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7. Surface Water Resources and Water Quality

7.1 Surface Water Resources

The following section describes the water resources and surface water flow aspects of the Project. The surface water flow environment interacts with other environmental aspects of the Project such as water quality and aquatic ecology. The potential impacts of the Project on water quality and aquatic ecology are assessed in **Section 7.2** and **Section 10** of the EIS.

7.1.1 Existing Environment

This section describes the existing water resources of the Granite Belt catchment and addresses the following aspects:

- regional and local catchment characteristics;
- stream characteristics;
- climate;
- historic and design flooding;
- water resource planning;
- water resource development; and
- flow statistics.

7.1.1.1 Catchment Characteristics

The proposed Emu Swamp Dam will be located in the Granite Belt catchment which is part of the Border Rivers Drainage Basin. The Border Rivers Drainage Basin has an area of approximately 42,000 km^2 in Queensland as shown in **Figure 7-1**Error! Reference source not found..

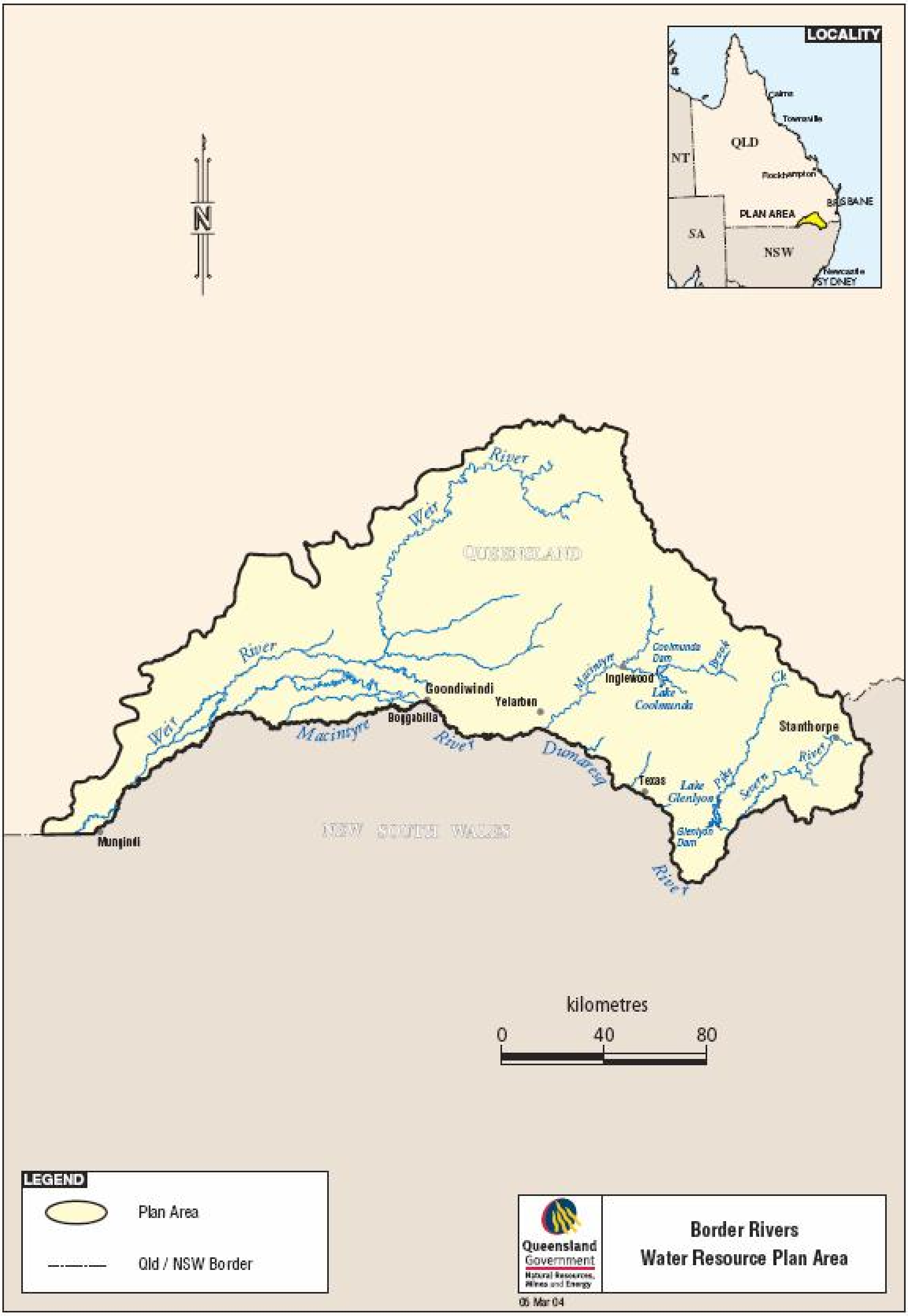
The Granite Belt catchment covers an area of approximately 1,300 km^2 and includes the Severn River and its upper tributaries. The dam site is located on the Severn River at the Adopted Middle Thread Distance (AMTD) of 264 km. The catchment area of the dam is 586 km^2, which represents 45% of the Granite Belt catchment and 1.4% of the Border Rivers catchment in Queensland. An overview of the dam catchment is presented in **Figure 7-2**.

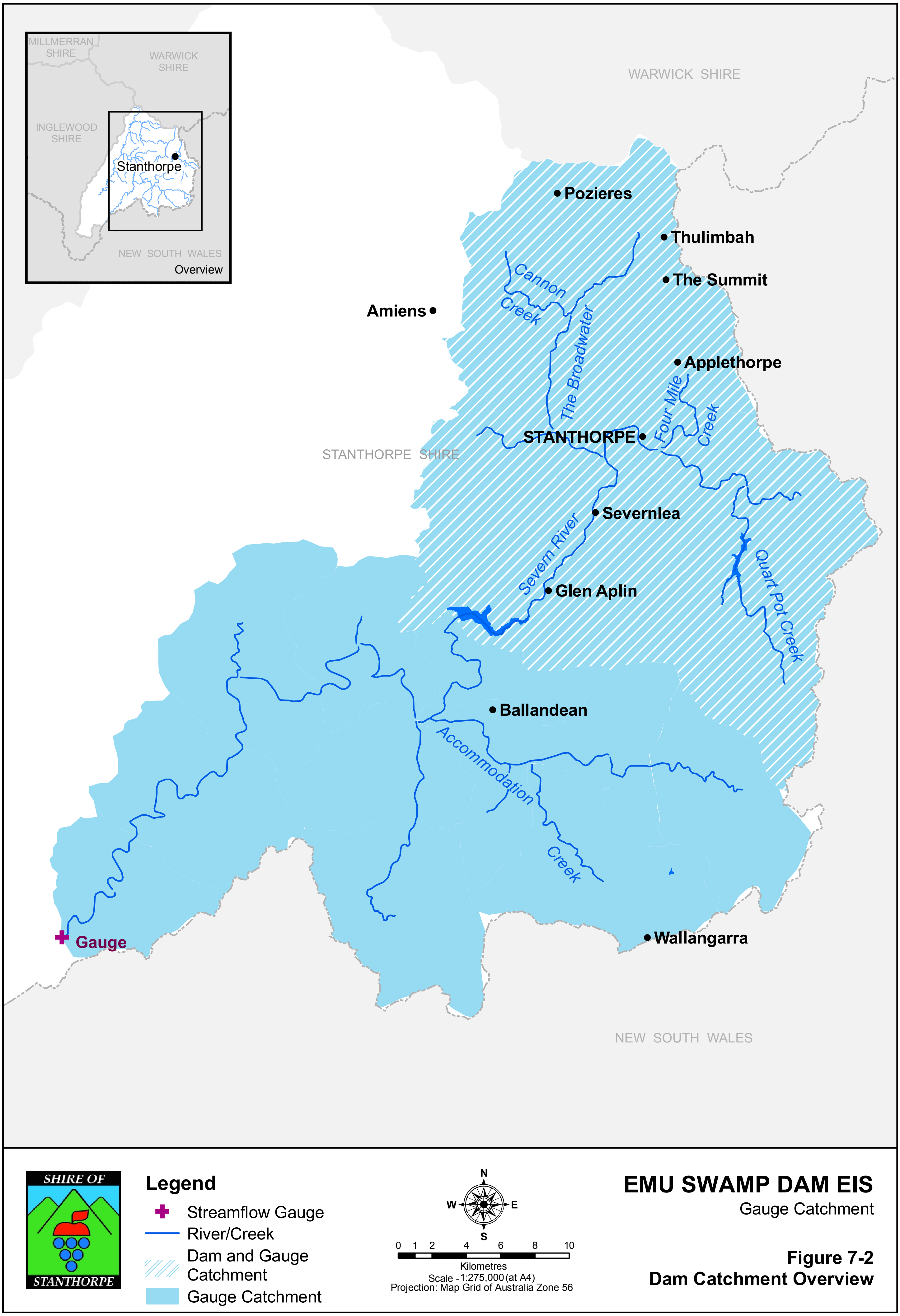
The major streams in the Granite Belt catchment are:

- The Broadwater;
- Cannon Creek;
- Quart Pot Creek;
- Four Mile Creek;
- Accommodation Creek; and
- Severn River.

The headwaters of the Broadwater and Cannon Creek are to the north in Herries Range. The headwaters of Quart Pot and Four Mile Creeks are in the Great Dividing Range. The Broadwater and Quart Pot Creek join to form the Severn River just west of Stanthorpe. The upper catchment is comprised of predominately forest and agricultural land uses. As shown in **Figure 7-2**, the Severn River flows south and combines with Accommodation Creek. Accommodation Creek rises in the Great Dividing Range and flows west to the Severn River. A large part of the Accommodation Creek catchment is in Girraween National Park. The Severn River then meanders south and west to Sundown National Park. After leaving Sundown National Park the Severn River joins with Pike Creek to become the Dumaresq River. The Pike Creek catchment includes the Glen Lyon Dam. The Dumaresq River flows west to become the Macintyre River and then the Barwon River before eventually flowing across the border into New South Wales.

- **Figure 7-1 Border Rivers Catchment Overview**





EMU SWAMP DAM EIS

Gauge Catchment

Figure 7-2
Dam Catchment Overview

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7.1.1.2 Stream Characteristics

The Severn River is characterised by a rocky bottom, pools and riffles. There is reported to be 26 barriers on the Severn River from the confluence of Quart Pot Creek and the Broadwater to Nundubbermere Falls in Sundown National Park. The majority of these barriers are weirs for private use. The locations, heights and capacities of these barriers are presented in **Table 7-1**.

- **Table 7-1 Barriers on the Severn River (AMTD 234 km – AMTD 281 km)**

AMTD	Height (m)	Capacity (ML)
	Confluence of Quart Pot Creek and the Broadwater	
281.0	2.5	8
279.9	1.0	10
278.5	1.0	10
276.2	1.5	15
275.2	1.5	22
274.8	2.3	64
269.9	2.4	52
267.5	3.0	5
266.2	3.5	120
265.5	1.0	1
264.5	1.0	7
264.0	3.4	10
264.0	5.0	5
264.0	Proposed Emu Swamp Dam Site	
262.7	1.2	7
262.5	1.4	0
260.5	4.0	140
259.3	2.9	38
256.1	3.2	220
252.0	Confluence of Accommodation Creek	
251.8	1.8	22
249.9	2.2	24
245.7	4.6	67
247.6	3.0	20
247.6	1.2	20
242.8	3.6	27
242.6	1.0	1
234.0	Nundubbermere Falls (6m)	

Source: Assessment Application for Fish Movement Exemption Fisheries Act 1994 (24 October 2005)

A number of these weirs are significant structures; nine weirs which are 3 m high or greater. **Figure 7-3** and **Figure 7-4** shows the 4.0 and 2.9 m weirs at AMTD 260.5 km and AMTD 259.3 km respectively.

- Figure 7-3 Severn River Weir AMTD 260.5 km

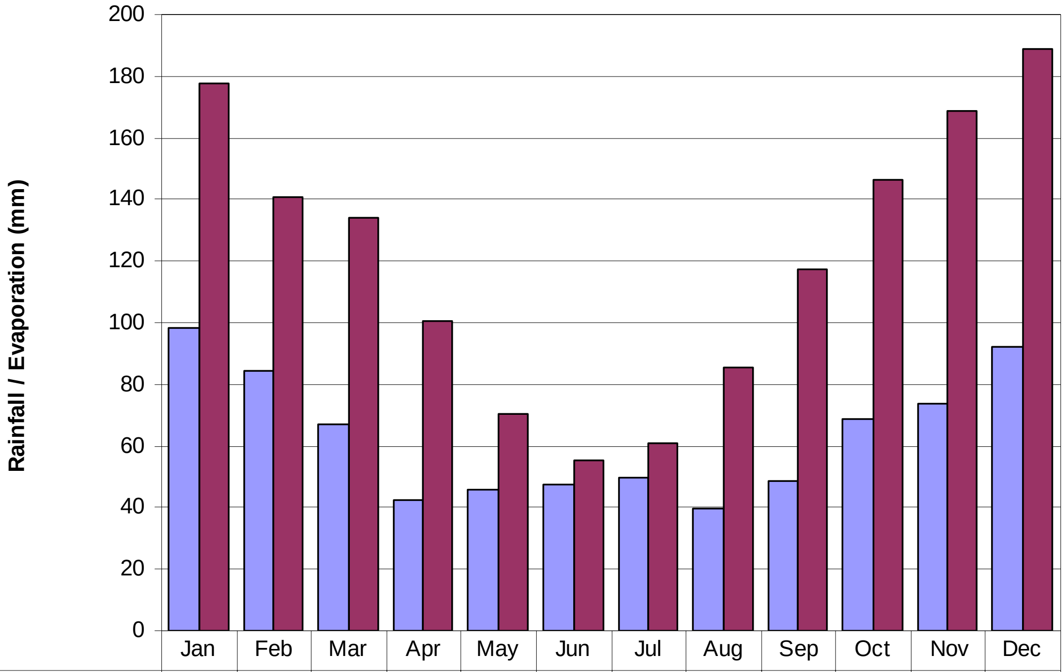
- Figure 7-4 Severn River Weir AMTD 259.3 km

7.1.1.3 Climate

Rainfall and Evaporation

Rainfall across the catchment displays seasonal variation, with there being higher mean rainfall in October to March. Evaporation varies significantly with season. Mean monthly evaporation is greater than mean monthly rainfall for all months. Mean monthly rainfall and evaporation data for Bureau of Meteorology (BoM) stations at Stanthorpe (041095) and Applethorpe (041175) respectively are presented in **Figure 7-5**.

- **Figure 7-5 Average Monthly Rainfall and Evaporation**

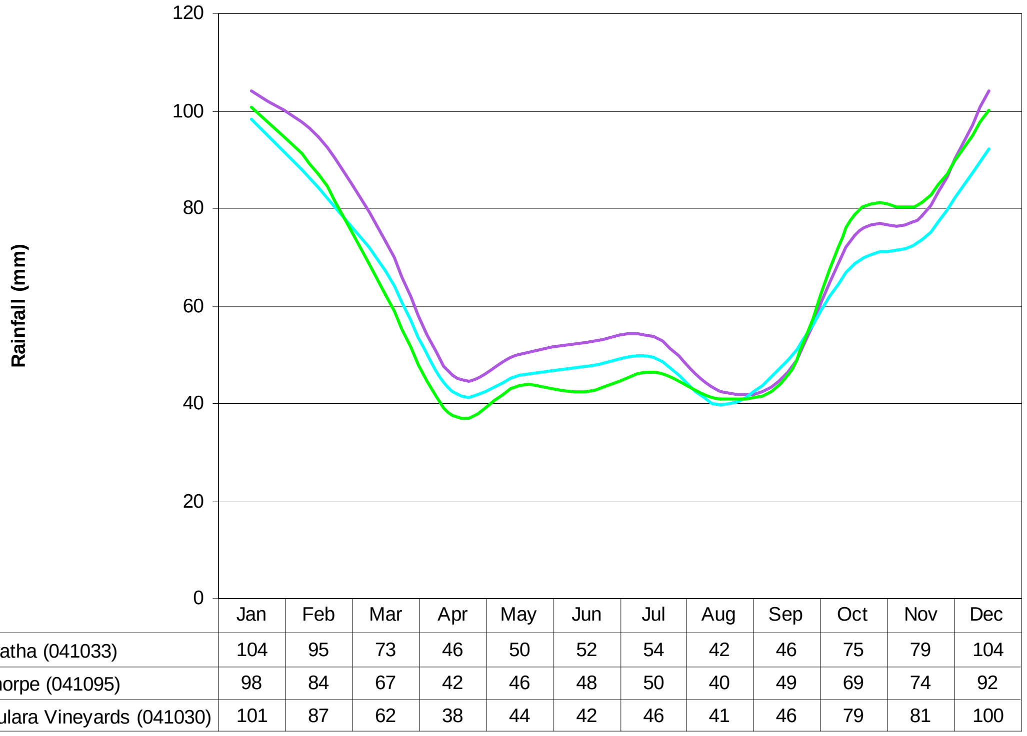


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
🟦 Rainfall (041095)	98	84	67	42	46	48	50	40	49	69	74	92
🟥 Evaporation (041175)	178	141	134	101	70	55	61	86	117	147	169	189

Rainfall Variability

Figure 7-6 presents the rainfall variability across the Emu Swamp Dam catchment. The three rainfall sites show a similar pattern and magnitude of rainfall. Carawatha is in the eastern part of the catchment, Stanthorpe is in the centre and Rumbalara Vineyards is near the dam site. **Figure 7-6** shows there is little variation in the rainfall across the dam catchment.

Figure 7-6 Variability of Rainfall Across the Emu Swamp Dam Catchment



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Carawatha (041033)	104	95	73	46	50	52	54	42	46	75	79	104
Stanthorpe (041095)	98	84	67	42	46	48	50	40	49	69	74	92
Rumbulara Vineyards (041030)	101	87	62	38	44	42	46	41	46	79	81	100

Table 7-2 compares the variability of annual rainfall for the three rainfall station sites. The difference between the maximum and minimum rainfalls at each site demonstrates the high variability of annual rainfalls in the area. The area has experienced wet periods and extended droughts over the past 100 years.

Table 7-2 Variability in Annual Rainfall

Site (BOM Gauge No)	Annual Rainfall (mm)		
	Minimum	Maximum	Mean
Carawatha (041033)	413	1303	820
Stanthorpe (040195)	368	1177	759
Rumbulara Vineyards (041030)	380	1135	767

Source: BoM 2007

7.1.1.4 Flooding

Historic Flooding

There is very limited flooding information for the Severn River. There are two river height gauges in the area and they are outlined in **Table 7-3**.

Table 7-3 River Height Stations

Station	Gauge No	River	Location	Period of Record
Ballandean	416318a	Severn	8 km downstream of dam site	8 years, June 1999 - present
Farnbro	416310a	Dumaresq	46 km downstream of dam site	45 years, Sept 1962 - present

Source: DNRW, 2007

The four largest recorded river heights and peak discharges at Farnbro are presented in **Table 7-4**.

- **Table 7-4 Historical Flooding at Farnbro (416310a)**

Date	River Height (m)	Peak Discharge (m^3/s)
December 1975	3.47	485
February 1976	6.24	1,600
May 1983	3.08	358
April 1988	3.90	624

Source: DNRW, 2007

There were also notable floods in 1872, 1890, 1919, 1920, 1928, 1933, 1941, 1953, and 1962 before the river height gauging commenced (BoM 2007).

Some level of flooding is experienced on average every 10 years or so. There is a notable absence of a flood event in the 1900-1919 period.

Design Flooding

A flood assessment has been undertaken for Emu Swamp Dam which included hydrologic (using RORB software) and hydraulic analyses (using MIKE11 software).

The RORB model was verified against the recorded flood event of April 1988 and then was used to predict the peak discharges for a range of Average Recurrence Interval (ARIs) flood events ranging from the 1 in 50 year to the Probable Maximum Flood (PMF) event (as outlined in **Table 7-5**). The PMF is the most extreme flood that can be reasonably expected to occur at the dam site. The PMF is an extremely rare event and it is estimated that the PMF has an ARI of 1 in 1,700,000 years.

- **Table 7-5 Design Peak Discharges at the Emu Swamp Dam Site**

ARI	Peak Discharge (m^3/s)
1 in 50 years	709
1 in 100 years	858
1 in 100,000 years	3,450
PMF	7,900

MIKE11, a 1D hydraulic modelling software package, was used to undertake the flooding assessment. The model extended 13 km from approximately AMTD 270 km to AMTD 257 km. This represents the section of river from approximately 6 km upstream of the proposed Emu Swamp Dam site to 7 km downstream of the dam site.

Table 7-6 presents the existing conditions predicted water levels for a number of locations on the Severn River.

- Table 7-6 Existing Design Peak Flood Levels

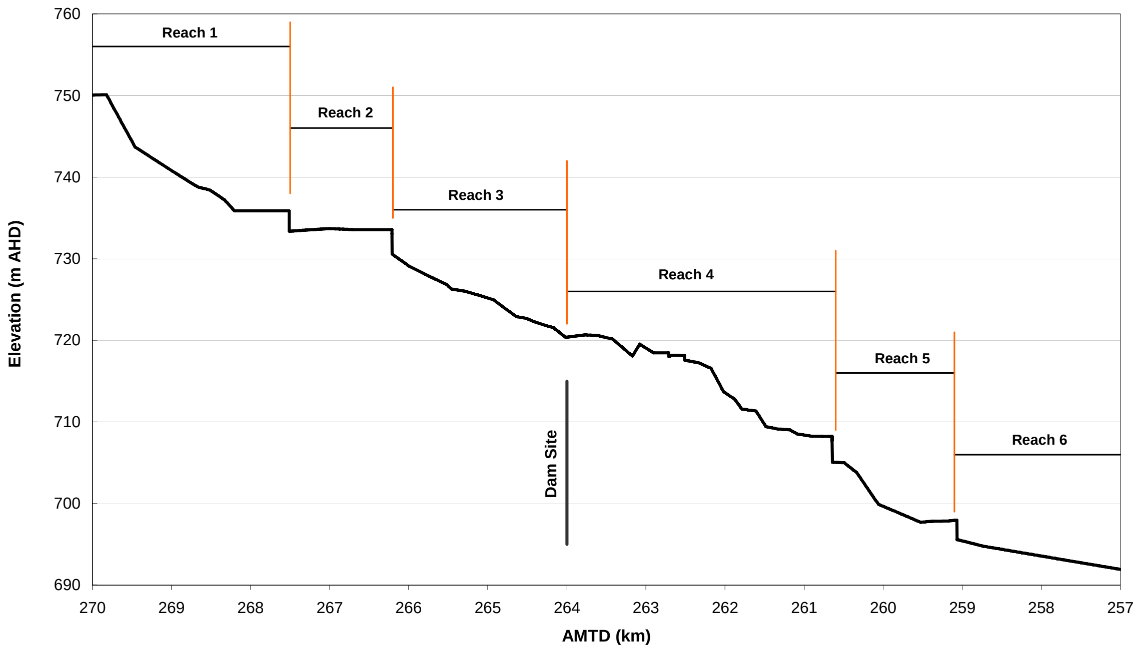
Location (AMTD)	Description	Predicted Peak Water Level (m AHD)	
		1 in 50 year ARI	1 in 100 year ARI
269.8	5.8 km upstream of dam site	752.70	752.88
269.0	5.0 km upstream of dam site	744.44	744.75
268.5	4.5 km upstream of dam site (Extent of Buffer)	741.04	741.32
264.0	Just downstream of dam site	725.16	725.60
262.0	2.0 km downstream of dam site	716.72	717.05
260.5	3.5 km downstream of dam site (above Mungall Weir)	709.27	709.58
259.3	4.7 km downstream of dam site (above Booth Weir)	701.76	702.01
257.0	7.0 km downstream of dam site	696.51	696.81

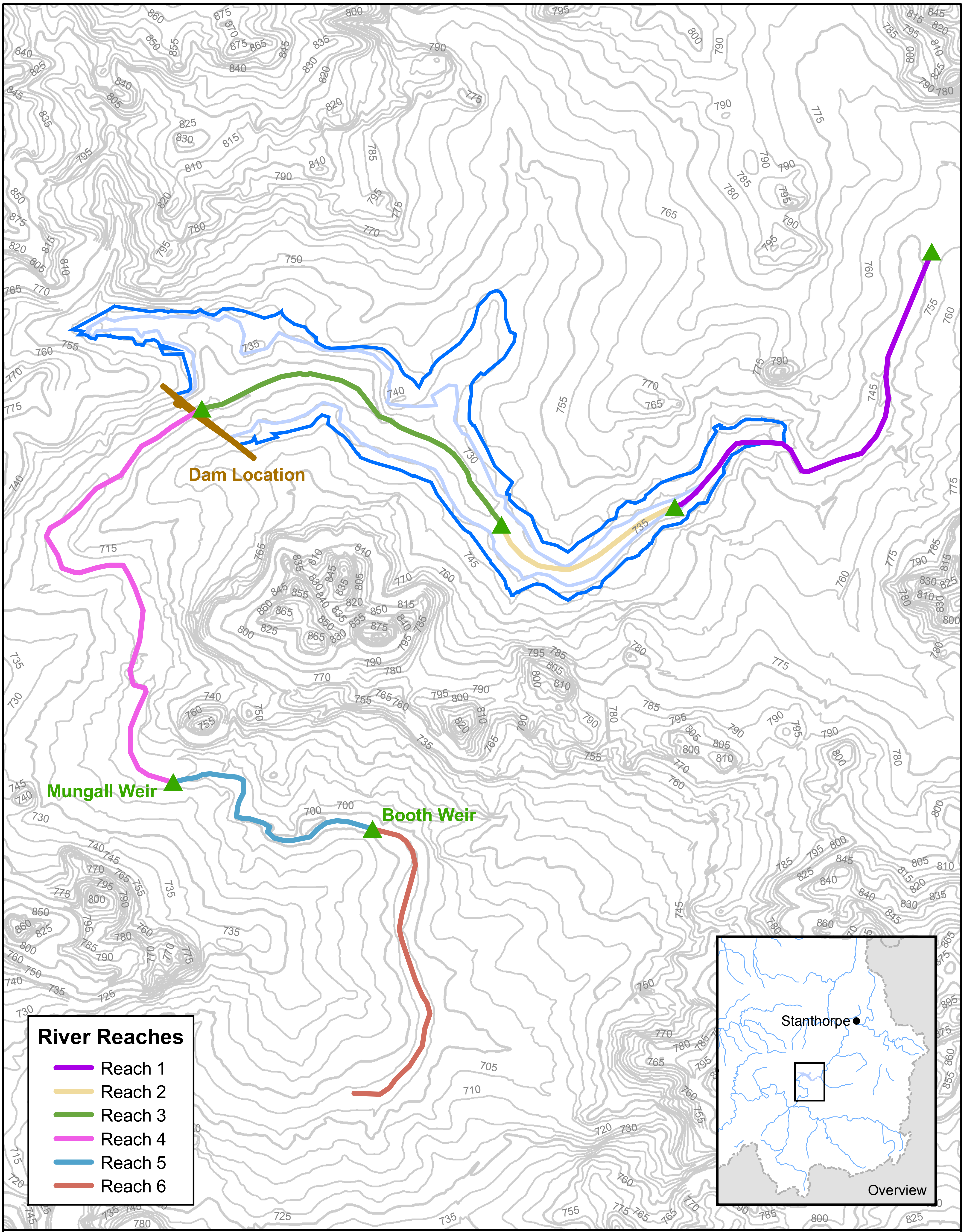
7.1.1.5 River Hydraulics (AMTD 257 – 270 km)

As discussed in **Section 7.1.1.2**, there are a number of weirs in the system which act as barriers to the river flow. **Figure 7-7** shows the longitudinal section of the Severn River (which covers the same extent as the flood modelling) from approximately 6 km upstream of the dam site to 7 km downstream. The locations of the significant weirs are also show in. **Figure 7-8**

This section of the Severn River includes six weirs greater than 2 m in height and four smaller weirs (refer **Table 7-1**).

- **Figure 7-7 Longitudinal Section of the Severn River (AMTD 257 – 270 km)**





SHIRE OF STANTHORPE

Legend

- ▭ Full Supply Level 734.5m AHD
- ▭ Full Supply Level 738m AHD
- — 5 metre contours
- ▲ Weirs

0 0.25 0.5 1
Kilometres
Scale - 1:30,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Dam and Surrounds

Figure 7-8
Significant Weirs

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The river is divided hydraulically into reaches by the larger existing weirs. The length of the reaches range from 1.4 to 3.6 km.

A preliminary assessment of the hydraulic behaviour of this section of the river was undertaken for the 1 in 2 year to the 1 in 100 year ARI flood events. The results showed the weirs at AMTD 260.5 km and AMTD 266.2 km are not drowned out even in a 1 in 100 year ARI event.

7.1.1.6 Water Resource Planning

Water Resource Plan

The *Water Resources (Border Rivers) Plan 2003* (WRP) was legislated to provide a sustainable framework for allocation and water management to achieve a balance between the consumptive need and the needs of the environment.

The Border Rivers WRP covers an area of approximately 42,000 km^2 including the following streams:

- Severn River;
- Dumaresq River;
- Weir River;
- Macintyre River; and
- Pike Creek.

The Border River WRP specifies a range of Environmental Flow Objectives (EFOs) and Water Allocation Security Objectives (WASOs). These EFOs and WASOs are determined using the DNRW Integrated Quantity and Quality Model (IQQM).

The dam is proposed in the Granite Belt subcatchment. There is an IQQM model which represents the Granite Belt system.

Draft Resource Operations Plan

The draft *Border Rivers Resource Operation Plan* (ROP) was released for consultation in January 2007. The purpose of the draft ROP is to set out the rules and requirements for the day-to-day management of stream flows and water infrastructure to achieve the plan objectives. The draft ROP is expected to be finalised in the near future.

IQQM Simulation

The DNRW IQQM represents the catchment flow response to climate conditions over a historical period. This model was set up and calibrated by DNRW as part of the development of the Border Rivers WRP in 2003.

There are two scenarios that form the basis of the assessment:

- predevelopment; and
- existing entitlements.

The DNRW supplied IQQM model has a simulation period from 1 September 1890 to 30 September 1996. The process of the IQQM assessment is to develop scenarios and assess them based on the historic climate sequence (1890 – 1996). Therefore information presented in this section will display a number of graphs showing the performance of various scenarios for given years. This represents how the scenario would perform subject to the same climate conditions experience in that year.

The predevelopment scenario represents flows within the system with all dams and water infrastructure removed and with no water extracted from the system. This provides information on the original flow regime of the system without any water resource development.

The existing entitlements scenario incorporates all existing water resource development within the catchment. It assumes full utilisation of all existing water entitlements which provides information on the committed entitlements and represents the approved level of water resource use in the catchment for existing conditions. The existing entitlement scenario is representative of the current existing environment and is the base case for the assessment of the impacts of the dam. This model includes 3 year capping to be in line with the Attachment 7(C) of draft ROP which was released in January 2007.

Environmental Flow Objectives

Node J on the Severn River at Farnbro (AMTD 198.6 km) is the nominated node for the assessment of the EFOs performance for flows from the Granite Belt catchment. EFOs are defined by a number of performance indicators which are described in **Table 7-7**.

- **Table 7-7 Environmental Flow Objectives Performance Indicators – Definitions**

Performance Indicators	Definition
Low Flow (days)	The total number of days in the simulation period in which the daily flow is not more than half the predevelopment median daily flow.
Summer Flow (days)	The average number of summer flow days in the simulation period. (summer flow days - days in summer in which the daily flow is more than the predevelopment median daily flow)
Beneficial Flooding Flow (ML)	The median of the wet season 90-day flows for the years in the simulation period. (Wet season 90-day flows – for a year means the total flow in a continuous 90-day period with the highest daily flows)
1 in 2 Year Flood (ML)	The daily flow that has a 50% probability of being reached at least once a year.

Table 7-8 compares the EFOs for the predevelopment and existing entitlements scenarios at Node J.

- **Table 7-8 Environmental Flow Objectives – Node J**

Performance Indicators	Predevelopment	Existing Entitlements	% of Predevelopment
Low Flow (days)	16,855	22,958	136
Summer Flow (days)	51	33	66
Beneficial Flooding Flow (ML)	34,623	22,561	65
1 in 2 Year Flood (ML)	4,608	2,651	58

Water Allocation Security Objectives

WASOs are calculated using IQQM for the water allocations of the system. The WASOs are defined in the Border Rivers WRP and are described in **Table 7-9**.

Table 7-9 Water Allocation Security Objectives Performance Indicators – Definitions

Performance Indicators	Definition
Annual Volume Probability (%)	The percentage of years in the simulation period in which the volume of water that may be taken by the group is at least the total nominal volume of the group.
45% Annual Volume Probability (%)	The percentage of years in the simulation period in which the volume of water that may be taken by the group is at least 45% the total nominal volume of the group.

7.1.1.7 Water Resource Development

Water Use

Water is extracted from the River and its tributaries for irrigation, stock and domestic and urban water supply use. Both supplemented water (i.e. from a dam) and unsupplemented water (i.e. run of river) is extracted from the waterways in the catchment.

Unsupplemented water licences within the River catchment take the form of area-based, volumetric or water harvesting licences. No recording or reporting is currently undertaken to assess the actual use of these entitlements. It is estimated that area licences of approximately 2,200 ha and volumetric licences of 1,800 ML currently exist within the Granite Belt catchment.

Water Storages

The urban supply is the only supplemented water supply in the Granite Belt catchment. This supply is an annual allocation of 700 ML for Stanthorpe Council from Storm King Dam. Water is supplied from Storm King Dam to Mt Marlay Treatment Plant to supply the town of Stanthorpe. The characteristics of Storm King Dam are outlined in **Table 7-10**.

Table 7-10 Storm King Dam Storage Characteristics

	Storm King Dam
Full Storage Volume (ML)	2,180
Full Storage Height (m)	9.5
Minimum Operating Volume (ML)	200
Inundated Area at Full Supply Level (ha)	78
Catchment Area (km^2)	95
Stream	Quart Pot Creek
AMTD (km)	300.7
Completed	1954

The performance of Storm King Dam predicted by IQQM for simulation period (1890-1996) is outlined in **Table 7-11**.

Table 7-11 Storm King Dam Performance

	Storm King Dam
Licence Volume (ML)	700
Mean Annual Diversion (ML)	652
Monthly Reliability (%)	94
Annual Reliability (%)	87

The mean annual diversion for Storm King Dam is predicted to be 652 ML at a monthly reliability of 94%. The Storm King Dam performance is driven by the critical period which is a drought from 1909 to 1916. The majority of the dam's failure to deliver the annual allocation occurs in this period.

7.1.1.8 Flow Statistics

Flow statistics have been determined at a number of locations to characterise the flow regime of the Severn River. These flow statistics are not EFOs as part of the water planning process. However they illustrate the River's behaviour annually, monthly and seasonally in terms of both magnitude and variability. The flows statistics of the mean annual flows (**Table 7-12)**, flow durations and monthly median daily flows, for both the predevelopment and the existing entitlements scenario, have been determined at the following locations:

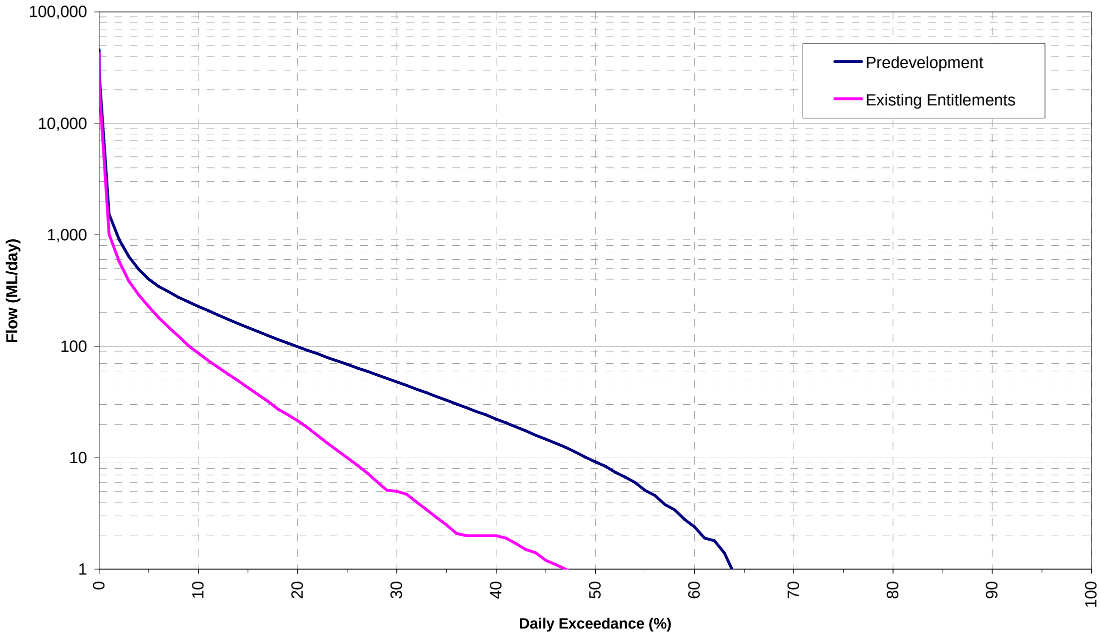
- Severn River at the dam site – AMTD 264 km (**Figure 7-9** and **Figure 7-10**);
- Severn River immediately downstream of the confluence with Accommodation Creek – AMTD 252 km (**Figure 7-11** and **Figure 7-12**); and
- Dumaresq River at Farnbro – ATMD 198.6 km (**Figure 7-13** and **Figure 7-14**).

The flow statistics at Farnbro represent Node J in the Border Rivers WRP and also the inflow to the Sundown National Park.

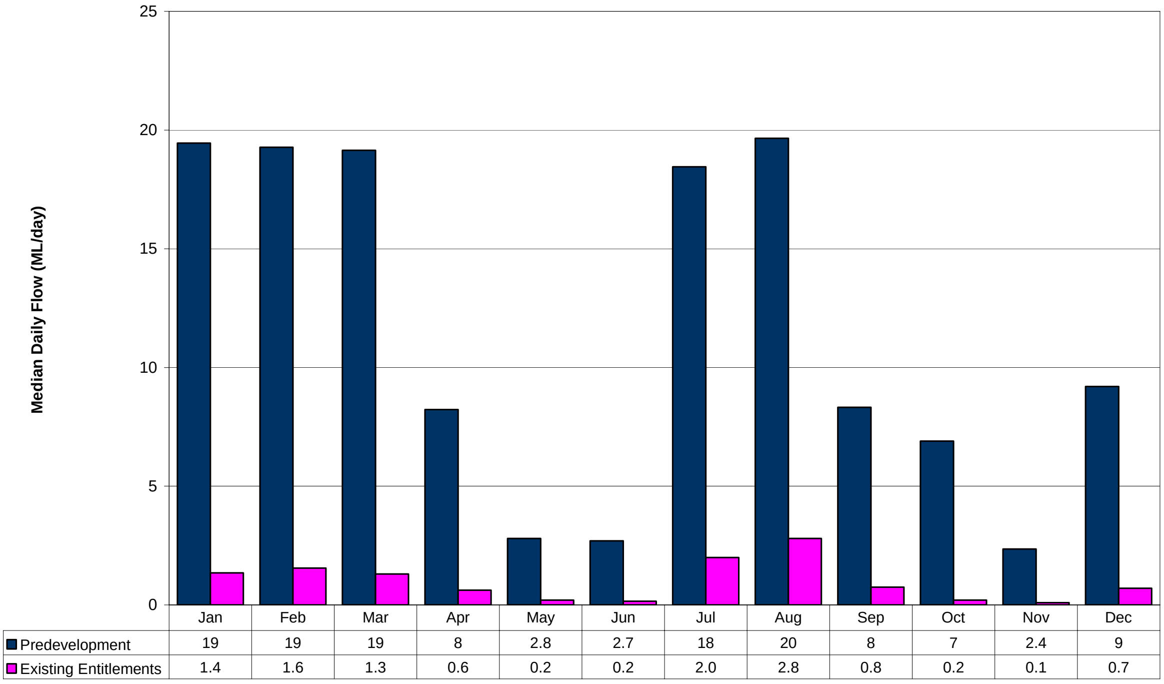
- **Table 7-12 Mean Annual Flows**

Location	Mean Annual Flow (ML)		
	Predevelopment Scenario	Existing Entitlements Scenario	% of Predevelopment
Dam site (AMTD 264 km)	38,600	21,600	56
Downstream of confluence Accommodation Creek (AMTD 252 km)	55,600	34,900	63
Farnbro (AMTD 198.6 km)	81,300	59,100	73

■ Figure 7-9 Flow Duration Curve – Emu Swamp Dam Site (AMTD 264 km)

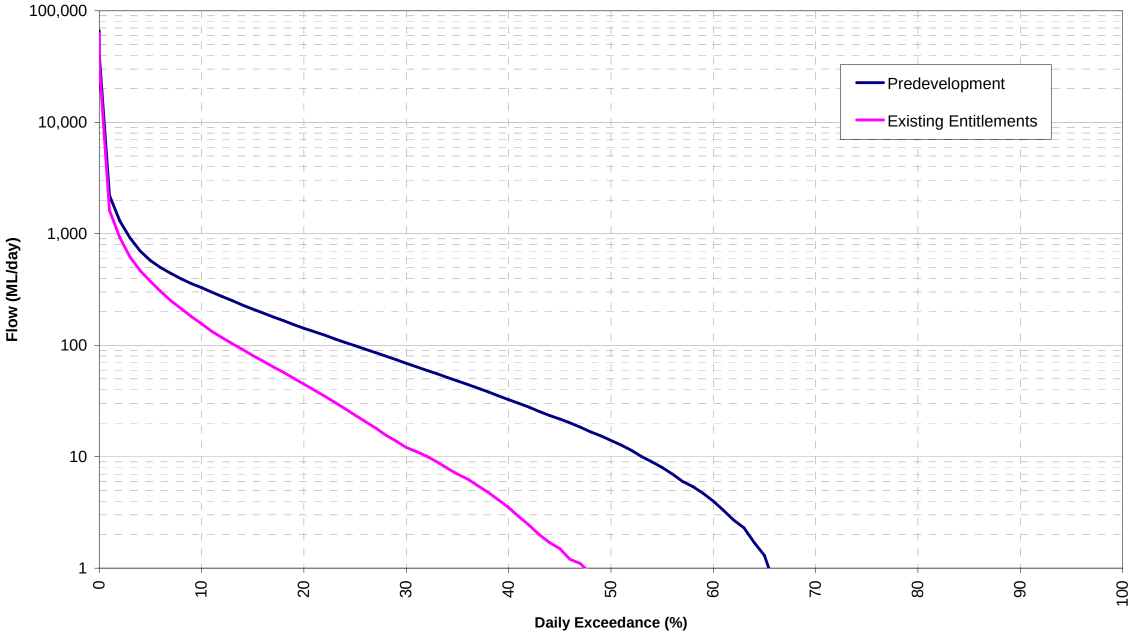


■ Figure 7-10 Monthly Median Daily Flows – Emu Swamp Dam Site (AMTD 264 km)

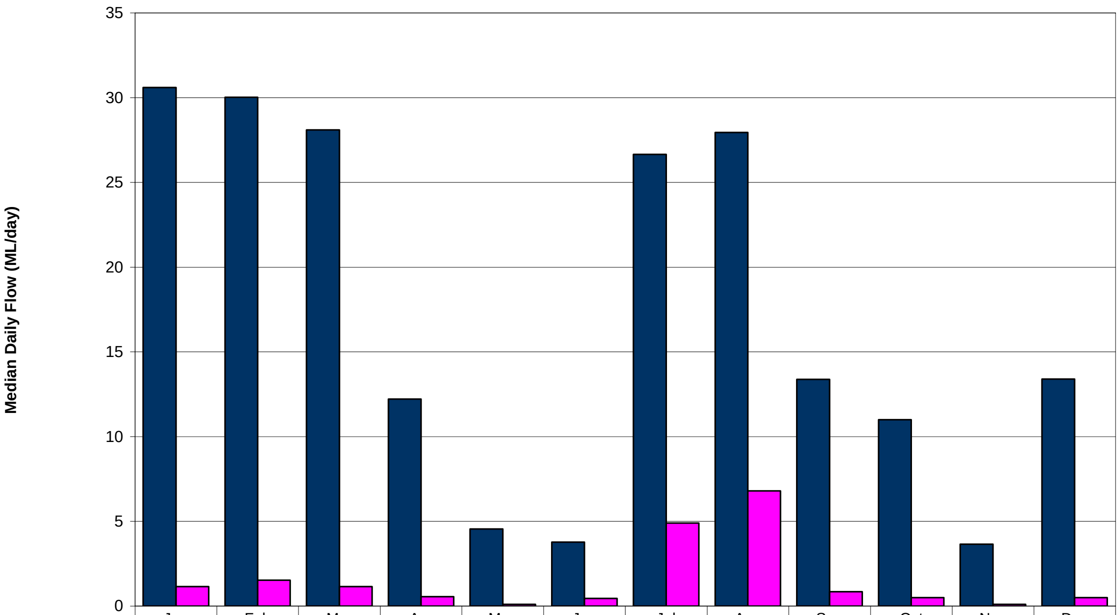


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
■ Predevelopment	19	19	19	8	2.8	2.7	18	20	8	7	2.4	9
■ Existing Entitlements	1.4	1.6	1.3	0.6	0.2	0.2	2.0	2.8	0.8	0.2	0.1	0.7

- **Figure 7-11 Flow Duration Curve – Downstream of Accommodation Creek Confluence (AMTD 252 km)**

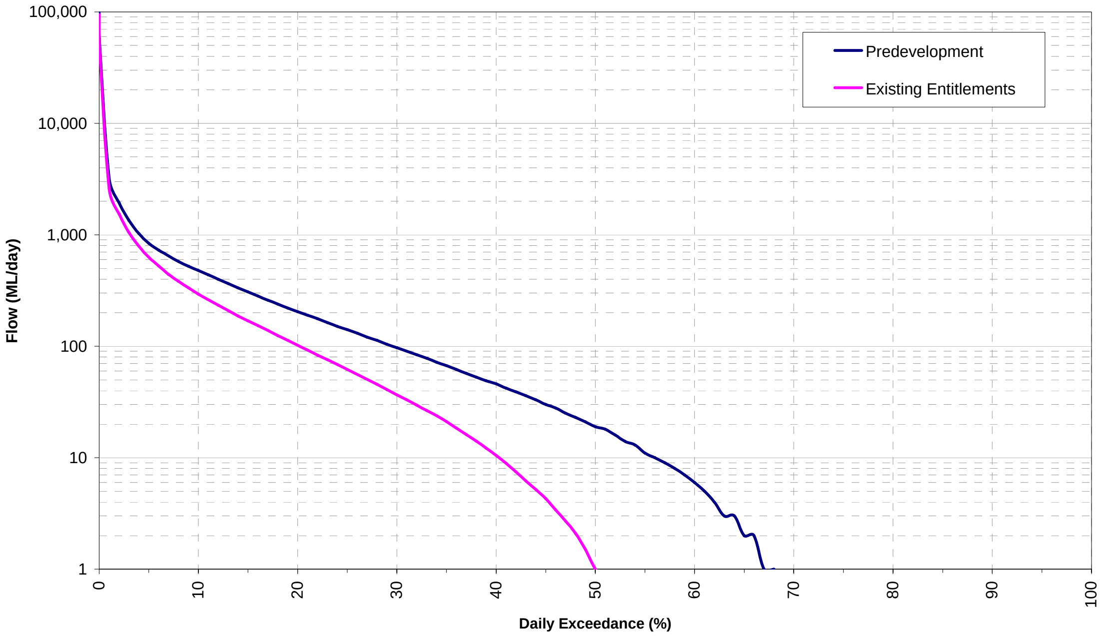


- **Figure 7-12 Monthly Median Daily Flows – Downstream of Accommodation Creek Confluence (AMTD 252 km)**

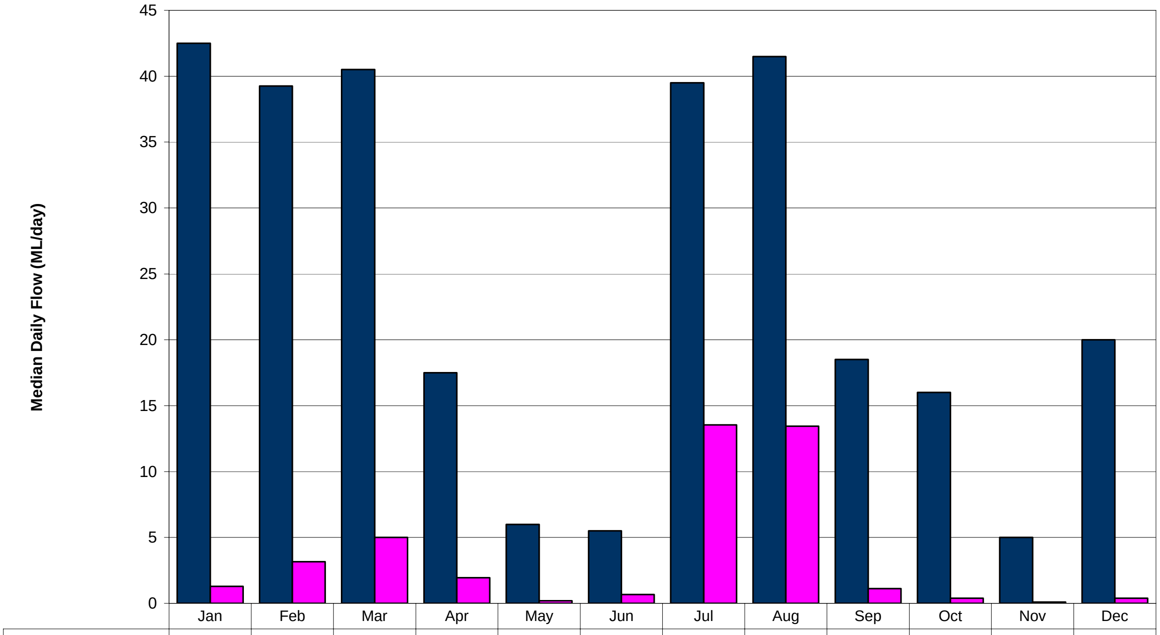


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
■ Predevelopment	31	30	28	12	4.6	3.8	27	28	13	11	3.7	13
■ Existing Entitlements	1.2	1.5	1.2	0.6	0.1	0.5	4.9	6.8	0.9	0.5	0.1	0.5

- **Figure 7-13 Flow Duration Curve – Farnbro Node J (AMTD 198.6 km)**



- **Figure 7-14 Monthly Median Daily Flows – Farnbro Node J (AMTD 198.6 km)**



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
■ Predevelopment	43	39	41	18	6.0	5.5	40	42	19	16	5.0	20
■ Existing Entitlements	1.3	3.2	5.0	2.0	0.2	0.7	14	13	1.1	0.4	0.1	0.4

These flow statistics highlight the following characteristics of the flow regime of the Severn River:

- the Severn River is an ephemeral stream;
- there is significant monthly variability in median daily flow;
- there is significant reduction from predevelopment to the existing entitlements scenario; and
- accommodation Creek inflows are significant.

The flow duration curves for the three locations show the Severn River is an ephemeral waterway. There is no flow at the dam for the predevelopment and existing entitlements scenarios for 31% and 37% of time respectively. Flows at the dam are below 1 ML/day for 36% and 53% of time for the predevelopment and existing entitlements scenarios respectively. This characteristic is also observed in the flow statistics downstream of the Accommodation Creek confluence and at Node J.

There is significant variation in the monthly median daily flow in the Severn River. The flow statistics show for the predevelopment scenario flows for January to March, July and August are substantially higher than the other months. The existing entitlements scenario also has considerably higher median daily flows for July and August.

There has been a significant reduction from the predevelopment to the existing entitlements scenario flows. The mean annual flow at the dam is 56% of the predevelopment flow. This shows the impact of the existing level of development in the catchment.

Accommodation Creek combines with the Severn River approximately 12 km downstream of the dam. Accommodation Creek and its tributaries contribute significantly to the inflows as they drain the Girraween National Park with an approximate area of 118 km^2. The Accommodation Creek inflows substantially increase the existing entitlements scenario monthly median flows. At Node J the existing entitlements scenario monthly median flows are further increased by inflows.

7.1.2 Impacts and Mitigation – Urban Water Supply Dam

This section describes the impacts upon the water resources of the Granite Belt catchment with the dam of 5,000 ML (734.5 m AHD) for the Urban Scheme and addresses the following aspects:

- construction;
- climatic extremes;
- flooding;
- pipelines;
- water resource planning
- yield assessment;
- environmental release strategy;
- water resource development;
- environmental flow objectives; and
- flow statistics.

7.1.2.1 Construction

Flows in the River will be maintained throughout construction. Construction of the dam wall and embankment will take place in several stages, as discussed in Section 3. Initially, the dam wall will be built on the right abutment side of the current channel. When this side is complete flows will be diverted through the completed outlet works.

Construction activities will be scheduled so that the impacts of flooding on the construction of the dam will be minimised. If a flood occurs during construction, there is little risk of damage to the partially built Roller Compacted Concrete (RCC) Wall. Even if the RCC Wall is overtopped the wall is unlikely to be damaged badly.

Water for construction will be drawn directly from the River under permit and treated on-site where necessary. Approximately 19 ML will be required during the construction period. Further detail on this and other permits required under the *Water Act 2000* for the construction period are identified in **Section 1**. All construction water will be treated and reused on site.

All proposed drainage structures associated with the dam including those necessary for supporting facilities such as access roads will be designed to the appropriate design standards. All designs will incorporate an appropriate level of flood immunity, minimisation of impacts to upstream landholders and mitigation of the impacts of velocity and scour.

7.1.2.2 Climatic Extremes

The effect of predictable climatic extremes on flows within the Severn River, and thus the availability of water, has been considered in the IQQM modelling. Modelling was undertaken for an historic sequence of 107 years from 1890 to 1996, which includes climatic extremes experienced during this time. This period includes historic droughts, such as the drought of 1909 to 1915 and large rainfall events such as the 1893 and 1976 floods.

Climatic extremes will also be considered in the design of the structural integrity of the RCC Wall and spillway. These will be designed to meet the standards set out in the Australian National Committee on Large Dams (ANCOLD) guidelines. The dam embankment and spillway will be able to withstand overtopping by the Probable Maximum Flood (PMF), which is the most extreme flood that can be reasonably expected to occur at the dam.

7.1.2.3 Flooding

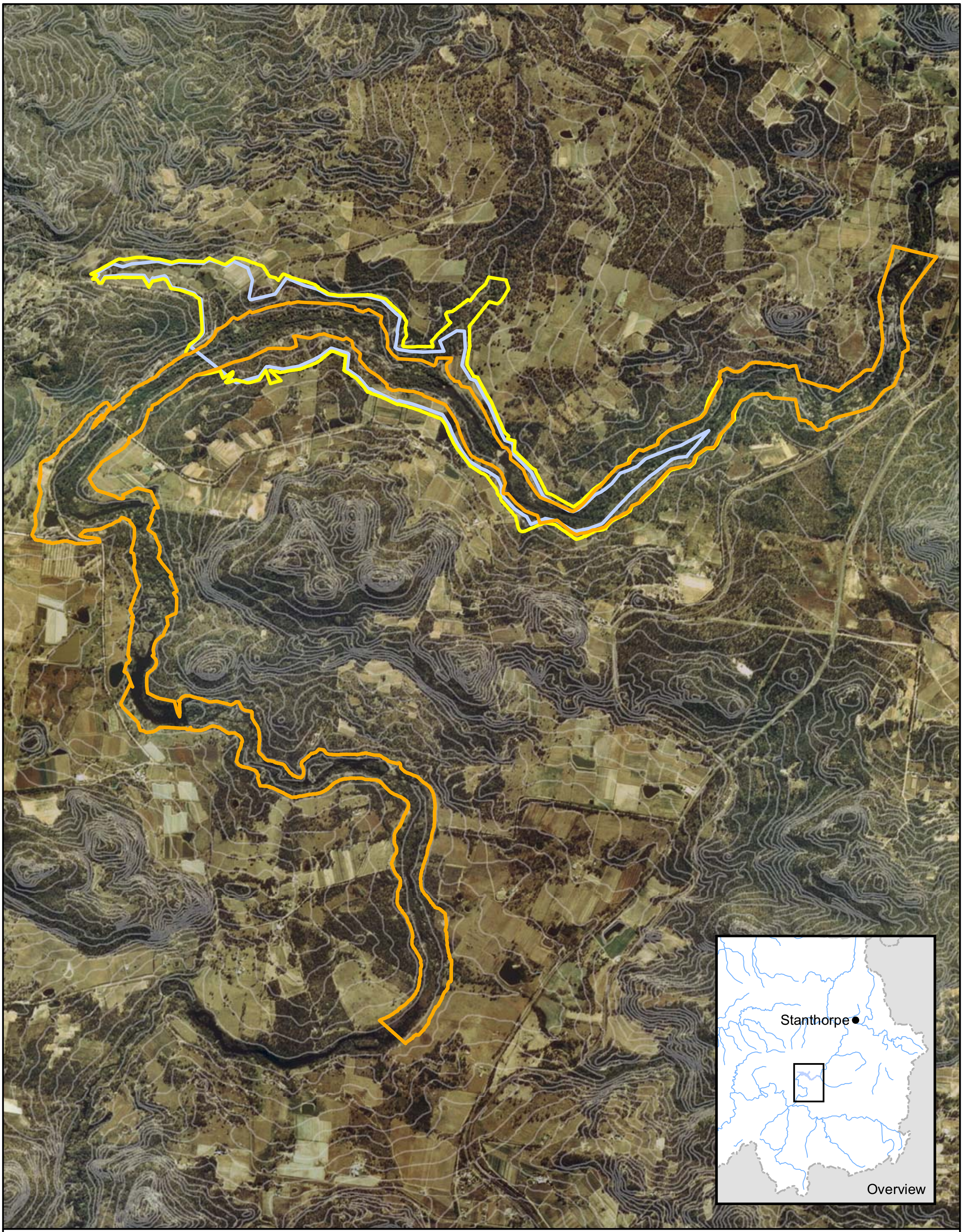
As part of the preliminary design process, a flood assessment was undertaken for the dam. This included hydrologic analysis and modelling of the catchment, as well as hydraulic modelling of the area surrounding the dam site. The models are described in detail in **Section 7.1.1.4**.

Flood scenarios with and without the dam scenarios were assessed for the 1 in 50 and 1 in 100 year ARI flood events.

For the dam scenario, it was assumed the dam was initially at full supply level (FSL) to give a conservative scenario. The critical storm duration with and without the dam was 24 hours for all design events.

Backwater effects from the dam will cause some localised flooding impacts in the areas surrounding the inundation area. **Figure 7-15** and **Figure 7-16** present the predicted inundation extent for both with and without dam for the 1 in 50 and 1 in 100 year ARI events, respectively.

Land will be acquired to the level of 738 m AHD and in addition to this a buffer area of approximately 200 m width will be established around the dam to maintain water quality and ecological connectivity. The buffer area is discussed in more detail in **Section 3** of the EIS.



SHIRE OF
STANTHORPE

Legend

- Full Supply Level 734.5m AHD
- 50 yr ARI inundation no dam
- 50 yr ARI inundation with dam
- 5 metre contours

N
W E
S

0 0.25 0.5 1
Kilometres
Scale -1:30,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Dam & Surrounds

Figure 7-15 Extent of Inundation in 1 in 50 Year ARI Event with and without the Urban Water Supply Dam

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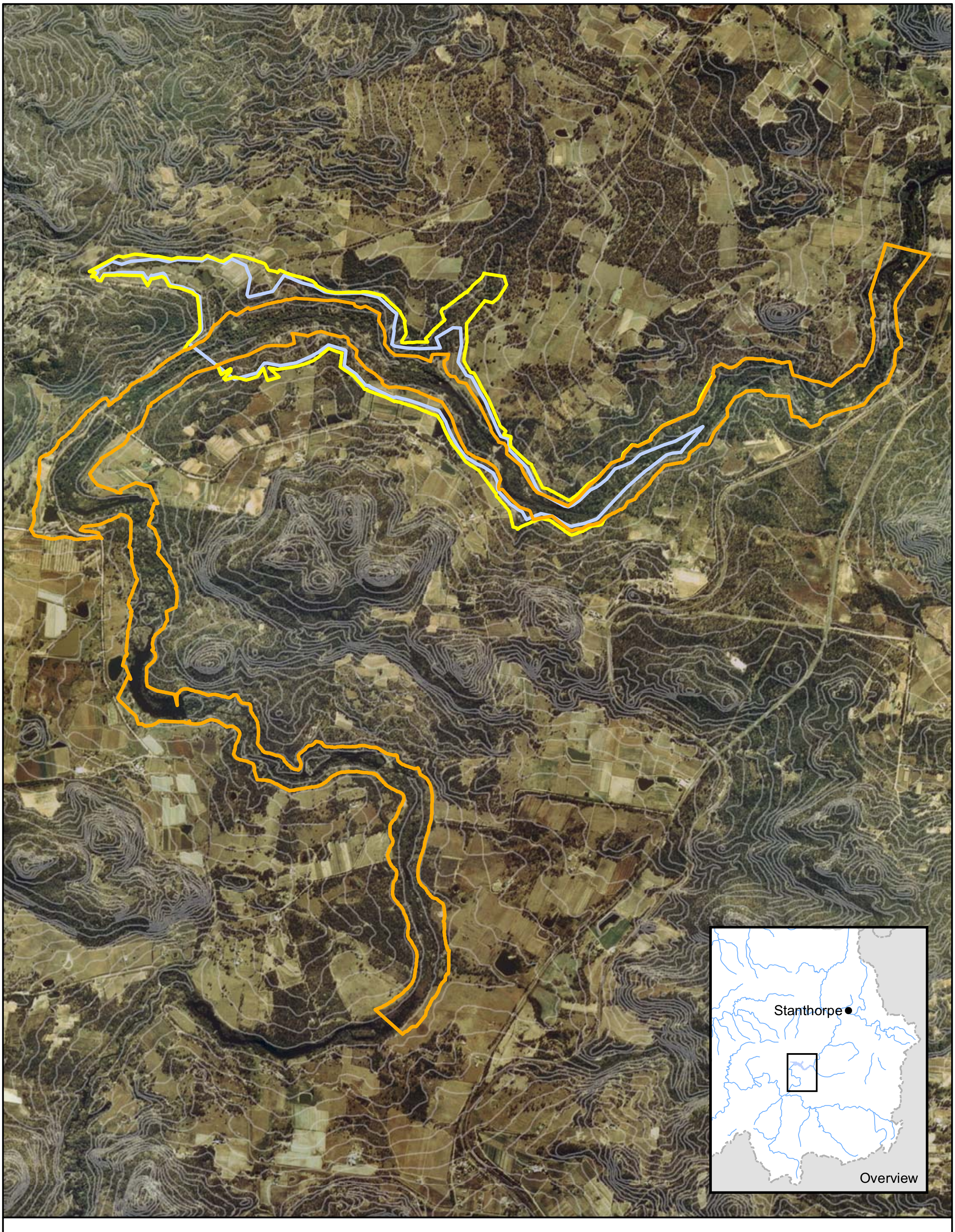

SHIRE OF STANTHORPE

Legend

- ▭ Full Supply Level 734.5m AHD
- ━ 100 yr ARI inundation no dam
- ━ 100 yr ARI inundation with dam
- ━ 5 metre contours

N
W E
S

0 0.25 0.5 1
Kilometres
Scale -1:30,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Dam & Surrounds

Figure 7-16 Extent of Inundation in 1 in 100 Year ARI Event with and without the Urban Water Supply Dam

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Table 7-13 and **Table 7-14** present the peak flood levels with and without the Urban Water Supply Dam for the 1 in 50 year and 1 in 100 year ARI events respectively.

- **Table 7-13 Peak Flood Levels – 1 in 50 year ARI Event (Urban Water Supply Dam)**

Location (AMTD)	Description	Predicted Peak Water Level (m AHD)		Change in Peak Flood Level (m)
		Without Dam	With Dam	
269.8	5.8 km upstream of Dam Site	752.70	752.70	0.00
269.0	5.0 km upstream of Dam Site	744.44	744.44	0.00
268.5	4.5 km upstream of Dam Site (Extent of buffer)	741.04	741.04	0.00
264.0	Just downstream of Dam Site	725.16	725.11	-0.05
262.0	2.0 km downstream of Dam Site	716.72	716.71	-0.01
260.5	3.5 km downstream of Dam Site (above Mungall Weir)	709.27	709.27	0.00
259.3	4.7 km downstream of Dam Site (above Booth Weir)	701.76	701.75	-0.01
257.0	7.0 km downstream of Dam Site	696.51	696.51	0.00

- **Table 7-14 Peak Flood Levels – 1 in 100 year ARI Event (Urban Water Supply Dam)**

Location (AMTD)	Description	Predicted Peak Water Level (m AHD)		Change in Peak Flood Level (m)
		Without Dam	With Dam	
269.8	5.8 km upstream of Dam Site	752.88	752.88	0.00
269.0	5.0 km upstream of Dam Site	744.75	744.75	0.00
268.5	4.5 km upstream of Dam Site (Extent of buffer)	741.32	741.32	0.00
264.0	Just downstream of Dam Site	725.60	725.53	-0.07
262.0	2.0 km downstream of Dam Site	717.05	717.04	-0.01
260.5	3.5 km downstream of Dam Site (above Mungall Weir)	709.58	709.58	0.00
259.3	4.7 km downstream of Dam Site (above Booth Weir)	702.01	702.01	0.00
257.0	7.0 km downstream of Dam Site	696.81	696.81	0.00

The results of the flood assessment show there is some minor reduction in peak flood levels downstream of the Urban Water Supply Dam. As discussed above, land will be protected around the dam to act as a buffer. The dam will have no adverse impact on flooding upstream or downstream of the buffer area.

Risk Assessment

The design flood capacity for the Emu Swamp Dam needs to comply with the *Guidelines on Selection of Acceptable Flood Capacity for Dams* (ANCOLD 2000a).

The selection of the design flood capacity uses a risk procedure that considers the population at risk and the severity of damage and loss (to services and business, to the society and to the environment) arising from a dam failure.

The ANCOLD guidelines allow a simple risk assessment approach to be used to select the Acceptable Flood Capacity.

The *Guidelines for Assessment of The Consequences of Dam Failure* (ANCOLD 2000b) provide a simple methodology for assessing Severity of Damages and Loss. Using this approach the severity (of a dam failure at Emu Swamp) can be taken as “Major” – the “Major” severity rating is considered possible due to the potential political implications, loss of services, dislocation of businesses and environmental impact.

There are two downstream buildings with potential Population at Risk (PAR). The total population at risk is less than 10 but probably greater than 1.

For a PAR of 1 to 10 persons and a “Major” Severity of Damage and Loss rating the Hazard Category is “High C”.

For a “High C” Incremental Flood Hazard Category (IFHC) rating the risk assessment process assigns an upper limit Flood Annual Exceedance Probability (AEP) in the range of:

- 10,000 year ARI to Probable Maximum Precipitation Design Flood (PMPDF), or
- 100,000 year ARI (with the lesser value to apply).

For the Emu Swamp site the PMF is 7,900 m^3/s, the PMPDF is 7,140 m ^{3}/s and the 100,000 year ARI is 3,460 m^3/s.

For the 100,000 year ARI, event ANCOLD (March 2000) allows a joint probability assessment to be made for the reservoir level (prior to the flood event).

For the Dam a conservative approach has been taken and a full reservoir has been adopted for all flood events.

The downstream effects of PMF and 100,000 year ARI Dam failure events for the Urban Water Supply Dam (FSL at 734.5 m AHD) are presented in **Table 7-15**. The estimated building floor levels are 712 m AHD at PAR1 and 702 m AHD at PAR2.

- **Table 7-15 Comparison of Inundation at PAR Sites (Urban Water Supply Dam)**

Flood Event	Peak Flood Level at PAR1 (m AHD)	Potential Inundation (m)	Peak Flood Level at PAR2 (m AHD)	Potential Inundation (m)
100,000 ARI – existing	704.8	Nil	700.2	Nil
100,000 ARI – developed (no breach)	704.8	Nil	700.2	Nil
100,000 ARI – developed (breach)	705.9	Nil	701.2	Nil
PMF – existing	708.0	Nil	703.1	1.1
PMF – developed (no breach)	708.0	Nil	703.1	1.1
PMF – developed (breach)	708.0	Nil	703.1	1.1
Sunny Day Failure	701.7	Nil	696.9	Nil

There is no inundation potential at PAR1 therefore it can be concluded that the population at risk at PAR1 is nil for both 1 in 100,000 year ARI and PMF events. There is no inundation potential at PAR2 for a dam breach during the 100,000 year ARI flood event therefore the population at risk at PAR2 is nil for the 1 in 100,000 year ARI event.

For the PMF – existing (no dam) event the PAR2 site is inundated to a depth of 1.1 m. For the PMF – developed (no dam breach and breach) event there is no incremental increase in inundation depth. So, provided there is no dam failure the construction of the dam does not change the risk situation at PAR2.

It is considered that 100,000 year ARI should be adopted as the Acceptable Flood Capacity for the dam.

7.1.2.4 Pipelines

The Urban Pipeline to supply water from the dam to Stanthorpe is approximately 23 km long, as shown in **Figure 3-5**. The pipeline will be constructed primarily in road reserves and there are four significant creek crossings in the pipeline route:

- Horan’s Gorge;
- Back Creek;
- Quart Pot Creek; and
- Kettle Swamp Creek.

A riverine protection permit will be obtained from DNRW for the pipeline to cross these creeks. Three construction methods may be employed at the creek crossing depending on the site:

- attach to an existing structure;
- directional drilling; and
- cut and cover trenching with erosion protection.

The design of the creek crossings employing the methods outlined above will result in no impacts to the hydraulic capacity of the waterway.

7.1.2.5 Water Resource Planning

Water Resource Plan

The WRP preserves existing water entitlements within the plan area as well as making the following provision for strategic reserve within the Stanthorpe Shire:

- town water supply – 1,500 ML (average annual volume); and
- irrigation and associated industry – 3,500 ML (average annual volume).

Resource Operations Plan

The draft ROP, released in January 2007, outlines the provision for unallocated water as outlined above for town water supply and for irrigation and associated industry. The Explanation Notes for the draft ROP, Chapter 2, provide a breakdown of the maximum volumes of unallocated water to be available in each subcatchment, expressed as a long term average annual take.

7.1.2.6 Yield Assessment

Although Stanthorpe Shire Council (SSC) perceives future need for an annual allocation of 1,500 ML, affordability considerations have led to Council pursuing an initial stage capacity of 750 ML. The existing entitlements IQQM model was modified to include the dam and a town water supply of 750 ML per year. The Stanthorpe Town water supply pattern was applied as presented in **Table 7-16**.

- **Table 7-16 Stanthorpe Water Supply Pattern**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
% of Annual Demand	9.7	9.4	8.8	8.2	7.0	6.1	7.0	7.0	8.2	8.8	9.1	10.6	100
Monthly Demand (ML)	73	71	66	62	53	46	53	53	62	66	68	80	750

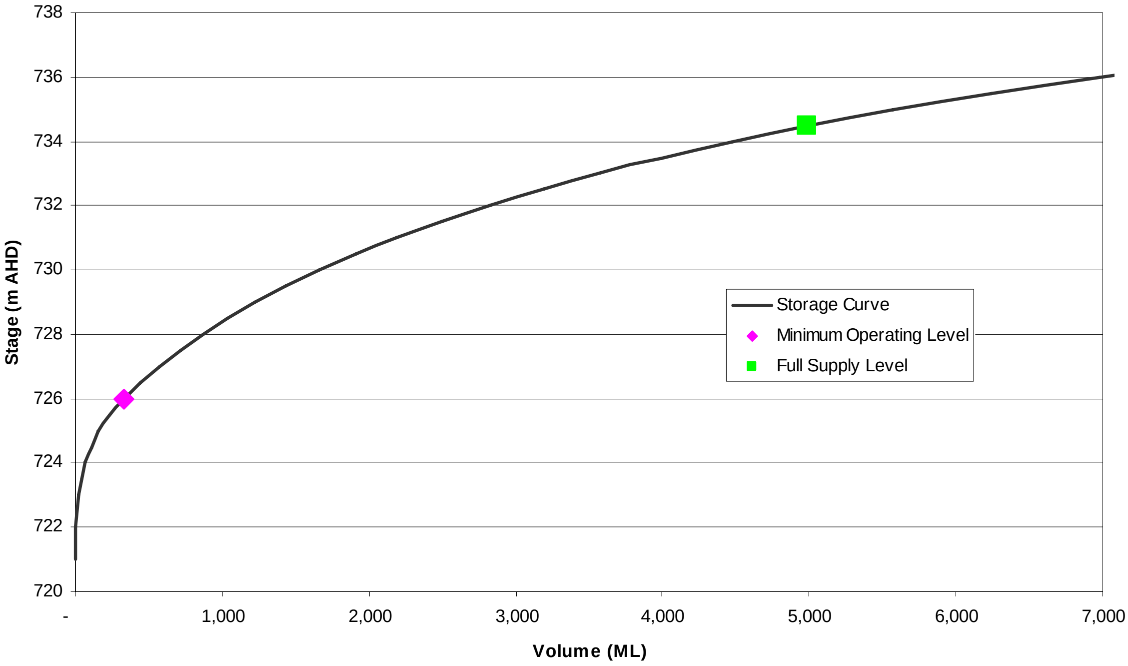
The adopted dam storage volume for the Urban Water Supply Dam is 5,000 ML. The storage characteristics of the dam used in the IQQM assessment are outlined in **Table 7-17**. The modelled storage curve for the Dam is presented in **Figure 7-17**.

Table 7-17 Dam Storage Characteristics (Urban Water Supply Dam)

	Emu Swamp Dam	Existing Storm King Dam
Full Storage Volume (ML)	5,000	2,180
Full Storage Level	734.5 (m AHD)	9.5 (m)
Minimum Operating Volume (ML)	330	200
Minimum Operating Level (m AHD)	726	N/A
Inundated Area at Full Supply Level (ha)	111	78
Bed Level (m AHD)	721	N/A
Catchment Area (km^2)	586	95
Stream	Severn River	Quart Pot Creek
AMTD (km)	264.0	300.7

Note: the minimum operating volume is the dead storage level

Figure 7-17 Dam Modelled Storage Curve (Urban Water Supply Dam)



Yield

Table 7-18 presents the predicted performance of the Dam using IQQM for the simulation period (1890 – 1996).

- **Table 7-18 Dam Performance (Urban Water Supply Dam)**

	Emu Swamp Dam
Licence Volume (ML/year)	1,500
Design Volume (ML/year)	750
Mean Annual Diversion (ML)	696
Monthly Reliability (%)	93
Annual Reliability (%)	89

The mean annual diversion for the Urban Water Supply Dam is predicted to be 696 ML at a monthly reliability of 93%. The dam performance is driven by the critical period which is the drought from 1909 to 1916. The majority of the Dam failures to deliver the annual allocation occurs in this period.

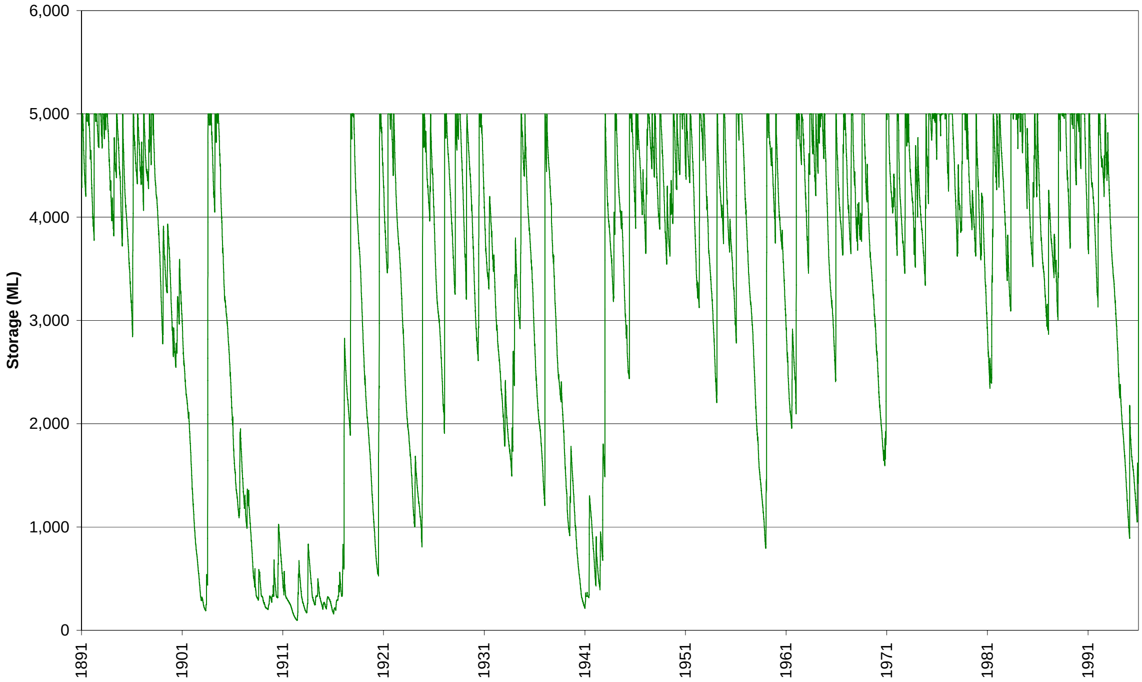
This is a full entitlement model and does not include any allowances for demand management. If the demand management methods are applied the Dam performance during droughts would be improved.

The nominal monthly reliability targets of other schemes are 95% for town water supply; the Dam has comparable water availability and reliability.

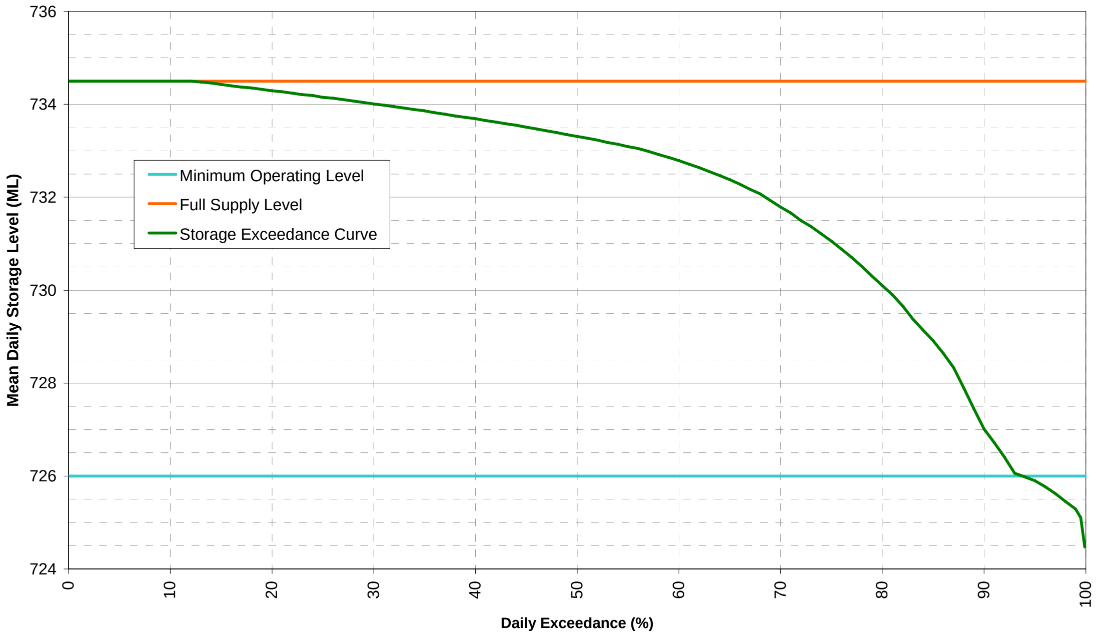
Dam Storage Behaviour

The response of the Dam storage has been assessed using the IQQM model including an annual allocation of 750 ML and is presented in **Figure 7-18**. **Figure 7-19** presents the modelled storage exceedance curve for the Dam with an annual allocation of 750 ML.

- **Figure 7-18 Dam Storage Behaviour (Urban Water Supply Dam)**



- **Figure 7-19 Dam Storage Level Behaviour (Urban Water Supply Dam)**



The exceedance curve shows the percentage of days during the simulation when the storage equals or exceeds a particular storage level. It can be seen that during the modelled simulation period (1890 – 1996), the Urban Water Supply Dam is above, at or near full capacity (i.e. less than 1 m below FSL) for 45% of the time. The dam is above 50% capacity for 72% of the time. The dam fails i.e. falls below the minimum operating level of 726 m AHD for about 7% of the time.

Spills

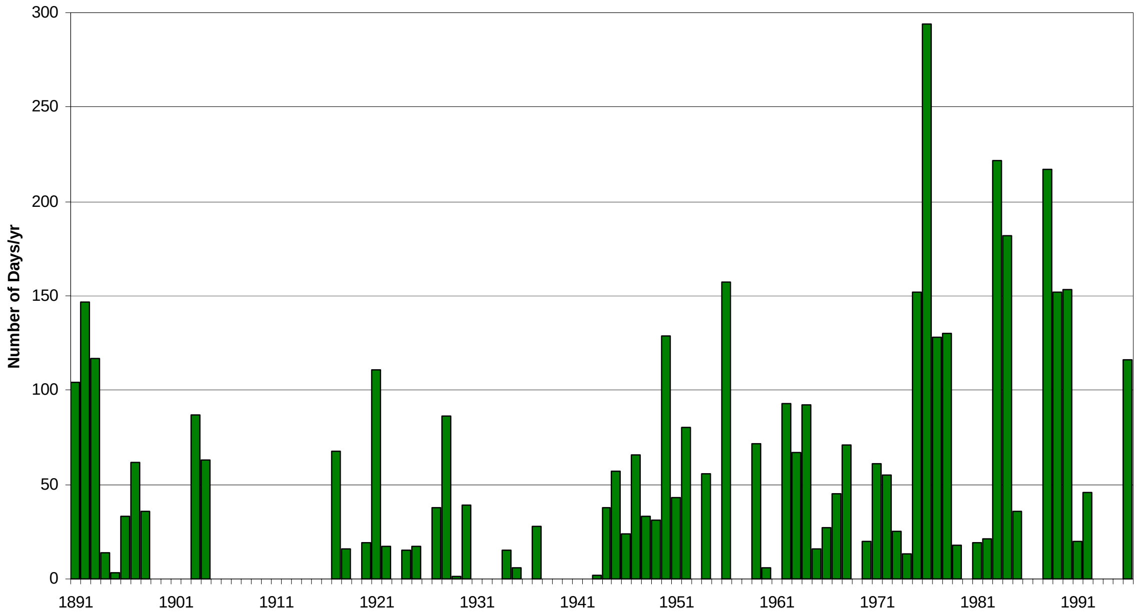
Table 7-19 presents the key spill statistics for the dam for the simulation period (1890 – 1996).

- **Table 7-19 Dam Spill Statistics (Urban Water Supply Dam)**

Spill Statistics		
Total no. of days of spill		4,427
Mean no. of days of spill per year		42
Total no. of years with spills		66
Mean period between spills	years	0.5
Longest period between spills	years	13.2

The assessment showed the dam spills on average 42 days per year and the average period between spills is 0.5 years. **Figure 7-20** shows the annual number of spill days in the simulation period.

- **Figure 7-20 Dam Annual Number of Spill Days (Urban Water Supply Dam)**



Initial Fill

The inflows into the Emu Swamp Dam were used to assess the predicted timing of the initial filling of the dam. The Emu Swamp Dam is proposed to have an environmental release strategy, as outlined in **Section 7.1.2.7**. It is assumed this strategy would be in place as soon as the Dam is constructed (i.e. during the initial filling). Therefore the total annual volume of inflows greater than 30 ML/day was calculated and is presented in **Figure 7-21**.

- **Figure 7-21 Total Annual Inflow to Dam (flows greater than 30 ML/day)**

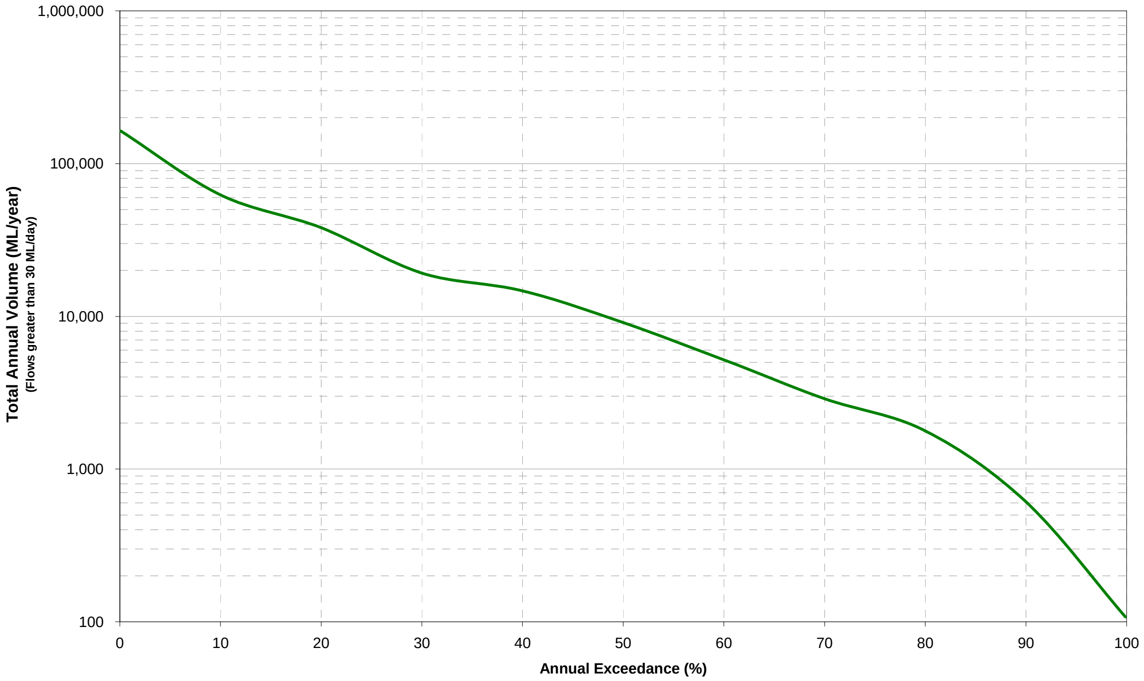


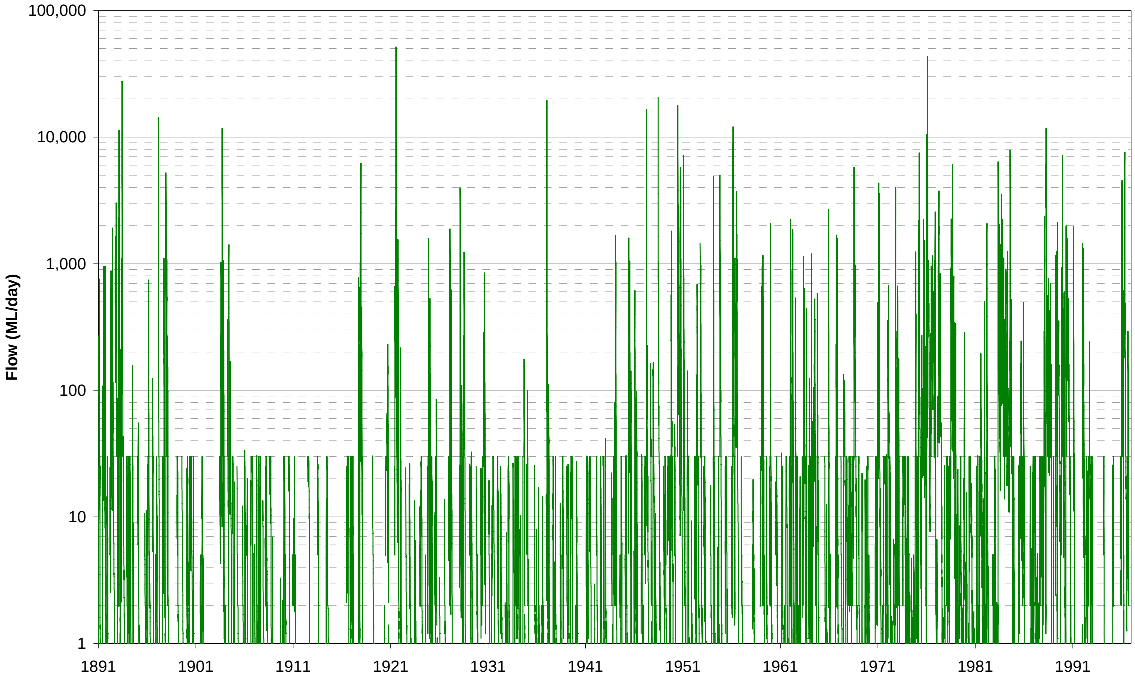
Figure 7-21 shows the median total annual volume inflow to the dam is approximately 10,000 ML.

This assessment shows there is a 50 – 60% probability of filling the dam in the first year while still maintaining the environmental release strategy as outlined **Section 7.1.2.7**.

7.1.2.7 Environmental Release Strategy

In order to meet the flow objectives set at Farnbro (Node J) an environmental release strategy is proposed for Emu Swamp Dam. The environmental release regime proposed is to pass flows up to 30 ML/day through the Dam. The IQQM model calculates the daily flow into the Dam. For inflows up to 30 ML/day the flow is released, for inflows greater than 30 ML/day only 30 ML/day is released. These releases are intended to provide environmental benefits and compensation flows for downstream water users. **Figure 7-22** shows the proposed environmental releases and spills for the Dam.

- **Figure 7-22 Dam Releases and Spills (Urban Water Supply Dam)**



7.1.2.8 Water Resources Development

The WASOs for the downstream water allocations are only able to be assessed using the final ROP IQQM model. The WASOs are not currently available as DNRW is currently finalising the WASOs to support the final ROP.

As discussed in **Section 7.1.2.7**, a release strategy has been proposed for the Dam. The majority of the water allocations downstream of the Dam have passing flow conditions of 0-25 ML/day before they can take water. The release strategy for the Dam releases all flows up to 30 ML/day from the Dam. This is designed to preserve the access to water for the existing water allocations.

A number of consultation sessions have been undertaken with DNRW including the supplying of the WASOs . DNRW has indicated their consideration of the WASOs with the Dam, subject to confirmation with the final ROP IQQM model.

7.1.2.9 Environmental Flow Objectives

The following tables present the EFO performance at Node J in two different manners. **Table 7-20** presents EFO performance predevelopment, existing entitlements and the Urban Water Supply Dam scenarios and presents a percentage change from existing entitlements to the urban water supply scenario. **Table 7-21** presents a percentage points change from existing entitlements to the urban water supply scenario relative to the predevelopment scenario. This method of assessment is presented as it is consistent with the DNRW assessment methodology.

- **Table 7-20 EFO Performance Indicators – Node J (Farnbro AMTD 198.6 km)**

Performance Indicators	Predevelopment	Existing Entitlements	Urban Water Supply Dam	
			Dam	% change from Existing Entitlements
Low Flow (days)	16,855	22,958	22,915	< 1
Summer Flow (days)	51	33	33	0
Beneficial Flooding Flow (ML)	34,623	22,561	20,457	-9
1 in 2 year Flood (ML)	4,608	2,651	2,276	-14

The EFO performance indicators show the Urban Water Supply Dam has no impact on the low flow days and the summer flow days. The Dam reduces the existing beneficial flooding flow by 9% and the 1 in 2 year flood by 14%.

- **Table 7-21 EFO Performance Indicators – Node J (Farnbro AMTD 198.6 km)**

Performance Indicators	% of Predevelopment		% points of Predevelopment Flow Change from Existing Entitlements
	Existing Entitlements	Urban Water Supply Dam	
Low Flow (days)	136	136	0
Summer Flow (days)	66	66	0
Beneficial Flooding Flow (ML)	65	59	-6
1 in 2 year Flood (ML)	58	49	-9

The EFO performance indicators show the Urban Water Supply Dam has no impact on the low flow days and the summer flow days. The Dam reduces the existing beneficial flooding flow by 6 percentage points and the 1 in 2 year flood by 9 percentage points relative to the predevelopment scenario.

The EFO targets are not currently available as DNRW is developing them for the final ROP. A number of consultation sessions have been undertaken with DNRW including the supplying of the above EFO performance indicators. DNRW have indicated their consideration of the EFO performance, subject to confirmation with the final ROP IQQM model.

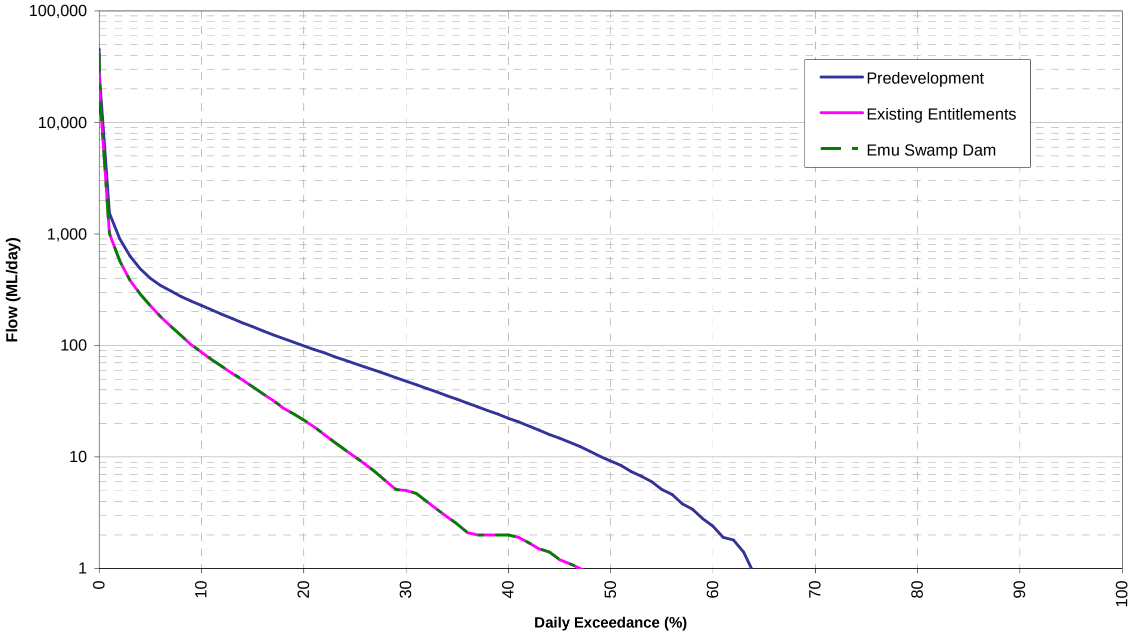
7.1.2.10 Flow Statistics

Flow statistics have been determined at a number of locations to characterise the flow regime of the Severn River. These flow statistics are not EFOs as part of the water planning process. However they illustrate the River's behaviour annually, monthly and seasonally in terms of both magnitude and variability.

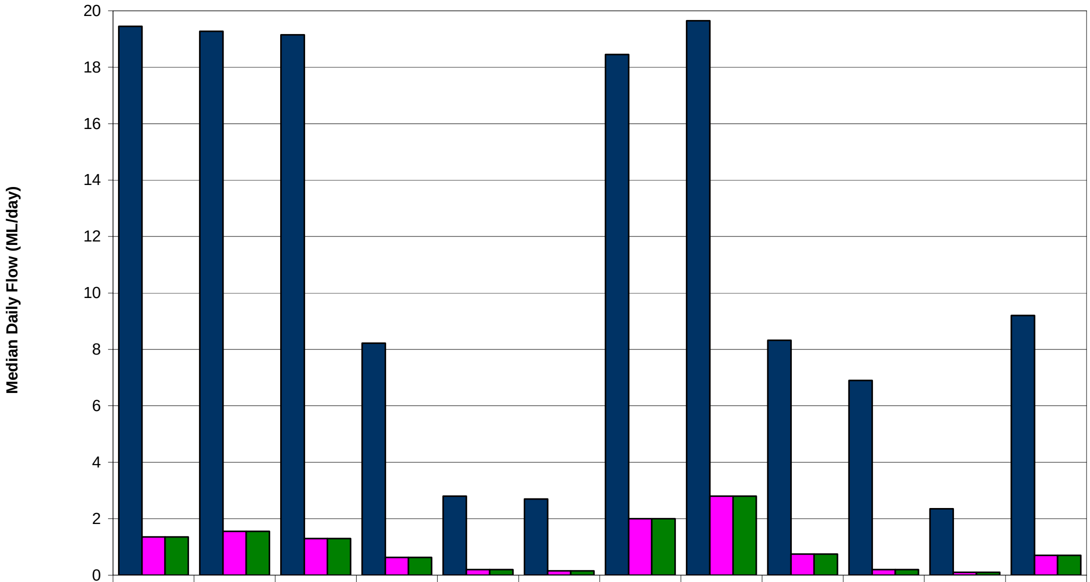
Upstream Flows

The Urban Supply Water Dam will have no impact on existing flows upstream of the inundation area. This is shown in the flow duration curve (**Figure 7-23**) and monthly median daily flows (**Figure 7-24**) presented for the node just upstream of the Dam.

- **Figure 7-23 Flow Duration Curve – Upstream of the Dam Site (AMTD 268 km)**



- **Figure 7-24 Monthly Median Daily Flows – Upstream of the Dam Site (AMTD 268 km)**



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
🟦 Predevelopment	19	19	19	8.2	2.8	2.7	18	20	8.3	6.9	2.4	9.2
🟪 Existing Entitlements	1.4	1.6	1.3	0.6	0.2	0.2	2.0	2.8	0.8	0.2	0.1	0.7
🟩 Emu Swamp Dam	1.4	1.6	1.3	0.6	0.2	0.2	2.0	2.8	0.8	0.2	0.1	0.7

Downstream Flows

The flows statistics for the mean annual flow (**Table 7-22**), flow duration curve and monthly median daily flow, for the predevelopment, existing entitlements and dam scenarios, have been presented at the following locations:

- Severn River at the Dam site – AMTD 264 km (**Figure 7-25** and **Figure 7-26**);
- Severn River immediately downstream of the confluence with Accommodation Creek – AMTD 252 km (**Figure 7-27** and **Figure 7-28**); and
- Dumaresq River at Farnbro – ATMD 198.6 km (**Figure 7-29** and **Figure 7-30**).

The flow statistics at Farnbro represent Node J in the Borders Rivers WRP and also the flows into the Sundown National Park.

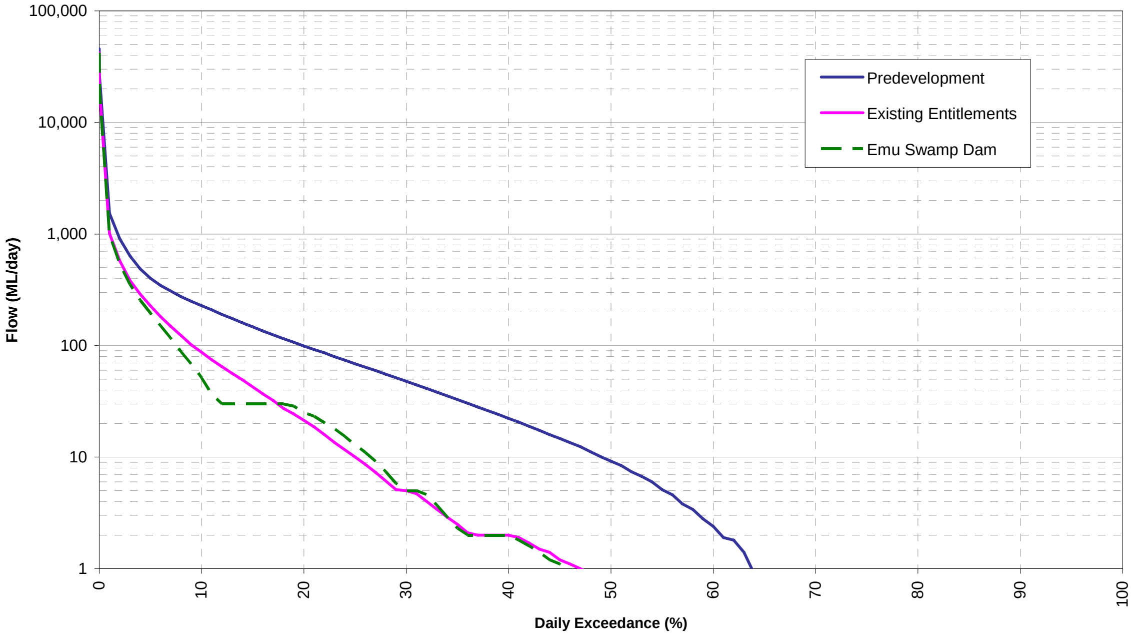
The presentation of the predevelopment, existing entitlements and dam scenarios highlights the incremental impact of the Dam as well as the overall change of the system from the predevelopment conditions.

- **Table 7-22 Comparison of Mean Annual Flows (Urban Water Supply Dam)**

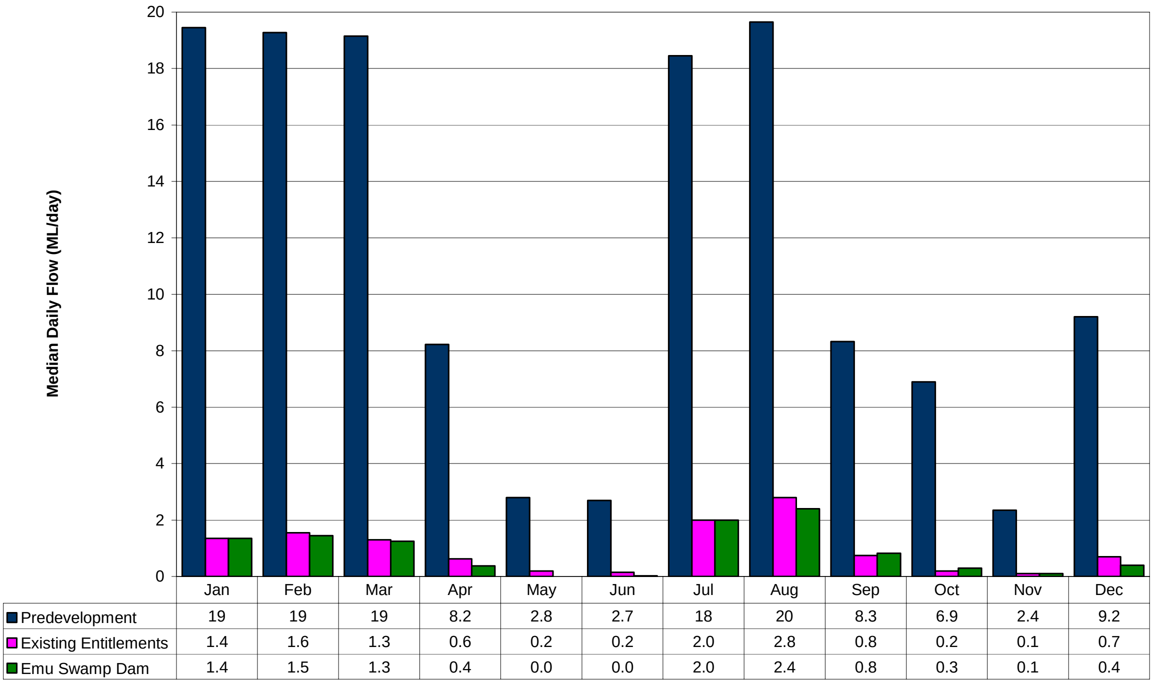
Location	Predevelopment Scenario	Existing Entitlements Scenario	Urban Water Supply Dam	
			Dam	% change from Existing Entitlements
Dam Site (AMTD 264 km)	38,600	21,600	19,500	-11
Downstream of confluence Accommodation Creek (AMTD 252 km)	55,600	34,900	33,200	-5
Farnbro (AMTD 198.6 km)	81,300	59,100	56,500	-5

There is significant reduction in the mean annual flows from the predevelopment to the existing entitlements scenario. The effect of the Dam is to reduce the existing entitlements scenario mean annual flows by 11% at the Dam site and by 5% downstream of Accommodation Creek.

- Figure 7-25 Flow Duration Curve – Downstream of the Dam Site (AMTD 264 km)

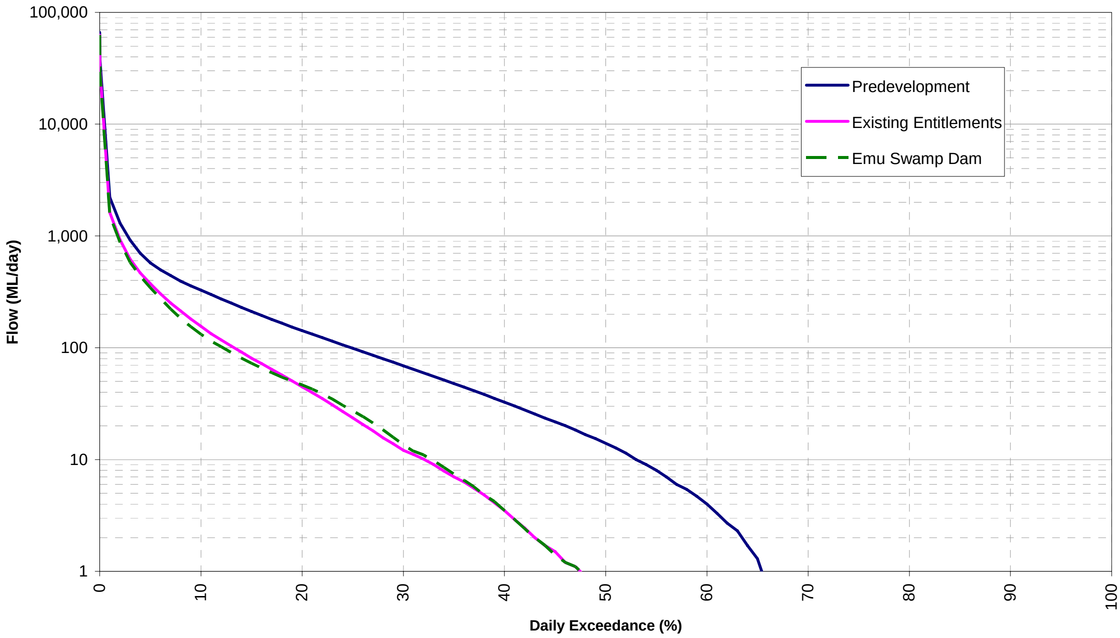


- Figure 7-26 Monthly Median Daily Flows – Downstream of the Dam Site (AMTD 264 km)

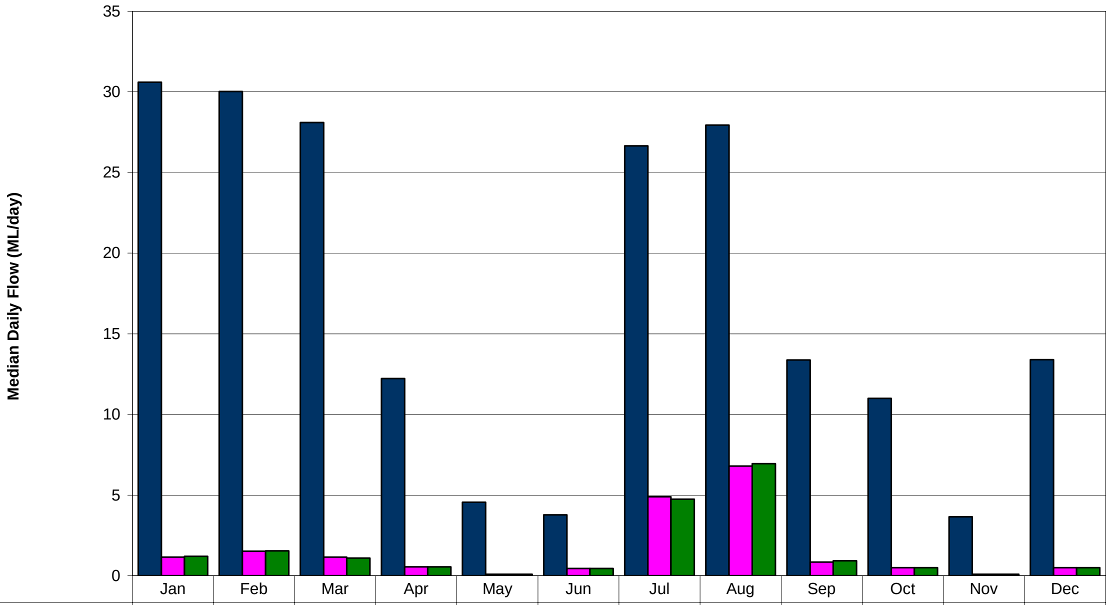


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Predevelopment	19	19	19	8.2	2.8	2.7	18	20	8.3	6.9	2.4	9.2
Existing Entitlements	1.4	1.6	1.3	0.6	0.2	0.2	2.0	2.8	0.8	0.2	0.1	0.7
Emu Swamp Dam	1.4	1.5	1.3	0.4	0.0	0.0	2.0	2.4	0.8	0.3	0.1	0.4

- Figure 7-27 Flow Duration Curve – Downstream of the Accommodation Creek Confluence (AMTD 252 km)

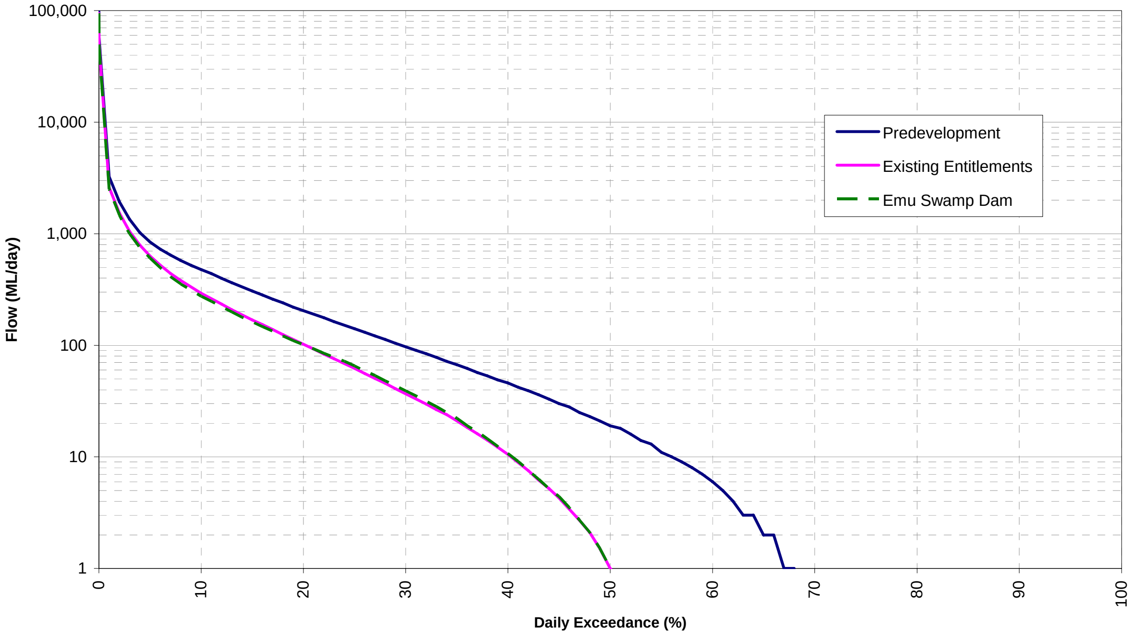


- Figure 7-28 Monthly Median Daily Flows – Downstream of the Accommodation Creek Confluence (AMTD 252 km)

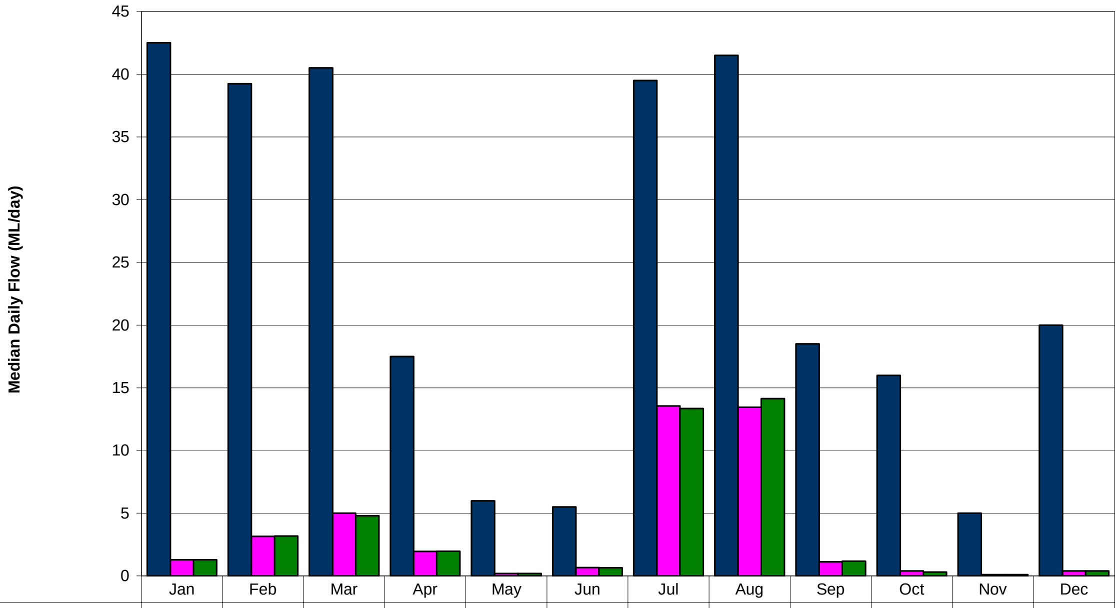


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
🟦 Predevelopment	31	30	28	12	4.6	3.8	27	28	13	11	3.7	13
🟪 Existing Entitlements	1.2	1.5	1.2	0.6	0.1	0.5	4.9	6.8	0.9	0.5	0.1	0.5
🟩 Emu Swamp Dam	1.2	1.6	1.1	0.6	0.1	0.5	4.8	7.0	0.9	0.5	0.1	0.5

- Figure 7-29 Flow Duration Curve – End of System Farnbro Node J (AMTD 198.6 km)



- Figure 7-30 Monthly Median Daily Flows – End of System Farnbro Node J (AMTD 198.6 km)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
■ Predevelopment	43	39	41	18	6.0	5.5	40	42	19	16	5.0	20
■ Existing Entitlements	1.3	3.2	5.0	2.0	0.2	0.7	14	13	1.1	0.4	0.1	0.4
■ Emu Swamp Dam	1.3	3.2	4.8	2.0	0.2	0.7	13	14	1.2	0.3	0.1	0.4

These flow statistics highlight the following characteristics of the flow regime of the Severn River:

- the Urban Water Supply Dam will have no impact on flow regime upstream of the proposed dam;
- impacts from the dam are localised to between the proposed dam and the confluence of Accommodation Creek;
- the dam has minimal impact on the flow regime downstream of Accommodation Creek; and

- the dam has negligible impact on the flow regime for Sundown National Park.

To mitigate the potential for the Urban Water Supply Dam to impact on flows an environmental release strategy is proposed for the dam. The environmental release regime proposed is to allow pass flows up to 30 ML/day through the dam. This release strategy means the frequent low flows and the infrequent high flows remain essentially unchanged from the existing entitlements scenario. However, the medium flows are impacted by the dam. These impacts of the dam are localised to the 12 km reach from the proposed dam to the confluence with Accommodation Creek. This reach is already highly impacted with five weirs and a number of irrigation water allocations.

There is a 5% change to the mean annual flow downstream of the confluence with Accommodation Creek. However, as shown in **Figure 7-27** and **Figure 7-28**, there is minimal change in the magnitude and variability of the flow regime from the existing entitlement scenario. The dam is will have minimal impact on existing entitlements scenario downstream of the Accommodation Creek.

There is a 5% change to the mean annual flow downstream of the Sundown National Park. However, as shown in **Figure 7-29** and **Figure 7-30**, there is negligible change in the magnitude and variability of the flow regime from the existing entitlement scenario. The dam is will have negligible impact on existing entitlements scenario Sundown National Park.

7.1.3 Impacts and Mitigation – Combined Urban and Irrigation Dam

This section describes the impacts upon the water resources of the Granite Belt catchment with the Combined Urban and Irrigation Dam with a volume of 10,500 ML (738 m AHD) and addresses the following aspects:

- construction;
- climatic extremes;
- flooding;
- pipelines;
- water resource planning
- yield assessment;
- environmental release strategy;
- water resource development;
- environmental flow objectives; and
- flow statistics.

7.1.3.1 Construction

Flows in the River will be maintained throughout construction. Construction of the RCC Wall will take place in several stages, as discussed in **Section 3**. Initially, the RCC Wall will be built on the right abutment side of the current channel. When this side is complete flows will be diverted through the completed outlet works.

The final stage of construction occurs once the section of the wall across the main channel is complete to existing river level.

Construction activities will be scheduled so that the impacts of flooding on construction will be minimised. If a flood occurs during construction, there is little risk of damage to the partially built RCC Wall. Even if the RCC Wall is overtopped the wall is unlikely to be damaged badly.

Water for construction will be drawn directly from the River under permit and treated on-site where necessary. Approximately 28 ML will be required during the construction period. Further detail on this and other permits required under the *Water Act 2000* for the construction period are identified in **Section 1** of the EIS. All construction water will be treated and reused on site for concrete batching and dust suppression.

All proposed drainage structures associated with the dam including those necessary for supporting facilities such as access roads will be designed to the appropriate design standards. All designs will incorporate an appropriate level of flood immunity, minimisation of impacts to upstream landholders and mitigation of the impacts of velocity and scour.

7.1.3.2 Climatic Extremes

The effect of predictable climatic extremes on River flows, and thus the availability of water, has been considered in the IQQM modelling. Modelling was undertaken for an historic sequence of 107 years from 1890 to 1996, which includes climatic extremes experienced during this time. This period includes historic droughts, such as the drought of 1909 to 1915 and large rainfall events such as the 1893 and 1976 floods.

Climatic extremes will also be considered in the design of the structural integrity of the embankment and spillway. These will be designed to meet the standards set out in the ANCOLD guidelines. The RCC Wall and spillway will be able to withstand overtopping by the Probable Maximum Flood (PMF), which is the most extreme flood that can be reasonably expected to occur at the proposed dam location.

7.1.3.3 Flooding

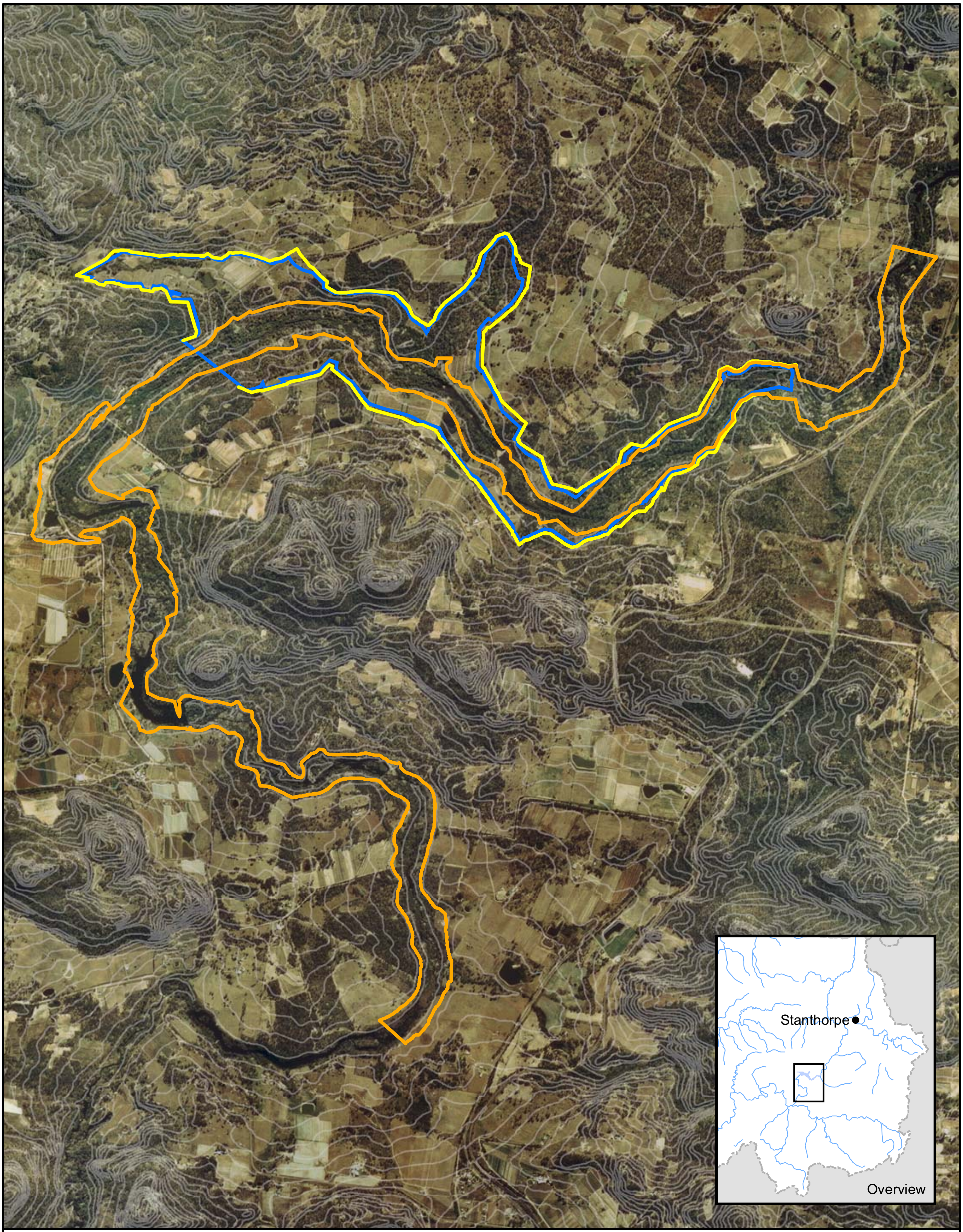
As part of the preliminary design process, a flood assessment was undertaken for the dam. This included hydrologic analysis and modelling of the catchment, as well as hydraulic modelling of the area surrounding the proposed dam location. The models are described in detail in **Section 7.1.1.4**.

Flood scenarios with and without the Combined Urban and Irrigation Dam were assessed for the 1 in 50 and 1 in 100 year ARI flood events.

For the Combined Urban and Irrigation Dam scenario, it was assumed the dam was initially at FSL to give a conservative scenario. The critical storm duration with and without the dam was 24 hours for all design events.

Backwater effects from the dam will cause some localised flooding impacts in the areas surrounding the inundation area. **Figure 7-31** and **Figure 7-32** and present the predicted inundation extent with and without the Combined Urban and Irrigation Dam for the 1 in 50 and 1 in 100 year ARI events, respectively.

Land will be acquired to the FSL (738 m AHD) and in addition to this a buffer area of approximately 200 m width will be established around the dam to maintain water quality and ecological connectivity. The buffer area is discussed in more detail in **Section 3** of the EIS.



SHIRE OF
STANTHORPE

Legend

Full Supply Level 738m AHD
50 yr ARI inundation no dam
50 yr ARI inundation with dam
5 metre contours

Kilometres
Scale -1:30,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Dam & Surrounds

Figure 7-31 Extent of Inundation in 1 in 50 Year ARI Event with and without the Combined Urban and Irrigation Dam

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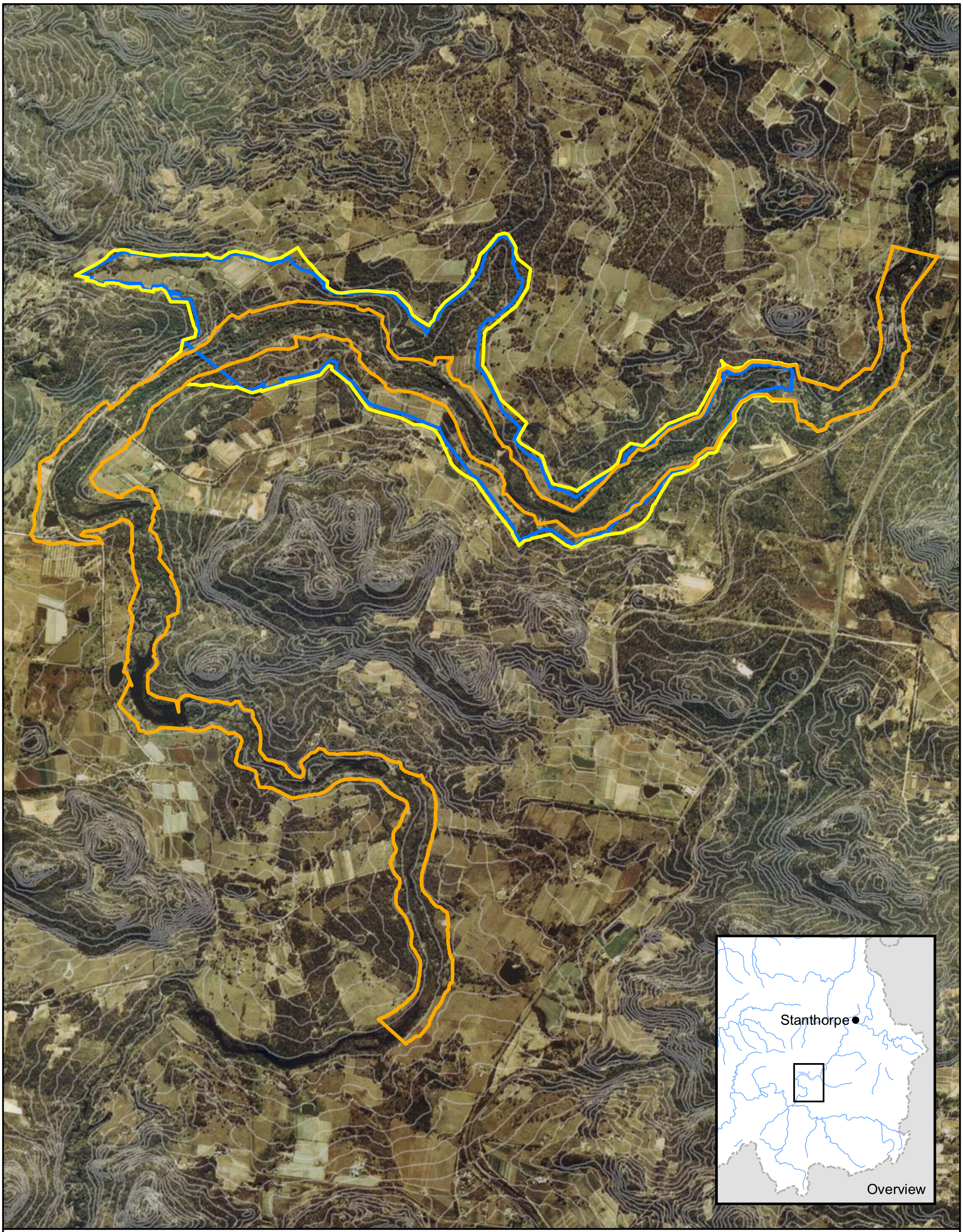

SHIRE OF
STANTHORPE

Legend

- ▭ Full Supply Level 738m AHD
- — 100 yr ARI inundation no dam
- — 100 yr ARI inundation with dam
- — 5 metre contours

N
W E
S

0 0.25 0.5 1
Kilometres
Scale -1:30,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Dam & Surrounds

Figure 7-32 Extent of Inundation in 1 in 100 Year ARI Event with and without the Combined Urban and Irrigation Dam

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Table 7-23 and **Table 7-24** present the peak flood levels with and without the Combined Urban and Irrigation Dam for the 1 in 50 year and 1 in 100 year ARI events respectively.

- **Table 7-23 Peak Flood Levels – 1 in 50 year ARI Event (Combined Urban and Irrigation Dam)**

Location (AMTD)	Description	Predicted Peak Water Level (m AHD)		Change in Peak Flood Level (m)
		Without Dam	With Dam	
269.8	5.8 km upstream of Dam Site	752.70	752.70	0.00
269.0	5.0 km upstream of Dam Site	744.44	744.44	0.00
268.5	4.5 km upstream of Dam Site (Extent of Buffer)	741.04	741.16	0.12
264.0	Just downstream of Dam Site	725.16	725.11	-0.05
262.0	2.0 km downstream of Dam Site	716.72	716.71	-0.01
260.5	3.5 km downstream of Dam Site (above Mungall Weir)	709.27	709.27	0.00
259.3	4.7 km downstream of Dam Site(above Booth Weir)	701.76	701.75	-0.01
257.0	7.0 km downstream of Dam Site	696.51	696.51	0.00

- **Table 7-24 Peak Flood Levels – 1 in 100 year ARI Event (Combined Urban and Irrigation Dam)**

Location (AMTD)	Description	Predicted Peak Water Level (m AHD)		Change in Peak Flood Level (m)
		Without Dam	With Dam	
269.8	5.8 km upstream of Dam Site	752.88	752.88	0.00
269.0	5.0 km upstream of Dam Site	744.75	744.76	0.01
268.5	4.5 km upstream of Dam Site (Extent of Buffer)	741.32	741.45	0.13
264.0	Just downstream of Dam Site	725.60	725.53	-0.07
262.0	2.0 km downstream of Dam Site	717.05	717.04	-0.01
260.5	3.5 km downstream of Dam Site (above Mungall Weir)	709.58	709.58	0.00
259.3	4.7 km downstream of Dam Site (above Booth Weir)	702.01	702.01	0.00
257.0	7.0 km downstream of Dam Site	696.81	696.81	0.00

The results of the flood assessment show there is some minor reduction in peak flood level downstream of the proposed dam location. As discussed above, land will protected around the dam to act as a buffer. The dam is predicted to increase flooding by approximately 0.1 m at the extent of the protected buffer (4.5 km upstream of the dam). This increase is very localised; within 500 m upstream of this location this impact is reduced to a negligible level.

Risk Assessment

The design flood capacity for the Emu Swamp Dam needs to comply with the *Guidelines on Selection of Acceptable Flood Capacity for Dams* (ANCOLD 2000a).

The selection of the design flood capacity uses a risk procedure that considers the population at risk and the severity of damage and loss (to services and business, to the society and to the environment) arising from a dam failure.

The ANCOLD guidelines allow a simple risk assessment approach to be used to select the Acceptable Flood Capacity.

The *Guidelines for Assessment of The Consequences of Dam Failure* (ANCOLD 2000b) provide a simple methodology for assessing Severity of Damages and Loss. Using this approach the severity of failure for the Combined Urban and Irrigation Dam) can be taken as "Major" – the "Major" severity rating is considered possible due to the potential political implications, loss of services, dislocation of businesses and environmental impact.

There are two downstream buildings with potential PAR. The total population at risk is less than 10 but probably greater than 1.

For a PAR of 1 to 10 persons and a "Major" Severity of Damage and Loss rating the Hazard Category is "High C".

For a "High C" Incremental Flood Hazard Category (IFHC) rating the risk assessment process assigns an upper limit Flood AEP in the range of:

- 10,000 year ARI to PMPDF, or
- 100,000 year ARI (with the lesser value to apply).

For the Emu Swamp site the PMF is 7,900 m^3/s, the PMPDF is 7,140 m $^3/s$ and the 100,000 year ARI is 3,460 m^3/s.

For the 100,000 year ARI, event ANCOLD (2000a) allows a joint probability assessment to be made for the reservoir level (prior to the flood event).

For the Combined Urban and Irrigation Dam a conservative approach has been taken and a full reservoir has been adopted for all flood events.

Comparison of the downstream effects of PMF and 100,000 year ARI Dam failure events for the Combined Urban and Irrigation Dam (FSL at 738 m AHD) is presented **Table 7-25**. The estimated building floor levels are 712 m AHD at PAR1 and 702 m AHD at PAR2.

Table 7-25 Comparison of Inundation at PAR Sites (Combined Urban and Irrigation Dam)

Flood Event	Peak Flood Level at PAR1 (m AHD)	Potential Inundation (m)	Peak Flood Level at PAR2 (m AHD)	Potential Inundation (m)
100,000ARI – existing	704.8	Nil	700.2	Nil
100,000ARI – developed (no breach)	704.8	Nil	700.2	Nil
100,000ARI – developed (breach)	707.2	Nil	702.3	0.3
PMF – existing	708.0	Nil	703.1	1.1
PMF – developed (no breach)	708.0	Nil	703.1	1.1
PMF – developed (breach)	708.0	Nil	703.1	1.1
Sunny Day Failure	703.8	Nil	698.9	Nil

There is no inundation potential at PAR1 therefore it can be concluded that the population at risk at PAR1 is nil for both 1 in 100,000 year ARI and PMF events.

The 1 in 100,000 year ARI event (existing and developed no breach) has no inundation potential. The 1 in 100,000 year ARI event (developed breach) has a potential inundation of 0.3 m.

For the PMF – existing (no dam) event the PAR2 site is inundated to a depth of 1.1 m. For the PMF – developed (no breach and breach) event there is no incremental increase in inundation depth.

It is considered that 100,000 year ARI event should be adopted as the Acceptable Flood Capacity for the dam.

7.1.3.4 Pipelines

The Urban and Irrigation Pipeline to supply water from the dam to Mt Marlay water treatment plant and irrigators is approximately 125 km long and is to be constructed primarily in road reserves as shown in **Figure 3-5**. There are seven significant creek crossings in the pipeline route:

- Horan’s Gorge;
- Back Creek;
- Quart Pot Creek;
- Kettle Swamp Creek;
- Cannon Creek;
- The Broadwater; and
- Ten Mile Creek.

A riverine protection permit will be obtained from DNRW for the pipeline to cross these creeks. Three construction methods maybe employed at the crossing depending on the site:

- attach to an existing structure;
- directional drilling; and
- cut and cover trenching with erosion protection.

The design of the creek crossings employing the methods outlined above will result in no impacts to the hydraulic capacity of the waterway.

7.1.3.5 Water Resource Planning

Water Resource Plan

The Border River WRP preserves existing water entitlements within the plan area as well as makes the following provision for strategic reserve within the Stanthorpe Shire:

- town water supply – 1,500 ML (average annual volume); and
- irrigation and associated industry – 3,500 ML (average annual volume).

Resource Operations Plan

The Border Rivers draft ROP, released in January 2007, outlines the provision for unallocated water as outlined above for town water supply and for irrigation and associated industry. The Explanation Notes for the draft ROP, Chapter 2, provide a breakdown of the maximum volumes of unallocated water available in each subcatchment, expressed as a long term average annual take. The total long term average annual unallocated water for irrigation available for subcatchments above the Combined Urban and Irrigation Dam is 1,740 ML.

7.1.3.6 Yield Assessment

Although SSC perceives future need for an annual allocation of 1,500 ML, affordability considerations have led to Council pursuing an initial stage capacity of 750 ML/year. An annual allocation for 1,740 ML has been adopted for irrigation.

The existing entitlements IQQM model was modified to include the dam, a town water supply annual allocation of 750 ML and an annual allocation of 1,740 ML for irrigation.

The Stanthorpe Town water supply pattern was applied as presented in **Table 7-26**.

Table 7-26 Stanthorpe Water Supply Pattern

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
% of Annual Demand	9.7	9.4	8.8	8.2	7.0	6.1	7.0	7.0	8.2	8.8	9.1	10.6	100
Monthly Demand (ML)	73	71	66	62	53	46	53	53	62	66	68	80	750

The irrigation supply pattern calculated in the IQQM model from a number of parameters including:

- pump capacity;
- crop types; and
- rainfall and evaporation.

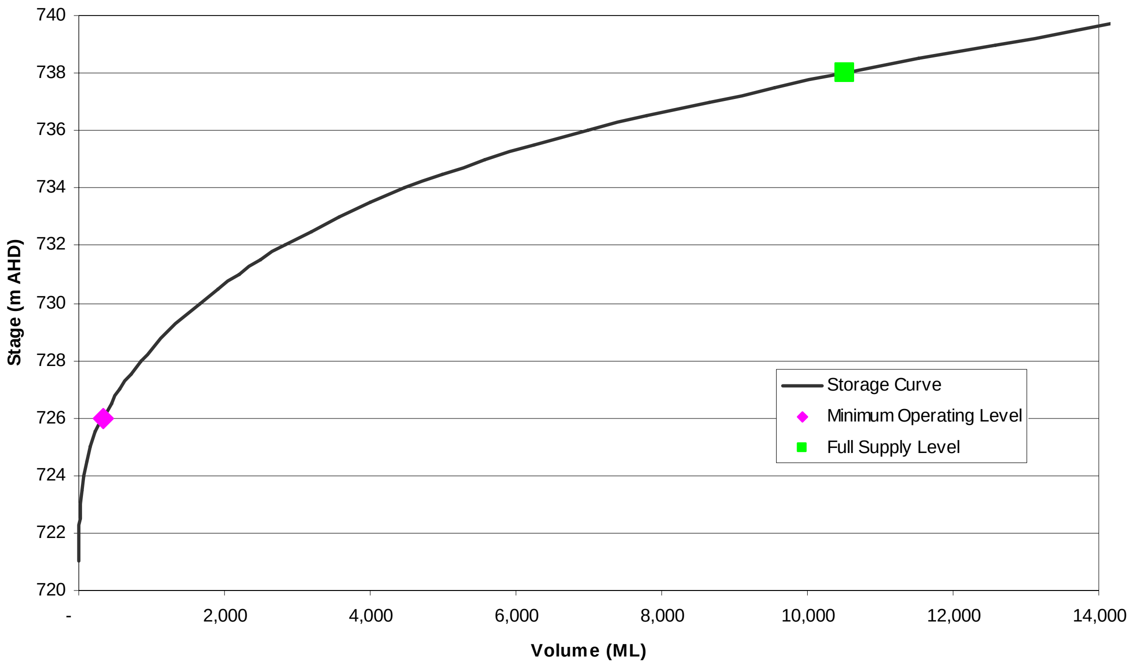
The adopted storage volume for the Combined Urban and Irrigation Dam is 10,500 ML. The storage characteristics of the dam used in the IQQM assessment are outlined in **Table 7-27**. The modelled storage curve for the dam is presented in **Figure 7-33**.

Table 7-27 Dam Storage Characteristics (Combined Urban and Irrigation Dam)

	Emu Swamp Dam	Existing Storm King Dam
Full Storage Volume (ML)	10,500	2,180
Full Storage Level	738.0 (m AHD)	9.5 (m)
Minimum Operating Volume (ML)	330	200
Minimum Operating Level (m AHD)	726	N/A
Inundated Area at Fully Supply Level (ha)	196	78
Bed Level (m AHD)	721	N/A
Catchment Area (km^2)	586	95
Stream	Severn River	Quart Pot Creek
AMTD (km)	264.0	300.7

Note: the minimum operating volume is the dead storage level

- **Figure 7-33 Dam Modelled Storage Curve (Combined Urban and Irrigation Dam)**



Yield

Table 7-18 presents the predicted performance of the dam using IQQM for the simulation period (1890-1996).

- **Table 7-28 Dam Performance (Combined Urban and Irrigation Dam)**

Characteristic	Town Water Supply	Irrigation Water Supply
Licence Volume (ML/year)	1,500	1,740
Design Volume (ML/year)	750	1,740
Mean Annual Diversion (ML)	698	1,302
Monthly Reliability (%)	93	75
Annual Reliability (%)	90	67

The mean annual diversion for the urban component of Combined Urban and Irrigation Dam is predicted to be 698 ML at a monthly reliability of 93%. The dam performance is driven by the critical period which is the drought from 1909 to 1916. The majority of the dam's failure to deliver the annual allocation occurs in this period.

This is a full entitlement model and does not include any allowances for demand management. If the demand management methods are applied the dam performance during droughts would be improved.

The nominal monthly reliability targets of other schemes are 95% for town water supply; the dam has comparable water availability and reliability.

The mean annual diversion for the irrigation component of the Combined Urban and Irrigation Dam is predicted to be 1,302 ML at a monthly reliability of 75%.

Dam Storage Behaviour

The response of the Dam storage has been assessed using the IQQM model, including an annual allocations of 750 ML and 1,740 ML for town and irrigation water supplies respectively, and is presented in **Figure 7-34**.

- **Figure 7-34 Dam Storage Behaviour (Combined Urban and Irrigation Dam)**

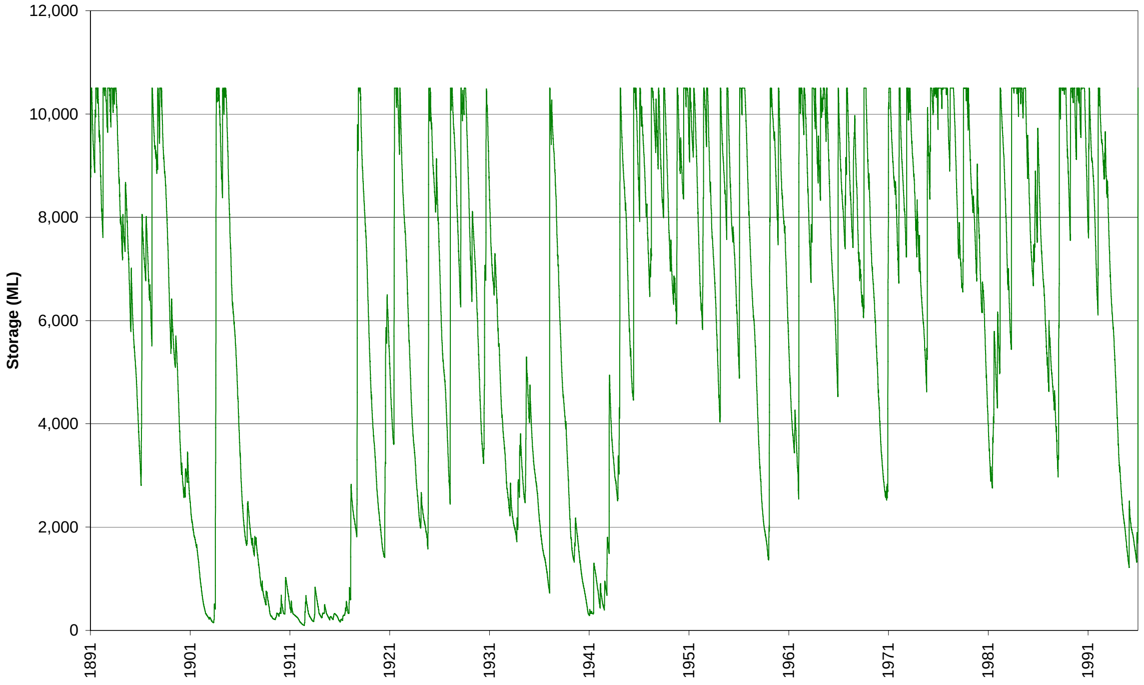
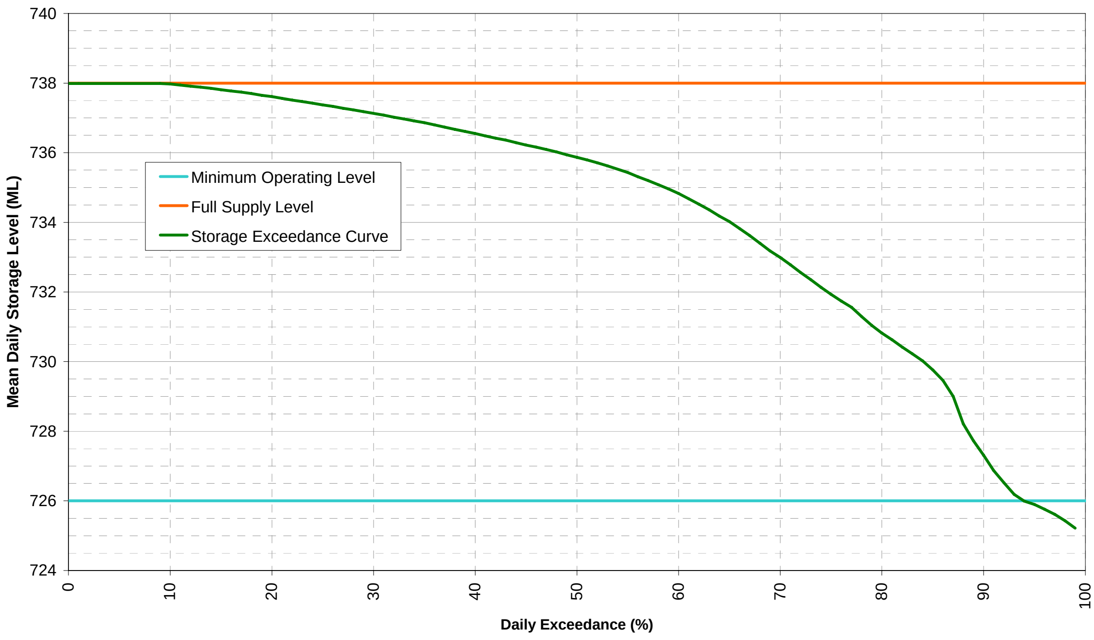


Figure 7-35 presents the modelled storage exceedance curve for the Combined Urban and Irrigation Dam with annual allocations of 750 ML and 1,740 ML for urban and irrigation water supplies respectively.

- **Figure 7-35 Dam Storage Level Behaviour (Combined Urban and Irrigation Dam)**



The exceedance curve shows the percentage of days during the simulation when the storage equals or exceeds a particular storage level. It can be seen that during the modelled simulation period (1890 – 1996) the dam is above, at, or near full capacity (i.e. less than 1 m below the FSL) for 32% of the time. The dam is above 50% capacity for 62% of the time. The dam fails i.e. falls below the minimum operating level of 726 m AHD for about 6% of the time.

Spills

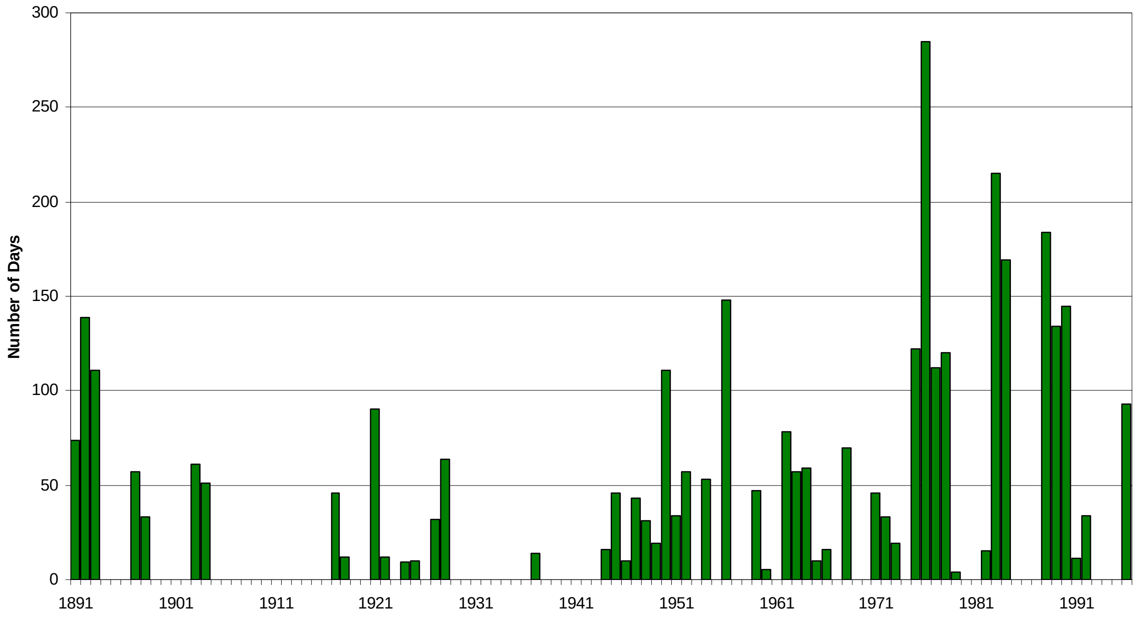
Table 7-29 presents the key spill statistics for the Combined Urban and Irrigation Dam for the simulation period (1890 – 1996).

- **Table 7-29 Dam Spill Statistics (Combined Urban and Irrigation Dam)**

Spill Statistics		
Total no. of days of spill		3,466
Mean no. of days of spill per year		33
Total no. of years with spills		52
Mean period between spills	(years)	0.6
Longest period between spills	(years)	13.3

The assessment showed the dam spills on average 33 days per year and the average period between spills is 0.6 years. **Figure 7-36** shows the annual number of spill days in the simulation period.

- **Figure 7-36 Dam Annual Number of Spill Days (Combined Urban and Irrigation Dam)**



Initial Fill

The inflows into the dam were used to assess the predicted timing of the initial filling of the dam. The Combined Urban and Irrigation Dam is proposed to have an environmental release strategy, as outlined in **Section 7.1.3.7**, it is assumed this strategy would be in place as soon as the dam is constructed (i.e. during the initial filling). Therefore the total annual volume of inflows greater than 30 ML/day was calculated and is presented in **Figure 7-37**.

- Figure 7-37 Total Annual Inflow to Dam (flows greater than 30 ML/day)

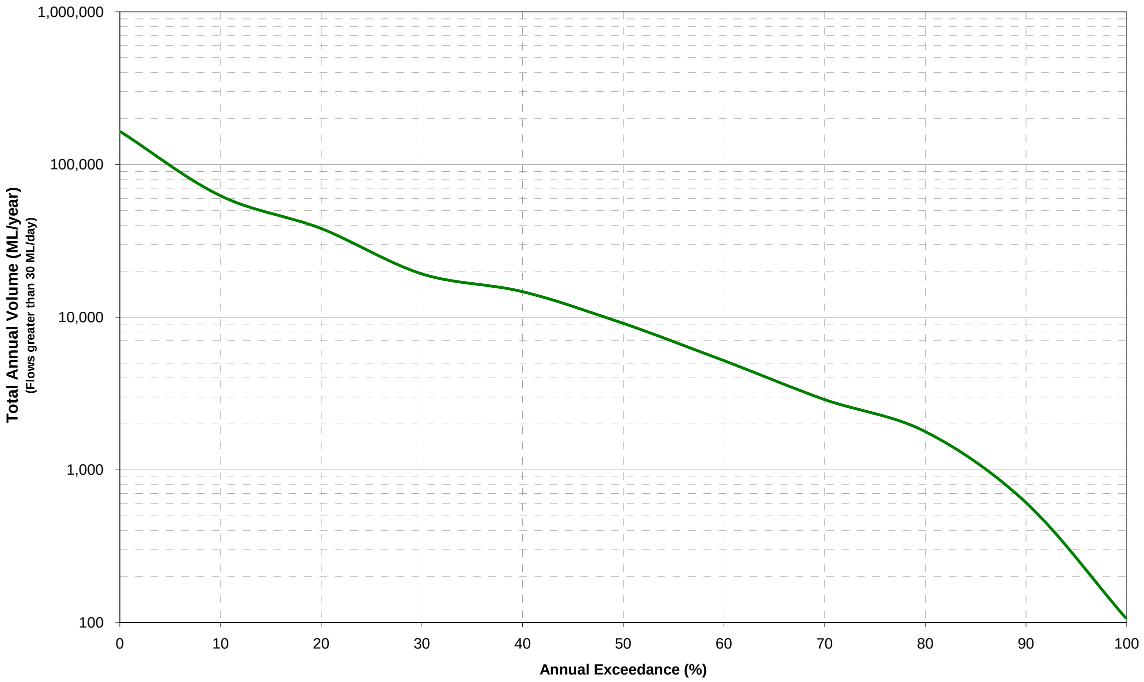


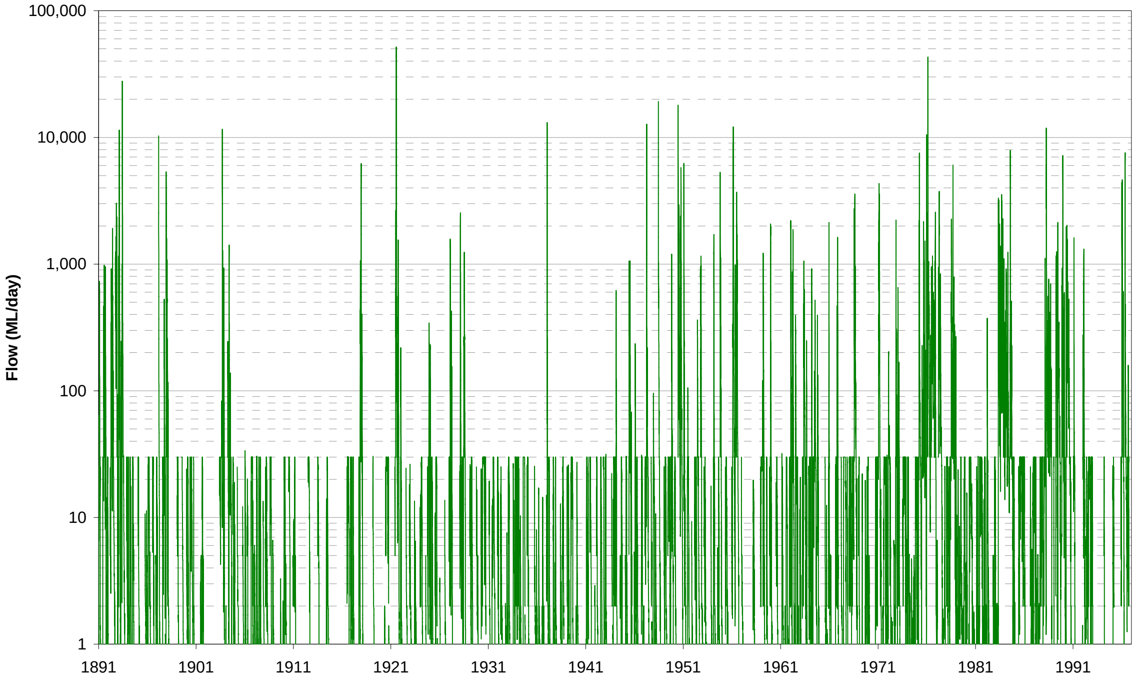
Figure 7-37 shows the median total annual volume inflow to the dam is approximately 10,000 ML.

This assessment shows there is a 40 – 45% probability of filling the Combined Urban and Irrigation Dam in the first year while still maintaining the environmental release strategy as outlined in the following section.

7.1.3.7 Environmental Release Strategy

In order to meet the flow objectives set at Farnbro (Node J) an environmental release strategy is proposed at the Combined Urban and Irrigation Dam. The environmental release regime proposed is to pass flows up to 30 ML/day through the Dam. The IQQM model calculates the daily flow into the dam. For inflows up to 30 ML/day the flow is released, for inflows greater than 30 ML/day only 30 ML/day is released. These releases are intended to provide environmental benefits and compensation flows for downstream water users. **Figure 7-38** shows the environmental releases and spills for the dam.

- **Figure 7-38 Dam Releases and Spills (Combined Urban and Irrigation Dam)**



7.1.3.8 Water Resources Development

The WASOs for the downstream water allocations are only able to be assessed using the final ROP IQQM model. The WASOs are not currently available as DNRW is currently finalising the WASOs to support the final ROP.

As discussed in **Section 7.1.3.7**, a release strategy has been proposed for the Combined Urban and Irrigation Dam. The majority of the water allocations downstream of the dam have passing flow conditions of 0-25 ML/day before they can take water. The release strategy for the dam releases all flows up to 30 ML/day from the dam. This is designed to preserve the access to water for the existing water allocations.

A number of consultation sessions have been undertaken with DNRW including the supplying of the WASOs. DNRW has indicated their consideration of the WASOs with the dam, subject to confirmation with the final ROP IQQM model.

7.1.3.9 Environmental Flow Objectives

The following tables present the EFO performance at Node J in two different manners. **Table 7-30 presents** EFO performance predevelopment, existing entitlements and the Combined Urban and Irrigation Dam scenarios and presents a percentage change from existing entitlements to the urban water supply scenario. **Table 7-31** presents a percentage points change from existing entitlements to the urban water supply scenario relative to the predevelopment scenario. This method of assessment is presented as it is consistent with the DNRW assessment methodology.

- **Table 7-30 EFO Performance Indicators – Node J (Farnbro AMTD 198.6 km)**

Performance Indicators	Predevelopment	Existing Entitlements	Combined Urban and Irrigation Dam	
			Dam	% change from Existing Entitlements
Low Flow (days)	16,855	22,958	22,915	< 1
Summer Flow (days)	51	33	33	0
Beneficial Flooding Flow (ML)	34,623	22,561	18,397	-18
1 in 2 year Flood (ML)	4,608	2,651	2,073	-22

The EFO performance indicators show the Combined Urban and Irrigation Dam has no impact on the low flow days and the summer flow days. The Dam reduces the existing beneficial flooding flow by 18% and the 1 in 2 year flood by 22%.

- **Table 7-31 EFO Performance Indicators – Node J (Farnbro AMTD 198.6 km)**

Performance Indicators	% of Predevelopment		% points of Predevelopment Flow Change from Existing Entitlements
	Existing Entitlements	Urban Water Supply Dam	
Low Flow (days)	136	136	0
Summer Flow (days)	66	66	0
Beneficial Flooding Flow (ML)	65	53	-12
1 in 2 year Flood (ML)	58	45	-13

The EFO performance indicators show the Combined Urban and Irrigation Dam has no impact on the low flow days and the summer flow days. The Dam reduces the existing beneficial flooding flow by 12 percentage points and the 1 in 2 year flood by 13 percentage points relative to the predevelopment scenario.

The EFO targets are not currently available as DNRW is developing them for the final Border River ROP. A number of consultation sessions have been undertaken with DNRW including the supplying of the above EFO performance indicators. DNRW have indicated their consideration of the EFO performance, subject to confirmation with the final ROP IQQM model.

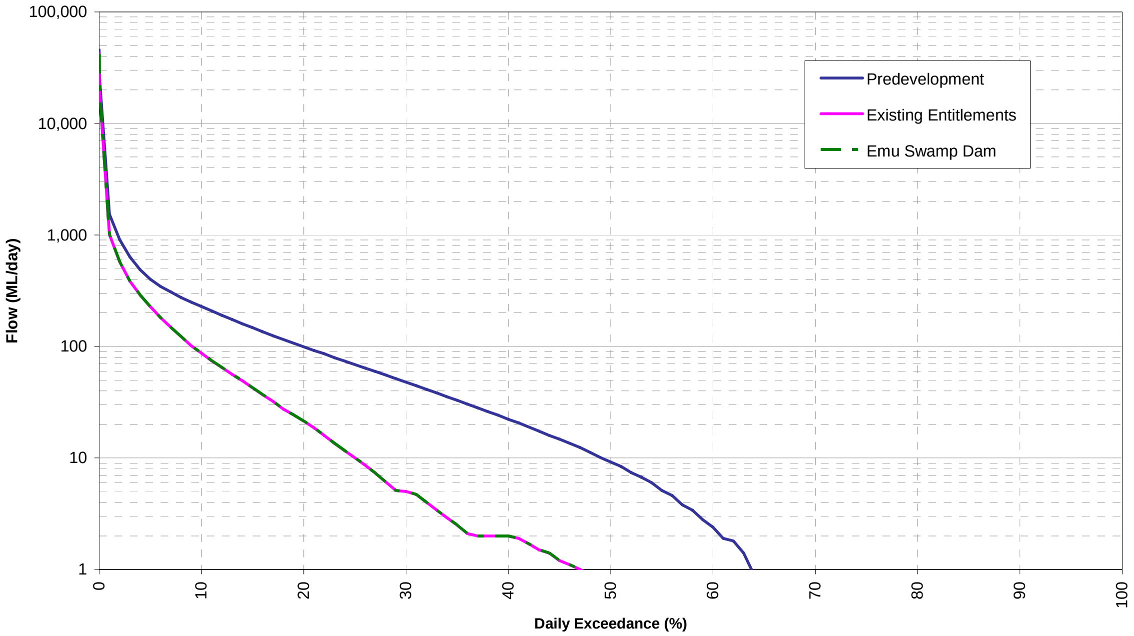
7.1.3.10 Flow Statistics

Flow statistics have been determined at a number of locations to characterise the flow regime of the Severn River. These flow statistics are not EFOs as part of the water planning process. However they illustrate the Severn River's behaviour annually, monthly and seasonally in terms of both magnitude and variability.

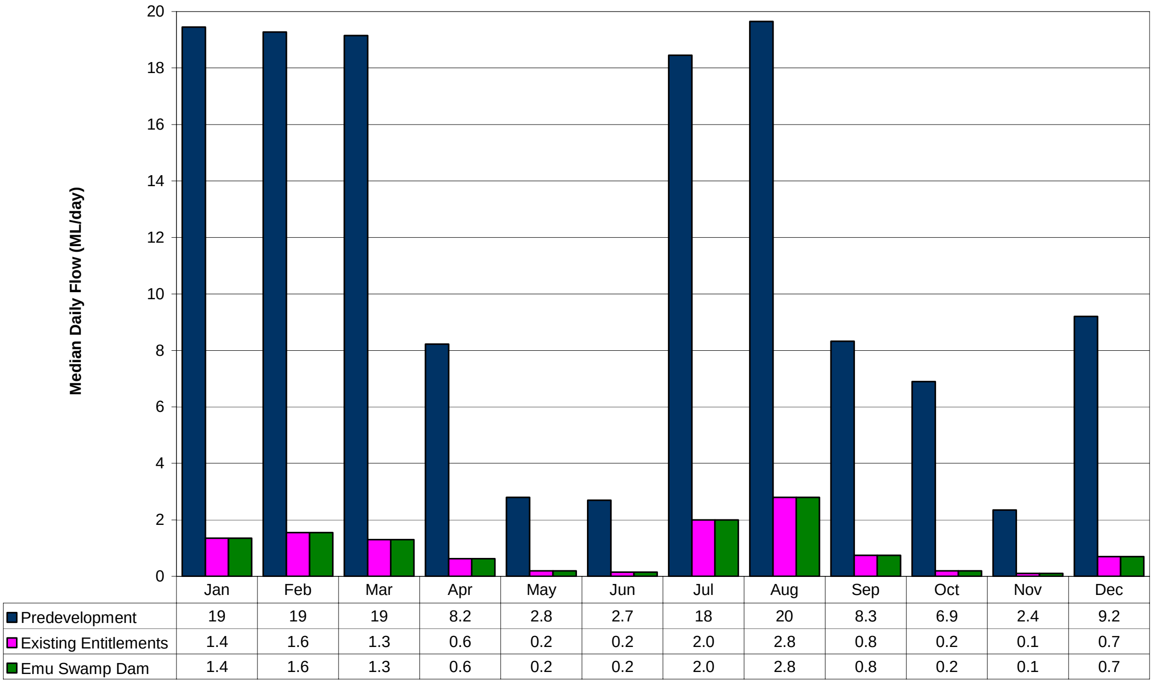
Upstream Flows

The dam will have not impact on existing flows upstream of the inundation area. This is shown in the flow duration curve (**Figure 7-39**) and monthly median daily flows (**Figure 7-40**) presented for the node just upstream of the dam.

- **Figure 7-39 Flow Duration Curve – Upstream of the Dam Site (AMTD 268 km)**



- **Figure 7-40 Monthly Median Daily Flows – Upstream of the Dam Site (AMTD 268 km)**



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
🟦 Predevelopment	19	19	19	8.2	2.8	2.7	18	20	8.3	6.9	2.4	9.2
🟪 Existing Entitlements	1.4	1.6	1.3	0.6	0.2	0.2	2.0	2.8	0.8	0.2	0.1	0.7
🟩 Emu Swamp Dam	1.4	1.6	1.3	0.6	0.2	0.2	2.0	2.8	0.8	0.2	0.1	0.7

Downstream Flows

The flows statistics for the mean annual flow (**Table 7-32**), flow duration curve and monthly median daily flow, for the predevelopment, existing entitlements and Combined Urban and Irrigation Dam scenarios, have been presented at the following locations:

- Severn River at the dam site – AMTD 264 km (

Figure 7-41 and **Figure 7-42**);

- Severn River immediately downstream of the confluence with Accommodation Creek – AMTD 252 km (**Figure 7-43** and **Figure 7-44**); and
- Dumaresq River at Farnbro – ATMD 198.6 km (**Figure 7-45** and **Figure 7-46**).

The flow statistics at Farnbro represent Node J in the Borders Rivers WRP and also the flows into the Sundown National Park.

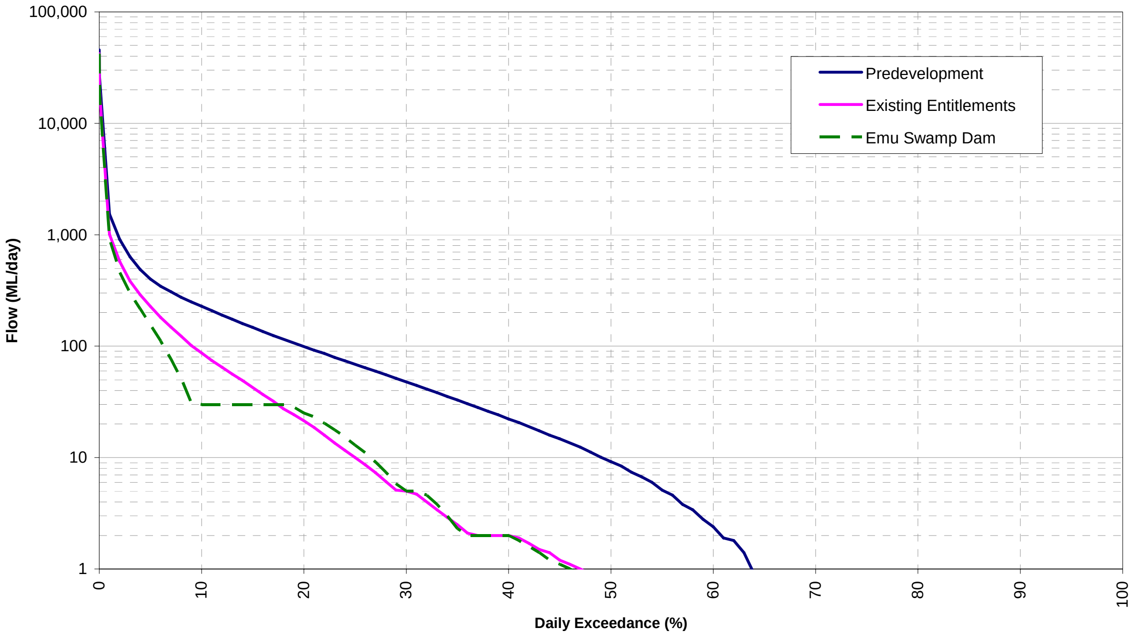
The presentation of the predevelopment, existing entitlements and Combined Urban and Irrigation Dam scenarios highlights the incremental impact of the dam as well as the overall change of the system from the predevelopment conditions.

- **Table 7-32 Comparison of Mean Annual Flows (Combined Urban and Irrigation Dam)**

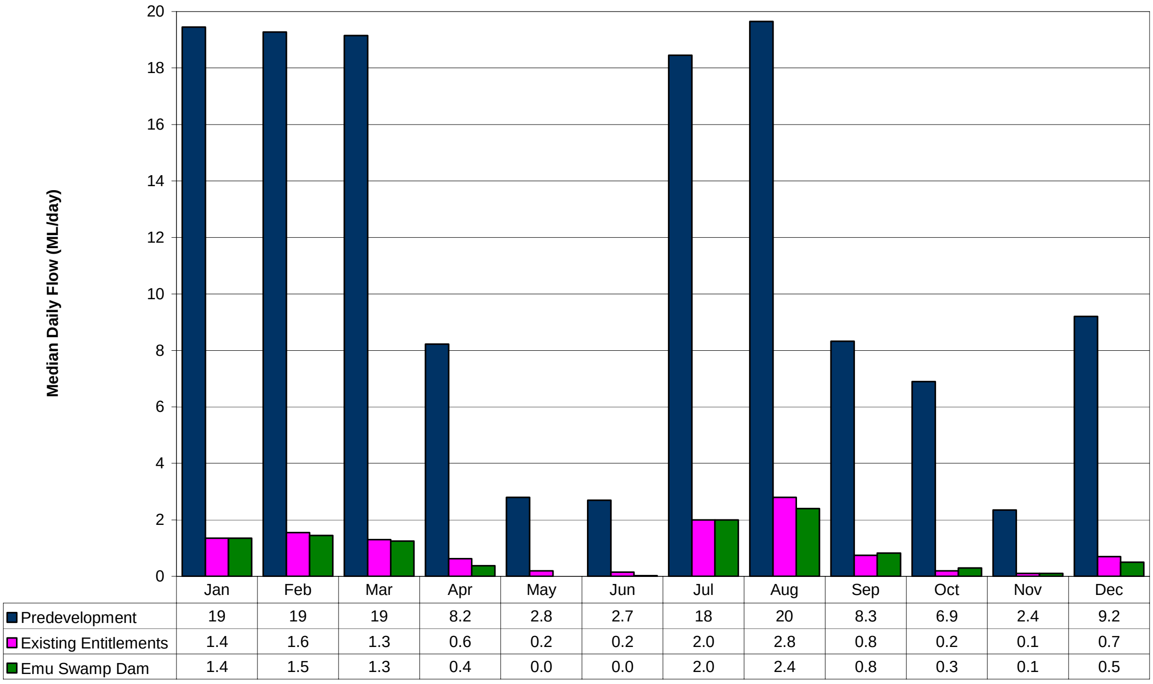
Location	Predevelopment Scenario	Existing Entitlements Scenario	Combined Urban and Irrigation Dam	
			Dam	% change from Existing Entitlements
Dam Site (AMTD 264 km)	38,600	21,600	17,600	-23
Downstream of confluence Accommodation Creek (AMTD 252 km)	55,600	34,900	31,300	-12
Farnbro (AMTD 198.6 km)	81,300	59,100	55,400	-7

There is significant reduction in the mean annual flows from the predevelopment to the existing entitlements scenario. The effect of the dam is to reduce the existing entitlements scenario mean annual flows by 23% at the proposed dam location and by 12% downstream of Accommodation Creek.

- **Figure 7-41 Flow Duration Curve – Downstream of the Dam Site (AMTD 264 km)**

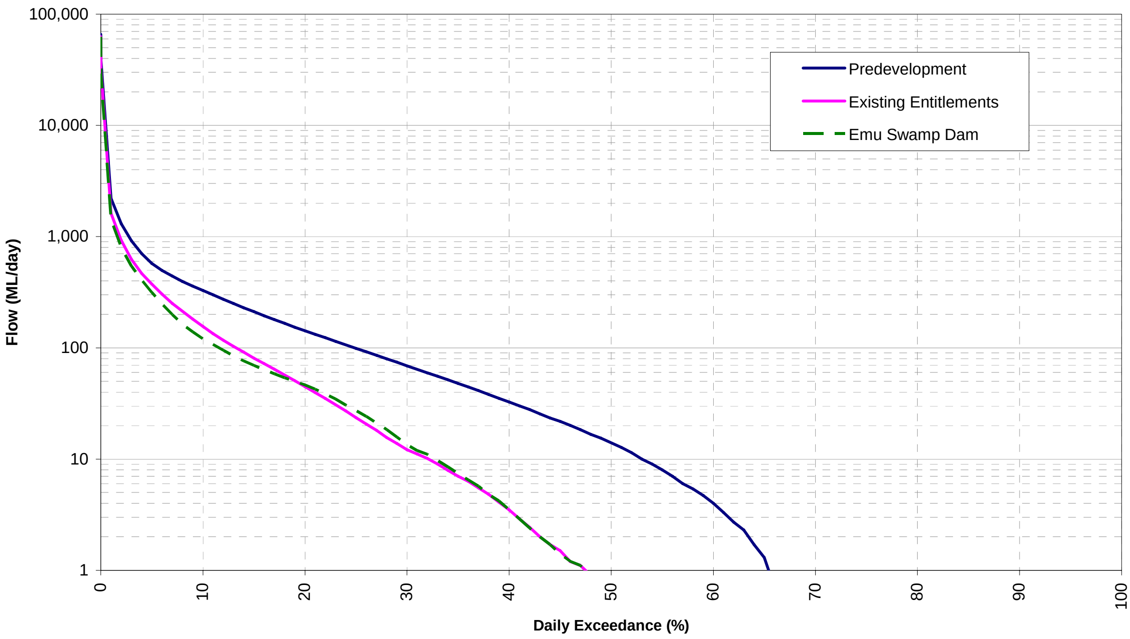


- **Figure 7-42 Monthly Median Daily Flows – Downstream of the Dam Site (AMTD 264 km)**

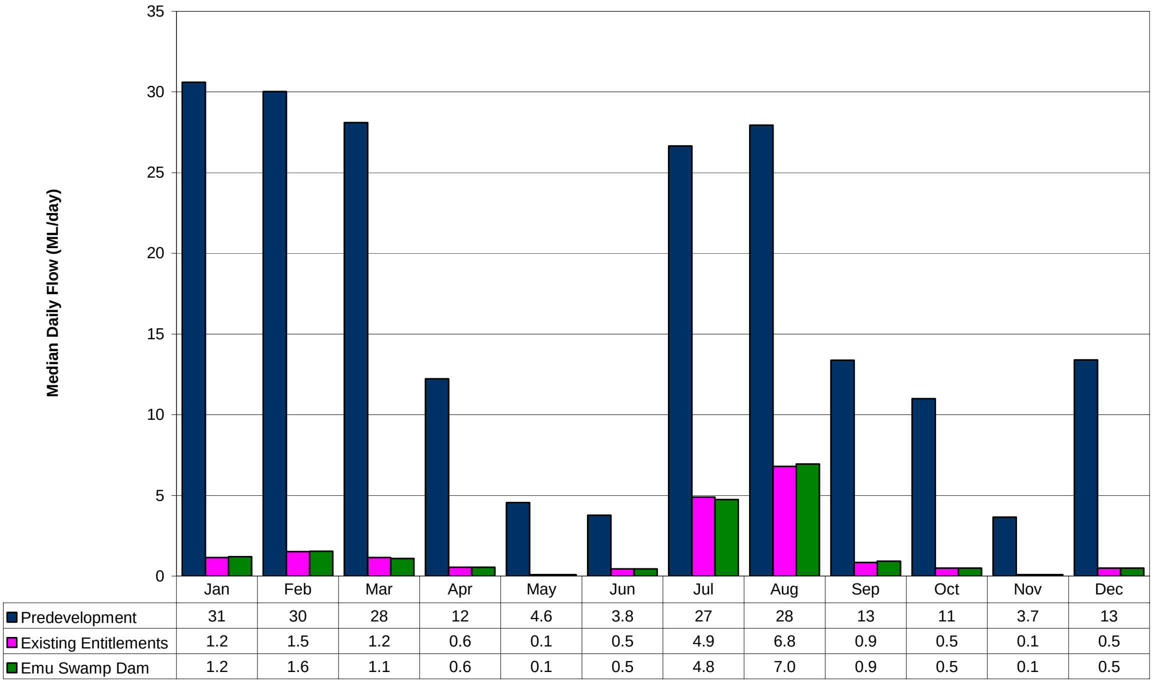


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
🟦 Predevelopment	19	19	19	8.2	2.8	2.7	18	20	8.3	6.9	2.4	9.2
🟪 Existing Entitlements	1.4	1.6	1.3	0.6	0.2	0.2	2.0	2.8	0.8	0.2	0.1	0.7
🟩 Emu Swamp Dam	1.4	1.5	1.3	0.4	0.0	0.0	2.0	2.4	0.8	0.3	0.1	0.5

- Figure 7-43 Flow Duration Curve – Downstream of the Accommodation Creek Confluence (AMTD 252 km)



- Figure 7-44 Monthly Median Daily Flows – Downstream of the Accommodation Creek Confluence (AMTD 252 km)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
🟦 Predevelopment	31	30	28	12	4.6	3.8	27	28	13	11	3.7	13
🟪 Existing Entitlements	1.2	1.5	1.2	0.6	0.1	0.5	4.9	6.8	0.9	0.5	0.1	0.5
🟩 Emu Swamp Dam	1.2	1.6	1.1	0.6	0.1	0.5	4.8	7.0	0.9	0.5	0.1	0.5

Figure 7-45 Flow Duration Curve – End of System Farnbro Node J (AMTD 198.6 km)

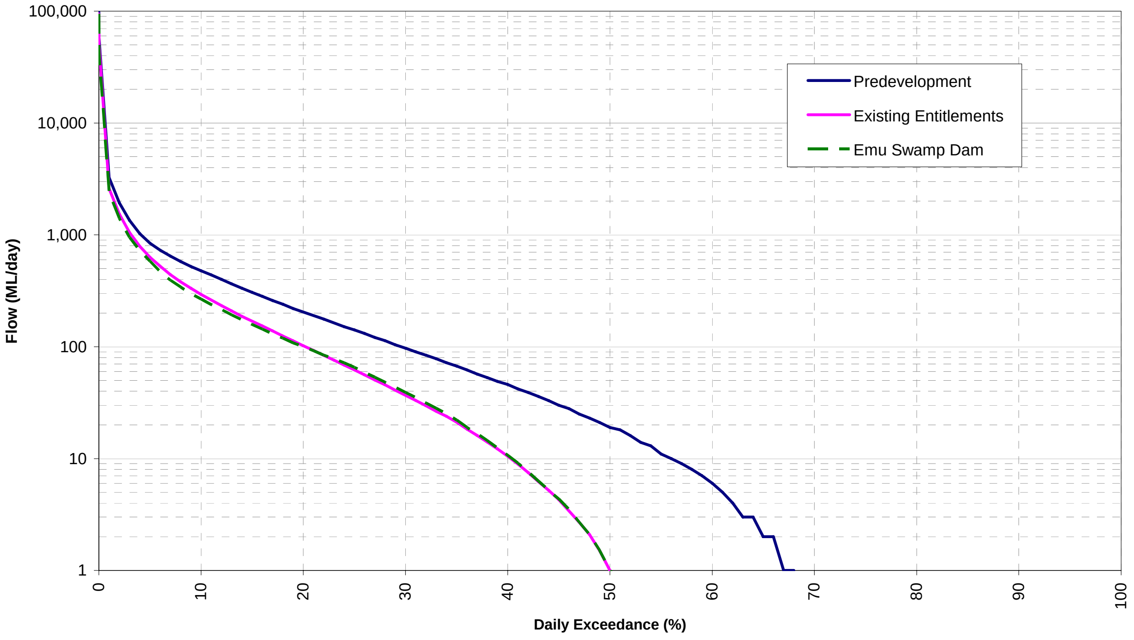
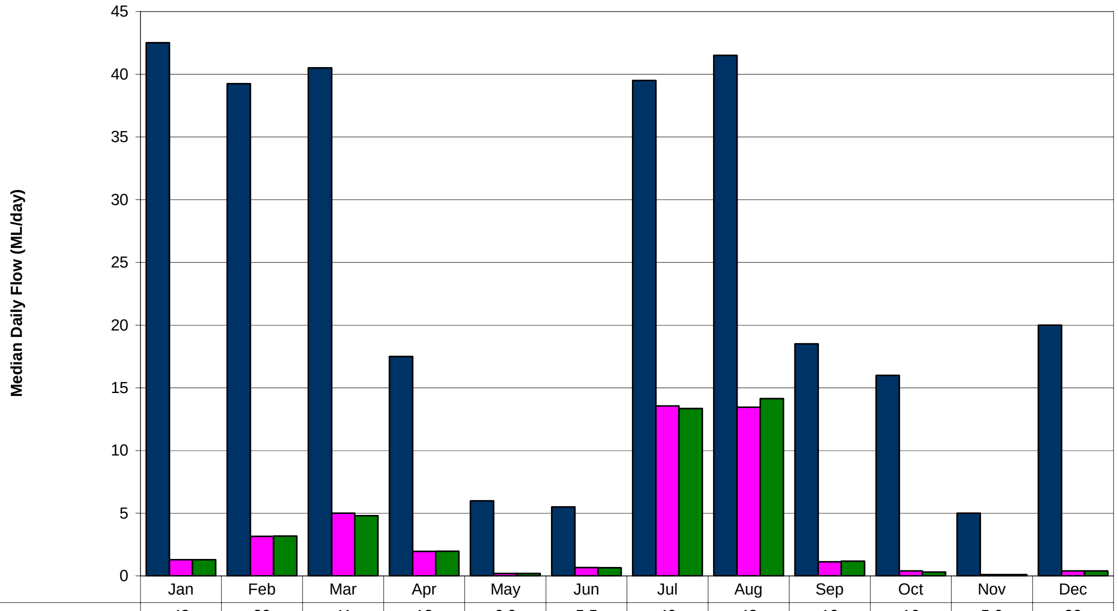


Figure 7-46 Monthly Median Daily Flows – End of System Farnbro Node J (AMTD 198.6 km)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
🟦 Predevelopment	43	39	41	18	6.0	5.5	40	42	19	16	5.0	20
🟪 Existing Entitlements	1.3	3.2	5.0	2.0	0.2	0.7	14	13	1.1	0.4	0.1	0.4
🟩 Emu Swamp Dam	1.3	3.2	4.8	2.0	0.2	0.7	13	14	1.2	0.3	0.1	0.4

These flow statistics highlight the following characteristics of the flow regime of the Severn River:

- the dam will have no impact on flow regime upstream of the dam;
- impacts from the dam are localised to between the dam and the confluence of Accommodation Creek;
- the dam has minimal impact on the flow regime downstream of Accommodation Creek; and
- the dam has negligible impact on the flow regime for Sundown National Park.

To mitigate the potential for the Combined Urban and Irrigation Dam to impacts of flows an environmental release strategy is proposed for the dam. The environmental release regime proposed is to allow pass flows up to 30 ML/day through the dam. This release strategy means the frequent low flows and the infrequent high flows remain essentially unchanged from the existing entitlements scenario. However, the medium flows are impacted by the dam. These impacts of the dam are localised to the 12 km reach from the dam to the confluence with Accommodation Creek. This reach is already highly impacted with five weirs and a number of irrigation water allocations.

There is a 12% change to the mean annual flow downstream of the confluence with Accommodation Creek. However, as shown in **Figure 7-43 and Figure 7-44,** there is minimal change in the magnitude and variability of the flow regime from the existing entitlement scenario. The dam is will have minimal impact on existing entitlements scenario downstream of the Accommodation Creek.

There is a 7% change to the mean annual flow downstream of the Sundown National Park. However, as shown in **Figure 7-29** and **Figure 7-46**, there is negligible change in the magnitude and variability of the flow regime from the existing entitlement scenario. The dam is will have negligible impact on existing entitlements scenario Sundown National Park.

7.2 Water Quality

7.2.1 Introduction

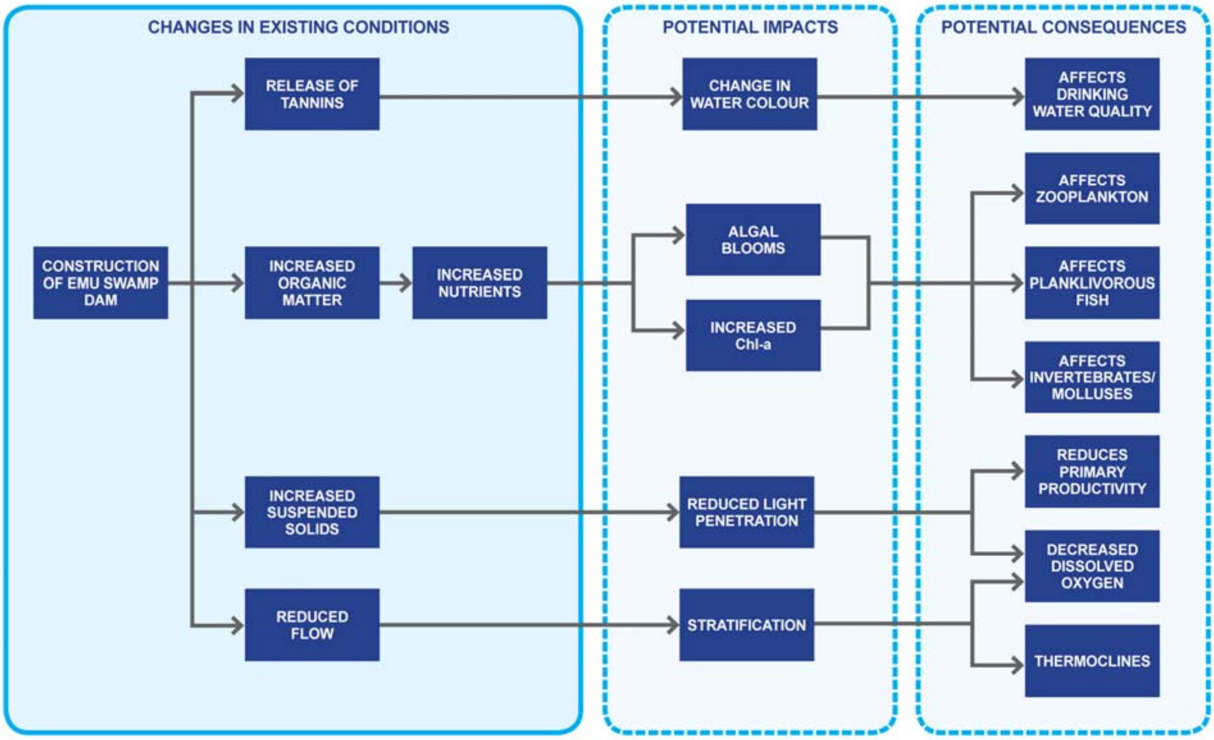
The following section describes the water quality conditions within the Severn River and surrounding catchment and an assessment of the potential impacts from the proposal, including the construction of pipelines with associated pump stations.

The assessment of water quality through:

- identifying the environmental values of the surface waterways;
- undertaking a literature review to identify the existing baseline data available within the proposed Emu Swamp Dam catchment;
- assessing the existing water quality conditions within the Catchment;
- identifying the potential impacts on the key environmental values identified from the proposal; and
- describing practical measures for protecting and enhancing water quality to ensure the protection of surrounding beneficial uses.

The types of potential impacts and likely consequences which will be addressed in this report have been illustrated in **Figure 7-47**. The potential impacts and likely consequences have been discussed in the context of describing future water quality conditions. The potential ecological impacts have been addressed in the terrestrial ecology and aquatic ecology sections of the EIS.

- **Figure 7-47 Potential Impacts and Consequences from Construction of Emu Swamp Dam**



7.2.2 Legislation, Policy and Best Practice Documents

The following documents were reviewed to identify the key environmental values and applicable water quality objectives for the Emu Swamp Dam catchment, incorporating the Severn River:

- *Australian Drinking Water Guidelines;*
- *Environmental Protection (Water) Policy 1997;*
- *Queensland Water Quality Guidelines 2006;*
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality; and*
- *Water Resources (Border Rivers) Plan 2003.*

7.2.2.1 Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines (the ADWG) are intended to provide a framework for good management of drinking water supplies that, if implemented, will ensure safety at point of use (NHMRC 2004). The ADWG are not Government legislation or policy, but rather provide a best practice document, for determining appropriate drinking water quality, for consumption in all parts of Australia. The ADWG are intended for use by the Australian community and all agencies with responsibilities associated with the supply of drinking water, including catchment and water resource managers, drinking water suppliers, water regulators and health authorities (NHMRC 2004).

The ADWG addresses the microbial limits, the physical and chemical requirements and the radiological limits of drinking water. The water in Emu Swamp Dam will be pumped to the existing Mt Marlay Water Treatment Plant, for treatment as potable water. The ADWG also discuss the specific methods associated with the chemical treatment of drinking water. The requirements for designing a rigorous water quality monitoring program, with suitable levels of quality control are also stipulated in the ADWG and were considered in the preparation of this document. Due consideration was also given to the operational parameters identified in the ADWG, for identifying the appropriate water quality parameters to be tested in Emu Swamp Dam, such as organic carbon and colour.

7.2.2.2 Environmental Protection (Water) Policy 1997

The *Environmental Protection (Water) Policy 1997* (EPP (Water)) is subordinate legislation under the EP Act 1994. This policy was developed to fulfil the objective of the *EP Act 1994*, in relation to protection of Queensland waters and contains a set of guidelines for the waters of Queensland. This policy is consistent with and should be seen as an extension of the *National Water Quality Management Strategy* and the *Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 Guidelines for Fresh and Marine Water Quality* (EPA, 2007).

The EPP (Water) provides a framework for developing environmental values through the integration of scientific research and community expectations (EPA 2007). The purpose of the policy is achieved by providing a framework for:

- identifying environmental values for Queensland waters;
- deciding and stating water quality guidelines and objectives to protect or enhance the environmental values;
- making consistent and equitable decisions about Queensland waters that promote efficient use of resources and best practice environmental management; and
- involving the community through consultation and education, and promoting community responsibility (EPA 2007).

The EPP (Water) describes the process for determining which water quality guidelines to use in water quality planning and decision making (EPA 2007).

The EPP (Water) identifies Environmental Values for waters (including beds and banks) in Queensland. Environmental Values describe the natural qualities and/ or beneficial uses of a water body that are to be protected (EPA 2007). Where these Environment Values are not listed, the Policy identifies qualities of a water body to be enhanced or protected.

Water Quality Objectives (WQOs) are established as quantitative targets to protect or enhance the Environmental Values identified for a water body. WQOs can be set for physical, chemical and biophysical components or indicators of aquatic environments (EPA 2007) generally referred to as guidelines that protect the stated Environmental Values for a water body. The Severn River and its tributaries are not listed under Schedule 1 of the EPP (Water).

7.2.2.3 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Guidelines)

The ANZECC guidelines have been prepared as part of Australia’s National Water Quality Management Strategy (NWQMS) and relate to New Zealand’s National Agenda for Sustainable Water Management (Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000). The purpose of the guidelines is to provide both government and the general community with a sound set of tools for assessing and managing ambient water quality in natural and semi-natural water resources (ANZECC and ARMCANZ 2000).

The ANZECC guidelines aim to protect environmental values through management goals that focus on issues (concerns or potential problems) (ANZECC and ARMCANZ 2000). Despite this, the guidelines are not mandatory and due to the vast range of environments, ecosystem types and food production systems in both Australia and New Zealand, it is recognised that a three-tiered approach including national, state or territory, and regional or catchment scales are required (ANZECC and ARMCANZ 2000).

In accordance with this recognition, the Queensland Water Quality Guidelines (QWQG) were developed to provide state-wide guidelines. In addition, the QWQG also provide the framework for establishment of local and regional guidelines.

7.2.2.4 Queensland Water Quality Guidelines

The *Queensland Water Quality Guidelines* (QWQG) (EPA 2006) were considered for application to the Severn River. The QWQG are intended to address the needs identified in the ANZECC Guidelines by:

- providing guideline values (numbers) that are tailored to Queensland regions and water types; and
- providing a process/framework for deriving and applying local guidelines for waters in Queensland (i.e. more specific guidelines than those in the QWQG).

The QWQG are technical guidelines, designed for the protection of Queensland aquatic ecosystems. They include relevant local and regional water quality data for fresh, estuarine and marine waters. The development of both regional and sub-regional guidelines is dependent on the availability of suitable reference data. Due to a lack of current data availability, the March 2006 QWQG contain no guideline values for the Murray Darling Regions, in which the Severn River is situated.

7.2.2.5 NSW Guidelines

The Severn River is a tributary of the Macintyre River. The Macintyre River's headwaters are in the Great Dividing Range in eastern New South Wales. The River then flows northwards to Queensland where it serves as part of the New South Wales/Queensland border. The Macintyre River is a major tributary of the Barwon River.

The NSW Border Rivers WQOs apply to all current and future licensed offtake points for town water supply and to specific sections of rivers that contribute to drinking water storages or immediately upstream of town water supply offtake points in NSW. The objectives also apply to subcatchments, or groundwaters used for town water supplies. These WQOs reference the *Australian Drinking Water Guidelines* (NHMRC & NRMMC 2004) for protecting town water supply, of which, the Australian Drinking Water Guidelines have been referenced as part of the present study.

7.2.2.6 Water Resources (Border Rivers) Plan 2003

The *Water Resource (Border Rivers) Plan* (WRP) was released by DNRW in 2003. The WRP was developed from an extensive stakeholder engagement program and a comprehensive water resource modelling process undertaken by the DNRW. One objective of the WRP is to maintain water quality at levels acceptable for water use and to support natural ecological processes.

7.2.3 Environmental Values

The environmental values highlighted in the ANZECC Guidelines, as well as the QWQG were used as the basis for adopting a set of environmental values for the Severn River. The approach highlighted in the ANZECC Guidelines for defining the waterbody and assigning a level of protection was also adopted in this section of the report, to aid in identifying appropriate water quality criteria in later sections.

7.2.3.1 Defining the Waterbody

In accordance with the ANZECC guidelines and for the purposes of defining the waterbody for this project, the creeks within the Emu Swamp Dam catchment area have been classified as Upland Rivers and Streams, which occur at altitudes >150 m.

7.2.3.2 Environmental Values

A description of the key assets and significant environmental values to be protected is provided within this section. Currently there are no environmental values or water quality objectives established for the Severn River, as per Schedule 1 of the EPP (Water). Therefore, the environmental values considered are those (qualities) highlighted in EPP (Water), as well as those listed in the ANZECC Guidelines and in the QWQG.

Environmental values are key environmental attributes that are important for the health of the ecosystem, public benefit, welfare, safety or health. These values require protection from the effects of pollution, waste discharge and modified sediment processes. The following environmental values are recognised in the ANZECC guidelines:

- aquatic ecosystems;
- primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods);
- recreation and aesthetics;
- drinking water;
- industrial water; and
- cultural and spiritual values.

All water resources are usually subject to one or more of the above environmental values. The Severn River has no environmental values established, so a conservative approach has been taken, whereby it was assumed that all appropriate environmental values are applied to the resource by default.

A more detailed description of the EPA values, as derived from the ANZECC Guidelines, are listed in the QWQG and presented in **Table 7-33**.

- **Table 7-33 Environmental Values for Different Water Uses**

Environmental Values	Definitions
Aquatic Ecosystems	▪ The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas. ▪ Waterways include perennial and intermittent surface waters, ground waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes, lagoons, natural and artificial channels and the bed and banks of waterways.
Primary industries	▪ Irrigation: Suitability of water supply for irrigation. ▪ Farm Water Supply: Suitability of domestic farm water supply, other than drinking water. ▪ Stock Watering: Suitability of water supply for production of healthy livestock. ▪ Aquaculture: Health of aquaculture species and humans consuming aquatic foods (such as fish, molluscs and crustaceans) from commercial ventures. ▪ Human Consumers of Aquatic Foods: Health of humans consuming aquatic foods.
Recreation and aesthetics	▪ Primary Recreation: Health of humans during recreation which involves direct contact and a high probability of water being swallowed, for example swimming. ▪ Secondary Recreation: Health of humans during recreation which involves indirect contact and a low probability of water being swallowed for example boating and fishing. ▪ Visual Amenity: Amenity of waterways for recreation which does not involve any contact with water.
Drinking Water	▪ Suitability of raw drinking water supply. This assumes minimal treatment of water is required.
Industrial uses	▪ Suitability of water supply for industrial use.

Source (EPA 2006) Referenced from Queensland Water Quality Guidelines, 2006.

All relevant environmental values need to be considered when evaluating a water body. The level of environmental and water quality protection must be determined to maintain each of the environmental values. Management goals that are established to protect the environmental values should reflect the specific problems and/or threats to the values, desired levels of protection and key attributes that must be protected (ANZECC and ARMCANZ 2000).

There are three levels of aquatic ecosystem condition and protection under the ANZECC Guidelines, which are high conservation/ ecological value systems, slightly to moderately disturbed systems and highly disturbed systems (ANZECC and ARMCANZ 2000). The high conservation/ecological value systems are effectively unmodified highly valued ecosystems. There are no aquatic ecosystems without some human influence but they typically occur in national parks, conservation reserves or in remote/inaccessible locations (ANZECC and ARMCANZ 2000).

The slightly to moderately disturbed systems are ecosystems that have been affected by human activity in a relatively small but measurable degree. The ecosystem integrity is largely retained while the biological communities remain in a healthy condition. The systems typically would have slightly to moderately cleared catchments with reasonably intact riparian vegetation. The highly disturbed systems are measurably degraded ecosystems of lower ecological value, such as the runoff from intensive agriculture into rural streams (ANZECC and ARMCANZ 2000).

7.2.3.3 Level of Protection

The State of the Rivers Report (Johnstone 1999) assessed 25 survey sites in the upper Severn River catchment, five of which correspond to sites used in the present survey. The report rated these sites, the results of which are presented in **Table 7-34**.

- Table 7-34 Sites Assessed in the Upper Severn River

Values	Condition
Aquatic Habitat Conditions	Very Poor - Poor
Aquatic Vegetation	Very Poor - Poor
Channel Diversity	Very Poor - Poor
Riparian Vegetation	Very Poor - Poor
Overall Condition of Reaches	Poor - Moderate
Immediate Environs	Poor - Very Good

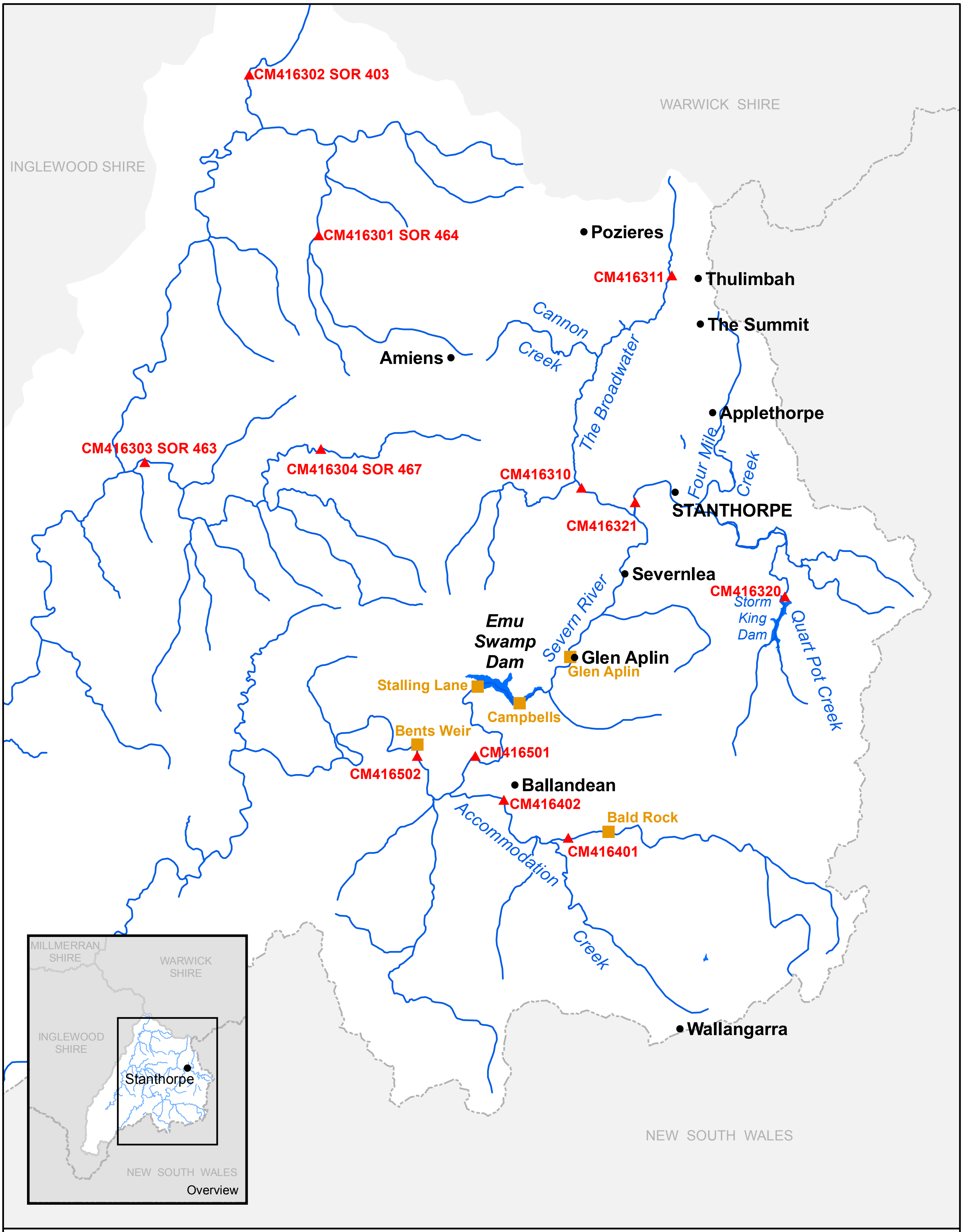
The ratings were related to existing water extraction, the level of agricultural development, the extent of land clearing and grazing, and historic tin mining. It should also be appreciated that sites with naturally low structural diversity, such as the bedrock glides often found in headwater streams of this region, would return a generally poor rating under this particular assessment approach. It was also noted that there were high levels of nitrogen present in the sub-catchment presumably from agricultural fertilisers. Therefore, based on the assessment undertaken in Johnstone (1999), and taking a more conservative approach to assigning a level of protection, the Severn River catchment is considered to be a slightly to moderately disturbed ecosystem, containing ecosystems which have been affected by human activity. Therefore, the 90% and 95% levels of protection (adopted trigger values from the ANZECC guidelines), were used to assess water quality condition within the catchment.

7.2.4 Existing Environmental Conditions

Existing water quality conditions of the Emu Swamp Dam Catchment have been assessed using:

- baseline monitoring data collected as part of the Stanthorpe Water Assessment and Monitoring Project (SWAMP) (monthly data from 2005-2007); and
- additional baseline water quality data was also collected as part of a one off water quality monitoring program in the Severn River by Ecology Management (data collected November-December 2006 and April 2007), to supplement the existing information on physicochemical conditions.

The water quality monitoring locations for SWAMP and Ecology Management are presented in **Figure 7-48**. This data was evaluated against the relevant Water Quality Objectives. For the purposes of this assessment, it was assumed that the data was of a satisfactory standard for interpretation.



SHIRE OF STANTHORPE

Legend

🟧 Ecology Management Water Quality Monitoring Sites

▲ SWAMP Water Quality Monitoring Sites

— River/Creek

🟦 Dam

N
W E
S

0 1 2 4 6 8 10
Kilometres
Scale -1:275,000 (at A4)
Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Gauge Catchment

Figure 7-48 Water Quality Monitoring Locations

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Adjacent Catchment to Proposed Dam

Water quality data reported from the SWAMP sites within creeks adjacent to the Emu Swamp Dam inundation area (north west of Emu Swamp) were evaluated against the Water Quality Objectives (ANZECC and ARMCANZ (2000); QWQG (2006)) and are summarised in **Table 7-35**.

The water quality results obtained from SWAMP data reported overall compliance with the ANZECC Water Quality Objectives and QWQG (2000) for the majority of the parameters tested. The median concentrations calculated for nutrients however, exceeded ANZECC Water Quality Objectives and Queensland Water Quality Guidelines. The total nitrogen and phosphorus concentrations were more than four times and three times higher respectively, than guideline values. The elevated concentrations may be attributed to surrounding agricultural land uses, geological features or groundwater influences in the catchment area.

The median concentrations for the majority of physio-chemical parameters tested reported overall compliance with guideline values. The temperature values reported for two of the sites however, were either under the 20th percentile or over the 80th percentiles derived for the entire catchment. Site specific guideline values were derived for temperature, given that no EPA WQOs existed for the catchment. The median concentrations of aluminium, zinc and copper also exceeded the ANZECC 95% protection level, whilst the median concentration of copper also exceeded the less conservative 90% protection level. These concentrations may be reflective of the geology of the area, but may also be influenced by surrounding agricultural runoff.

- **Table 7-35 Evaluation of Water Quality in Adjacent Catchment from SWAMP Monitoring Data**

Water Quality Parameter	ANZECC Water Quality Objectives [a]	ANZECC Water Quality Objectives [b]	Queensland Water Quality Guidelines [c]	CM416301	CM416302	CM416303	CM416304	Units
Total Phosphorus	<20 µg/L	<20 µg/L	<30 µg/L	**73**	**42**	**48.5**	**51.5**	µg/L
Total Nitrogen	<250 µg/L	<250 µg/L	<250 µg/L	**1100**	**650**	**480**	**530**	µg/L
Turbidity	2-25 NTU	2-25 NTU	<25 NTU	**60**	12	12	**31**	NTU
Temperature	20th – 80th percentile; 12.9-25.6 ˚C**			**16-26.3**	**11.8-22.8**	17.34-24.62	12.64-24.24	ºC
pH	6.5-7.5	6.5-7.5	6.5-8.2	7.1	6.9	6.7	6.9	
Conductivity	30-350 µS/cm	30-350 µS/cm	75th Percentile, 325 µS/cm	250, **340***	200, 220*	180, 190*	380, **400***	µS/cm
Total Suspended Solids	<40mg/L[d]	<40mg/L[d]	-	**66**	19	7	22	mg/L
Iron	<300 µg/L	<300 µg/L	Level 1: 50 µg/L Level 2: 200 µg/L	**270**	**750**	90	90	µg/L
Manganese	<1700 µg/L	<2500 µg/L	Level 1: 50 µg/L Level 2: 200 µg/L	30	30	30	30	µg/L
Aluminium	<55 µg/L	<80 µg/L	-	70	60	90	75	µg/L
Zinc	<8 µg/L	<15 µg/L	-	**20**	**10**	**20**	**10**	µg/L
Copper	<1.4 µg/L	<1.8 µg/L	-	**30**	**30**	**30**	**30**	µg/L
Boron	<370 µg/L	<680 µg/L	-	60	30	20	20	µg/L

Note: bold figures indicate exceedance of guideline values

[a] based on 95% level of protection

[b] based on 90% level of protection

[c] Upland Streams

[d] These are indicative values

[*] 75th Percentile for Salinity QWQG

[**] Derived from SWAMP data across the 15 sites from 2006-2007.

Upstream of Proposed Dam

Water quality data reported from the SWAMP and Ecology Management water quality monitoring programs, from sites within creeks upstream of Emu Dam, within the catchment, were evaluated against the ANZECC and ARMCANZ (2000) and QWQG (2006) Water Quality Objectives and are summarised in **Table 7-36** and **Table 7-37**.

The water quality results obtained from the Ecology Management data (see **Table 7-36**) demonstrated overall compliance with the ANZECC Water Quality Objectives and Queensland Water Quality Guidelines for the majority of the parameters tested. The dissolved oxygen (DO) concentrations however, were below the 20th percentile for both of the sites sampled, and over the 80th percentile for one of the sites. The pH levels reported were elevated at both sites sampled compared to ANZECC guidelines, although only one of the sites (Glen Aplin) reported pH above the Queensland Water Quality Guidelines. The other physico-chemical parameters tested by Ecology Management were reported within guideline values. As DO was not compliant with ANZECC Guidelines or QWQG, this parameter should be included in the suite of analyses undertaken as part of the SWAMP. A site specific guideline value for DO should then be derived for inclusion in the water quality monitoring program, during the construction and operation of Emu Swamp Dam.

The SWAMP data (**Table 7-37**) demonstrated overall compliance with the ANZECC Water Quality Objectives and Queensland Water Quality Guidelines for the majority of the parameters tested. The median concentrations for nutrients however, exceeded the ANZECC Water Quality Objectives and Queensland Water Quality Guidelines. The median total phosphorous and nitrogen concentrations were up to 11 times and 5 times higher respectively than guideline values.

The median concentrations calculated from the physio-chemical data demonstrated overall compliance with the WQOs, with the exception of temperature and pH. The median temperatures for three of the seven sites were either under the 20th percentile, or over the 80th percentile, and pH was elevated at four of the seven sites. The median concentration of zinc and copper exceeded the ANZECC 95% protection level, whilst the median concentration of copper exceeded the less conservative 90% protection level.

Given the observed results, site specific guideline values will need to be adopted for nutrients, temperature, pH, conductivity, zinc and copper, in addition to DO, for areas upstream of the proposed Emu Swamp Dam. These derived site specific guideline values shall then be used to investigate water quality compliance during construction and operation upstream of the dam.

The water quality results for the catchment area of the proposed Emu Swamp Dam are comparable to the adjacent catchment. There were elevated nutrient levels found in the water in both catchment areas and the degree of exceedance was similar. The physio-chemical properties were also simular, except for turbidity, which was only elevated in the adjacent catchment.

Water in the Emu Swamp Dam catchment was more alkaline than that tested from the adjacent catchment. The metal concentrations reported in the catchments were similar, except for aluminium in the adjacent catchment, which exceeded the guideline values at each of the sites and was below the guideline value in the Emu Swamp Dam catchment.

- **Table 7-36 Evaluation of Upland Streams Water Quality and Ecology Management based on SWAMP Monitoring Data**

Water Quality Parameter	ANZECC Water Quality Objectives	Queensland Water Quality Guidelines	Glen Aplin	Campbells Deep	Units
Temperature	20th – 80th percentile; 12.9-25.6 °C**	20th – 80th percentile; 12.9-25.6 °C**	**18.1**	**17.2**	ºC
Conductivity	30-350 µS/cm	75th Percentile, 325 µS/cm	**143**	**n/a**	µS/cm
Dissolved Oxygen (% saturation)	20th – 80th percentile; 90-110%	20th – 80th percentile; 98-108%	**54.94-135.8**	**36.68-54.5**	%
pH	6.5-7.5	6.5-8.2	**8.7**	**8.01**	
Turbidity	2-25 NTU	<25 NTU	**17**	**8**	NTU

** Derived from SWAMP data across the 15 sites from 2006-2007

n/a – not available.

Table 7-37 Evaluation of Upstream Water Quality based on SWAMP Monitoring Data

Water Quality Parameter	ANZECC Water Quality Objectives [a]	ANZECC Water Quality Objectives [b]	Queensland Water Quality Guidelines [c]	CM416310	CM416311	CM416319	CM416320	CM416321	CM416322	CM416324	Units
Total Phosphorus	<20 µg/L	<20 µg/L	<30 µg/L	**91**	**180**	**35.5**	**40.5**	**20.5**	**44**	**230**	µg/L
Total Nitrogen	<250 µg/L	<250 µg/L	<250 µg/L	**1000**	**1300**	**525**	**1050**	**560**	**780**	**861.99**	µg/L
Turbidity	2-25 NTU	2-25 NTU	<25 NTU	10	22.5	10	10	10	10	10	NTU
Temperature	20th – 80th percentile; 12.9-25.6 °C**	20th – 80th percentile; 12.9-25.6 °C**	20th – 80th percentile; 12.9-25.6 °C**	13.6-25.3	**12.0-20.4**	**22.5-27.0**	**15.8-26.1**	14.9-25.5	16.2-21.4	17-25.4	ºC
pH	6.5-7.5	6.5-7.5	6.5-8.2	6.5	6.85	**7.8**	**8.5**	7.35	**7.6**	**7.6**	
Conductivity	30-350 µS/cm	30-350 µS/cm	75th percentile, 325 µS/cm	295, **345***	**715, 792.5***	220, 270*	180, 182.5*	270, **342.5***	265, 280*	300, 320*	µS/cm
Total Suspended Solids	<40mg/L[d]	<40mg/L[d]		28	35	5.5	6	6	7	7.5	mg/L
Iron	<300 µg/L	<300 µg/L	Level 1: 50 µg/L Level 2: 200 µg/L	100	10	**235**	**205**	**250**	10	80	µg/L
Manganese	<1700 µg/L	<2500 µg/L	Level 1: 50 µg/L Level 2: 200 µg/L	30	30	30	30	30	30	30	µg/L
Aluminium	<55 µg/L	<80 µg/L	-	50	50	50	50	50	50	50	µg/L
Zinc	<8 µg/L	<15 µg/L	-	**40**	**120**	**20**	**10**	**10**	**10**	**10**	µg/L
Copper	<1.4 µg/L	<1.8 µg/L	-	**30**	**30**	**30**	**30**	**30**	**30**	**30**	µg/L
Boron	<370 µg/L	<680 µg/L	-	40	80	20	25	20	30	30	µg/L

[a] based on 95% protection levels

[b] based on 90% protection levels

[c] Upland Streams

[d] These are indicative values

* 75th Percentile for Salinity QWQG (2006)

** Derived from SWAMP data across the 15 sites from 2006-2007

Downstream of Emu Swamp Dam

Water quality data reported from the SWAMP and Ecology Management (Accommodation Creek) programs, at sites within creeks downstream of Emu Swamp Dam, were evaluated against the ANZECC and ARMCANZ (2000) and QWQG (2006) Water Quality Objectives and are summarised in **Table 7-38** and **Table 7-39**.

The water quality physico-chemical results reported by Ecology Management (**Table 7-38**) were within the ANZECC Water Quality Objectives and Queensland Water Quality Guidelines for the majority of the parameters. The results for dissolved oxygen however, were below the 20% percentile for the 3 sites sampled and pH was low at one of sites sampled.

The water quality results obtained from the SWAMP data (**Table 7-39**) demonstrated overall compliance with the ANZECC Water Quality Objectives and Queensland Water Quality Guidelines, with the exception of nutrients, temperature and some metals. The median concentrations calculated for nutrients across all of the sites exceeded the ANZECC Water Quality Objectives and Queensland Water Quality Guidelines. The elevated concentrations may be attributed to surrounding agricultural land uses, geological features or groundwater influences in the catchment area.

The median concentrations of the physio-chemical parameters tested demonstrated overall compliance with guideline values, except for temperature where all four sites reported values less than the 20th percentile. The median concentration of zinc and copper exceeded the ANZECC 95% protection level, whilst the median concentration of copper exceeded the less conservative 90% protection level.

Nutrient concentrations in the lower catchment, downstream of the proposed Emu Swamp Dam, although elevated above guidelines, were slightly less than the concentrations reported upstream of the dam and in the adjacent catchment, which is most likely reflective of intense agriculture practices in the upper catchment. The pH levels were slightly more alkaline upstream of the dam, compared to downstream. DO was low throughout the dam catchment, possibly reflective of low flow conditions.

As reported for upstream of Emu Swamp Dam, site specific guideline values will need to be adopted for nutrients, as well as temperature, zinc and copper, in areas downstream of the dam. These derived site specific guideline values shall then be used to investigate water quality compliance during construction and operation downstream of the dam and should be developed as part of the construction EMP. DO levels should continue to be monitored during construction and should not be reduced below historic concentrations.

- **Table 7-38 Evaluation of Downstream Creeks Water Quality based on SWAMP Monitoring Data**

Water Quality Parameter	ANZECC Water Quality Objectives	Queensland Water Quality Guidelines	Accommodation Ck	Bald Rock Ck	Bents Weir
Temperature	20th – 80th percentile; 12.9-25.6 ^{o}C**	20th – 80th percentile; 12.9-25.6 ^{o}C**	14.88-16.54	23.45-25.56	17.37-19.54
Conductivity	30-350 µS/cm	75th Percentile, 325 µS/cm	43	**951***	n/a
Dissolved Oxygen (% saturation)	20th – 80th percentile; 85-110%	20th – 80th percentile; 98-108%	**36.08-57.92**	**67.92-83.36**	**25.8-52.46**
pH	6.5-7.5	6.5-8.2	7.5	**5.8**	7.4
Turbidity	2-25 NTU	<25 NTU	9.3	**113.6**	3

* Result uncertain, as reported by Ecology Management

** Derived from SWAMP data across the 15 sites from 2006-2007

- **Table 7-39 Evaluation of Downstream Water Quality based on SWAMP Monitoring Data**

Water Quality Parameter	ANZECC Water Quality Objectives a	ANZECC Water Quality Objectives b	Queensland Water Quality Guidelines c	CM416331	CM416332	CM416341	CM416342
Total Phosphorus	<20 µg/L	<20 µg/L	<30 µg/L	**39.5**	**50**	**51**	30
Total Nitrogen	<250 µg/L	<250 µg/L	<250 µg/L	**550**	**600**	**820**	**680**
Turbidity	2-25 NTU	2-25 NTU	<25 NTU	10	10	10	10
Temperature	20th – 80th percentile; 12.9-25.6 °C**	20th – 80th percentile; 12.9-25.6 °C**	20th – 80th percentile; 12.9-25.6 °C**	**11.14-25.06**	**12.1-23.74**	**9.28-25.38**	**12.7-26.2**
pH	6.5-7.5	6.5-7.5	6.5-8.2	6.6	6.9	7	7.4
Conductivity	30-350 µS/cm	30-350 µS/cm	75th Percentile, 325 µS/cm	50, 70*	160, 270*	250, 265*	210, 210*
Total Suspended Solids	<40mg/L[d]	<40mg/L[d]	-	7	7	8	6
Iron	<300 µg/L	<300 µg/L	Level 1: 50 µg/L Level 2: 200 µg/L	90	190	50	140
Manganese	<1700 µg/L	<2500 µg/L	Level 1: 50 µg/L Level 2: 200 µg/L	30	30	30	30
Aluminium	<55 µg/L	<80 µg/L	-	50	50	50	50
Zinc	<8 µg/L	<15 µg/L	-	**10**	**10**	**10**	**10**
Copper	<1.4 µg/L	<1.8 µg/L	-	**30**	**30**	**30**	**30**
Boron	<370 µg/L	<680 µg/L	-	10	20	30	20

[a] based on 95% protection levels

[b] based on 90% protection levels

[c] Lowland Streams

[d] These are indicative values

* 50th and 75th Percentiles for Salinity QWQG

** Derived from SWAMP data across the 15 sites from 2006-2007

Drinking Water Guidelines

Water quality data reported from the SWAMP and Ecology Management sampling programs from sites within the Severn River were evaluated against *Australian Drinking Water Guidelines* (NHMRC 2004) and are presented in **Table 7-40**. A number of human health parameters such as bacteria (faecal and total coliforms) and blue green algae have not been previously tested. There have been no reported blooms of blue-green algae at Storm King Dam which is in the same catchment as Emu Swamp Dam. Monitoring of nuisance algae and chlorophyll-A should be implemented to assist with managing the potential for algal blooms, which may occur due to elevated nutrient loads entering the dam.

DO, pH and temperature were reported in a number of instances above the Australian Drinking Water Guidelines and therefore, these should be monitored before, during and after construction in both the dam and at the pipeline outlet point. The water quality monitoring program in the Severn should obtain a copy of the Mt Marlay water treatment plant water quality standards, in order to check that the water quality conditions are suitable for use by the plant.

- **Table 7-40 Evaluation of SWAMP and Ecology Management sampling programs from sites within the Severn River with the Australian Drinking Water Guidelines**

Indicator	NHMRC (2004) criteria (trigger values)*	CM416310	CM416311	CM416319	CM416320	CM416321	CM416322	CM416324	Glen Aplin	Campbells Deep
Blue-green algae	>500 algal cells/mL - increase monitoring. < 2000 algal cells/mL - water may be used for potable supply. >2000 algal cells/mL - immediate action indicated; seek expert advice. >6500 algal cells/mL - seek advice from health authority. >15 000 algal cells/mL - may not be used for potable supply except with full water treatment, which incorporates filtration and activated carbon.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Turbidity	Site-specific determinant	10	22.5	10	10	10	10	10	17	8
Total Dissolved Solids	> 500 mg/L (approximate conductivity 1000 µS/cm)	295	715	220	180	270	265	300	143	n/a
Faecal coliforms*	0 faecal coliforms per 100 mL (0/100 mL)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	95% of samples should be 0 coliforms/ 100 mL throughout the year.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total coliforms*	Up to 10 coliform organisms may be accepted occasionally in 100 mL. Coliform organisms should not be detected in 100 mL in any two consecutive samples.									
Dissolved Oxygen	> 85% saturation	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**54.9-135.8**	**36.7-54.5**
pH	6.5-8.5	6.5	6.85	7.8	8.5	7.35	7.6	7.6	**8.7**	8.0
Temperature	<20°C (Indicative value only)	13.6-**25.3**	12.0-**20.4**	22.5-**27.0**	15.8-**26.1**	14.9-**25.5**	16.2-**21.4**	17.0-**25.4**	18.1	17.2

* Values given are NHMRC criteria for raw waters before disinfection or clarification. n/a - data not available. Tabulated data was based on the determination of median values, except where 20th and 80th percentiles are provided.

Herbicides in the Emu Swamp Dam Catchment

Herbicides in the Emu Swamp Catchment were monitored on four sampling occasions in 2005 and 2006 and this data is presented in **Table 7-41**. Individual sample results instead of medians were compared with trigger values, because the majority of sample locations were sampled on less than three occasions. Of the four herbicides examined, diuron was reported an order of magnitude higher than the low reliability trigger values. Diuron however, did not exceed the health based guideline value of 30 µg/L (NHMRC 2004).

- **Table 7-41 Concentrations (µg/L) of Herbicides in the Emu Swamp Dam Catchment**

Site ID	Sample Date	Atrazine	Diuron	Hexazinone	Tebuthiuron
CM416301	Feb-06	< 0.01	< 0.01	0.60	-
	Apr-06	-	< 0.01	0.06	< 0.01
CM416302	Feb-06	0.01	< 0.01	< 0.01	-
	Apr-06	-	< 0.01	< 0.01	< 0.01
CM416303	Feb-06	< 0.01	< 0.01	0.06	< 0.01
CM416304	Feb-06	< 0.01	< 0.01	< 0.01	< 0.01
	May-06	-	< 0.01	< 0.01	< 0.01
CM416310	Feb-06	< 0.01	< 0.01	< 0.01	-
CM416311	Feb-06	< 0.01	< 0.01	< 0.01	-
CM416319	Feb-06	0.05	0.03	< 0.01	< 0.01
	Feb-06	0.01	**1.50**	< 0.01	-
	Apr-06	-	**4.10**	< 0.01	< 0.01
CM416320	Feb-06	0.01	< 0.01	< 0.01	< 0.01
	Apr-06	-	< 0.01	< 0.01	< 0.01
CM416321	Apr-06	-	< 0.01	< 0.01	< 0.01
CM416324	Feb-06	< 0.01	**2.20**	< 0.01	-
	Apr-06	-	**4.80**	< 0.01	< 0.01
CM416331	Nov-05	0.01	< 0.01	< 0.01	-
	Feb-06	< 0.01	< 0.01	< 0.01	-
	Apr-06	-	< 0.01	< 0.01	< 0.01
CM416332	Nov-05	0.02	< 0.01	< 0.01	-
	Feb-06	< 0.01	< 0.01	< 0.01	-
	Apr-06	-	< 0.01	< 0.01	< 0.01
CM416341	Feb-06	< 0.01	< 0.01	< 0.01	0.04
	May-06	-	< 0.01	< 0.01	0.04
CM416342	Feb-06	< 0.01	< 0.01	< 0.01	0.02
ANZECC 95% Level of Protection		13	0.2*	75*	2.2
ANZECC 90% Level of Protection		45	0.2*	75*	20

* Low reliability trigger values

7.2.5 Key Activities and Potential Impacts

The key activities and potential impacts arising from the project, which have the potential to influence the drinking water supply and environmental values of Emu Swamp Dam, as described in previous sections, are examined in this section of the report. The broad activities and potential impacts from construction and operation of Emu Swamp Dam identified include:

- during and post-construction activities contributing to erosion and sediment runoff;

- construction activities contributing to the suspension of sediment in the water column from disturbance during site establishment;
- post-construction activities influencing water quality conditions from organic material inundation associated with rising water levels and stratification from reduced mixing in the water column;
- suspension of sediments from filling of Emu Swamp Dam; and
- construction activities contributing to potential chemical and fuel spills.

7.2.5.1 Construction Related Activities and Potential Impacts

The main impacts during the Emu Swamp Dam construction phase relate to the physical disturbance of the stream bed in the works area, runoff from disturbed areas and the subsequent potential impacts on water quality. The impacts are largely limited to the footprint of the development area. The key activities that will require management mitigation measures to be implemented, to prevent or minimise adverse water quality impacts are presented as follows:

- activities that have the potential to increase sedimentation and erosion processes:
  - creation of a temporary water storage in the impoundment area for construction water has the potential to introduce suspended sediments into the river, at times when environmental flows are released downstream of these works;
  - construction of the coffer dam, has the potential to introduce suspended sediments into the river, when water is diverted during flood events;
  - clearing of vegetation and stripping of topsoils during the site establishment has the potential to degrade water quality from erosion processes, increased organic loads and runoff;
  - excavation of upper bedrock along the footprint of the dam has the potential to cause excessive erosion and sediment runoff;
  - construction of new access roads, hardstand area for offices and car parking, site offices, laboratory, storage, crib, ablution services, workshop, maintenance facility and hardstand all have the potential to cause erosion, runoff and water quality degradation;
  - construction of pump station (trench to hold pump inlet manifold and pump discharge pipeline) has the potential to cause excessive erosion and sediment runoff; and
- activities that have the potential to degrade water quality conditions:
  - handling and storage of fuels during site establishment has the potential to degrade water quality from increased risk of chemical spills;
  - construction of new access roads, hardstand area for offices and car parking, site offices, laboratory, storage, crib, ablution services, workshop, maintenance facility and hardstand all have the potential to cause water quality degradation, resulting from potential fuel spills and concrete, chemical and tarmac spills into the waterway; and
  - construction and management of bunded fuel tanks, dangerous goods containers, hazardous chemicals and regulated and workshop wastes (metal, tyres, filters, batteries) plus handling and storage of fuels during the site establishment has the potential to contaminate the waterway.

In addition to the potential environmental impacts from dam construction, the major construction activities for the Urban and Irrigation Pipelines, which have the potential to cause excessive erosion, sediment runoff and introduce pollutants into waterways are as follows:

- clearing activities;
- trench excavation including drilling and blasting in rock (where required) for buried pipes;
- concrete pedestal construction for above ground pipes;
- directional drilling for road, rail and creek crossings;

- pipe delivery and stringing;
- pipe laying and jointing;
- trench backfilling/surface reinstatement;
- construction of pump stations, valve chambers etc ; and
- pump, electrics and telemetry installation.

7.2.5.2 Potential Operational Impacts

The operational activities which have the potential to compromise water quality conditions include the following:

- runoff from the new adjacent roadways into Emu Swamp Dam and the Severn River. This may result in increased sediment, and pollutant loads into the waterway. Motor vehicles will be the principal source of any pollutants present in road runoff, derived from tyres, clutch and brake linings, hydraulic fluids, automotive fuels, and particulates from exhaust emissions;
- construction of the dam wall and spillway will reduce flow through this section of the river, potentially reducing the degree of mixing in the water column, which may result in stratification within the dam and the creation of a thermocline and reduced dissolved oxygen concentrations at depth. The dam however, will be <5 m deep and therefore, there should not be significant reductions in temperature and DO at depth, as long as there is sufficient mixing through the water column;
- reduced flow conditions may contribute to an increased potential for algal blooms. Nutrient concentrations in the Emu Swamp Dam catchment are elevated, however, concentrations likely to occur in the dam would not be dissimilar to those reported for Quart Pot Creek in Storm King Dam, which does not have a history of algal blooms;
- disturbed sediment in the storage area will move to the lowest parts of the storage and fill the existing channel and low points. In the interim, sediments may be resuspended in the water column compromising water quality conditions;
- organic plant material (either left over from clearing activities, existing vegetation, or new regrowth) within the storage will rot during filling of the dam, and may lead to oxygen depletion, which has the potential to influence water quality conditions in the Severn River; and
- changes in flows from dam construction have the potential to influence water quality conditions by impacting on the amount of water in the catchment, the degree of mixing occurring and sedimentation processes.

7.2.6 Mitigation Measures

Construction

Considering the potential soil erosion and sedimentation issues raised from the construction process, the following management mitigation measures should be implemented:

- stormwater diverted around the construction sites, will need to be treated prior to discharge downstream into the Severn River in order to control the amount of suspended solids, organic matter and contaminants present in the water from construction runoff. Treatment would primarily involve the use of sediment ponds and flocculants if the suspended solid do not settle out of the water in the ponds;
- stormwater and flows from the Severn River collected within the construction site in the temporary water storage will be treated and reused for construction water. Treatment should be primarily aimed at removing the suspended solids via settlement ponds;
- exposed soils should be stabilised by using materials such as mulch, biodegradable matting, and geotextile fabrics;
- revegetation of areas impacted by all construction activities outside of the inundation area;
- rate of stormwater flow within the construction area should be reduced by using energy dissipation techniques;

- measures should be implemented to minimise sediment taken offsite and to other areas of the dam construction site by construction vehicles, via the use of wash down bays;
- bunding and appropriate storage of fuels and other hazardous/ flammable materials. Spill containment kits should be available on site; and
- oil containment booms and oil spill recovery equipment should be available when working adjacent to rivers and creeks.

Some sediment laden water may need to be discharged into the Severn River, downstream of the dam. A number of procedures should be implemented to treat sediment laden water including:

- filtering runoff from the site, using hay bales, geotextile fabrics, and silt curtains (once the sediments are introduced into the waterway);
- using sedimentation basins (i.e. settlement ponds) where sediment settles prior to discharge. Chemical flocculants can also be used to hasten settlement, especially when fine sediments are present. However, the use of flocculants (i.e. aluminium sulphate) will need to be managed from a human health and ecological risk standpoint. The construction EMP will need to refer to the appropriate material safety datasheets, if such chemicals are to be used on site;
- undertaking a routine water quality monitoring program (every second month program with four (4) event based occasions per year when inflows exceed 30 ML/day) upstream and downstream of the construction works for the following parameters:
  - temperature, pH, and turbidity;
  - nuisance algae (with specific reference to blue-green algae) and chlorophyll-a; and
  - DO, Total Phosphorous, Total Nitrogen, Iron and Manganese.
- site specific water quality guidelines, which will be developed in the construction EMP, shall be adopted for nutrients, temperature, pH, conductivity, zinc and copper for areas upstream of the dam, and temperature, zinc and copper, in areas downstream of the dam, using the 20th, 50th and 80th percentiles provided in the EIS. These derived site specific guideline values shall then be used to investigate water quality compliance during construction and operation. Mitigation and remedial procedures shall be outlined in the EMP if the site specific water quality guidelines are exceeded. DO levels should continue to be monitored upstream and downstream with specific intention to compare the values to ensure that the construction activities are not negatively impacting on DO levels. The downstream DO level should not be significantly lower than the upstream DO level;
- any sediment removed from the temporary water storage, or sediment basins should generally be dewatered on site and used as construction fill material. This dredge material would need to be assessed for contamination if disposed of off-site.

Operation

The controls to mitigate any environmental impacts from operational activities will need to be detailed in the Operational EMP. The types of management mitigation measures that will need to be implemented include:

- on-going revegetation/maintenance of areas impacted by construction activities;
- implementing appropriate sediment management controls in areas with exposed soils;
- undertaking a routine (quarterly) water quality monitoring program in the dam for the first 3 years of operation for the following parameters:
  - temperature, pH, turbidity, colour, organic carbon;
  - nuisance algae, chlorophyll-a;
  - herbicides (namely diuron); and
  - DO, algal composition, Total Phosphorous, Total Nitrogen, Aluminium, Iron and Manganese.

- a fixed site water quality meter with data logger is recommended for installation at the outlet pipe, which is connected to the Urban Pipeline. The approach would involve the installation of telemetry capability for real-time monitoring during operation of the dam;
- implementation of baseline monitoring programs for pesticide and herbicide use in drinking water catchments. Monitoring should be implemented in order to ensure that there are no cumulative effects caused by the dam. If exceedance values, listed in the ANZECC guidelines, are reached then targeted monitoring upstream should be conducted in order to locate the source;
- the water quality monitoring program should also be targeted towards testing the water drawn from the outlet pipe, to ensure that water sourced by the Mt Marlay water treatment plant is of a satisfactory quality; and
- to maintain water quality conditions in Emu Swamp Dam, it will be necessary to undertake additional slashing and removal of vegetation ahead of reservoir filling in order to reduce the amount of organic matter. Increased organic matter in the dam will likely increase biological oxygen demand (BOD), increase total Nitrogen and decrease DO with an overall effect of reduced water quality. Controlled burning/slashing and removal of the grass vegetation would also be effective in removing biomass, which has grown in areas previously cleared.