11. Water quality

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11.1 Introduction

11.1.1 Overview

This section describes the water quality characteristics of water resources associated with the Lower Fitzroy River Infrastructure Project (Project). The assessment addresses how existing water quality will be impacted by the Project and, where applicable, identifies methods by which these impacts can be avoided, mitigated and/or managed. The assessment addresses water quality aspects within Part B, Section 5.92 – 5.103 of the terms of reference (ToR) for the environmental impact statement in relation to surface water quality. A table cross-referencing the ToR requirements is provided in Appendix B. Appropriate management measures relating to water quality have been used to inform the environmental management plan (EMP) (Chapter 23).

11.1.2 Regulatory framework

11.1.2.1 Overview

Water quality parameters are governed and guided by the following legislation, policies, guidelines and strategies:

- Commonwealth:
  - *National Environment Protection Council Act 1994* (Cth) and National Environment Protection Measures (NEPMs)
  - National Water Quality Management Strategy (NWQMS), including the Australian Water Quality Guidelines (AWQGs) meaning the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (October 2000), prepared by the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ)(2000)
  - Australian Drinking Water Guidelines (ADWG) (2011) prepared by the National Health and Medical Research Council (NHMRC) in collaboration with the Natural Resource Management Ministerial Council
  - The Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA 2010) and the Reef Water Quality Protection Plan 2013.
- State:
  - *Water Act 2000* (Qld) (Water Act)
  - *Environmental Protection Act 1994* (Qld) (EP Act), the Environmental Protection Regulation 2008 and the Environmental Protection (Water) Policy 2009 (EPP Water)
  - Queensland Water Quality Guidelines (QWQGs) (version 3) (DERM 2009a)

Water quality guidelines relevant to the Project have been developed at different spatial scales (national, state and local). Where there is more than one set of guidelines applicable the most locally appropriate guideline takes precedence.

Further detail on relevant legislation is provided in Chapter 3. Guideline water quality values adopted for the assessment are discussed further in Section 11.1.4.

11.1.2.2 National Environment Protection Measures

The *National Environment Protection Council Act 1994* (Cth), and complementary State and Territory legislation allow the National Environment Protection Council to make NEPMs. NEPMs are a special set of national objectives designed to assist in protecting or managing particular aspects of the environment.

NEPMs can be made about a variety of environmental matters as prescribed by the *National Environment Protection Council Act 1994* (Cth) including ambient marine, estuarine and fresh water quality and general guidelines for the assessment of site contamination.

The National Environment Protection (Assessment of Site Contamination) Measure has a desired environmental outcome to provide adequate protection of human health and the environment, where site contamination has occurred, through the development of an efficient and effective national approach to the assessment of site contamination.

11.1.2.3 National Water Quality Management Strategy

The NWQMS is a joint national approach to improving water quality in Australian (and New Zealand) waterways. It was originally endorsed by two Ministerial Councils - the former ARMCANZ and the former ANZECC. Since 1992 the NWQMS has been developed by the Australian and New Zealand Governments in cooperation with state and territory governments. Ongoing development is currently overseen by the Standing Council on Environment and Water and the NHMRC (http://www.environment.gov.au/water/policy-programs/nwqms/).

The NWQMS aims to protect the nation's water resources, by improving water quality while supporting the businesses, industry, environment and communities that depend on water for their continued development. The NWQMS consists of three major elements, namely: policy; process; and guidelines.

The AWQGs and ADWGs are part of a suite of documents forming the NWQMS:

- The AWQGs provide guideline values for different indicators to protect both aquatic ecosystems and human uses of waters (such as primary industry (for example irrigation and general water use, stock drinking water, aquaculture); recreation and aesthetics; human drinking water; industrial water; and cultural and spiritual values).
- The ADWGs provide guideline values for good management of drinking water supplies to ensure safety at point of use and address health and aesthetic quality aspects of supplying good quality drinking water. While the Proponents and other end users may need to consider drinking water quality (including preparation and implementation of a drinking water quality management plan), the Project will not directly supply drinking water and as such the ADWGs are not considered further.

11.1.2.4 Water Quality Guidelines for the Great Barrier Reef Marine Park

The Great Barrier Reef is a World Heritage Area (GBRWHA) and a multiple use Marine Park (GBRMP) with values including aquatic ecosystems, primary industry, recreation and aesthetics, and cultural and spiritual values.

While the Project area and/or associated activities are not within the GBRWHA or the GBRMP, the Fitzroy Basin is designated as a Great Barrier Reef Catchment Area under the *Great Barrier Reef Protection Amendment Act 2009* (Qld). The Reef Water Quality Protection Plan 2013 (Reef Plan) is a collaborative program of coordinated projects and partnerships designed to improve the quality of water in the Great Barrier Reef though improved land management in reef catchments, including the Fitzroy Basin.

The Reef Plan's primary focus is diffuse source pollution from broadscale land use. The Reef Plan sets targets for improved water quality and land management practices and identifies actions to improve the quality of water entering the reef. Initially established in 2003, the plan was updated in 2009 and 2013.

11.1.2.5 Water Act 2000

The Water Act (amongst others) provides for the sustainable management of water and other resources. It is the overarching legislation which sets out rights to surface and groundwater resources, the control of works with respect to surface and groundwater conservation, protection and irrigation as well as some aspects of supply, drainage and flood control. Water related development is regulated by the Water Act in parallel to the *Sustainable Planning Act 2009* (Qld).

Subordinate legislation, namely the Water Resource (Fitzroy Basin) Plan 2011 (Fitzroy WRP) and the Fitzroy Basin Resource Operations Plan 2004 (Chapter 9 Surface water resources), set out the strategic framework for the allocation and sustainable management of water specifying the outcomes and strategies used to address the full range of social, economic and environmental goals. The specific outcomes and objectives within the Fitzroy WRP related to water quality include:

- Section 15 - Specific ecological outcomes

  (a) to protect flows and water quality for flow-spawning fish and endemic species, including, for example, the Fitzroy golden perch (*Macquaria ambigua oriens*)

- Section 27 - Matters to be considered for environmental management rules

  (1) In deciding the environmental management rules to be included in the resource operations plan, the chief executive is to consider (d) the impact the taking of, or interfering with, water may have on (ii) water quality

- Section 30 - Matters to be considered for infrastructure operating rules

  (1) In deciding the infrastructure operating rules to be included in the resource operations plan for water infrastructure or proposed infrastructure for supplemented water, the chief executive is to consider (a) the impact of the infrastructure's or proposed infrastructure's operation on (i) water quality.

11.1.2.6 Environmental Protection Act 1994

In relation to water resources, environmental values (EVs) are described as qualities of water that are suitable for supporting aquatic ecosystem values and human use values. The EPP Water seeks to achieve the objectives of the EP Act in relation to Queensland waters, including tidal, non-tidal, lakes, wetlands and groundwater.

This purpose is achieved within a framework that includes identifying EVs such as aquatic ecosystems, water for drinking, water supply, water for agriculture, industry and recreational use for Queensland waters and stating corresponding water quality guidelines and water quality objectives (WQOs) to enhance or protect the EVs. The water quality guidelines are quantitative measures or statements for indicators, including contaminant concentration or sustainable load measures of water, that protect a stated EV.

For EVs and WQOs, Schedule 1 of the EPP Water categorises waters of the Fitzroy Basin into sub-basins:

- Callide Creek Catchment, including all waters of the Callide Creek catchment within the Dawson River Sub-basin
- Comet River Sub-basin
- Dawson River Sub-basin, further divided into upper and lower Dawson plan areas
- Fitzroy River Sub-basin
- Isaac River Sub-basin
- Mackenzie River Sub-basin
- Nogoa River Sub-basin.

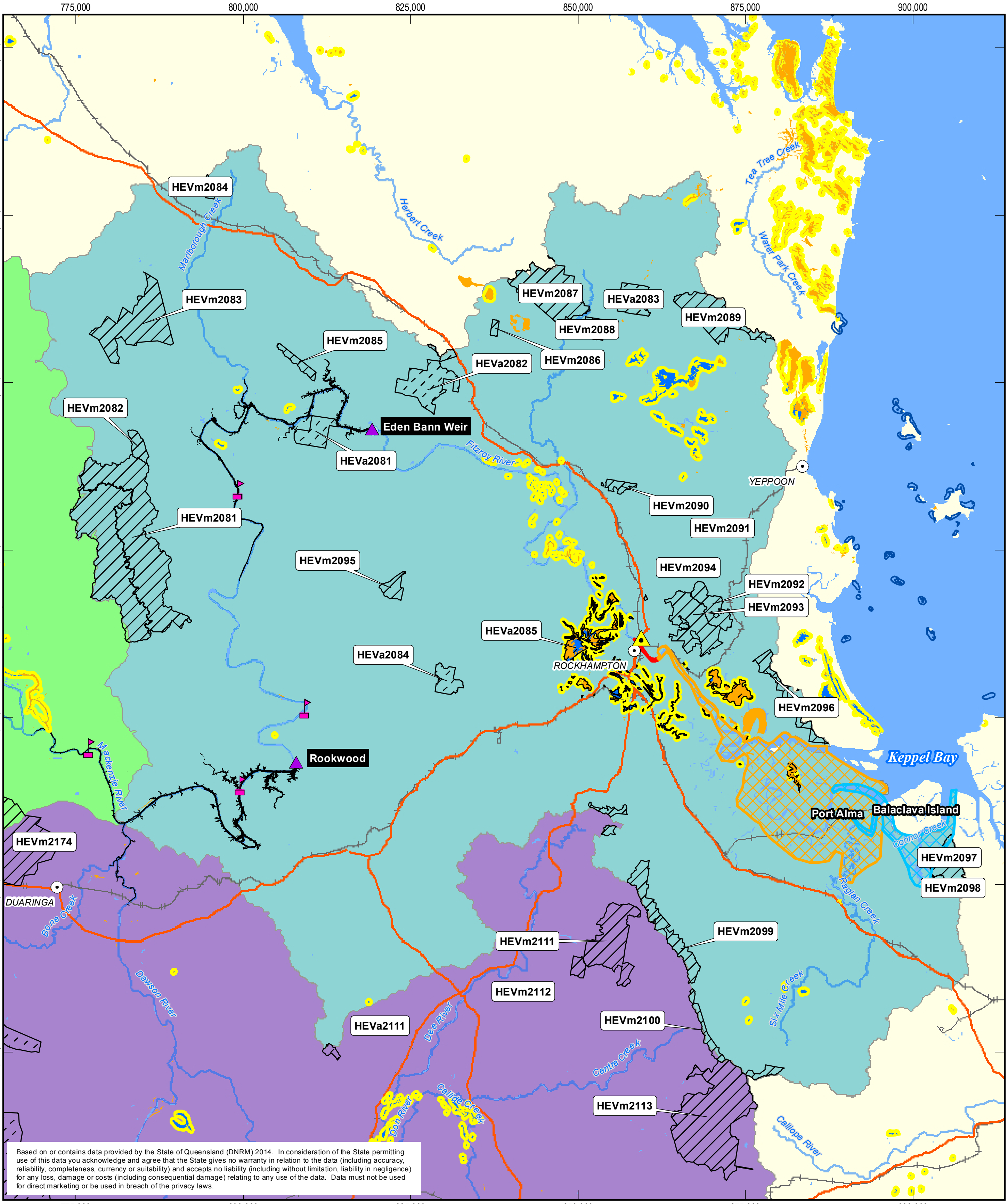
Eden Bann Weir and the impoundment (existing and proposed), the proposed Rookwood Weir and part of the impoundment, Glenroy Crossing, Hanrahan Crossing and Riverslea Crossing, The Gap and Riverslea gauging stations and the Eden Bann Weir monitoring locations at Wattlebank and Glenroy Crossing are situated within the Fitzroy River Sub-basin plan area (Figure 11-1).

The upper reaches of the proposed Rookwood Weir impoundment are located in the lower Dawson River Sub-basin plan area (Figure 11-2). The upper reaches of the proposed Rookwood Weir impoundment and the Foleyvale Crossing are located in the south-east of the Mackenzie River Sub-basin plan area (Figure 11-3).

As at September 2011, in accordance with schedule 1 of the EPP Water, EVs and WQOs for the Fitzroy River, Mackenzie River and Dawson River sub-basins, respectively, were finalised and are provided in:

- EPP Water Fitzroy River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Fitzroy River Sub-basin
- EPP Water Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin
- EPP Water Dawson River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Dawson River Sub-basin except the Callide Creek Catchment.

The sub-basin plans define EVs with respect to aquatic ecosystems and human uses. WQOs are defined with respect to water type (fresh waters, lakes and reservoirs, groundwater, estuarine and tidal waters and wetlands) and the management intent (or a defined level of protection) (for example, high ecological value (HEV) or moderately disturbed). These EVs and WQOs have been used to inform the assessment.



LEGEND

Weir Location	Highways (National)	High Ecological Significance Wetlands	Management Intent for Waters	Sub-Catchment	Marine / estuarine waters
Fitzroy Barrage	Railway	Wetland Protection Area (Trigger Area)	High ecological value fresh waters (maintain)	Dawson River	Upper estuary
River Crossing	Waterway (Major)	Wetland Protection Areas	High ecological value fresh waters (achieve)	Fitzroy River	Middle estuary
Populated places	Impoundment area			Mackenzie River	Enclosed coastal waters, lower estuary

1:785,000 (at A4)

0 2.5 5 10 15 20

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Australian 1984
Grid: AGD 1984 AMG Zone 55

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Fitzroy River Sub-basin plan area

Figure 11-1

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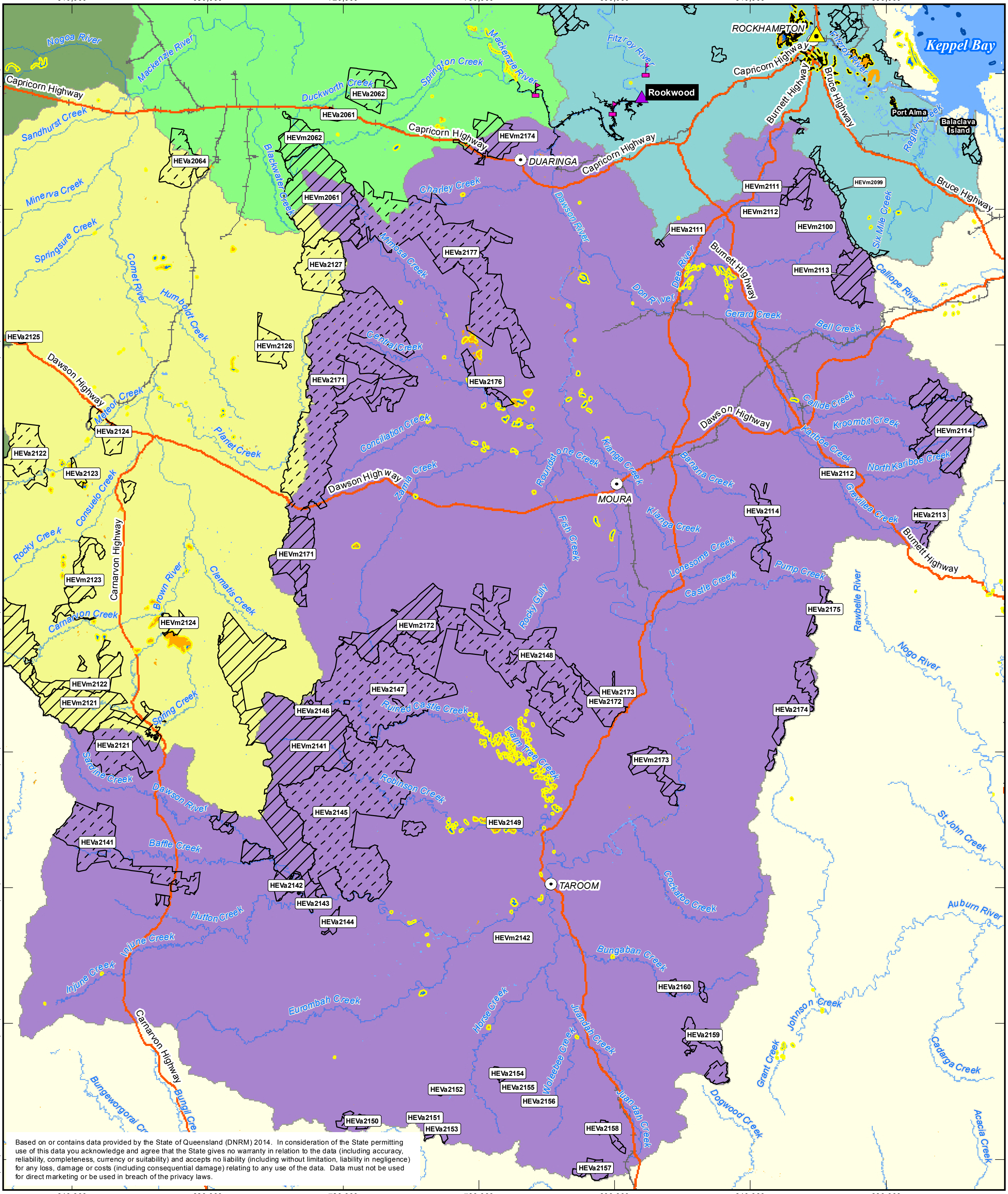
Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Weir Locations - 2008; DNRM: Railways, Roads, Dam, Sub-catchments - 2012; DEPH -Marine waters, Management Intent for Waters, Wetland Protections Areas (and Triggers), High Ecological Significance Wetlands (2014). Created by: MS *See Appendix for disclaimers and copyrights.



LEGEND

Weir Location	Highways (National)	High Ecological Significance Wetlands	Management Intent for Waters	Sub-Catchments
Fitzroy Barrage	Railway	Wetland Protection Area (Trigger Area)	High ecological value fresh waters (maintain)	Fitzroy River
River Crossing	Waterway (Major)	Wetland Protection Areas	High ecological value fresh waters (achieve)	Comet River
Populated places	Impoundment area			Mackenzie River
				Dawson River
				Nogoa River

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Dawson River Sub-basin plan area **Figure 11-2**

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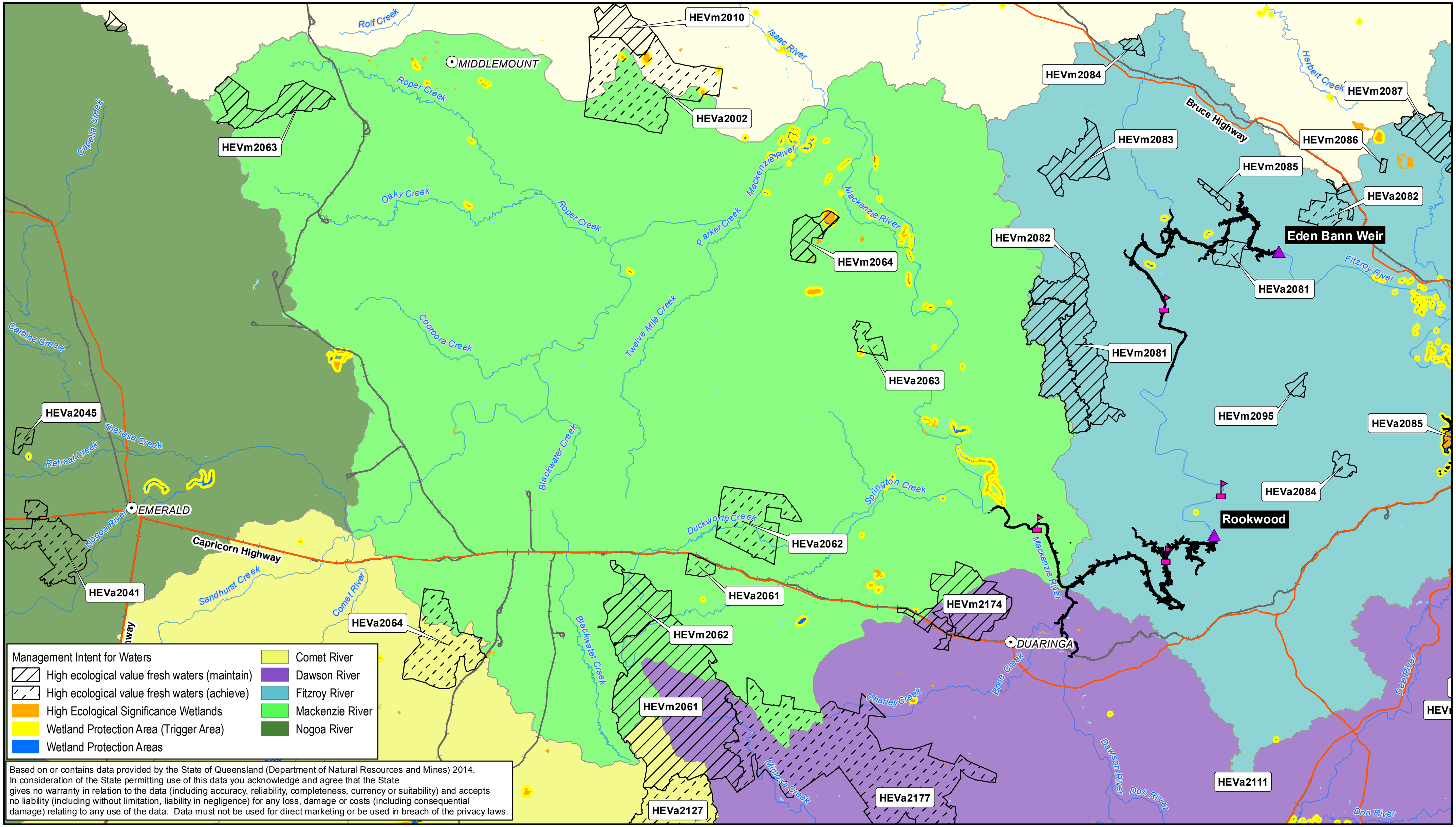

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Kilometres

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

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LEGEND

- Weir Location
- Populated Places
- River Crossing
- Highways (National)
- Railway
- Waterway (Major)
- Impoundment area

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Mackenzie River
Sub-basin plan area

Figure 11-3

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Water resources can also be impacted by contamination, which can in turn affect the water quality. Contamination of the environment is defined under the EP Act as the release (whether by act or omission) of a contaminant into the environment. A contaminant can be:

- A gas, liquid or solid
- An odour
- An organism (whether alive or dead), including a virus
- Energy, including noise, heat, radioactivity and electromagnetic radiation
- A combination of contaminants.

The Environmental Protection Regulation 2008 outlines a hierarchy of preferred procedures to deal with waste water and contaminants to water.

11.1.2.7 Queensland water quality guidelines

One of the main aims of the QWQG is to provide a mechanism to tailor guidelines to better address the natural regional and local variability in water quality across Queensland and provide the technical basis for WQOs contained in sub-basin plans under Schedule 1 of the EPP Water. The QWQG provide:

- Guideline values (numbers) that are tailored to Queensland regions and water types
- A process/framework for deriving and applying local guidelines for waters in Queensland.

The six regional water types adopted for the QWQG are the Wet Tropics and Eastern Cape; Gulf Rivers; Central Coast; Lake Eyre; Murray-Darling; and South East. The Project falls within the Central Coast region.

Consistent with the AWQGs the broad water types defined in the QWQG directly applicable to the Project area include:

- Lowland fresh waters (lowland rivers and streams)
- Lakes (fresh water lakes / reservoirs)
- Wetlands (palustrine).

Further, three aquatic ecosystem conditions are recognised against which levels of protection are assigned, namely:

- Level 1: high conservation/ecological value systems
- Level 2: slightly to moderately disturbed systems, noting that the EPP Water recognises the potential to distinguish slightly from moderately disturbed systems and establish different management intents
- Level 3: highly disturbed systems.

11.1.3 Assessment scope and objective

The objectives of the water quality assessment are to:

- Describe the general water quality characteristics (physical and chemical) of the lower Dawson, lower Mackenzie and Fitzroy Rivers (the study area). Parameters include temperature, dissolved oxygen, chlorophyll, turbidity, pH, conductivity and nutrients

- Generally describe water quality characteristics of the Fitzroy River estuary and GBRWHA receiving waters
- Describe the EVs (identified in the EPP (Water)) of the study area
- Assess likely water quality parameters associated with the Project construction and operation to established water quality guidelines relating to applicable EVs, including the protection of aquatic ecosystems and species
- Assess and provide information on how potential changes to water quality as a result of all phases (construction and operation) of the Project may impact the EVs of the study area.

The assessment is based on water quality characteristics of the waterways determined through the study.

The short-term temporal changes in the water quality characteristics of the Fitzroy Basin, specifically with respect to recent human-induced alterations related to mine dewatering following flood events is also discussed.

11.1.4 Approach and methodology

11.1.4.1 Overview

A detailed desktop assessment was undertaken to determine the general surface water quality characteristics of the lower Dawson, lower Mackenzie and Fitzroy Rivers. This included:

- Desktop assessment and literature review of available information (i.e. relevant scientific and grey literature), including a review of the Queensland Government's (DERM 2009b) study on the impacts of mining activities on Fitzroy Basin water quality
- Review and analysis of water quality data acquired from the Department of Natural Resources and Mines (DNRM)
- Comparison of the available data with the applicable water quality guidelines for the region.

11.1.4.2 Desktop assessment

The desktop assessment consisted of a review of available literature and water quality datasets.

In January and February 2008, the wet season prior to Project inception studies, significant rainfall events across the Fitzroy Basin resulted in the flooding of a number of coal mines which subsequently discharged water into watercourses at multiple locations within the Fitzroy Basin. Mine dewatering was particularly prevalent within the Isaac / Connors and Nogoa sub-catchments, which are located to the north and west, upstream of the lower Mackenzie River (DERM 2009b), flowing to the Fitzroy River. This practice continued in the subsequent wet years also experiencing high rainfall events (up to 2013) and as a result, a long-term strategy for improved and ongoing water quality monitoring and management in the Fitzroy Basin is being implemented by the Queensland Government (Queensland Government 2013a).

Studies were commissioned by the Queensland Government (DERM 2009b) on the cumulative impacts of mine dewatering on water quality in the Fitzroy Basin. Independent results showed that mine dewatering changed the water quality characteristics of affected waterways within the Fitzroy Basin. These waterways were identified as still being affected at the time of investigations pertaining to the Project (that is during the period 2008 to 2009). Therefore, planned field investigations to determine baseline water quality conditions were considered to be compromised as the data was unlikely to be representative of pre-mine dewatering conditions. In order to overcome this, long-term water quality data from DNRM[1] was utilised to describe general baseline conditions prior to commencement of mine water discharges and the Queensland Government (DERM 2009b) study was utilised to describe any potential changes to the baseline water quality conditions of the Fitzroy Basin (including the lower Dawson, lower Mackenzie and Fitzroy Rivers) as a result of the mine water discharge. Short-term water quality data from DNRM was sourced to describe general water quality conditions following the mine water discharge events.

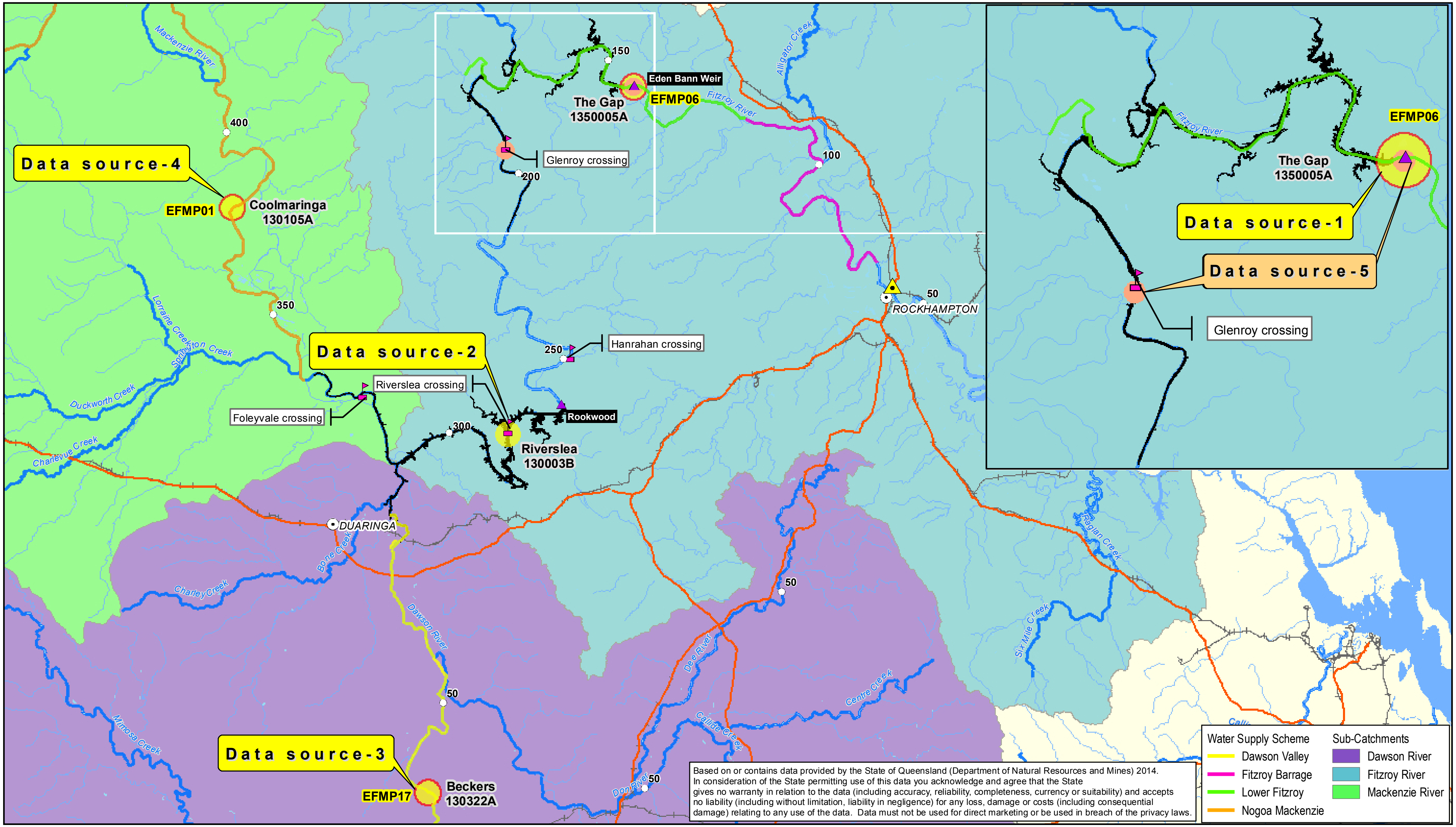
In order to assess water quality characteristics of the study area, long-term, mine dewatering event and short term datasets were obtained and evaluated to analyse the most appropriate data. This included data from DNRM stream gauging stations and from SunWater Limited (SunWater) monitoring at the Eden Bann Weir site. Data were sourced from the following stream gauges and monitoring locations (Figure 11-4):

- Data source 1: DNRM stream gauge 130005A (The Gap) (142.1 km Adopted Middle Thread Distance (AMTD)), located on the Fitzroy River 1 km upstream of Eden Bann Weir, within the existing impoundment (Lower Fitzroy Water Supply Scheme). Prior to the construction of the Eden Bann Weir in 1994, this location was an unregulated section of the Fitzroy River
- Data source 2: DNRM stream gauge 130003B (Riverslea) (276 km AMTD), located on an unregulated section of the Fitzroy River approximately 11 km AMTD upstream of the proposed weir site at Rookwood
- Data source 3: DNRM stream gauge 130322A, (Beckers) (AMTD 71 km): located on a regulated section of the Dawson River (Dawson Valley Water Supply Scheme), 71 km AMTD upstream of the Mackenzie River confluence and 12 km AMTD downstream of Neville Hewitt Weir
- Data source 4: DNRM stream gauge 130105A (Coolmaringa) (AMTD 376 km): located on a regulated section of the Mackenzie River (Nogoa Mackenzie Water Supply Scheme), 66 km AMTD upstream of the confluence with the Dawson River, 54 km downstream of Tartrus Weir
- Data source 5: Eden Bann Weir - data collected at various intervals from September 2001 to October 2013 was analysed from three monitoring sites associated with Eden Bann Weir:
  - Tailwater: Fitzroy River at Wattlebank (139 km AMTD), located approximately 2 km downstream of Eden Bann Weir
  - Headwater: Fitzroy River at The Gap (as per data source 1 above)
  - Inflow: Glenroy Crossing on the Fitzroy River, located approximately 60 km upstream of Eden Bann Weir.

Data was assessed against the EPP Water EVs and WQOs.

Table 11-1 summaries the datasets used from each stream gauging station.

[1] Stream Gauging Station Network available for download through the DNRM Water Monitoring Data Portal (DNRM 2012b) (http://watermonitoring.dnrm.qld.gov.au/host.htm)



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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

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LEGEND

- Weir Location
- Fitzroy Barrage
- River Crossing
- Populated Places
- AMTD (km)
- Highways (National)
- Railway
- Waterway (Major)
- Waterway (Minor)
- Impoundment area
- Enhanced monitoring location
- Data source (1-4)
- Data Source (5)

Data Source
1 - The Gap
2 - Riverslea
3 - Beckers
4 - Coolmaringa
5 - Eden Bann Weir

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Data source locations

Figure 11-4

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Table 11-1 Summary of water quality datasets

Stream gauge station	Long-term dataset	Mine dewatering event	Short-term dataset
Fitzroy River at The Gap (within Eden Bann Weir pond)	1964 – 2006	October 2008 – January 2009	March 2009 – November 2012
Fitzroy River at Riverslea	1964 – 2006	October 2008 – December 2008	September 2010 – October 2012
Dawson River at Beckers	1964 – 2006	No data (Not sampled)	April 2009 – November 2012
Mackenzie River at Coolmaringa	1972 – 2006	October 2008 – December 2008	April 2009 – October 2012

Key

Long-term datasets:	Several decades of data
Mine dewatering event datasets:	Late 2008 / early 2009 (summary of post mine dewatering sampling)
Short-term datasets:	Recently collected data 2009 - 2012

The desktop assessment also reviewed available literature and water quality data pertaining to the Fitzroy River estuary and GBRWHA receiving waters. The literature was used to inform a general characterisation of water quality in estuarine and marine environments downstream of the Project.

Datasets were evaluated based on:

- Intent of original data collection
- Location of sampling points
- Time period during which samples were collected
- Reliability and representativeness of the data
- Parameters being recorded
- Method of data collection.

11.1.4.3 Data analysis

Water quality parameters

In order to characterise the general ambient water quality conditions in the study area prior to discharge from the flooded mines, a subset (four water stream gauging stations: The Gap, Riverslea, Beckers and Coolmaringa) of the data was analysed to describe baseline conditions.

The stream gauging station sites were selected for analysis because they are situated upstream and downstream of both Eden Bann Weir and the proposed Rookwood Weir site locations and provided the most complete and spatially appropriate datasets.

Summary statistics for water quality parameters were acquired for each of the sites over the entire period in which parameters were sampled to provide a 'snapshot' of the general water quality characteristics of each of the four monitoring sites in the decade preceding the 2008 mine dewatering event (long term dataset) as well as the short term dataset.

In addition SunWater data collected at Eden Bann Weir for various intervals between 2001 and 2013 was analysed to describe baseline conditions within and immediately downstream of the existing impoundment.

It is acknowledged that there are some gaps in water quality data where not all water quality parameters were recorded at specific sites. The datasets used in the assessment are considered sufficient for the scope of this study which is to provide a general characterisation/baseline understanding of the water quality upstream and downstream of proposed Project infrastructure. The long term dataset for Riverslea was not complete (data was missing for the period 1998-2007).

Summary statistics were provided for the following water quality parameters (as available and relevant):

- pH
- Electrical conductivity (EC)
- Water temperature
- Dissolved oxygen (DO)
- Turbidity
- Total Suspended Solids (TSS)
- Total Nitrogen (TN)
- Total Phosphorus (TP)
- Chlorophyll a.

Within the summary statistics, *median* values have been assessed against the adopted guidelines. Median values were selected for assessment as these are likely to provide the most representative indication of the baseline values of each water quality parameter, and are less likely to be impacted by extreme values.

Metals concentration data sourced from existing monitoring programs is limited for the Project area. Available parameters were limited to:

- Aluminium (Al)
- Copper (Cu)
- Iron (Fe)
- Magnesium (Mg)
- Manganese (Mn)
- Zinc (Zn).

These parameters represent the baseline monitoring programs conducted by DNRM and as such are considered to represent the relevant primary ecosystem toxicants of the Fitzroy system. Whilst this limited data set has been analysed, it is not considered necessary to assess a broad suite of potential metals and metalloids as the Project is considered unlikely to contribute to input of toxicants into the water system. Analysed data was compared to the appropriate guidelines.

No bacterial data was located for the Project. Given the low population densities in the Fitzroy Basin and Project areas (Chapter 18 Social impact assessment) and the absence of potential sources it can be expected that bacterial levels would be low.

Potential nutrient loads

A study was conducted to determine the rate at which the nitrates (N) and phosphates (P) will break down within the impoundment areas during the Project's operation. This was carried out to determine the Project's effect on the nutrient load (TN and TP) of the Fitzroy system.

The above ground vegetation biomass for N and P was calculated using the Full Carbon Accounting Model (FullCAM) (Richards and Evans 2000). The FullCAM program requires a series of GPS data points to be entered into the program. For the purposes of this exercise, ten GPS points were chosen to be entered. These data points then provided an average location for the program to be simulated around. The program identifies a number of parameters, including: soil data; regional soils list; maximum above ground forest biomass; forest productivity index (annual rate); average air temperature; rainfall; open-pan evaporation; forest topsoil moisture deficit; and tree species groups for Queensland.

Running the FullCAM program provided an output which shows the total dry mass of above ground biomass per hectare. Below ground biomass was calculated using the National Carbon Accounting System (Australian Greenhouse Office, 2002). The proportion of above ground biomass for coarse and fine root masses, as well as stems, bark, branches and leaves was identified. A range of literature was used to derive an approximate proportion of nutrient to dry mass for acacia woodland and eucalypt woodland (1.02 per cent nitrogen component of dry mass per hectare). A decay coefficient of 0.62 yr^{-1} was adopted. The calculations for the phosphorus component also adopt literature figures for the approximate proportions of nutrient to dry mass for acacia woodland and eucalypt woodland (0.18 per cent phosphorous component of dry mass per hectare). A decay coefficient of 0.51 yr^{-1} was adopted.

Contaminated land

A Stage 1 site contamination assessment was conducted for the Project (Chapter 5 Land). The data is used where applicable.

11.1.4.4 Water quality objectives and guideline values

Schedule 1 of the EPP Water outlines EVs for waters. EVs identified within the study area include:

- Aquatic ecosystem EVs (moderately disturbed waters)
- Human use EVs
  - Primary industries (including irrigation, farm supply and use, stock watering, aquaculture and human consumption of aquatic foods)
  - Recreation and aesthetics (including primary and secondary contact recreation and visual recreation)
  - Drinking water
  - Industrial uses
  - Cultural and spiritual values.

Aquatic ecosystems are further defined in terms of the level of aquatic ecosystem condition namely HEV or highly, moderately or slightly disturbed waters. Ecosystem condition corresponds to the level of protection or management intent of the corresponding WQOs.

Schedule 1 of the EPP Water defines WQOs at a sub-basin level and specific to water types to protect aquatic ecosystem and human use EVs (Section 11.2.1). Where local guidelines are not available the EPP Water in turn references to the AWQGs, QWQGs and others as applicable. Notably, local guidelines are not available for toxicants in water and sediment with regard to protection of aquatic ecosystems.

Where more than one EV applies to a given waterbody or type, the adoption of the most stringent WQO for the identified EV is taken to apply to each water quality parameter in order to protect all identified EVs. 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. Human use EV WQOs applicable to the Project are consistent across the Fitzroy River, Dawson River and Mackenzie Sub-basin plan areas.

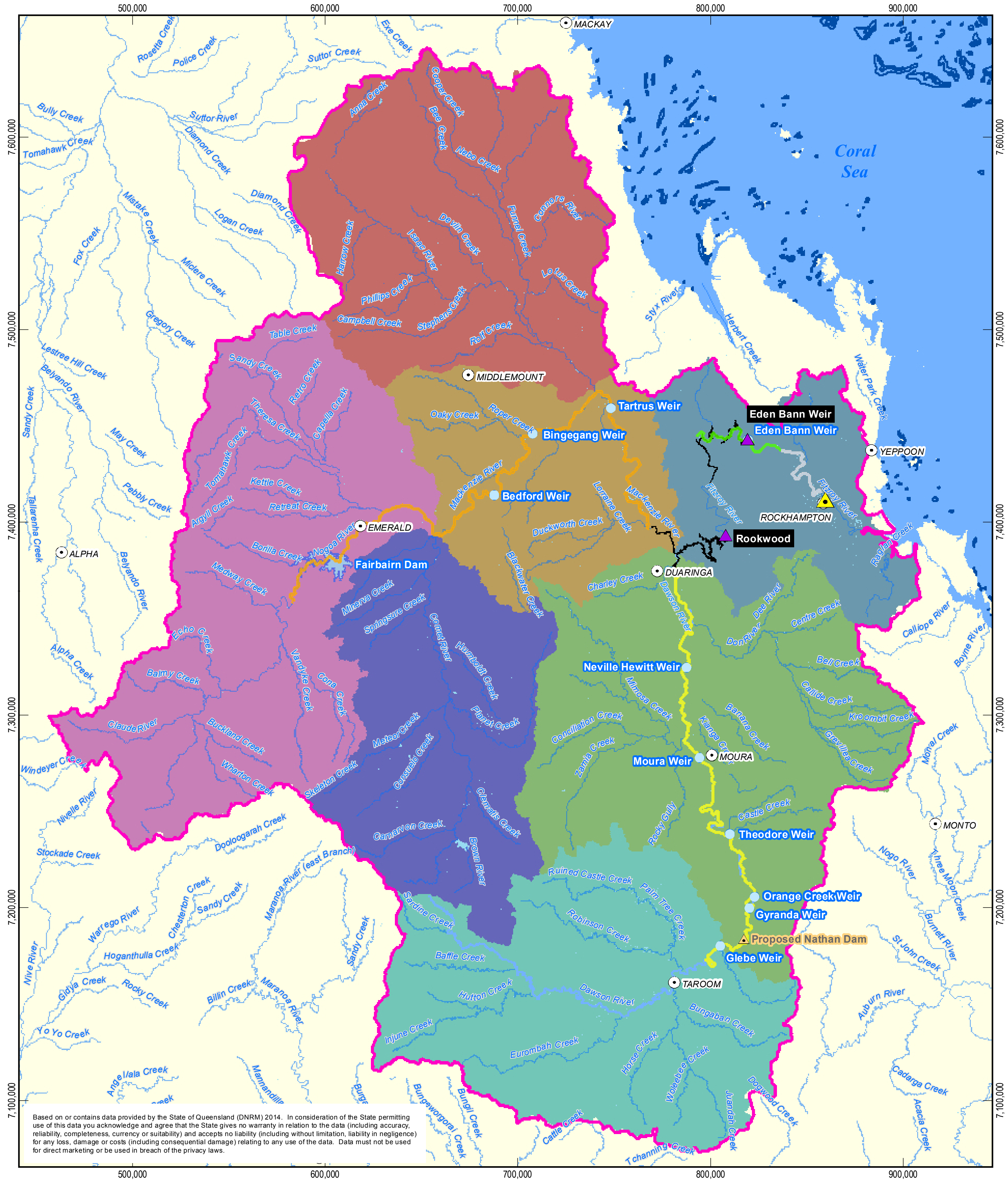
The existing water quality and WQOs relevant to the water types (and for aquatic ecosystems the level of protection attributed to the ecosystem) in the Project area are discussed further in Section 11.2.3, 11.2.4 and 11.2.5.

11.2 Existing environment

11.2.1 Catchment and sub-catchment characteristics

Catchment characteristics are described in detail in Chapter 9 Surface water and summarised as follows:

- 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 11-5.
- These sub-catchments are highly regulated:
  - 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.
- 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.



LEGEND

Weir Location	Fitzroy Catchment	Sub Catchment (DNRM)	Water Supply Scheme
Fitzroy Barrage	Impoundment area	Lower Dawson River / Fitzroy River	Dawson Valley
Existing weir		Comet River / Noga River	Fitzroy Barrage
Populated places		Isaac - Connors Rivers / Mackenzie River	Lower Fitzroy
Waterway (Major)		Upper Dawson River	Nogoa Mackenzie

1:2,650,000 (at A4)

0 12.5 25 50 75 100

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

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Gladstone Area Water Board, Sunwater
Lower Fitzroy River Infrastructure Project

Job Number	41-20736
Revision	A
Date	25 Mar 2014

Fitzroy Basin and Sub-catchments

Figure 11-5

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Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Weir Locations - 2008; DNRM: Railways, Roads, Dam, Existing Weir - 2010, Sub-catchments - 2012. Created by: 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 (Chapter 21 Cumulative impacts)
- 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 (Chapter 5 Land)
- 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 (Chapter 5 Land)
- Agricultural production is the main land use adjacent to the lower Mackenzie River. The landscape has been substantially modified through land clearing to accommodate cattle grazing (Chapter 5 Land)
- Flooding is common in the Fitzroy Basin as described in Chapter 4 Climate, natural hazards and climate change and discussed in Chapter 9 Surface water resources
- 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 (reflecting the potential for salt mobilisation) within the study area indicates a low to moderate salinity hazard (Chapter 5 Land). Naturally-occurring salts occur in soils of the Fitzroy Basin. Due to the variable geology across the sub-catchments three salinity zones are identified, of which the Fitzroy Central zone is relevant to the Project
- 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), and disposal of by-product water associated with coal seam gas extraction contribute high 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 2009b). 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 2013b). Relative to the Project areas, specifically data source locations 1, 3 and 4, respectively, enhanced monitoring of water quality is being undertaken by DNRM on:
  - The Fitzroy River at Eden Bann Weir (EFMP06) (data source location 1)

– The Dawson River at Beckers (EFMP17) (data source location 3)
– The Mackenzie River at New Dumbarton (EFMP01) (data source location 4) (Figure 11-4).

These catchment characteristics have the potential to influence water quality in the study area. Human-induced and environmental influences on water quality include:

- Runoff from adjacent agricultural land, exacerbated by the historical 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 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.

11.2.2 Seasonal variation

11.2.2.1 The Fitzroy Basin

The Fitzroy Basin sits within a savannah, subtropical climate – as such this basin experiences variable rainfall patterns. While the majority of annual rainfall is observed during the summer months, the Fitzroy Basin is still subjected to high inter-annual variability where intense rainfall can be followed by extensive dry periods. In turn, the variable rainfall patterns influence the water quality of the Fitzroy Basin, particularly in the absence of 'flushing flows' on a seasonal basis to control the growth of algae, and to dilute and/or transport accumulated organic and inorganic substances in surface water.

This natural variability in surface water quality is reflected in the DEHP's *Environmental Protection Policy 2009 – Fitzroy River sub-basin environmental values and water quality objectives* (DEHP 2013) in which the guidelines specifically consider the influence of water level and hydrological connectivity on water quality. Dissolved oxygen levels are particularly variable within the Fitzroy Basin. In some instances, rainfall events can reduce levels of dissolved oxygen with the influx of organic matter. Variability in dissolved oxygen is also observed in the Fitzroy Basin where isolated surface water becomes stagnant, which naturally results in dissolved oxygen values below 50 per cent saturation and during periods of elevated turbidity values can drop to levels blow 10 per cent (DEHP 2015). Natural seasonal variability is also observed in nutrient levels, particularly nitrogen, where the accumulation of organic matter within isolated surface water raises the organic nitrogen levels in the absence of surface flows (DEHP 2013). Water temperature is also seasonally driven, and is reflective of the ambient air temperature (DEHP 2013; DERM 2011).

11.2.2.2 Receiving environment

The discharge from the Fitzroy Basin flows to the Great Barrier Reef World Heritage Area. Water quality within the Fitzroy River estuary and marine receiving environment experiences seasonal fluctuations which are highly influenced by flows from the Fitzroy Basin (DEHP 2014). The hydrodynamic conditions and biophysical processes within the marine receiving environment also contribute towards water quality (DEHP 2014). For example, cyclones within or near the Fitzroy Basin increase turbidity in the marine environment through 1) increased overland runoff, which results in the washing of eroded sediment into the bay, and 2) storm energy resuspending sediment within the marine environment itself (Brodie et al. 2008).

11.2.3 Fitzroy River

The Project area within the EPP Water Fitzroy River Sub-basin plan area (excluding Eden Bann Weir) is dominated by Fitzroy River catchment fresh waters and freshwater riparian areas. The existing Eden Bann Weir is defined as a freshwater lake or reservoir. Palustrine wetlands are dispersed along the length of the Fitzroy River. There are no wetlands of high ecological significance directly associated with the Project area (Chapter 7 Aquatic ecology). All EVs are prescribed for the Fitzroy River main channel in the Project areas within the Fitzroy River Sub-basin. Aquatic ecosystems within the Fitzroy River Sub-plan Project area are classed as moderately disturbed. The Aricia State Forest is defined as an area of HEV (HEVa2081) (Figure 11-1). The Project is not expected to adversely impact on, or alter, the management of the Aricia State Forest and consideration of WQOs for this area in relation to the Project area not included.

11.2.3.1 Fitzroy River at The Gap

A summary of the physio-chemical water quality parameters analysed for the Fitzroy River at The Gap (within the Eden Bann Weir impoundment) are presented in Table 11-2 and Table 11-3 (DNRM and SunWater data, respectively). For comparative purposes SunWater water quality data for the Eden Bann Weir inflow (monitored upstream at Glenroy Crossing) and tailwater (monitored downstream at Wattlebank) are also provided in Table 11-2 and Table 11-3.

In accordance with the EPP Water and with reference to aquatic ecosystems, the water area or type at The Gap is defined as a freshwater lake or reservoir. The management intent for The Gap is that of a moderately disturbed aquatic ecosystem. WQOs to protect moderately disturbed aquatic ecosystems in a freshwater lake or reservoir (including consideration of toxicants) are presented in Table 11-4 and compared to the existing median values.

pH

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 2009b). 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).

Table 11-2 Summary of DNRM water quality data from the Fitzroy River at The Gap

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
Long-term dataset (1964 – 2006)									
pH	150	1964-2006	6.7	7.0	**7.6**	8.1	9.1	7.6	0.5
EC @ 25°C (µS/cm)	150	1964-2006	70.0	94.8	**168.5**	596.4	910.0	258.0	198.4
Water temperature (°C)	104	1972-2006	16.0	19.0	**25.4**	29.5	34.1	25.0	3.9
DO (mg/L)	32	1997-2006	4.0	4.3	**6.3**	7.4	8.9	6.2	1.2
Turbidity (NTU)	87	1982-2006	1	5	**100**	1,266	2,136	361	526
TSS (mg/L)	134	1973-2006	3.0	9.3	**147.5**	974.2	1,730.0	289.4	381.2
TN (µg/L)	38	1998-2006	300	450	**1,110**	2,230	2,760	1,220	700
TP (µg/L)	54	1994-2006	40	60	**330**	850	1,090	410	320
Al soluble (µg/L)	59	1990-2006	<0.05	<0.05	**20.0**	222.0	800.0	59.49	125.81
Cu (µg/L)	64	1990-2006	<0.3	<0.3	**20.0**	50.0	70.0	20.94	17.70
Fe soluble (µg/L)	81	1973-2006	<0.01	<0.01	**30.0**	480.0	2,700	215.68	487.67
Mg (µg/L)	No data	-	-	-	**-**	-	-	-	-
Mn soluble (µg/L)	55	1983-2006	<0.01	<0.01	<**0.01**	26.0	30.0	6.7	10.9
Zn soluble (µg/L)	55	1991-2006	<0.01	<0.01	**10.0**	40.0	100.0	18.18	24.73
Mine dewatering event dataset (October 2008 – January 2009)									
pH	4	Oct 2008 – Jan 2009	7.8	8.0	**8.6**	8.6	8.6	8.4	0.4
EC @ 25°C (µS/cm)	4	Oct 2008 – Jan 2009	652.0	667.3	**705.0**	763.0	787.0	712.3	55.8
Water temperature (°C)	4	Oct 2008 – Jan 2009	24.6	25.5	**29.6**	32.0	32.2	29.0	3.6
DO (mg/L)	4	Oct 2008 – Jan 2009	6.1	6.7	**8.4**	9.2	9.3	8.1	1.4
Turbidity (NTU)	4	Oct 2008 – Jan 2009	3.0	3.6	**6.0**	72.8	101.0	29.0	48.0
TSS (mg/L)	No data	Oct 2008 – Jan 2009	-	-	**-**	-	-	-	-

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
TN (µg/L)	4	Oct 2008 – Jan 2009	320	332	**360**	690	830	470	240
TP (µg/L)	4	Oct 2008 – Jan 2009	20	20	**25**	110	140	50	60
Al soluble (µg/L)	4	Oct 2008 – Jan 2009	12.0	14.9	**21.8**	68.9	89.0	36.2	35.5
Cu (µg/L)	4	Oct 2008 – Jan 2009	2.0	2.0	**3.3**	6.3	7.0	3.9	2.4
Fe soluble (µg/L)	4	Oct 2008 – Jan 2009	6.1	7.0	**9.5**	10.0	10.0	8.8	1.8
Mg (µg/L)	No data	Oct 2008 – Jan 2009	-	-	**-**	-	-	-	-
Mn soluble (µg/L)	No data	Oct 2008 – Jan 2009	-	-	**-**	-	-	-	-
Zn soluble (µg/L)	4	Oct 2008 – Jan 2009	2.0	2.8	**4.8**	33.0	45.0	14.2	20.6
Short-term dataset (2009 – 2012)									
pH	34	Mar 2009 – Nov 2012	7.3	7.4	**8.0**	8.3	8.6	7.9	0.4
EC @ 25°C (µS/cm)	34	Mar 2009 – Nov 2012	97.0	153.3	**290.0**	704.9	844.0	371.9	224.3
Water temperature (°C)	34	Mar 2009 – Nov 2012	17.4	19.2	**25.7**	28.9	30.1	24.6	3.6
DO (mg/L)	34	Mar 2009 – Nov 2012	2.5	4.5	**7.1**	9.3	15.5	7.2	2.5
Turbidity (NTU)	34	Mar 2009 – Nov 2012	1.0	4.0	**91.0**	277.0	408.0	107.6	121.3
TSS (mg/L)	34	Mar 2009 – Nov 2012	1.0	8.3	**42.0**	213.2	420.0	88.2	103.9
TN (µg/L)	34	Mar 2009 – Nov 2012	160	260	**620**	904	1,700	588	303
TP (µg/L)	34	Mar 2009 – Nov 2012	54	65	**177**	334	390	188	110
Al soluble (µg/L)	34	Mar 2009 – Nov 2012	50	50	**50**	825	1,800	259	429
Cu (µg/L)	34	Mar 2009 – Nov 2012	30	30	**30**	30	40	30	2
Fe soluble (µg/L)	34	Mar 2009 – Nov 2012	10	10	**60**	467	990	173	241
Mg (µg/L)	34	Mar 2009 – Nov 2012	3,000	4,310	**10,400**	29,700	40,000	14,712	10,368
Mn soluble (µg/L)	34	Mar 2009 – Nov 2012	10	10	**10**	10	10	10	0
Zn soluble (µg/L)	34	Mar 2009 – Nov 2012	10	10	**10**	90	490	37	85

Table 11-3 Summary of SunWater water quality data for Eden Bann Weir

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
Fitzroy River at Wattlebank 130002B (tailwater)									
pH	232	Sep 2001 – Oct 2013	6.6	7.3	**7.7**	8.3	9.7	7.8	0.4
EC @ 25°C (µS/cm)	208	Sep 2001 – Oct 2013	123.0	149.0	**239.0**	636.0	885.0	323.5	207.3
Water temperature (°C)	235	Sep 2001 – Oct 2013	14.5	18.0	**24.8**	27.9	33.3	24.3	3.8
DO (mg/L)	230	Sep 2001 – Oct 2013	1.2	4.5	**7.5**	12.0	19.2	7.9	3.3
Turbidity (NTU)	222	Sep 2001 – Oct 2013	<2.0	9.2	**133.2**	854.0	1,372.4	274.1	334.0
TSS (mg/L)	11	Sep 2001 – Jun 2004	7.0	9.3	**29.0**	170.0	190.0	62.2	65.8
TN (µg/L)	92	Sep 2001 – Oct 2013	240	381	**665**	1,101	2,300	733	347
TP (µg/L)	92	Sep 2001 – Oct 2013	20	55	**155**	369	1800	205	227
Chlorophyll a (µg/L)	11	Sep 2001 – Jun 2004	0.00	0.07	**1.60**	11.00	26.00	5.00	7.81
Fitzroy River at The Gap 130005A (headwater)									
pH	754	Sep 2001 – Oct 2013	3.7	7.1	**7.6**	8.3	9.8	7.6	0.7
EC @ 25°C (µS/cm)	731	Sep 2001 – Oct 2013	74.0	147.0	**240.0**	605.0	877.0	304.8	189.2
Water temperature (°C)	761	Sep 2001 – Oct 2013	14.4	18.0	**24.3**	28.2	31.2	23.8	3.7
DO (mg/L)	707	Sep 2001 – Oct 2013	0.0	4.2	**6.8**	12.1	18.4	7.2	3.1
Turbidity (NTU)	719	Sep 2001 – Oct 2013	0.0	8.9	**108.0**	751.2	2,654.0	272.3	387.4
TSS (mg/L)	12	Sep 2001 – Jun 2004	6.0	11.1	**39.5**	178.0	250.0	72.2	80.8
TN (µg/L)	93	Sep 2001 – Oct 2013	180	332	**640**	1,068	2,400	713	368
TP (µg/L)	93	Sep 2001 – Oct 2013	30	51	**160**	376	1,800	205	228

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
Chlorophyll a (µg/L)	12	Sep 2001 – Jun 2004	0.00	0.28	**2.14**	6.01	16.00	3.24	4.47
Fitzroy River at Eden Bann inflow (Glenroy Crossing)									
pH	75	Oct 2007 – Oct 2013	6.8	7.4	**8**	8.7	9.1	8.02	0.51
EC @ 25°C (µS/cm)	74	Oct 2007 – Oct 2013	148	191	**324.5**	803.9	1125	426.69	262.28
Water temperature (°C)	75	Oct 2007 – Oct 2013	18.0	20.5	**27.0**	28.9	31.7	26.0	3.1
DO (mg/L)	72	Oct 2007 – Oct 2013	3.5	5.9	**8.5**	11.7	15.3	8.6	2.3
Turbidity (NTU)	71	Oct 2007 – Oct 2013	0.0	4.2	**45.1**	617.0	1,292.8	190.5	315.7
TN (µg/L)	39	Oct 2007 – Oct 2013	130	238	**490**	794	1,200	505	239
TP (µg/L)	39	Oct 2007 – Oct 2013	30	39	**92**	299	445	144	113

Table 11-4 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[45]	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	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) (dissolved)	1.4[6]	20.0	3.3	30	-	-	-

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]
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.

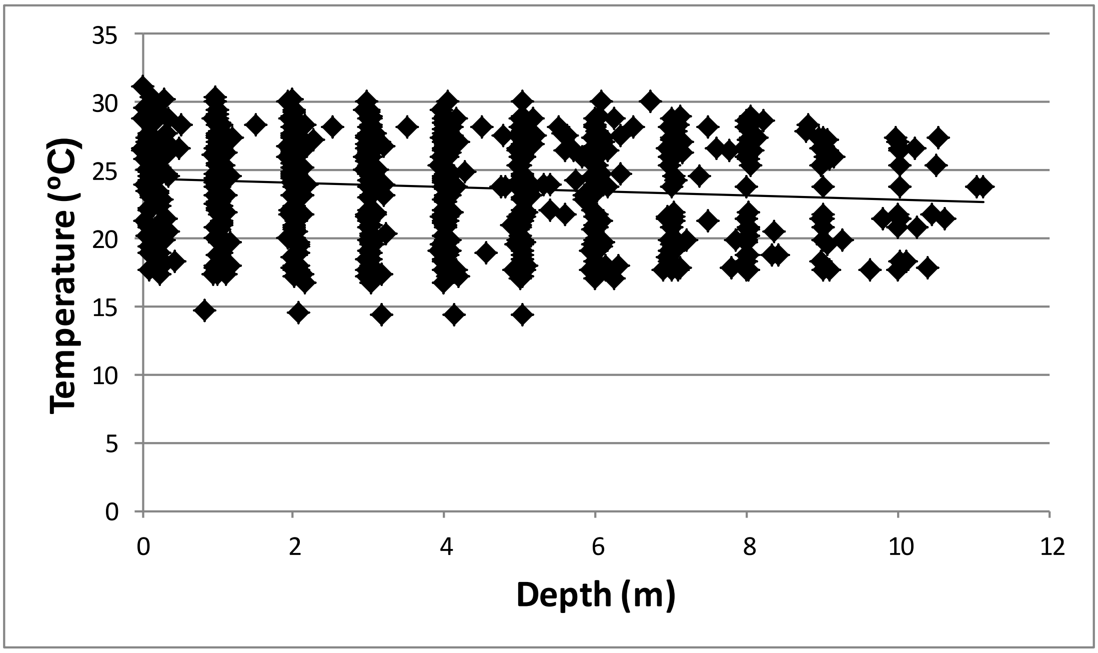
Electrical conductivity

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 ADWG.

Temperature

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 11-6), as expected within a shallow impoundment resulting in little to no stratification.

Figure 11-6 Temperature within the Eden Bann Weir impoundment

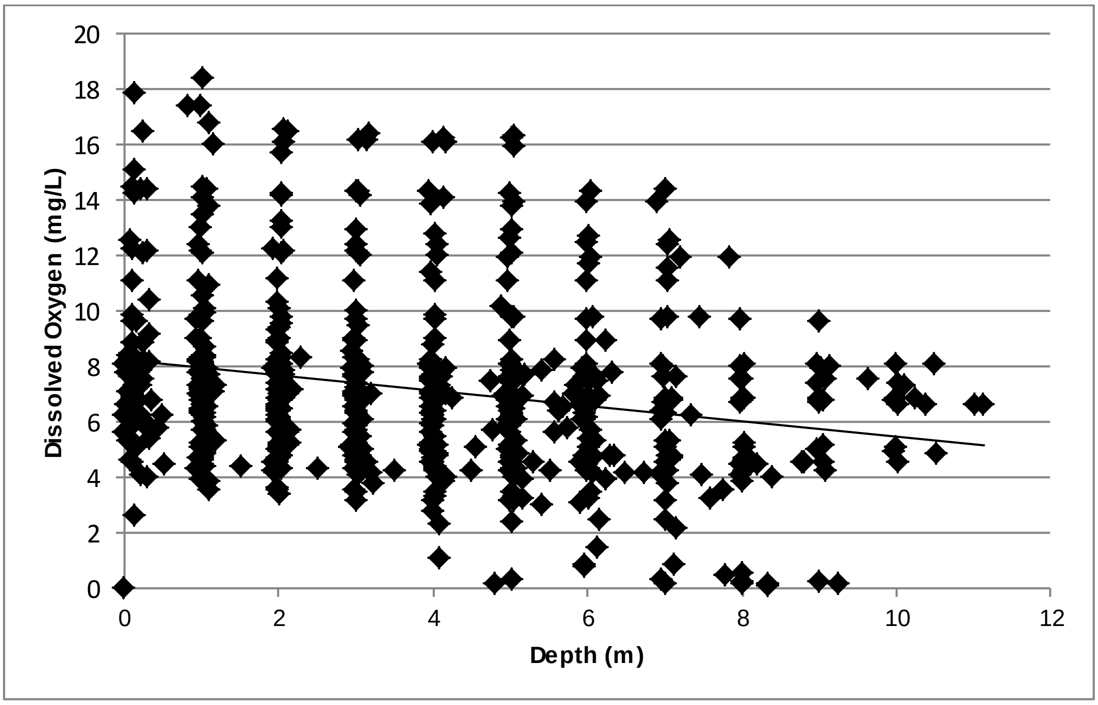


Source: SunWater water quality data (September 2001 – October 2013)

Dissolved oxygen

The median concentration of DO at The Gap was greater than WQO. Figure 11-7 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.

Figure 11-7 Dissolved oxygen concentration within the Eden Bann Weir impoundment



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

Turbidity

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 (Sections 11.2.3.2, 11.2.4 and 11.2.5) and as reported for other storages in the Fitzroy Basin, for example Glebe Weir (168 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.

Sediment management is a consideration in design of the weirs. Current sediment management on the Fitzroy River is achieved by transmission of the sediment under or through the weirs. The existing Eden Bann Weir is of low height and allows transmission of sediment over the weir because the velocities in the channel are high. Sand is only deposited in a narrow zone directly upstream of the weir. All other sand is washed over the weir and downstream. Similarly the Fitzroy Barrage is fitted with vertical lift gates that are lifted out of the stream flow during a flood event to allow unimpeded transfer of sediment.

Nitrogen and phosphorus

The concentrations of nutrients (TN and 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).

Dissolved metals

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).

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 11-5 together with SunWater's adopted action levels and monitoring systems.

Table 11-5 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.

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.

Water quality impacts on aquatic fauna are described in Chapter 7 Aquatic fauna.

11.2.3.2 Fitzroy River at Riverslea

A summary of the water quality parameters analysed for the Fitzroy River at DNRM's Riverslea gauge is presented in Table 11-6.

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 11-7, as compared to the existing median values.

Table 11-6 Summary of water quality data from the Fitzroy River at Riverslea

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
Long-term dataset (1975-2003)									
pH	57	1975-2003	6.8	7.2	**7.7**	8.2	9.4	7.7	0.5
EC @ 25°C (µS/cm)	56	1975-2003	70.0	160.0	**309.5**	531.5	790.0	323.4	146.7
Water temperature (°C)	69	1975-2003	15.0	18.0	**25.0**	31.0	34.2	24.9	4.9
DO (mg/L)	21	1995-2003	4.9	6.4	**8.2**	11.0	12.3	8.5	2.0
Turbidity (NTU)	42	1982-2003	1.0	1.7	**36.7**	100.0	430.0	60.9	78.5
TSS (mg/L)	52	1975-2003	3.0	8.1	**33.0**	386.8	1,114.0	144.6	227.4
TN (µg/L)	6	2000-2003	230	-	**-**	-	1,120	610	280
TP (µg/L)	11	1994-2003	20	20	**130**	490	1,030	230	300
Al soluble (µg/L)	15	1990-2003	<0.05	4.0	**40.0**	200.0	660.0	89.33	172.07
Cu (µg/L)	No data	-	-	-	**-**	-	-	-	-
Fe soluble (µg/L)	34	1982-2003	<0.01	10	**60.0**	1,091.0.	3,000.0	382.94	619.64
Mg (µg/L)	No data	-	-	-	**-**	-	-	-	-
Mn soluble (µg/L)	13	1985-2003	<0.01	<0.01	**10.0**	18.0	30.0	10.0	8.16
Zn soluble (µg/L)	12	1990-2003	<0.01	<0.01	**10.0**	10.0	30.0	7.5	8.66
Mine dewatering event (October 2008-December 2008)									
pH	4	Oct 2008-Dec 2008	7.5	7.5	**7.9**	8.4	8.3	7.9	0.5
EC @ 25°C (µS/cm)	4	Oct 2008-Dec 2008	302.0	462.2	**938.0**	1,213.6	1,288.0	866.5	419.3
Water temperature (°C)	4	Oct 2008-Dec 2008	28.1	28.5	**29.3**	29.4	29.4	29.0	0.6

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
DO (mg/L)	4	Oct 2008-Dec 2008	5.3	5.3	**5.7**	9.1	10.5	6.8	2.5
Turbidity (NTU)	4	Oct 2008-Dec 2008	5	55	**184**	602	776	287	337
TSS (mg/L)	No data	-	-	-	**-**	-	-	-	-
TN (µg/L)	4	Oct 2008-Dec 2008	370	470	**700**	1,180	1,300	790	470
TP (µg/L)	4	Oct 2008-Dec 2008	30	70	**150**	350	430	190	170
Al soluble (µg/L)	4	Oct 2008-Dec 2008	6.0	9.5	**44.4**	85.7	92.0	46.7	41.4
Cu (µg/L)	4	Oct 2008-Dec 2008	2.0	2.1	**4.7**	7.7	8.0	4.8	3.1
Fe soluble (µg/L)	4	Oct 2008-Dec 2008	7.0	8.3	**13.7**	18.8	20.0	13.6	5.6
Mg (µg/L)	No data	-	-	-	**-**	-	-	-	-
Mn soluble (µg/L)	4	Oct 2008-Dec 2008	1.7	3.4	**11.8**	34.9	43.0	17.1	18.3
Zn soluble (µg/L)	4	Oct 2008-Dec 2008	3.0	6.3	**14.5**	41.0	52.1	21.0	21.4
Short-term dataset (July 2008 – October 2012)									
pH	25	July 2008 – Oct 2012	7.1	7.2	**7.9**	8.3	8.3	7.8	0.4
EC @ 25°C (µS/cm)	25	July 2008 – Oct 2012	95.0	141.2	**306.0**	661.8	666.0	366.4	197.8
Water temperature (°C)	25	July 2008 – Oct 2012	15.9	18.5	**24.8**	29.2	30.5	23.9	4.0
DO (mg/L)	25	July 2008 – Oct 2012	4.3	4.9	**7.3**	10.5	13.9	7.9	2.2
Turbidity (NTU)	25	July 2008 – Oct 2012	1	4	**91**	277	408	108	121
TSS (mg/L)	25	July 2008 – Oct 2012	4	7	**46**	256	343	90	104
TN (µg/L)	25	July 2008 – Oct 2012	170	212	**550**	862	960	496	259
TP (µg/L)	25	July 2008 – Oct 2012	47	63	**170**	310	330	174	104

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
Al soluble (µg/L)	25	July 2008 – Oct 2012	50	50	**50**	1,032	2,900	460	763
Cu (µg/L)	25	July 2008 – Oct 2012	30	30	**30**	30	130	34	20
Fe soluble (µg/L)	25	July 2008 – Oct 2012	10	10	**60**	582	1,400	251	386
Mg (µg/L)	25	July 2008 – Oct 2012	2,200	3,640	**10,000**	22,600	24,000	11,960	7,254
Mn soluble (µg/L)	25	July 2008 – Oct 2012	10	10	**10**	10	10	10	0
Zn soluble (µg/L)	25	July 2008 – Oct 2012	10	10	**10**	10	50	12	8

Table 11-7 Median values and water quality objectives at Riverslea

Water quality parameter	WQO[1]	Median values (DNRM)[2]		
		Long-term	Mine dew atering	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) (dissolved)	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.

pH

The median pH recorded at Riverslea was within the WQO and indicates an alkaline environment.

Electrical conductivity

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.

Dissolved oxygen

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.

Turbidity

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 (Chapter 4 Climate, natural hazards and climate change) resulting in significant sediment laden runoff entering the watercourses in the Fitzroy River Sub-basin.

Temperature

The long-term median water temperature of 25 ºC was recorded at Riverslea.

Nitrogen and phosphorus

The median concentration of nutrients (TN and TP), copper and zinc were greater than the WQO at Riverslea.

Blue green algae

Chlorophyll a was not recorded at Riverslea.

11.2.4 Lower Dawson River

The Project area within the lower Dawson River Sub-basin plan area is dominated by lower Dawson River catchment fresh waters and freshwater riparian areas. There are no freshwater lakes or reservoirs on the Dawson River within the Project area extent. Palustrine wetlands are dispersed along the length of the lower Dawson River. There are no wetlands of high ecological significance directly associated with the Project area (Chapter 7 Aquatic ecology). All EVs except those relating to aquaculture are prescribed for the lower Dawson main channel within the Project area as is it within the unregulated reaches. Aquatic ecosystems within the lower Dawson River Sub-plan Project area are classed as moderately disturbed. There are no areas of HEV associated with the Project area with the Dawson River sub-basin.

A summary of the water quality parameters analysed with respect to EVs and WQOs for the lower reaches of the Dawson River (as recorded at DNRM's Beckers' gauging station) are presented in Table 11-8.

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 11-9 and compared to existing median values.

pH

Similarly to the Fitzroy River, the median pH recorded at Beckers was within the WQO and indicates an alkaline environment.

Electrical conductivity

The median EC recorded at Beckers was less than the WQO under baseflow conditions.

Temperature

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.

Table 11-8 Summary of water quality data from the Dawson River at Beckers

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
Long-term dataset (1964-2006)									
pH	116	1964-2006	6.8	7	**7.6**	8.0	8.2	7.6	0.3
EC @ 25°C (µS/cm)	116	1964-2006	70.0	128.5	**191.5**	274.0	790.0	201.8	79.0
Water temperature (°C)	93	1971-2006	13.0	17.8	**26.7**	30.0	33.5	25.0	5.1
DO (mg/L)	42	1995-2006	2.9	4.1	**6.6**	8.4	9.8	6.4	1.7
Turbidity (NTU)	73	1984-2006	1.0	15.8	**100.0**	528.0	994.0	192.1	231.2
TSS (mg/L)	89	1973-2006	2.0	11.8	**50.0**	350.8	606.0	105.8	140.5
TN (µg/L)	19	1998-2006	470	550	**930**	1,310	1,750	970	310
TP (µg/L)	54	1993-2006	30	58	**250**	480	720	260	170
Al soluble (µg/L)	58	1990-2006	<0.05	<0.05	**50.0**	299.0	1,210	109.48	190.86
Cu (µg/L)	No data	-	-	-	**-**	-	-	-	-
Fe soluble (µg/L)	77	1969-2006	<0.01	<0.01	**70.0**	652.0	4,200	337.66	819.91
Mg (µg/L)	No data	-	-	-	**-**	-	-	-	-
Mn soluble (µg/L)	55	1984-2006	<0.01	<0.01	**10.0**	30.0	90.0	11.45	16.92
Zn soluble (µg/L)	54	1990-2006	<0.01	<0.01	**10.0**	50.0	210.0	23.78	34.12
Mine dewatering event (2008-2009)									
No data									

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
Short-term dataset (April 2009 – November 2012)									
pH	15	Apr 2009 – Nov 2012	7.0	7.2	**7.7**	8.0	8.3	7.7	0.4
EC @ 25°C (µS/cm)	15	Apr 2009 – Nov 2012	107.0	126.1	**247.5**	515.8	660.0	301.7	172.9
Water temperature (°C)	15	Apr 2009 – Nov 2012	14.9	16.2	**20.5**	29.9	34.6	22.6	5.5
DO (mg/L)	15	Apr 2009 – Nov 2012	5.4	6.6	**7.9**	11.5	12.5	8.3	2.1
Turbidity (NTU)	15	Apr 2009 – Nov 2012	2.0	5.2	**54.0**	503.8	610.0	168.3	216.4
TSS (mg/L)	15	Apr 2009 – Nov 2012	6.0	10.4	**30.0**	450.0	565.0	145.6	198.5
TN (µg/L)	15	Apr 2009 – Nov 2012	350	376	**670**	1,260	1,300	764	338
TP (µg/L)	15	Apr 2009 – Nov 2012	43	47	**160**	456	550	216	178
Al soluble (µg/L)	15	Apr 2009 – Nov 2012	50	50	**120**	590	1,400	294	360
Cu (µg/L)	15	Apr 2009 – Nov 2012	30	30	**30**	30	30	30	0
Fe soluble (µg/L)	15	Apr 2009 – Nov 2012	10	14	**200**	452	930	222	245
Mg (µg/L)	15	Apr 2009 – Nov 2012	2,300	2,500	**5,200**	11,600	16,000	6,707	4,022
Mn soluble (µg/L)	15	Apr 2009 – Nov 2012	10	10	**10**	10	10	10	0
Zn soluble (µg/L)	15	Apr 2009 – Nov 2012	<0.01	<0.01	**120**	590	1400	281	370

Table 11-9 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) (dissolved)	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.

Dissolved oxygen

The median concentration of DO was within the WQO at Beckers.

Turbidity

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.

Nitrogen and phosphorus

The median concentration of nutrients (TN and TP), copper and zinc were greater than the WQO at Beckers. The median concentration of aluminium historically were less than the WQOs, however the median short-term concentration of aluminium was greater than the WQO.

Blue green algae

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).

11.2.5 Lower Mackenzie River

Overview

Mackenzie River catchment fresh waters and freshwater riparian areas dominate waters in the Project area within the Mackenzie River Sub-basin. There are no freshwater lakes or reservoirs on the Mackenzie River within the Project area extent. Palustrine wetlands are dispersed along the length of the lower Mackenzie River. There are no wetlands of high ecological significance directly associated with the Project area (Chapter 7 Aquatic ecology). All EVs are prescribed for the Mackenzie River main channel in the Project areas within the Mackenzie River Sub-basin. There are no areas of HEV associated with the Project area within the Mackenzie River sub-basin. Aquatic ecosystems within the Mackenzie River Sub-plan Project area are classed as moderately disturbed.

A summary of the water quality parameters analysed with respect to EVs and WQOs for the Mackenzie River (as recorded at DNRM's Coolmaringa gauging station) are presented in Table 11-10.

In accordance with the EPP Water and with reference to aquatic ecosystem 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 11-11 and compared to the existing median values.

pH

Similarly to the Fitzroy and Dawson Rivers, the median pH recorded at Coolmaringa was within the WQO and indicates an alkaline environment.

Electrical conductivity

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.

Temperature

Median water temperature at Coolmaringa is approximately 26 ºC.

Dissolved oxygen

The median concentration of DO was within the WQO in the Mackenzie River at Coolmaringa.

Turbidity

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.

Table 11-10 Summary of water quality data from the Mackenzie River at Coolmaringa

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
Long-term dataset (1972-2006)									
pH	135	1972-2006	6.8	7.0	**7.5**	8.0	8.8	7.5	0.4
EC @ 25°C (µS/cm)	135	1972-2006	87.0	137.8	**205.0**	392.8	670.0	243.8	108.1
Water temperature (°C)	102	1973-2006	15.0	18.0	**26.0**	30.0	35.0	24.9	4.8
DO (mg/L)	36	1995-2006	0.0	4.6	**7.3**	9.7	16.5	7.2	2.9
Turbidity (NTU)	79	1981-2006	1.0	3.6	**67.0**	202.8	498.0	84.5	97.8
TSS (mg/L)	126	1973-2006	1	10	**60**	454	1,614	149	245
TN (µg/L)	21	1998-2006	220	270	**610**	910	1,110	630	250
TP (µg/L)	46	1994-2006	20	30	**80**	300	350	120	100
Al soluble (µg/L)	57	1985-2006	0	0	**50**	274	1,500	135	262
Cu (µg/L)	7	1994-2006	1000	-	**-**	-	16,000	5,857	4,811
Fe soluble (µg/L)	76	1973-2006	0	10	**60**	585	2,000	200	345
Mg (µg/L)	No data	-	-	-	**-**	-	-	-	-
Mn soluble (µg/L)	55	1984-2006	0	0	**10**	30	30	11	12
Zn soluble (µg/L)	57	1985-2006	0	0	**10**	40	80	18.	18
Mine dewatering event (October 2008-December 2008)									
pH	4	Oct 2008-Dec 2008	7.4	7.6	**7.9**	8.3	8.3	7.9	0.5
EC @ 25°C (µS/cm)	4	Oct 2008-Dec 2008	441	459	**918**	1,336	1,336	903	500
Water temperature (°C)	4	Oct 2008-Dec 2008	26.1	26.6	**28.5**	29.2	29.3	28.1	1.5
DO (mg/L)	4	Oct 2008-Dec 2008	4.4	4.9	**7.0**	9.0	9.4	6.9	2.2
Turbidity (NTU)	4	Oct 2008-Dec 2008	9.0	9.0	**102.5**	609.7	787.0	250.3	368.5
TSS (mg/L)	No data	-	-	-	**-**	-	-	-	-

Water quality parameter	No. of samples	Sample period	Minimum	10th percentile	Median	90th percentile	Maximum	Mean	Standard deviation
TN (µg/L)	4	Oct 2008-Dec 2008	350	490	**1,320**	1,800	1,800	1,200	730
TP (µg/L)	4	Oct 2008-Dec 2008	30	80	**410**	610	610	370	290
Al soluble (µg/L)	4	Oct 2008-Dec 2008	12.0	19.1	**45.8**	67.2	72.0	43.9	26.0
Cu (µg/L)	4	Oct 2008-Dec 2008	2.0	2.3	**3.5**	4.3	4.4	3.4	1.1
Fe soluble (µg/L)	4	Oct 2008-Dec 2008	8.3	8.8	**10.0**	21.0	25.7	13.5	8.2
Mg (µg/L)	No data	-	-	-	**-**	-	-	-	-
Mn soluble (µg/L)	4	Oct 2008-Dec 2008	1.0	1.0	**2.7**	5.9	6.5	3.2	2.7
Zn soluble (µg/L)	4	Oct 2008-Dec 2008	8.0	11.9	**27.9**	49.6	56.0	29.9	20.5
Short-term dataset (April 2009 –Oct 2012)									
pH	10	April 2009 –Oct 2012	7.4	7.5	**8.0**	8.3	8.4	8.0	0.3
EC @ 25°C (µS/cm)	10	April 2009 –Oct 2012	195.0	219.3	**332.0**	578.0	623.0	394.8	166.9
Water temperature (°C)	10	April 2009 –Oct 2012	18.3	18.8	**25.9**	29.5	31.0	24.8	4.8
DO (mg/L)	10	April 2009 –Oct 2012	6.3	6.3	**7.0**	8.5	8.6	7.2	0.9
Turbidity (NTU)	10	April 2009 –Oct 2012	3.0	3.9	**21.5**	73.1	227.0	44.7	67.0
TSS (mg/L)	10	April 2009 –Oct 2012	6.0	6.9	**17.5**	59.3	188.0	38.4	54.5
TN (µg/L)	10	April 2009 –Oct 2012	210	210	**375**	672	775	409	189
TP (µg/L)	10	April 2009 –Oct 2012	49.0	52.6	**91.0**	165.0	240.0	107.6	57.9
Al soluble (µg/L)	10	April 2009 –Oct 2012	50	50	**50**	249	690	138	200
Cu (µg/L)	10	April 2009 –Oct 2012	30	30	**30**	30	30	30	0
Fe soluble (µg/L)	10	April 2009 –Oct 2012	10	10	**50**	218	380	97	121
Mg (µg/L)	10	April 2009 –Oct 2012	5,500	6,130	**10,450**	20,200	22,000	13,130	6,372
Mn soluble (µg/L)	10	April 2009 –Oct 2012	10	10	**10**	10	10	10	0
Zn soluble (µg/L)	10	April 2009 –Oct 2012	10	10	**10**	11	20	11	3

Table 11-11 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	28.48	25.9
DO (mg/L) (% saturation)	Not defined (85-110)[4]	7.25 (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) (dissolved)	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	27.85	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.

Nitrogen and phosphorus

The concentration of nutrients (TN and TP) was less than the WQO, except during the mine dewatering period.

Dissolved metals

The median concentration of copper and zinc were greater than the WQO at Coolmaringa, which is similar to the Fitzroy and Dawson Rivers.

Blue green algae

Chlorophyll a was not recorded for Coolmaringa.

11.2.6 Fitzroy River estuary and Great Barrier Reef World Heritage Area receiving waters

11.2.6.1 Overview

Estuarine areas of the Fitzroy River extend approximately 56 km from the Fitzroy Barrage (some 80 km downstream of Eden Bann Weir) to Keppel Bay. The Fitzroy River estuary has a 5 m tidal range and includes Port Alma, Raglan Creek, Connor Creek and Balaclava Island. In accordance with the EPP Water and shown in Figure 11-1 estuarine waters of the Fitzroy River are within the Fitzroy River Sub-basin plan area and comprise the:

- Upper estuary
- Middle estuary
- Enclosed coastal waters (lower estuary).

Palustrine wetlands occur adjacent to the river, mainly associated with middle estuary areas. Areas of HEV are identified in both fresh water and estuarine/marine water. In the lower portion of the middle estuary salt evaporation ponds occur (Figure 11-1).

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 2012-13 Report Card (Fitzroy Partnership for River Health 2013) 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.

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).

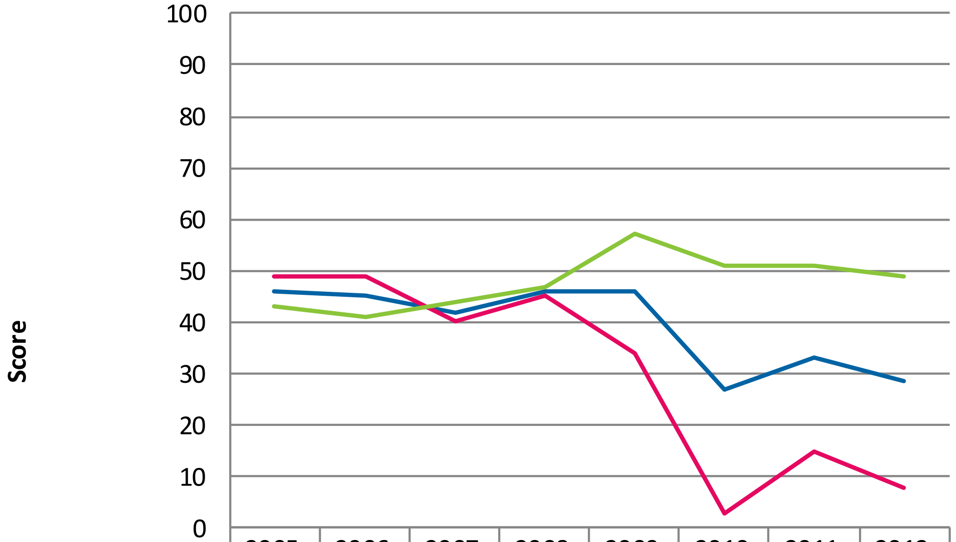
Thirty-five onshore catchment areas drain into the GBRWHA. These catchments have undergone extensive development for agricultural production, urban expansion, transport infrastructure, tourism and mining. As a result elevated levels of pollutants from these catchments are entering the reef, with agricultural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

EVs for the GBRWHA include aquatic ecosystems, primary industries, recreation and aesthetics and cultural and spiritual values. The management intent for waters of the GBRWHA is defined for HEV or slightly disturbed waters (GBRMPA 2010).

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. Much of the 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 11-8 shows the trend in overall inshore water quality, chlorophyll a and TSS scores in the Fitzroy region since 2005. 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). Nutrient loads and pesticide/herbicides concentrations are discussed in Section 11.2.6.3 and Section 11.2.6.4, respectively.

Figure 11-8 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

11.2.6.2 Sedimentation

The Fitzroy River transports sediments and nutrients (Section 11.2.6.3), 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 1 m t/a of suspended sediment was transported via waterways of the Fitzroy Basin compared to recent long-term estimates of between 3 to 4.5 M t/a (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). Wallace et al. (2014) reports that during the period 1 July 2011 to 30 June 2012 (monitoring year) the highest estimated TSS yields were obtained from the North Johnstone (200 t km^{-2}), South Johnstone (150 t km^{-2}) and Pioneer (140 t km $^{-2}$) catchments.

Episodic, generally short-lived flow/flood events during the summer months carry the majority of the suspended sediment from the Fitzroy River to the Fitzroy estuary (Webster et al. 2006). Event based water quality data for the Fitzroy Basin indicates sediment concentrations ranging between 0.1 g/L and 2 g/L with event mean concentrations of around 0.5 – 0.8 g/L (Johnston et al. 2008). Sediments tend to be small with the major sediment class deposited in Keppel Bay being mud (grain size less than 63 µm).

Flocculation of fine sediments (that is the aggregation of individual sediment particles due to altered electrostatic attraction in a conducting medium, such as saline water) facilitates suspension of sediments. The strong tidal, shallow-water environment that characterises Keppel Bay is not conducive to flocculation and as such sediments remain 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).

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).

The Fitzroy Basin and estuary has been identified as one of the major sources of pollutants into the Great Barrier Reef lagoon (The State of Queensland 2015). The Reef Water Quality Protection Plan reported that the Fitzroy River at Rockhampton delivered a total TSS load of 1.3 M t of during 2011/12 (Wallace et al. 2014). During the same period, the monitored catchments generated approximately 5.6 M t of TSS. As such the Fitzroy load represents 24 per cent of this input (Wallace et al. 2014). 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).

11.2.6.3 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).

Wallace et al. (2014) reports that during the 1 July 2011 to 30 June 2012 period (monitoring year) the load of TN and TP from the Fitzroy Basin was 6.4 kt and 2.7 kt respectively.

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).

11.2.6.4 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 agrochemcials 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. Wallace et al. (2014) reports that during the 1 July 2011 to 30 June 2012 period (monitoring year) the largest monitored annual load of total atrazine occurred in the Fitzroy (1,000 kg).

11.2.7 Contaminated land

The Stage 1 site contamination assessment (Chapter 5 Land) identified nine possible contaminated sites within 500 m of the Eden Bann Weir Stage 3 impoundment, one site within the impoundment and Eden Bann Weir itself. Excluding the weir, potential areas of interest were related to cattle pens with associated cattle dips/ spray races and above ground storage tanks. Eden Bann Weir site accommodates a workshop, storeroom and hydraulic equipment.

At the Rookwood Weir site, four possible contamination sites were located within 500 m of the impoundment. The potential areas of interest were related to possible cattle pens (without associated structures) and a possible historical cattle dip. One groundwater bore (existing, water supply) is located within the Rookwood Weir impoundment (Chapter 10 Groundwater).

While land use practices such as large scale clearing to support agricultural production (primarily grazing) in the Project area influences water quality within the catchment overall, it is unlikely that the individual, isolated and geographically dispersed areas identified for potential contamination contribute significantly to the existing quality of water within the Project area.

11.2.8 Groundwater

Raymond and McNeil (2011) divide the Fitzroy Basin into 44 discrete chemistry zones. Three of these zones are traversed by the Project area as summarised in Table 11-12. Chapter 10 Groundwater provides further detail.

Groundwater salinity is variable across the southern portion of the North East Coast region (BoM 2010), incorporating the Project area. This variability is also reflected in Table 11-12.

Table 11-12Groundwater chemistry zones within the Project area

No.	Name	Cations	Anions	Salinity	Electrical conductivity (µS/cm)			
					Depth	20^{th} percentile	50^{th} percentile	80^{th} percentile
14	Prospect Fitzroy	Na	HCO_3	Low - moderate	Shallow	1,006	1,619	2,765
					Deep	756	1,420	2,150
22	Fitzroy	Balanced	Cl	Moderate	Shallow	1,403	2,220	3,722
					Deep	1,507	2,735	5,279
34	Isaac Dawson	Na	Cl	Saline	Shallow	498	2,150	8,910
					Deep	3,419	6,100	16,000

11.3 Potential impacts and mitigation measures

11.3.1 Construction phase

Construction activities may result in temporary, localised impacts on water quality:

- Increased turbidity through terrestrial sediment laden runoff from erosion as a result of ground disturbance (excavation and earthworks, road construction) or vegetation removal and on-site cleaning activities (for example concrete batching plant, vehicle washdowns, etc.)
- Increased turbidity and sedimentation as a result of in-stream works (earthworks, dewatering of foundations and cleaning foundations and grouting)
- Pollution of waterways through contaminant spillage (including hydrocarbons), release of untreated water from storages or through during dewatering or disturbance of existing contaminated land.

Disturbance of the ground cover and vegetation clearing are required for construction which has the potential to expose surfaces to runoff and erosion. Material, whether it is sediment or other contaminants (including nutrients and metals), has the potential to mobilise directly into the waterways via runoff.

Runoff from roads used during the construction may contain dust, fuel, dissolved metals and other contaminants, all of which can affect water quality. The introduction of compounds to waterways can result in both short and long-term degradation of water quality. Any introduction of organic and inorganic material has the potential to influence both the local surface water quality at the point source as well as downstream.

In aquatic ecosystems, increased suspended sediment loads can reduce light penetration, clog fish and invertebrate gills, decrease water temperature, lead to a reduction in dissolved oxygen concentrations and introduce sediment-bound contaminants into the water (Dunlop et al. 2005). Increased turbidity can also reduce photosynthesis in submerged macrophytes and benthic and planktonic algae. When sediment settles out it may bury habitat and smother sedentary organisms.

Machinery, equipment and materials used in construction will contain oil, fuel and other potential environmental contaminants. Works involving construction equipment within and adjacent to the existing weir and other waterways can potentially introduce contaminants (particularly hydrocarbons) to the aquatic environment in the event of a spill or leak from machinery or storages.

Aside from the existing Eden Bann Weir itself (where, during construction, hydrocarbons, chemicals and other materials will be stored) no potentially contaminated sites were identified within construction areas during the desktop Stage 1 site contamination assessment (Chapter 5 Land). Potential impacts from contamination as a result of construction activities are readily mitigated and managed through implementation of a construction EMP (CEMP) (Chapter 23 Environmental management plan) and are therefore considered negligible.

The presence of acid sulfate soils (ASS) within Project areas is considered to be unlikely (Chapter 4 Land). Potential degradation of water quality as a result of disturbance to ASS is therefore not expected.

Onsite sewerage treatment is not proposed. Onsite treatment of wastewater is limited to greywater sources (Chapter 15 Waste), stormwater runoff, washdown water (concrete batch plants) and water from dewatering which is captured within settling ponds.

Given the composition, temporary nature and localised extent of predicted impacts during construction and the distance to estuarine and marine waters (more than 80 km) it is not expected that water quality within Keppel Bay or the GBRWHA will be impacted as a result of construction activities.

Further to undertaking in-stream works during drier periods and sequencing works to account for periods of high flows and rainfall events (Chapter 2 Project description) construction impacts will be managed through development and implementation of a CEMP, inclusive of erosion and sediment controls, as described in Chapter 23 Environmental management plan. Management measures will include the following:

- Significant ground disturbing activities (embankment excavations and construction of coffer dams) are scheduled to be undertaken during drier periods reducing the potential for erosion and sediment laden runoff entering the watercourse
- Installation of diversions and erosion controls such as sediment basins (amongst others) will direct clean water away from construction areas and allow site affected water to settle prior to re-entering the river. Diversions and erosion controls, including sediment basins will be designed having regard to Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites (Institution of Engineers Australia 1996) (or similar) and Urban Stormwater Quality Planning Guidelines 2010 (Department of Environment and Resource Management 2010), including requirements for emergency planning as applicable
- Wastewater from all sources will be stored, treated and tested prior to release to the environment having regard for WQOs defined in the EPP Water (for the Fitzroy River Sub-basin in particular)
- Clearing of vegetation for site facilities and access will be restricted to minimum areas required to undertake the works reducing the extent of exposure of soil to erosion influences
- Storage and use of potentially contaminating and polluting materials such as hydrocarbons, service and refuelling areas will be restricted to defined and protected (bunded) areas
- Storage and handling of contaminants will comply with relevant guidelines and Australian standards (Chapter 20 Hazard and risk).

11.3.2 Operations phase

11.3.2.1 Initial filling phase

Construction of Eden Bann Weir and Rookwood Weir are scheduled to be completed within a two and a half year period with final works concluding at the end of a dry season (Chapter 2 Project description) to allow for impoundment during the following wet season. As discussed in Chapter 9 Surface water resources, it is expected that impoundment of Eden Bann Weir and Rookwood Weir will occur within a single wet season over a relatively short period (in the order of one to two months). Modelled data shows that even in a representative dry year (using the 10th percentile) full supply volumes are achieved (Chapter 9 Surface water resources). It is expected that full supply volumes and overtopping/spilling will be achieved annually.

Prior to the first fill, it is not intended to clear vegetation from within the watercourse. Consequently that vegetation will decay (over time) releasing methane, carbon dioxide and nutrients and reducing dissolved oxygen levels in the water column. Nutrients will then be conveyed downstream and output to the Fitzroy estuary, particularly during flood events. It can be expected that some reduction in water quality will occur during the first filling period (particularly with regard to nutrients (TN and TP) and subsequently turbidity and DO).

To assess the potential contribution of nutrients, an assessment was performed using the FullCAM program (Section 11.1.4). The results in Table 11-13 show that that more than half the available TN and TP is liberated in the first year of impoundment and will reduce significantly in each subsequent year for a period of approximately six years.

Table 11-13 Rates of decay for total nitrogen and total phosphorous

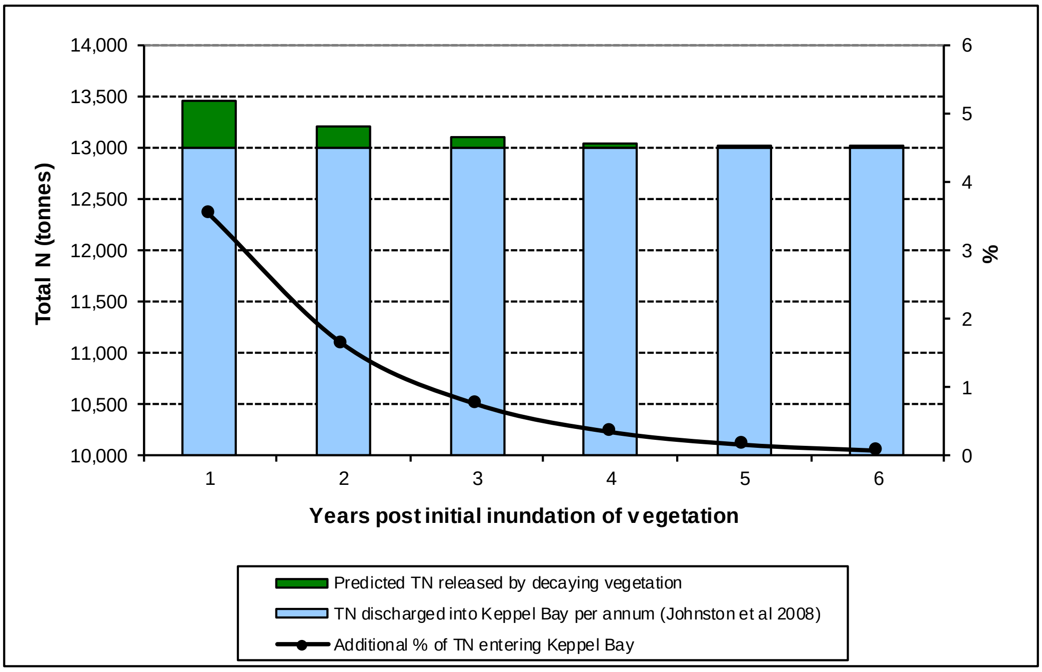
Year	Eden Bann Weir		Rookwood Weir	
	Decay rate - TN (tonnes/year)*	Decay rate - TP (tonnes/year)*	Decay rate - TN (tonnes/year)*	Decay rate - TP (tonnes/year)*
1	458	90	645 (TN)	127 (TP)
2	211	36	347	51
3	98	14	187	20
4	45	6	100	8
5	21	2	54	3
6	10	1	29	1
Total	842	149	1200	211

*Rounded

The predicted changes to water quality (increased TN and TP and reduced DO) have the potential to impact upon the operation of the Glenmore Water Treatment Plant which is located upstream of the barrage. The plant supplies treated water to Rockhampton Regional Council and Livingstone Shire Council. This impact is expected to be low in the context of the scale of natural rainfall and flood related events, which also impact water quality. Figure 11-9 illustrates that for both TN and TP at Eden Bann Weir, the overall contribution of nutrients to the system is predicted to be low in the context of the overall quantities that are transported annually from the Fitzroy Basin to the GBRWHA (as described by Johnston et al. 2008). Moreover, the percentage contribution declines markedly after the first year to negligible proportions after several years. Figure 11-10 shows a similar trend for the proposed Rookwood Weir.

The combined contributions of liberated TN and TP from both Eden Bann Weir and Rookwood Weir are depicted in Figure 11-11. The combined values for both TN and TP are relatively small, and decrease markedly beyond the first year of operation.

Figure 11-9 Project (Eden Bann Weir) TN and TP contribution to existing annual loads



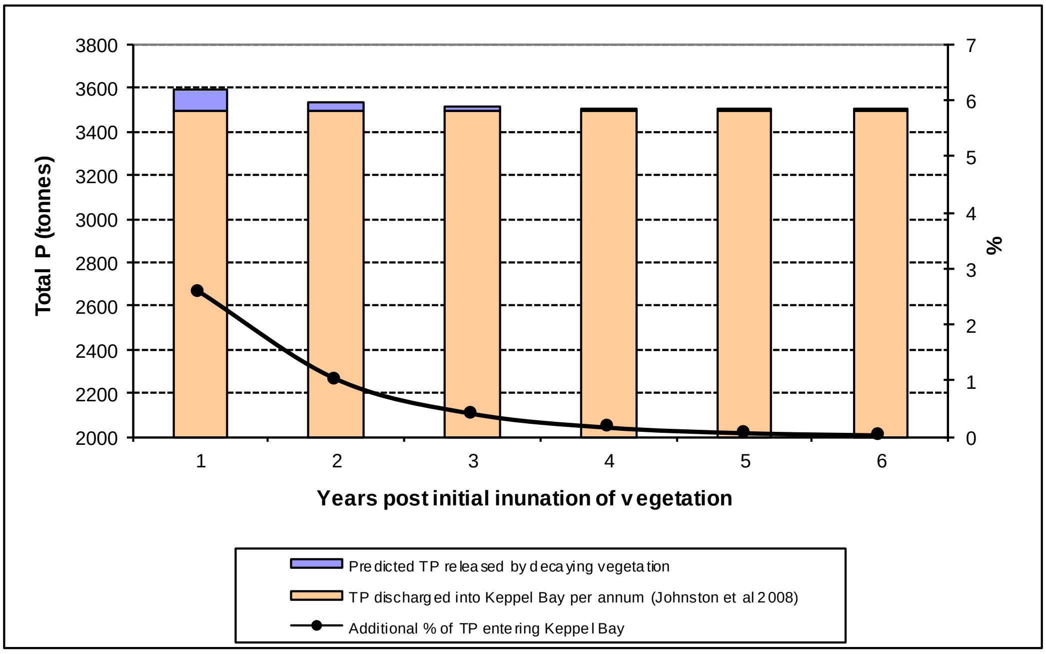
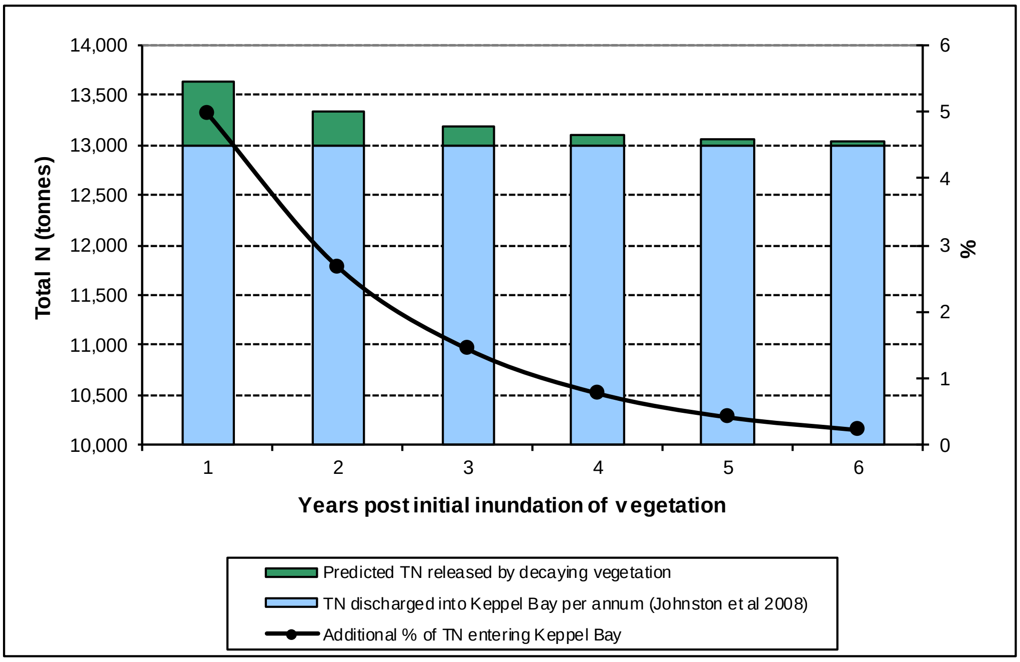


Figure 11-10 Project (Rookwood Weir) TN and TP contribution to existing annual loads



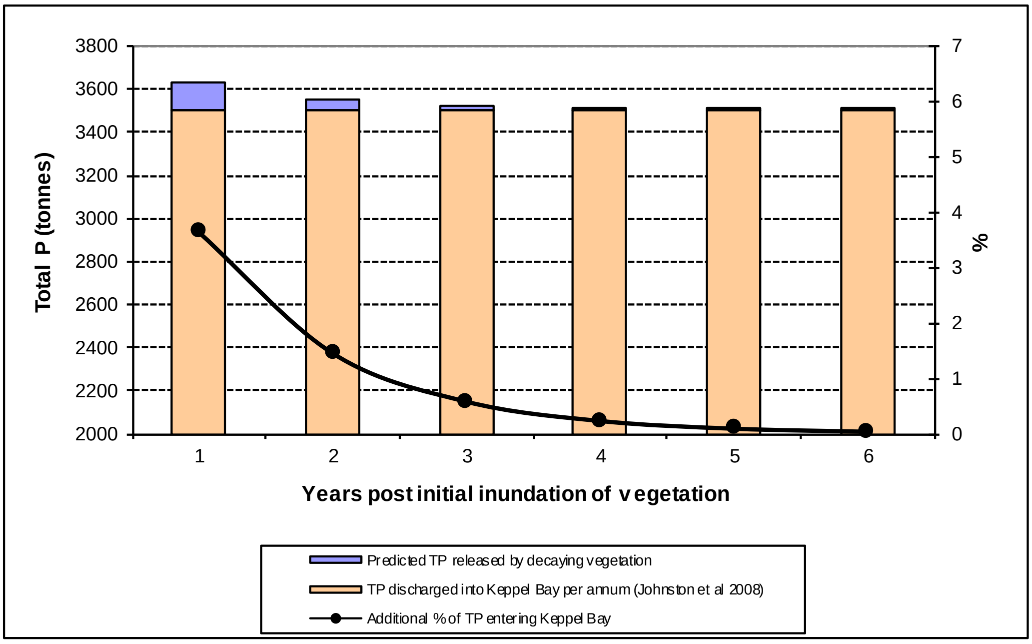
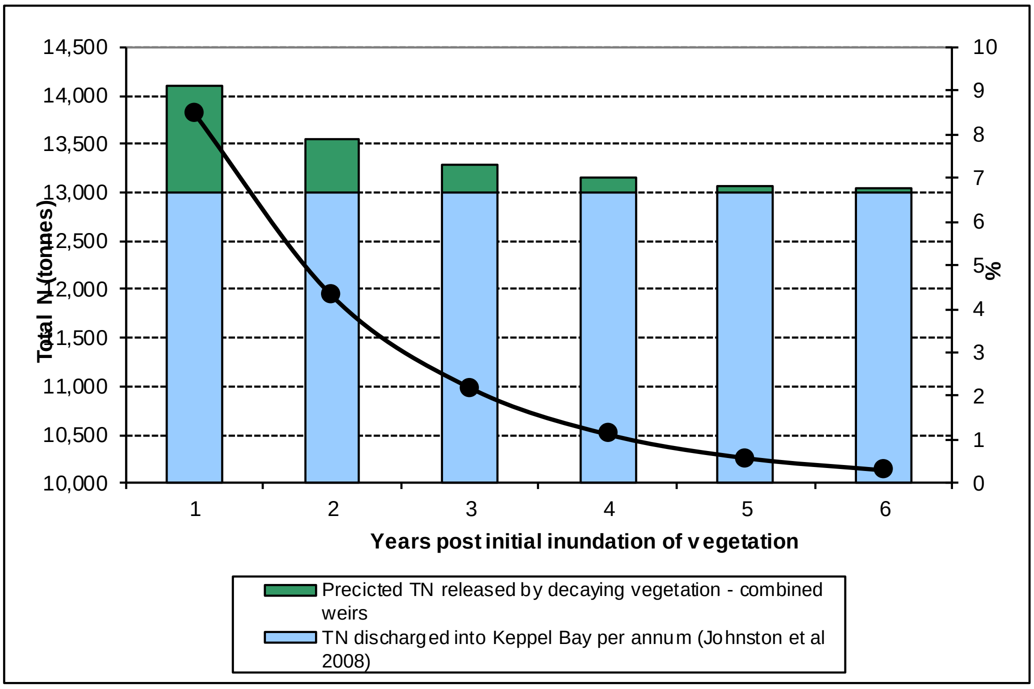
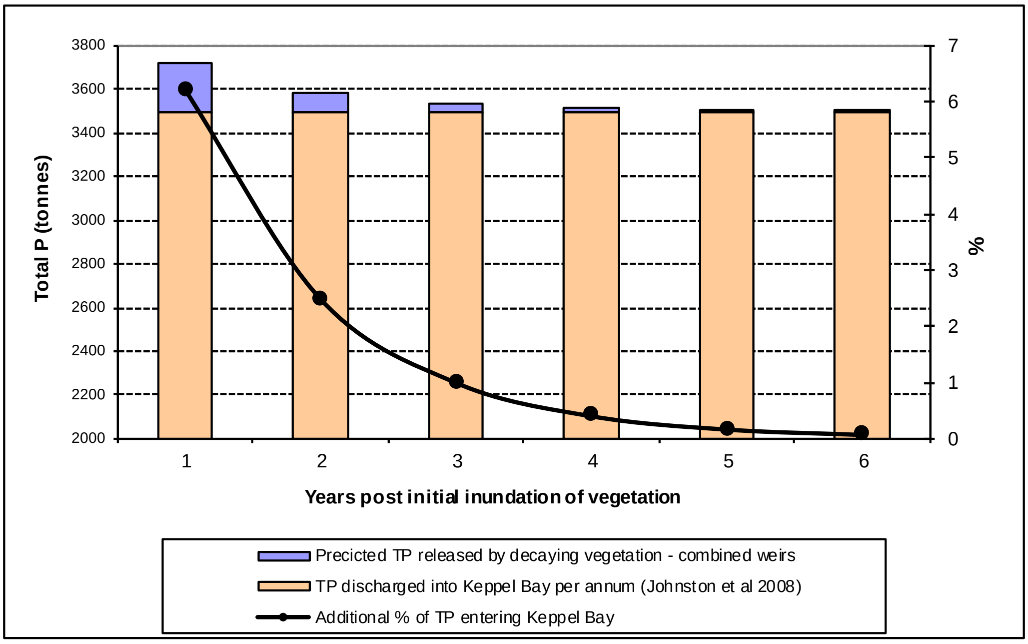


Figure 11-11 **Project (Eden Bann Weir and Rookwood Weir) TN and TP contribution to existing annual loads**





While localised short-term increases in nutrient levels, as well as increased turbidity and reduced DO are expected to occur, wet season inflows, overtopping of the spillway, operational releases and releases through fishways and outlet works will dilute and flush nutrients and materials within and from the impoundment and it is not expected that elevated levels will persist for extended durations.

During detailed design, operational strategies (including initial operation) will be developed including water quality monitoring programs covering upstream, impoundment and downstream environments. Differential offtakes will facilitate mixing to improve the quality of water released.

Weir operations will generally mimic natural river flows (Chapter 2 Project description; Chapter 9 Surface water resources) and the weirs will reach full supply volumes and are drawn down annually. Excluding TN and TP liberated as a result of decaying vegetation it is not expected that water quality characteristics in the first years of operation will be significantly different from those during subsequent years of 'normal' operation as discussed in sections below.

11.3.2.2 Normal operations phase

It is evident from existing conditions described in Section 11.2 that water quality in the Project areas is heavily influenced by anthropogenic factors; particularly land use practices associated with cropping and grazing activities. It is expected that existing anthropogenic impacts on water quality will persist following weir development. The Project will not directly change or influence land use practices adjacent to the impoundments; it is not intended that adjacent land will be wholly acquired and/or stock excluded from river margins. Vegetation cover within the river bed and banks will be retained in the first instance but will decay and recede over time.

As is evidenced from operation of the existing Eden Bann Weir compared to un-impounded reaches of the Fitzroy, Dawson and Mackenzie rivers, the following water quality impacts are expected with regard to EVs, given Project operational strategies align with those employed at the existing Eden Bann Weir. As applicable, mitigation and management measures are described below. Chapter 23 Environmental management plan, describes monitoring programs relevant to water quality parameters:

- DO
  - DO levels within the impoundments will vary through the water column, reducing with depth which may result in stratification. Storages within the Fitzroy Basin are reported to be unstratified most of the year, or only slightly stratified during the warmer months (September – January) (SKM 2010)
  - DO levels within the impoundments are expected to be lower compared to un-impounded reaches and will generally be less than the WQOs for lakes/reservoirs. It is noted however that DO levels recorded for Eden Bann Weir are currently less than the WQO, but are comparable to levels elsewhere in the system. Discussion on the impacts associated with reduced levels of DO on aquatic ecosystems is provided in Chapter 7 Aquatic fauna
  - Operationally it is predicted that the weirs will reach full supply volumes within relatively short periods annually and be drawn down over a period of approximately eight months every year thereby reducing the opportunity for stratification (reduced time at depth)
  - Differential (multi-level) offtakes will facilitate that water released through outlet works is mixed, improving the DO (together with mediating temperature) to achieve the WQOs. This is currently achieved at Eden Bann Weir.
- Turbidity

  - Existing turbidity levels within the Fitzroy, Dawson and Mackenzie rivers are greater than WQOs as a result of sediment entering the waterways from runoff and erosion
  - SedNet catchment modelling (Carroll et al. 2010) identifies hillslope erosion as the dominant source of sediment (67 per cent), followed by gully erosion (26 per cent) and channel erosion (seven per cent). Less than 30 per cent of suspended sediment is contributed by the Fitzroy sub-catchment (Nogoa and Comet sub-catchments reportedly contribute on average the highest volumes) (Carroll et al. 2010). The sediment load at The Gap/Eden Bann Weir is considered consistent with combined loads from the four major tributaries (Nogoa, Comet, Isaac and Dawson rivers) (Joo et al. 2005)
  - Turbidity within the impoundments are expected to exceed the WQOs as a result of existing land practices within the catchment and natural processes
  - The Project itself is not expected to alter the sediment load within the system. Project design facilitates that sediment will be swept over the weir as the velocities determined (through hydraulic modelling) are in excess of 5 m/s. Local deposition at the upstream face of the new weirs is expected and low level outlets will be provided to assist in flushing this sediment downstream. Aside from local areas of lower velocity around weir structures such as towers and intakes, the weirs are expected to provide unimpeded transfer of sediment downstream (Chapter 9 Surface water resources).
- Nutrients
  - Concentrations of TN and TP within the Fitzroy and Dawson rivers and at Eden Bann Weir are greater than the WQO. WQOs for TN and TP on the Mackenzie River are greater than those set for the Fitzroy and Dawson rivers. TN and TP concentrations in the Mackenzie River are within WQO limits
  - As discussed above (Section 11.3.2.1) TN and TP concentrations will peak on first fill and decline over a six year period. The Project itself is not expected to alter the median concentration of TN and TP downstream within the Fitzroy River after this time.
- Blue green algae
  - An increase in blue green algae or cyanobacteria can cause an algal bloom and adversely impact on water quality. Poor water quality and the potential for toxicity can consequently result in impacts on aquatic fauna, cause disruption to drinking water supplies, recreational activities and water-dependent industries, and pose a risk to livestock, wildlife and human health (DSEWPaC 2012)
  - Blue green algae can occur when still or slow-flowing water, abundant sunlight and sufficient levels of nutrients, especially nitrogen and phosphorus, are present. In particular, blue green algae favours conditions created by stratification whereby surface water forms a warm top layer exposed to sunlight and nutrients with cooler bottom layers with low DO levels
  - The potential for blue green algae blooms to occur within the impoundments is considered to be low
  - Monitoring of blue green algae at Eden Bann Weir generally returned low hazard levels with the majority of readings below the hazard trigger level (0.4 mm^3/L for the combined total of all cyanobacteria). Further SKM (2010) reported that a review of storages within the Fitzroy Basin indicate that blue green algae blooms are not a feature of these storages
  - Both GAWB and SunWater monitor blue green algae within existing storages in the Boyne and Fitzroy Basins respectively and manage the potential risks through the implementation

of established protocols and action plans. This includes the publishing of blue green algae levels as warnings to the public, landholders and water users. It is intended that the Project infrastructure will be managed in accordance with the existing measures

  - The impoundments will not facilitate recreational activities. For the most part the impoundments are flanked by private properties with few opportunities and no facilities for public recreational users to access the waterways. The risk of adversely impacting human health as a result of algal blooms developing is minimal.

- Salinity (EC)
  - Salinity (measured as EC) within the Project area waters is generally less than the WQOs (excluding periods associated with mine water releases)
  - EC recorded at Eden Bann Weir indicates that the EC of impoundment waters is comparable to un-impounded river reaches.

11.3.2.3 Downstream erosion

While it is possible that some localised erosion may occur immediately downstream of the weir sites, it is considered that the potential contribution to current sediment load will be negligible. Further, erosion protection works downstream of the weirs will reduce the potential for scour and erosion thereby minimising the potential to increase sediment loads. Similarly, it is proposed to retain vegetation within the weir ponds prior to and during inundation. This will mean that exposed areas are minimised which reduces the potential for erosion. Chapter 9 Surface water resources, provides further details on erosion protection measures.

11.3.2.4 Water quality impacts on the GBRWHA

The Project will not directly impact water quality in the GBRWHA as the Project is located 141.2 km AMTD upstream of the GBRWHA. Potential indirect impacts on the Great Barrier Reef resulting from changes to flow are assessed in Chapter 9 Surface water resources. Potential water quality impacts on the GBRWHA are described as follows:

- Modelling and statistical analysis (Chapter 9 Surface water resources) has shown that with the Fitzroy Basin Resource Operations Plan in place, there is no significant difference between current modelled freshwater flow regimes and the flow regimes projected with additional infrastructure associated with the Project in place
- While it is possible that some localised erosion may occur at the weir sites during operation it is considered that the potential contribution of the Project to the current sediment load in the Fitzroy River is negligible
- Other than from decaying vegetation, the Project will not directly contribute nutrients downstream to the Fitzroy River and subsequently the GBRWHA. Water quality impacts as a result of decaying vegetation will be minor in the short term during the initial years of operation and will not persist into long-term operations
- The Project will not change land use practices and anthropogenic inputs of fertilisers, pesticides and herbicides from catchment sources are expected to persist
- Weir design and operations will seek to reduce the potential for the release of poor quality water, through measures such as multi-level off takes, and discharges of poorly oxygenated water to the GBRWHA are not expected

- Aside from local areas of lower velocity around weir structures such as towers and intakes, the weirs are expected to provide unimpeded transfer of sediment downstream.

The Fitzroy Basin is one of the major contributors of the anthropogenic TSS load to the Great Barrier Reef lagoon, with grazing lands (gully and hillslope erosion) and streambank erosion the main sources. Fine sediment (under 16 micrometres) material is the fraction most likely to reach the Great Barrier Reef lagoon, and is present at high proportions in the TSS from the Fitzroy Basin (Kroon et al. 2013).

The Project itself is not expected to adversely impact on sedimentation (neither increase nor decrease) movement within the system. Project design facilitates that sediment will be swept over the weir as the velocities determined (through hydraulic modelling) are in excess of 5 m/s. Local deposition at the upstream face of the new weirs is expected and low level outlets will be provided to assist in flushing this sediment downstream. Aside from local areas of lower velocity around weir structures such as towers and intakes, the weirs are expected to provide unimpeded transfer of sediment down the river.

With appropriate mitigation, and given the distances upstream of Rookwood Weir and Eden Bann Weir from the river mouth (265.3 km and 141.2 km respectively) no change to the quality of water delivered to the GBRWHA is expected.

11.4 Summary

Desktop assessments were undertaken to determine general surface water quality characteristics. Planned field investigations in 2009 to determine baseline water quality conditions for the purposes of this assessment were halted as data was considered to be compromised by coal mine de-watering in the Fitzroy Basin area as a result of high rainfall events in 2008. The desktop assessment consisted of a review of the available literature and water quality datasets. In order to assess water quality characteristics of the study area, long-term, mine dewatering event and short term datasets were obtained and evaluated. This included data from DNRM stream gauging stations and from SunWater Limited at Eden Bann Weir. The EPP Water defines EVs and WQOs for the Fitzroy River, Mackenzie River and Dawson River sub-basins which were used to inform the assessment.

As one of the largest catchments on the eastern seaboard of Australia, the Fitzroy Basin has a large agricultural production base, accounting for almost 90 per cent of land use in the Basin area. These activities, combined with point source inputs from mining operations, reduced or altered flows from weirs and the natural climatic variability of the region, have the potential to affect water quality in the lower Dawson, Mackenzie and Fitzroy Rivers. Changes to water quality can impact the waterway's ability to support ecosystems or provide water for stock or irrigation, and may impact EVs downstream in the Fitzroy estuary and within Keppel Bay (GBRMPA 2010).

Construction activities may create short-term, localised impacts on water quality, such as erosion, run-off and sedimentation and have the potential to introduce pollutants (hydrocarbons). However, the quantum of this impact on areas downstream of the Project is expected to be minimal. Further to undertaking in-stream works during drier periods and sequencing works to account for periods of high flows and rainfall events, construction impacts will be managed through development and implementation of a CEMP, inclusive of erosion and sediment controls.

In terms of operational impacts, it is evident from existing conditions that water quality in the Project area is heavily influenced by anthropogenic factors in the catchment area and these existing impacts on water quality will persist. Existing turbidity levels within the Fitzroy, Dawson and Mackenzie rivers are greater than WQOs as a result of sediment entering the waterways from runoff and erosion. The Project itself is not expected to alter the sediment load within the system and apart from local areas of lower velocity around weir structures such as towers and intakes, the weirs are expected to provide unimpeded transfer of sediment downstream.

Prior to the first fill it is not intended to clear vegetation from within the watercourse. Consequently that vegetation will decay over time releasing methane, carbon dioxide and nutrients and reducing dissolved oxygen levels in the water column. While localised short-term increases in nutrient levels, as well as increased turbidity and reduced DO are expected to occur, wet season in flows, overtopping of the spillway, operational releases and releases through fishways and outlet works will dilute and flush nutrients and materials within and from the impoundment. As a consequence, effects on downstream water quality are expected to be minor in the initial operational phase and it is not expected that elevated levels will persist for extended durations.

Stratification will be impeded by the continued drawdown of water over a period of approximately eight months every year, thus reducing time at depth. Differential (multi-level) offtakes will facilitate that water released through outlet works is mixed, improving the DO (together with mediating temperature) to achieve the WQOs. The potential for blue green algae blooms to occur within the impoundments is considered to be low. A water quality monitoring program including pre, during and post construction will be implemented and monitoring of blue green algae would be conducted.