7. Existing environment

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7.1 Overview

This chapter provides a description of the physical, socio-economic and cultural environment within and surrounding the Lower Fitzroy River Infrastructure Project (Project). The information provided in the chapter addresses the requirements of Part C of the terms of reference for the environmental impact statement (EIS) in relation to the existing environment.

7.2 Local climate and seasonal conditions

The nearest Bureau of Meteorology (BoM) station to the Project is Rockhampton Aero (station ID: 039083). Rockhampton, located approximately 60 km east of the Project area, is dissected by the Tropic of Capricorn and is characterised by a humid coastal and sub-coastal subtropical climate.

Climate statistics compiled for the Project area are illustrated in Figure 7-1. Analysis of the climate statistics indicates that the region experiences hot summer months from November to April. A cooler, usually dry winter period then follows from May to October. Monthly mean maximum and minimum and highest and lowest recorded temperatures are shown in Table 7-1.

The annual mean maximum temperature is 28.3°C (Table 7-1). The warmest months are November to March, with mean maximum temperatures during these months ranging from 30.5 to 32.1 °C. The coolest month is July, with a mean minimum and maximum temperature of 9.5°C and 23.1°C, respectively.

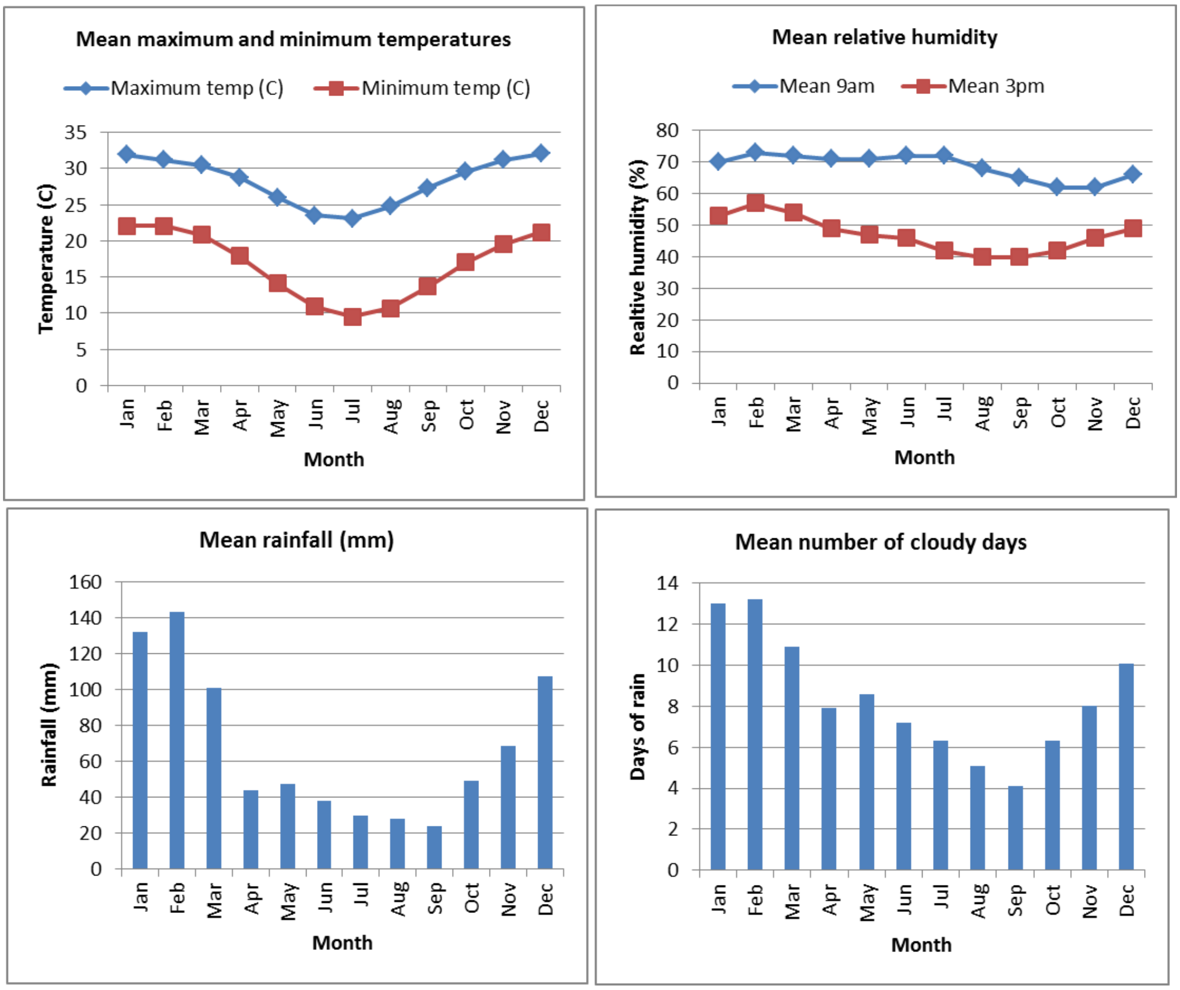
Summer rainfall months typically have a high relative humidity. Winter months have a lower relative humidity and are typically warm, mild days with cool to cold nights. Morning frosts throughout the months of May to August are common in the Project area.

Seasonal irregularity is a defining feature of the study area, with long dry spells often followed by intense wet season rainfalls. Mean annual rainfall is 811.9 mm, with recorded annual totals ranging between 360 mm in 2002 to 1,631 mm in 1973 as shown in Table 7-2. The highest daily rainfall recorded was 348 mm on 25 January 2013 and the highest monthly rainfall recorded was 660.2 mm in January 1974. Both of these events were associated with a strong, positive Southern oscillation Index (La Niña event) for Australia.

Mean daily evaporation for Rockhampton is shown in Table 7-2 and ranges from an average of 3.5 mm per day in June to 7.6 mm per day in December.

The Rockhampton area experiences winds predominantly from the south-east and east (with a frequency of around 35 to 40 per cent of the time). Average wind speeds are typically in the 10 to 20 km/h range as shown in Figure 7-3.

Figure 7-1 Climate statistics



Source: BoM 2013, Rockhampton Aero

Table 7-1 Temperature summary

Month	Mean maximum temp (°C)	Mean minimum temp (°C)	Highest recorded temp (°C)	Lowest recorded temp (°C)
January	31.9	22.1	42.5	16.3
February	31.2	22.1	43.3	16.2
March	30.5	20.8	42.1	11.0
April	28.8	17.9	35.4	4.7
May	26.0	14.1	32.6	2.9
June	23.5	10.9	32.3	**-1.0**
July	23.1	**9.5**	30.6	-0.9
August	24.8	10.7	35.1	-0.3
September	27.3	13.7	37.1	3.4
October	29.6	17.0	41.1	7.0
November	31.2	19.5	**45.3**	9.4
December	**32.1**	21.2	41.3	10.2
Annual	**28.3**	**16.6**	**45.3**	**-1.0**

Note: highest and lowest monthly mean temperatures are shown in red and blue text, respectively.

Source: BoM 2013, Rockhampton Aero

Figure 7-2 Average annual rainfall (Rockhampton)

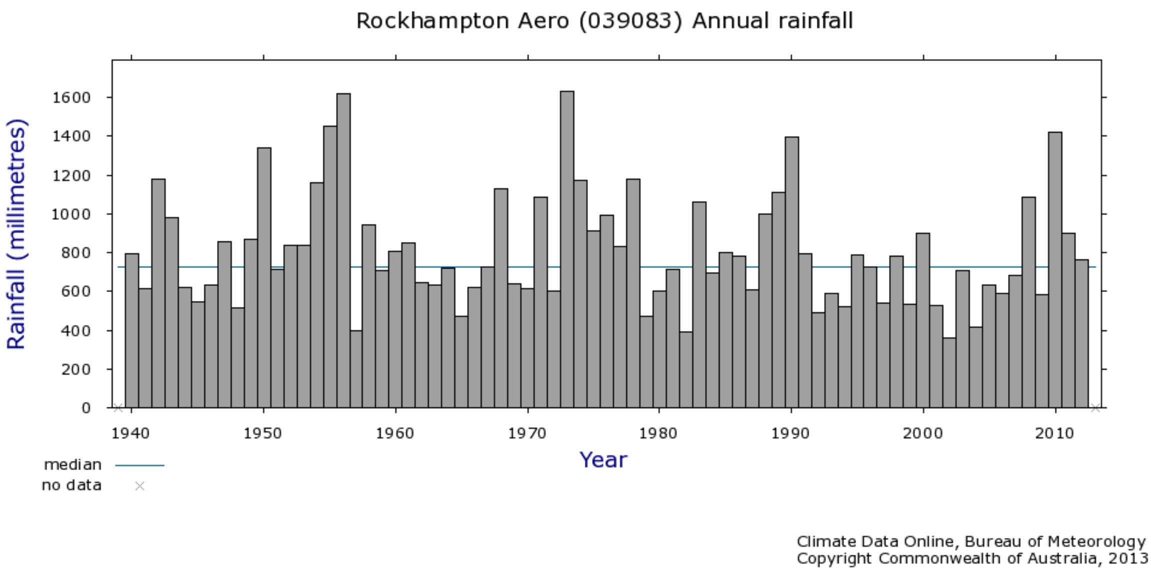
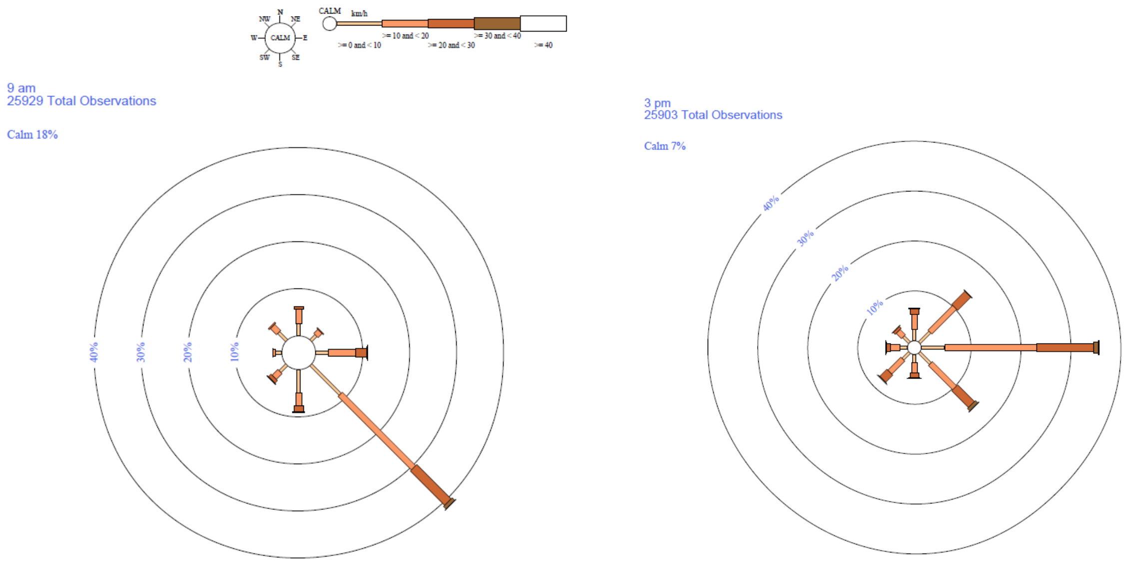


Figure 7-3 Annual wind rose 09:00 am (left) and 03:00 pm (right)



Source: Beaureau of Meterology 2013, Rockhampton Aero

Table 7-2 Evaporation summary

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily evaporation (mm)	7.3	6.5	6.2	5.3	4.1	3.5	3.6	4.4	5.7	6.8	7.5	7.6	**5.7**

Source: BoM 2013, Rockhampton Aero

7.3 Extreme environmental events

7.3.1 Floods

The Fitzroy Basin is described as having an immense size and fan-like shape which is capable of producing severe flooding following heavy rainfall events (BoM 2011). Major floods can result from either the Dawson or the Mackenzie Rivers. Significant flooding in the Rockhampton area can also occur from heavy rain in the local area below Riverslea, which is near the proposed Rookwood Weir site.

The Fitzroy River at Rockhampton has a long and well-documented history of flooding with flood records dating back to 1859. The highest flood occurred in January 1918 and reached 10.11 m on the Rockhampton gauge[1] (8.65 m Australian height datum (AHD)). In 2010/2011 the Fitzroy River reached 9.20 m on the Rockhampton gauge (7.75 m AHD) (BoM 2011) (approximately 4 m higher that the full supply level of the Fitzroy Barrage impoundment at 3.78 m AHD). More recently in late January/early February 2013, ex-Tropical Cyclone Oswald produced heavy to intense rainfall over the eastern Australian coast and resulted in major flooding of the Connors, Isaac, Mackenzie

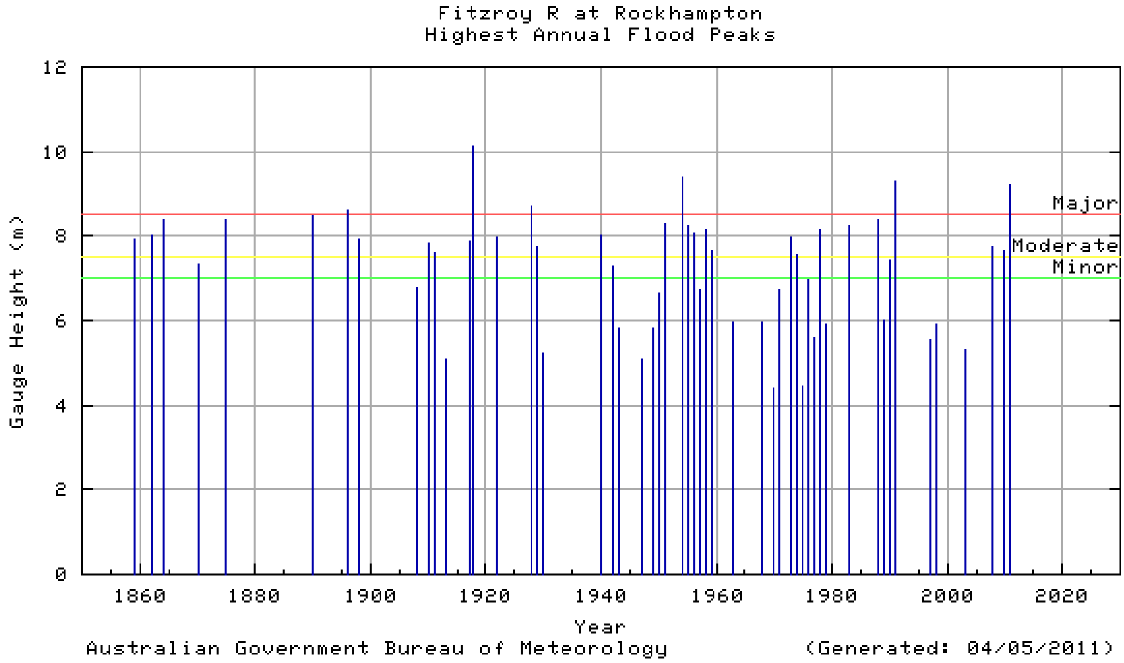
[1] The Rockhampton gauge (Bureau station number 039264) is on the Fitzroy River at 56.6 km AMTD and the reduced level of the gauge zero is -1.450 m AHD.

and Fitzroy rivers (amongst others). At the Rockhampton gauge, the Fitzroy River peaked at 8.60 m (BoM 2013a).

Figure 7-4 shows significant flood peaks in the Fitzroy River at Rockhampton and indicates major, moderate and minor flood peaks defined by BoM (2013b) as follows:

- **Minor flooding:** Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged
- **Moderate flooding:** The area of inundation is substantial in rural areas requiring the removal of stock. Main traffic routes may be submerged and the evacuation of some houses may be required
- **Major flooding:** Extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required.

Figure 7-4 Significant flood peaks – Fitzroy River, Rockhampton



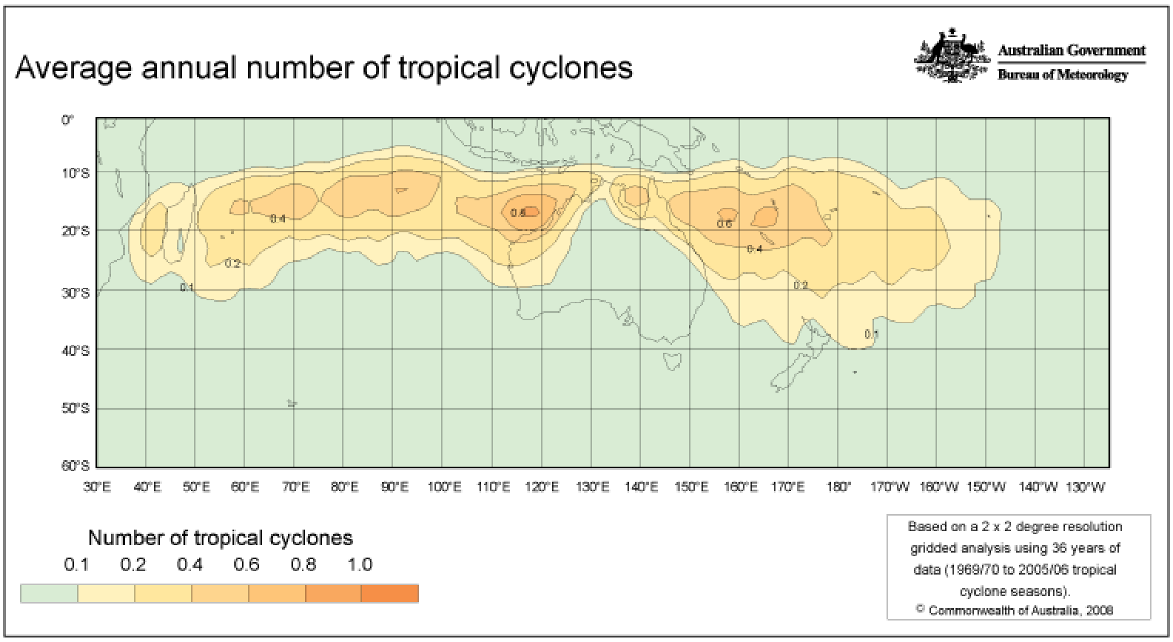
In general in the region, the flood extents for the current 1 in 2 annual exceedance probability (AEP) event are typically contained within the river banks. Anabranch flows develop during the 1 in 5 AEP event. Flooding starts becoming quite extensive across the river floodplains and anabranches start to run full during a 1 in 20 AEP event. Further detail on flood hydrology and hydraulics is provided in Appendix P.

7.3.2 Tropical cyclones

Tropical cyclones are defined as low pressure systems that form over warm tropical waters and have well defined wind circulations of at least gale force strength (sustained winds of 63 km/h or greater with gusts in excess of 90 km/h). The Project area is located within the Australia Eastern Region for cyclone activity. The cyclone season occurs each year from November through to April although cyclones are known to occur outside of this period. Strong winds, heavy rains, flooding and storm surges can be associated with cyclone activity.

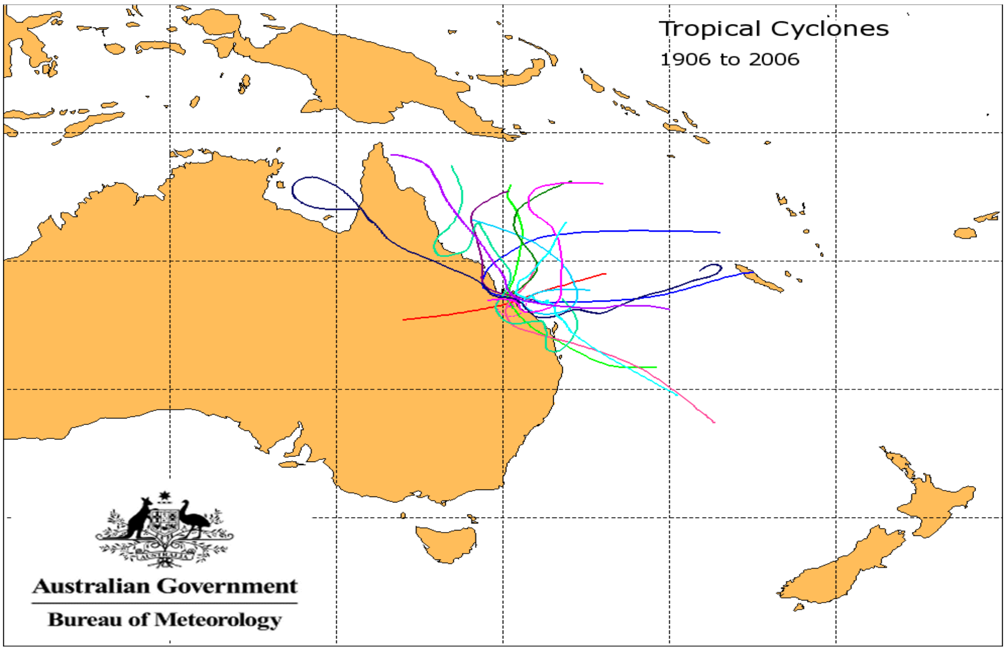
Figure 7-5 shows the average number of tropical cyclones through the Australian region and surrounding waters based on a 36 year period from the 1969/70 to 2005/06 tropical cyclone season (BoM 2013b).

Figure 7-5 Average annual number of tropical cyclones (1969/70 – 2005/06)



For the period 1906 to 2006, 42 cyclones have been recorded crossing within 200 km of Rockhampton. Of these, 12 cyclones were recorded crossing within 100 km of Rockhampton as shown in Figure 7-6. Five of these occurred in February, two in January and one in December, March, April, May and June. One unnamed cyclone passed within 50 km of Rockhampton in February 1949. In more recent times (early 2013), ex-tropical Cyclone Oswald produced heavy rainfall and flooding in the Project areas.

Figure 7-6 Recorded tropical cyclones within 100 km of Rockhampton (1906-2006)



7.3.3 Severe storms

Severe storms are localised events usually affecting smaller areas than tropical cyclones. A severe thunderstorm is defined by the BoM (ND) as one which produces: hail with a diameter of 2 cm or more, wind gusts of 90 km/h or more; flash floods, tornadoes or any combination of these.

Severe storms in the region are generally confined to the spring and summer months (Fitzroy Shire Council and Rockhampton City Council 2007) and occur on average at least twice per year (Aurecon 2012). The effects of storms are usually localised and may include damage from torrential rain and flash flooding, high wind, hail and lightning which pose a risk due to economic loss and fatalities. Flash flooding from these events can be quite damaging, for example rainfall intensities of 600 mm in 56 hours were recorded in Yaamba in 1994 and 200 mm in 3 hours in Rockhampton in 2008 (Aurecon 2012). These rainfall events were equivalent to 100 year to 150 year average recurrence interval (ARI) events.

The average thunderstorm in the Rockhampton area has an 8 km wide front and a path up to 64 km long. The highest recorded wind speed in Rockhampton is 159 km/h for a severe storm in November 1971 and this compares to recorded wind speeds of 161 km/h during the tropical cyclone from the 7 to 16 February 1949 (Aurecon 2012).

7.3.4 Drought

Like much of Central Queensland, the Project area frequently experiences drought conditions, the most recent being between 2000 and 2007. Hydrographs presented in Section 7.5.2 show that during drought conditions, wet season flows were sustained at a similar magnitude to those occurring historically but over a shorter period of the season, whilst dry season flows generally decreased throughout the season.

Project demand triggers may arise as result of drought conditions in the region (Chapter 1 Description of the action). Yield estimates for the Project and the influence that drought may have on yield are discussed in Appendix P.

7.3.5 Extreme temperatures

Maximum temperatures in Queensland typically occur between November and February but days of excessive heat have been known to occur anytime between October and March (Aurecon 2012). Using the threshold for temperature within the top 5 per cent of daily maximum temperatures for a continuous three-day period, Queensland has experienced at least 18 heatwave events since 1899 giving an ARI of 5 to 6 years (Aurecon 2012). Of these, 10 occurred in January, three in December, two in March, two in November and one in February. The highest temperature recorded was 45.3 ºC in November 1990. Monthly mean maximum and minimum and highest and lowest recorded temperatures are shown in Table 7-1.

The preparation and implementation of workplace health and safety procedures would reduce the risk to site staff of dehydration, heat stroke and sunburn. Appropriate design standards will facilitate functionality of operational components, for example the operational control building is fitted with appropriate air-conditioning to protect electrical equipment.

Extreme cold temperatures are not considered a hazard in the region with the lowest average minimum temperature being 9.5 °C (Table 7-1).

7.3.6 Bushfires

The Queensland Government's State Planning Policy mapping identifies the areas within and adjacent to the Eden Bann Weir Project footprint as medium to very high risk bushfire hazard areas. The areas along the Fitzroy River within and adjacent to the Rookwood Weir Project footprint are classified as medium to high risk while areas along the Mackenzie and Dawson rivers are generally classified as medium risk with a few areas of high risk.

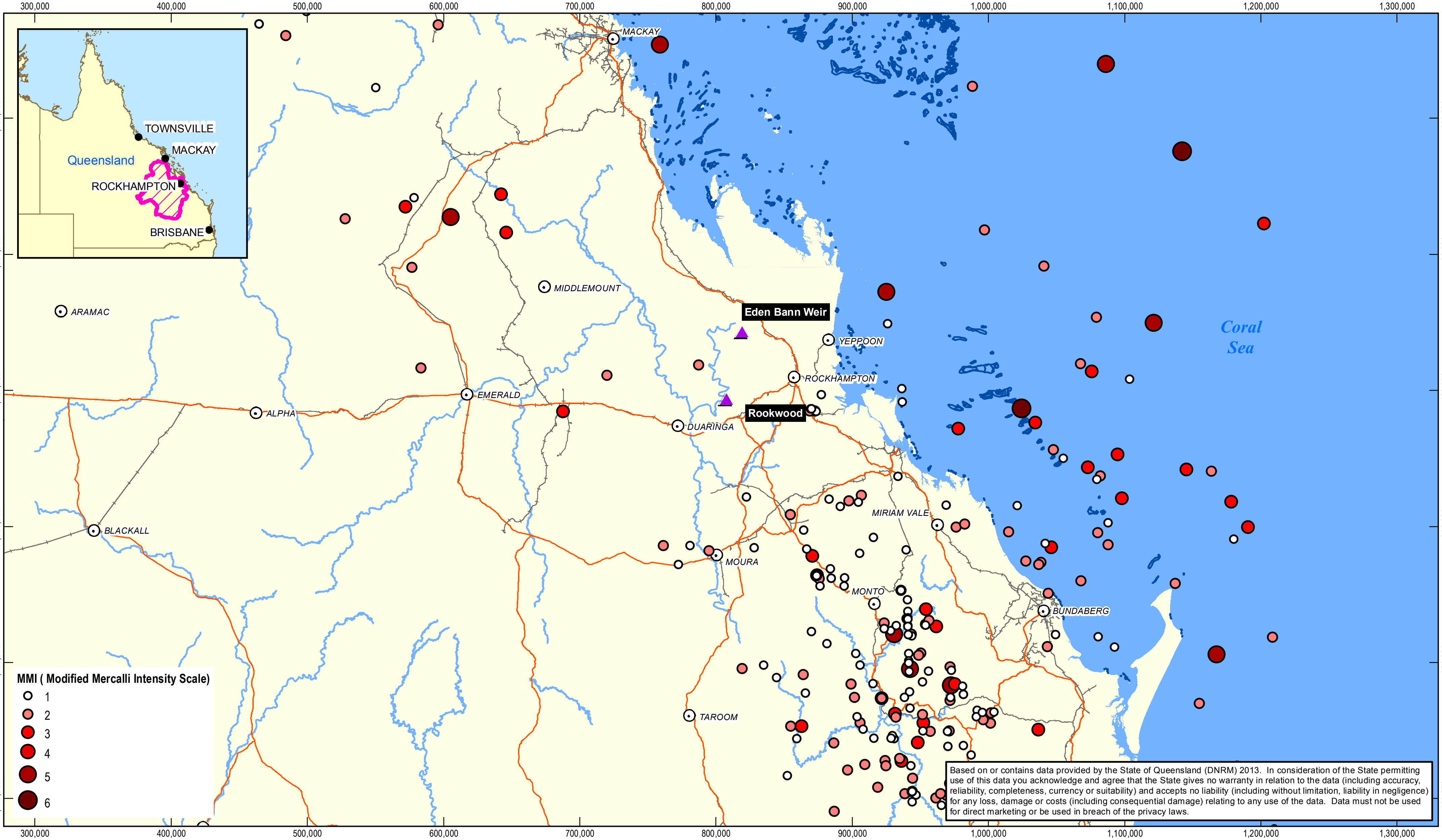
7.3.7 Seismic activity

A seismic hazard assessment undertaken for the Project by the Seismology Research Centre (a division of Environmental Systems and Services) informs this section. Due to Australia's position within a major tectonic plate, its relative tectonic activity is low compared with countries situated near plate boundaries, where high activity is attributed to relative plate movement. Australia does however experience intraplate stress (typically horizontal compression) due to the collision and thrusting of the Indo-Australian plate under the Eurasian plate. The rate of accumulation of this stress is low and consequently earthquakes allowing the release of the stresses are less frequent. A low level of activity does not imply that large damaging earthquakes do not occur but rather that long recurrence intervals between such events exists.

The earthquake catalogue shows the Project area to be below average in recorded seismicity in relation to the rest of Australia. Figure 7-7 shows earthquakes recorded in Queensland since the 1960s.

Earthquakes resulting in Modified Mercalli Intensity[2] (MMI) 3 and above (vibrations which are strong enough to be felt) within 200 km of the Eden Bann Weir and proposed Rookwood Weir site are presented in Table 7-3.

[2] MMI provides a physical description of the effects of shaking that can be expected at a specific locality and indicates the severity of an earthquake (ESS 2009).



1:3,735,000 (at A4)

0 25 50 75 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Populated places
- Weir Location
- Highways (National)
- Railway
- Waterway (Major)
- Fitzroy Catchment
- Reef

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Lower Fitzroy River Infrastructure Project

Job Number	41-20736
Revision	C
Date	01 Aug 2014

Earthquakes recorded in Queensland from 1960 to 2013

Figure 7-7

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Level 9, 145 Ann Street Brisbane QLD 4000 Australia T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007), Earthquakes (2013); Sunwater: Weir Locations - 2008; DNRM: Railways, Roads, Reef (2010).
Created by: MS *See Appendix for disclaimers and copyrights.

Table 7-3 Earthquakes resulting in MMI 3 and above

Date/time	Place	Distance from the Project (km)	Depth (km)	Richter magnitude (ML)	Intensity (MMI)
06/06/1918, 18H14	Bundaberg	Eden Bann Weir: 248 Rookwood: 253	10	6.0	3
06/12/1989, 22H00	Bowen Basin	Eden Bann Weir: 45 Rookwood: 55	4	4.0	3
02/11/1998, 17H09	Swain Reefs	Eden Bann Weir: 110 Rookwood: n/a	0	4.7	3

The Project area is predicted to experience earthquake intensities of MMI 3 approximately every 18 years. Intensities of MMI 6 (when standard housing experiences damage) are expected to occur approximately once every 871 years for Rookwood Weir and once every 902 years for Eden Bann Weir. Waves are reported to be seen on lakes and ponds at intensities of MMI 7 predicted to occur every 4,000 years and 3,840 years at Eden Bann Weir and Rookwood Weir, respectively. Intensities of MMI 10 and higher will cause damage to dams and embankments. Intensities of MMI 10 are predicted to occur every 270,000 years for Eden Bann Weir and every 290,000 years for Rookwood Weir.

7.4 Air quality

Air pollution sources on a regional scale, ascertained by a search of the National Pollutant Inventory (NPI), identified that the Rockhampton region's (post code 4700) indicative top pollutant sources for the 2010/2011 reporting period were from:

- Water supply, sewerage and drainage services (ammonia)
- Mineral, metal and chemical wholesaling (toluene, total volatile organic compounds, xylenes)
- Waste treatment, disposal and remediation activities (carbon monoxide and hydrogen sulphide) (Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2011a).

The largest air pollutant was identified as ammonia (6,400 kg/year) from water supply, sewerage and drainage services, specifically the South Rockhampton Sewage Treatment Plant. This was followed by approximate total emissions of Total Volatile Organic Compounds (VOCs) of 520 kg/yr from mineral, metal and chemical wholesaling (DSEWPaC 2011a).

The NPI search was also conducted for the Ridgelands, Morinish and Glenroy regions (post code 4702), whose post code also encompassed the coal mining towns of Emerald, Blackwater and Moura (DSEWPaC 2011b). This was a broad scale search and while the results are skewed by the influence of coal mining in the region, the influence of Stanwell Power Station on ambient air quality is also evident. Stanwell Power Station is a coal fired power station located approximately 22 km west of Rockhampton, 30 km south of Eden Bann Weir and 30 km east of the proposed Rookwood Weir site. The NPI search identified that the indicative top pollutant sources for the 2010/2011 reporting period were from:

- Electricity generation (24 different substances emitted)
- Coal mining (31 different substances emitted)

- Other non-metallic mineral product manufacturing (23 different substances emitted)
- Sheep, beef cattle and grain farming (8 different substances emitted, primarily ammonia)
- Cement, lime, plaster and concrete product manufacturing (17 different substances emitted)
- Other non-metallic mineral mining and quarrying (53 different substances emitted) (DSEWPaC 2011b).

The largest air pollutant was identified as oxides of nitrogen (approximately 27,750,000 kg/yr) primarily from electricity generation. This was followed by approximate total emissions of PM_{10} µm (approximately 27,440,000 kg/yr) primarily from coal mining. Sulfur dioxide was the third highest air pollutant (approximately 25,000,000 kg/yr) primarily from electricity generation (DSEWPaC 2011b).

The Project area is remote and rural in nature, not located within or in proximity to industrial, manufacturing or mining zones and not associated with feedlots or intensive cropping. Land use at both Eden Bann Weir and the proposed Rookwood Weir site comprise broad scale cattle grazing operations. As such the ambient background levels of gaseous pollutants and odours described above is considered to be negligible but the 'natural' dust load is considered to be important for the assessment.

Local anthropogenic sources of air emissions include:

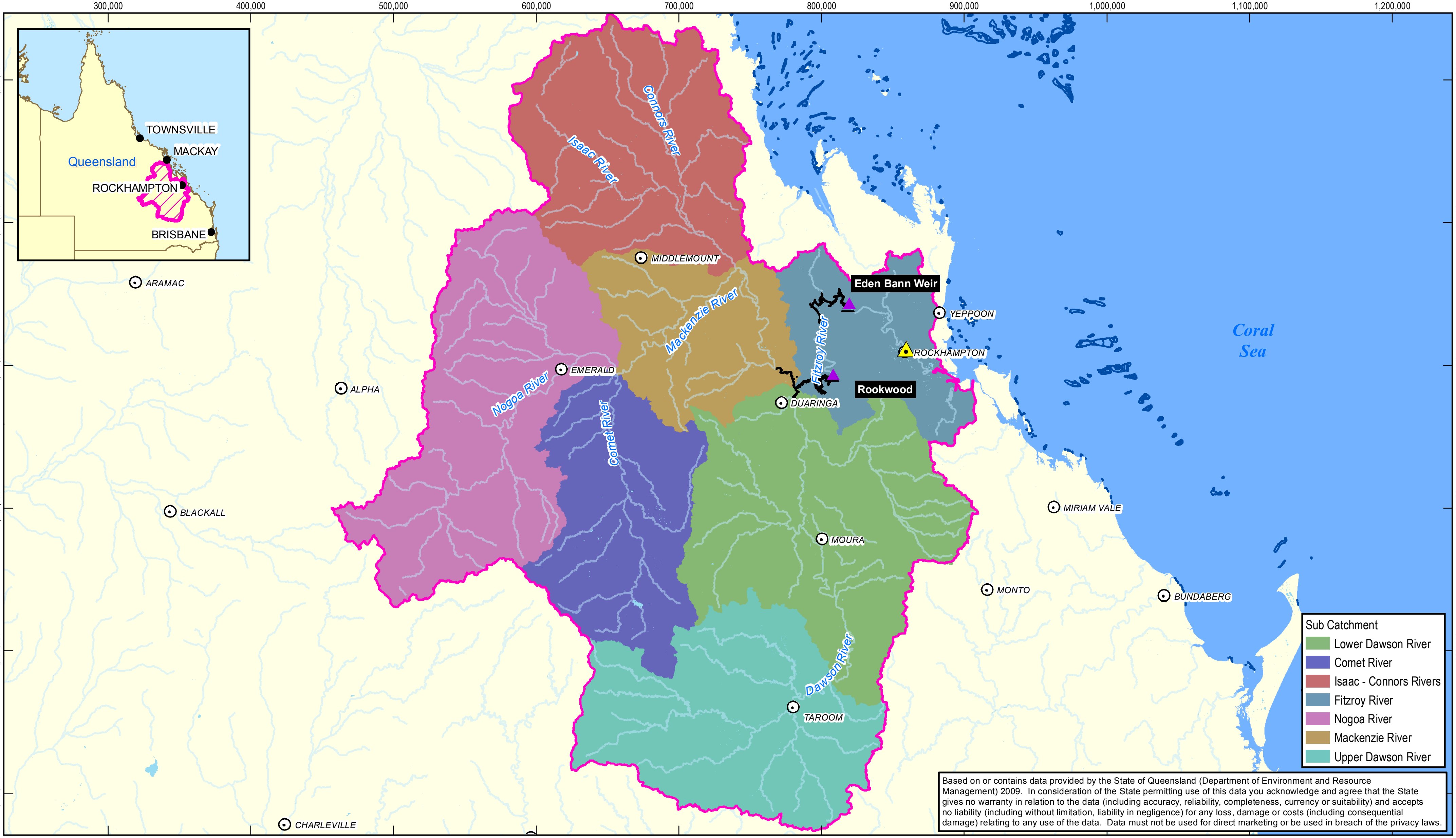
- Dust emissions from cattle grazing operations and associated clearing
- Dust emissions from vehicles travelling on unsealed roads
- Exhaust emissions from vehicles using local roads
- Gases and fine particle emissions from bushfires and controlled burns.

7.5 Surface water

7.5.1 Catchment and sub-catchment characteristics

The Fitzroy Basin is the largest catchment on the eastern seaboard of Australia (approximately 142,000 km^2 in extent) and consists of six major sub-catchments for the purposes of water resource planning, namely: Isaac / Connors; Nogoa; Comet; Mackenzie; Dawson; and Fitzroy as shown in Figure 7-8. These sub-catchments are regulated through the following water supply schemes:

- Dawson Valley Water Supply Scheme: proposed Nathan Dam, Glebe Weir, Gyranda Weir, Orange Creek Weir, Theodore Weir, Moura Weir and Neville Hewitt Weir
- Nogoa Mackenzie Water Supply Scheme: Fairbairn Dam, Selma Weir, Bedford Weir, Bingegang Weir and Tartrus Weir
- Lower Fitzroy Water Supply Scheme: Eden Bann Weir
- Fitzroy Barrage Water Supply Scheme: Fitzroy Barrage.



1:3,600,000 (at A4)

0 25 50 75 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- Fitzroy Barrage
- Waterway (Major)
- Waterway (Minor)
- Fitzroy catchment
- Lakes
- Impoundment area

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Lower Fitzroy River Infrastructure Project

Job Number	41-20736
Revision	D
Date	29 Aug 2014

Fitzroy Basin and Sub-catchments

Figure 7-8

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Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Weir Locations - 2008; DERM: Sub-catchments - 2012. Created by: AJ/MS *See Appendix for disclaimers and copyrights.

Although sparsely populated, the Fitzroy Basin has been largely modified for human land use practices. Agricultural production accounts for almost 90 per cent of land use with 81.7 per cent being livestock grazing (Johnston et al. 2008). Other notable land uses include State Forest (6.65 per cent), nature conservation (4.54 per cent) and mining (0.38 per cent (Johnston et al. 2008). Existing mining activities are concentrated in the northern and western parts of the Basin. As of 2008, approximately 55 mines (45 of which were coal mines) and 20 medium-to-large quarries were located in the central Queensland region, of which a large number occur within the Fitzroy Basin.

In order to support human activities (i.e. agriculture, mining, industry, urban centres) in a climatically-variable system, rivers within the Fitzroy Basin have been heavily regulated with five dams (large and small), 11 weirs and a large tidal barrage. These include Fairbairn Dam, Glebe Weir, Gyranda Weir, Orange Creek Weir, Theodore Weir, Moura Weir, Neville Hewitt Weir, Bedford Weir, Bingegang Weir, Tartrus Weir, Eden Bann Weir and the Fitzroy Barrage (Marsden and Power, 2007). Nathan Dam is proposed on the Dawson River within the Basin, along with the Project.

The aquatic ecosystems within the Fitzroy Basin are host to a range of aquatic flora and fauna species, several of which are endemic to the area (Section 7.9). The Basin supports high native freshwater fish diversity.

Eden Bann Weir and the proposed Rookwood Weir are located within the Fitzroy sub-catchment and the impoundment associated with Rookwood Weir will affect the lower reaches of the Mackenzie and Dawson sub-catchments.

The Fitzroy sub-catchment is dominated by the Fitzroy River that forms from the confluence of the Mackenzie and Dawson Rivers (at 310 km adopted middle thread distance (AMTD)), and flows out to the Great Barrier Reef World Heritage Area. Two water storage infrastructure developments currently occur within the Fitzroy sub-catchment; Eden Bann Weir (at 141.2 km AMTD); and the Fitzroy Barrage (at 59 km AMTD) which is located in Rockhampton. Land clearing has occurred extensively where agricultural production occurs adjacent to the Fitzroy River. However, fringing woodland and alluvial floodplain vegetation has been retained along much of the river (including where agricultural activities are practiced). Rocky hills and ranges which are unsuitable for grazing also retain relatively larger, better connected patches of woodland vegetation.

The Dawson sub-catchment dominates the south eastern part of the Fitzroy Basin. The Dawson River originates in the Carnarvon and Expedition Ranges north of Injune, from where it flows to the south east towards Taroom before changing to a northerly course until it meets the Mackenzie River. Five weirs occur on the Dawson River, including Glebe Weir, Gyranda Weir, Theodore Weir, Moura Weir and Neville Hewitt Weir. The landscape adjacent to the lower reaches of the Dawson River is predominantly flat. Land use is dominated by agricultural practices, particularly cattle grazing and cropping (i.e. wheat). While woodland vegetation in the riparian zone and adjacent alluvial floodplain has been retained in many places, significant tracts of land behind this vegetated buffer have been cleared (either partially or completely) to facilitate agricultural production.

The Mackenzie River forms from the confluence of the Nogoa and Comet Rivers. Water storage infrastructure along the Mackenzie River includes Bedford Weir, Bingegang Weir and Tartrus Weir. Located upstream of the Mackenzie River confluence on the Nogoa River is Fairbairn Dam. Water is extracted from these storages for crop irrigation, coal mining, and urban consumption.

Agricultural production is also the dominant land use adjacent to the lower Mackenzie River. The landscape has been substantially modified through land clearing to accommodate cattle grazing.

The Fitzroy Basin has fairly low levels of severely salt-affected land, but there are some areas where extensive land-use change has occurred in areas with high potential for salt mobilisation. Salinity hazard mapping[3] (reflecting the potential for salt mobilisation) within the study area indicates a low to moderate salinity hazard. Naturally-occurring salts occur in soils of the Fitzroy Basin.

Point-source inputs from mining operations in the Fitzroy Basin contribute to temporary increases in salinity in waterways. In particular, de-watering of mines (coal) contributes elevated concentrations of salts and non-natural organic compounds to waterways of the catchment (Johnston et al. 2008). Following the flood events of January 2008, in the order of 138 GL of mine-affected water was discharged from flooded mines between February and September 2008. Discharge occurred from multiple sources within the Fitzroy Basin, particularly within the Isaac-Connors sub-catchment (Hart 2008). Major concerns of the impacts of this discharge on water quality in the catchment were increased salinity, increased concentrations of metals and variations in pH (DERM 2009). Hart (2008) reports that high salinity most likely posed no catastrophic effects (i.e. major fish kills) and salinity levels post dewatering have reduced. Mine water releases have continued in subsequent wet years due to high rainfall events and ongoing releases are being made through the Queensland Government coal mine water release pilots (Queensland Government 2013).

7.5.2 Historic and current flow regimes

To characterise flows within the Fitzroy, Mackenzie and Dawson Rivers (as reflective of flows in the Project area) flow data from four Department of Natural Resources and Mines (DNRM) stream gauging stations (The Gap, Riverslea, Coolmaringa and Beckers[4]) was assessed. A common historic period of data was determined as the period 1974 to 2009. Flow patterns for a more 'current' period (that is the last ten years of data[5]) were evaluated by interrogating data for the period 1999/2000 to 2009.

For each dataset (that is at each gauging station), and for each period within the dataset (that is historic and current records), the following information has been prepared to inform discussion on stream flow characteristics in the Project area:

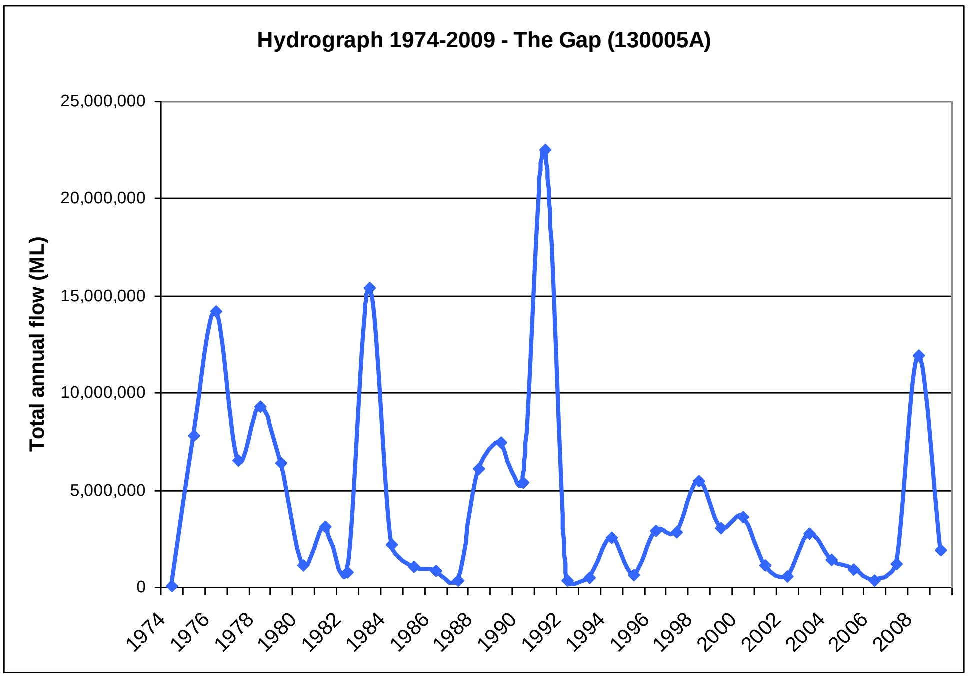
- Hydrographs presenting flow discharges and the longer term variability in flows (as total annual flow) as shown in Figure 7-9 and Table 7-10 for the historic and current periods, respectively at each gauging station
- Flow duration curves summarising the range and distribution of flows as shown in Figure 7-11 for the historic and current periods at all selected gauging stations

[3] Source: http://www.nrm.qld.gov.au/salinity/pdf/fitzroy_map.pdf

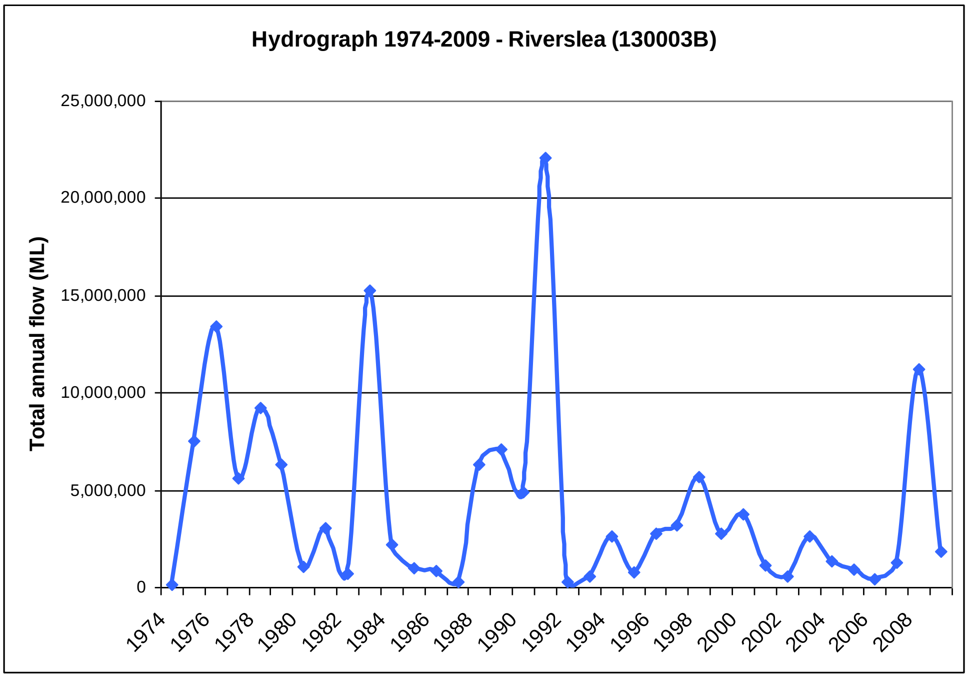
[4] Stream flow data is not available from the BoM station at Laurel Bank, located approximately 12 km upstream from the Fitzroy Barrage. This station does not record stream flow data but rather acts as a flood warning river height station.

[5] Data analysis was undertaken in 2009. It is considered that for the purposes of the EIS the datasets interrogated reflect the historic and current flow regimes within the Fitzroy, Dawson and Mackenzie Rivers. The period analysed incorporates the recent prolonged drought years. Further, no new areas have been regulated and operational regimes of the system remain largely unchanged from 2009.

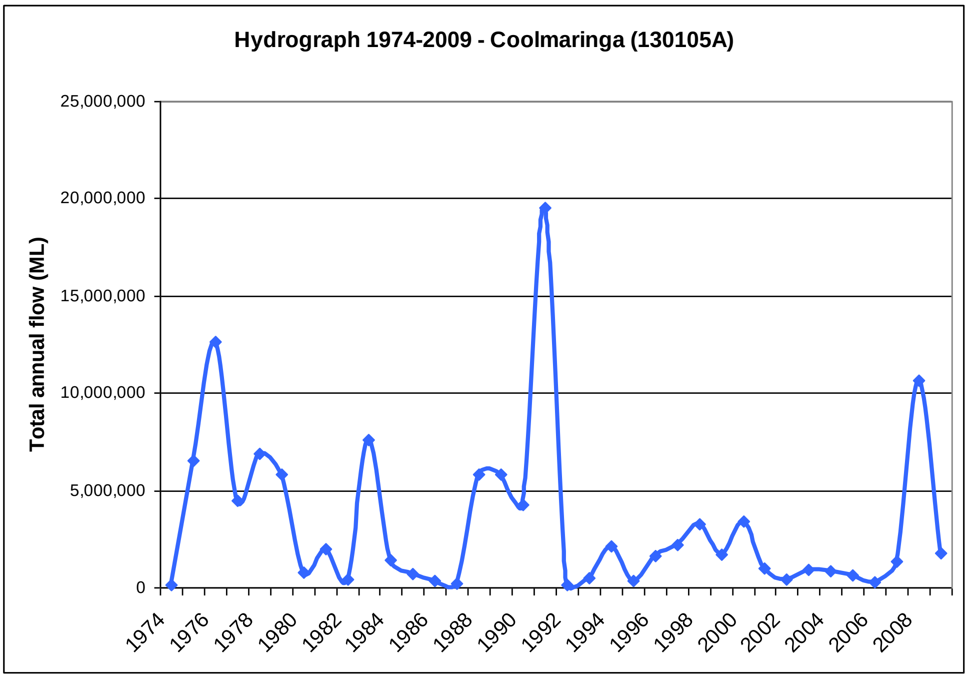
Figure 7-9 Hydrographs for the historic period (1974 – 2009)



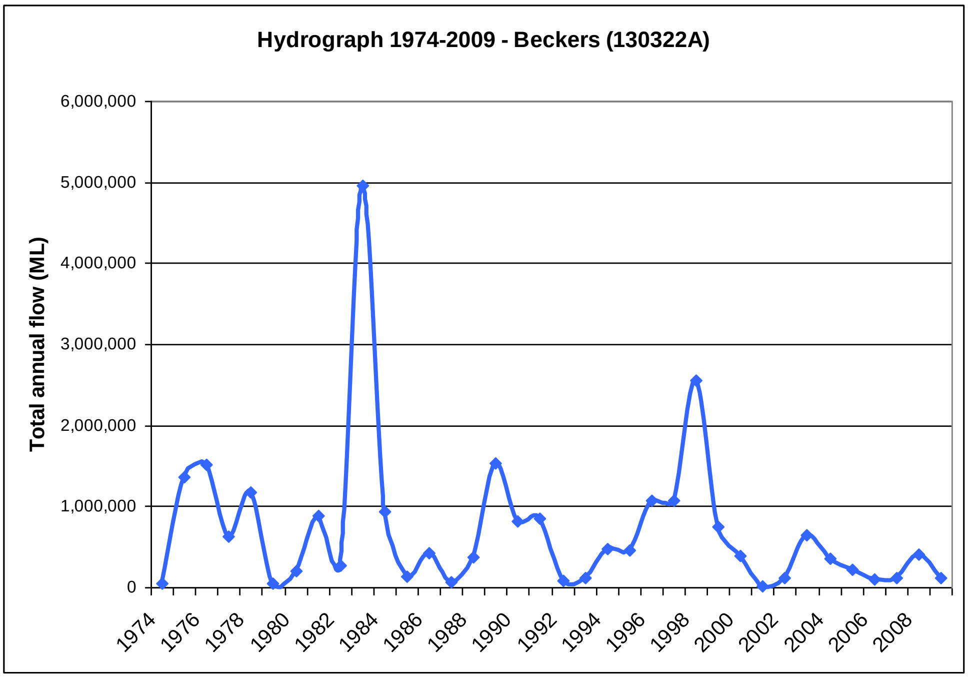
(a) The Gap gauging station (130 005A) (Fitzroy River)



(b) Riverslea gauging station (130 003B) (Fitzroy River)

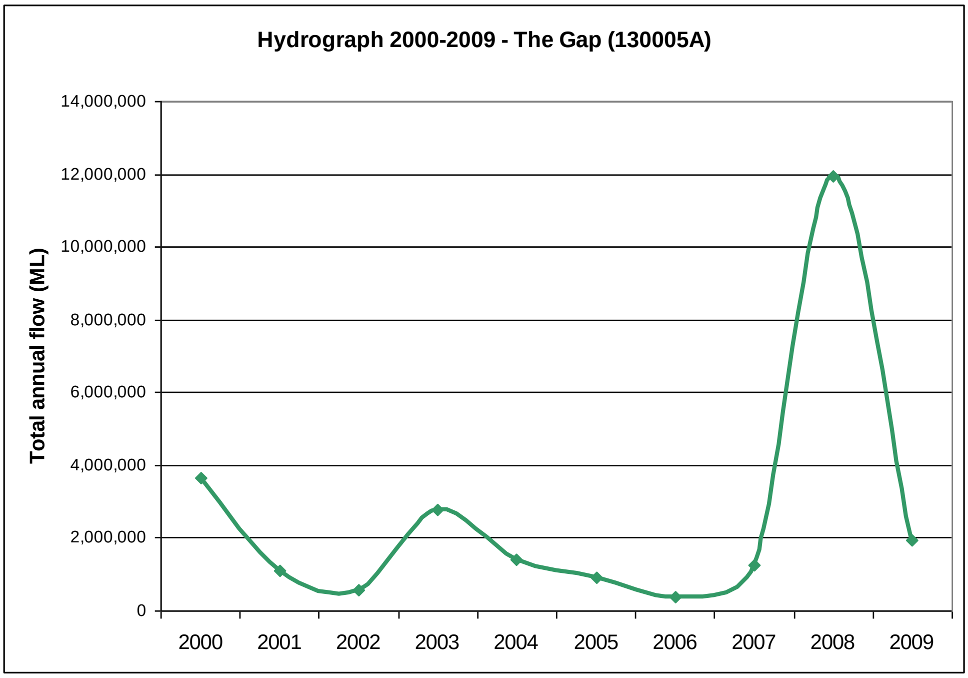


(c) Coolmaringa (130 105A) gauging station (Mackenzie River)

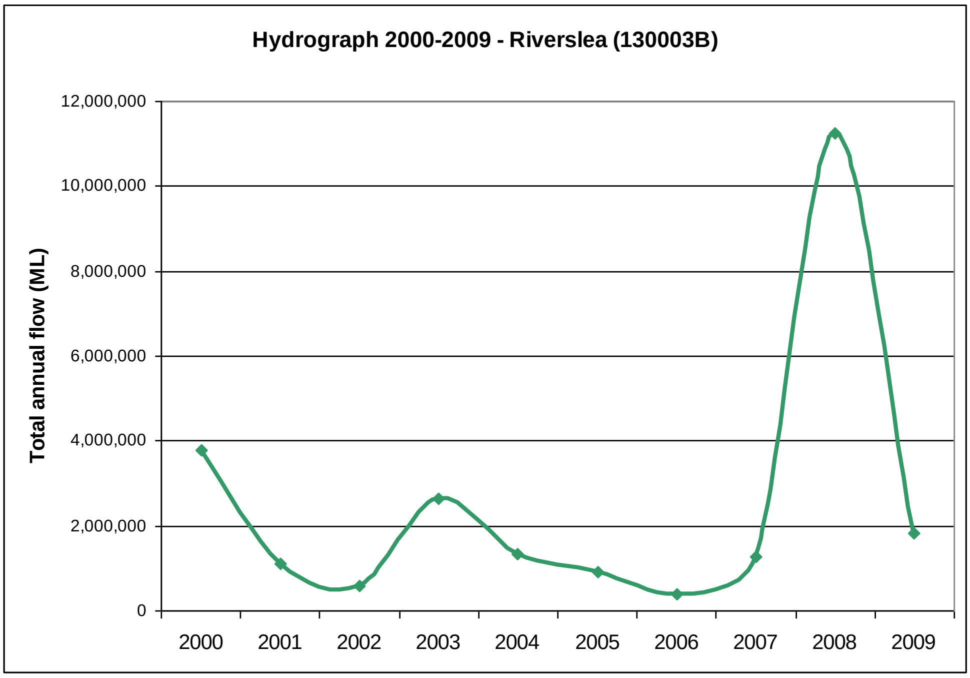


(d) Beckers gauging station (130 322A) (Dawson River)

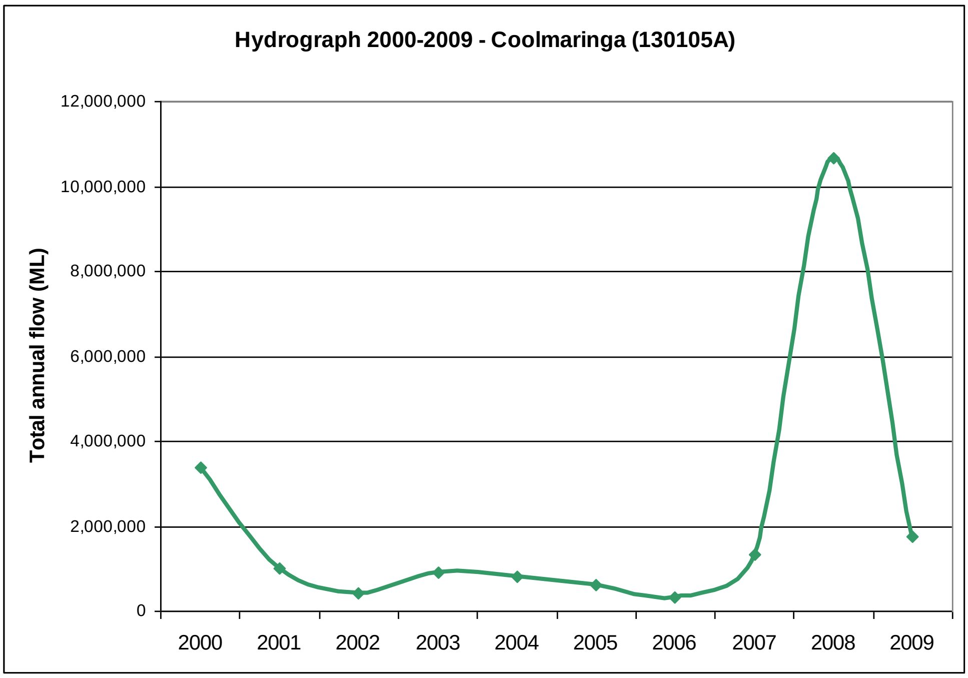
Figure 7-10 Hydrographs for the current period (1999 – 2009)



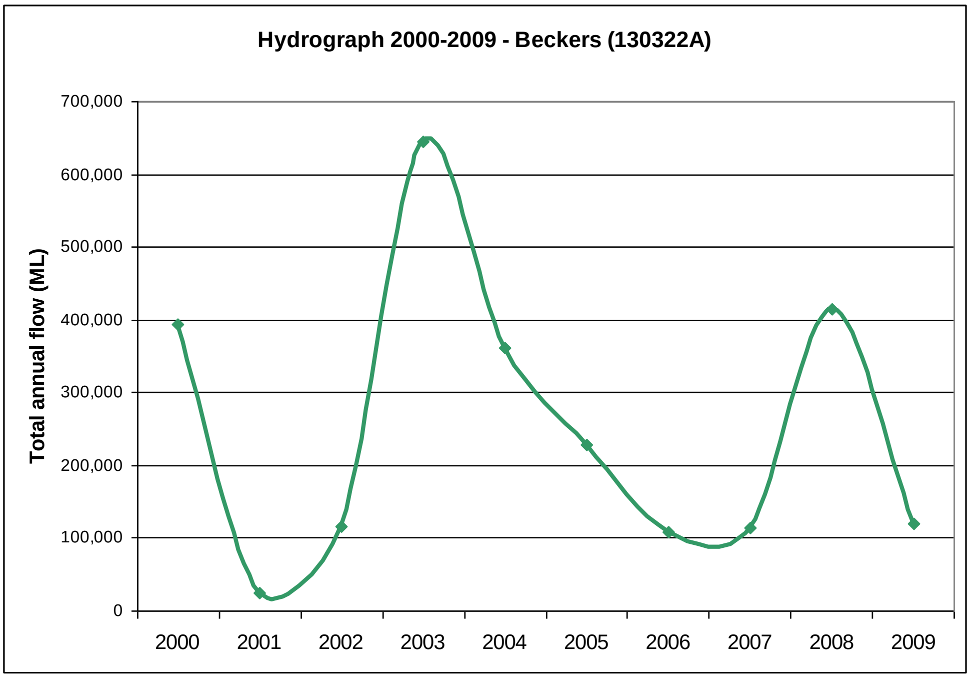
(a) The Gap gauging station(130 005A) (Fitzroy River)



(b) Riverslea gauging station (130 003B) (Fitzroy River)



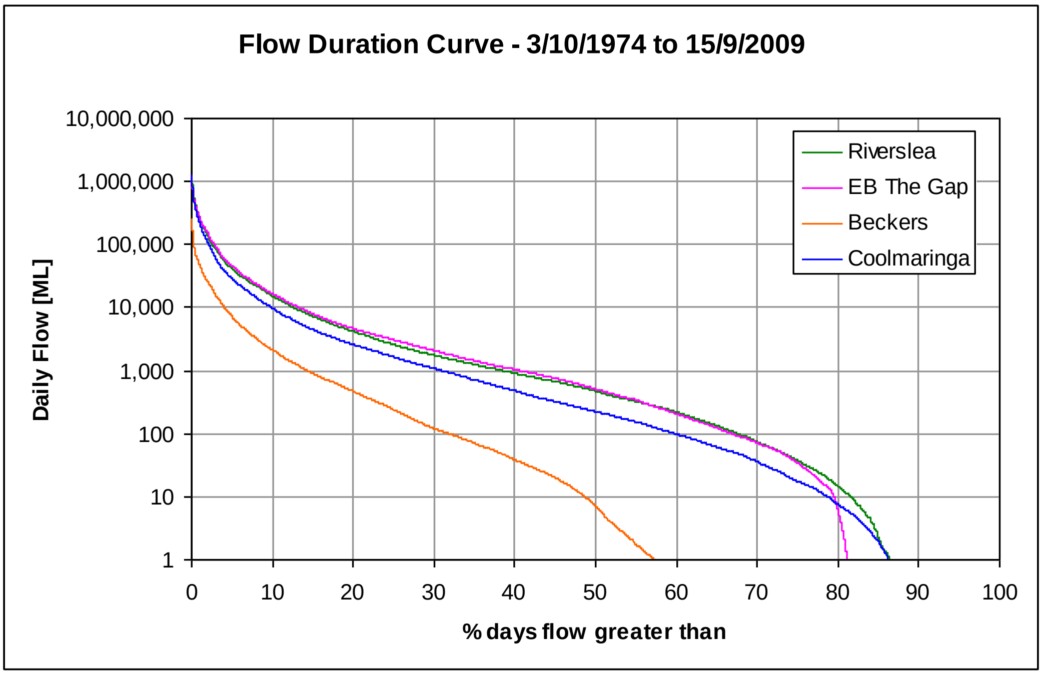
(c) Coolmaringa (130 105A) gauging station (Mackenzie River)



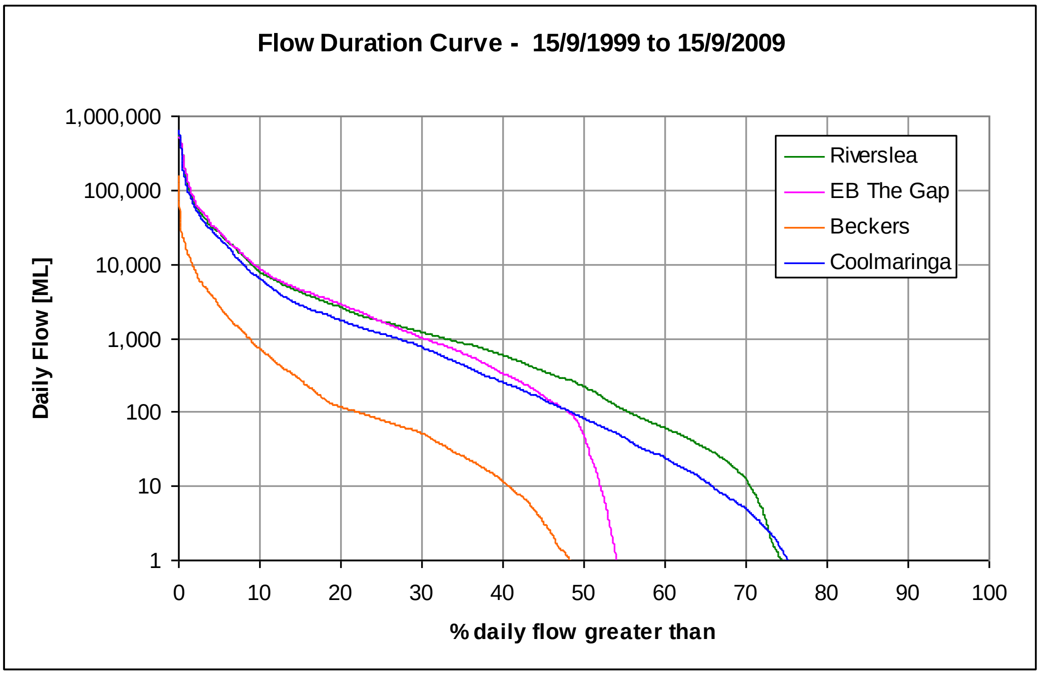
(d) Beckers gauging station (130 322A) (Dawson River)

Figure 7-11 Flow duration curves for the historic and current periods

(a) Historic period (1974 – 2009)



(b) Current period (1999 – 2009)



- The average total monthly flow (in megalitres (ML)) reflecting the seasonal variability in flow as shown in Figure 7-12 historic and current periods for each gauging station.

Rainfall in the Fitzroy Basin is highly variable. However rainfall generally decreases with increasing distance from the coast along with topographical influences. High rainfall events are generally associated with monsoonal conditions or tropical cyclones in summer along with thunderstorms, which occur more frequently in inland parts of the Fitzroy Basin (Keane 2004). Winter rainfall generally results from cold fronts and upper trough systems. This variable rainfall and subsequent runoff influence flows in river systems within the Fitzroy Basin and its sub-catchments, including the Fitzroy, Mackenzie and Dawson rivers (Keane 2004). Prolonged dry conditions and drought are also characteristic features of the region (Section 7.3.4).

Flows in the Mackenzie River (and subsequently the Fitzroy River) are erratic and largely driven by cyclonic action, severe storms and tropical low pressure systems characteristic of the north of the Fitzroy Basin.

These highly variable and unpredictable flows are clearly shown in hydrographs presented in Figure 7-9 (specifically (a), (b) and (c) for the Fitzroy River at The Gap and Riverslea, and the Mackenzie River at Coolmaringa, respectively). Historically total annual flows range from almost zero to 22,500,000 ML. Peak flows generally coincide with extreme weather events, in particular flood events that occurred during the recording period in 1978, 1983, 1991 and 2008. The extended period of low flows reflect the prolonged drought of 2001 to 2007.

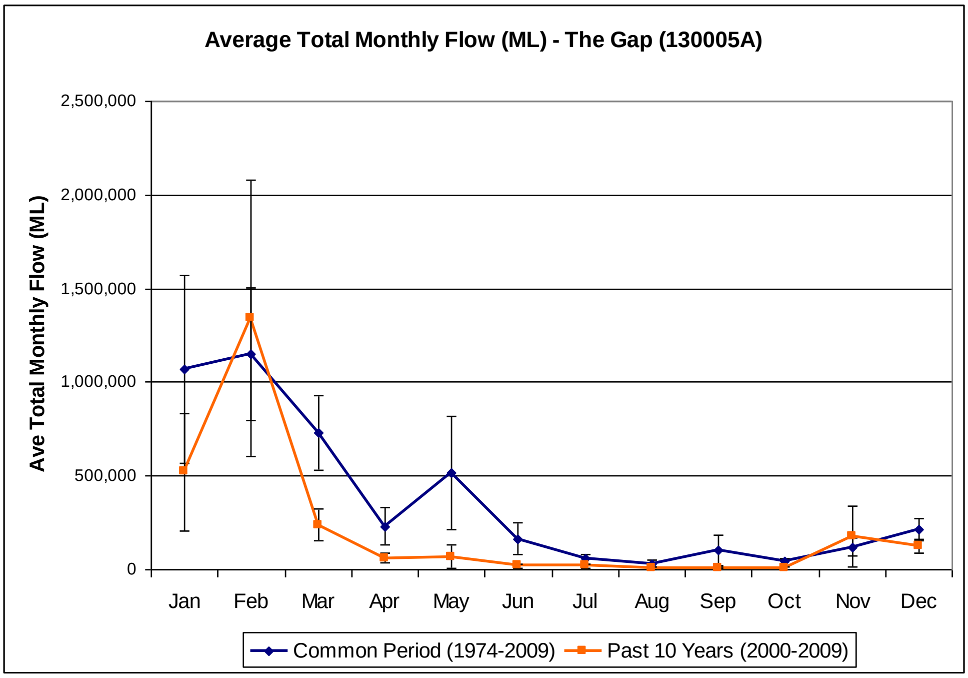
Data graphs for last ten years indicate the effects of the prolonged drought period that was experienced from 2001 to 2007.

While the Dawson River also exhibits variable flows, the order of magnitude is much reduced (between zero and 5,000,000 ML annually) as shown in Figure 7-9 (d). This is as a result of drivers associated with less extreme climatic events in the sub-catchments that feed the Dawson sub-catchment much further to the west within the Fitzroy Basin. The Dawson River itself is also classified as a lower order stream than the Mackenzie and Fitzroy rivers. Further its gauge at Beckers receives flows from a catchment of only 40,500 km^2 in extent compared to catchments of 76,645 km^2, 131,385 km^2 and 135,757 km^2 associated with the Coolmaringa, Riverslea and The Gap gauges, respectively.

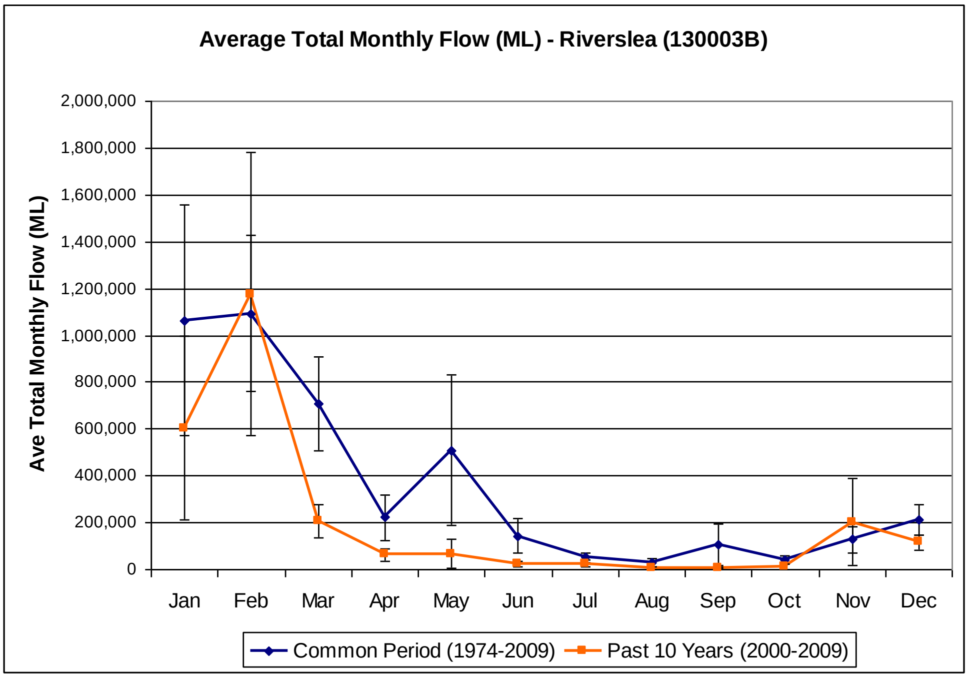
The hydrographs (Figure 7-10 (a), (b) and (c)) for the current period demonstrate the impact of drought conditions experienced in central-north Queensland during the period 2000 to 2007 on the inter-annual variability of flow and the long-term sustainability of flow that is prolonged periods of below average annual flow.

The relative position of flow duration curves reflects differences in the magnitude of flow. Where climatic conditions are more or less similar between river systems then the magnitude of flow is primarily determined by the size of the respective catchment. As discussed above, the Fitzroy River and Mackenzie River gauges have the larger catchment areas and subsequently greater flows compared to the Dawson River gauge. This is evident in Figure 7-11 (a) where the stream flows in the Fitzroy River appear similar to those of the Mackenzie River with The Gap, Riverslea and Coolmaringa gauging stations recording around 80 per cent of the days as having flows greater to 10 ML and 10 per cent of days with flows above 10,000 ML. Noticeably flows in the Dawson River are lower overall with only 50 per cent of days reaching flows greater than 10 ML per day.

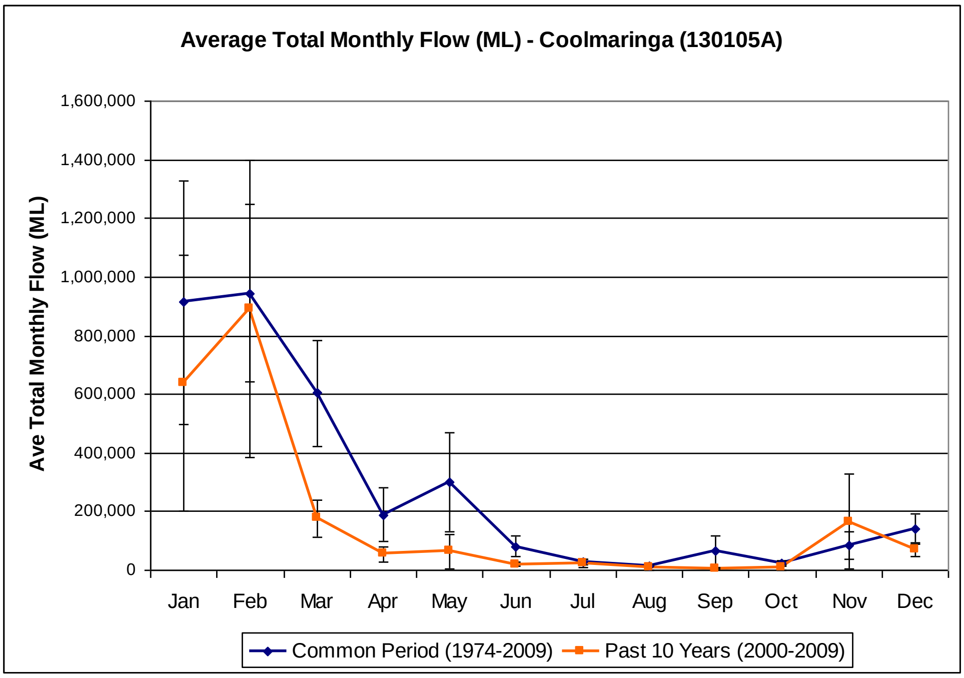
Figure 7-12 Total average monthly flows for the historic and current periods



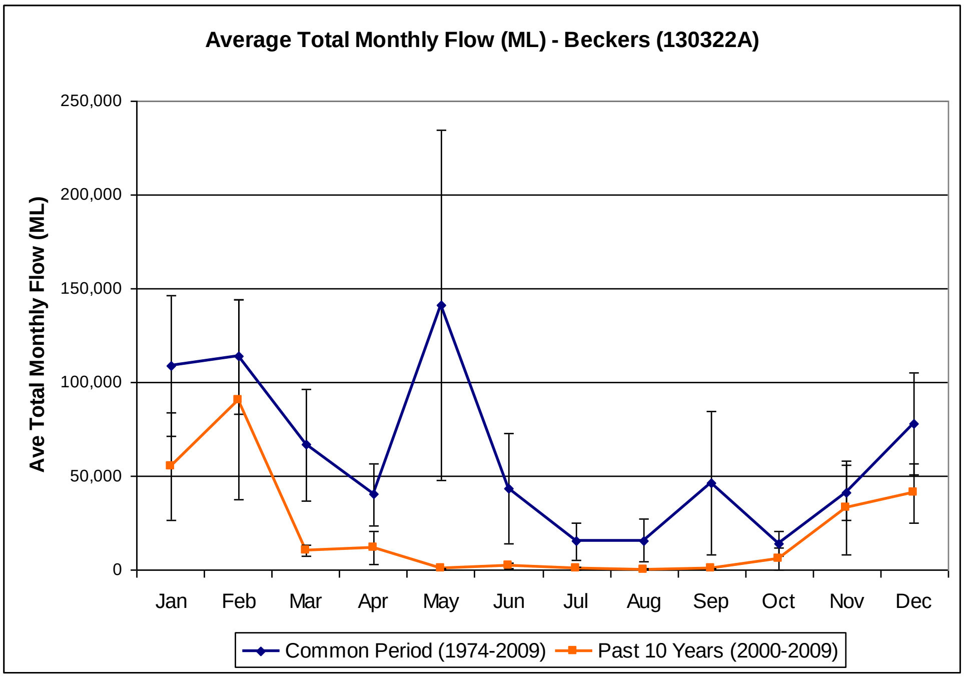
(a) The Gap gauging station (130 005A) (Fitzroy River)



(b) Riverslea gauging station (130 003B) (Fitzroy River)



(c) Coolmaringa gauging station (130 105A) (Mackenzie River)



(d) Beckers gauging station (130 322A) (Dawson River)

Note: standard error (standard deviation of the sampling distribution) represented by vertical bars.

The shape of the flow duration curves and thus the distribution and range of flows is controlled by catchment characteristics such as land use, geology and topography, as well as variations in local climatic conditions. A consistency in shape suggests a general similarity in catchment and climatic conditions. Deviations from the general shape (for example a truncation of low flows at The Gap) are likely to be the result of the gauge being drowned out by inundation from storage behind the existing Eden Bann Weir which prevents the measurement of low flows. This is shown in Figure 7-11 (a) where the upper reaches of the Fitzroy River (at Riverslea) and the lower reaches of the Mackenzie River (at Coolmaringa) present around 95 per cent of days with flows between 1 and 10 ML per day compared to the Fitzroy River at the Gap where only 80 to 81 per cent of flows are between 1 and 10 ML per day.

Recent records (1999 – 2009) reflect considerably lower daily flows with only 65 to 70 per cent of days having flow greater than 10 ML on the Mackenzie and upper Fitzroy rivers (Figure 7-11 (b)). Similarly daily flows on the lower Dawson River at Beckers are also reduced with in the order of 40 per cent of daily flows being 10 ML. This is consistent with drought conditions experienced across the region and reflected in the records at all the selected gauging stations. Flow duration curve shape is maintained again reflecting the influence of the catchments on the flows at the selected gauging stations, albeit that daily flows are significantly reduced.

In general average monthly flow volumes (Figure 7-12) show a consistent seasonal pattern of high summer flows and low winter flows on the Fitzroy and Mackenzie Rivers, peaking at around 1,200,000 ML per month and 900,000 ML per month, respectively and falling to almost zero flow in the winter months. This seasonality in flow is less marked on the Dawson River and may reflect differences in localised climatic conditions. The Dawson sub-catchment does not typically experience regular intense rainfall events associated with cyclones and is rather susceptible to severe thunderstorms particularly during the summer months (SKM 2012). Flows are markedly reduced (with the peak at around 120,000 ML monthly) possibly attributed to the climatic conditions and the smaller catchment area associated with the Beckers gauging station.

During recent drought conditions, wet season flows in all catchments appear to have been sustained at a similar magnitude to those occurring in the historic period but over a shorter period of the season, whilst dry season flows have generally decreased throughout the season.

7.5.3 Water quality

7.5.3.1 Overview

Catchment characteristics described in Section 7.5.1 have the potential to influence water quality in the Project area. Human-induced and environmental influences on water quality include:

- Runoff from adjacent agricultural land, exacerbated by the historic clearing of significant tracts of vegetation
- Point source inputs, for example, from mining operations. The results of post-mine dewatering sampling in late 2008 / early 2009 indicated that such inputs increased electrical conductivity (EC) and alkalinity levels in the lower Mackenzie and Fitzroy Rivers
- Reduced / altered flows from weirs and water extraction, including those on the Dawson, Mackenzie and Fitzroy Rivers
- Natural seasonal climatic variability affecting flow regimes in waterways throughout the Basin, with extreme instances resulting in flooding or drought. Climatic factors are likely to be a fundamental driver of water quality variability in the Fitzroy Basin

- The natural geology of soils in the region. The literature review indicates that the saline and alkaline geology of the region is likely to influence water quality in the Fitzroy Basin.

Schedule 1 of the Queensland Environmental Protection (Water) Policy (EPP Water) defines water quality objectives (WQOs) at a sub-basin level and specific to water types to protect aquatic ecosystem and human use environmental values. Aquatic ecosystem WQOs are in general more stringent than those defined for human use EVs and as such where these are met, human use EV WQOs are taken to be met. Where local guidelines are not available the EPP Water in turn references to the Australian Water Quality Guidelines (AWQGs), Queensland Water Quality Guidelines (QWQGs) and others as applicable.

7.5.3.2 Fitzroy River at The Gap

The existing Eden Bann Weir is defined as a freshwater lake or reservoir. Aquatic ecosystems within the Fitzroy River Sub-plan Project area are classed as moderately disturbed. WQOs to protect moderately disturbed aquatic ecosystems in a freshwater lake or reservoir (including consideration of toxicants) are presented in Table 7-4 and compared to the existing median values.

Existing physio-chemical water quality characteristics of the Fitzroy River at The Gap are summarised as follows:

- The median pH was within the WQO and the pH recorded within the impoundment indicates a largely alkaline environment; a reflection of the fact that most Fitzroy soils are alkaline (DERM 2008). An increase in pH was associated with the period following mine dewatering. Acid mine drainage was reportedly not an issue associated with the mines in question (Hart 2008).
- EC (representative of salinity) at The Gap was less than the WQOs. This is supported by SunWater data that indicates that median EC within the Eden Bann Weir impoundment was also less than the WQO. In the short-term dataset while EC levels were greater than the WQO, the trend is decreasing following significantly elevated levels recorded during mine dewatering. During mine dewatering EC levels reportedly resulted in Rockhampton's water supply having a poor taste but was not considered likely to have caused any serious health problems (Hart 2008). The median EC level recorded during mine dewatering (705 µS/cm) is within the 'good' palatability range for raw water under the Australian Drinking Water Guidelines (ADWG)
- The long-term median water temperature at The Gap is 25.35 ºC. SunWater data recorded a median of 24.3 ºC. Trend analysis shows only a slight reduction in temperature over depth within the weir (Figure 7-13), as expected within a shallow impoundment resulting in little to no stratification
- The median concentration of dissolved oxygen (DO) at The Gap was greater than WQO. Figure 7-14 shows that there is a trend for the concentration of DO to decrease with depth (albeit slightly) within the Eden Bann Weir impoundment suggesting a low level of stratification within the water column.

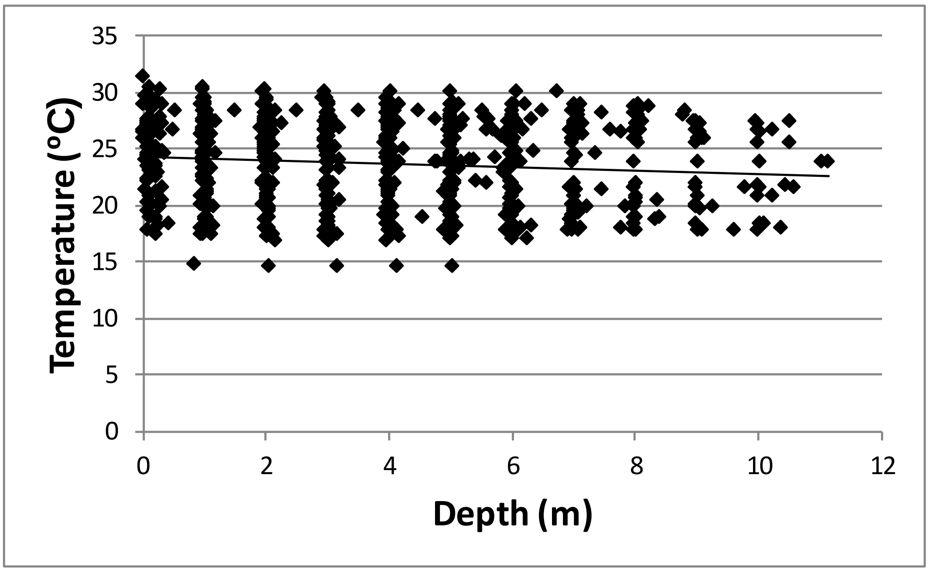
Table 7-4 Median values and water quality objectives for The Gap/Eden Bann Weir

Water quality parameter	WQOs[1]	Median values (DNRM)[2]			Median values (SunWater)[2]		
		Long-term	Mine dewatering	Short-term	Wattlebank[8]	The Gap	Inflow[8]
pH	6.5–8.0[3]	7.6	8.6	8.0	7.7	7.6	8.0
EC @ 25°C (µS/cm)	<250[4,5]	168.5	705.0	290.0	239.0	240.0	324.5
Water temperature (°C)	Not defined	25.4	29.6	25.7	24.8	24.3	27.0
DO (mg/L) (% saturation)	Not defined (90-110)[3]	6.3	8.4	7.1 (87)	7.5 (97)	6.8 (83)	8.5 (113)
Turbidity (NTU)	1-20[3]	100.0	6.0	91.0	133.2	108.0	45.1
TSS (mg/L)	No data[3]	147.5	-	42.0	29.0	39.5	-
TN (µg/L)	<350[3]	1,110	360	620	665	640	490
TP (µg/L)	<10[3]	330	25	177	155	160	92
Al soluble (µg/L)	55[6]	20.0	21.8	50	-	-	-
Cu (µg/L)	1.4[6]	20.0	3.3	30	-	-	-
Fe soluble (µg/L)	300[7]	30.0	9.5	60	-	-	-
Mg (µg/L)	Not defined	-	-	10,400	-	-	-
Mn soluble (µg/L)	1900[6]	<0.01	-	10	-	-	-
Zn soluble (µg/L)	8[6]	10.0	4.8	10	-	-	-
Chlorophyll a (µg/L)	<5.0[3]	-	-	-	1.60	2.14	-

1 WQOs under baseflow (unless where specified as high flow) conditions.
2 Where a median value exceeds the WQO the value is highlighted in red.
3 The values for these indicators are based on the QWQGs Central Coast regional water quality guidelines.
4 No flow/baseflow.
5 The values for these indicators are based on sub-regional low flow water quality guidelines derived by DEHP as part of the process to establish EVs and WQOs in the Fitzroy Basin.
6 In the absence of local guidelines trigger values are based on Table 3.4.1 of the AWQGs. The protection level attributed to these toxicants is based on the framework provided in Table 3.4.2 of the AWQGs. The 95 per cent protection level applies to slightly to moderately disturbed ecosystems represented at The Gap.
7 Based on the current Canadian guideline level provided in the AWQGs as an interim indicative working level in the absence of sufficient data to establish a reliable trigger value.
8 Wattlebank is located immediately downstream of Eden Bann Weir (tailwater) and provides water quality data in relation to releases. The Glenroy Road inflow data is monitored upstream outside of the existing Eden Bann Weir impoundment. Data is provided for comparison to water quality within the impoundment and not assessed against the freshwater lake/reservoir WQOs.

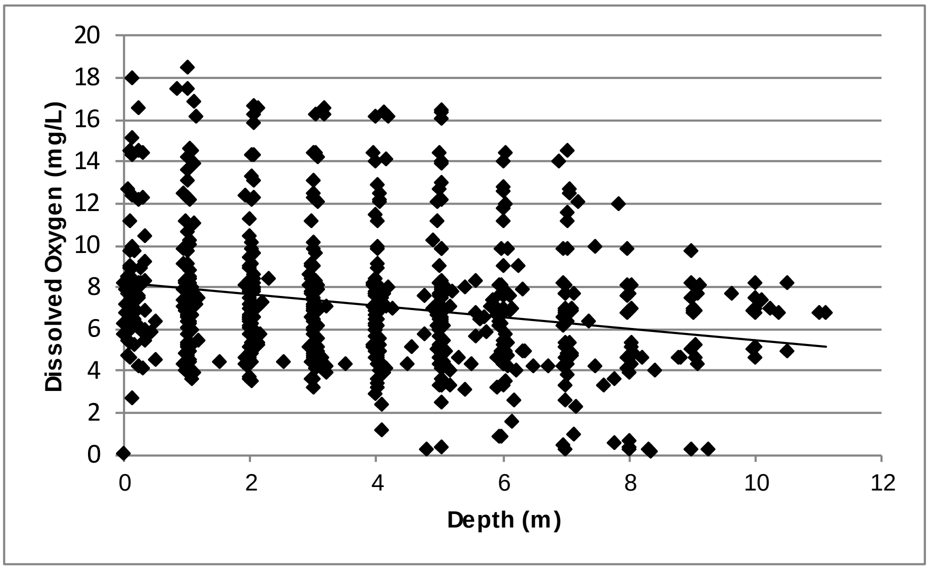
- Turbidity at The Gap was greater than the WQO but are consistent with generally high turbidity levels observed within the Fitzroy, Mackenzie and Dawson rivers and as reported for other storages in the Fitzroy Basin, for example Glebe Weir 168 Nephelometric turbidity units (NTU) (SKM 2012). The turbidity level of the Eden Bann Weir inflow at Glenroy Crossing (45.1 NTU) was less than the WQO for fresh waters but exceed those for lakes/reservoirs
- The concentrations of nutrients, total nitrogen (TN) and total phosphorous (TP) within the Eden Bann Weir impoundment are greater than the WQOs. Notably the concentration of nutrients that flow into Eden Bann Weir were also greater that the WQOs (490 µg/L and 92 µg/L for TN and TP, respectively), which is consistent with the concentration of nutrients recorded throughout the Project area. The concentration of nutrients in waters within the Fitzroy Basin are influenced by land use practices and derived from runoff from croplands and pasturelands, and sourced from agricultural fertilisers and manure, together with high erosion and sedimentation during flood events (Johnston et al. 2008)
- The median concentration of dissolved copper and zinc recorded at The Gap by DNRM were greater than the WQOs. The concentration of dissolved metals in the Fitzroy River, may be associated with naturally mineral-rich soils which occur throughout the Fitzroy Basin (Taylor and Jones 2000). The concentration of dissolved metals in the waterways of the catchment may contribute to the observed results (Taylor and Jones 2000).

Figure 7-13 Temperature within the Eden Bann Weir impoundment



Source: SunWater water quality data (September 2001 – October 2013)

Figure 7-14 Dissolved oxygen concentration within the Eden Bann Weir impoundment



Source: SunWater water quality data (September 2001 – October 2013)

Blue green algae

High cyanobacteria cell densities occur at various times throughout waterways of the Fitzroy Basin though no large toxic algal blooms have been recorded (Nobel et al. 1997). Factors known to influence the development of algal blooms in the Fitzroy River include turbidity, light and layering of the water column (CSIRO 2000). The potential for blue green algae to occur in high densities is typically heightened towards the end of the dry season, as the turbidity of the river decreases (as a result of an extended period since wet season flushing) and light penetration into the water column improves (CSIRO 2000).

While surface nutrient concentrations are typically depleted at this (drier) time of year due to reduced (minimal) flows, local winds can promote mixing of the water column, thereby bringing nutrients from the bottom layer to the surface which promotes algal growth (CSIRO 2000).

SunWater monitors blue green algae levels within the Eden Bann Weir impoundment. *Anabaena circinalis, Aphanizomenon ovalisporum, Cylindrospermopsis raciborskii* and *Microcystis aeruginosa* are specifically monitored with regard to their potential to produce harmful cyanotoxins. Blue green algae biovolumes recorded for Eden Bann Weir are generally low, ranging between 0 and 6 mm^3/L (median 0 mm^3/L; mean 0.44 mm^3/L) over 98 samples. Hazard levels used to assess the potential danger posed by blue green algae to humans at Eden Bann Weir are based on the Guidelines for Managing Risks in Recreational Water (NHMRC 2008; SunWater 2014). The guideline levels are shown in Table 7-5 together with SunWater's adopted action levels and monitoring systems.

None of the sampling events triggered a high action alert level. Forty-one per cent of the samples triggered the moderate/amber level alert mode. The remaining 59 per cent of the samples triggered the low action level (green surveillance mode). By default zero readings are taken to represent a low action level.

In addition the median chlorophyll a (as an indicator of algal growth) recorded within the Eden Bann Weir impoundment was less than the WQO.

Table 7-5 Blue green algae guideline hazard levels

NHMRC Guideline	Action level	Monitoring system
≥500 to <5000 cells/mL *M. aeruginosa* or biovolume equivalent of >0.04 to <0.4 mm^3/L for the combined total of all cyanobacteria	Low	Green level surveillance mode: Routine sampling to measure cyanobacterial levels
≥5000 to <50 000 cells/mL *M. aeruginosa* or ≥0.4 to <4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume or ≥0.4 to <10 mm^3/L for the combined total of all cyanobacteria where known toxin producers are not present	Moderate	Amber level alert mode: Investigations into the causes of the elevated levels and increased sampling to enable the risks to recreational users to be more accurately assessed
Level 1 guideline: ≥10 µg/L total microcystins or ≥50 000 cells/mL toxic *M. aeruginosa* or biovolume equivalent of ≥4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume OR Level 2 guideline: ≥10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present or cyanobacterial scums are consistently present	High	Red level action mode: Local authority and health authorities to warn the public that the water body is considered to be unsuitable for primary contact recreation

7.5.3.3 Fitzroy River at Riverslea

In accordance with the EPP Water and with reference to aquatic ecosystems, the water area or type at Riverslea is defined as Fitzroy River Sub-basin fresh waters and Fitzroy River Sub-basin main trunk fresh waters. The management intent for Riverslea is that of a moderately disturbed aquatic ecosystem. WQOs to protect these moderately disturbed aquatic ecosystems (including consideration of toxicants) are presented in Table 7-6 as compared to the existing median values.

Existing physio-chemical water quality characteristics of the Fitzroy River at Riverslea are summarised as follows:

- The median pH recorded at Riverslea was within the WQO and indicates an alkaline environment
- The median EC recorded at Riverslea was less than the WQO under baseflow conditions, however, the median EC was greater than WQO for high flow conditions
- Long-term median concentration of DO was within the WQO, as is the short-term median. However, following a period during mine dewatering the median concentration of DO was greater than the WQO
- The long term median turbidity within the fresh water reach was generally less than the WQO. In the short-term turbidity was greater than the WQO and this can be attributed to recent flood events (Section 7.3.1) resulting in significant sediment laden runoff entering the watercourses in the Fitzroy River Sub-basin
- The long-term median water temperature of 25 °C was recorded at Riverslea
- The median concentration of nutrients (TN and TP), copper and zinc were greater than the WQO at Riverslea

- Chlorophyll a was not recorded at Riverslea.

Table 7-6 Median values and water quality objectives at Riverslea

Water quality parameter	Water Quality Objectives[1]	Median values (DNRM)[2]		
		Long-term	Mine dewatering	Short-term
pH	6.5-8.5[3]	7.7	7.9	7.9
EC @ 25°C (µS/cm)	<445 (baseflow)[3] <250 (high flow)[3]	309.5	938.0	306.0
Water temperature (°C)	16 – 34^0 C [4]	25.0	29.3	24.8
DO (mg/L) (% saturation)	Not defined (85-110)[5]	8.2 (97)	5.7 (78)	7.3 (85)
Turbidity (NTU)	<50[5]	36.7	184	91
TSS (mg/L)	<85[4]	33.0	-	46
TN (µg/L)	<500[5]	-	700	550
TP (µg/L)	<50[5]	130	150	170
Al soluble (µg/L)	55[6]	40.0	44.4	50
Cu (µg/L)	1.4[6]	-	4.7	30
Fe soluble (µg/L)	300[7]	60.0	13.7	60
Mg (µg/L)	Not defined	-	-	10,000
Mn soluble (µg/L)	1900[6]	10.0	11.8	10
Zn soluble (µg/L)	8[6]	10.0	14.5	10
Chlorophyll a (µg/L)	<5.0[5]	-	-	-

1 WQOs under baseflow (unless where specified as high flow) conditions.

2 Where a median value exceeds the WQO the value is highlighted in red.

3 The values for these indicators are based on sub-regional low flow water quality guidelines derived by DEHP as part of the process to establish EVs and WQOs in the Fitzroy Basin.

4 The values are applied to protect suitability for primary contact recreation based on ANZECC guidelines.

5 The values for these indicators are based on the QWQGs Central Coast regional water quality guidelines.

6 In the absence of local guidelines trigger values are based on Table 3.4.1 of the AWQGs. The protection level attributed to these toxicants is based on the framework provided in Table 3.4.2 of the AWQGs. The 95 per cent protection level applies to slightly to moderately disturbed ecosystems represented at Riverslea.

7 Based on the current Canadian guideline level provided in the AWQGs as an interim indicative working level in the absence of sufficient data to establish a reliable trigger value.

7.5.3.4 Lower Dawson River

As per the EPP Water and with reference to aquatic ecosystems, the water area or type represented at Beckers comprises lower Dawson River Sub-basin waters and lower Dawson River Sub-basin main trunk waters. The management intent for these waters is that of a moderately disturbed aquatic ecosystem. WQOs to protect moderately disturbed aquatic ecosystems in these waters are presented in Table 7-7 and compared to existing median values.

Table 7-7 Median values and water quality objectives for aquatic ecosystems at Beckers

Water quality parameter	WQO[1]	Median values (DNRM)[2]		
		Long-term	Mine dewatering	Short-term
pH	6.5-8.5[3]	7.6	-	7.7
EC @ 25°C (µS/cm)	<340 (baseflow)[4] <210 (high flow)[3]	191.5	-	247.5
Water temperature (°C)	Not defined	26.7	-	20.5
DO (mg/L) (% saturation)	Not defined (85-110)[4]	6.6 (88)	-	7.9 (90)
Turbidity (NTU)	<50[4]	100.0	-	54.0
TSS (mg/L)	<10[4]	50.0	-	30.0
TN (µg/L)	<500[4]	930	-	670
TP (µg/L)	<50[4]	250	-	160
Al soluble (µg/L)	55[5]	50.0	-	120
Cu (µg/L)	1.4[5]	-	-	30
Fe soluble (µg/L)	300[6]	70.0	-	200
Mg (µg/L)	Not defined	-	-	5,200
Mn soluble (µg/L)	1900[5]	10.0	-	10
Zn soluble (µg/L)	8[5]	10.0	-	120
Chlorophyll a (µg/L)	<5.0[4]	-	-	-

1 WQOs under baseflow (unless where specified as high flow) conditions.
2 Where a median value exceeds the WQO the value is highlighted in red.
3 The values for these indicators are based on sub-regional low flow water quality guidelines derived by DEHP as part of the process to establish EVs and WQOs in the Fitzroy Basin.
4 The values for these indicators are based on the QWQGs Central Coast regional water quality guidelines. For EC, the values are based on Appendix G of the QWQG.
5 In the absence of local guidelines trigger values are based on Table 3.4.1 of the AWQGs. The protection level attributed to these toxicants is based on the framework provided in Table 3.4.2 of the AWQGs. The 95 per cent protection level applies to slightly to moderately disturbed ecosystems represented at Beckers.
6 Based on the current Canadian guideline level provided in the AWQGs as an interim indicative working level in the absence of sufficient data to establish a reliable trigger value.

Existing physio-chemical water quality characteristics of the Dawson River at Beckers are summarised as follows:

- The median pH recorded at Beckers was within the WQO and indicates an alkaline environment
- The median EC recorded at Beckers was less than the WQO under baseflow conditions
- The long-term dataset recorded a median temperature of 26.7 ºC whereas the short-term data indicates cooler temperatures with a median of 20.5 ºC
- The median concentration of DO was within the WQO
- The long term median turbidity within the fresh water reach was greater than the WQO, however the median short-term turbidity data indicates a reduction in turbidity in more recent times

- The median concentration of nutrients (TN and TP), copper and zinc were greater than the WQO. The median concentration of aluminium historically were less than the WQOs, however the median short-term concentration of aluminium was greater than the WQO
- Chlorophyll a was not recorded at Beckers. Reports for Neville Hewitt Weir (12 km upstream of Beckers) indicate that very little aquatic macrophyte growth occurs which is characteristic of the region. Further no potentially toxic blue green algae have been recorded in Neville Hewitt Weir since sampling began in 2002 (SunWater 2011).

7.5.3.5 Lower Mackenzie River

In accordance with the EPP Water and with reference to aquatic ecosystem guidelines, the water area or type at Coolmaringa comprises Mackenzie River Sub-basin waters and Mackenzie River Sub-basin main trunk waters. The management intent for these waters is that of a moderately disturbed aquatic ecosystem. WQOs are presented in Table 7-8 and compared to the existing median values.

Table 7-8 Median values and water quality objectives for aquatic ecosystems at Coolmaringa

Water quality parameter	WQO[1]	Median values (DNRM)[2]		
		Long-term	Mine dewatering	Short-term
pH	6.5-8.5[3]	7.5	7.85	8.02
EC @ 25°C (µS/cm)	<310 (baseflow)[3] <210 (high flow)[3]	205	917.5	332
Water temperature (°C)	Not defined	26	28.5	25.9
DO (mg/L) (% saturation)	Not defined (85-110)[4]	7.3 (87)	7 (90)	7.0 (87)
Turbidity (NTU)	<50[4]	67	102.5	21.5
TSS (mg/L)	<110[3]	60	-	17.5
TN (µg/L)	<775[3]	610	1,320	375
TP (µg/L)	<160[3]	80	410	91
Al soluble (µg/L)	55[5]	50	45.8	50
Cu (µg/L)	1.4[5]	-	3.5	30
Fe soluble (µg/L)	300[6]	60	10	50
Mg (µg/L)	Not defined	-	-	10,450
Mn soluble (µg/L)	1900[5]	10	2.7	10
Zn soluble (µg/L)	8[5]	10	27.9	10
Chlorophyll a (µg/L)	<5.0[4]			

1 WQOs under baseflow (unless where specified as high flow) conditions.
2 Where a median value exceeds the WQO the value is highlighted in red.
3 The values for these indicators are based on sub-regional low flow water quality guidelines derived by DEHP as part of the process to establish EVs and WQOs in the Fitzroy Basin.
4 The values for these indicators are based on the QWQGs Central Coast regional water quality guidelines. For EC, the values are based on Appendix G of the QWQG.
5 In the absence of local guidelines trigger values are based on Table 3.4.1 of the AWQGs. The protection level attributed to these toxicants is based on the framework provided in Table 3.4.2 of the AWQGs. The 95 per cent protection level applies to slightly to moderately disturbed ecosystems represented at Coolmaringa.
6 Based on the current Canadian guideline level provided in the AWQGs as an interim indicative working level in the absence of sufficient data to establish a reliable trigger value.

Existing physio-chemical water quality characteristics of the Mackenzie River at Coolmaringa are summarised as follows:

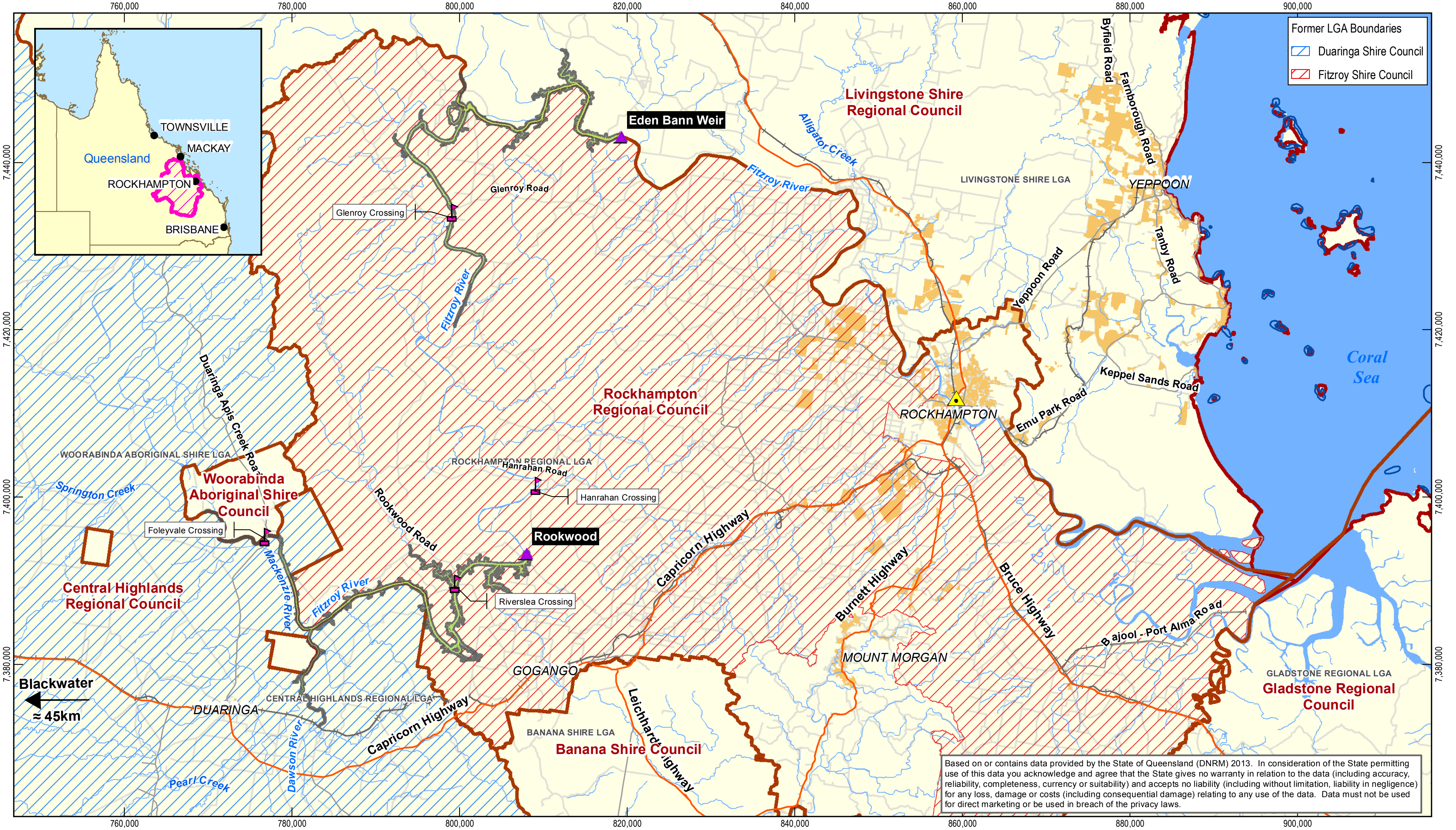
- The median pH recorded at Coolmaringa was within the WQO and indicates an alkaline environment
- The long term median EC recorded at Coolmaringa was less than the WQO under baseflow conditions. However, the short term median EC was greater than the WQO under baseflow conditions
- Median water temperature at Coolmaringa is approximately 26 ºC
- The median concentration of DO was within the WQO in the Mackenzie River
- The long term median turbidity within the fresh water reach was greater than the WQO. However, the median short-term turbidity data indicates a reduction in turbidity in more recent times
- The concentration of nutrients (TN and TP) was less than the WQO, except during the mine dewatering period
- The median concentration of copper and zinc were greater than the WQO at Coolmaringa, which is similar to the Fitzroy and Dawson Rivers
- Chlorophyll a was not recorded for Coolmaringa.

7.6 Land use and planning

7.6.1 Planning schemes

The required works for the Project and their associated impacts will affect the local government areas of the Livingstone Shire Council, Rockhampton Regional Council (RRC), Central Highlands Regional Council (CHRC) and Woorabinda Aboriginal Shire Council (WASC). Figure 7-15 shows the boundaries of the local government areas relative to the Project areas.

The section of the Fitzroy River affected by the Eden Bann Weir raising acts as a boundary for the Livingstone and former Fitzroy local governments. As a result, the raising of the Eden Bann Weir will be subject to assessment under both the Fitzroy Planning Scheme 2005 and the Livingstone Shire Planning Scheme 2005. Impoundment associated with Rookwood Weir will extend along the Fitzroy River and into the Mackenzie and Dawson Rivers. The western bank of the Mackenzie and Dawson rivers are within the CHRC area, specifically the former Duaringa Shire Council area and will be subject to assessment against the Duaringa Shire Planning Scheme 2007. Sections of impoundment impact on WASC areas. There is no current planning scheme in force for the impoundment associated with the WASC area. As such the Rookwood Weir development will not trigger assessment by the WASC (Chapter 3 Planning and approvals).



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0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- River Crossing
- Fitzroy Barrage
- Highway
- Major Road
- Streets (Local)
- Local Government Boundary
- Railway
- Waterway
- Fitzroy Basin
- Urbanised Area
- Rookwood Impoundment Stage 1
- Rookwood Impoundment Stage 2
- Eden Bann Impoundment Stage 2
- Eden Bann Impoundment Stage 3

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Local government areas

Figure 7-15

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7.6.2 Land use

The RRC LGA encompasses a total land area of over 18,300 km^2 including national parks, state forests, coastline and islands. The main urban centre is Rockhampton, with a smaller centre at Yeppoon. There are numerous small towns and villages, both along the coast and in the rural hinterland. Rural land within the LGA is used mainly for cattle raising, pineapple growing, fruit growing, forestry and mining. Power generation and tourism are also important industries.

Within the CHRC LGA the largest town in the Project vicinity is Blackwater. Other towns are Duaringa, Dingo, Bluff and Bauhinia. Primary industries in the LGA include agriculture (cattle, wheat and grain production) and coal mining.

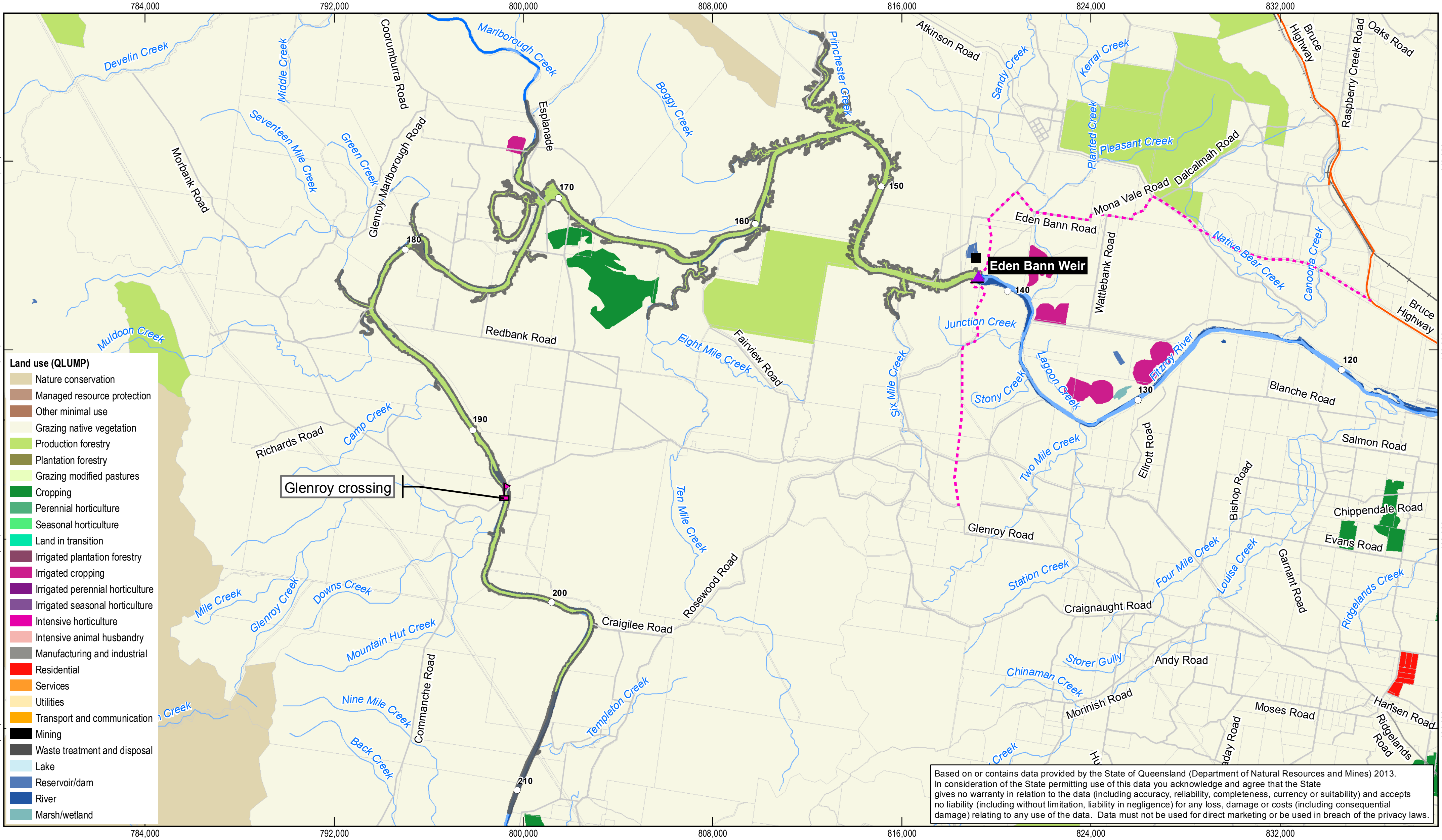
The Woorabinda Aboriginal Shire LGAs comprise five parcels of land within the CHRC LGA. The Woorabinda Aboriginal Shire comprises the only Deed of Grant in Trust Aboriginal community within the Central Queensland region.

Areas of good soils that exist along the Fitzroy River form part of larger properties and largely remain undeveloped to intensive agriculture. The lack of development along the river can in part be explained by the formidable barrier the Fitzroy River forms to transport corridors, while the periodic large floods that inundate these properties have also hindered more intensive development of these better lands (Keane 2004).

With its wide channel, high flood flows and broad floodplain, only three high level bridges (two road and one rail) cross the Fitzroy River and these are located within one kilometre of each other in the centre of Rockhampton, where the land on both banks is high and flood free. The main north-south rail and road routes along the Queensland coast cross the Fitzroy River via these three bridges, while the transport routes to the inland centres further west are located well away from the Fitzroy River (Keane 2004).

As a result of the Fitzroy River being difficult to cross, access to properties along the Fitzroy River is largely by local gravel roads, which branch off from the main highways and road systems that service inland centres. These properties, located approximately an hour by road from Rockhampton, have largely remained beef cattle grazing properties since they were first settled well over a hundred years ago (Keane 2004).

The Project is located in a rural area. The main activity occurring on properties affected by the Project is cattle breeding and fattening as illustrated in Figure 7-16 and Figure 7-17 for Eden Bann Weir and the Rookwood site respectively. There is some crop cultivation for grains and a small number of properties with irrigation licences. The most common use of the river is for stock watering with cattle generally accessing the water directly or via pump/trough systems. The large rural properties common to the Project areas are generally served by unsealed roads, often single lane, branching from the major arteries of the Bruce and Capricorn Highways.



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Eden Bann Weir
Landuse

Figure 7-16

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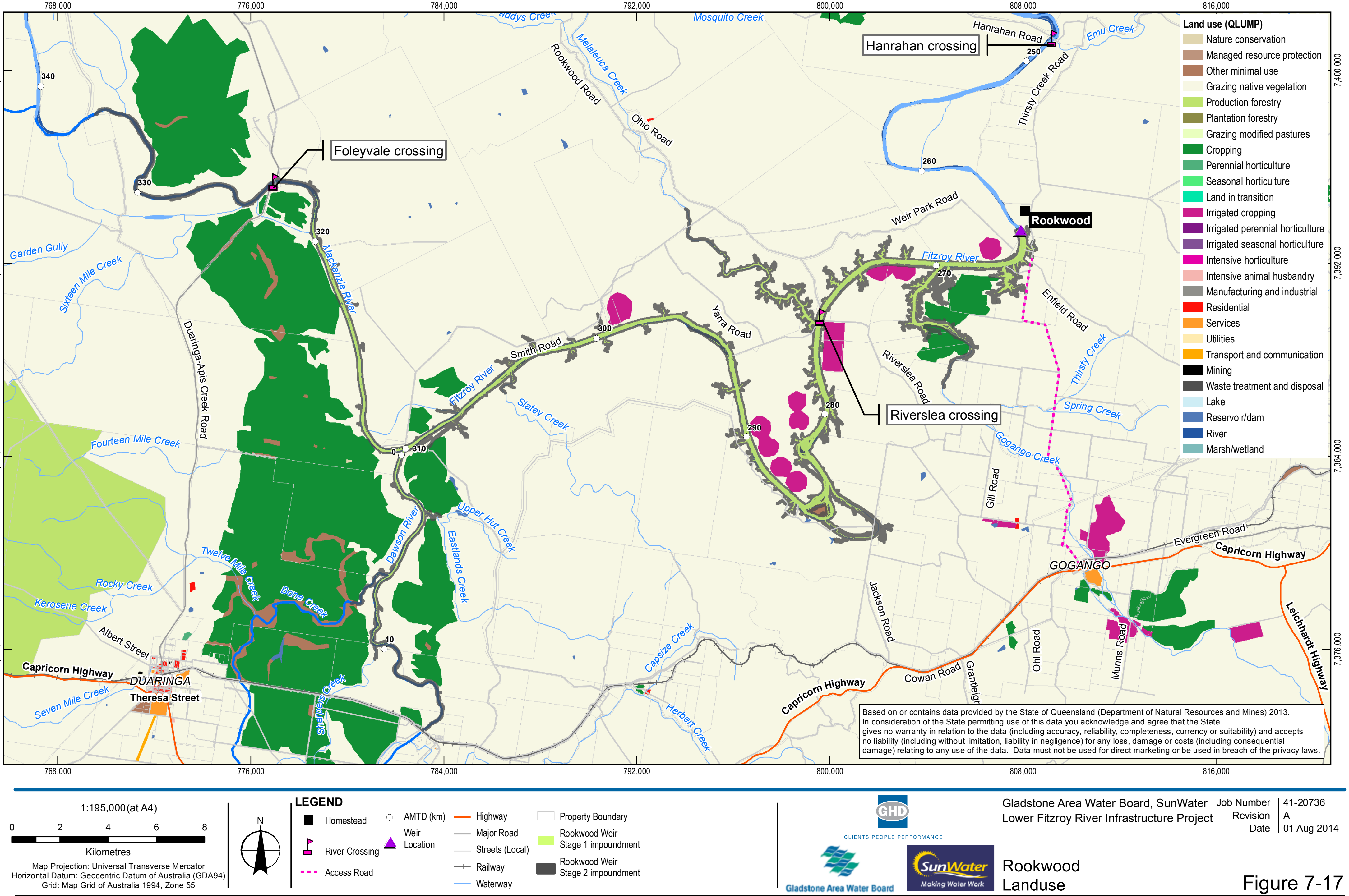

Rookwood Landuse

Figure 7-17

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7.7 Reserves, protected and sensitive environmental areas

Reserves (primarily for the purposes of camping, water, roads and stock) and protected areas (including state forests, conservation parks, national parks and nature refuges) and within an approximate 20 km radius of the Project area are as follows (Figure 7-18):

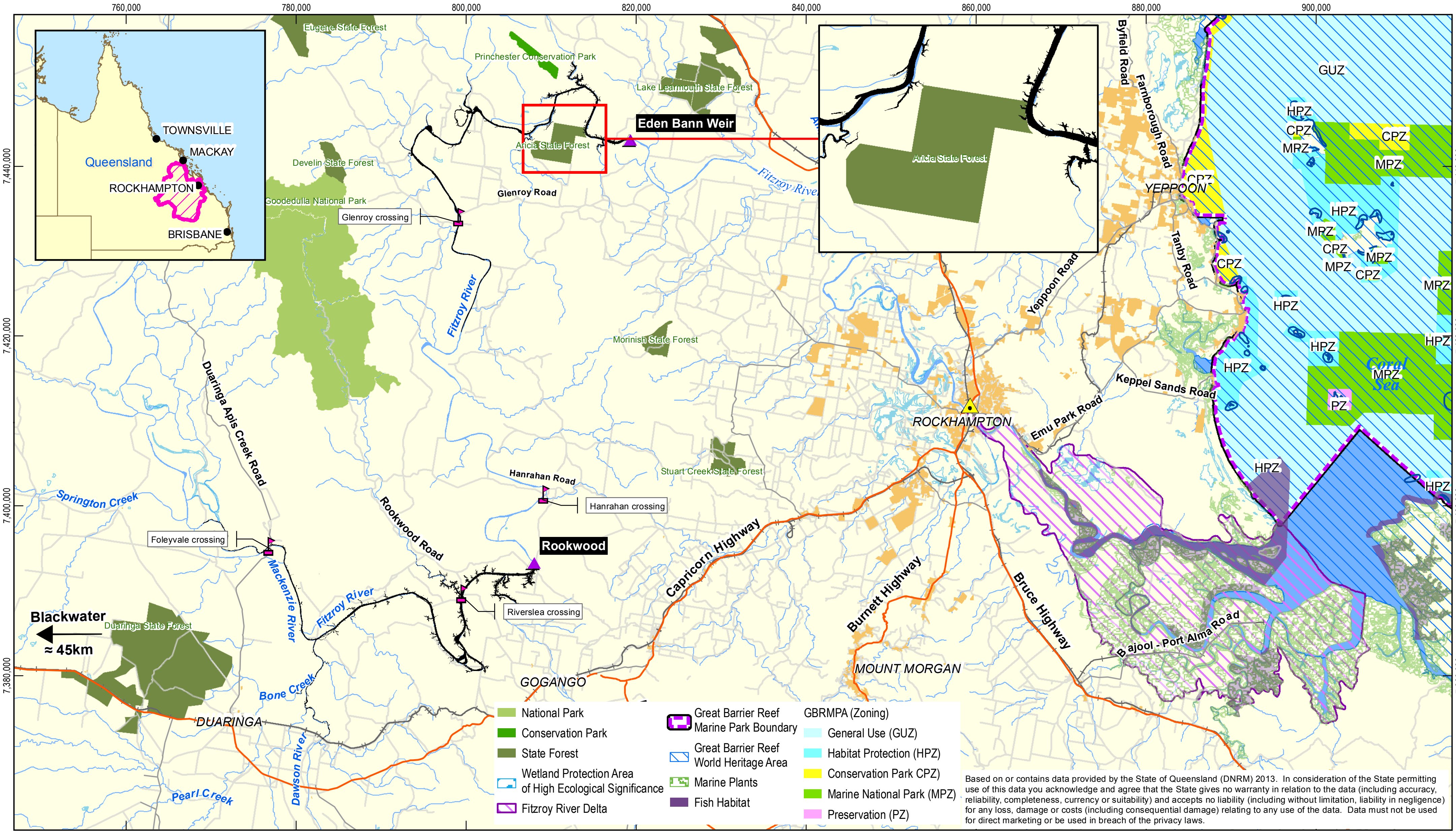
- Goodedulla National Park
- Princhester Conservation Park
- Lake Learmouth State Forest
- Aricia State Forest
- Euegene State Forest
- Develin State Forest (adjoining the north-eastern corner of the Goodedulla National Park)
- Morinish State Forest
- Stuart Creek State Forest
- Duaringa State Forest.

Only the Aricia State Forest directly interacts with the Project. The north-eastern boundary (at approximately 147 km AMTD) and the north-western corner (at approximately 160 km AMTD) border the existing Eden Bann Weir impoundment.

A number of endangered, of concern and least concern regional ecosystems are situated in the Project area and discussed in Section 7.8.2.

There are no wetlands of high ecological significance directly associated with the Project footprint. Three Great Barrier Reef wetland protection areas located adjacent (within two kilometres) to the Eden Bann Weir Project footprint. One Great Barrier Reef wetland protection area and wetland of high ecological significance is located between 100 m and 350 m from the proposed Rookwood Weir impoundment at 334 km AMTD on the Mackenzie River.

Other sensitive environmental areas are located downstream of the Project as described in Section 7.10.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- River Crossing
- Fitzroy Barrage
- Highway
- Major Road
- Streets (Local)
- Railway
- Waterway
- Fitzroy Basin
- Urbanised Area
- Impoundment Area

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Reserves, protected areas and sensitive environmental areas

Figure 7-18

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7.8 Terrestrial ecology

7.8.1 Regional context

The Project is located in the Brigalow Belt bioregion which contains a variety of landscapes ranging from rugged ranges and undulating hills to valleys and flat alluvial plains. This bioregion is characterised by the presence of Brigalow (*Acacia harpophylla*). Dominant vegetation communities include eucalypt woodlands, grasslands, brigalow-belah forests (*Acacia harpophylla, Casuarina cristata*), semi-evergreen vine thickets and open forests of ironbarks (*Eucalyptus* spp.), bloodwoods (*Corymbia* spp.), poplar box (*Eucalyptus populnea*), spotted gum (*Corymbia citriodora*) and cypress pine (*Callitris glaucophylla*).

The bioregion is also characterised by a high level of habitat loss. In particular, the lowlands (e.g. alluvial and clay plains) and riparian zones have been extensively cleared for agriculture. Vegetation and fauna communities associated with these landscapes have therefore declined significantly. Threatening processes identified within the bioregion include: vegetation clearing, linear infrastructure development, urban development, mining, road maintenance, grazing, altered water flows, impoundments, reduced water quality, altered fire regimes, weeds and pests (DERM 2008).

Within the Brigalow Belt bioregion, the Project footprint is located within five subregions: the Marlborough Plains, Mount Morgan Ranges, Boomer Range, Isaac-Comet Downs and the Dawson River Downs subregions.

7.8.2 Flora values

Desktop assessments, vegetation mapping, field surveys and bio-condition assessments were undertaken to determine existing flora values within the Project footprint.

Flora values identified within the Project footprint are as follows:

- Endangered (26 ha), of concern (240 ha) and least concern (1,681 ha) regional ecosystems classified under the *Vegetation Management Act 1999* (Qld) (VM Act)
- Endangered (162 ha), of concern (334 ha) and least concern (63 ha) high value regrowth
- Mapped essential habitat for five flora species:
  - *Macrozamia serpentina* and *Capparis humistrata* listed as endangered under the Nature Conservation Act 1992 (Qld) (NC Act)
  - *Stackhousia tryonii* listed as near threatened under the NC Act
  - *Capparis thozetiana* listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) and NC Act
  - *Pimelea leptospermoides* listed as vulnerable under the EPBC Act and near threatened under the NC Act.
- Brigalow (*Acacia harpophylla* dominant and co-dominant) threatened ecological community
- Up to 100 individual black ironbox (*Eucalyptus raveretiana)* plants within the Rookwood Weir impoundment.

Chapter 10 Listed threatened species and ecological communities provides further detail and an assessment of impacts on EPBC Act listed species and communities.

Regional ecosystems occurring within the Project footprint are shown in Figure 7-19 and Figure 7-20 and described in Table 7-9 for Eden Bann Weir and Rookwood Weir respectively. Regional ecosystem mapping at a scale of 1:30,000 is provided in Appendix I. Remnant vegetation is typically fragmented across the landscape as a result of historic clearing including parts of the riparian zone of the lower Dawson, lower Mackenzie and Fitzroy rivers. Patches of high value regrowth are mapped by DNRM (2011) along the Fitzroy, Dawson and Mackenzie rivers within the Project footprint. The bio-condition assessment of regrowth areas found that habitat elements essential for long-term recovery were lacking or highly degraded and it was noted that many sites would be unlikely to recover rapidly without management (Nangura 2007). Introduced plants and weeds are ubiquitous across the Project area. Eight weeds listed under Queensland legislation, five of which are Weeds of National Significance were recorded during field studies (Table 7-10).

Table 7-9 Regional ecosystems within the Project footprint

RE	Regional ecosystem short description	VM Act class	Eden Bann Weir	Rookwood Weir
11.3.1	*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains	Endangered	✓	✓
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Of concern	✓	✓
11.3.3	*Eucalyptus coolabah* woodland on alluvial plains	Of concern	✓	✓
11.3.3c	Palustrine wetland. *Eucalyptus coolabah* woodland to open-woodland (to scattered trees) with a sedge or grass understorey in back swamps and old channels	Of concern	✓	
11.3.4	*Eucalyptus tereticornis* and/or *Eucalyptus spp.* tall woodland on alluvial plains	Of concern	✓	✓
11.3.9	*Eucalyptus platyphylla, Corymbia spp.* woodland on alluvial plains	Least concern	✓	
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* fringing drainage lines	Least concern	✓	✓
11.3.25c	Riverine wetland or fringing riverine wetland. *E. camaldulensis* or *E. tereticornis* open-forest to woodland. Occurs fringing drainage lines derived from Serpentinite	Least concern	✓	
11.3.25f	Riverine wetland or fringing riverine wetland	Least concern	✓	✓
11.3.27	Freshwater wetlands	Least concern	✓	
11.3.38	*Eucalyptus tereticornis, Melaleuca viridiflora, Corymbia tessellaris* and *Eucalyptus fibrosa* subsp. (Glen Geddes) tall woodland with a grassy ground layer. Occurs on alluvial plains and broad drainage lines derived from serpentine	Endangered	✓	
11.3.38a	Riverine wetland or fringing riverine wetland. *Melaleuca bracteata* low woodland	Endangered	✓	

RE	Regional ecosystem short description	VM Act class	Eden Bann Weir	Rookwood Weir
11.11.1	*Eucalyptus crebra* +/- *Acacia rhodoxylon* woodland on old sedimentary rocks with varying degrees of metamorphism and folding	Least concern		✓
11.11.7	*Eucalyptus fibrosa* subsp. (Glen Geddes), *E. xanthope* woodland on serpentine	Least concern	✓	
11.11.7a	Eucalyptus fibrosa subsp. fibrosa +/- Corymbia spp. +/- Eucalyptus spp. woodland with a diverse shrub layer including several endemic species. Occurring on undulating low hills and colluvial aprons	Least concern		
11.11.10	Eucalyptus melanophloia woodland on deformed and metamorphosed sediments and interbedded volcanics	Of concern	✓	
11.12.1	*Eucalyptus crebra woodland* on igneous rocks	Least concern	✓	
11.12.2	*Eucalyptus melanophloia* woodland on igneous rocks	Least concern	✓	✓

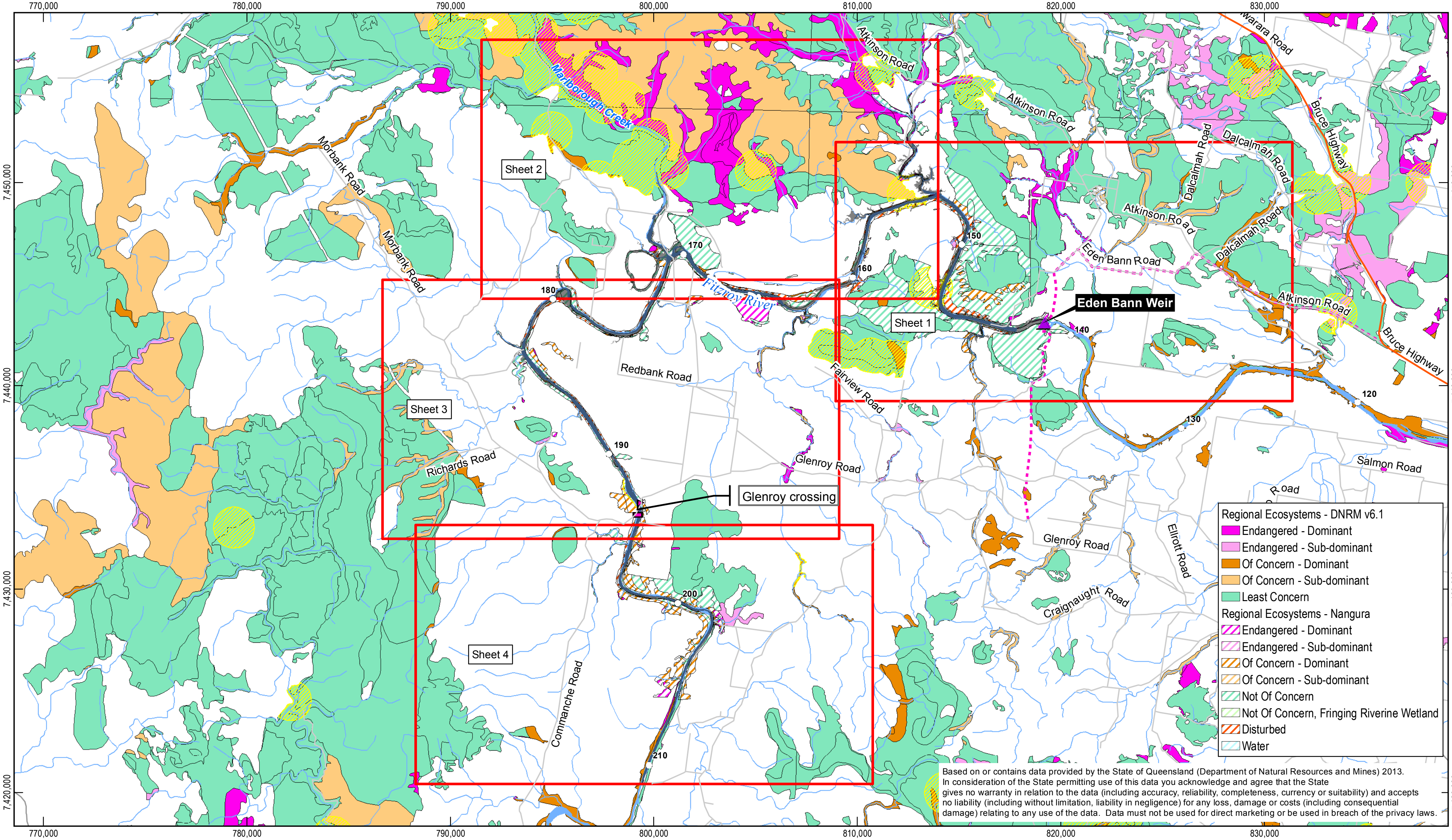
Source: Nangura 2007 and DNRM RE mapping (Version 6.1, 2011)

Table 7-10 Significant weeds identified during field surveys

Weed species	Declared plant class*	WONS^	Comment
Prickly acacia (*Acacia nilotica*)	Class 2	Yes	Very scarce, only a handful of specimens sighted across
Mother of millions (*Bryophyllum delagoense*)	Class 2	No	Very scarce, one patch located near the proposed Rookwood Weir site
Balloon vine (*Cardiospermum grandiflorum*)	Class 3	No	Occasional to sometimes common, mostly on grassy river bank areas
Rubbervine (*Cryptostegia grandiflora*)	Class 2	Yes	Locally common in a few locations. Dominant population in bed of Melaleuca Creek
Lantana (*Lantana camara*)	Class 3	Yes	Occasional presence, rarely common
Prickly pear (*Opuntia sp*)	Class 2	No	Occasional presence, usually not on lower river banks
Parkinsonia (*Parkinsonia aculeata*)	Class 2	Yes	Occasional presence, rarely common. Controlled on most properties
Parthenium (*Parthenium hysterophorus*)	Class 2	Yes	Occasional to common in actively grazed areas. Scarce or absent in many areas surveyed. Rapid changes to population with rainfall

*Declared plants under the *Land Protection (Pest and Stock Route Management) Act 2002* (Qld). These plants are targeted for control because they have, or could have, serious economic, environmental or social impacts

^Weeds identified by the Commonwealth Government as most significant based on invasiveness, impacts, potential for spread and socio-economic and environmental values



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Kilometres

Map Projection: Universal Transverse Mercator
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Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- River Crossing
- Highway
- Major Road
- Secondary Roads
- Access Road
- Impoundment Area
- Waterway
- Watercourse
- Grid Index
- Essential Habitat

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Eden Bann Weir Regional Ecosystem Mapping

Index Map Figure 7-19

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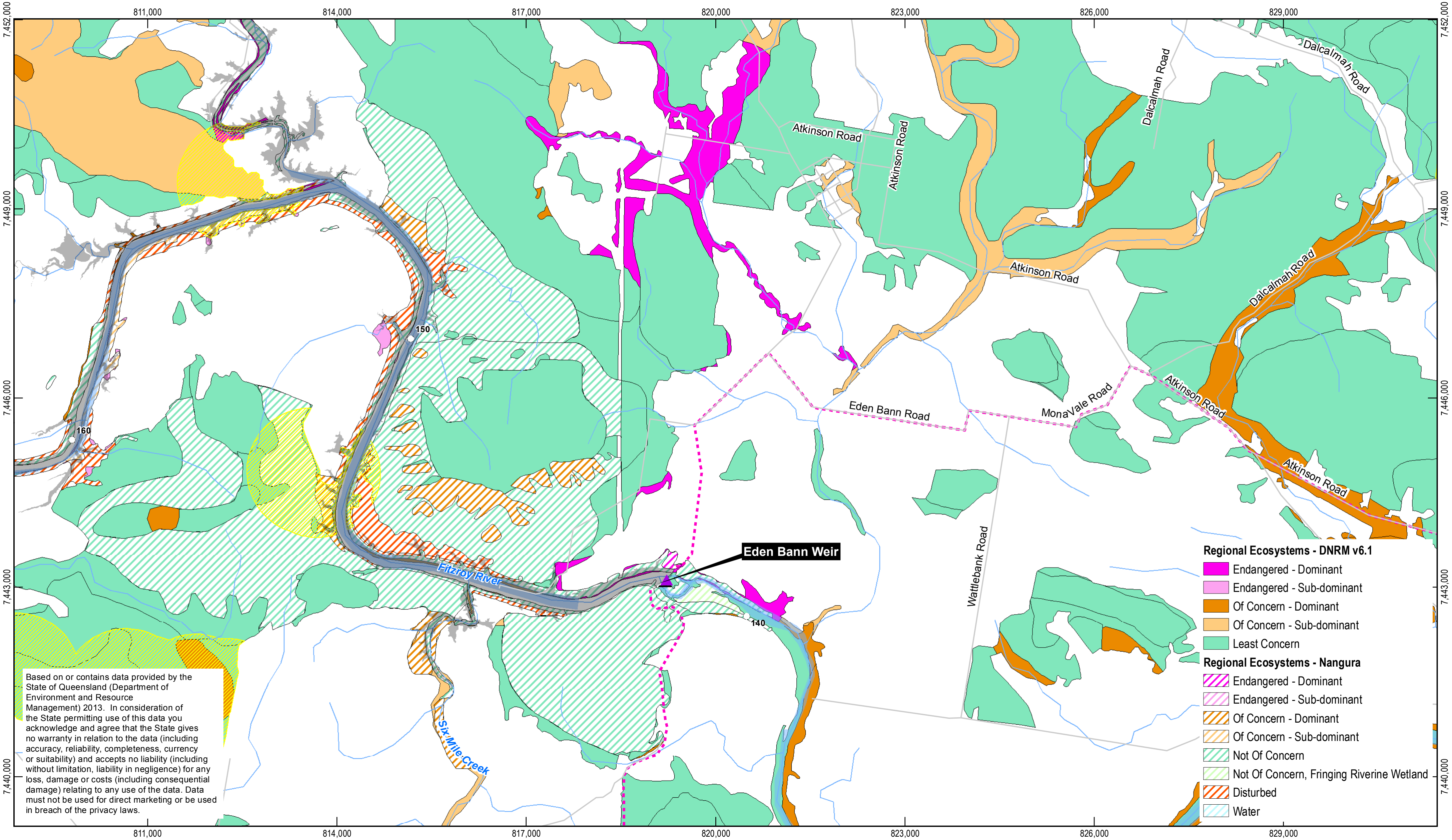

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0 1 2 3

Kilometres

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Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- River Crossing
- Highway
- Major Road
- Secondary Roads
- Access Road
- Impoundment Area 20.2 FSL
- Waterway
- Watercourse
- Essential Habitat

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Figure 7-19 Sheet 1 of 4

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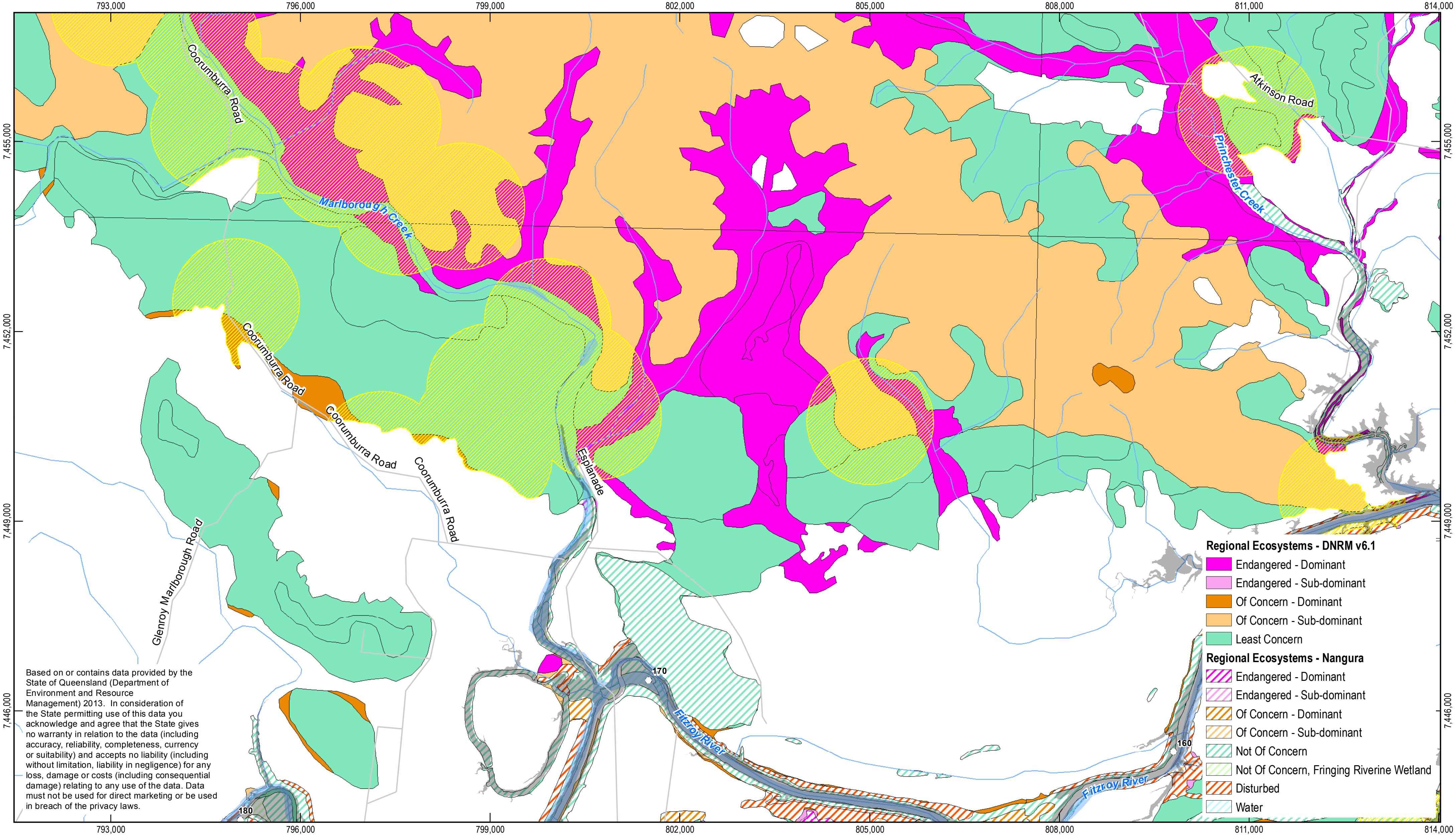

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Kilometres

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- Watercourse
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Eden Bann Weir Regional Ecosystem Mapping

Figure 7-19
Sheet 2 of 4

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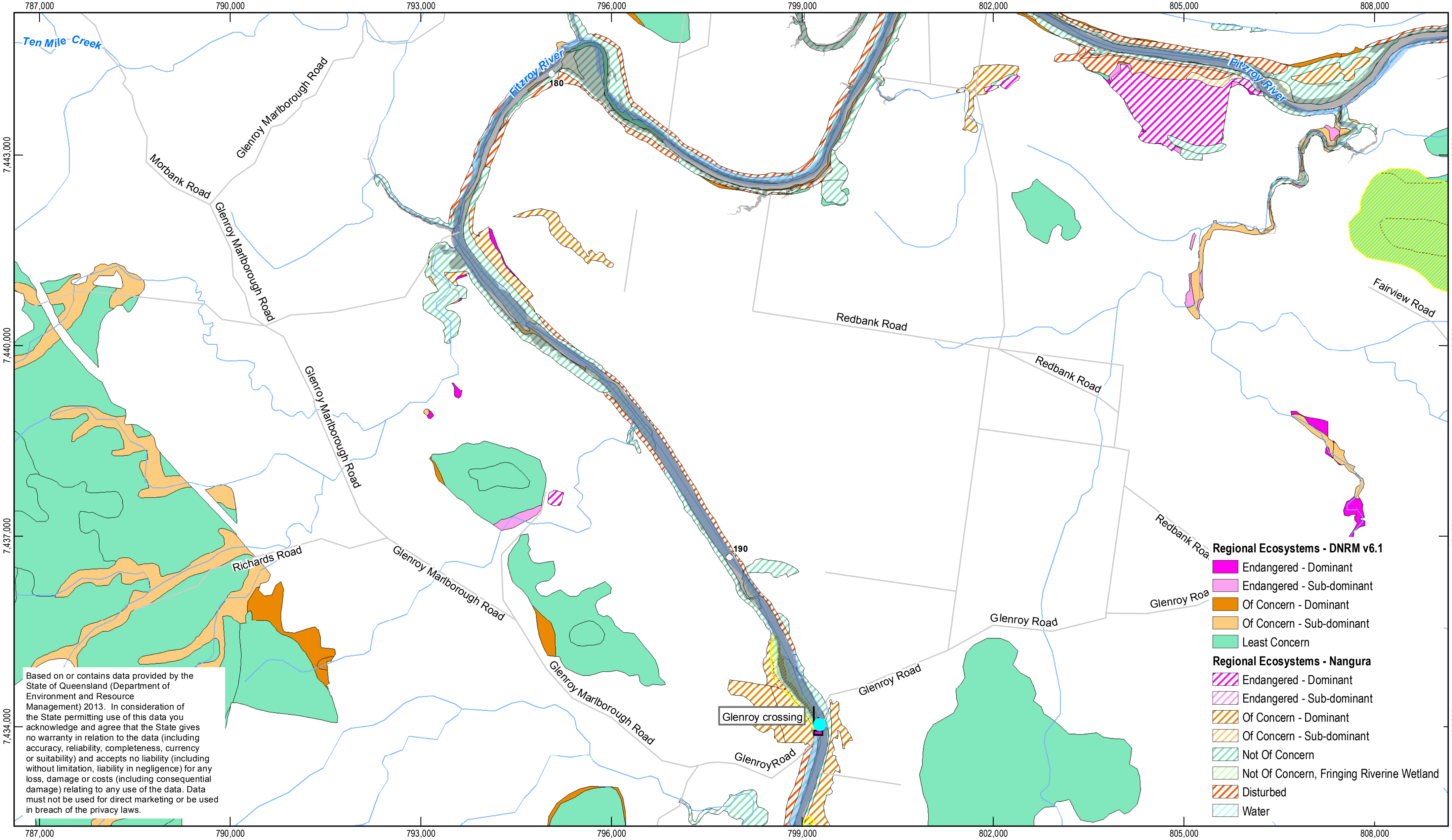

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Kilometres

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Eden Bann Weir Regional Ecosystem Mapping

Figure 7-19 Sheet 3 of 4

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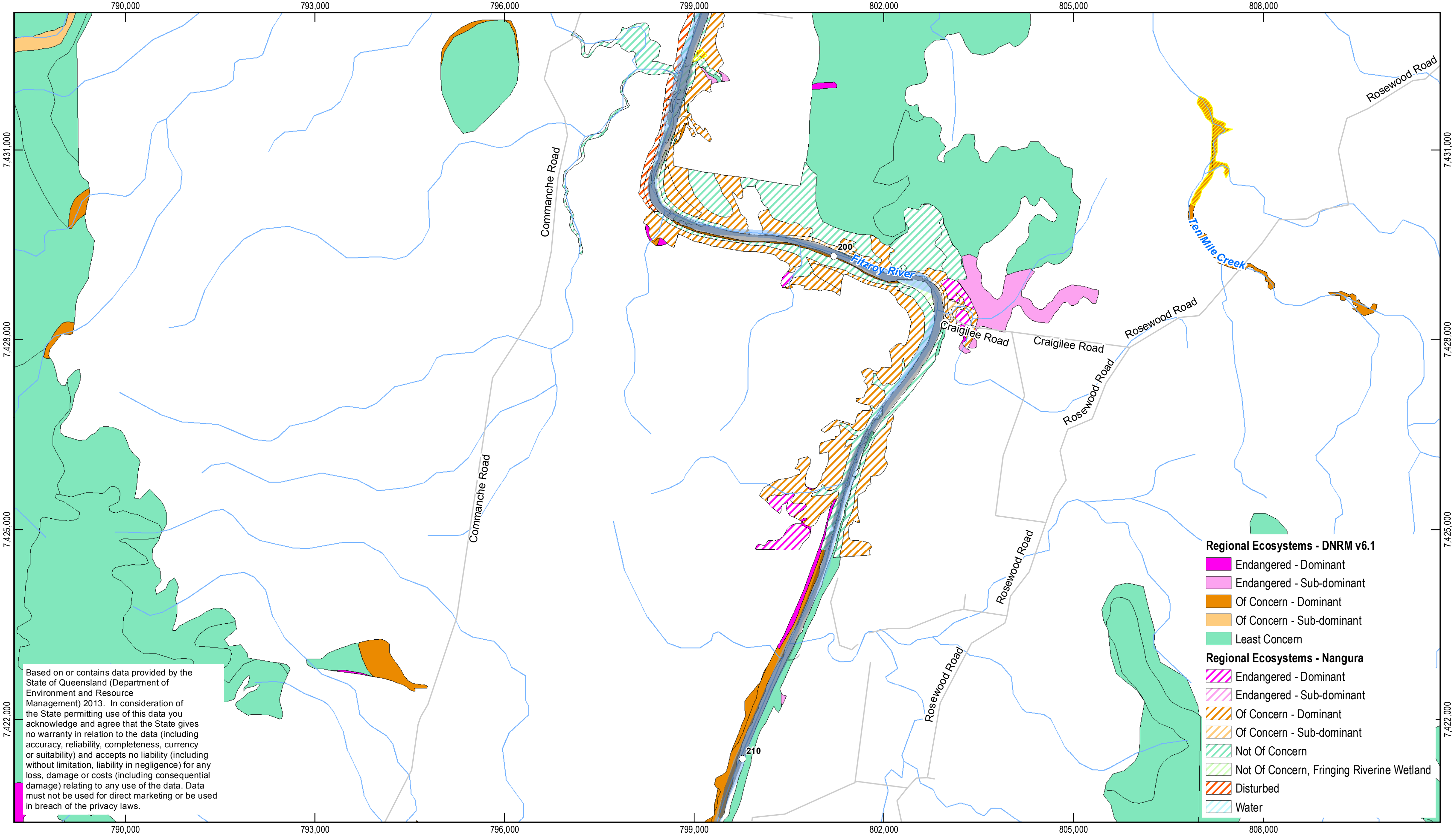

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Kilometres

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Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- River Crossing
- Highway
- Major Road
- Secondary Roads
- Access Road
- Impoundment Area 20.2 FSL
- Waterway
- Watercourse
- Essential Habitat

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Eden Bann Weir Regional Ecosystem Mapping

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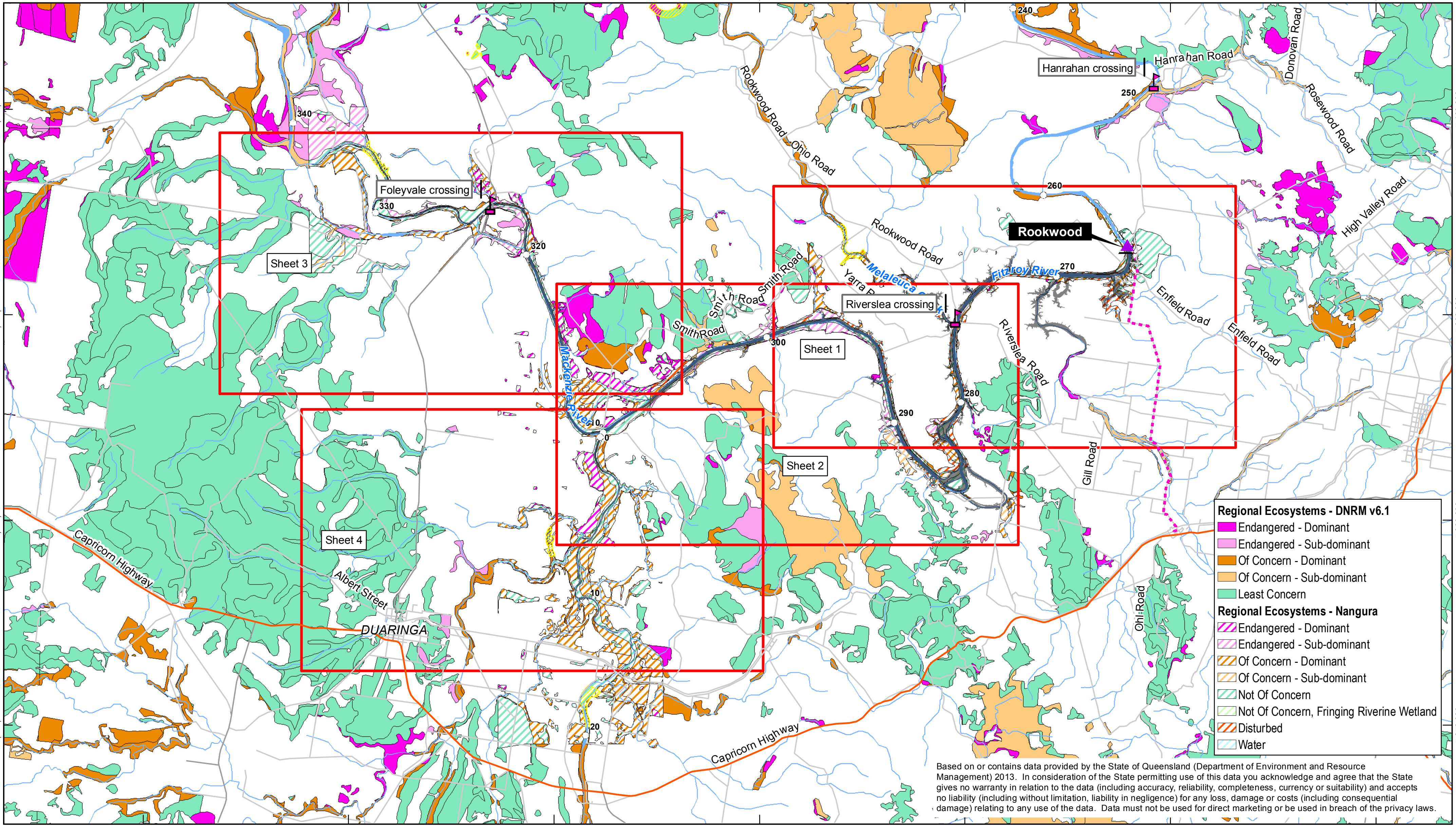

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- River Crossing
- Highway
- Major Road
- Secondary Roads
- Access Road
- Impoundment Area (Stage 2)
- Watercourse
- Waterway
- Grid Index
- Essential Habitat

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Rookwood Weir Regional Ecosystem Mapping

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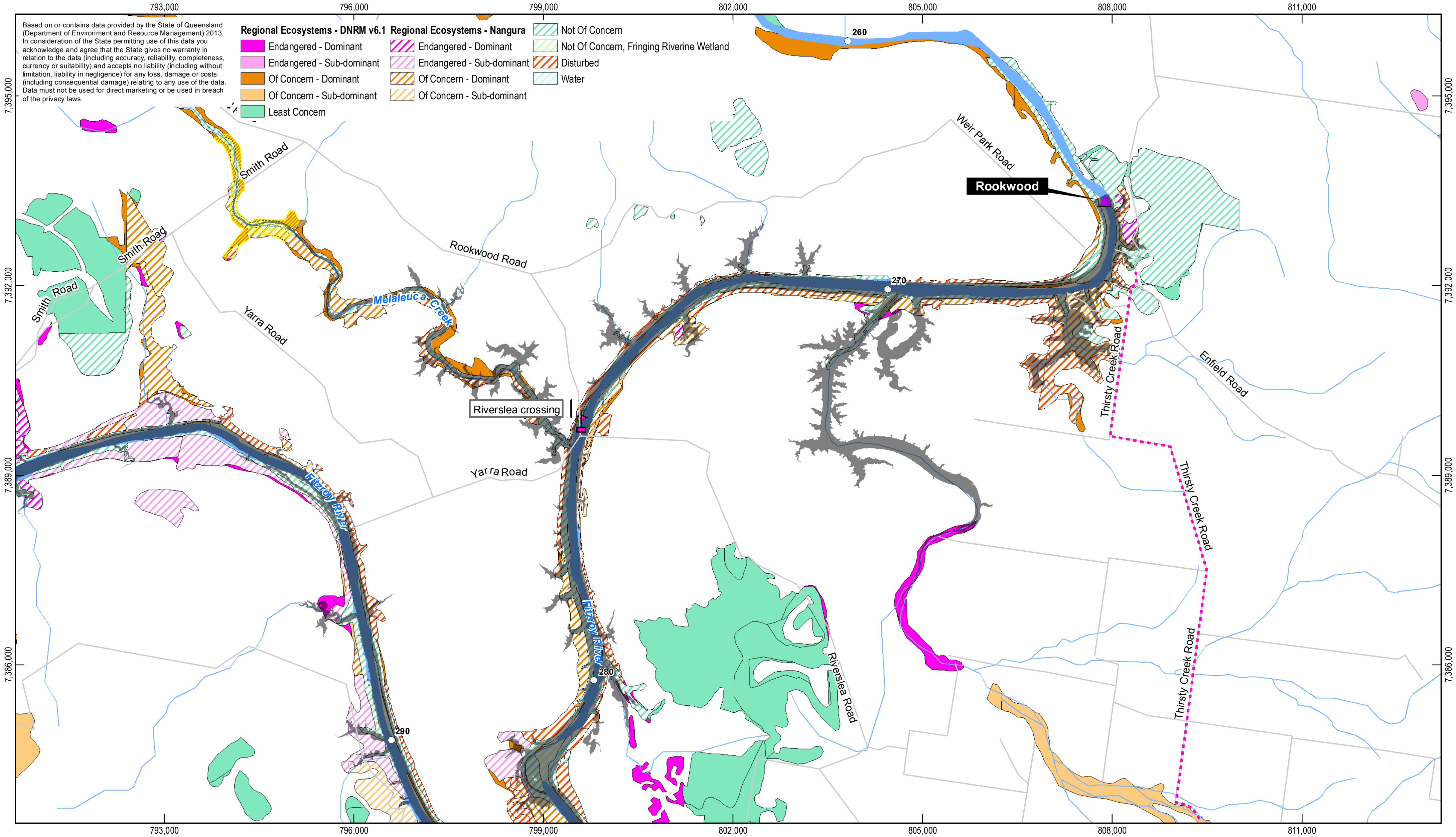

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Kilometres

Map Projection: Universal Transverse Mercator
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Grid: Map Grid of Australia 1994, Zone 55

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LEGEND

- AMTD (km)
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- Secondary Roads
- Access Road
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- Waterway
- Essential Habitat

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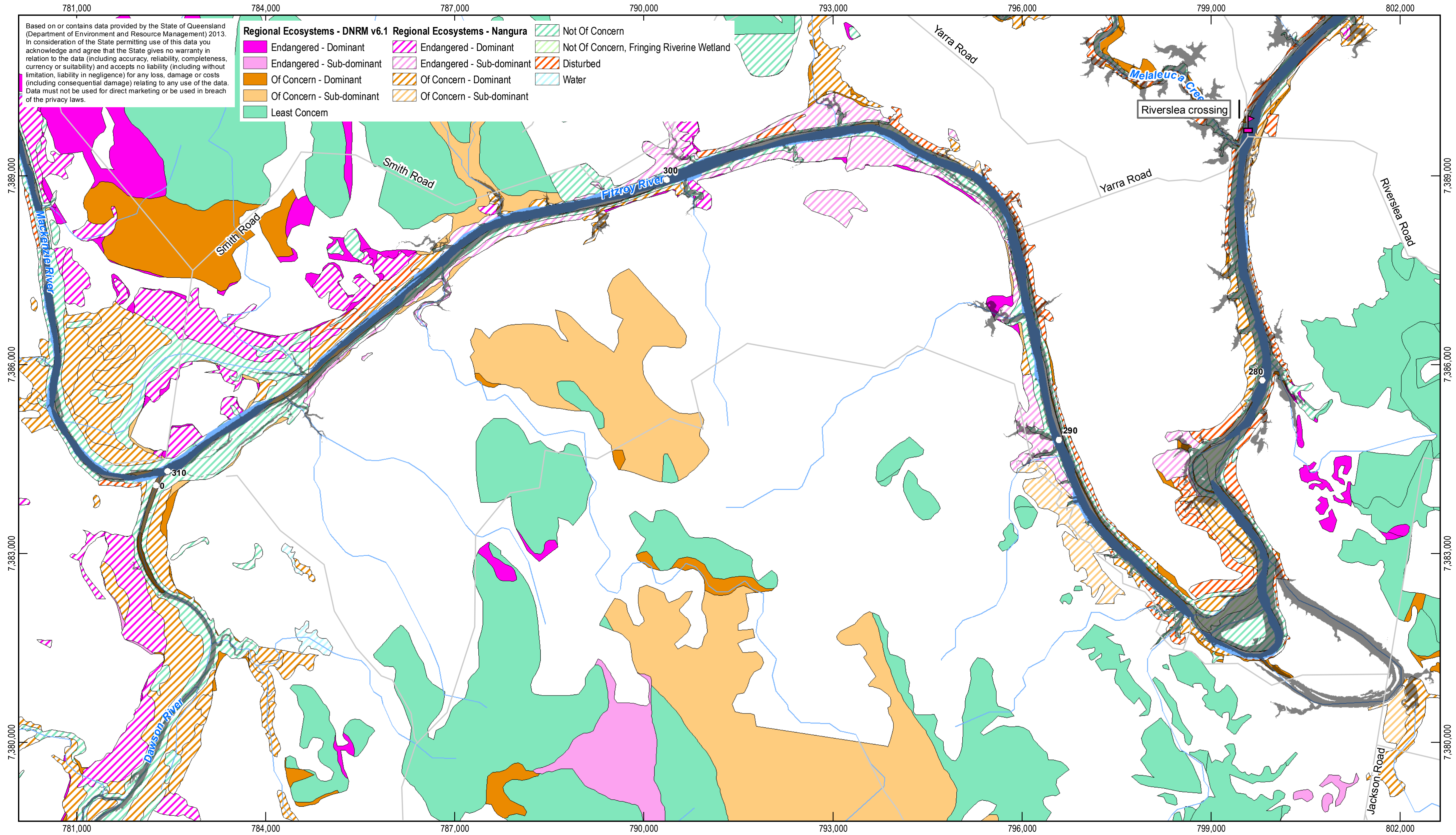

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Kilometres

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Horizontal Datum: Geocentric Datum of Australia (GDA94)
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LEGEND

- AMTD (km)
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- River Crossing
- Highway
- Major Road
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- Access Road
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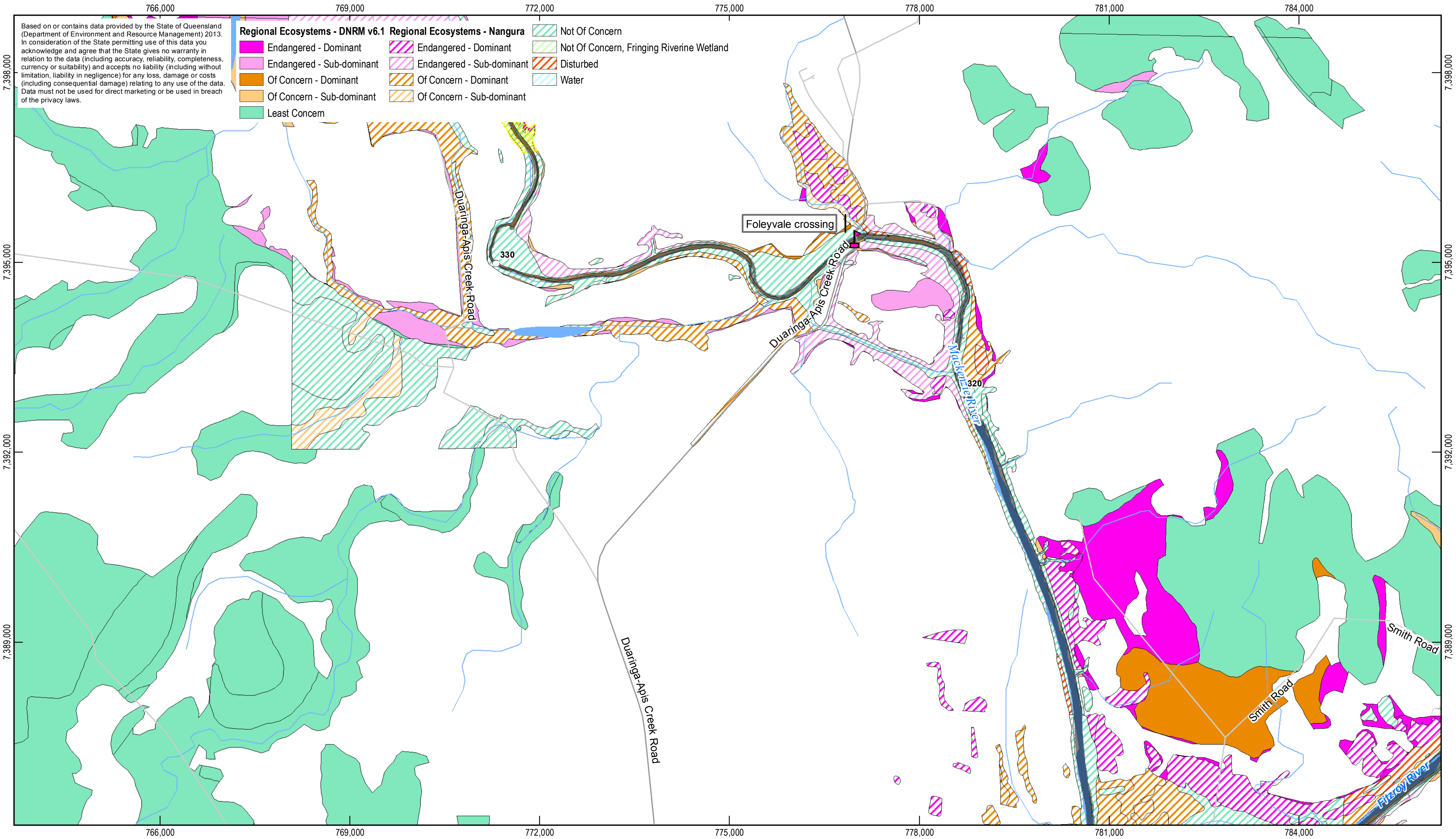

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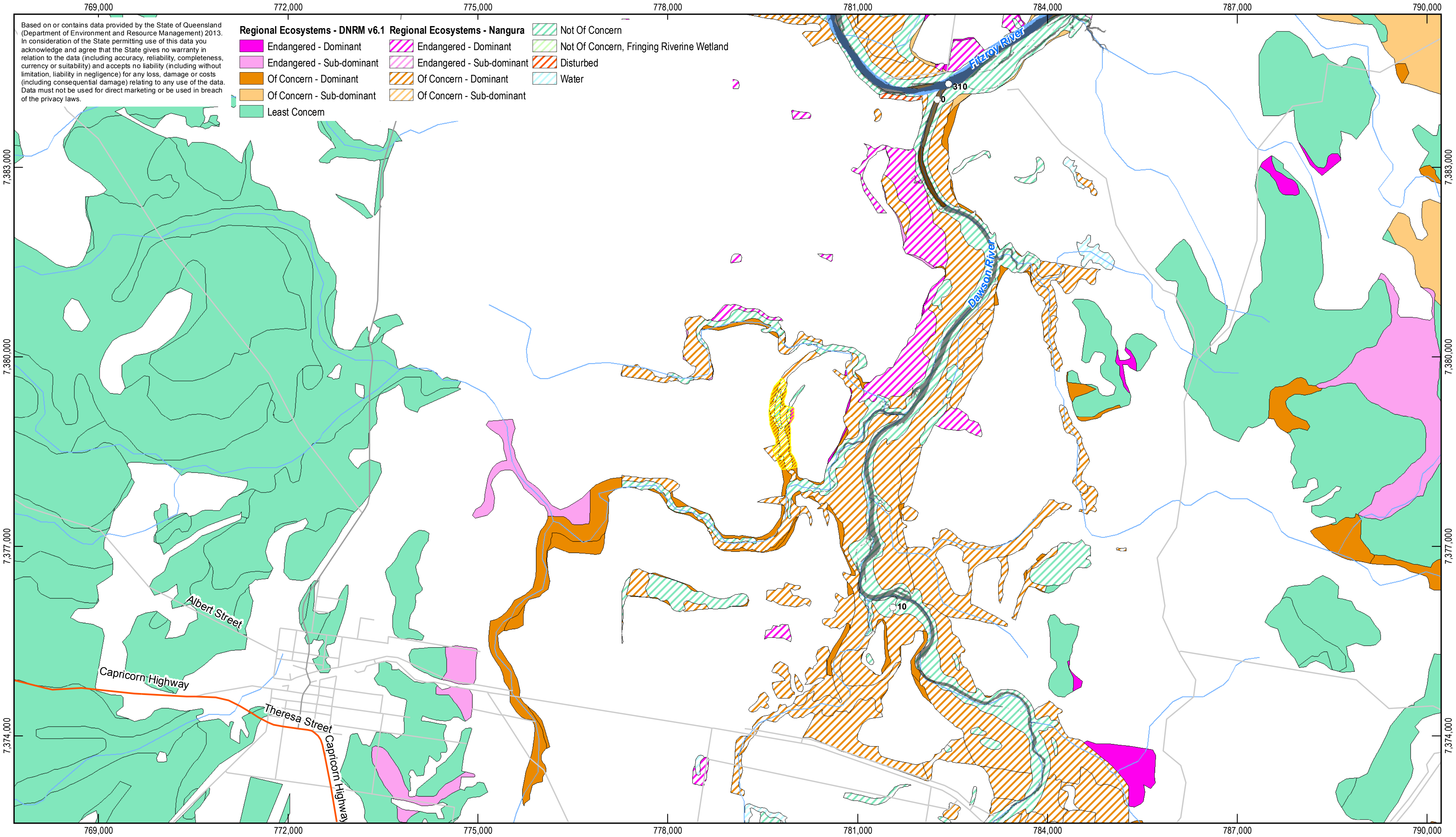

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7.8.3 Terrestrial habitats

Terrestrial habitat types, characteristics and values within the Project footprint are summarised in Table 7-11. Terrestrial fauna habitats are highly seasonal, responding to changes in rainfall and river flow. Ephemeral off-stream water bodies and creeks represent sensitive terrestrial fauna habitats within the Project footprint. Such habitats provide resources for a wide array of animals, including amphibians (breeding and foraging), reptiles (foraging), ground-dwelling mammals (foraging), microchiropteran bats (foraging) and birds (foraging and nesting amongst dense riparian vegetation).

Ecological resources and habitats critical to the long-term viability of conservation significant terrestrial species are unlikely to occur within the Project footprint. Nonetheless, fragmented habitats that occur within and adjacent to the Fitzroy River are likely to provide resources for small localised populations of threatened species, as well as a wide diversity of common, generalist species that are tolerant of a modified landscape matrix. Since much of the lowland landscape has been cleared for agricultural development, riparian habitat corridors perform a valuable role, maintaining connectivity between habitat remnants.

Although the landscape has been significantly altered through land clearing, remnants of fauna habitat types identified within the Project footprint provide sufficient foraging, shelter and breeding resources for at least 158 species within the Eden Bann Weir Project footprint and at least 208 species within the Rookwood Weir Project footprint (as identified during wet and dry season field surveys).

Much of the landscape surrounding the Project footprint has been cleared, predominantly for agriculture. This is particularly the case on lowland alluvial floodplains, where cattle grazing on cleared pasture is the dominant land use. Vegetation in these otherwise cleared or fragmented landscapes tends to be concentrated along the riparian fringe of the Fitzroy, Dawson and Mackenzie rivers and adjoining creeks. Extensive open woodland communities on low rocky hills and less disturbed floodplains represent important habitat nodes within the disturbed landscape matrix. Large tracts of land to the north and west of the Project footprint are mapped as state significant habitat remnants. These large, relatively in-tact habitats are also likely to act as a source for fauna dispersal across the landscape. Fauna dispersal across the fragmented landscape is likely to be facilitated, at least in part, by vegetation corridors adjacent to the Fitzroy, Dawson and Mackenzie Rivers and adjoining creeks.

Table 7-11 Terrestrial habitat types, characteristics and values

Habitat type	Characteristics	Value for wildlife	Representative habitat
Open woodland with grassy understorey and *Melaleuca* riparian fringe	• Riparian fringe of Melaleuca • Low-moderate density mature eucalypts • Sparse shrub layer • Complex understorey with native grasses and sedges • Fallen woody debris and leaf litter • Hollows and stags	Habitat value for: • Canopy-nesting birds • Skinks, dragons, geckos, snakes • Tree and burrowing frogs • Koalas, possums, gliders • Bandicoots, rodents, macropods Relative ecological value (REV): Moderate	
Open woodland with weedy understorey and *Melaleuca* riparian fringe	• Sparse density mature eucalypt canopy present • Shrub layer dominated by weed species • Understorey dominated by weedy grass	Habitat value for: • Canopy, shrub and grassland birds • Snakes, skinks, dragons • Macropods, bandicoots • Rodents, possums REV: Moderate	
Open woodland on rocky hillside	• Low density stunted eucalypts • Areas of Casuarina and vine thicket • Sparse understorey vegetation • Rocky substrate • Abundance of fallen logs and woody debris	Habitat value for: • Canopy nesting birds • Snakes, skinks, dragons, geckos • Small ground mammals REV: High	
Brigalow	• Few mature canopy trees • Moderate density acacia shrub layer • Sparse understorey vegetation • Relatively complex ground substrates • Leaf litter, fallen woody debris	Habitat value for: • Shrub-nesting birds • Skinks, dragons, geckos, snakes • Macropods REV: High	

Habitat type	Characteristics	Value for wildlife	Representative habitat
Open woodland on sandy substrate	• Sandy substrate • Relatively simple understorey • Shrub layer largely absent • Mature eucalypts • Stags abundant • Many hollows	Habitat value for: • Canopy birds and waterbirds • Possums, koalas, gliders REV: Moderate	
Melaleuca on sandy substrate	• No tall canopy trees • Dense low Melaleucas • No understorey vegetation • Sandy substrate • Relatively low habitat complexity • Seasonally inundated	Habitat value for: • Shrub-nesting birds and waterbirds • Skinks, dragons, snakes • Nesting habitat for crocodiles and turtles REV: High	
Melaleuca forest	• Dense canopy of short Melaleucas • Shrub layer dominated by castor oil plant *(Ricinus communis)* • Bare muddy substrate • Often inundated (seasonally) • Low diversity of ground-level microhabitats	Habitat value for: • Shrub and canopy-nesting birds • Waterbirds • Rodents REV: Moderate	
Narrow riparian fringe	• Moderate-density tree layer of eucalypts • Dense but narrow shrub layer of juvenile eucalypts • Understorey of leaf litter, grass and woody debris • Very narrow, exposed to edge effects of noise, light and weeds • Corridor for wildlife movement	Habitat value for: • Pasture-adapted birds • Possums • Grass skinks, wall skinks, bearded dragons • Introduced/native rodents REV: Moderate	

Habitat type	Characteristics	Value for wildlife	Representative habitat
Agricultural land	• Tree and shrub layer absent • Uniform ground cover of short to long grazed grass • Few logs or woody debris • Structurally simple	Habitat value • Pasture land birds • Raptors • Snakes • Macropods REV: Low	
Creeks	• Narrow stream • Shallow-slow flowing water • High density of overhanging vegetation • High density of shrub and ground-level vegetation • High density of in-stream debris	Habitat value for: • Forest birds, waterbirds • Water dragons, snakes • Frogs • Ground mammals • Microchiropteran bats REV: High	
Off-stream water bodies	• Seasonally connected to main river system by floodwaters • High density of overhanging vegetation • High abundance of in-stream debris	Habitat value for: • Forest birds, waterbirds • Burrowing and ephemeral breeding frogs • Snakes • Ground mammals • Microchiropteran bats REV: High	

7.8.4 Terrestrial fauna

Fauna species diversity (including common species, threatened species, marine and/or migratory species and introduced species) was recorded through desktop analysis and field fauna surveys. Table 7-12 present the number of mammals, birds, reptiles and amphibians recorded according to desktop assessment and field surveys for Eden Bann Weir and Rookwood Weir.

Five threatened terrestrial fauna species were recorded within the Project footprint during field surveys. One EPBC Act threatened species, squatter pigeon (*Geophaps scripta scripta*), was identified at both Eden Bann Weir and Rookwood during wet and dry season surveys. Three NC Act threatened species were observed at both Eden Bann Weir and Rookwood Weir during the wet and dry season surveys: little pied bat (*Chalinolobus picatus*), black-necked stork (*Ephippiorhynchus australis*), black-chinned honeyeater (*Melithreptus gularis*). The cotton pygmy-goose (*Nettapus coromandelianus*) was also observed at Rookwood Weir. Two NC Act listed special least concern species (koala and echidna) was also recorded during the field surveys.

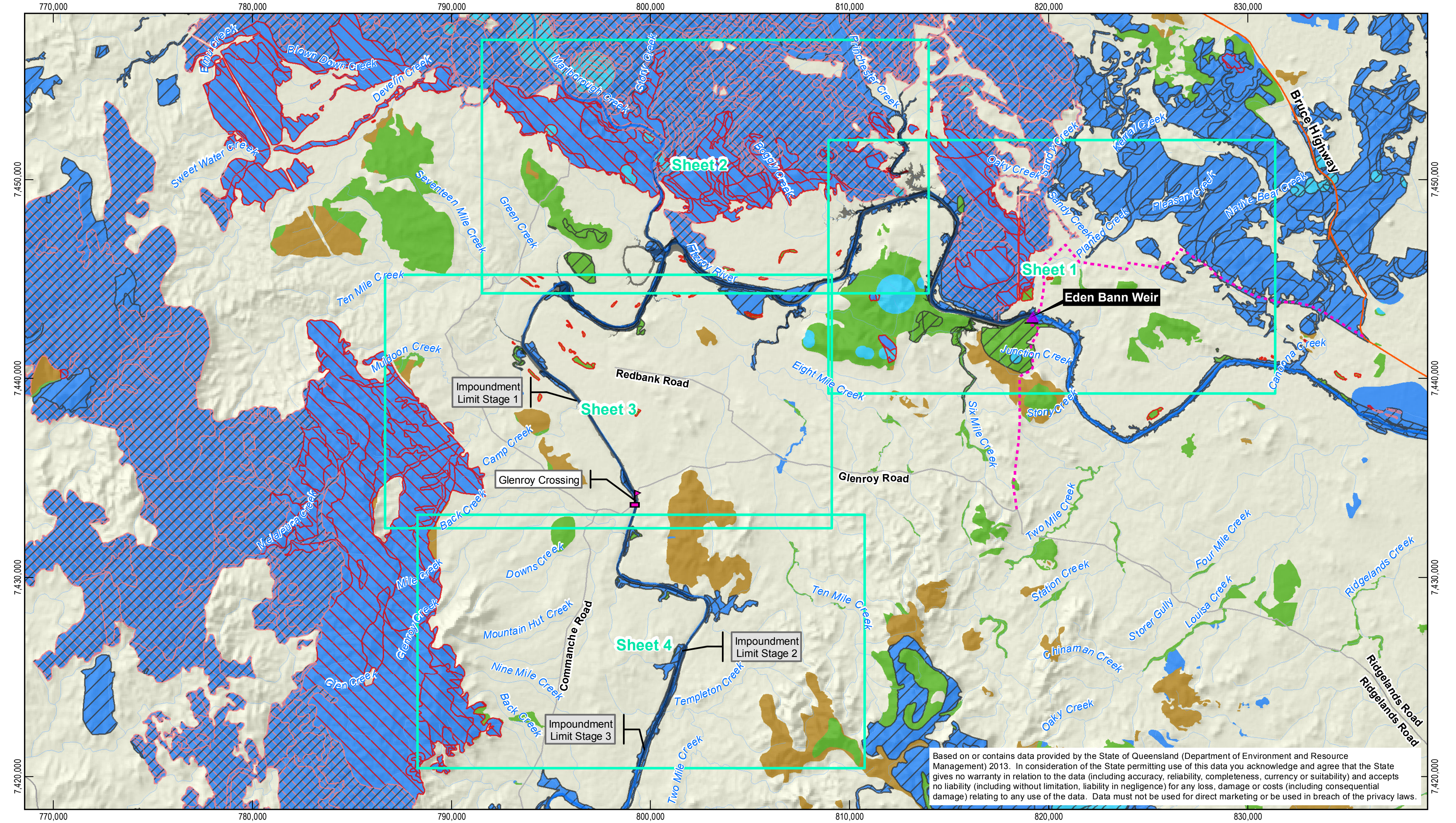
Chapter 10 Listed threatened species and ecological communities provides further detail and an assessment of impacts on EPBC Act listed terrestrial fauna species.

7.8.5 Biodiversity and connectivity

Habitat connectivity has been impacted on in lower lying areas by historic and contemporary vegetation clearing for agriculture. The most extensive areas of interconnected habitat exist on higher reaching ground where limited vegetation clearing has occurred. These areas support extensive networks of open woodland habitats with rocky substrate. Given their connectivity and unique resource values, these areas have high ecological value as habitat and regional corridors for wildlife movement. Under the Queensland Government's Biodiversity Planning Assessment mapping, these areas are classified as being state significant bioregional wildlife corridors (Figure 7-21 and Figure 7-22, for Eden Bann Weir and Rookwood Weir respectively). Within the agricultural lowland areas, vegetation has been retained predominantly along the riparian fringe. Although this lowland vegetation has been subjected to significant edge effects and impacts from cattle, it plays an important ecological role, providing both habitat and a level of connectivity between habitat remnants. Connectivity and biodiversity values in the upper reaches of the proposed impoundment are limited to fragmented patches of riparian fringe vegetation largely unconnected to other remnant habitat.

Table 7-12 Terrestrial fauna species predicted to occur or recorded during field surveys

Value	Predicted to occur (Protected Matters search tool)	Previously recorded			Field surveys
		Wildlife Online	Queensland Museum specimen database	Birds Australia Atlas	
Eden Bann Weir					
Species diversity		4 amphibians 7 reptiles 9 mammals 75 birds	5 amphibians 13 reptiles 1 mammal	70 birds	12 amphibians 20 reptiles 28 mammals 98 birds
EPBC Act threatened species	4 reptiles 3 mammals 6 birds	1 mammal 1 bird		1 bird	1 bird (squatter pigeon)
NC Act threatened species	4 reptiles 2 mammals 6 birds	2 mammal 2 birds	1 reptile	1 bird	1 mammal 3 birds
EPBC Act 'marine' / 'migratory' species	16 birds	16 birds	-	17 birds	24 birds
Introduced / pest species	4 mammals	1 amphibian 4 mammals	-	-	1 amphibian 5 mammals
Rookwood Weir					
Species diversity		6 amphibians 9 reptiles 14 mammals 112 birds	6 reptiles 3 mammals	148 birds	12 amphibians 22 reptiles 41 mammals 133 birds
EPBC Act threatened species	4 reptiles 3 mammals 5 birds		1 mammal		1 bird (squatter pigeon)
NC Act threatened species	4 reptiles 2 mammals 5 birds	3 birds	1 mammal	3 birds	2 mammals 4 birds
EPBC Act 'marine' / 'migratory' species	14 birds	21 birds	-	39 birds	23 birds
Introduced / pest species	5 mammals	1 amphibian 5 mammals	-	-	1 amphibian 8 mammals



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Kilometres

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N

LEGEND

- Weir Location
- River Crossing
- Access Road
- Waterway
- Highway
- Road
- Impoundment Area
- Grid Index

BPA Qualifying Information
- Bioregional Corridor
- Habitat Remnant
- Habitat Remnant and Bioregional Corridor

Biodiversity Significance
- State Habitat for EVR taxa
- State
- Regional
- Local or Other Values

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Figure 7-21

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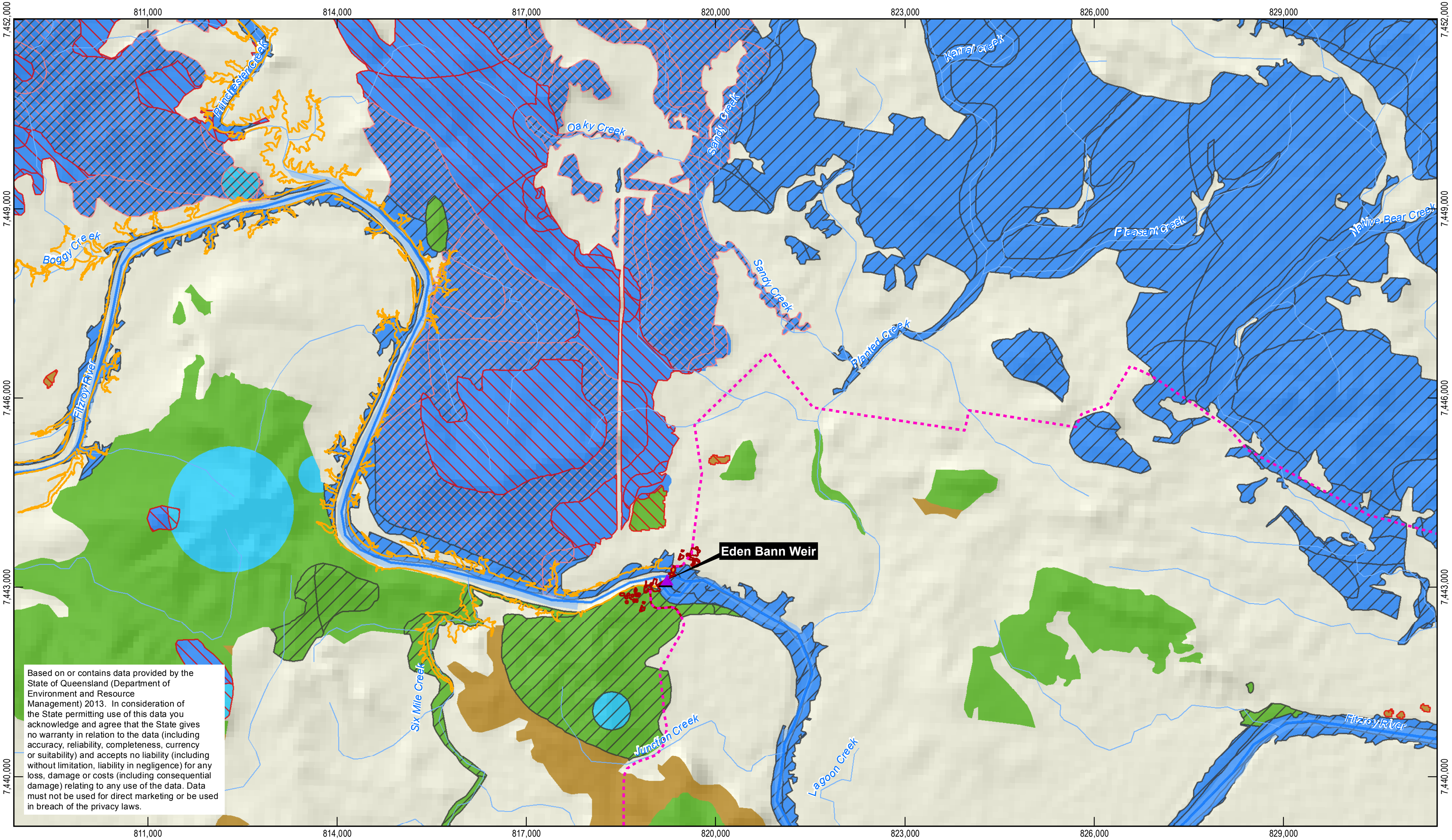

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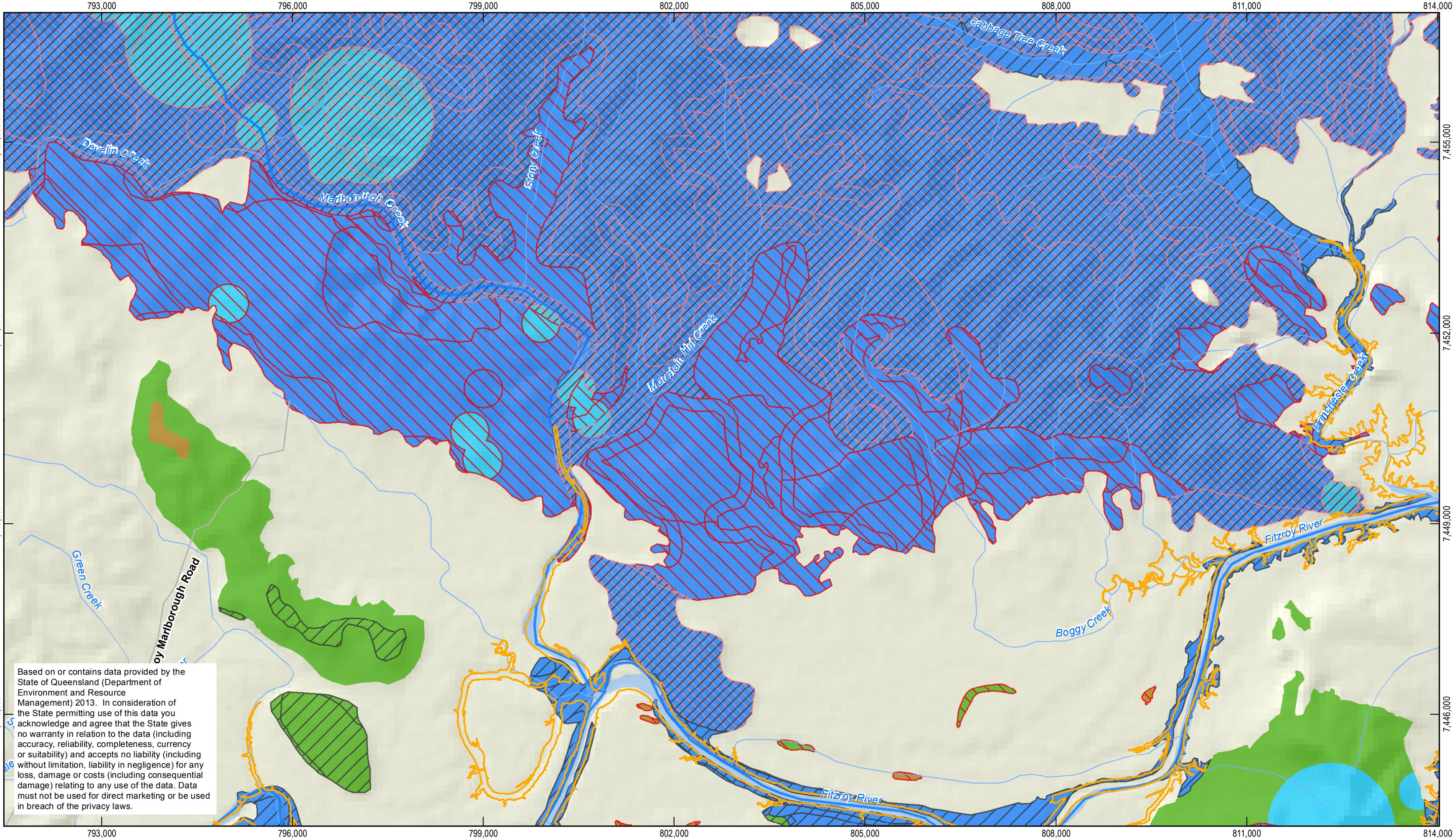

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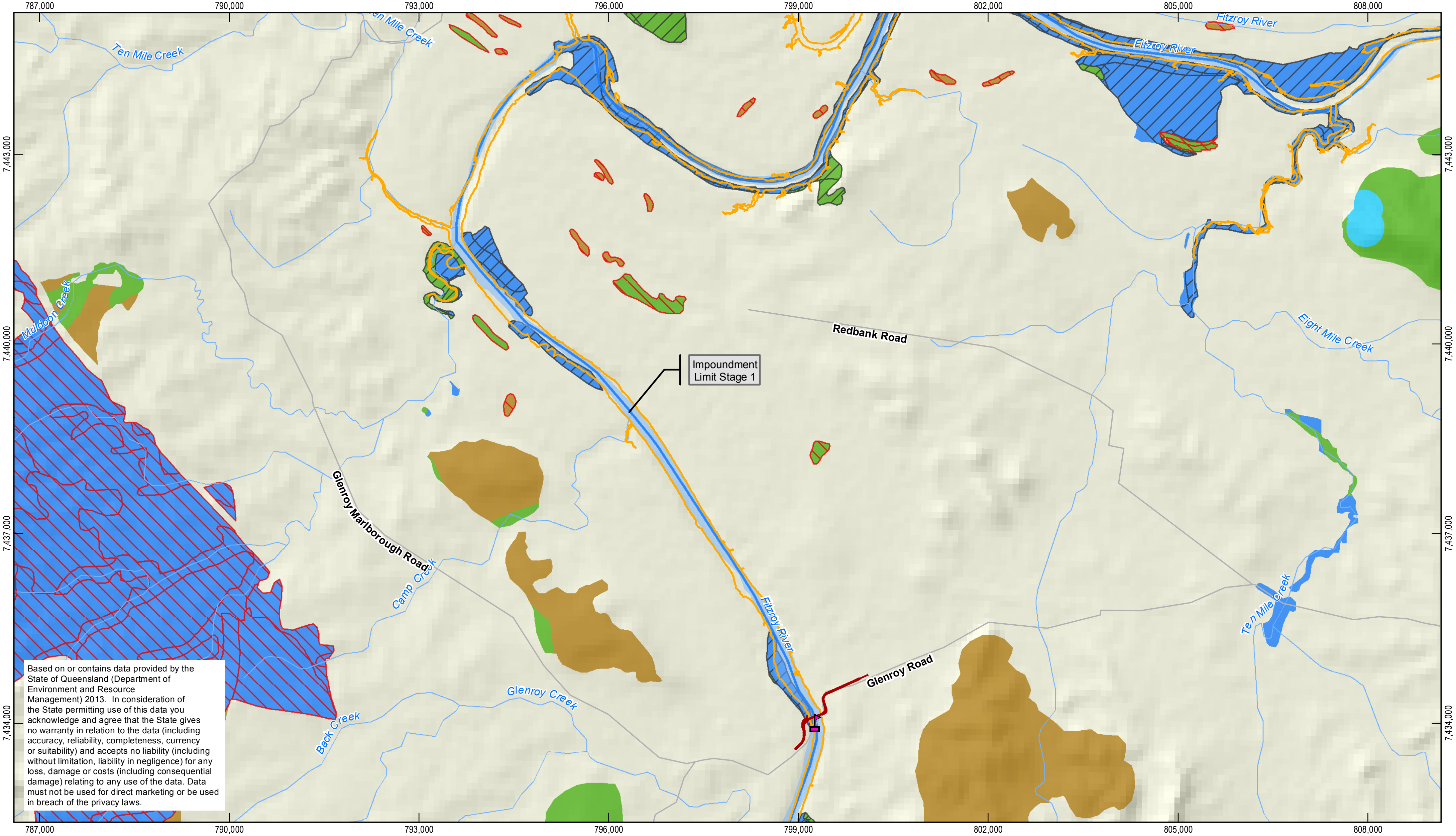

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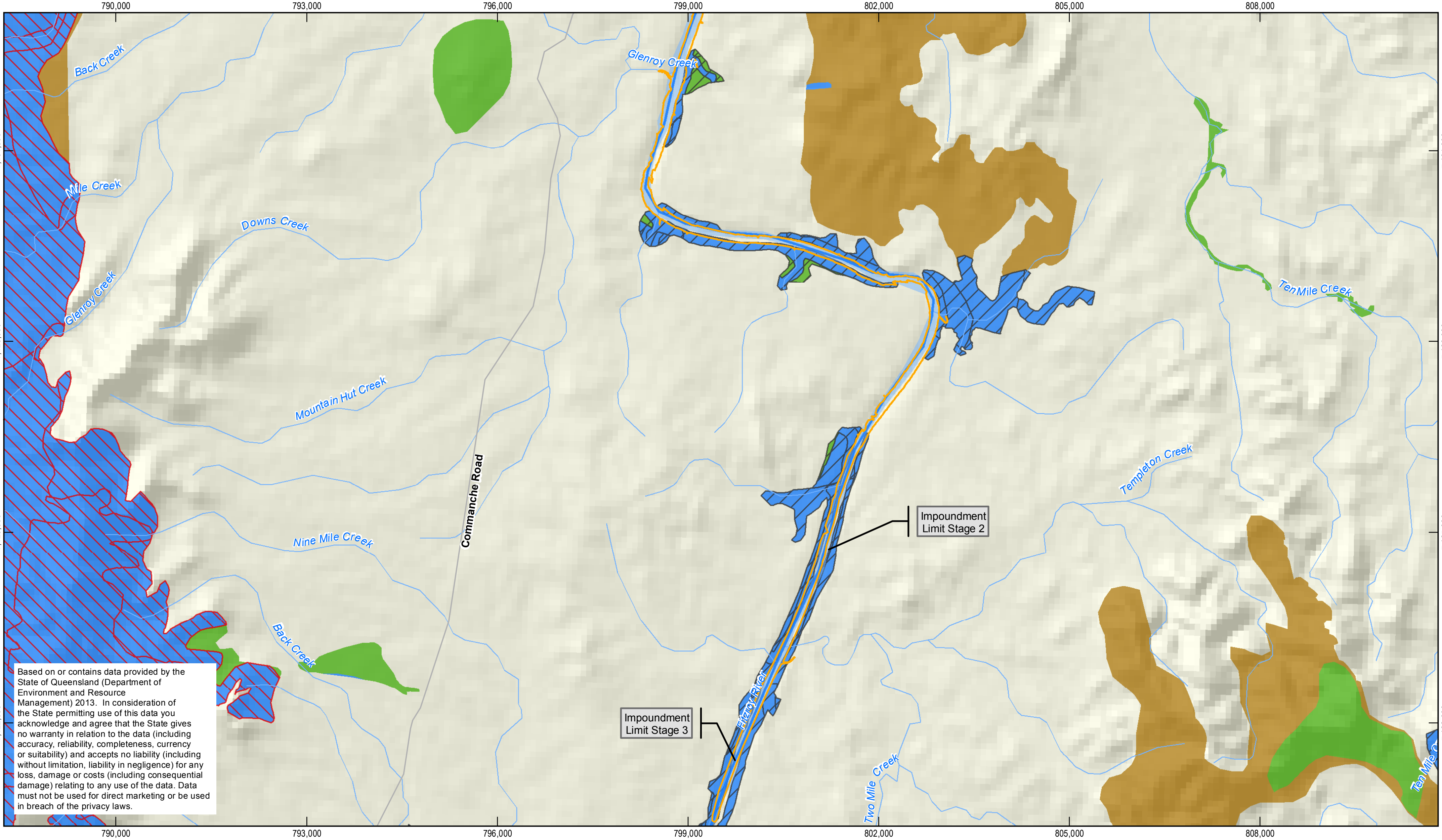

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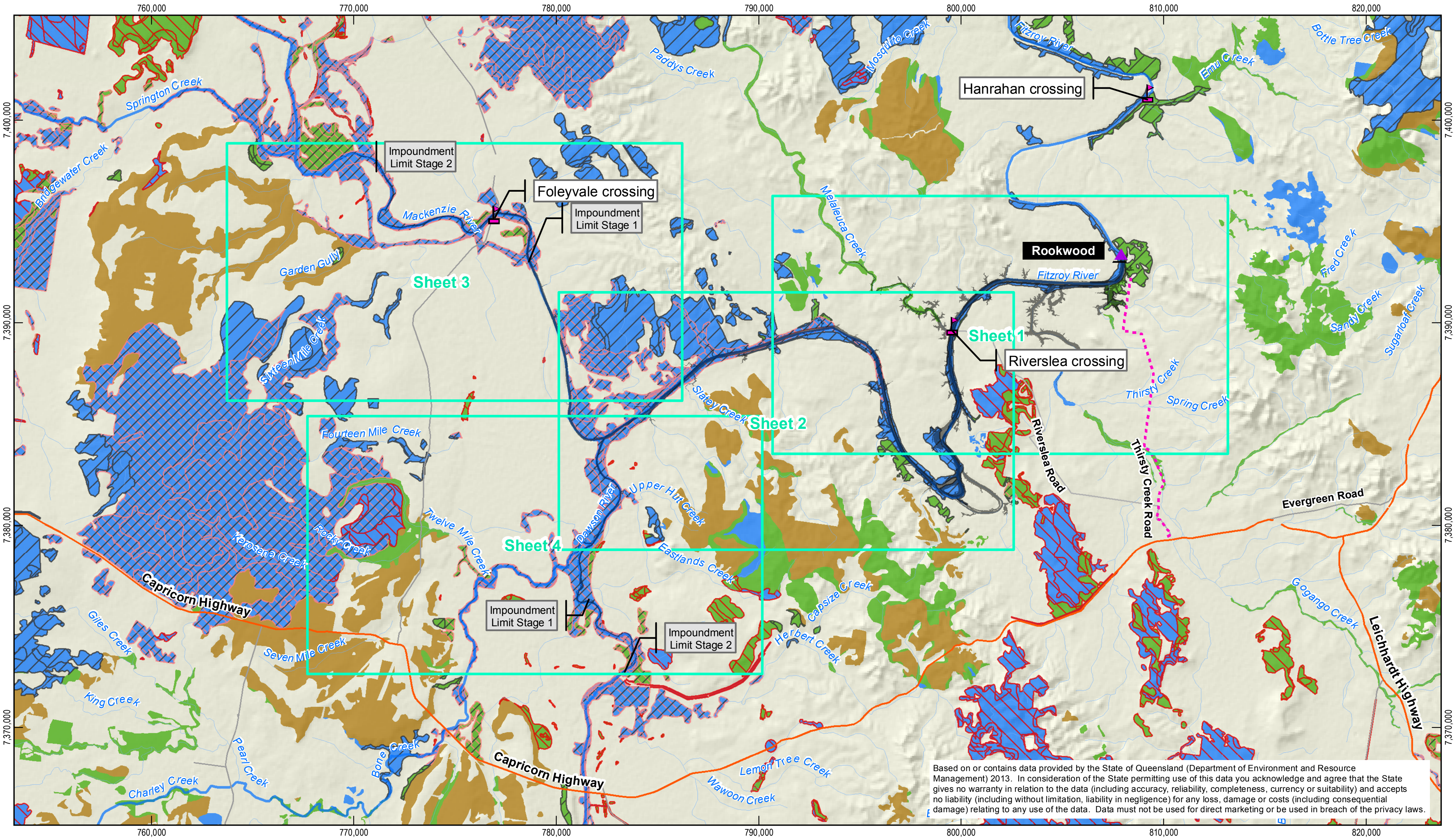

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- River Crossing
- Waterway
- Highway
- Major Road
- Access Road
- Impoundment Area
- Grid Index

BPA Qualifying Information
- Bioregional Corridor
- Habitat Remnant
- Habitat Remnant and Bioregional Corridor

Biodiversity Significance
- State
- Regional
- Local or Other Values

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Rookwood Biodiversity
Planning Assessment mapping

Index Map
Figure 7-22

G:\41\20736\GIS\Projects\MXD\200_Report\4120736_230_Rev_E_Index.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com.au W www.ghd.com.au

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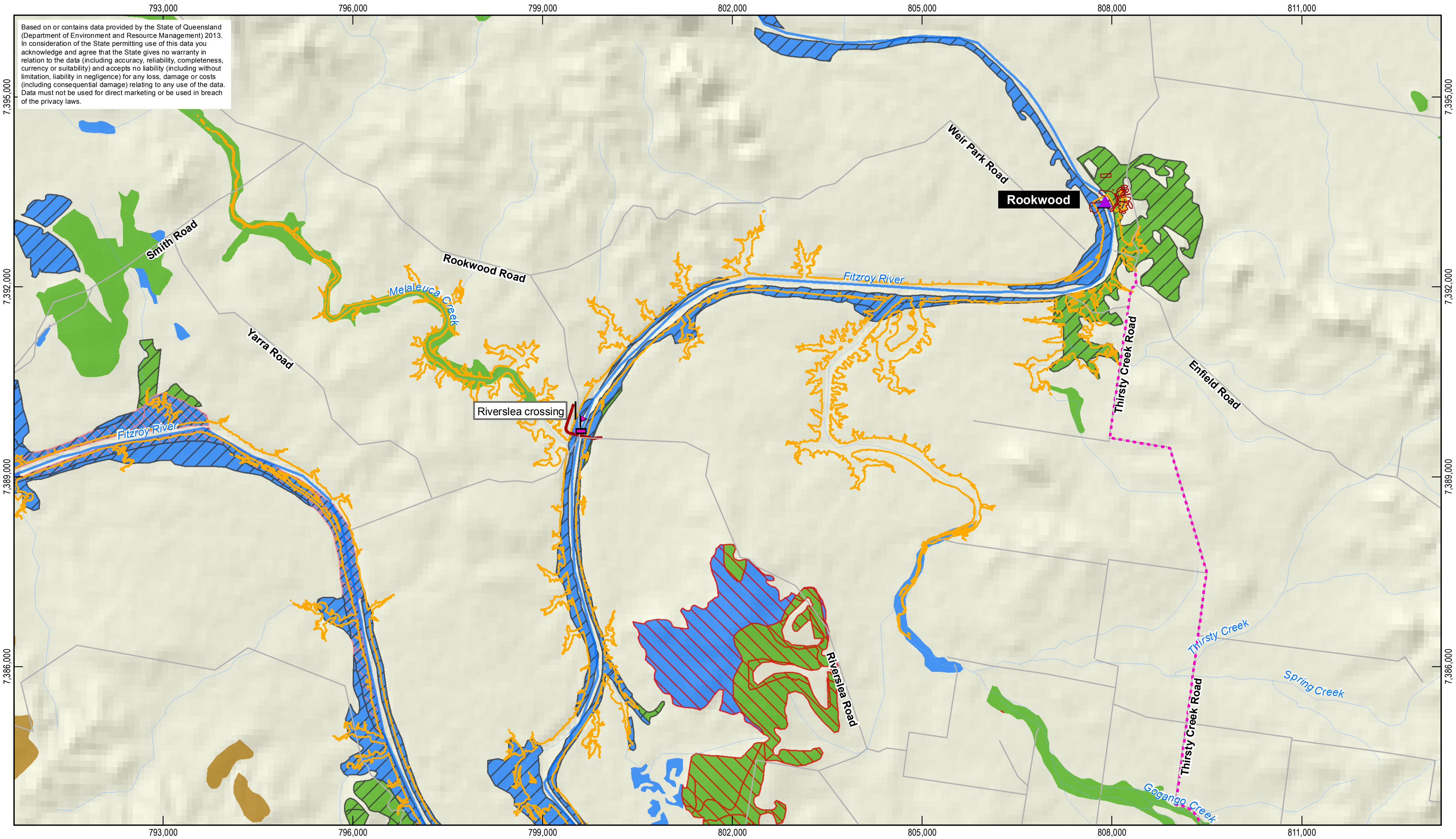

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

Weir Location
River Crossing
Highway
Road
Access Road
Waterway
Impoundment Area
Construction Footprint

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Figure 7-22
Sheet 1 of 4

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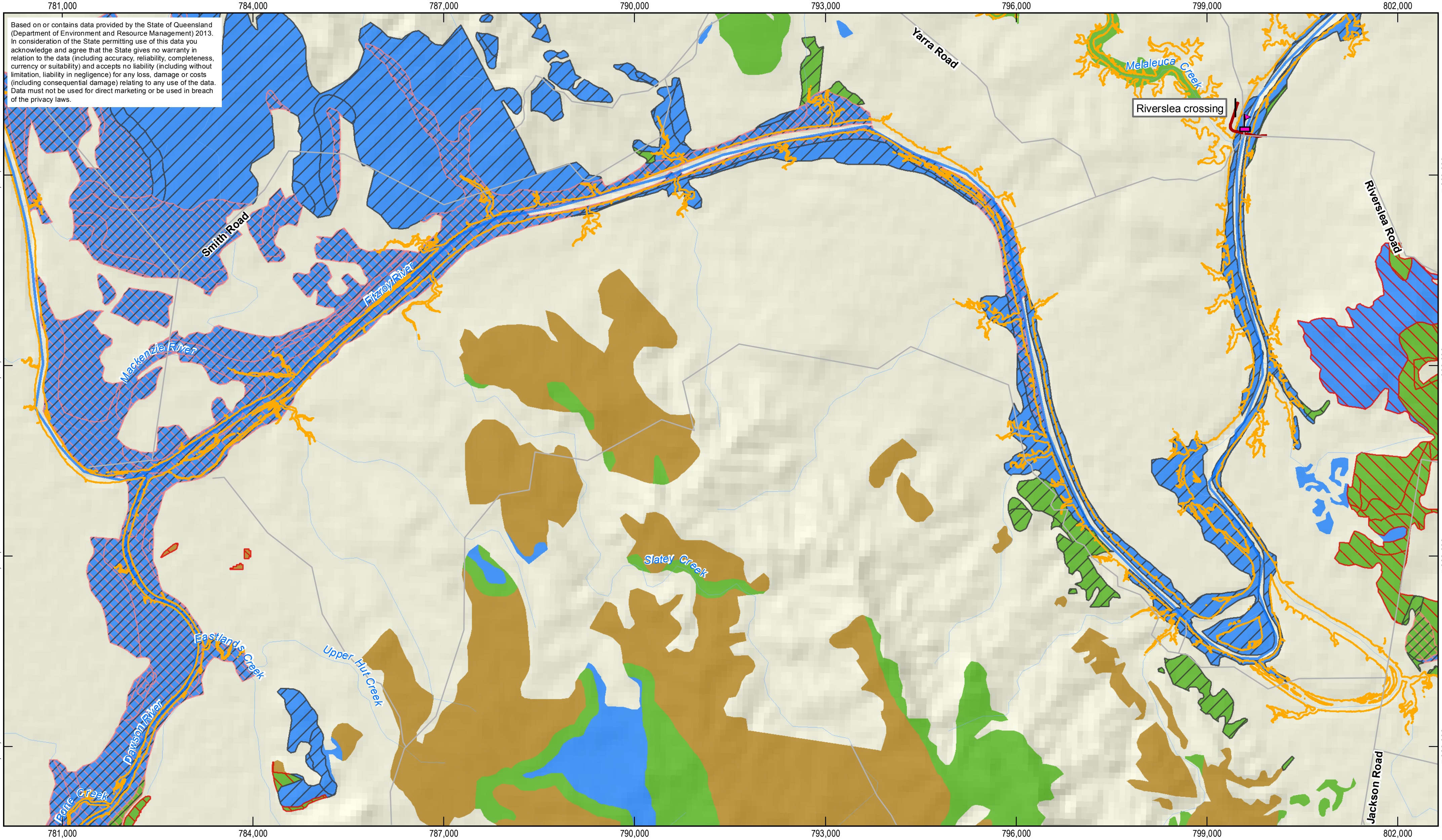

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- River Crossing
- Highway
- Road
- Access Road
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- Impoundment Area
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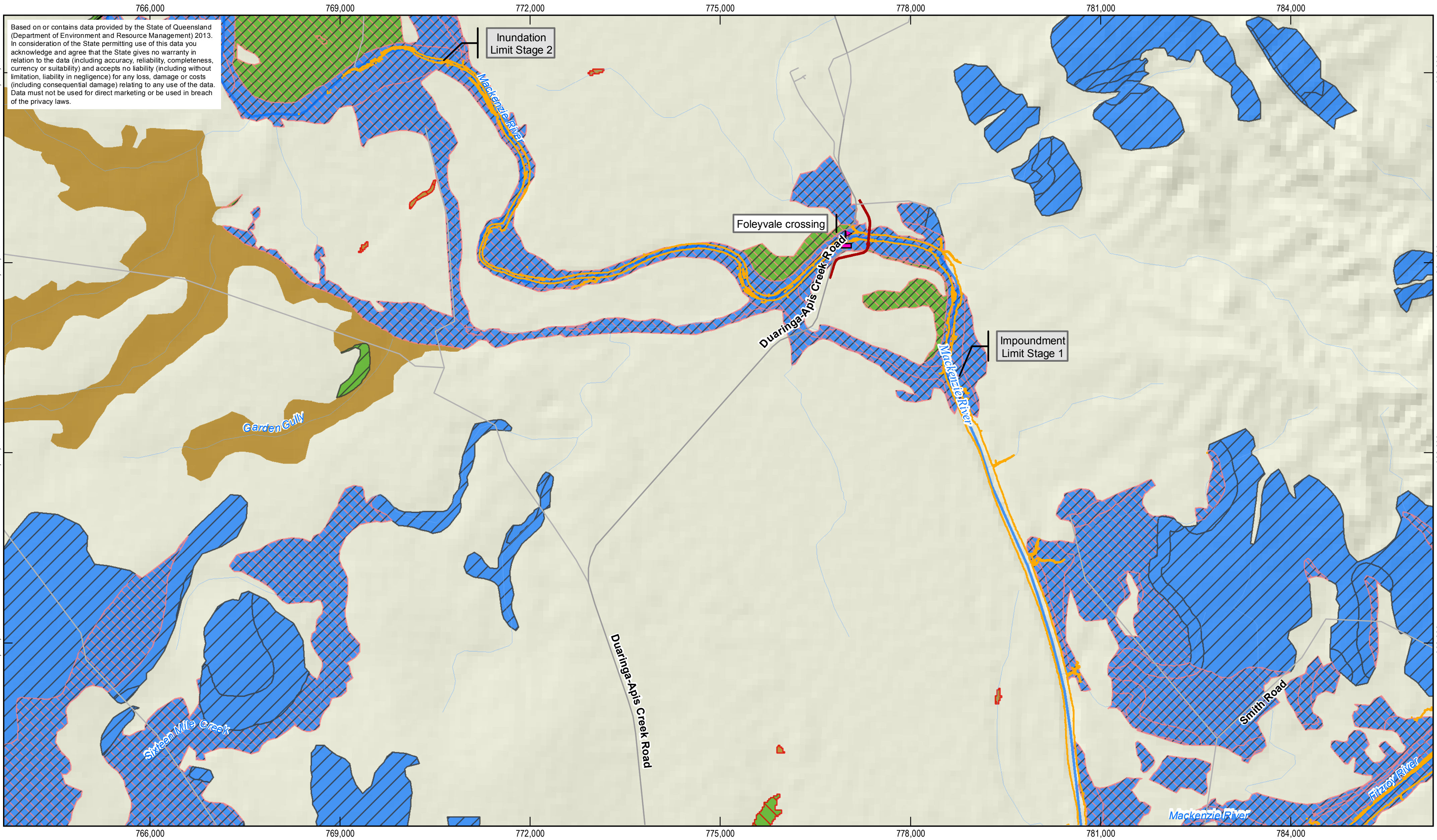

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- River Crossing
- Highway
- Road
- Access Road
- Waterway
- Impoundment Area
- Construction Footprint

BPA Qualifying Information
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Figure 7-22
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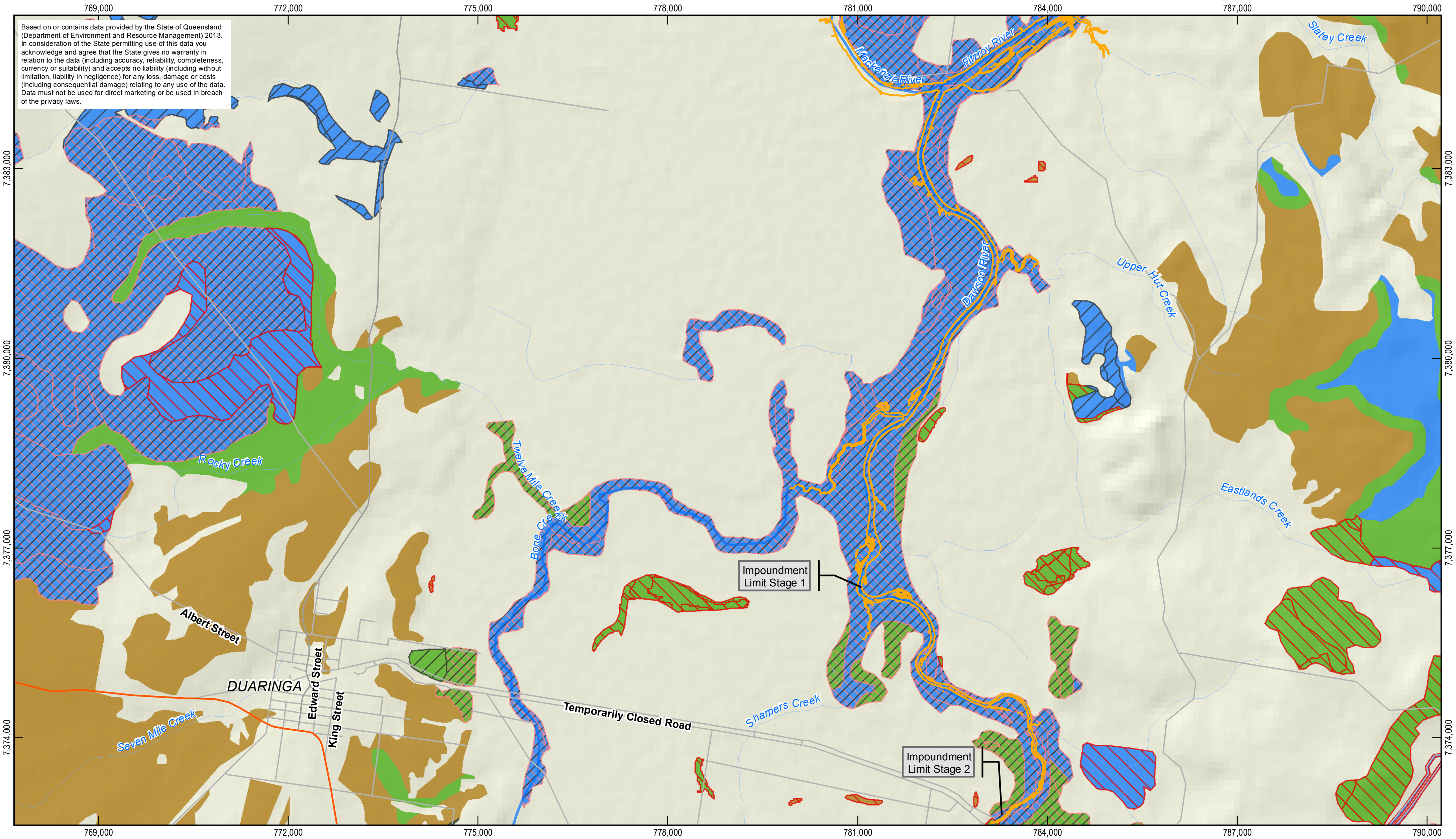
Data Sources: © Copyright Commonwealth of Australia (Geoscience Australia): Waterways (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: BPA -2009 ;GHD:Access Road (2013); ESRI: SRTM Hillshade (2008). Created by: MS



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- River Crossing
- Highway
- Road
- Access Road
- Waterway
- Impoundment Area
- Construction Footprint

BPA Qualifying Information
- Bioregional Corridor
- Habitat Remnant
- Habitat Remnant and Bioregional Corridor

Biodiversity Significance
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- Regional
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Figure 7-22
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7.9 Aquatic ecology

7.9.1 Aquatic habitats

Aquatic habitats in the Dawson, Mackenzie and Fitzroy rivers are highly dynamic. The temporal distribution and spatial extent of the aquatic habitat types is related to fluctuating water levels driven by factors including:

- Rainfall or lack thereof within the Fitzroy sub-catchment and upstream catchments
- Management of water storages, for example, Eden Bann Weir and the Fitzroy Barrage
- Extraction of water from waterways by adjacent land holders
- Evaporation and ground seepage.

Approximately 942 ha of natural (not impounded) aquatic habitat exists within the Project footprint comprising 282 ha within the Eden Bann Weir impoundment and 660 ha within the Rookwood Weir impoundment (Appendix J and Appendix K). Aquatic habitat types that occur within the Project footprint are described in Table 7-13 and the spatial distribution of in-channel aquatic habitats is provided in Figure 7-23 and Figure 7-24 for Eden Bann Weir and Rookwood Weir footprints, respectively.

Due to the highly unpredictable nature of these individual drivers, and the combined influence of the variable interactions of these factors, aquatic habitat distribution and extent is in a constant state of flux.

During and post-wet season (approximately November to April), the lower Dawson, lower Mackenzie and Fitzroy rivers primarily exist as deep fast-flowing channels (run habitat) in which in-channel aquatic habitats such as pools and riffles are inundated as a result of a significant increase in water depth and velocity. Depending on localised rainfall patterns, creek habitats may increase in depth and width as flow rates increase. Off-stream water body habitats such as billabongs may also be inundated during flooding events as river levels rise above bank height (observed downstream of the Eden Bann Weir during wet season surveys). This periodic flooding is important to off-stream water bodies to recharge water levels, provide flushing and allow for biological connectivity with the main stream.

In the dry and pre-wet season (approximately April to October) as flows decline following the wet season, the river channel is transformed into a series of pool-riffle-run sequences. These sequences were prevalent upstream of Rookwood during dry season field surveys. Off-stream water bodies lose connection with the main channel, and, unless recharged by groundwater / unseasonal rainfall, begin to recede. As the dry season persists, many riffle and run habitats dry out and much of the river exists as a series of isolated non-flowing pools (Limpus et al. 2007; Marsden and Power 2007). These pools act as refugia for aquatic fauna during the dry season (Limpus et al. 2007).

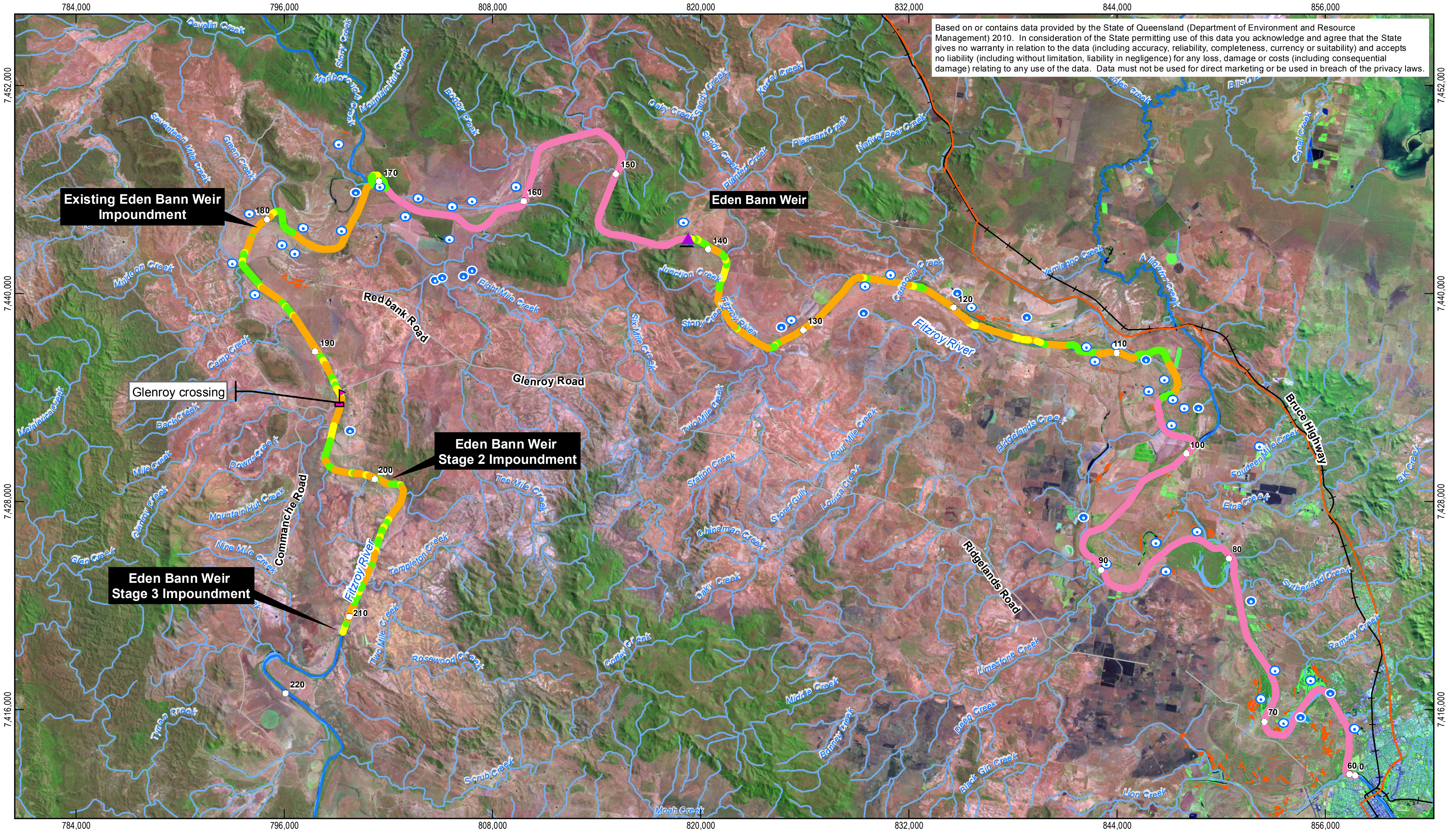
Variability of climate and the influence on hydrology also affects the diversity and abundance of macrophytes in the Project footprint. Fluctuating water levels in impoundments and turbidity were cited as potential explanations of an observed lack of submerged macrophytes upstream of weirs on the Dawson River. Algae diversity is also relatively low in the Fitzroy Basin catchment. Two declared weeds of national significance (*Salvinia molesta* and *Hymenachne amplexicaulis*) were recorded around the Project area, degrading aquatic vegetation and ecosystems.

Table 7-13 Aquatic habitat types

Habitat type	Description
Impounded pool	• Non-flowing, typically deep water impounded within the bed and banks of a river upstream of a weir • Depth and linear extent is variable, and dependent on local to catchment-wide climatic factors and infrastructure operations
Pool	• Relatively deep, still/very slow flowing water over variable substrates (silt, sand, stony or rocky) that occur naturally within the riverine environment[6] • Occurs in the main channel, and may become isolated into a series of discrete water holes during dry conditions when flow ceases and water levels drop • The low (or zero) velocity of water flow differentiates a pool habitat from a faster flowing run habitat
Run	• Relatively deep, flowing unbroken water over a sandy, stony or rocky bed • May occur immediately upstream and downstream of a riffle zone • Fast flowing water during high flow/flood conditions may result in the conversion of slow flowing pool habitats and shallow riffle habitats into runs
Riffle	• Shallow (<0.3 m), fast-flowing (>0.2 m/s) reaches over a stony bed • The unique combination of shallow, fast flowing water that is (relatively) highly oxygenated and flows over hard substrate differentiates this habitat type from pool and run habitats
Off-stream water body	• Defined as palustrine wetlands (vegetated swamps, billabongs), oxbow lakes, and farm dams (lacustrine habitats) in the floodplain adjacent to the main channel[7] of the lower Dawson, lower Mackenzie and Fitzroy Rivers • No formal assessment during field surveys with the general characteristics deduced based on observations throughout the wider study area
Creek	• Small tributaries adjoining the main river channel that persist for varying distances across the adjacent floodplain and beyond • The variable geomorphology of these habitats (depth, width, and length), adjacent land use and proximity to water infrastructure varies the characteristics and potential fauna habitat values these waterways feature

[6] AusRivAS 2001

[7] For the purpose of this assessment, off-stream water bodies within 1 km of the main channel and the lower reaches of adjoining creeks were considered.



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0 3 6 9 12

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

Legend

- AMTD (km)
- Weir Location
- River Crossing
- Highway
- Minor Road
- Watercourse (Major)
- Watercourse (Minor)
- Railway
- Waterway
- Off-stream Waterbodies
- Lacustrine
- Palustrine
- Aquatic Habitats
- Pool
- Riffle
- Run
- Weir Pool
- Wetland Protection Area

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Spatial distribution of in-channel aquatic habitats within and downstream of the Eden Bann Weir footprint

Figure 7-23

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_916_Aquatic_Habitats_Rev_B.mxd

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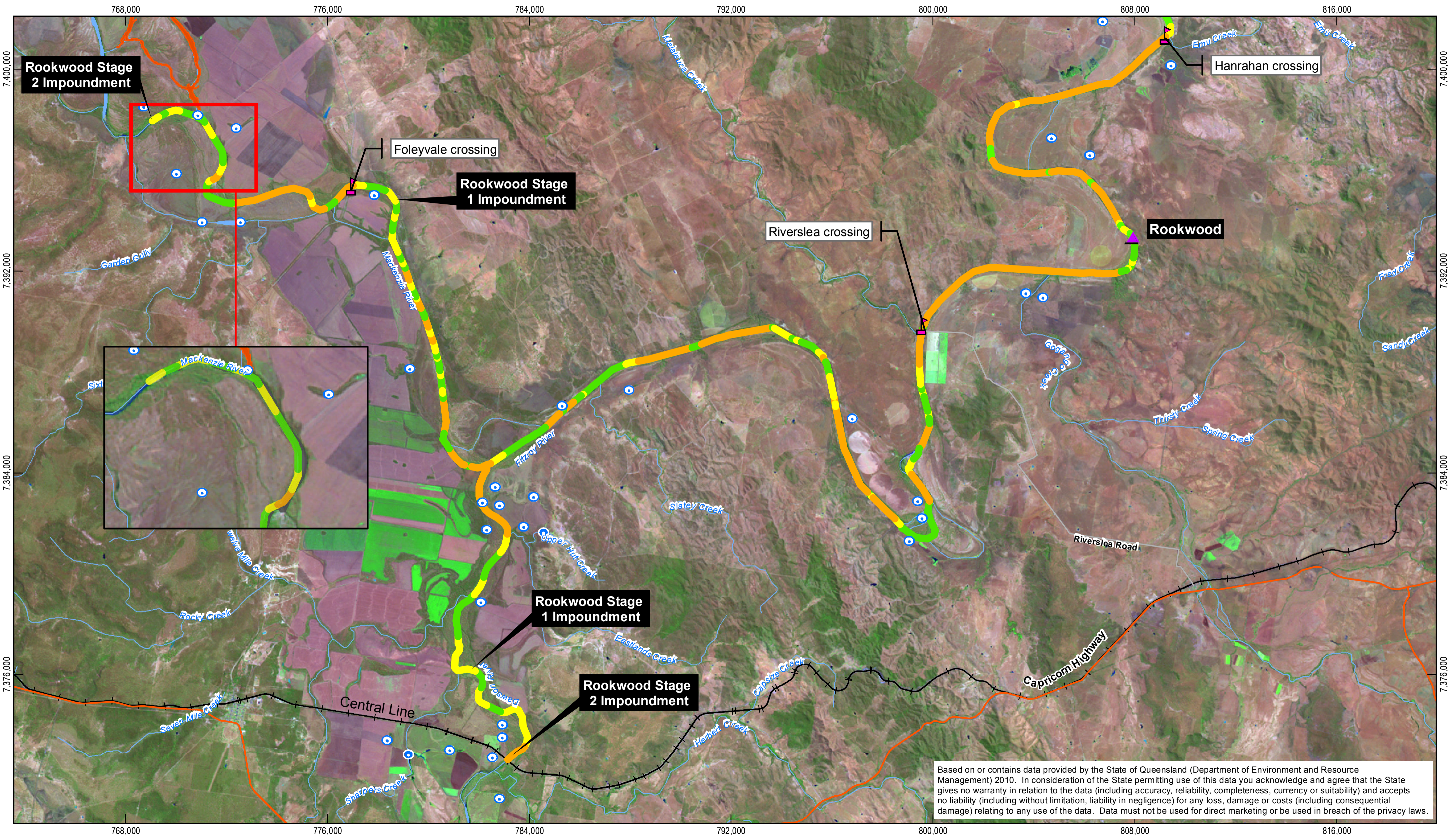
Data Source: GHD: Fauna Survey/2009; © Copyright Commonwealth of Australia (Geoscience Australia): Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Roads - 2010, Railways - 2010, Imagery - 2005, WPA v2.1 (2011). Created by MS.



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0 2 4 6 8

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Legend

- Weir Location
- River Crossing
- Highway
- Minor Road
- Railway
- Waterway
- Waterway
- Stage 1 impoundment
- Stage 2 impoundment
- Off-stream Waterbodies
- Lacustrine
- Palustrine
- Aquatic Habitats
- Pool
- Riffle
- Run
- Impoundment pool
- Wetland Protection Area

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Spatial Distribution of Off-stream Water Bodies and Creeks within the Rookwood project footprint

Figure 7-24

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Data Sources: Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; GHD: Waterbodies - 2010; DNRM: Roads - 2010, Railways - 2010, Imagery/2005. Created by IH,MS

7.9.2 Aquatic fauna

Aquatic species predicted to occur or recorded in the study area include 34 fish species, seven reptiles, one mammal, 86 taxa of macroinvertebrates and 105 macrophytes[8]. Table 7-14 summarise the total number of aquatic fauna species recorded according to the information source for the Eden Bann and Rookwood respectively.

No EPBC or NC Act listed-fish species have been previously recorded or are predicted to occur in the Project area. The Fitzroy River turtle is endemic to the Fitzroy Basin catchment and is listed as vulnerable under the EPBC Act and the NC Act. The estuarine crocodile (*Crocodylus porosus*) is listed as marine and migratory under the EPBC Act and vulnerable under the NC Act.

Table 7-14 Aquatic fauna species predicted to occur or recorded during field surveys

Value	Predicted to occur	Previously recorded			Field surveys
		Wildlife Online	Queensland Museum specimen database	Previous studies	
Eden Bann Weir					
Species diversity	NA	24 fish 5 reptiles	2 reptiles	34 fish 7 reptiles 1 mammal (predicted) 86 macroinvertebrate taxa	10 fish 3 reptiles 59 macroinvertebrate taxa
EPBC Act threatened species	1 reptile	1 reptile	1 reptile	1 reptile	1 reptile
NC Act threatened species	1 reptile	2 reptiles	1 reptile	2 reptiles	2 reptiles
EPBC Act 'marine'/ 'migratory' species	1 reptile	1 reptile	-	1 reptile	1 reptile
Endemic/ range restricted species	1 reptile	2 fish 2 reptiles	1 reptile	3 fish 2 reptiles	1 reptile
Introduced / pest species	-	-	-	3 fish	-
Rookwood Weir					
Species diversity	n/a	8 fish 4 reptiles 1 mammal	1 fish 1 reptile	34 fish 7 reptiles 1 mammal 86 macroinvertebrate taxa 105 macrophytes	18 fish 2 reptiles 59 macroinvertebrate taxa

[8] 105 species of macrophyte previously recorded within the broader Fitzroy Catchment

Value	Predicted to occur	Previously recorded			Field surveys
		Wildlife Online	Queensland Museum specimen database	Previous studies	
EPBC Act threatened species	1 reptile	1 reptile	1 reptile	1 reptile	1 reptile
NC Act threatened species	1 reptile	2 reptiles	1 reptile	2 reptiles	1 reptile
EPBC Act 'marine' / 'migratory' species	1 reptile	-	-	1 reptile	-
Endemic/ range restricted species	1 reptile	1 fish 2 reptiles	1 fish 1 reptile	3 fish 2 reptiles	2 fish 1 reptile
Introduced / pest species	n/a	-	-	3 fish	1 fish

7.10 Downstream environment

7.10.1 Overview

The Fitzroy Basin is the largest catchment on the eastern seaboard of Australia, and is second only to the Murray-Darling Basin as Australia's largest catchment. It extends over an area of approximately 142,000 km^2 of central and eastern Queensland about the Tropic of Capricorn. It consists of six major sub-catchments: Isaac / Connors, Nogoa, Comet, Mackenzie, Dawson and Fitzroy. The Fitzroy River flows into the southern end of the Great Barrier Reef at Keppel Bay in the Capricorn-Bunker Group. The environment downstream of the Project footprint comprises the Fitzroy Barrage impoundment, the Fitzroy River estuary and Fitzroy River Fish Habitat Area (FHA), Keppel Bay, the Great Barrier Reef World Heritage Area (GBRWHA), the Great Barrier Reef Marine Park (GBRMP) and Great Barrier Reef Coast Marine Park (GBR Coast MP).

7.10.2 Freshwater habitat

The Fitzroy River downstream of Eden Bann Weir has been highly impacted by human land-use. The landscape predominantly consists of alluvial plains that have been extensively cleared for grazing, agriculture and urban development. Population density is higher along this section of the river than in proximity to the Eden Bann Weir or Rookwood Weir Project footprints.

Aquatic habitats within this section of the Fitzroy River have been altered by the existing Fitzroy Barrage. The Fitzroy Barrage is located within the town of Rockhampton at 59.6 km AMTD and forms a barrier between the freshwater and tidal reaches of the Fitzroy River. The Fitzroy Barrage holds a maximum of 80,000 ML of water in a 55 km long impoundment confined to the river and some tributary creeks (SunWater 2008). The impoundment created as a result of the Fitzroy Barrage is the dominant aquatic habitat type in this section of the Fitzroy River. Natural pools and riffle and run habitats are also present

The Fitzroy River downstream of Eden Bann Weir also supports a number of old oxbow lakes and off-stream billabongs. Many of these are identified as Great Barrier Reef wetland protection areas. There are several creeks joining this section of the Fitzroy River, the largest of which is

Alligator Creek. The river banks in the vicinity of the Fitzroy River and Alligator Creek junction provide nesting habitat for conservation significant turtle species.

7.10.3 Estuarine and marine habitat

The aquatic environment downstream of the Fitzroy Barrage is tidally dominated and fresh water entering the estuary is regulated by releases from the barrage. Events sufficiently large enough to produce major delivery of fresh water downstream occur only one to two times per year. The Fitzroy River discharges into the southern end of the Great Barrier Reef at Keppel Bay in the Capricorn-Bunker Group.

A number of sensitive environmental areas occur within or adjacent to the aquatic environments downstream of the Fitzroy Barrage. These include:

- GBRWHA, GBRMP and GBR Coast MP (Section 7.10.4)
- Fitzroy River FHA (FHA-072)
- Four Directory of Important Wetlands – Fitzroy River Delta, GBRMP Wetland, Northeast Curtis Island Wetland, Narrows Wetland
- A number of Great Barrier Reef wetland protection areas of High Ecological Significance.

The location of the sensitive environmental areas located downstream of the Project footprint are shown in Figure 7-18. The marine environment downstream of the Project is characterised by a relatively homogenous habitat of soft-sediment, sparse algae not unique to the region, with highly variable water depths partitioned by shoals and channels with surrounding creeks being comparatively shallow. Open mudflats, mangrove forests and samphire forblands dominate the intertidal communities.

The waters within the Fitzroy River estuary provide habitat for a range of marine species that are also known to occur throughout the wider coastal waters of northern Australia. Specifically, the area is known to support a low to medium density dugong population (Marsh et al. 2005; Grech and Marsh 2007), marine turtles and coastal dolphin species (GHD 2011a;b). The Fitzroy River estuary region is a habitat of relatively important conservation value for the Australian snubfin dolphin (*Orcaella heinsohni*) and is home to the southernmost resident population of this species in Australian waters (Cagnazzi 2013). The area also supports internationally and nationally important populations of migratory shorebirds (GHD 2001c).

A valuable commercial and recreational fishery exists within the region as recognised through the establishment of the Fitzroy River FHA. The Fitzroy River FHA includes parts of the Fitzroy River estuary, Raglan Creek and the wetland systems surrounding North Curtis Island (DNPRSR 2015). Habitat values include extensive saltpans and saline grasslands fed by mangrove-lined creeks as well as mangrove forests, mud and sand flats, rocky headlands and brackish lagoons (DNPRSR 2015).

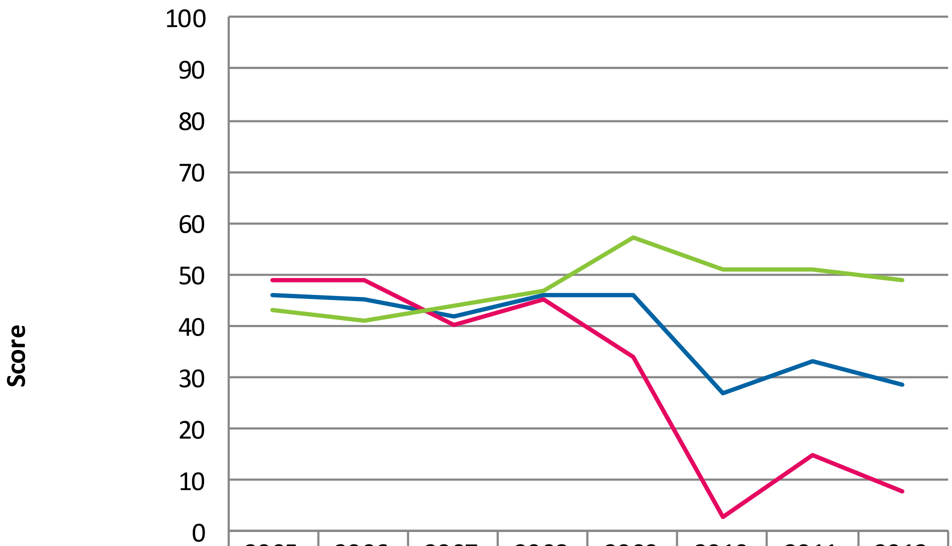
The Fitzroy Partnership for River Health draws together waterway monitoring data for the Fitzroy Basin in order to report on and score the health of local rivers, the estuary and marine waters. The 2010-11 Report Card (Fitzroy Partnership for River Health 2011) indicates that overall the Fitzroy River estuary is in fair condition and graded C indicating a mix of good and poor levels of water quality and other biological health indicators, with:

- Good results for oxygen, TN, dissolved phosphorus and chlorophyll
- Fair results for turbidity, TP and dissolved nitrogen

- Poor recruitment of barramundi (potentially due to unseasonal early post-winter flows).

The Great Barrier Reef Report Card 2011 (State of Queensland 2013b) indicates that the Fitzroy region's inshore water quality declined from moderate to poor for the 2010 – 2011 representing a departure from the relatively stable condition experienced since 2005 – 2006. This decline is attributed to flooding associated with extreme weather events over the 2010/11 summer that resulted in much higher than normal discharges from most catchment rivers. The Great Barrier Reef Report Card 2012/2013 indicates that the Fitzroy region's inshore water quality remained poor. During 2011/12 there was three times the above median discharge, however, these flows were still well below the 2010/11 wet season flows (State of Queensland 2015). Figure 7-25 shows the trend in overall inshore water quality, chlorophyll a and total suspended solids (TSS) scores in the Fitzroy region since 2005 to 2011. Chlorophyll a concentrations exceeded the Great Barrier Reef Marine Water Quality Guideline limits for 99 per cent and 89 per cent of inshore areas in the dry and wet seasons, respectively and TSS exceeded guidelines for 55 per cent and 45 per cent of inshore areas in the dry and wet season, respectively (State of Queensland 2013b). The TSS in the Fitzroy region continued to exceed the Great Barrier Reef Water Quality Guidelines by 53 per cent and 55 per cent during 2012 and 2013 respectively due to the ongoing flooding and re-suspension of finer sediment particles by wind and wave action (State of Queensland 2015). Chlorophyll a was rated as very poor in 2012 and 2013 and exceeded the Great Barrier Reef Water Quality Guidelines by 97 per cent and 85 per cent of the inshore area in the dry and wet season respectively (State of Queensland 2015).

Figure 7-25 Fitzroy region inshore water quality trends



	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
Overall water quality score	46	45	42	46	46	27	33	28.5
Chlorophyll a	49	49	40	45	34	3	15	8
Total suspended solids	43	41	44	47	57	51	51	49

Note: Score reflects a standardised scale of 1 – 100 with a one representing very poor conditions and 100 representing very good conditions.

Source: State of Queensland 2015

The Fitzroy River transports sediments and nutrients, from natural and anthropogenic sources, from the upstream catchment to its various estuaries and eventually Keppel Bay (Webster et al. 2006). It is estimated that prior to European settlement approximately one million tonnes per annum of suspended sediment was transported via waterways of the Fitzroy Basin compared to recent long-term estimates of between 3 to 4.5 million tonnes per annum (Johnston et al. 2008; Packett et al. 2009). Sediments delivered to the Fitzroy River estuary are derived almost exclusively from erosion in the upper Fitzroy Basin (Douglas et al. 2005). Turner et al. (2013) reports that during the 1 July 2010 to 30 June 2011 period (monitoring year) the highest estimated TSS yields were obtained from the Comet River (82 t/km^2), followed by the Dawson River (63 t/km^2) and the Theresa Creek (20 t/km^2) sub-catchments.

Transport of sediments from the Fitzroy Basin catchment to the Fitzroy River estuary and Keppel Bay primarily occurs during episodic, generally short-lived flood events in the wet season. The strong tidal, shallow-water environment that characterises Keppel Bay results in sediments remaining in a constant state of suspension and re-suspension (Webster et al. 2006). As a result suspended sediment concentrations remain high year-round, particularly near the mouth of the Fitzroy River where tidal flows are particularly vigorous (Webster et al. 2006). This in turn severely limits opportunities for primary producers (i.e. phytoplankton, algae, seagrass and coral) to inhabit the Fitzroy River delta environment.

7.10.4 Great Barrier Reef World Heritage Area

7.10.4.1 Overview

The GBRWHA extends along the Queensland coast from the Cape York Peninsula to just north of the City of Bundaberg and from the low water mark to the outer boundary of the Great Barrier Reef Marine Park, which is beyond the edge of the continental shelf. The GBRWHA does not extend inland along tidal rivers and waterways.

The Great Barrier Reef is the largest reef system in the world extending over 2,300 km along the northern Queensland continental shelf. It comprises an archipelagic complex of 2,900 reefs over an area of approximately 344,000 km^2 (GBRMPA 2010). The GBRWHA contains extensive areas of seagrass, mangrove, sandy and muddy seabed communities, inter-reefal areas, deep oceanic waters and island communities (DSEWPAC 2012).

In 1975 a marine park was established around the Great Barrier Reef. The GBRMP is a multiple-use area supporting a range of communities and industries. The GBRMP is covered by a zoning plan with 33 per cent of the GBRMP afforded marine national park status. Special Management Areas have also been created. The GBR Coast MP is a State marine park running the length of the GBRMP providing protection for Queensland tidal lands and tidal waters. The GBR Coast MP supports the creation of a zoning system within, and complimentary to, the GBRMP; habitat protection, conservation park, marine national park and preservation zones as shown in Figure 7-18. Zoning aims to protect the Great Barrier Reef's unique biodiversity, while continuing to provide opportunities for the use of and access to the marine park.

Thirty-five onshore catchment areas drain into the GBRWHA. These catchments have undergone extensive development for agricultural production, urban expansion, transport infrastructure, tourism and mining. As a result elevated levels of pollutants from these catchments are entering the reef, with agricultural land use activities reportedly the largest contributor (State of Queensland 2013). The Fitzroy Basin (the largest catchment) drains to the GBRWHA through the Fitzroy River estuary at Rockhampton discharging to Keppel Bay.

7.10.4.2 Water quality

Overview

The Fitzroy Basin and estuary has been identified as one of the major sources of pollutants into the Great Barrier Reef lagoon (State of Queensland 2013a) and is one of 11 priority reef catchments monitored for water quality under the Queensland Government's Paddock to Reef Program (Wallace et al. 2014). The 2013 risk assessment rated the Fitzroy region as presenting a high risk to water quality with the main pollutant being sediment from grazing (State of Queensland 2013a). Key threats to the reef water quality overall include nitrogen, sediment and pesticides.

The Fitzroy River estuary and Keppel Bay act as natural chemical reactors, transforming the physical and chemical properties of the nutrients and sediments before they are integrated into deltaic and beach areas (Webster et al. 2006). The rest of the material is usually transported northwards, with eastward transport only occurring under larger flooding conditions (Packett et al. 2009). During flood events it is possible for the mobilisation of nutrients, sediments and pesticides to be transported to the middle and outer reefs of the Great Barrier Reef (Packett et al. 2009). The majority of the nutrient load in the upper catchment is only mobilised during flood events, through either dissolved organic particles or materials attached to sediment particles. Floods thereby account for a disproportionately large component of nutrients delivered from the Fitzroy catchment to the marine environment (Webster et al. 2006). This is further evident from elevated sediment and nutrient concentrations recorded during 2010/11 coinciding with above annual rainfall and an exceedance of the long-term mean annual discharge (Turner et al. 2013).

Sedimentation

Long term annual sediment exports from the Fitzroy River Basin into the Great Barrier Reef lagoon (2 – 4 Mt/y) account for one third of the lagoon's total input (Packett et al. 2009). The Fitzroy catchment was reported to deliver a total TSS load of seven million tonnes during the 2010/11 monitoring year (Turner et al. 2013). This represents a substantial increase from pre-industrial modelled input values. Recent studies have highlighted the negative effects of increased nutrient, sediment and pesticide loads on the health of key marine habitats such as seagrasses, corals and algae (Packett et al. 2009). Water quality therefore plays an important role in the resilience of these habitats, with poor water quality impacting the ability for these habitats to adapt to both localised anthropogenic pressures and accelerated climate change (Packett et al. 2009).

Nutrient loads

Studies undertaken by the CSIRO (Kroon et al. 2010) have derived baseline (anthropogenic) pollutant loads (as derived from the Fitzroy Natural Resource Management region) as follows:

- TSS = 2,850 kt/a
- Nutrients:
  - TN = 13,454 t/a
  - TP = 3,945 t/a
  - Pesticides: PS II = 2,269 kg/a

Pollutant loads from the Fitzroy Basin to the Great Barrier Reef lagoon have increased since European settlement threefold for TSS, nine times for TN and doubled for TP.

Flood events account for a disproportionately large fraction of nutrient delivery to the Fitzroy River estuary (Webster et al. 2006). During high flow conditions nutrients tend to be transported downstream as organic particles or attached to sediment particles (Webster et al. 2006). Inflows of nutrients (dissolved and particulate) into waterways of the Fitzroy Basin (and ultimately into the Fitzroy River estuary and Keppel Bay) are predominantly derived from upper reaches of the Fitzroy Basin (Douglas et al. 2005).

Turner et al. (2013) reports that during the 1 July 2010 to 30 June 2011 period (monitoring year) the load of TN and TP from the Fitzroy Basin was 35.8 kt and 15 kt respectively. The load of TN comprises 3.8 kt of dissolved inorganic nitrogen, 15 kt of dissolved organic nitrogen and 17 kt of particulate nitrogen (Turner et al. 2013).

Nutrient inputs from wastewater treatment plants and urban storm water discharge within the Rockhampton area (which is downstream of the proposed Project) contribute a substantially lower proportion of inputs to the Fitzroy River estuary (Douglas et al. 2005) than land use practices in the upper reaches of the Fitzroy Basin. Unlike the dissolved and particulate nutrients derived upstream of the Fitzroy Barrage which tend to flow into the Fitzroy River estuary during flood events (a very small continuous input can be attributed to flows through the Fitzroy Barrage fish ladder during low flow conditions), inputs of predominantly inorganic dissolved nutrients from the Rockhampton area are continuous (Douglas et al. 2005).

Pesticides and herbicides

The concentrations of pesticides in waterways are highest in areas of intensive agricultural activity including sugarcane and cotton. Considerable quantities of pesticides and herbicides are applied for agricultural grazing and cropping purposes, along roadways and rail lines and within urban areas (Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management 2006). The primary agrochemicals in use include: diuron, atrazine, ametryn, simazine, hexazinone, 2, 4- D and tebuthiuron. Of the herbicide residues most commonly found in surface waters in the Great Barrier Reef region, diuron, atrazine, ametryn, hexazinone are derived largely from areas of sugarcane cultivation, while tebuthiuron is derived from rangeland beef grazing areas (Kroon et al. 2013). Atrazine and diuron are also used for weed control, particularly in sorghum.

Herbicides including atrazine and its breakdown products, diuron, hexazinone, simazine and tebuthiuron are recorded for estuarine and marine waters in the Fitzroy region. Atrazine, diuron and tebuthiuron loads have been calculated with an event mean concentration above the guideline trigger values in the GBRMPA Water Quality Guidelines for at least one flood event at a basin scale (Johnston et al. 2008). Packett et al. (2009) estimated that in the order of 2.1 t atrazine and 1 t tebuthiuron were exported into the Great Barrier Reef lagoon from the 2008 flood event. Similarly, tebuthiuron and metolachlor were detected in flood waters in Keppel Bay during the 2010/11 wet season at concentrations that met or exceeded the GBRMPA water quality guidelines (State of Queensland 2013b). Long-term monitoring of pesticides indicates that there is an increasing trend in the detection of herbicides in the Fitzroy Basin since 2005. The Great Barrier Reef Report Card 2011 (State of Queensland 2013b) reports that in 2010-2011 period, the higher herbicide concentrations typical of the wet season were sustained for longer periods of time.

7.11 Socio-economics

7.11.1 Local community profile

In general, the local community includes the people owning or operating land adjacent to the Fitzroy, Dawson and Mackenzie Rivers within the local study area. The local study area consists predominantly of large, rural agricultural (cattle grazing) land holdings. Settlement in the area is sparse and scattered. Landholdings comprise a mix of owner-occupied homesteads and non-resident landholders residing elsewhere in the region (i.e. Rockhampton and Yeppoon) yet travel regularly to their properties.

The majority of landholdings within the Project area are owner-operated. Three properties have been identified as being owned by companies or individuals and managed by an employed property manager. In addition to themselves working the property, many of the landholders employ contractors occasionally, or on a seasonal basis.

All the respondents from the landholder survey and the landholder interviews reported cattle breeding and/or fattening as the main activity taking place on their land. All of the landholders also stated they are ‘working the property’ or described themselves as farmers when asked about occupation. There is also some crop cultivation, and a small number have irrigation licences.

There is a mix of household types throughout the local study area. Five of the households were identified as family households with children, and three were identified as family households with no children. There is also one single household in the area. As with the population of the regional study area, the landholders have a relatively high median age.

The landholders have generally owned and lived at their properties for ‘a very long time’. When asked how long they have lived on their properties typical answer was ‘decades’, ‘a long time’, or even ‘a lifetime’. In addition, some of these landholders belong to families with ties to the land dating back to the late 19th century. There are only a few landholders who have recently purchased their properties or moved to the property.

The population of the local study area has a slightly higher median age compared to the age profile of the regional study area and that of the State. The population in the local study area exhibits more traditional family patterns, with higher proportions of married people, compared to the regional study area and the remainder of the State. Income levels are relatively similar to the regional and State study areas.

7.11.2 Social infrastructure, services and facilities

7.11.2.1 Local study area

Apart from basic infrastructure and services such as utilities, roads and crossings, police services and primary schools, there are no community services or facilities available in the local study area. To access most types of services, residents in the local and regional study area travel to Rockhampton. The roads and crossings over the Fitzroy, Mackenzie and Dawson Rivers are particularly important to the community, as they provide the only direct access to Rockhampton for many residents. The Capricorn Highway passes through the local study area and intersects with the Bruce Highway in Rockhampton. There are also several secondary roads and smaller tracks passing through the local study area, many of which are unsealed. Residents in the local study area regularly travel to Rockhampton to access services.

7.11.2.2 Regional study area

Some of Queensland's largest power stations are located in and around the regional study area. These include the Stanwell, NRG Gladstone and Callide power stations, which produce the majority of the State's power. Ergon Energy is the major distributor of energy in the region. Fitzroy River Water (a business unit of RRC) supplies water and sewerage services in the Rockhampton area and bulk water to the former Fitzroy Shire and de-amalgamated Livingstone Shire. Raw water from the Fitzroy River is treated at Rockhampton's Glenmore Water Treatment Plant and pumped to the various reservoirs located around the city. The plant has the capacity to treat 120 ML of water per day.

There are various forms of mass media and communications services available throughout the regional study area, including television networks, radio stations, newspapers, post offices and telecommunications such as internet connection, telephone and mobile phone connections. The local study area is however not covered in full by mobile phone and internet services.

Transport infrastructure in the regional study area services both passenger and commercial activities. The closest airport to the Project site is the Rockhampton Airport which sees approximately 750,000 domestic passengers pass through the terminal annually.

Rockhampton is a major node in Queensland's railway system. Aurizon Network Pty Ltd operates the rail network in the regional study area, specifically the Blackwater system which is a coal rail network that also services a number of domestic users including Stanwell and Gladstone Power Stations, Cement Australia and the Comalco Refinery. Rockhampton is serviced by the Brisbane to Cairns Tilt passenger train and the Brisbane to Cairns Sunlander. The tourist train to Longreach, 'The Spirit of the Outback', also stops over in Rockhampton and traverses part of the Blackwater system through Gogango. There are no passenger services at Gogango Station.

Two commercial ports service the region, namely Port Alma and the Port of Gladstone. Keppel Bay Marina (50 km north-east of Rockhampton) provides recreational port facilities.

7.12 Cultural heritage

7.12.1 Indigenous cultural heritage

Native title searches revealed that a number of native title claims exist (or did exist) over the Project area including:

- Eden Bann Weir
  - Darumbal People QC2012/008, QUD6131/1998 (comprising combined claims QC1997/021, QUD6131/1998 and QC1999/001, QUD6001/1999)
- Rookwood
  - Darumbal People (former uncombined claim QC1997/021, QUD6131/1998)
  - Gangulu People (former claim QC97/36; QUD6144/1998)
  - Kangoulu People (former claim QC98/25; QUD6195/1998)
  - Ghungalu People (former claim QC99/16; QUD6226/1998).

In addition, a portion of the Rookwood Project footprint was not the subject of a claim, however, following public notification and discussion with the aforementioned parties, the Jetimarala People were identified as custodians.

The native title claim areas for each party and unclaimed areas are shown in Figure 7-26 for the Eden Bann Weir and Rookwood site, respectively.

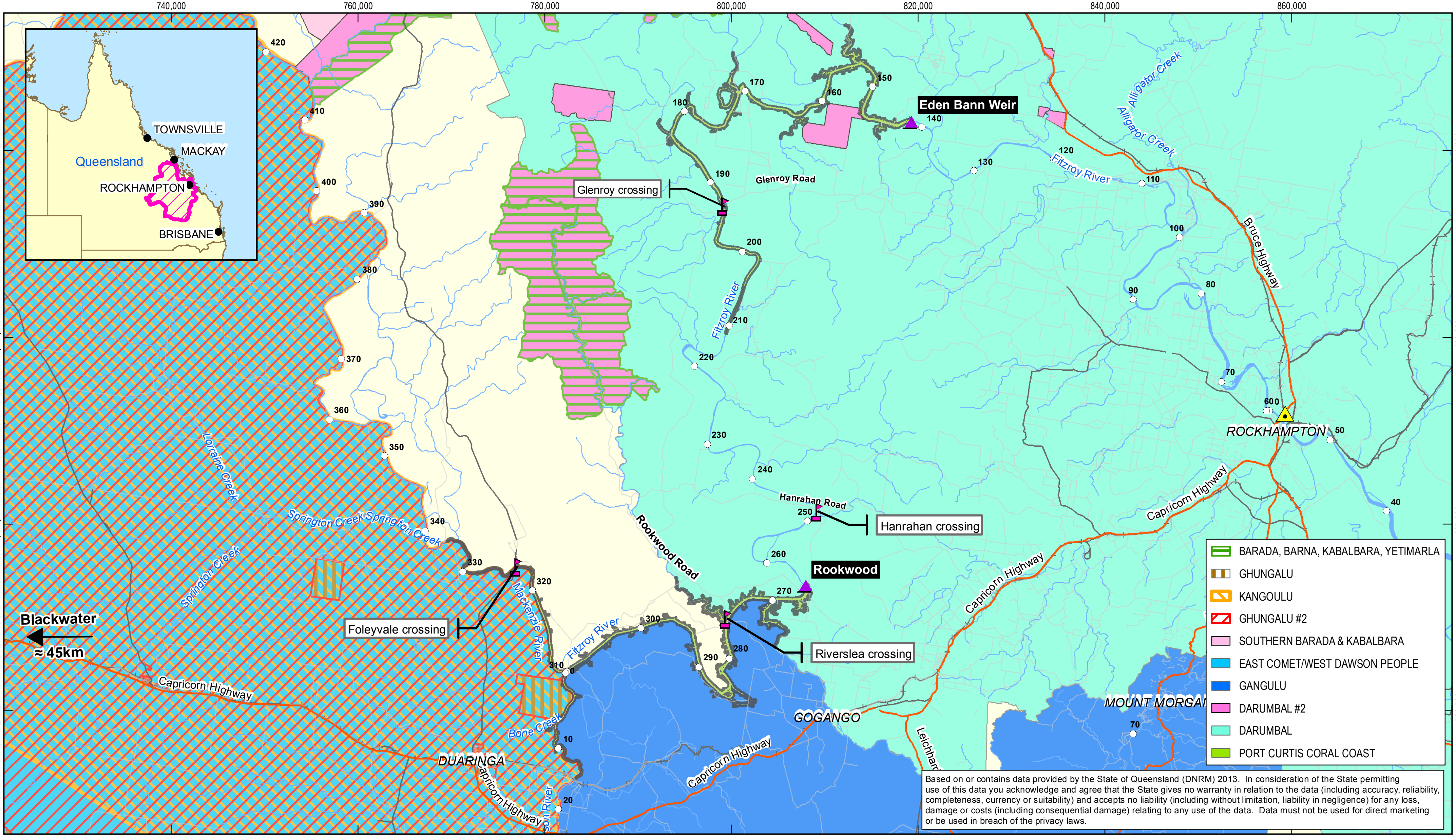
Two CHMPs were developed with the Darumbal Endorsed Parties to address previously separate claims and current combined claim areas. Separate CHMPs were developed with the Gangulu Endorsed Parties and the Jetimarala Endorsed Parties. A combined CHMP was developed for the Kangoulu and Ghungalu Endorsed Parties. All CHMPs have been approved by the State Government. CHMPs are confidential documents between the parties and not disclosed herein.

Desktop database searches and preliminary field surveys were undertaken to identify the presences of areas and objects that may be impacted by the Project, in consultation with Aboriginal parties. Desktop searches have not identified any potential impacts to places listed on relevant registers or protected by provisions of the aforementioned legislations except for 28 places (largely stone artefacts) within the buffered area for Eden Bann Weir listed on the Queensland cultural heritage database and register. Field survey results have identified locations that possess a range of cultural places and values that constitute Aboriginal cultural heritage as defined in the *Aboriginal Cultural Heritage Act 2003* (Qld). These areas and objects include stone artefact scatters, shell middens, and scarred trees as well as places of traditional significance.

7.12.2 Non-Indigenous cultural heritage

Desktop searches revealed no places of non-Indigenous cultural heritage significance within the Project footprint. The assessment of impacts on the GBRWHA has indicated that indirect impacts on the GBRWHA caused by changes in stream flow and water quality in the Fitzroy River are not considered to be significant (Chapter 9 World Heritage properties and National Heritage places).

As the Fitzroy River is subject to regular flooding, there are few structures of non-Indigenous cultural heritage located on or near the lower Fitzroy River. Searches and surveys did not identify any items of non-Indigenous cultural heritage that would be impacted by the Project. The Riverslea hut has been identified as the only structure of significance in proximity to the Project development site and impoundments.



1:550,000 (at A4)

0 5 10 15 20 Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- Fitzroy Barrage
- River Crossing
- Highway
- Major Road
- Streets (Local)
- Railway
- Waterway
- Fitzroy Basin
- Urbanised Area
- Rookwood Impoundment Stage 1
- Rookwood Impoundment Stage 2
- Eden Bann Impoundment Stage 2
- Eden Bann Impoundment Stage 3

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Gladstone Area Water Board

SunWater Making Water Work

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision B
Date 31 Jul 2014

Native title claim areas

Figure 7-26

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