (modified after Whitaker *et al*, 1974).

Age	Formation name	Geological mapping symbol	Lithology	Thickness (m)	Depositional environment
Cainozoic	Alluvium	Qa	Alluvium	> 15 m in places	Fluviatile
Cainozoic	Alluvial gravel and sand	Cza	Alluvial gravel and sand	Unknown	Fluviatile
Middle Jurassic	Injune Creek Group	Jmi	Sublabile to labile sandstone, siltstone, mudstone, locally basal conglomerate	> 150	Fluviatile to Paludal
Lower - Middle Jurassic	Hutton Sandstone	Jh	Quartzose Sandstone, minor siltstone, probably shale	120 - 232	Mainly fluviatile
Lower Jurassic	Evergreen Formation	Jle	Labile to sublabile sandstone, oolitic ironstone, shale, silstone	165 - > 247.8	Fluviatile and lacustrine, with moinor possible marine incursion
	Precipice Sandstone	Jlp	Quartzose sandstone, siltstone, minor shale	97.5 - 120	Fluviatile

With respect to groundwater Forbes noted that the Precipice Sandstone forms a good aquifer and generally produces plentiful supplies of potable subartesian water. Forbes noted also that springs are common in the creeks cutting the Precipice Sandstone and in many places these creeks are perennial. Whitaker *et al.* also noted that the Precipice Sandstone is a good source of groundwater supply.

Forbes suggested that the Evergreen Formation is generally an aquiclude, although the Boxvale Sandstone member is a useful aquifer and yields good subartesian water in many areas in the south west quarter of the Taroom 1:250,000 scale sheet area as well as a little artesian water. Whitaker *et al.* also considered that the Evergreen Formation is in general an aquiclude.

With respect to the Hutton Sandstone, Forbes suggested that this formation was not a reliable supplier of potable water and that within it the distribution of water supplies was erratic and it is commonly brackish. Whitaker *et a*l. suggested that the Hutton Sandstone is generally not a good aquifer with similar rationale to that of Forbes being advanced.

Forbes also suggested that the alluvium of the larger streams on the Taroom 1:250,000 scale map generally yield good supplies of groundwater at shallow depth

A composite surface geological map of the area around the impoundment of Glebe Weir created from GIS coverages supplied by Withnall et al (2005) and NRM (2007) is shown in Figure 8-8. A key to the geological mapping symbols used in Figure 8-8 is provided in Appendix 8-A.

8.4.1.2 Overview of hydrogeological reporting

- Regional hydrogeological reporting

The key hydrogeological references for the area are:

- Hyder Consulting 1997 Impact Assessment Study for Proposed Dawson Dam, October
- Quarantotto, P. 1989 Hydrogeology of the Surat Basin, Queensland, Geological Survey of Queensland Record 1989/26
- Department of Natural Resources 1996 Report on the Impact of Nathan Dam on Boggomosses and Regional Hydrology, Resource Sciences Centre, Resource Condition and Trend Unit, Water Assessment and Planning, November
- Scriven. D. 1995 Report on Groundwater Flow Modelling of the Nathan Dam Site, Queensland Department of Primary Industries – Water Resources, Water resources Division, Groundwater Assessment Group, April; and
- Scriven, D. 1996 Report on a Groundwater Flow Model for the Modelling of Effects on Boggomosses Near the Nathan Dam Site, Queensland Department of Primary Industries – Water Resources, Water resources Division, Groundwater Assessment Group

Quarantotto (1989) provided a detailed overview regional summary of the aquifers of the Surat Basin.

Quarantotto noted that the Dawson River, Hutton Creek, Injune Creek and Cockatoo Creek as well as many smaller brooks flowing into them are fed by springs emanating from the Precipice Sandstone, Boxvale Sandstone Member of the Evergreen Formation, and Hutton and Gubberamunda Sandstones. He indicated that some of these springs are related to faults, while others are topography related. Quarantotto noted that in some areas of the Surat Basin the Hutton Sandstone hosts springs and that an appreciable number of springs are located in the Hutton Creek area, to the north east of Injune.

Quarantotto prepared a potentiometric surface contour plan of the Precipice Sandstone and this plan (reproduced as Figure 8-9) indicates a general groundwater flow direction within this unit to the east.

Quarantotto also prepared a potentiometric surface contour plan of the Hutton Sandstone (reproduced as Figure 8-10) and in the western section of the basin indicates a groundwater flow direction to the south and to the east.

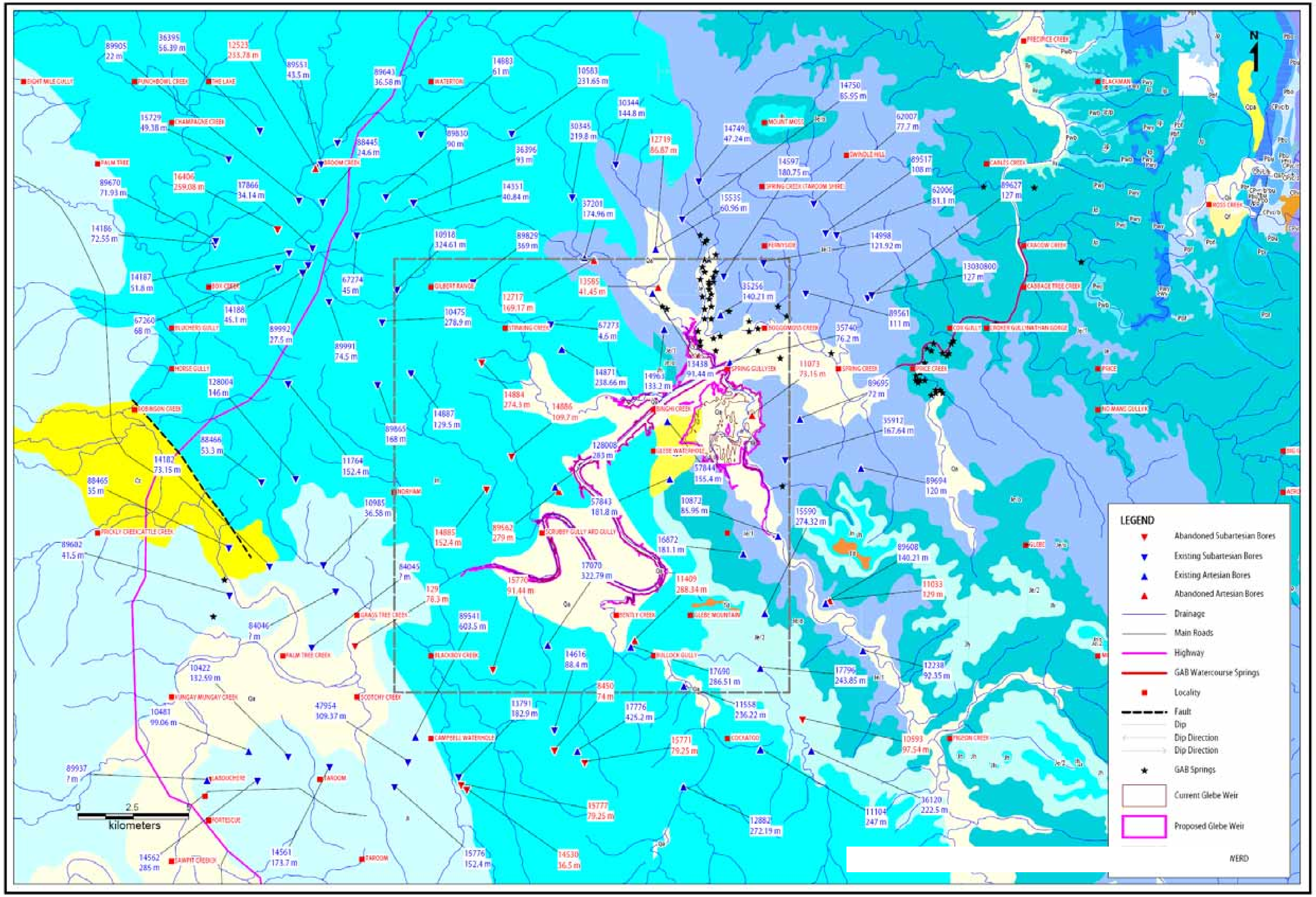

Figure 8-8. Composite surface geological map (After NRM 2007 & Withnall *et al* 2005)

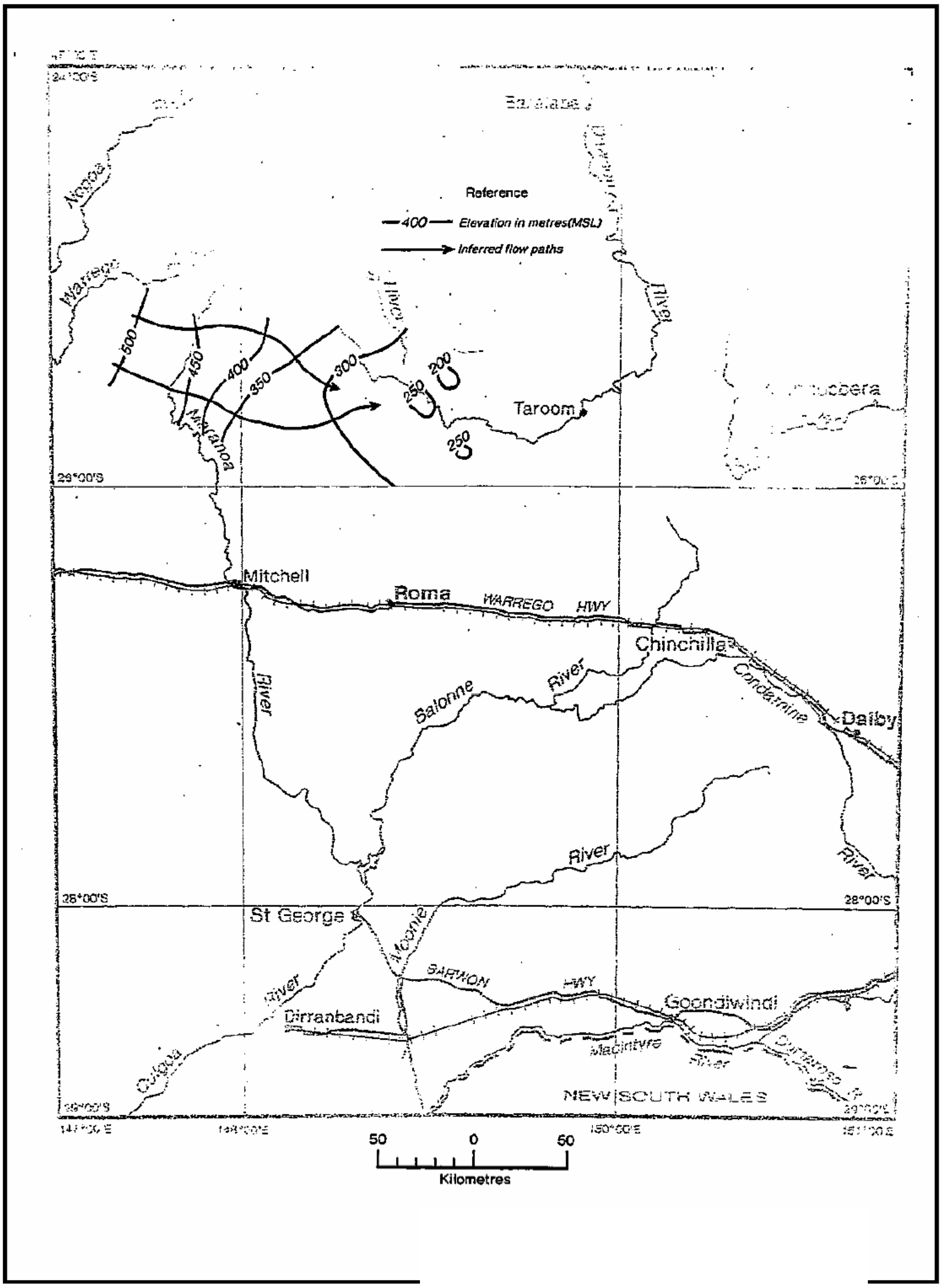

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Figure 2
POTENTIOMETRIC SURFACE, PRECIPICE SANDSTONE (AFTER QUARANTOTTO 1989)

Figure 8-9. Potentiometric Surface, Precipice Sandstone (Quarantotto, 1989)

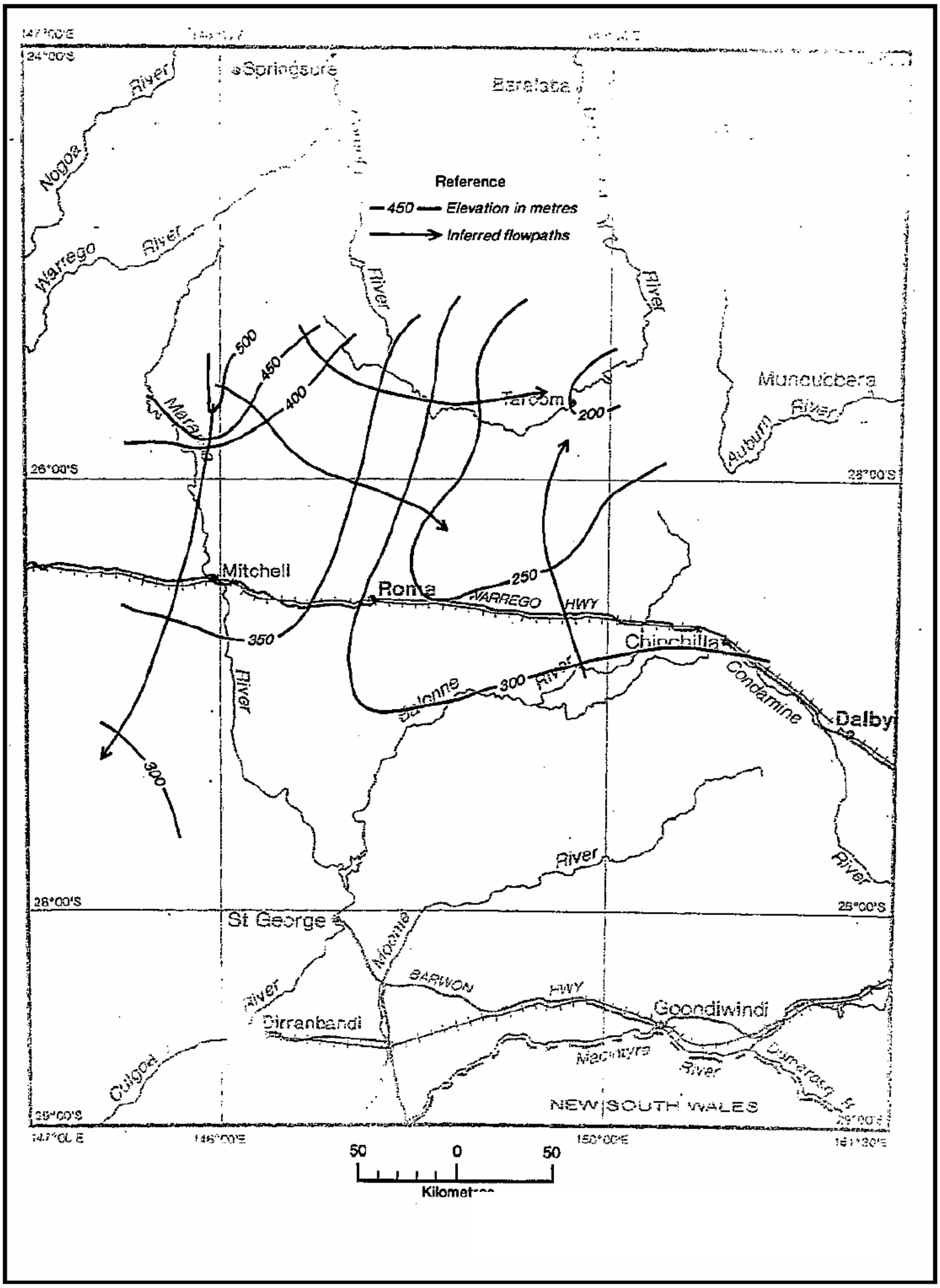

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Figure 3
POTENTIOMETRIC SURFACE, HUTTON SANDSTONE (AFTER QUARANTOTTO 1989)

Figure 8-10. Potentiometric Surface, Hutton Sandstone (Quarantotto, 1989)

- Detailed hydrogeological reporting

Scriven (1995 and 1996) documented the preparation of predictive hydrogeological models for the Precipice Sandstone using Aquifer Simulation Model (ASM) code and MODFLOW code. The aim of this modelling work was to predict the impact of a proposed dam on the Dawson River at 313.9 km AMTD on boggomosses, which are permanent springs that issue from aquifers of the Surat Basin section of the Great Artesian Basin.

Scriven noted that many of the bores that tap the Precipice Sandstone in the Dawson River valley are artesian (i.e. they freely flow because at their locations the potentiometric surface of the aquifer is above the ground surface).

Scriven regarded the Evergreen Formation as a confining layer over the Precipice Sandstone aquifer except in areas downstream of 316 km AMTD on the Dawson River, downstream of which the Precipice Sandstone outcrops. Scriven noted that in this section the river acts as a drain receiving discharge from the Precipice Sandstone. Scriven prepared groundwater elevation contours for the Precipice Sandstone that are largely in accordance with the regional groundwater elevation contours prepared by Quarantotto (1989).

DNR (1996) have indicated that the boggomoss springs of the Taroom – Dawson River area are dynamic mound springs that have outlets that close from time to time. NRW consider that all of the boggomoss springs are fault controlled and are expressions of groundwater discharge from the Great Artesian Basin. NRW identified five groups of boggomosses and these groups were:

- Boggomoss Creek Group;
- Price Creek Group;
- Gorge Creek Group;
- Upper Cockatoo Creek Group; and
- Palm Tree Group

On the basis of groundwater chemistry, NRW attributed the discharge from all of these groups of springs to discharge from the Precipice Sandstone except for those of the Palm Tree Group near Taroom, the discharge from which they attributed to Hutton Sandstone – Eurombah Formation.

DNR's major focus was in the determination of impacts from the proposed Nathan Dam on the boggomosses and their report gave no consideration to the raising of Glebe Weir alone. With respect to the raising of Nathan Dam, DNR indicated that the major impact for the boggomosses that were not inundated by the dam impoundment was an increase in discharges associated with an increase in head.

DNR indicated that the boggomoss group that occurs in Boggomoss Creek lies on a linear feature and they attributed this to the presence of a fault that ultimately connected the underlying Precipice Sandstone through the overlying Evergreen Formation to the surface.

8.4.2 NRW groundwater database data

A search of the NRW groundwater database (GWDB) was undertaken for the following area to obtain the location of bores for which records are available.

- Latitude -25.369002° to -25.637890°; and
- Longitude 149.797820° to 150.098609°

A location plan for all of the bores recorded by the NRW groundwater database (GWDB) located within the broad region around Glebe Weir plotted over available surface geological mapping, is provided in Figure 8-8. In addition to the location of the recorded bores, Figure 8-8 also indicates the location of both artesian springs and watercourse springs obtained from Fensham and Fairfax (2005).

The bores indicated in Figure 8-8 have been subcategorised as either artesian / subartesian and existing / abandoned condition.

Summary details for a subset of the bores indicated to lie within a 350 km^2 area within a reasonably close proximity of the impoundment of Glebe Weir (from NRW WERD database, see Figure 8-8 for search boundary location) are provided in Table 8-23.

The vast majority of bores in the area draw groundwater supplies from either the Precipice Sandstone or Hutton Sandstone (Table 8-23). It should be noted that where some of the subartesian bores have been spudded in a younger formation and then penetrate down to the Precipice Sandstone, the vast majority of the bores will have cross connected the formations through which the bores have penetrated due to a generalised lack of annular grouting which has historically been reserved for artesian bores.

Table 8-23. Summary details for subset of bores within a 350 km^2 area centred on the impoundment of Glebe Weir

Bore registered number	Existing (Y/N)	Nature of bore	Natural surface elevation (m AHD)	Total recorded bore depth (m bGL)	Total cased depth (m bGL)	Interpretation of formation tapped	Reported yield (L/s)	Most recent reported groundwater electrical conductivity (S/cm)
10872	Yes	Artesian	179.19	85.95	86	Precipice Sandstone	2	310
10918	Yes	Subartesian	243.26	324.61	140.2	Precipice Sandstone (?)	NA	NA
11073	No	Artesian	174.09	73.15	73.2	Precipice Sandstone	0.82	210
11409	No	Artesian	206.72	288.34	288.3	Precipice Sandstone	NA	NA
11558	Yes	Artesian	188.93	236.22	236.2	Hutton Sandstone	0.63	150

Bore registered number	Existing (Y/N)	Nature of bore	Natural surface elevation (m AHD)	Total recorded bore depth (m bGL)	Total cased depth (m bGL)	Interpretation of formation tapped	Reported yield (L/s)	Most recent reported groundwater electrical conductivity (S/cm)
13438	Yes	Artesian	189.22	91.44	91.5	Boxvale Sandstone Member & Precipice Sandstone	0.51	177
13585	No	Artesian	191.06	41.45	41.4	Precipice Sandstone	NA	NA
14597	Yes	Subartesian	221.29	180.75	180.7	Precipice Sandstone	7.6	NA
14871	Yes	Artesian	221.45	238.66	238.7	Precipice Sandstone	NA	157
14884	No	Subartesian	233.9317	274.30	274.3	Precipice Sandstone	NA	NA
14885	No	Subartesian	200.1283	152.4	NA	Hutton Sandstone	NA	NA
14886	No	Subartesian	209.8252	109.7	109	Hutton Sandstone	NA	NA
14887	Yes	Subartesian	262.42	129.50	NA	Hutton Sandstone	NA	NA
14963	Yes	Artesian	193.91	133.2	133.2	Precipice Sandstone	3.16	103
14998	Yes	Subartesian	213.2	121.92	122	Precipice Sandstone	1.14	NA
15590	Yes	Artesian	229.9	274.32	274.3	Boxvale Sandstone Member & Precipice Sandstone (?)	0.95	150
15770	No	Subartesian	227.2801	91.44	91.5	Hutton Sandstone	NA	NA
16872	Yes	Artesian	195.96	181.1	181.1	Precipice Sandstone	7.58	130
17070	Yes	Artesian	208.06	322.79	322.8	Precipice Sandstone	3.33	130
17690	Yes	Artesian	198.84	286.51	286.5	Precipice Sandstone	NA	146
17796	Yes	Artesian	200.08	243.85	243.85	Precipice Sandstone	NA	155
35256	Yes	Artesian	200.49	140.21	139	Precipice Sandstone	0.03	220
35740	Yes	Artesian	178.29	76.2	76.2	Precipice Sandstone	1.81	336
35912	Yes	Subartesian	216.53	167.64	167.7	Precipice Sandstone	1.5	NA

Bore registered number	Existing (Y/N)	Nature of bore	Natural surface elevation (m AHD)	Total recorded bore depth (m bGL)	Total cased depth (m bGL)	Interpretation of formation tapped	Reported yield (L/s)	Most recent reported groundwater electrical conductivity (S/cm)
36395	Yes	Subartesian	259.18	56.39	56.4	Hutton Sandstone	NA	NA
57843	Yes	Artesian	181.8	181.8	182	Precipice Sandstone	6.02	255
57844	Yes	Artesian	183.98	155.4	155.4	Precipice Sandstone	6.94	360
67273	Yes	Subartesian	229.34	4.60	4.6	Hutton Sandstone	NA	NA
89562	No	Artesian	209.81	279.00	279	Precipice Sandstone	17.8	341
89829	Yes	Subartesian	249.25	369.00	366.5	Precipice Sandstone	13.2	NA
89937	Yes	Artesian	194.69	N/A	N/A	Injune Creek Group ? / Hutton Sst ?	NA	NA
128008	Yes	Artesian	209.34	283	283.12	Precipice Sandstone	NA	NA

8.4.3 Current groundwater use in the vicinity of Glebe Weir

It is evident that there is a considerable number of existing bores that draw groundwater from the aquifers of the Surat Basin in the vicinity of Glebe Weir.

The predominant use of groundwater in this area is for stock and domestic purposes with there being only one groundwater entitlement that included irrigation use. That entitlement included a 74 ML/a allocation from the Precipice Sandstone for domestic supply, irrigation and stock use.

For all of the remaining groundwater entitlements, only six entitlements were located that included domestic use while six entitlements were assigned to purely stock use. One entitlement was identified that listed “amenities” as the authorised purpose.

8.4.4 Potential impacts and mitigation measures

It is unlikely that any groundwater will be used for construction purposes at the Glebe Weir site as surface water will be available from the weir impoundment. Accordingly the key potential groundwater-related impacts associated with the proposed raising of Glebe Weir are:

- potential waterlogging of land immediately adjacent to the downstream extent of the levee proposed to be constructed on the left bank of the Dawson River near Boggomoss Creek;

- potential waterlogging of land on the right bank of the Dawson River immediately adjacent to the downstream extent of the revised impoundment adjacent to Cockatoo Creek; and
- a theoretical reduction in direct discharge of groundwater from the Hutton Sandstone to the Dawson River in the area of the impoundment of Glebe Weir due to the slight increase in head in the impoundment associated with the raising of the weir crest level.

The following sections describe these issues in further detail.

8.4.4.1 Potential waterlogging of land immediately adjacent to downstream extent of levee proposed for left bank of Dawson River

In the area of Boggomoss Creek, there are a series of springs that discharge from the Precipice Sandstone up through fault pathways in the overlying Evergreen Formation aquiclude into alluvium associated with both the Dawson River and Boggomoss Creek.

The alignment of the proposed levee bank has been selected to exclude boggomosses from the impoundment area.

Local landholders undertake irrigated agriculture of the soils immediately to the east of the proposed levee and that they have done so historically using centre pivot irrigators. It is possible and in fact likely that the presence of the boggomoss discharge in this area predisposes the alluvium to waterlogging during periods of significant rainfall. Seepage flows from a tributary of Boggomoss Creek draining from the north-east have been diverted by a shallow drain into a back channel of this floodplain along the northern side of the cultivation or order to reduce the potential waterlogging impact on the irrigated area.

The imposition of a head of water at 172.9 m AHD in the impoundment of the weir (when full) immediately adjacent to these areas raises some concerns regarding how the groundwater levels in the areas immediately downstream of the proposed levee will react.

The available topographic contours for the land in this area are shown in Figure 8-11, and it is evident from this figure that the natural surface immediately adjacent to the proposed levee will be at or below the proposed revised crest level of the weir. The area of greatest concern is where the inundation by the current weir is reduced as a result of the placement of the levee.

Little information is currently available regarding the shallow geology of the alluvium in this area. The landholder noted from his experience that there is approximately 40 feet of blacksoil, underlain by a green-coloured clay about 10 feet thick above a sand layer from which artesian flows come. In the absence of more detailed data it is not possible to be definitive regarding the potential waterlogging risk. Boggomoss No 8, one of the known homes to the Boggomoss Snail, is almost 1 km from this levee so is unlikely to be impacted by any increased waterlogging (Figure 8-13). The floodplain in this area is reached by high river flood levels such that the levees would have naturally drowned out on average once every four years (section 8.3.2.1). It would be expected that groundwater levels would decline significantly during extended droughts. Similarly the groundwater level can be expected to decline each year as the raised weir draws down, more so during extended dry periods. The boggomoss communities evolved in this highly variable water regime. However given the limited knowledge of local shallow geology, some risk does exist.

In order to reduce any risk associated with increased groundwater levels, SunWater will cease irrigation in at least the two centre pivot locations nearest Boggomoss Ck (Figure 8-12). The lessee (the land is owned by the State) will be compensated fairly. SunWater has discussed this approach with the lessee and while he is of the opinion, based on his long term experience at the site and his knowledge of the boggomoss site, that irrigation and waterlogging issues could not possibly impact on Boggomoss no.8, he will cooperate with the approach and discuss new locations for the irrigators with SunWater. In addition, on the outside of the levee in the area assessed to be at some risk of waterlogging, a significant barrier of riparian trees will be planted to take up any seepage from the weir. The trees will serve multiple roles, restoring considerable riparian and floodplain habitat that has historically been lost.

A series of long-term groundwater monitoring bores will be established prior to raising of the weir between the levee and Boggomoss no.8. If the groundwater monitoring demonstrates persistent elevated groundwater conditions beyond what would normally be experienced, subsurface drainage will be installed to lower shallow groundwater levels.

In summary, unmitigated risks from waterlogging to Boggomoss no.8 are estimated to be low. Proposed mitigation strategies will further reduce the level of risk. A monitoring program is proposed that will be able to identify if any changes in groundwater levels actually occur. A further mitigation strategy has been identified that will be capable of solving any such issues should they occur. This program will ensure that the boggomoss is not impacted so the mitigated risk is nil.

8.4.4.2 Potential development of waterlogging of land on right bank

Whilst it is noted that there is some potential for waterlogging in a very small area near the proposed levee on the right bank (Figure 8-14), it should be noted that this risk is not unequivocal. If alluvium in this area between Cockatoo Creek and the Dawson River is highly permeable then significant subsurface through-flow could potentially mitigate against the development of shallow water levels.
No information is currently available regarding the shallow geology of the alluvium in this area. In the absence of such data it cannot be definitively regarded as a potential waterlogging risk. The area of potential waterlogging is cleared grazing land and within 150 m downstream of the levee the area is totally cleared and used for centre pivot irrigation of pasture (Figure 8-14). As the environmental risk is low and the area potentially impacted is small, no mitigation is proposed other than to fence the area to keep stock out.

8.4.4.3 Impacts on groundwater discharge

As indicated in Section 7-2 of this report, available data, particularly the work of Quarantotto (1989) indicate that groundwater in the Hutton Sandstone has a similar overall flow pattern to that of the Precipice Sandstone in the general vicinity of Taroom.

Groundwater flowing through the Hutton Sandstone from the west and south-west must discharge to the Dawson River valley as it thins to zero thickness at its eastern outcrop edge at approximately AMTD 331.5 km.

The rate of discharge from the Hutton Sandstone would be expected to be less than that of the Precipice Sandstone largely because the Hutton Sandstone is a far poorer aquifer.

The current FSL for Glebe Weir is 170.54 mAHD and, some bores in the area to the north-west of the impoundment indicate a groundwater elevation of approximately 200 mAHD, accordingly there will be some groundwater flow from the Hutton Sandstone into the impoundment of Glebe Weir at current levels.

Mapping of watercourse springs was undertaken after construction of Glebe Weir, hence does not indicate if the current impoundment of Glebe Weir hosts watercourse springs.

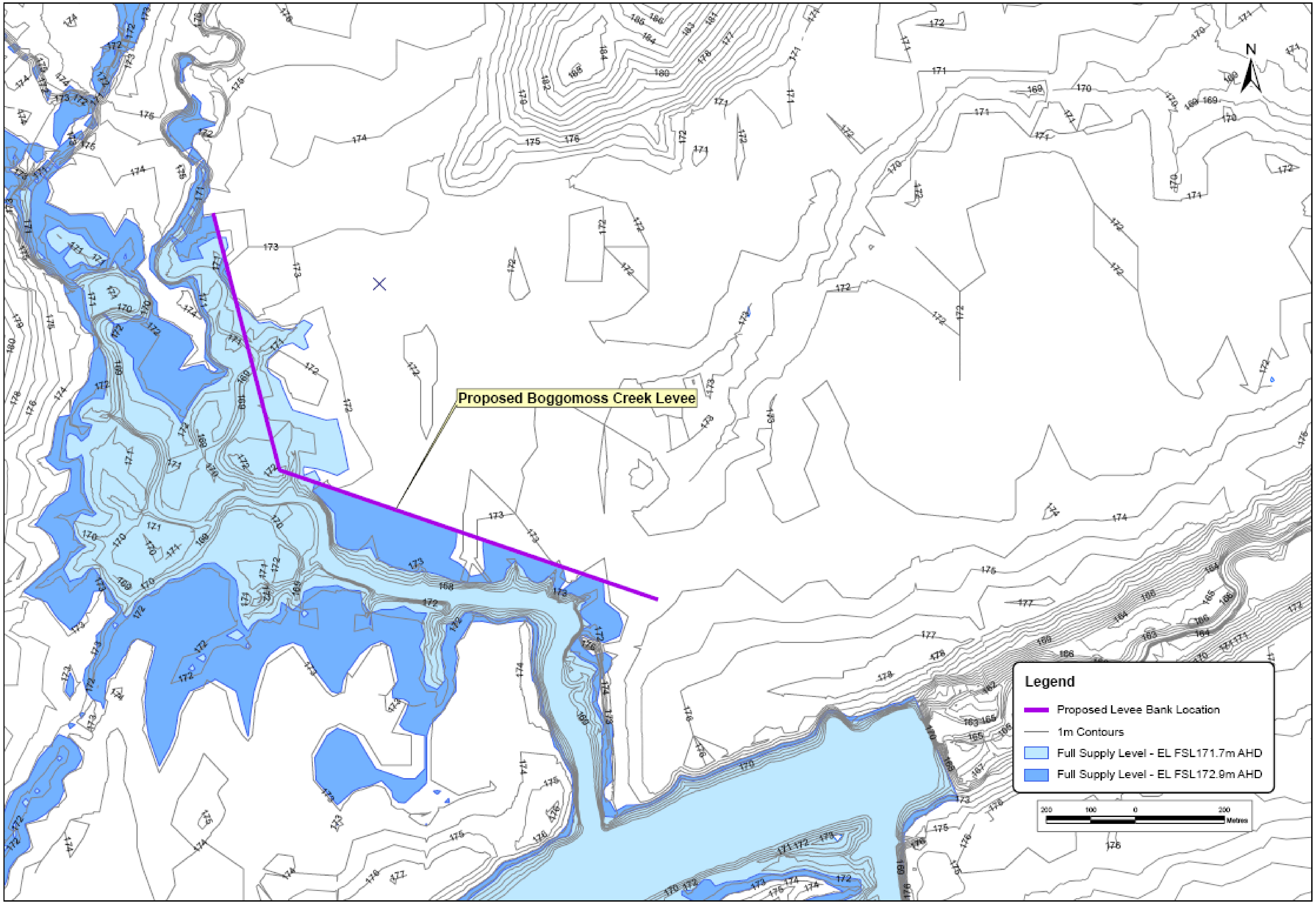

Figure 8-11. Topographic areas adjacent to left bank area of weir

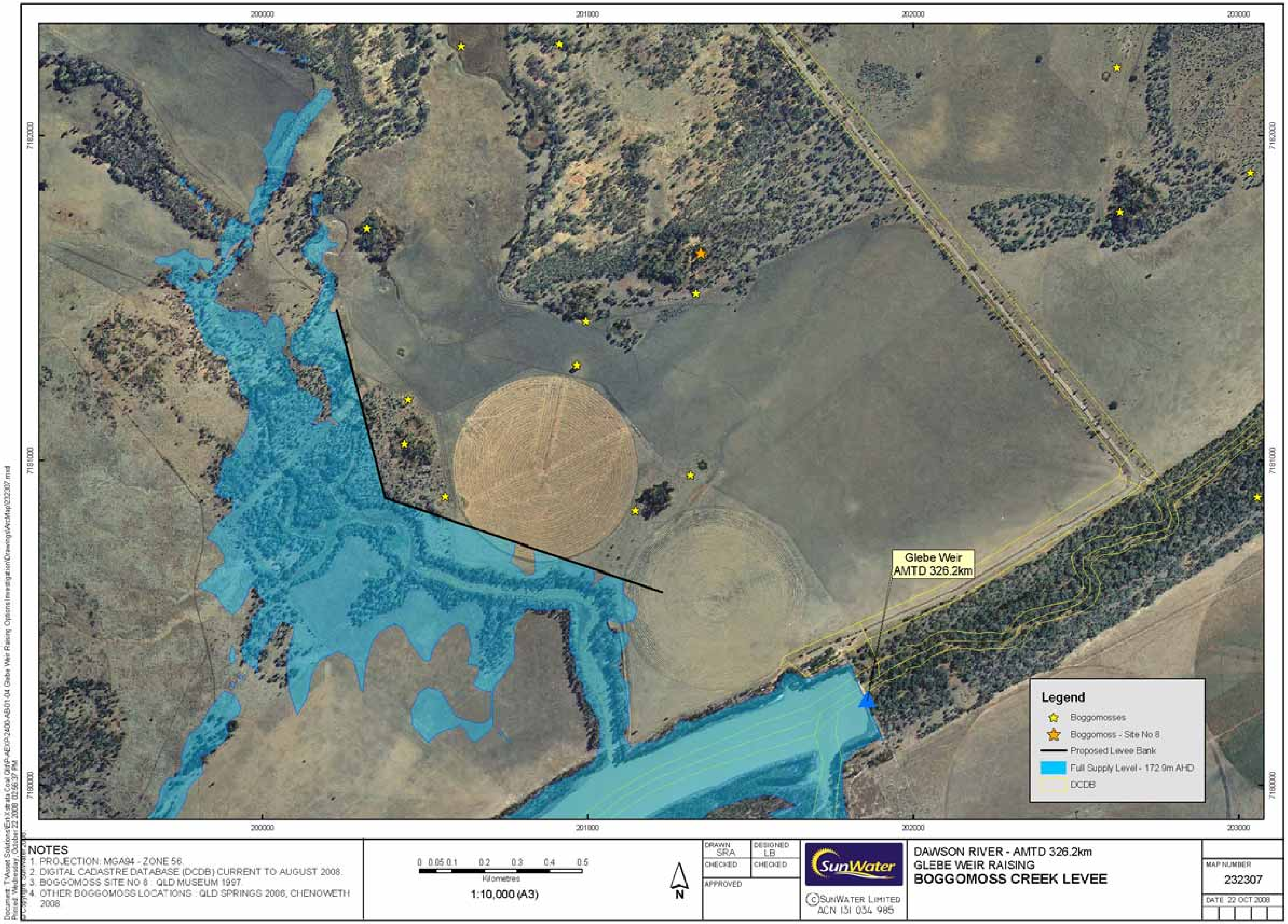

Figure 8-12. Boggomoss Creek levee showing irrigation area and Boggomoss no.8

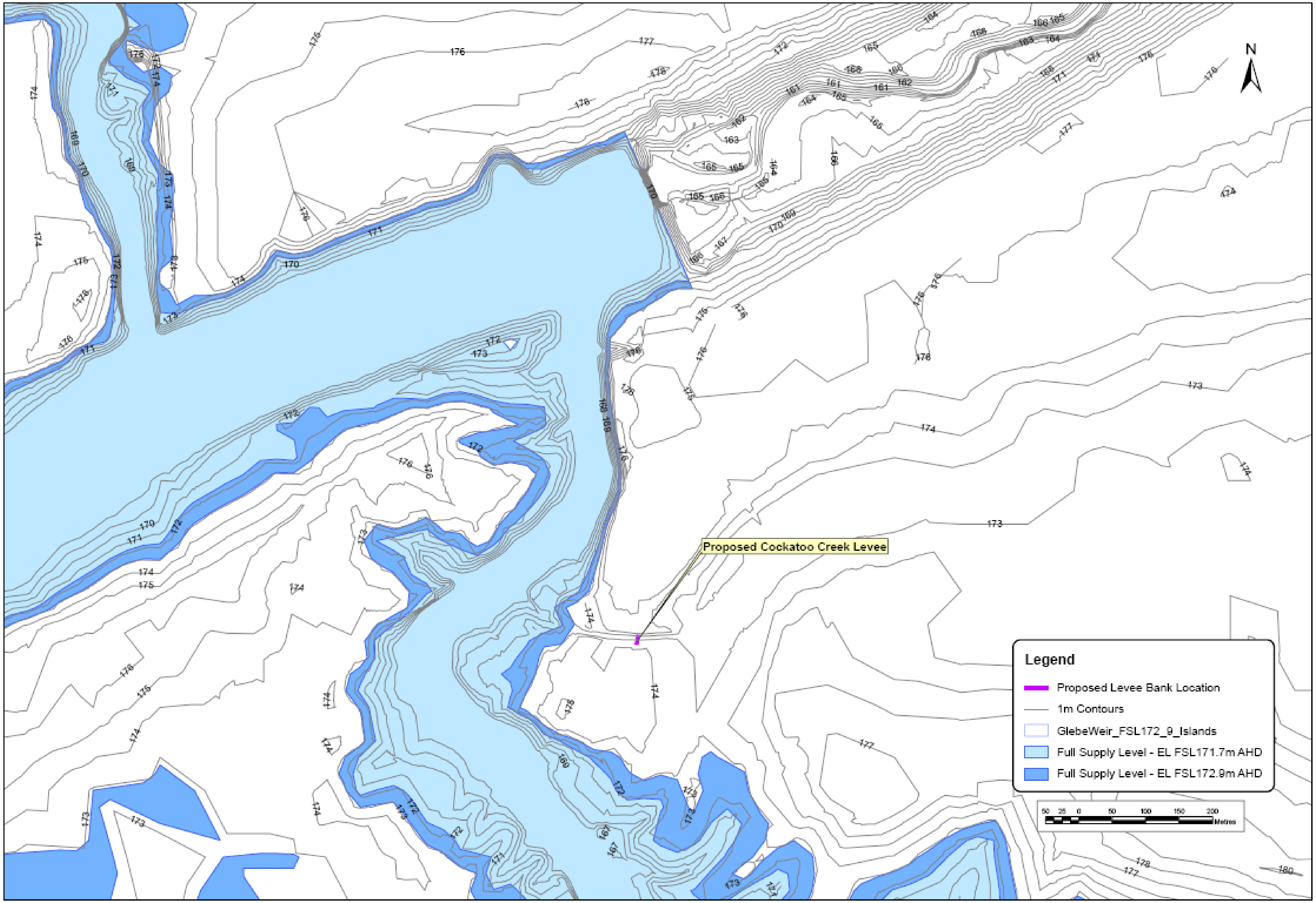

Figure 8-13. Topographic contours adjacent to right bank of weir

The rate of groundwater discharge from the Hutton Sandstone to the Dawson River will be impacted on by the differential groundwater head between the Hutton Sandstone and the river. The greater the differential head, the greater the flow to the river. The original construction of the weir would have imposed a significant additional head in the order of up to 9.6 m above that which prevailed before the construction of the weir. Thus the creation of the existing impoundment of Glebe Weir would have resulted in a reduced groundwater gradient between the Hutton Sandstone and the impoundment. This reduction in head would have been expected to result in shallower groundwater levels in the Hutton Sandstone immediately adjacent to the impoundment and also slightly shallower groundwater levels in areas more remote from the impoundment.

In comparison to the impact of imposition of the increased head in the river due to the existing Glebe Weir impoundment, the incremental head of 2.36 m associated with the proposed raising of the crest level of the Weir would be expected to have a negligible, almost immeasurable impact on upstream local groundwater levels in the area except in the immediate vicinity of the impoundment. As such, no mitigation is proposed.

The Hutton Sandstone springs located in the Palm Creek Area near Taroom would not be expected to be impacted measurably by the impact of the increased head in the river associated with the impoundment.

8.4.5 Conclusions

The key conclusions of this assessment were:

- the raising of Glebe Weir will not impact on the hydrogeology of the Precipice Sandstone as it is confined beneath the Evergreen Formation and Hutton Sandstone within the impoundment of the weir and because, in the area downstream of the weir, the river gains water from the Precipice Sandstone rather than losing it to the sandstone;
- in the vicinity of the current impoundment, the Hutton Sandstone will be discharging groundwater to the river in much the same way as the Precipice Sandstone does, though the overall flow rate from the Hutton Sandstone would be expected to be much less than that from the Precipice Sandstone because the Hutton Sandstone is a much poorer aquifer;
- the raising of Glebe Weir will very slightly reduce the head differential between the Hutton Sandstone and the river in the impoundment area and this would be expected to very slightly reduce the discharge from the Hutton Sandstone to the river and very slightly raise groundwater levels in the Hutton Sandstone;
- within the limits of currently available information, there appears to be a risk that the raising of the weir crest level could lead to shallow groundwater levels and waterlogging of alluvium in the lower reaches of Boggomoss Creek in the area immediately to the east of the new levee, and in the area to the east of the lower reaches of Cockatoo Creek ; and
- unmitigated impacts of waterlogging are unlikely to reach Boggomoss no. 8. Appropriate mitigation and monitoring measures will ensure no impacts to the critically endangered Boggomoss Snail (*Adclarkia dawsonensis*).

8.5 Surface water quality

This section describes the existing environment for water quality that may be affected by the Glebe Weir raising, in the context of environmental values as defined in local, State and national guidelines. The discussion is focused on both local and catchment scales, as well as related to the potential uses of water from the raising.

8.5.1 Description of Environmental Values

8.5.1.1 Environmentally sensitive areas

Environmentally sensitive areas, including the Fitzroy estuary, Great Barrier Reef, Shoalwater Bay and Corio Bay, are a substantial distance from Glebe Weir, with the estuary commencing 636 km downstream. On referral to the Australian Government, these items were not included in the controlling provisions by DEWHA therefore significant impact in these areas was not considered likely. In terms of water quality, environmentally sensitive areas constitute the Glebe weir pool itself and the river downstream to Gyranda Weir.

8.5.1.2 Environmental values

Environmental values (EVs) for waterways are the qualities of the water that make it suitable for supporting aquatic ecosystems and human water uses. An explanation of the possible suite of environmental values that can be chosen for protection is given in Table 8-24.

EVs chosen for protection are determined in accordance with the *Environmental Protection (Water) Policy 1997* (EPP Water) or documents listed in Schedule 1 of the EPP Water. In the case of Glebe Weir, there is no document listed in Schedule 1. Therefore, the EVs chosen for protection in the Glebe Weir and upstream and downstream waterways are determined from the EPP Water and SunWater information and are shown in Table 8-25.

8.5.1.3 Water quality objectives

Water quality objectives (WQOs) are long-term goals for water quality management that need to be met to protect the chosen EVs.

WQOs are determined in accordance with the EPP Water or documents listed in Schedule 1 of the EPP Water. In the case of Glebe Weir, there is no document listed in Schedule 1. Therefore, the WQOs are determined from the EPP Water, the *Queensland Water Quality Guidelines* (QWQG) (EPA, 2006a) and the *Water Resource (Fitzroy Basin) Plan 1999* (NRW, 1999). Key WQOs for the Glebe Weir and upstream and downstream waterways that are affected by the Glebe Weir are shown in Table 8-26.

Table 8-24. Explanation of possible suite of environmental values.

Explanation of Environmental Values for Waterways	
Environmental Value	**Description**
Aquatic ecosystem	The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas – for example, biodiversity, ecological interactions, plants, animals, key species (such as turtles, platypus, seagrass and dugongs) and their habitat, food and drinking water. See below for details of three possible 'levels of protection' contained in the Australian Water Quality Guidelines (ANZECC & ARMCANZ, 2000). Waterways include perennial and intermittent surface waters, groundwaters, tidal and non-tidal waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes, lagoons, canals, natural and artificial channels and the bed and banks of waterways. Level 1: High ecological/conservation value ecosystems *'effectively unmodified or other highly valued systems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations. While there are no aquatic ecosystems in Australia and New Zealand that are entirely without some human influence, the ecological integrity of high conservation/ecological value systems is regarded as intact.' (AWQG 2000; 3.1-10)* Level 2: Slightly–moderately disturbed ecosystems *'Ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically, freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation; marine systems would have largely intact habitats and associated biological communities. Slightly–moderately disturbed systems could include rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoralism, or marine ecosystems lying immediately adjacent to metropolitan areas.'* (AWQG 2000; 3.1-10) Level 3: Highly disturbed ecosystems *'These are measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be some shipping ports and sections of harbours serving coastal cities, urban streams receiving road and stormwater runoff, or rural streams receiving runoff from intensive horticulture. The third ecosystem condition recognises that degraded aquatic ecosystems still retain, or after rehabilitation may have, ecological or conservation values, but for practical reasons it may not be feasible to return them to slightly–moderately disturbed condition.' (AWQG 2000; 3.1-10)* e.g. Seagrass (Goal within the Aquatic ecosystem EV): • Maintenance or rehabilitation of seagrass habitat. (Applies only to tidal waterways.)
Human consumers of aquatic foods	Health of humans consuming aquatic foods — such as fish, crustaceans and shellfish (other than oysters) from natural waterways. e.g. Oystering (Goal within the EV of Human consumers of aquatic foods): • Health of humans consuming oysters from natural waterways and commercial ventures. (Applies only to tidal waterways.)

Explanation of Environmental Values for Waterways	
Environmental Value	**Description**
Primary recreation:	• Health of humans during recreation which involves direct contact and a high probability of water being swallowed — for example, swimming, surfing, windsurfing, diving and water-skiing.
Secondary recreation:	• Health of humans during recreation which involves indirect contact and a low probability of water being swallowed — for example, wading, boating, rowing and fishing.
Visual recreation:	• Amenity of waterways for recreation which does not involve any contact with water — for example, walking and picnicking adjacent to a waterway.
Cultural and spiritual values	• Indigenous and non-indigenous cultural heritage — for example: • custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities; • symbols, landmarks and icons (such as waterways, turtles and frogs); and • lifestyles (such as agriculture and fishing).
Industrial use	• Suitability of water supply for industrial use — for example, food, beverage, paper, petroleum and power industries. Industries usually treat water
Aquaculture	• Health of aquaculture species and humans consuming aquatic foods (such as fish, molluscs and crustaceans) from commercial ventures.
Drinking water supply	• Suitability of raw drinking water supply. This assumes minimal treatment of water is required — for example, coarse screening and/or disinfection.
Irrigation	• Suitability of water supply for irrigation – for example, irrigation of crops, pastures, parks, gardens and recreational areas.
Stock watering	• Suitability of water supply for production of healthy livestock. .
Farm water supply	• Suitability of domestic farm water supply, other than drinking water. For example, water used for laundry and produce preparation.

Table 8-25. Environmental values for Glebe Weir and upstream and downstream waterways

Environmental values [1,2]	**Water**	**Glebe Weir and upstream and downstream waterways affected by Glebe Weir**
Aquatic ecosystems		✓
Human consumer		✓
Primary recreation		✓
Secondary recreation		✓
Visual recreation		✓
Cultural and spiritual values		✓
Industrial use		✓
Aquaculture		✓
Drinking water		✓
Irrigation		✓
Stock water		✓
Farm supply		✓

Notes:
1. ✓ means the EV is selected for protection
2. Blank indicates the EV is not chosen for protection

Table 8-26. Key WQOs for Glebe Weir and upstream and downstream waterways

Parameter	Upstream and Downstream Waterways WQOs (median unless otherwise stated)	Glebe Weir WQOs (median unless otherwise stated)
Turbidity	<50 NTU	1-20 NTU
Suspended Solids	<10 mg/L	na
Chlorophyll a	<5 µg/L	<5 µg/L
Total Nitrogen	<500 µg/L	<350 µg/L
Total Phosphorus	<50 µg/L	<10 µg/L
Dissolved Oxygen	85%-100% saturation	*
pH	6.5-8.0	6.5-8.0

Notes:
* Stagnant pools in intermittent streams naturally experience DO below 50% saturation. Lower values may occur at night but should not be 10% to 15% lower than daytime values. DO values consistently less than 50% are likely to significantly impact on the ongoing ability of fish to persist in a waterbody. DO values <30% saturation are toxic to some fish species. These levels should be applied as the absolute lower limit guidelines for DO. Very high DO (supersaturation) values can be toxic to some fish.
"na" means not available

8.5.1.4 Existing water quality

The existing water quality and ecological health were assessed using:

- Dawson Dam IAS and Supplementary Report, Hyder 1997 & 1998;
- SunWater water quality data set 2001-2008;
- SunWater blue-green algae monitoring results for Glebe Weir, and fish kills records, and
- Pre- and post-wet season data collected as part of current Nathan Dam EIS baseline studies.

Data from the Dawson Dam IAS and Supplementary Report consisted of spot samples and profiles at a number of sites from upstream of Glebe Weir to Theodore Weir over a 2 year period. Key findings from the reports are:

- sampling after short-term flow stoppage (no releases) during spring and early summer in 1996 showed minor stratification and moderate deoxygenation upstream of Glebe Weir. Dissolved oxygen concentration was much lower 5 km downstream of Glebe Weir
- sampling at low flow conditions in 1997 showed deoxygenation persisted upstream of the weirs. At Glebe Weir stratification occurred at 2.5 m depth and oxygen levels declined to 1.5 mg/L below 3.5 m depth. No stratification was observed downstream of the weir; and.
- sampling after a prolonged flow stoppage (no releases) during spring and early summer in 1997 showed major stratification and severe deoxygenation at all riverine sites between Glebe Weir and Theodore Weir. Sampling in the Glebe Weir showed only minor temperature stratification and deoxygenation.

The SunWater water quality sampling results is derived from three sites relative to Glebe Weir; an inflow site for which data only exists as monthly surface spot data since October 2007; a tail water (downstream) site with surface spot data collected quarterly from December 2001 to September 2004, no data for 2005 or 2006, then monthly from September 2007; a headwater site with spot or profile data quarterly from September 2001 to September 2004 and monthly data since (Appendix 8- B). As with any water quality data set one must exercise some caution in its interpretation and there are some odd results in the headwater site profiles. For example the surface sample in December 2001, June 2002 and June 2004 shows extremely low conductivity and turbidity results that bring the rest of the data into question. Similarly in March 2004 the temperature profile is the inverse to what is normally expected yet all other parameters match the expected profile. It should be noted that some recent profile data has been averaged over the depth of the water column with the note that no stratification was evident.

The baseline in situ water quality data consists of the following parameters:

- water temperature (°C);
- electrical conductivity (μS/cm);
- pH;
- dissolved oxygen (mg/L and % saturation); and
- turbidity (NTU).

Data were obtained from 7 sites pre-wet and 11 post-wet (2007/8). In pre-wet samples, four sites were sampled prior to a small flood and five, with two overlapping, were sampled during the flood. Sampling was by profiling of the water column in 0.5m increments where the depth allowed (Figure 8-14). Overnight logging was undertaken at a number of sites post-wet (Figure 8-15). Sampling included main channel sites upstream, within and downstream of the weir and in Gyranda Weir plus a number of tributary sites. Many tributaries are very ephemeral as they were dry both pre-and post wet, despite good sized channels.

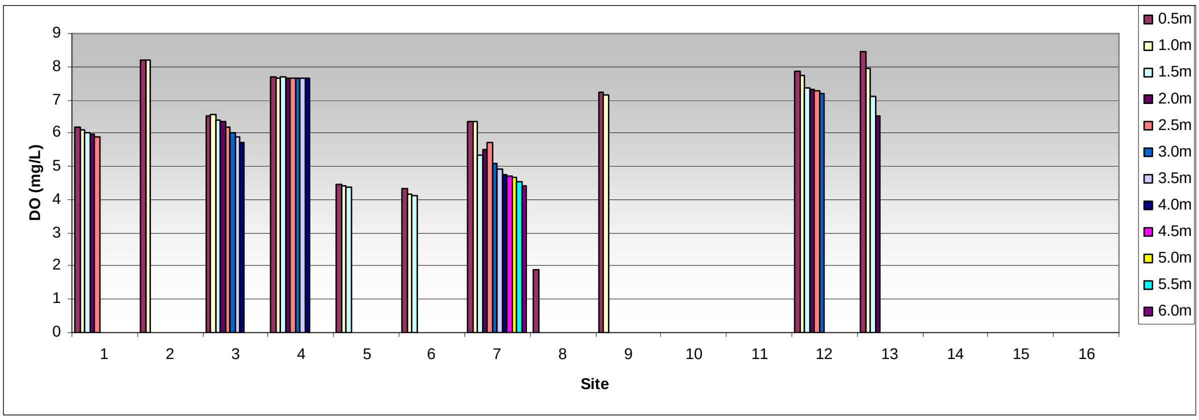

Figure 8-14. DO (mg/L) measurements at each site, recorded in 0.5m depth increments.

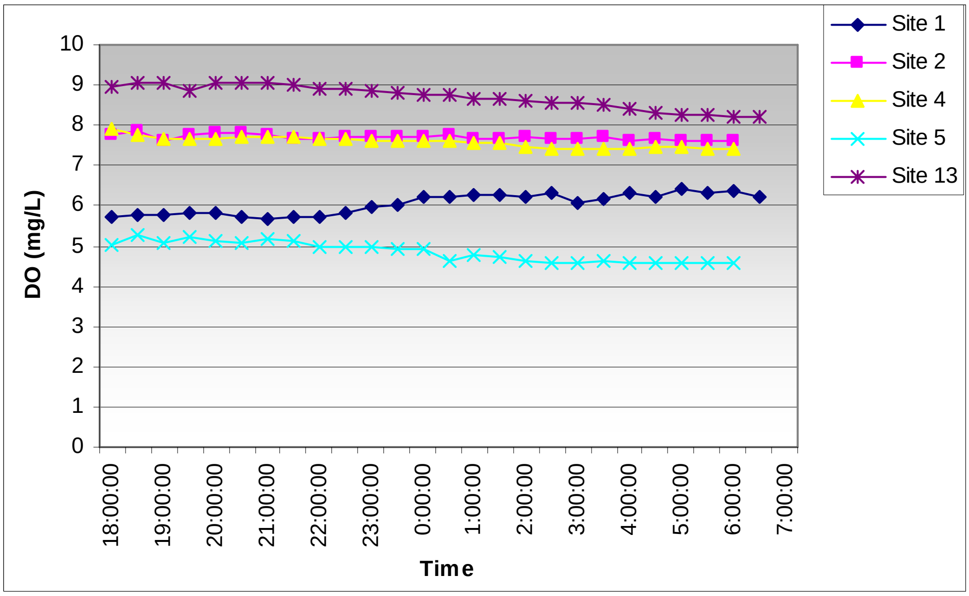

Figure 8-15. Surface DO (mg/L) logged overnight for 12 hours at 5 sites.

Bottled samples were also collected post-wet from a selection of sites across one day and couriered overnight to the laboratory for analysis. The samples were analysed for the following:

- Electrical Conductivity (µS/cm),
- Total Suspended Solids (mg/L),
- Salinity (Estimated TDS via calculation, mg/L),
- Turbidity (NTU),
- Total Hardness (Calcium Hardness & Magnesium Hardness, mg/L),
- Alkalinity ($CaCO_3$, mg/L),
- Total Nitrogen (inc. NO_X & TKN) plus NO_2, NO_3, NH_3,
- Total Phosphorus and Reactive Phosphorus,
- Phenoxy Acid herbicides (µ/L), Glyphosate &AMPA (µ/L),
- Organo-chlorine (OC) and Organo-phosphorus (OP) pesticides (µg/L),
- Faecal Coliforms (MPN),
- a full total metal scan (ICP/MS) , and
- Mercury.

Water samples were collected from approximately 20 cm below the water surface.

Results of these programs indicate:

- the quality of water in the weir pool is strongly linked to recent flows, for example the SunWater data shows very low DO in March and April 2008 and this was a result of a failed wet season, followed by a low level flow in March. In fact the sample in March was collected on the second day the weir spilled. The series from

November 2005 to January 2006 is also informative as a small flush occurred in early November, bringing highly turbid, low DO water, then the weir was fully flushed in December such that by January it had higher DO levels except in very deep water.

- the first inflows often occur as relatively small events and are of poor quality water.
- the weir stratifies at times of extended zero inflow but the depth of stratification varies. The occurrence and degree of stratification varies from year to year.
- riverine pools can also stratify in zero flow conditions.
- DO decreases with depth in weir and natural pools and can be very limiting in deep water.
- in extended no flow periods the weir and riverine pools show decreased surface turbidity, increased conductivity and can show supersaturated DO levels.
- the main changes during flooding that were observed in the pre-wet sampling were significantly increased turbidity (doubling from about 600NTU) and lowered conductivity.
- SunWater blue green algal records show highest counts in October 2001 and December 2003 (peak cell counts per species of 8570 with *Aphanocasps holsatica* most common with occasional significant representation by *Anabaena spiroides, Planktolyngbya minor* and *Cylindrospermopsis raciborskii*). No significant numbers have been recorded since.
- no fish kills have been recorded but in September 2006 70 Kreft's river turtles (*Emydura macquarii krefftii*) were found dead when the weir was at base levels. The cause of the kill was not determined but they may have drowned on the intake screens.
- releases from the weir during winter and spring, sometimes into summer, are the only flow in the river.
- the nearest site downstream from the weir often shows low DO, whether the weir is releasing or not.
- nutrient levels generally exceed guideline levels and tend to be higher in the weir pool.
- the post-wet season survey did not detect elevated pesticide concentrations.

In Figure 8-14, Figure 8-15 and Figure 8-16, sites 1 and 3 are natural pools 59.2 and 15.1 km upstream of the weir; site 2 is a glide (a flowing but not turbulent habitat) 39.2 km upstream, site 13 is in a tributary 16.8 km upstream, site 4 is in the weir near the wall, site 12 is in the weir in Cockatoo Ck, sites 5 and 6 are shallow riverine pools 4.7 and 11.2 km downstream from the weir and site 7 is in Gyranda weir pool, 41.7 km downstream.

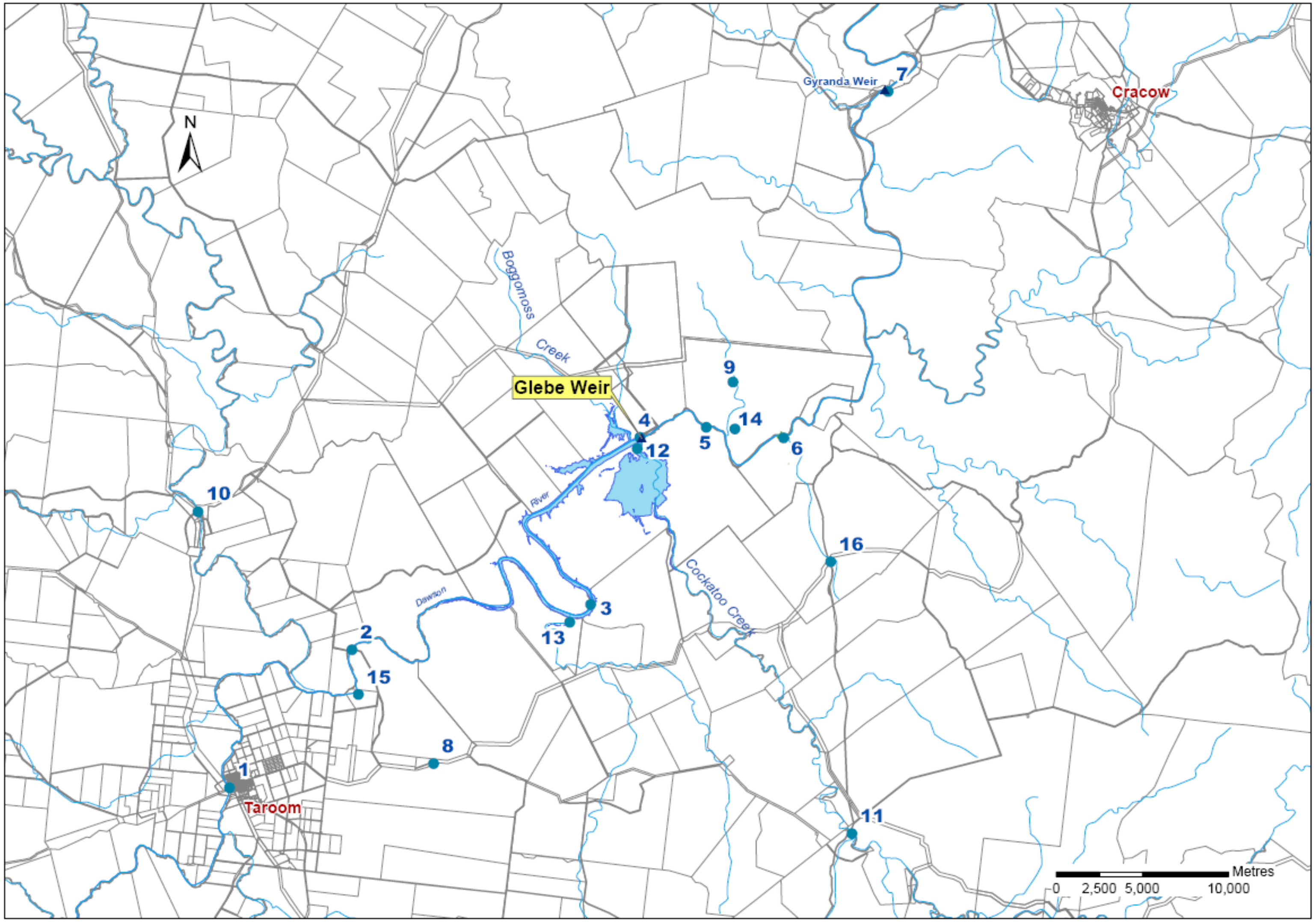

Figure 8-16. Water quality sample locations (Ecowise, 2008).

The wider Fitzroy River catchment is characterised by relatively high inputs of nutrients, compared to other Australian catchments (Meecham 2003, Moss *et al*. 1992); fluctuating and often low DO concentrations (Berghuis and Long 1999) and high turbidity (Meecham 2003). The upper Dawson catchment in the vicinity of Glebe Weir appears characteristic of the overall catchment and reflects historic land clearing and agricultural land use practices.

Despite the occasionally stressful water quality conditions, the aquatic fauna (Chapter 13) appears healthy.

8.5.2 Potential impacts and mitigation measures

8.5.2.1 Construction phase

- Local impacts

Construction activities for both the weir raising and pipeline construction have the potential to impact locally on water quality, including:

Weir raising:

- land clearing, excavation, levee and road construction and plant wash-down have the potential to release sediment and nutrients;
- concrete batching plants and washout of concrete carrying equipment have the potential to release aggregate, cement and cement additives;
- fuel storage and refueling activities have the potential to release hydrocarbons;
- chemical storage and use have the potential to release a range of chemicals;
- toilets and ablution blocks have the potential to release sewage and greywater containing nutrients, pathogens and raising biochemical oxygen demand (BOD); and
- construction wastes and rubbish could potentially be released to waterways.

Pipeline construction:

As well as the above potential impacts, pipeline construction may release sediment and nutrients to waterways during trenching and creek crossings.

- Mitigation measures during construction

A Draft Environmental Management Plan (Glebe EMP) addressing all issues potentially impacting on water quality, has been developed and is included in Chapter 21. The Glebe EMP includes standard mitigation measures which are highly likely to be successful at reducing potential impacts, such as:

- Erosion and Sediment Control Plan and Stormwater Management Plan including measures such as working during dry periods, staged clearing and rehabilitation of work sites, diversion of stormwater away from disturbed areas, collection and re-use of stormwater;
- collection and treatment of concrete wastes from batching plants and truck wash-out areas;
- bunding and roofing of fuel storage areas and fixed refueling points to contain fuel in case of spills and to prevent ingress of rainwater and stormwater, provision of clean-up material in case of spills;
- bunding and roofing of chemical storage areas to contain chemicals in case of spills and to prevent ingress of rainwater and stormwater, provision of clean-up material in case of spills;
- provision of collection, treatment and disposal facilities for sewage and greywater (the latter will be re-used where appropriate);
- Waste Management Plan including minimisation, recycling and disposal; and
- training and education of the workforce.

The EMP also includes systems for monitoring, reporting and continual improvement of mitigation measures.

Works that involve soil disturbance, particularly in and near watercourses, have the greatest potential for impact, mainly associated with sediment entering the watercourse. While this can be minimised by concentrating such work in the normal dry season and by the control measures noted above, unseasonal rain and flows are possible and sediment runoff from these areas will be unavoidable in such circumstances. The impact on water quality will be minor and temporary because the area in question is small compared to the catchment area, the incoming water will also be high in suspended solids and storms / flows in the dry season tend to be short-lived events.

8.5.2.2 Operation phase

□ On aquatic ecosystem Environmental Values

Raising the Glebe Weir by 2.36 m will:

- increase the depth by up to 2.36m;
- increase the capacity by approximately 70%;
- extend the tailwaters of the weir pool 2.3 km up the Dawson River, 1.5 km up Cockatoo Creek and 0.5 km up Boggomoss Creek ; and
- create spill-over areas near Cockatoo Ck and Boggomoss Creek that are relatively shallow and broad.

<u>During first filling of the raised weir</u>

It is likely that the weir will fill quickly as the capacity currently represents just 3.2% of the mean annual flow and this will become approximately 5.9%. The remaining vegetation and the soils of the newly inundated area will react with the incoming water and release nutrients, tannin and carbon, providing a significant BOD. Depending on the size of early flows, this may be largely flushed or it may, in the low inflow scenario, stay largely within the weir pool. The degree of impact can be estimated by the proportion of the pool area that is represented by these new areas. In terms of river or creek length inundated the new area represents an 11.3% increase on the existing Glebe Weir so is a relatively small proportion of the total. The newly inundated area will dry first as the weir is drawn down each year, usually commencing in July. If the pool then receives little or no follow up flow after first filling, the water quality in the pool would be expected to decline with low dissolved oxygen, particularly at depth, and potential stratification and turnover in the dry season with a slightly higher probability of doing so than is currently the case. The new nutrients are likely to stimulate algal growth, including blue-green algae, until these nutrients are flushed but this may take several seasons.

The shallow overbank areas of inundation near Cockatoo and Boggomoss creeks are connected to the weir pool via a narrow channel and each enters the pool very near the weir wall. As such there will probably be limited interaction between the water bodies except near the point of entry. These overbank areas will react quickly to air temperature and wind due to their open shallow nature. They are also more likely to grow macrophytes and algae (though limited by turbidity) but these will die off as the water level recedes. When wet again, this organic matter will release nutrients into the water column. These areas will be very dynamic but, as noted, as they have only a limited connection to the weir pool and it is near the wall, they will have limited impact on weir water quality per se.

Mitigation of these potential impacts is suggested to include reducing the vegetation cover on the area to be inundated. While it is beneficial to leave a number of larger riparian trees on the edges of the water body intact, the smaller trees, shrubs and ground litter should be removed.

During operating conditions of the raised weir

The water quality in the weir pool during operating conditions will likely be similar to what it is now but with a greater likelihood of low DO and stratification because there will be a larger body of permanent water. It will also differ more from natural pools because the total depth will be much greater. The time of greatest risk is post wet season when the pool settles down. It will also take a larger flow to flush the water body, though flows of the necessary volume occur in most years.

The shallow edge areas of the weir pool are the most biologically productive and it will remain rare that these areas are impacted by reduced DO or other water quality parameters.

As the overbank areas and the deeper parts of the weir pool are close to the pipeline and downstream offtakes, they may impact on the quality of extracted water. Extraction from the bottom only means that water of low dissolved oxygen and high turbidity, but not blue green algae, is most likely to be released. As the mine does not require high quality water for coal washing, the issue is largely irrelevant to them as a user. As noted, there are no downstream users (other than stock watering) until Gyranda Weir so released water quality will not impact upon them to any greater extent than it does now. The user at risk is the natural environment both within the weir pool and downstream over a distance of perhaps 10-20 kilometres, the distance over which the water quality is likely to improve.

As the increased capacity of the weir allows it to catch a higher proportion of incoming small flows, this reduces the natural flushing of downstream environments and increases the length of dry spells, thereby extending the period in which poor water quality can develop (Figure 8-7). The release strategy for downstream users currently largely mitigates this impact at baseflow levels and should continue to do so because releases tend to occur at times of likely greatest stress.

Mitigation strategies can be directed at reducing the risk of stratification in the first place, maximising the ability to extract the best quality waters and / or maximising the mixing of extracted waters. Mechanical means of achieving the former exist (aerators) but their success has been variable. Reducing water temperature and algal growth in parts of the waterbody through shading has potential benefits but requires considerable maintenance and is labour intensive. In a relatively shallow water body the benefits of circulation and aeration by propellers of outboard motors should not be discounted. Winter fishing competitions could achieve multiple benefits. Multi-level offtakes are a very effective means of withdrawing the best quality water, being with highest dissolved oxygen, lowest turbidity and lowest algal content, but have historically only been incorporated on much larger structures due to high costs. Cone dispersion valves can rapidly assist re-aeration of release water as can the increase of turbulence downstream through creation of riffle zones. The design includes provision for a multi-level offtake and potential changes to the outlets will be investigated with the aim of improving re-aeration.

Catchment management actions that reduce erosion and nutrient runoff will aid in the long term and the Fitzroy Basin Association is an active group in a priority catchment.

Monitoring programs need to improved beyond the current monthly spot profiles and should include a thermistor string at or near the offtake and concurrent monitoring of upstream and downstream riverine pools so the differences between the weir pool and natural pools can be ascertained.

- On human use EVs

Impacts in the weir pool

If turn-over and blue-green algal blooms were to become much more common, there could potentially be a reduction in recreational opportunities, such as boating, fishing and swimming. However, the high turbidity will continue to mitigate algal growth by reducing light penetration, so that algal activity only occurs in the top layer of water. The weir currently has an algal management plan and a warning system for blue-green algal alerts (similar to a bushfire hazard warning sign). The system has never needed to be used. Any river water is not suitable for direct potable consumption. Stock water extracted from the weir pool is unlikely to cause problems.

Impacts downstream of the weir pool

As noted there are no extractive users within the downstream area that may be impacted by poor water quality. Low DO and high turbidity are characteristic of the rivers of the region. The nearest town water extraction is at Theodore (approximately 95km downstream) and no change to operations would be expected here.

No mitigation beyond that noted above is suggested.

- On Matters of National Environmental Significance

It is extremely unlikely that water quality issues associated with the raising of the Glebe Weir and operation of the pipeline will have significant impacts on matters of national environmental significance (MNES) for several reasons. Glebe Weir is a substantial distance from the estuary of the Fitzroy River, a distance of some 636 km. The increased extraction of water from the Dawson system will result in a reduction in mean annual flow of only 0.6 % at Beckers (71km above the junction with the Mackenzie River). This extraction will comply with all objectives of the WRP and all relevant EFOs and WASOs. Some of these statistics actually show slight improvements as a result of changes to management included in the operation of the system as a result of the raising of Glebe Weir.