CHAPTER 8

GLADSTONE – FITZROY

PIPELINE PROJECT

Environmental Impact Statement

Aquatic Flora and Fauna

Gladstone Area Water Board

Contents

Gladstone Area Water Board

Figures

Tables

8. Aquatic Flora and Fauna

8.1 Introduction

8.1.1 Background

This chapter presents a description of existing (baseline) conditions within the project area, an assessment of potential project impacts, and an outline of strategies that will be employed to mitigate these potential impacts. This chapter was prepared in accordance with the Gladstone Fitzroy Pipeline EIS Terms of Reference (ToR) (October 2007), specifically items outlined in Section 3.3.4, and consideration of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act).

The key ecological functional groups considered in this chapter are:

- Aquatic macrophytes and habitats
- Macroinvertebrates
- Fish (estuarine and freshwater)
- Freshwater turtles
- Marine megafauna (marine mammals and marine reptiles).

This chapter does not consider semi-Aquatic mammals (e.g. platypus, water rat) or amphibians (as applicable) - they are considered in Chapter 7, Terrestrial Fauna.

8.1.2 Study Aims

In accordance with the ToR (Appendix A), this chapter aims to:

- Identify Aquatic fauna and flora present or likely to be present (including the presence of any Rare, Threatened or otherwise noteworthy Aquatic species or communities), and their habitats
- Provide a description of patterns and the distribution of Aquatic flora and fauna
- Describe the habitat requirements and the sensitivity of Aquatic flora species to changes in flow regime, water levels and water quality in the project area
- Discuss potential project impacts on Aquatic flora and fauna (particularly noteworthy species), including:
  - Assessment of any impacts the project may have on Aquatic flora and fauna, habitat or the inhibition of propagation during construction and operation of the project, including consideration of short and long-term duration impacts
  - Any proposed stream diversions, causeway construction and crossing facilities, stockpiled material and other impediments that will restrict free movement of fish, including if seasonal construction of waterway crossings can avoid fish spawning periods
  - Identification of necessary permits/authorities required by the project (e.g. permits under the *Fisheries Act 1994* (Qld) to construct temporary or permanent waterway barriers)
  - Mitigation measures to prevent the creation of new mosquito and biting midge breeding sites during construction (e.g. in quarries and borrow pits)
  - Mitigation measures to prevent the introduction, transfer or facilitation of exotic, non-indigenous and noxious plants (including blue green algae) and water borne insect pests.

8.1.3 Project Area Location

Sattler and Williams (1999) identify 13 biogeographic regions (bioregions) within Queensland, principally on the basis of terrestrial vegetation community and landscape characteristics. Two of these bioregions are represented in the project area, namely the Brigalow Belt South and Southeast Queensland bioregions. The Bajool to Gladstone section of the project area is situated within both bioregions, whereas the Fitzroy to Bajool section is located entirely within the Brigalow Belt South bioregion. To date, no bioregional classification framework exists for freshwater environments.

Most of the area of the two bioregions is situated within a semi-arid climatic zone, which is hot and persistently dry. The Fitzroy River is the major watercourse within the project area (see Figure 8.1) and drains an approximate area of 150,000 km^2 of Central Queensland, before discharging into the Great Barrier Reef Marine Park (GAWB 2006). The Fitzroy Basin catchment is the second largest river basin in Australia and periodically experiences major flooding, which mainly occurs in summer. The Calliope River catchment adjoins the Fitzroy Basin catchment to the south. Most streams within this section of the project area are intermittently low order ephemeral drainages, with the largest stream being Larcom Creek (see Section 8.5.1.3).

8.2 Methodology

8.2.1 Nomenclature and Terminology

In this chapter, the *project area* refers to lands and waterways within the Gladstone-Fitzroy Pipeline corridor extending from the Fitzroy River in the north to the Gladstone State Development Area (GSDA) in the south. The average width of the investigated corridor is approximately 100 m, whereas the right-of-way (ROW) has an approximate width of 30 m. The project area is considered in two sections:

- Section 1, the northern section, is referred to here as the *Fitzroy to Bajool section*
- Section 2, the southern section, is referred to here as the *Bajool to Gladstone section*.

These two sections are considered separately in this chapter.

The term *surrounding area* refers generally to the lands within a 2 km radius of the project area.

Within this report, the conservation status of a species may be described as *Endangered, Vulnerable, Rare, Culturally Significant* or *Common*. These terms are used in accordance with the provisions of the *Nature Conservation Act 1992* (Qld) (NC Act) and its amendments[1], and/or the EPBC Act. *Threatened* is a commonly used term to collectively describe Endangered and Vulnerable species.

Declared (pest or noxious) weeds are those defined under the *Land Protection (Pest and Stock Route Management) Act 2002* (Qld) *(Land Protection Act)*. This Act defines three different categories of pest (Class 1, Class 2 and Class 3 pests), on the basis of their present distribution and extent in Queensland, and their potential environmental, social or economic impact.

Noxious fish are listed in schedule 5A of the *Fisheries Regulation 1995* (Qld). Within the text, introduced flora and fauna species are denoted with an asterisk (*).

Nomenclature throughout this chapter follows Pusey et al. (2004) for fish and Henderson (2002) for Aquatic vegetation. For the purposes of this study, Aquatic macrophytes were defined as submergent, emergent and overhanging plants, detectable with the naked eye, within the wetted reaches of watercourses within the project area.

Habitat types are considered at two spatial scales: meso-habitats and micro-habitats. Meso-habitats are broad habitat types that are roughly the same scale as the channel width and delineated by localised slope, channel shape, and structure. Riffles, runs, glides, shoals, pools, and off-stream wetlands/anabranches represent potential types of meso-habitats.

Micro-habitats are smaller scale features, and are defined here as relatively homogeneous areas, approximately the same scale as used by an individual fish engaged in a specific activity, such as feeding or spawning. Tree-snags, undercut banks, gravel bars and submergent vegetation are examples of in-stream habitat units at the micro-habitat scale.

For the purpose of this study, Downstream Left Bank (DLB) and Downstream Right Bank (DRB) refer to the riverbank on the left and right hand side of the observer respectively, as they face downstream.

8.2.2 Review of Existing Data

8.2.2.1 Information Review

The following key information sources were reviewed:

- Vegetation and Fauna Habitat Assessment for the Stanwell-Gladstone Infrastructure Corridor (SGIC), prepared by HLA Envirosciences (2007) on behalf of the Coordinator-General
- Queensland Environmental Protection Agency (EPA 2002) Biodiversity Assessment and Mapping Methodology (BAMM). This reference outlines Threatened and near-Threatened species (priority species) within Queensland
- Freshwater fish and Aquatic macroinvertebrate records for the Fitzroy and Calliope River catchments. Important data sources include Byron et al (1992); Conrick et al (1997), DNR (1998), Duivenvoorden and Roberts (1996), Long and Berghuis (1996) and Pusey et al (2004).

All information sources used are referenced in the document, and are documented in the references section at the end of this chapter.

8.2.2.2 Spatial Data

Several Geographical Information System (GIS) datasets were used:

- Rectified aerial photo mosaic of the project area and surrounds
- Cadastre
- Regional Ecosystem (RE) vegetation mapping (Version 5.0 with Dec 2006 Amendments)
- Biodiversity Planning Assessment (BPA) mapping (Version 3.4 – 7 March 2005)
- Ramsar wetland areas
- Queensland EPA estate (i.e. National Parks etc.).

[1] For the purposes of this report, relevant Nature Conservation Act 1992 (Qld) regulations and amendments refer to the Nature Conservation (Wildlife) Regulation 1994 (Qld) and reprinted as in force on 8 March 2004 (including amendments up to 2004 SL No. 9).

8.2.2.3 Public Database Records of Listed EVR Species

Two public access databases with restricted locational precision were searched to identify Endangered, Vulnerable and Rare (EVR) Aquatic flora and fauna known to occur, or to have occurred, in the project area:

- Wildlife Online (EPA 2007) database. This is a Queensland EPA internet-based database that stores records of plant collections and fauna sightings (and other groups such as algae and fungi) for a search area defined by the user. EVR and other notable flora and fauna species can be selected from the search outputs. Search results are included in Appendix E4.
  - EPBC Act Protected Matters Report (DEWHA 2007). This is a Commonwealth Department of Environment and Water Resources (DEWHA) internet-based database, and its associated search tool, enables the user to generate a report that will assist with determining whether matters of national environmental significance or other matters protected by the EPBC Act are likely to occur in the area of interest. This includes EPBC Act-listed EVR species, Migratory and other notable species of national significance, Threatened ecological communities, and other features of national conservation significance (i.e. Ramsar Wetlands, Commonwealth Marine Areas, World Heritage Places, National Heritage Places, Commonwealth Lands). Search results are included in Appendix E4.

Searches were done in both public domain databases by specifying coordinates (defining a rectangle) that contained the entire project area. Note that these database outputs should be considered as indicative only, and have been considered in this chapter in the context of habitat conditions present within the project area, and the potential for these habitats to support listed species and communities.

8.2.3 Field Investigations and Data Analysis

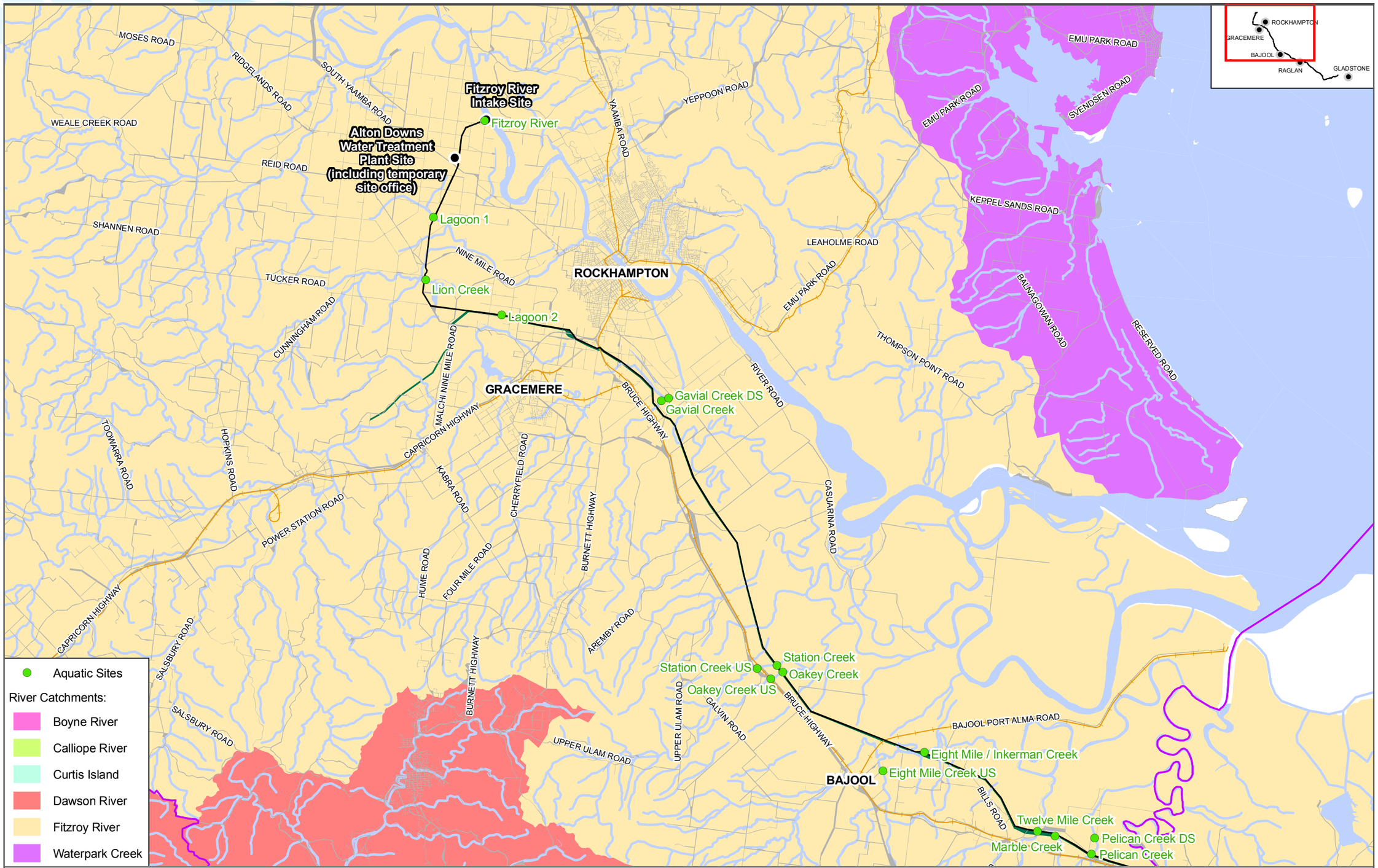
On the basis of a review of spatial data, six main drainages were identified within the project area, namely Fitzroy River, Gavial Creek, Inkerman Creek, Twelve Mile Creek, Raglan Creek and Larcom Creek (see Figure 8.1). Furthermore, two semi-permanent floodplain lagoons and approximately 24 ephemeral drainages of varying size were identified within the project area.

Of these streams and minor drainages, a total of 16 sites were selected for site assessments. Sites were selected on the basis that: (i) they were considered to be representative of the main Aquatic meso-habitat types found within the project area; (ii) they encompassed all major creeks within the project area; and/or (iii) they encompassed habitat types utilised by Aquatic species of conservation and fisheries significance (Table 8.1).

Marine and Aquatic habitat and flora surveys were undertaken at 16 representative sites situated within the project area. Surveys were done inclusive of 23 to 28 August 2007.

Table 8.1 Location (Projection: WGS 84) and Types of Waterbodies Investigated at Representative Sites Located within the Project Area

Section	Catchment	EASTINGS	NORTHINGS	Creek name	Description	Water present (> 5 m² surface area)
Fitzroy to Bajool	Fitzroy	237757.6	7421346.8	Fitzroy River	Perennial River - Permanent pool	✓
	Fitzroy	234722.3	7415613.7	Lagoon 1	Semi-permanent lagoon	✓
	Fitzroy	234247.0	7411906.5	Lion Creek	Ephemeral drainage	×
	Fitzroy	238770.8	7409818.3	Lagoon 2	Semi-permanent lagoon	✓
	Fitzroy	248222.3	7404730.1	Gavial Creek	Semi-permanent waterbody	×
	Fitzroy	253897.5	7388885.4	Station Creek US	Ephemeral drainage	×
	Fitzroy	254704.2	7388278.4	Oakey Creek US	Ephemeral drainage	×



Gladstone - Fitzroy Pipeline Project

Figure 8.1 - Location of Survey Points within the Project Area

Sheet 1 of 2

The Right of Way
Project Infrastructure
Railway Line
Road Reserve
Waterways
LGA Boundary
SGIC
GSDA

0 5 10 15 km

1:200,000 at A3

N

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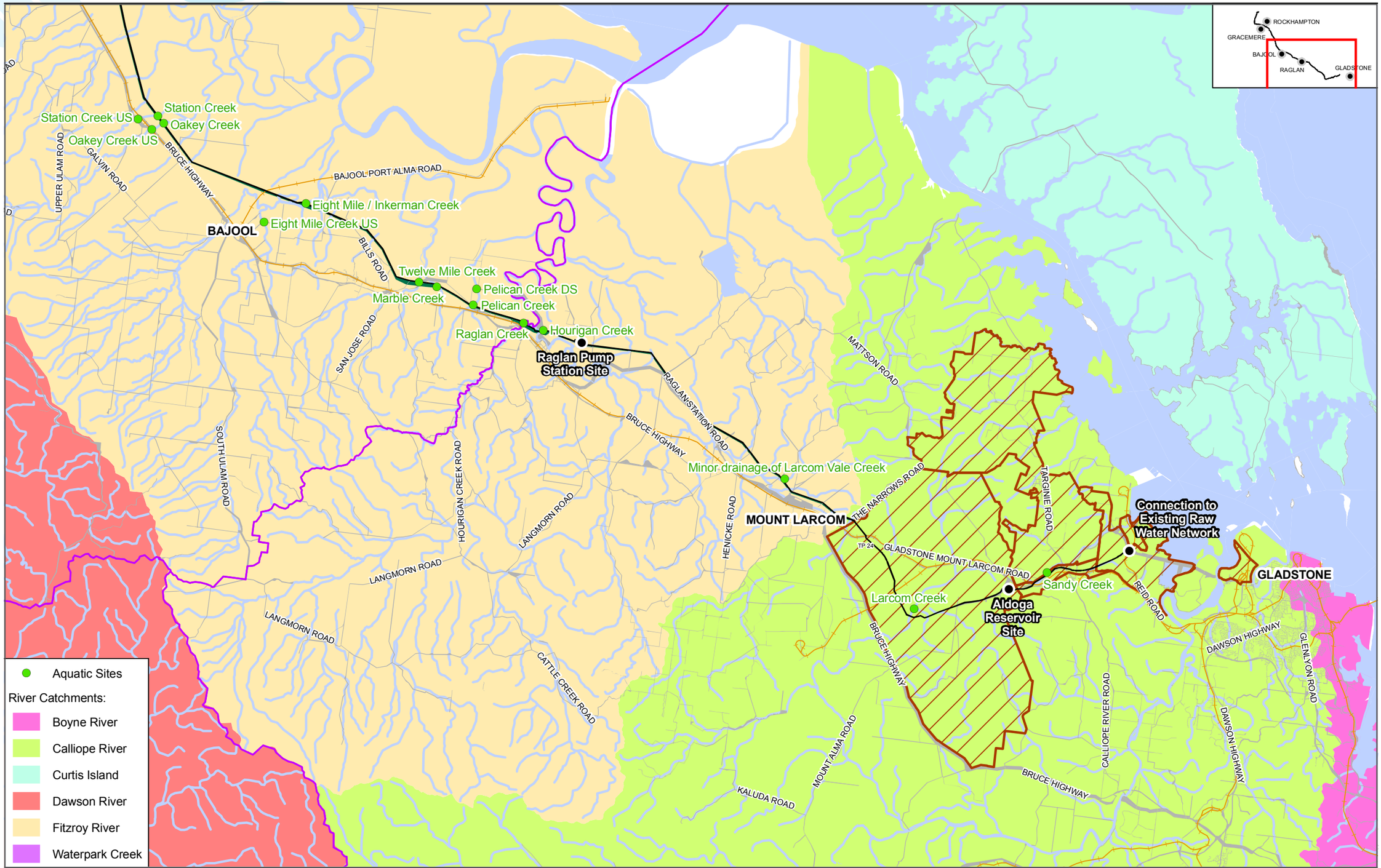


While every care is taken to ensure the accuracy of this data, the Gladstone Area Water Board (GAWB) makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the plan being inaccurate or incomplete in any way and for any reason. It should also be noted that final survey of the pipeline alignment and SGIC boundary are yet to occur and may result in changes to the alignments depicted here.

Section	Catchment	EASTINGS	NORTHINGS	Creek name	Description	Water present (> 5 m² surface area)
Bajool to Gladstone	Fitzroy	263824.2	7383895.9	Inkerman Creek	Macro-tidal creek	✓
	Fitzroy	270515.3	7379234.3	Twelve Mile Creek	Permanent pool	✓
	Fitzroy	271564.6	7378956.2	Marble Creek	Ephemeral drainage	×
	Fitzroy	273718.1	7377870.7	Pelican Creek	Ephemeral drainage	✓
	Fitzroy	276719.8	7376800.5	Horrigan Creek	Ephemeral drainage	×
	Fitzroy	277873.1	7376388.1	Raglan Creek	Macro-tidal creek	✓
	Fitzroy	292145.7	7367585.7	Unnamed tributary of Larcom Vale Creek	Ephemeral drainage	×
	Calliope	299816.4	7359922.2	Larcom Creek	Permanent pool	✓
	Calliope	307680.8	7362046.9	Sandy Creek	Ephemeral drainage	×

8.2.3.1 Aquatic Habitats

A survey of the habitat characteristics of each site was undertaken, documenting riparian vegetation characteristics, stream substrate composition and profile, adjacent land uses and several other indicators of habitat 'condition'.

Sampling sites were all located on main watercourses within the project area and numerous representative ephemeral drainages and wetlands intersecting the proposed pipeline corridor, as shown in Table 8.1. Photographs were taken of representative features at each site, and the position was recorded with a hand-held GPS.

Sampling methods were based on Arthington (1996). 50 m long transects (fibreglass tapes) were placed parallel to the littoral edge on each riverbank, with the transect origin (0 m) set at the upstream extent of the site. Two separate but related methods were used to sample habitats and Aquatic flora on these transects.

Method 1. The first method involved dividing the stream into five equal segments (perpendicular to the transect line), consisting of two bank segments, a centre-of-stream segment and two segments either side of the centre-of-stream and the banks. Four random points were selected along each of the five sub-transects, to give a total of 20 points.

The following parameters were measured within 1 m² quadrats placed at each sample point along each transect:

- Wetted stream width
- Percentage riparian cover (projected foliage cover)
- Depth
- Mean water velocity
- Substrate composition (mud/sand/fine gravel/coarse gravel/cobble/rock/bedrock)
- Percentage cover of each macrophyte species
- Percentage cover of filamentous algae
- Percentage cover of overhanging vegetation
- Percentage cover of emergent vegetation
- Percentage cover of leaf litter
- Percentage cover of large woody debris (more than 15 cm diameter)
- Percentage cover of small woody debris (less than 15 cm diameter).

Method 2. Pusey *et al.* (2004) suggests that Method 1 does not provide an adequate sample of bank and littoral habitats, hence an alternate method was used to supplement the information obtained in Method 1. 50 m long by 1 m wide belt transects were sampled on each stream bank. Each transect was divided into 12.5 m long segments to gain an appreciation of within-site variability and to assist data collection. Sampling was restricted to the littoral zone, and excluded terrestrial vegetation except for the immediate riparian strip. The percentage cover of each of the following parameters was measured within each segment:

- Canopy cover
- Aquatic macrophytes
- Filamentous algae
- Periphyton
- Overhanging vegetation
- Submergent vegetation
- Emergent vegetation
- Leaf litter
- Large woody debris (more than 15 cm diameter)
- Small woody debris (less than 15 cm diameter)
- Undercut banks
- Overhanging roots.

Macrophyte sampling was done by hand due to the shallow nature of the sites. Substrate composition was estimated by eye from hand-gathered samples in shallow areas and by an extended scoop in deeper sections. Depth was measured using a graduated pole. Macrophyte samples were identified in the field or were collected for later identification in the laboratory.

8.2.3.2 Water Quality measurements

Water quality sampling was done on a single occasion in order to gain a snapshot assessment of the physio-chemical characteristics of water at each site within the project area. Note that these data therefore do not account for temporal variability in water quality conditions[2] and should not be considered to be representative of water quality over longer time scales.

Sampling procedures follow those outlined in the Queensland EPA (1999) sampling manual. Physical water quality parameters were measured in situ using a calibrated water quality meter (Yeokal Model 611) at approximately 0.2 m in depth. Measurements were obtained for the following parameters:

- Water temperature (°C)
- Conductivity (µS/cm)
- Salinity (g/L)
- Dissolved oxygen (mg/L and % saturation)
- pH
- Redox (mV)
- Turbidity (NTU).

8.3 Assumptions and Limitations

All habitat and water quality sampling was conducted between 23 and 27 August 2007 between 07:00 and 18:00 hours. Although there were moderate amounts of recent rainfall occurring prior to the survey period, the area is recognised as having experienced drought conditions for an extended period (more than five years) at the time of the survey. Consequently, there was a scarcity of permanent to semi-permanent waterbodies within the project area at the time of sampling, and conditions sampled here should not be considered as representative of conditions at other times. Drought conditions would directly affect factors such as the distribution and extent of Aquatic macrophytes, for example, which were extremely sparse during the field investigations conducted for this EIS.

Assessments of Aquatic fauna species and communities within the project area were derived from reviews of existing information from the wider area, together with habitat surveys and knowledge of the known habitat requirements of these species. Information acquired from public databases was current at the time database searches were undertaken (i.e. 2007). This report does not take into account any inclusions, exclusions or conservation status changes that may have occurred since that time. Note that with the exception of the translocated populations of some fish species (e.g. Mary River Cod (*Maccullochella peelii*)) no species of Aquatic invertebrates or freshwater fish of conservation significance (as listed under legislation) are known to occur in the project area. Other listed species known from catchments encompassing the project area include the Fitzroy River Turtle (*Rheodytes leukops*), which is endemic in the Fitzroy River catchment. The project area does not represent optimal habitat for this species, hence targeted surveys were not undertaken for this species.

[2] e.g. diurnal variations in pH and dissolved oxygen in response to variations in biological processes, tidal variations in salinity and biological productivity, changes in turbidity in response to flow conditions and biological productivity.

8.4 Relevant Legislation and Policy

There are several relevant Queensland and Commonwealth statutes and policies that need to be considered from an Aquatic ecology perspective, including (but not limited to):

- *Nature Conservation Act 1992* (Qld) and *Nature Conservation (Wildlife) Regulation 2006* (Qld), which lists Threatened plants and animals at a State (Queensland) level;
- *Environment Protection & Biodiversity Conservation Act 1999 (Cth).* The EPBC Act lists Threatened plants and animals at a Commonwealth level, and considers a number of other matters of National Environmental Significance that are not considered to be of relevance to the proposal. See Chapter 6, Section 6.1 and Appendix G for an assessment specifically dealing with the project's relevant matters of National Environmental Significance (Threatened Species and Ecological Communities) under the EPBC Act.
- *Fisheries Act 1994* (Qld) protects fisheries habitat, including Marine plants, and lists certain fish species of conservation significance
- *Fisheries Regulation 1995* (Qld) lists noxious fish within Queensland
- *Vegetation Management Act 1999* (Qld) outlines *Endangered, Of Concern* and *Not Of Concern* REs, which includes several types of Marine plant and wetland community types
- *Coastal Protection and Management Act 1995* (Qld) and *State Coastal Management Plan* (Qld)
- *Land Protection (Pest and Stock Route Management) Act 2002* (Qld) lists declared (pest or noxious) weeds within Queensland.

8.5 Baseline

8.5.1 Aquatic habitats

8.5.1.1 Overall general context

The project area traverses the low-lying Fitzroy River delta and the more elevated northern reaches of the Calliope River catchment (Figure 8.1). The Fitzroy River catchment has an approximate area of 11,006 km^2, which represents approximately 7.5 percent of the total catchment area (142,537 km^2) of the Fitzroy River Basin.

A digital terrain model (DEM) was generated from broad scale topographical data for the Fitzroy and Calliope River catchments (1:100,000 topographic data; GEODATA 9 Second DEM Version 2) using the Vertical Mapper mapping package (Figure 8.2). Based on this DEM, it was estimated that the total length of waterways within the lower Fitzroy River Basin was 13,585 km, with most waterways consisting of low (first and second) order drainages. The Calliope River catchment had a mapped area of approximately 2,236 km^2, with the 4,077 km of waterways also mostly comprised of first and second order streams (Table 8.2).

Both the Fitzroy River and the Calliope River catchments have been significantly modified by catchment clearing, with approximately 88 percent and 83 percent of lands cleared for grazing respectively. Grazing and dry land cropping have together resulted in broad-scale soil erosion and sediment movement within the catchment (CRCCH 2004).

Table 8.2 Stream Lengths (km) of Different Stream Orders within the Lower Fitzroy River Catchment and the Calliope River Catchment

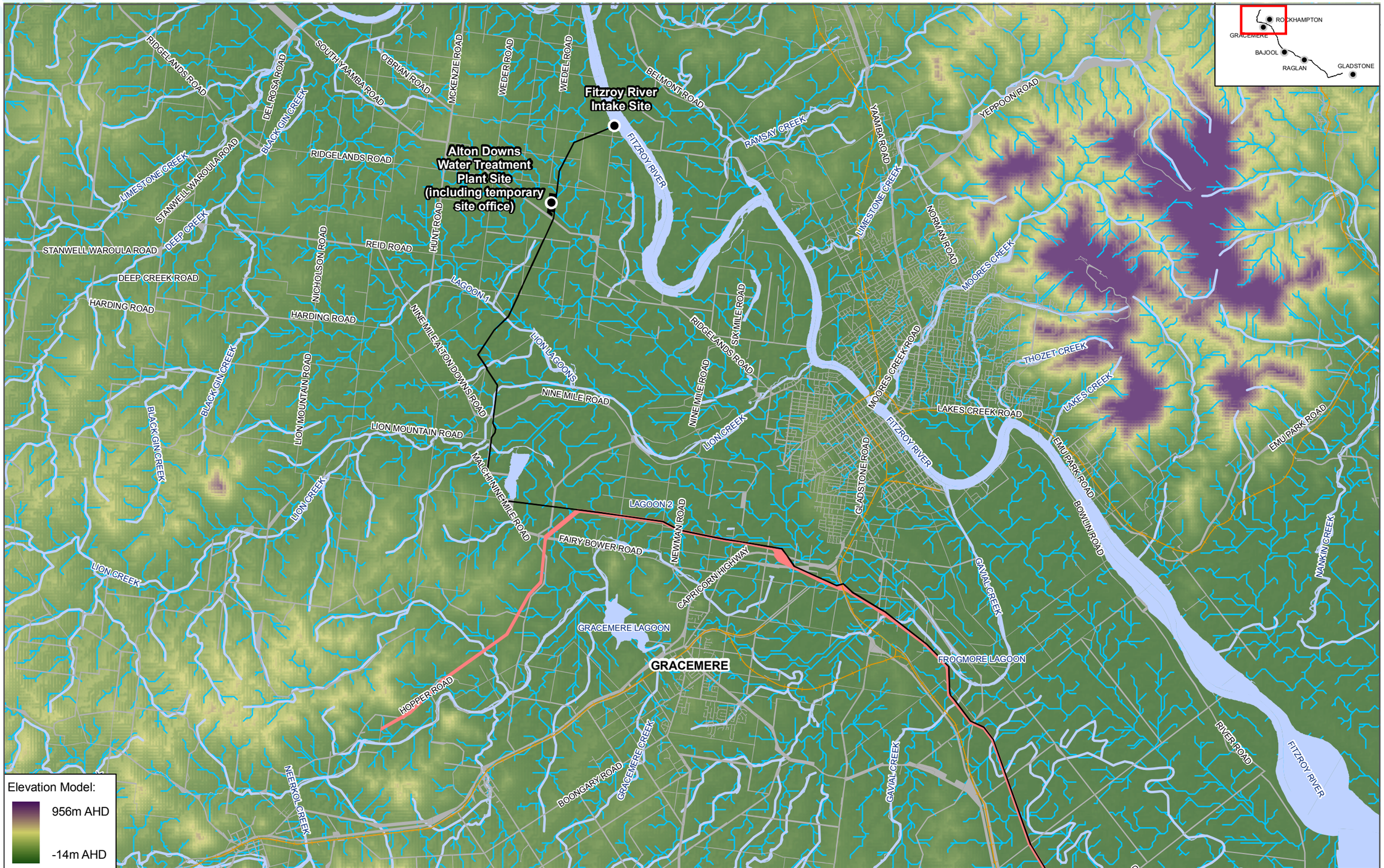
Stream order	Lower Fitzroy River catchment	Calliope River catchment
1	6662	2004
2	3340	987
3	1826	562
4	911	290
5	430	131
6	241	66
7	60	37
8	115	0
Total	13585	4077

Approximately 30 streams and drainages have been identified within the project area (see Table 8.3), which can be classified into the following broad biophysical habitat classes:

- *Perennial freshwater rivers and streams.* Representative meso-habitats included pool and run habitats. Note that micro-habitat structure varied greatly among representative waterways within this habitat class, as described in Sections 8.5.1.2 and 8.5.1.3
- *Floodplain lagoons / wetlands.* These semi-permanent freshwater waterbodies occur throughout the Fitzroy River delta, and link to the Fitzroy River and its tributaries during floods
- *Ephemeral drainages.* These represented the most common habitat class within the project area. Aquatic meso-habitat conditions vary in response to flow conditions, and would potentially include temporal run, glide, riffle and pool habitat during flow periods, and dry creek bed and temporary isolated pools during dry conditions.
  - *Macro-tidal channels.* These are estuarine channels that are regularly inundated by tidal waters, and completely drain at low tide
  - *Upper estuary creek.* This habitat class was represented by small semi-permanent pools on muddy substrate, and are typically only influenced by tidal action during spring tides.

Table 8.3 Broad Habitat Characteristics of Waterways in the Project Area

Site	Substrate type	Bed compaction	Habitat class
Fitzroy River	Mud	Low compaction. 100% unconsolidated fine sediment	Perennial river – permanent pool
Lagoon 1 and Lagoon 2	Fine silts and clays	Low compaction. Limited range of sediment size, little overlapping, some packing and structure, but can be dislodged very easily	Semi-permanent floodplain lagoon
Lion Creek	Fine silts and clays	Low compaction. Limited range of sediment size, little overlapping, some packing and structure, but can be dislodged very easily	Ephemeral drainage
Gavial Creek	Silts and clays	Low compaction. Limited range of sediment size, little overlapping, some packing and structure, but can be dislodged very easily	Semi-permanent pool environments within natural defined channels
Station and Oakey Creeks	Clays, sand cobbles/gravel	Low compaction. Limited range of sediment size, little overlapping, some packing and structure, but can be dislodged with moderate ease	Ephemeral drainage
Inkerman Creek	Marine clays	Low compaction. 100% unconsolidated fine sediment	Macro-tidal creek
Twelve Mile Creek	Clay	Low compaction. 100% unconsolidated fine sediment	Upper estuary creek with permanent pool
Raglan Creek	Marine clays	Low compaction. 100% unconsolidated fine sediment	Macro-tidal creek
Unnamed tributary of Larcom Vale Creek	Sand/gravel	Moderate compaction. Wide diversity of sediment sizes, little overlapping, some packing but can be dislodged with moderate ease	Ephemeral drainage
Larcom Creek	Sand/gravel and mud	Moderate compaction. Wide diversity of sediment sizes, little overlapping, some packing but can be dislodged with moderate ease	Perennial in-stream pool
Sandy Creek	Sandy silts	Moderate compaction. Wide diversity of sediment sizes, little overlapping, some packing but can be dislodged with moderate ease	Ephemeral drainage



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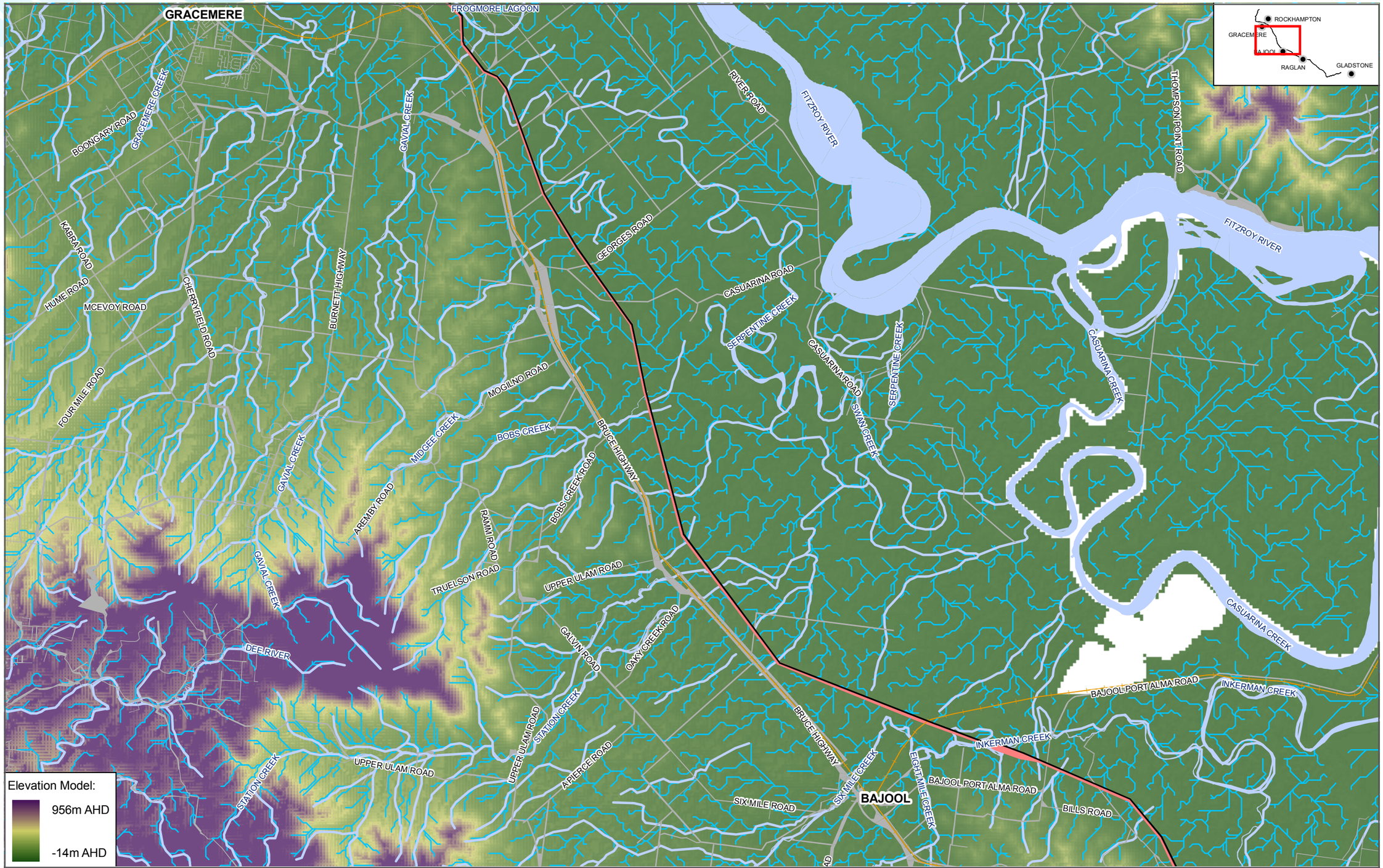


Gladstone - Fitzroy Pipeline Project

Figure 8.2 - Catchment DEM Derived from Broad-scaleTopographical Data, Showing Derived Streams and Drainages

Sheet 2 of 4

The Right of Way
Project Infrastructure
Railway Line
Road Reserve
Waterways
Drainage Lines
LGA Boundary
SGIC
GSDA

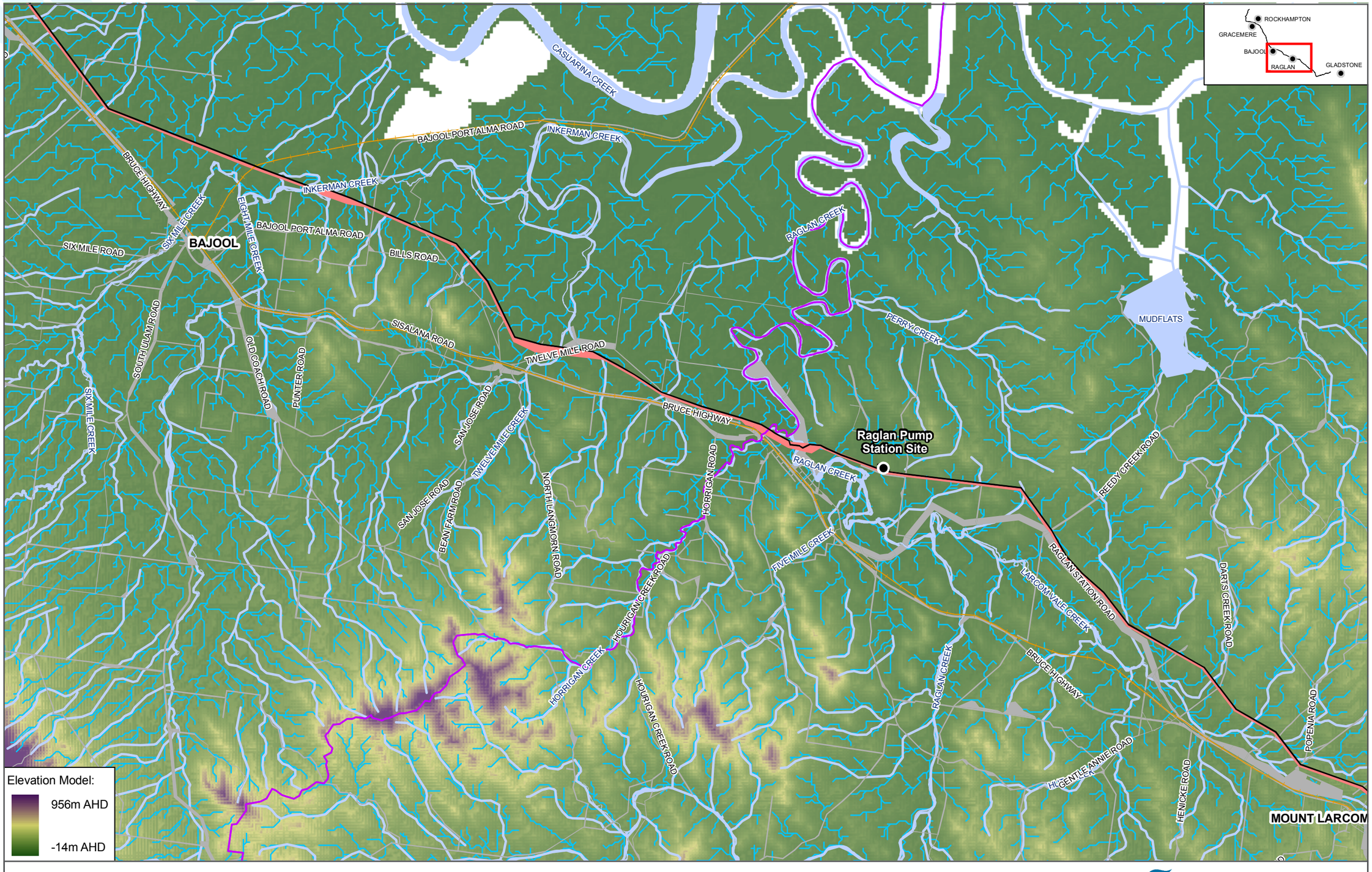
0 2 4 6 8 km

1:100,000 at A3

N

Gladstone Area Water Board

ARUP



Gladstone - Fitzroy Pipeline Project

Figure 8.2 - Catchment DEM Derived from Broad-scaleTopographical Data, Showing Derived Streams and Drainages

Sheet 3 of 4

The Right of Way
Project Infrastructure
Railway Line
Road Reserve
Waterways
Drainage Lines
LGA Boundary
SGIC
GSDA

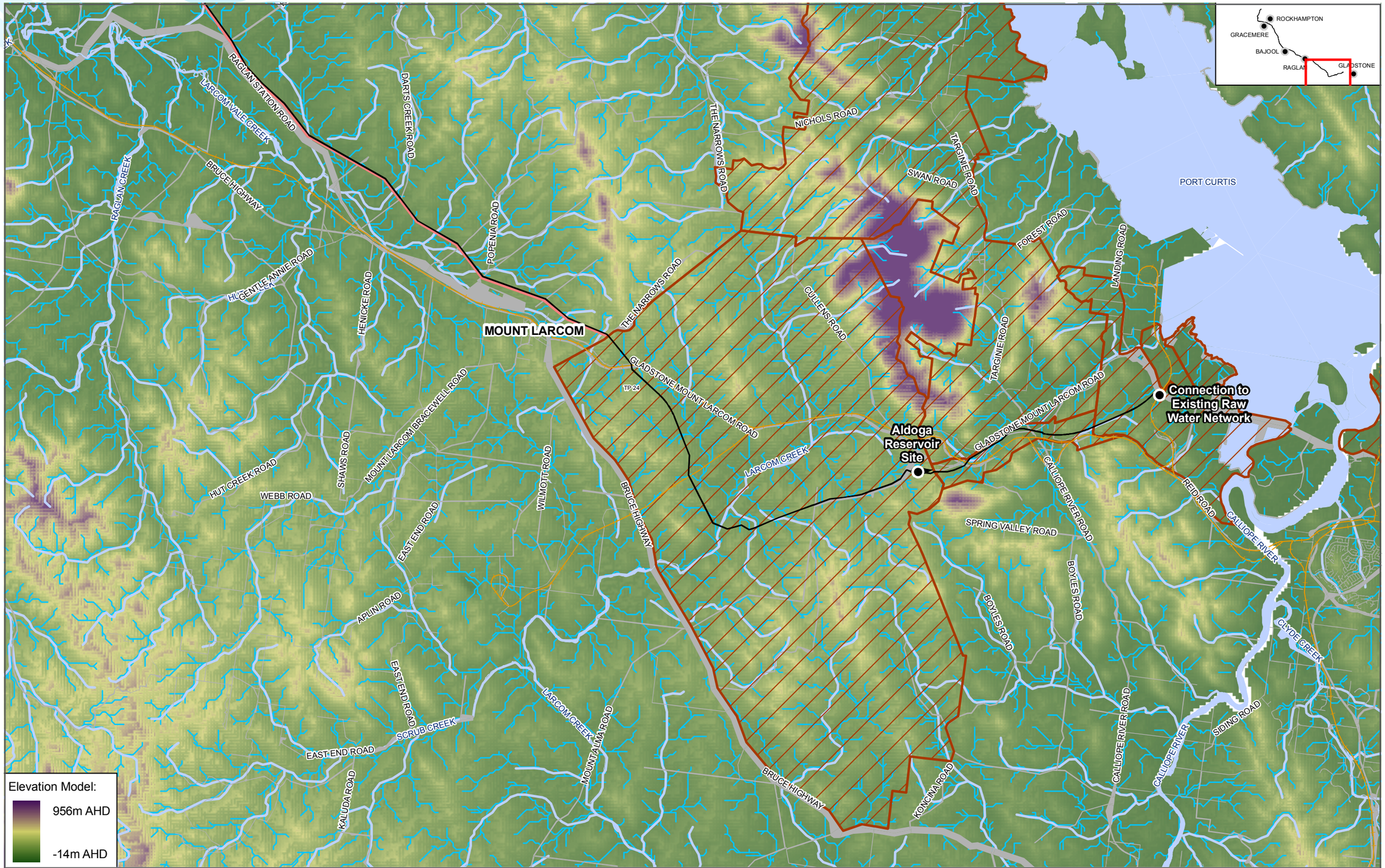
0 2 4 6 8 km

1:100,000 at A3

N

Gladstone Area Water Board

ARUP



Gladstone - Fitzroy Pipeline Project

Figure 8.2 - Catchment DEM Derived from Broad-scaleTopographical Data, Showing Derived Streams and Drainages

Sheet 4 of 4

8.5.1.2 Fitzroy to Bajool

Broad-scale Aquatic Habitat Features

There are four broad Aquatic meso-habitat types within the Fitzroy to Bajool section of the project area:

- *Perennial freshwater rivers and streams.* This habitat type was represented by the Fitzroy River. The section of the Fitzroy River within the project area is located within a weir pool habitat that has formed upstream of the Fitzroy Barrage (Marsden and Power 2007)
- *Floodplain lagoons/wetlands.* This habitat class is relatively common on the Fitzroy River coastal plains, and is known to represent an important habitat from a fisheries perspective. Many of these wetlands represent oxbow lakes, which are former river meanders that have been cut off from the main channel. At least two floodplain lagoons occur within the project area (Lagoons 1 and 2 – see description Sites 2 and 4), although others occur within 10s to 100s of metres from the project area
- *Semi-permanent pool environments within natural defined channels.* Gavial Creek is the only representative of this habitat class within the project area, and is most likely an extension of Frogmore Lagoon. No water was present within the creek at the time of sampling, although an anecdotal report from a long time local resident suggests that this is a more or less permanent waterbody that has dried during the current drought. This habitat class includes pool and run meso-habitats during periods of flow
- *Ephemeral drainages.* Ephemeral drainages with a natural defined channel represented the most extensive habitat type within this section of the project area. This habitat was represented by approximately eight major drainages, with Lion, Station and Oakey Creeks the largest of these. This habitat class includes pool and run meso-habitats.

A detailed habitat description for each of the field survey sites is provided in Appendix E4.3. Photos of the major Aquatic habitat sites within this section of the project area are presented in Figure 8.3.

Figure 8.3 Aquatic Habitats within the Fitzroy to Bajool Section of the Project Area

Fitzroy River

Lagoon 2

Lion Creek

Gavial Creek

Station Creek

Oakey Creek

8.5.1.3 Bajool to Gladstone

Broad-scale Aquatic Habitat Features

There were four broad Aquatic habitat classes within the Bajool to Gladstone section of the project area:

- *Macro-tidal estuarine channels*. Representative creeks included Inkerman and Raglan Creeks
- *Perennial freshwater rivers and streams*. This habitat class was confined to sections of Larcom and Twelve Mile Creeks within and adjacent to the project area
- *Upper estuarine creek*. This habitat class represents mall semi-permanent pools on muddy substrate with occasional tidal intrusion. These channels were confined to sections of Horrigan Creek within and adjacent to the project area
- *Ephemeral drainages*. This was the most common habitat class within this section of the project area. This habitat was represented by up to 15 drainages, with Marble Creek, Sandy Creek and various drainages of Larcom Vale Creek representing the largest of these.

A detailed habitat description for each of the field survey sites is provided in Appendix E4. Photos of the major Aquatic habitat sites within this section of the project area are presented in Figure 8.4.

Figure 8.4 Aquatic Habitats within the Bajool to Gladstone section of the project area

Inkerman Creek

Twelve Mile Creek

Pelican Creek

Horrigan Creek

Figure 8-4 Aquatic Habitats within the Bajool to Gladstone section of the project area, cont.

Raglan Creek

Unnamed tributary of Larcom Vale Creek

Larcom Creek

Sandy Creek

8.5.2 Floodplain Wetlands

8.5.2.1 General context

A search on the EBPC database identified that there are no Ramsar wetlands within or directly adjacent to the project area. The closest Ramsar wetland is the Shoalwater and Corio Bays site, which is located within the same catchment as the project area (approximately 46 km to the northeast).

Two nationally important wetland areas listed under the Directory of Important Wetlands occur within the project area and/or immediate surrounds (Environment Australia 2001), including:

- The Fitzroy River floodplain wetlands
- The Fitzroy River delta wetlands.

The location of these nationally important wetland areas is shown in Figure 8.5. The Fitzroy River floodplain and delta encompasses a large area adjacent to the project area. The wetlands in this river floodplain and delta are considered to have exceptionally high ecological and functional values (Environment Australia 2001, QWP 2006). In regard to Aquatic ecology, the wetlands in the southern Fitzroy River catchment provide a number of key functions for the region, namely fish passage, fish nursery areas and dry season refuge areas for Aquatic species (QWP 2006).

The Great Barrier Reef Marine Park is also listed as a nationally important wetland (Environment Australia 2001) and is located approximately 49 km downstream of the northern most extent of the project area on the Fitzroy River. The southern extent of the project area is approximately 9 km from the protected Narrows estuarine area, which is part of the Great Barrier Reef Marine Park.

Wetlands within the project area contribute to maintaining a connection between freshwater and Marine environments, which is essential in providing fish passage between freshwater and Marine waters for Migratory species, including Spangled Perch (*Leiopotherapon unicolor*), Sea Mullet (*Mugil cephalus*) and Barramundi (*Lates calcarifer*). As such, the wetlands provide important nursery habitats fish, including species of recreational and commercial significance (e.g. Barramundi) (QWP 2006). During dry periods, the permanent freshwater lagoons (e.g. Frogmore lagoon) provide refuge areas for Aquatic flora and fauna when ephemeral waterbodies are dry (QWP 2006).

Most of the wetlands located within or near the project area are thought to be important freshwater wetlands, providing ecological functions for fisheries and bird-life, especially the Great Barrier Reef Marine Park (Veitch and Sawynok 2005).

8.5.2.2 Fitzroy to Bajool

Eight primary wetlands occur within the Fitzroy to Bajool section of the project area, comprising part of the Fitzroy River Floodplain wetlands. These are separated into two main groups: the Gavial Creek lagoons and floodplain wetlands adjacent to the Fitzroy River.

The Gavial Creek lagoons are situated south of Rockhampton and include Gavial Creek, Yeppen, Woolwash, Frogmore, and Bates Lagoons. Those adjacent to the Fitzroy River include the Nankin Creek Wetlands and the Barramundi Creek and Redhill Coastal Wetlands. These lagoons link to Gavial Creek during large floods. Veitch and Sawynok (2005) consider that the floodplain lagoons in the middle reaches of the Fitzroy River presently represent critical habitats for a wide range of fish species, as they are the only off-stream wetlands on the southern side of the river that still retain natural connectivity to the tidal reaches of the river.

Serpentine Lagoon is an additional wetland that is located south of Rockhampton, northeast of the Gavial Creek lagoons. Serpentine Creek has at least five major barriers to fish movements, greatly reducing its fish habitat values.

8.5.2.3 Bajool to Gladstone

Key wetlands within the Bajool to Gladstone section of the project area are all associated with the extensive wetland system of the Fitzroy River delta. These include Inkerman, Twelve Mile and Raglan Creeks. In addition, located to the northwest of Raglan Creek is Pelican Lagoon, an off-stream freshwater to brackish lagoon.

8.5.3 Aquatic Vegetation

8.5.3.1 General Context

With some notable exceptions, the Aquatic macrophyte flora of the Fitzroy region is poorly documented. Seasonal Aquatic macrophyte surveys undertaken by Noble and Rummenie (1996) and Duivenvoorden (1992) within the Fitzroy River catchment noted the following key characteristics for the region:

- A species richness of five to eight Aquatic macrophytes was typically recorded at each site
- The most widespread and abundant Aquatic macrophytes were Sedges (*Cyperus* spp.), Knotweed (*Persicaria* spp.), Lignum (*Muehlenbeckia* spp.) and Nardoo (*Marsilea* spp.)
- The species richness of submergent and floating macrophytes was typically greater in spring than winter, which was partly due a greater presence of Ottelia (*Ottelia alismoides*) and Curly Pondweed (*Potamogeton crispus*)
- Aquatic macrophyte community structure was highly dynamic with species composition changing greatly from year to year.

In the project area a total of 47 macrophyte species have been recorded (Table 8.4). Only six species were recorded in the present EIS surveys (August 2007), which are detailed below for each section of the project area. The Aquatic macrophytes observed in the present study were recorded from five of the 13 freshwater sites and were restricted to permanent waterbodies (i.e. Twelve Mile, Larcom and Pelican Creeks, Fitzroy River and Lagoon 1). Compared to the wider region (Duivenvoorden 1992, Noble and Rummenie 1996), species richness in the project area was low, ranging from one to three species per site. The results obtained here are consistent with other recent surveys undertaken within the project area in terms of species composition and species richness (HLA 2006, HLA 2007, Enertrade 2006). It is suspected that the low abundance and richness of macrophytes in the project area was largely a result of habitat degradation due to land clearing and grazing. Ongoing drought conditions at the time of sampling were also associated with a lack of permanent to semi-permanent waterbodies within the project area, reducing the area of available habitat.

Conservation Values

A review of the EPBC Protected Matters Report (DEWHA 2007) and the Wildlife Online (QEPA 2007) database for Aquatic macrophyte species of conservation significance identified no Threatened species occurring, or likely to occur within the project area.

HLA (2006) has recognised *Aponogeton queenslandicus* could potentially occur within the Aquatic habitats of the project area. This macrophyte species is listed as Threatened by the NSW Department of Environment and Climate Change (DEC). Although the preferred habitat for this species was common throughout the project area, this species was not observed during the present study or other previous studies in the project area. It is considered unlikely that *Aponogeton queenslandicus* would be found within the area, as its distribution is restricted to west of the Great Dividing Range (DEC 2007).

8.5.3.2 Fitzroy to Bajool

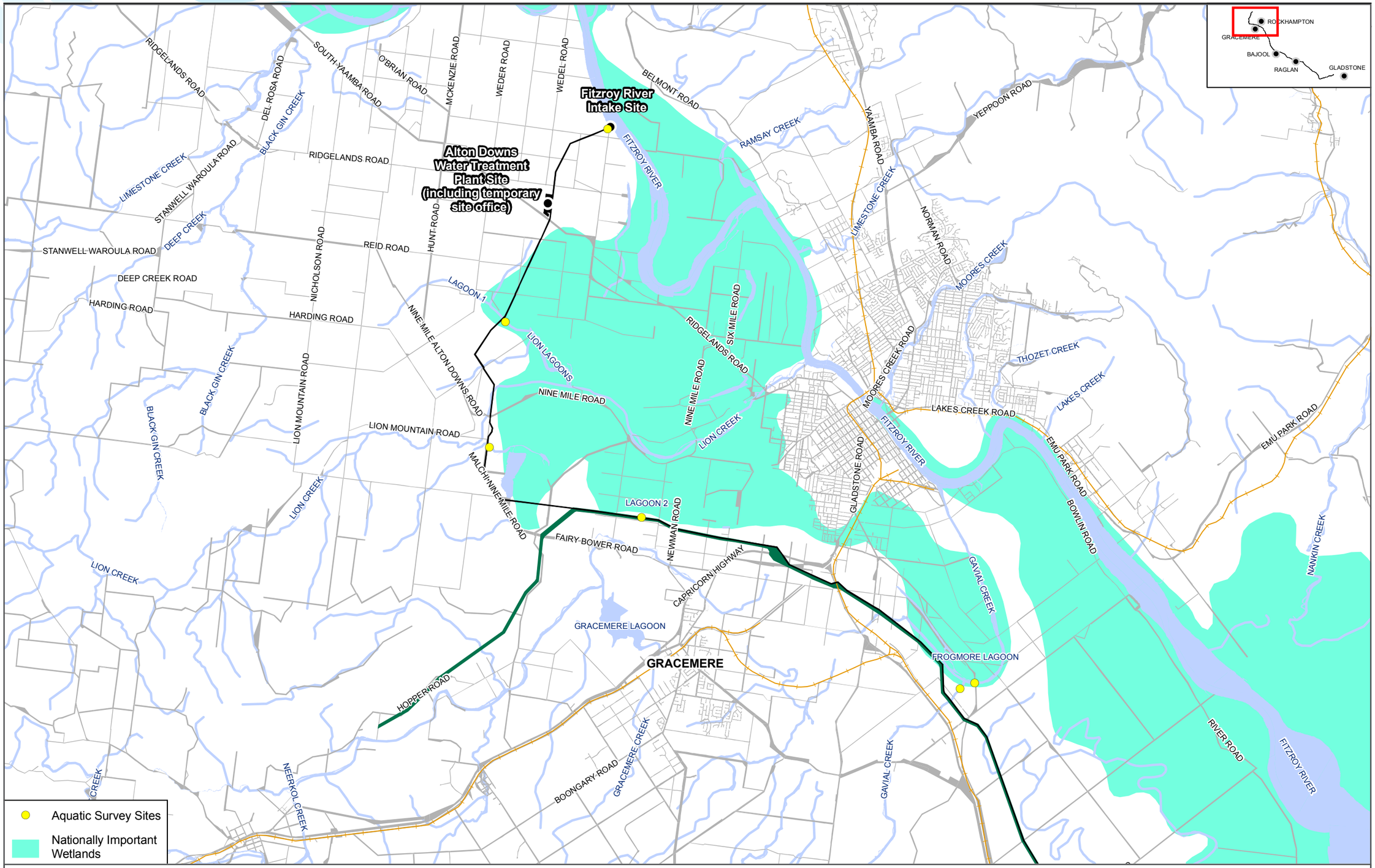
The Wildlife Online (QEPA 2007) database identified a total of 31 common Aquatic macrophyte species predominately from the family Cyperaceae (20 species) that have previously been identified within the project area (Table 8.4). During the study, two macrophytes species were recorded within the Fitzroy to Bajool section of the project area, namely:

- The floating Aquatic macrophyte Water Hyacinth* (*Eichhornia crassipes*), on the Fitzroy River at the extraction point and present along the entire DRB. Water Hyacinth* is a Class 2 declared plant (noxious weed) under the *Land Protection Act*
- An emergent sedge or rush was recorded in dense aggregations in damp margins adjacent to Lagoon 1 (Site 2). High cattle grazing pressure meant no intact specimens of this species were available for identification purposes.

8.5.3.3 Bajool to Gladstone

Table 8.4 displays a total of 18 macrophyte species previously recorded within the Bajool to Gladstone section of the project area (Wildlife Online (QEPA, 2007)). During baseline investigations undertaken for this EIS, BMT WBM identified five species occurring at three of the more permanent freshwater locations within the project area, these being:

- A native Lily (*Nymphaea* spp.) was recorded at the two permanent freshwater pool environments (Twelve Mile Creek and Larcom Creek)
- The emergent macrophytes Bunchy Sedge (*Cyperus polystachyos*) and *Typha* spp. along DRB sections of Twelve Mile Creek
- The emergent sedge or rush observed at Lagoon 1 was abundant at Pelican Creek but, again, no intact specimens were available for identification due to cattle grazing
- Dense in-stream cover of the submergent species Hornwort (*Ceratophyllum demersum*) was present within Larcom Creek.



Gladstone - Fitzroy Pipeline Project

Figure 8.5 - Location of Wetlands within the Project Area and Surrounding Region

Sheet 1 of 4

The Right of Way | **Project Infrastructure** | **Railway Line** | **Road Reserve** | **Waterways** | **LGA Boundary** | **SGIC** | **GSDA**

0 2 4 6 8 km

1:100,000 at A3

N

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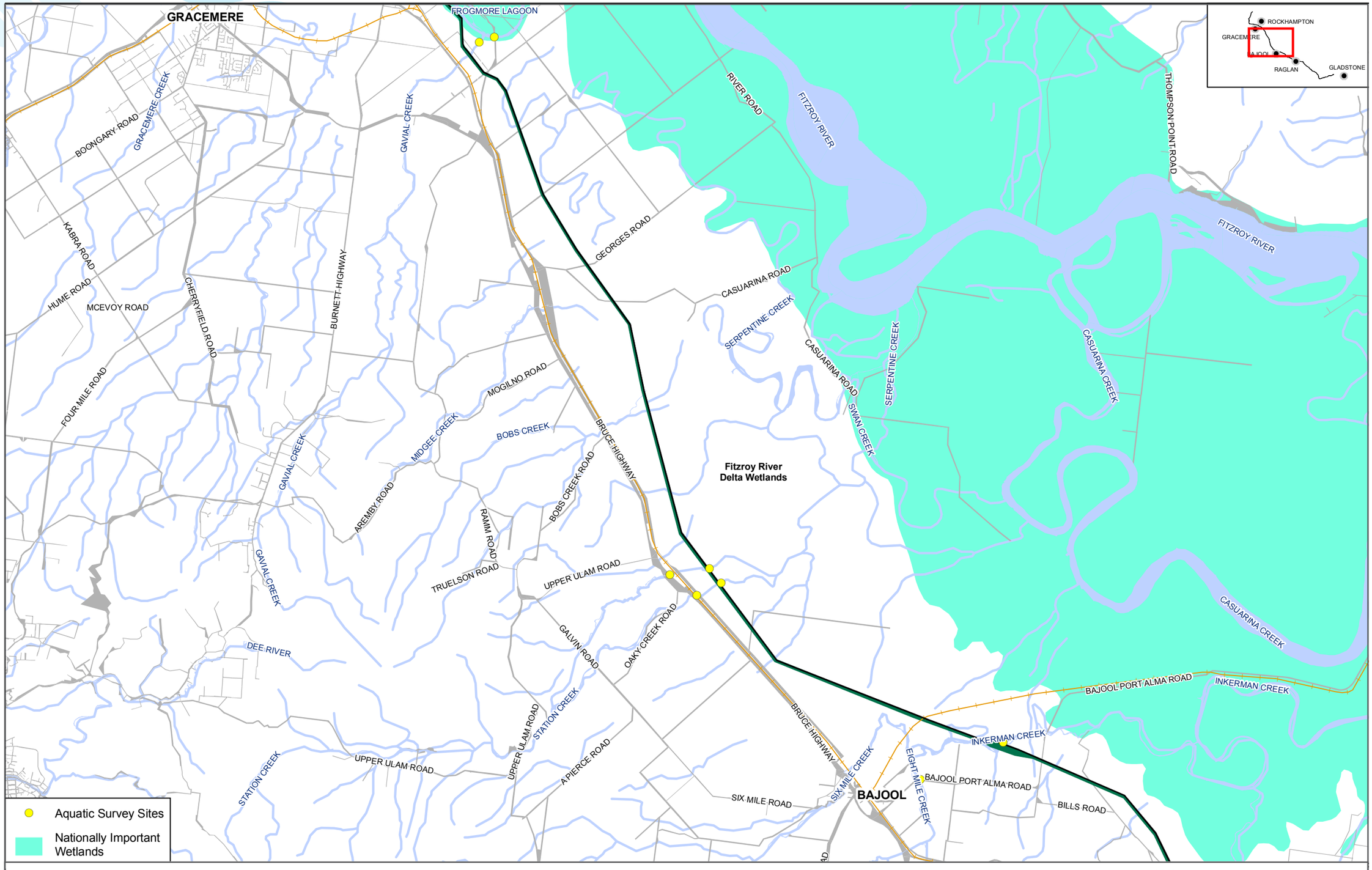
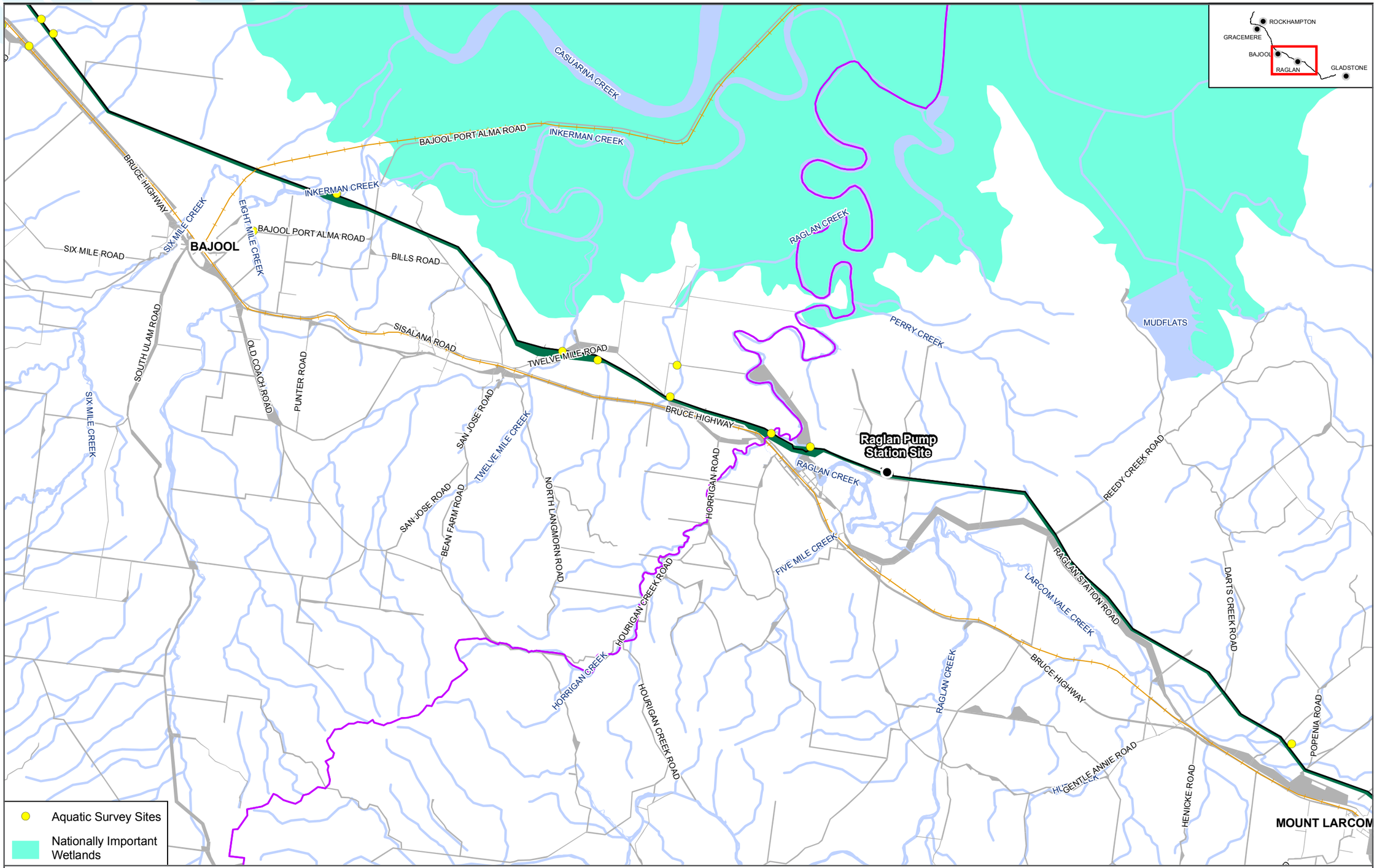


While every care is taken to ensure the accuracy of this data, the Gladstone Area Water Board (GAWB) makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the plan being inaccurate or incomplete in any way and for any reason. It should also be noted that final survey of the pipeline alignment and SGIC boundary are yet to occur and may result in changes to the alignments depicted here.



Gladstone - Fitzroy Pipeline Project

Figure 8.5 - Location of Wetlands within the Project Area and Surrounding Region

Sheet 3 of 4

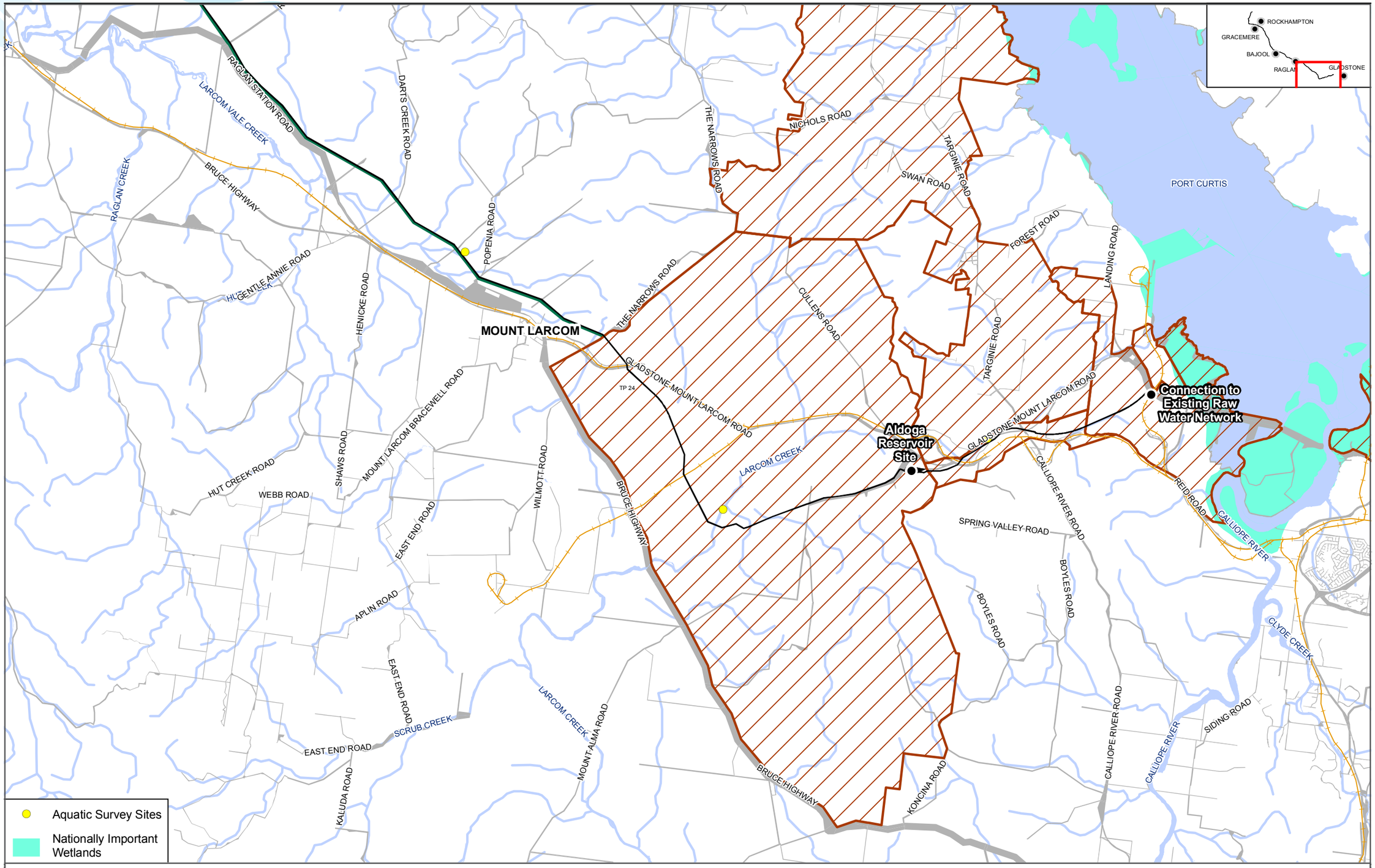


Table 8.4 Aquatic Macrophytes Recorded Within the Project Area (Wildlife Online (QEPA, 2007))

Scientific name	Common name	Project area distribution	Conservation status	Origin (Plant NET)	Recorded Aug'07 (EIS surveys)	Preferred habitat (Plant NET)
Amaryllidaceae						
Crinum flaccidum	Murray Lily	Section 2 only	Common	Native	N	Inland rivers, often along sandy floodways
Crinum pedunculatum	River Lily	Section 2 only	Common	Native	N	Swamps and stream banks in coastal districts
Proiphys cunninghamii	Moreton Bay Lily	Section 2 only	Common	Native	N	Wet sclerophyll forest and on rainforest margins, usually on clay-loams in coastal districts
Araceae						
Typhonium brownii	Black Arum Lily	Section 2 only	Common	Native	N	Rainforest margins, in sheltered gullies and along creek banks
Cyperaceae						
Cyperus alopecuroides	Mat Sedge	Section 1 only	Common		N	
Cyperus compressus	Flat Sedge	Section 1 only		Introduced	N	Disturbed open situations, sandy moist habitats
Cyperus digitatus	-	Section 1 only	Common		N	Swamp margins, lagoons and lakes
Cyperus fulvus	Sticky Sedge	Section 1 only	Common	Native	N	Open woodland or forest, often in a grassy understorey
Cyperus gracillis	McCoy Grass	Section 1 only	Common	Native	N	Open woodland and grassland
Cyperus involucratus	Umbrella Plant	Section 1 only		Introduced	N	
Cyperus javanicus	-	Section 1 only	Common		N	Common in marshy areas, stream banks
Cyperus perangustus	-	Section 1 only	Common		N	
Cyperus platystylis	-	Section 1 only	Common	Native	N	Coastal areas on floating mats in swamps
Cyperus polystachyos	Bunchy Sedge	Section 1 only	Common	Native	Y	Open, often disturbed environments
Cyperus rotundus	Nutgrass	Section 1 only		Introduced	N	Weed in disturbed situations, mostly around habitation but occasionally infesting crops
Cyperus scaber	-	Section 1 only	Common	Native	N	Heath on coastal dunes
Cyperus sesquiflorus	-	Section 1 only	Common	Introduced	N	Damp coastal sandy soils
Cyperus sphaeroideus	-	Section 1 only	Common	Native	N	Undisturbed damp habitats, often in woodland
Fimbristylis dichotoma	Common Fringe Rush	Section 1 only	Common	Native	N	Widespread in a variety of habitats
Fimbristylis ferruginea	-	Section 1 only	Common	Native	N	Coastal brackish or fresh water swamps

Scientific name	Common name	Project area distribution	Conservation status	Origin (Plant NET)	Recorded Aug'07 (EIS surveys)	Preferred habitat (Plant NET)
Fimbristylis littoralis	Finger Fush	Section 1 only	Common	Native	N	Saltmarshes
Schoenoplectus litoralis	Club Rush	Section 1 only	Common	Introduced	N	Swampy areas
Schoenus ornithopodioides	-	Section 1 only	Common		N	
Scleria mackaviensis	-	Section 1 only	Common	Native	N	Drier sites in open forest and woodland, often on rocky slopes
Haloragaceae						
Myriophyllum spp		Section 1 & 2	Common	Native/exotic	N	
Myriophyllum verrucosum	Red Water Milfoil	Section 1 only	Common	Native	N	Various habitats, from deep water to exposed mud
Juncaceae						
Juncus polyanthemus	-	Section 1 only	Common	Native	N	Coastal swamps
Menyanthaceae						
Nymphoides indica	Water Snowflake	Section 2 only	Common	Native	N	Coastal districts in still and flowing water on a variety of substrates
Nymphaeaceae						
Nymphaea caerulea	Cape Waterlily	Section 2 only		Introduced	N	
Nymphaea violacea	Native Waterlily	Section 2 only	Common		Y	Water 1-3 m deep in lagoons and slow moving creeks, in soft mud which may be a further 1 m deep
Onagraceae						
Ludwigia octovalvis	Willow Primrose	Section 2 only	Common	Native	N	Wet or seasonally wet places, mainly in inland irrigation districts
Ludwigia peploides subsp. Montevidensis	Water Primrose	Section 2 only	Common		N	Stationary and slow moving waterbodies, creek bank, and swamps
Poaceae						
Arundinella nepalensis	Reed Grass	Section 1 only	Common	Native	N	Drainage ways in dry woodland and grassland
Paspalum dilatatum	Water Couch	Section 1 only		Introduced	N	Damp areas and margins of waterbodies, creeks, streams, channels and drains on the coast and inland
Phragmites australis	Common Reed	Section 2 only	Common	Native	N	Widespread in wet places especially at the edge of streams and tidal waters

Scientific name	Common name	Project area distribution	Conservation status	Origin (Plant NET)	Recorded Aug'07 (EIS surveys)	Preferred habitat (Plant NET)
Polygonaceae						
Muehlenbeckia florulenta	Lignum	Section 1 only	Common	Native	N	Seasonally flooded low-lying areas of grey clay soils
Persicaria attenuata		Section 1 & 2	Common	Native	N	Margins of open swamps and wetlands
Persicaria decipiens	Slender Knotweed	Section 2 only	Common	Native	N	Common on creeks and river banks, margins of lagoons, swamps and channels on the coast and inland
Persicaria orientalis	Princes Feathers	Section 1 only	Common	Native	N	Widespread near water
Pontederiaceae						
Eichhornia crassipes	Water Hyacinth	Section 1 only		Introduced Declared noxious weed	Y	Stationary or slow-flowing, nutrient-rich water
Potamogetonaceae						
Potamogeton crispus	Curly Pondweed	Section 2 only	Common	Native	N	Slow-flowing freshwaters, also tolerant of slightly saline water
Potamogeton pectinatus	Fennel Pondweed	Section 1 & 2	Common	Native	N	Slightly saline to saline stationary water to approximately 4 m deep.
Potamogeton tricarinatus	Floating Pondweed	Section 2 only	Common	Native	N	Widespread in slowly flowing water of rivers and creeks to approximately 3 m deep
Salicaceae						
Salix humboldtiana	Chilean Willow	Section 1 only		Introduced	N	Riparian tree species
Typhaceae						
Typha domingensis	-	Section 2 only	Common	Native	Y	Swamps, margins of lakes and streams, irrigation channels and drains Reasonably salt-tolerant and can become a problem in drains
Typha orientalis	-	Section 2 only	Common	Native	N	Widespread in swamps, margins of lakes and streams, irrigation channels and drains
Ceratophyllaceae						
Ceratophyllum demersum	Hornwort	Section 2 only	Common	Native	Y	Widespread in wetlands, prefers alkaline or nitrogen rich waters

8.5.4 Marine Vegetation

8.5.4.1 General context

Marine plants are referred to in this section as those plants specified in, and protected under, the *Fisheries Act 1994* (Qld) and *Fisheries Regulation 1995* (Qld). Marine plants do not include declared species listed under the *Land Protection Act*. Under the *Fisheries Act*, the term Marine Plant includes true Marine species (mangroves, seagrass, saltmarsh), as well as species that typically occur adjacent to tidal lands including species such as *Casuarina glauca*, Melaleuca and *Cynodon dactylon*. This study considers all species and communities which occur directly adjacent to tidal lands and which may have some effect on Marine plants of fisheries value.

The mainland coastal plains situated between Calliope River and the Fitzroy River contain extensive tidal wetlands, which cover an area of approximately 450 km² (refer to Table 8.5 and Figure 8.6). These tidal wetlands are mainly comprised of mangrove forests and thickets (194.1 km²), saltmarsh communities (254.1 km²) and sedgelands (2.9 km²). As noted in Section 8.5.2, the Fitzroy River delta wetlands are listed in the Australian Directory of Important Wetlands (Environment Australia 2001) and are therefore considered to be of national significance.

Table 8.5 Marine Vegetation Types Mapped within the Region (RE Vegetation Mapping)

RE code	RE identification	Approximate area within project area vicinity[1]	Vegetation Management Act
11.1.2	*Samphire forbland* on marine clay pans	245.2 km²	Not of Concern
11.1.3	Sedgelands on marine clay pan	2.9 km²	Of Concern
11.1.4	Mangrove forest/woodland on marine clay pans	184.7 km²	Not of Concern
12.1.1	*Casuarina glauca* open forest on margins of marine clay pans	-	Of Concern
12.1.2	Saltpan vegetation including grassland and herb land on marine clay pans	8.9 km²	Not of Concern
12.1.3	Mangrove shrubland to low closed forest on marine clay plains and estuaries.	9.4 km²	Not of Concern

Samphire communities (dominated by succulent species) were the most extensive form of marine and saltmarsh vegetation identified within the broader region. The most extensive saltmarsh communities occurred adjacent to Casuarina, Inkerman, Raglan and Connor Creeks, located east of the project area (Figure 8.6).

Sedgelands are typically located landward of saltmarsh communities. These communities are typically associated with periodic or semi-permanent inundation by freshwater, although they may also be subject to occasional tidal influence. The most extensive sedgelands in the wider region occurred along Alligator Creek, situated approximately 11 km northeast from Inkerman Creek.

The most extensive mangrove forests in the broader region occurred in the lower Fitzroy River, primarily along Connor Creek and The Narrows. The Wildlife Online (QEPA, 2007) database listed nine mangrove species within the project area (Table 8.6).

Table 8.6 Mangrove Species Identified within the Project Area (Wildlife Online (QEPA, 2007))

Scientific name	Common name	Project area distribution	Conservation status
Avicenniaceae			
Avicennia marina	Grey Mangrove	Section 2 only	Common
Avicennia marina subsp. Australasica	Eastern White Mangrove	Section 2 only	Common
Euphorbiaceae			
Excoecaria agallocha	Milky Mangrove	Section 1 & 2	Common
Myrsinaceae			
Aegiceras corniculatum	River Mangrove	Section 2 only	Common
Myrtaceae			
Osbornia octodonta	Myrtle Mangrove	Section 2 only	Common
Plumbaginaceae			
Aegialitis annulata	Club Mangrove	Section 2 only	Common
Rhizophoraceae			
Bruguiera gymnorhiza	Large-fruited Orange Mangrove	Section 2 only	Common
Ceriops tagal	Yellow Mangrove	Section 2 only	Common
Rhizophora stylosa	Spotted Mangrove	Section 2 only	Common

8.5.4.2 Fitzroy to Bajool

No marine vegetation occurs within the Fitzroy to Bajool section of the project area. The closet area of mapped marine vegetation to this section of the project area is situated approximately 7 km downstream of the project area on Oakey Creek.

8.5.4.3 Bajool to Gladstone

Isolated areas of mangroves and saltmarsh communities occur within the Bajool to Gladstone section of the project area. RE mapping, together with ground-truthing in the present study, identified approximately 0.06 km^2 of mangrove forest on Raglan Creek and approximately 0.013 km^2 of mangrove forest at Inkerman Creek. No saltmarsh vegetation has been identified within the project area through RE mapping, however, sparse saltmarsh communities dominated by Pigweed (*Portulaca bicolor*) surrounding the tidal regions of Inkerman Creek were noted during surveys.

8.5.5 Macroinvertebrates

8.5.5.1 General

Freshwater

Numerous studies have examined the Aquatic (freshwater) macroinvertebrate fauna of the lower Fitzroy and Calliope River catchments. Most of these studies have examined Aquatic macroinvertebrates specifically to assess and monitor the current 'condition' and human impacts on streams (Conrick *et al.* 1997, Duivenvoorden and Roberts 1996, Noble and Rummenie 1996, URS 2007). These studies typically involved sampling of Aquatic macroinvertebrates using standard 'river health' monitoring methods (described in DNR 2001), with taxa typically identified to family level. Few studies have examined the species composition and assemblage structure of Aquatic macroinvertebrates in the wider catchment, and for this reason little is known of the population status and distribution of constituent species. Table 8.7 lists the macroinvertebrate species likely to be present within the project area.

Broad-scale 'river health' assessments in the Fitzroy River catchment (Conrick *et al.* 1997, Duivenvoorden and Roberts 1996) have found that:

- The most abundant taxa were *Coleoptera* (beetles), *Diptera* (flies/midges), *Ephemeroptera* (mayflies), *Hemiptera* (true bugs), *Odonata* (dragon and damsel flies), *Trichoptera* (caddis flies), Bivalvia (mussels), *Gastropoda* (snails), *Decapoda* (shrimps and crayfish); and *Isopoda* (shrimp-like animals) (Table 8.7). At this broad taxonomic level, the observed taxa composition was similar to that observed in most other coastal Queensland catchments (Choy and Marshall 1999, Conrick 2001, Conrick *et al.* 1997, Metzeling *et al.* 2003)
- Macroinvertebrate family richness (number of families) was typically more than 25 taxa per sampling occasion, with a maximum of 44 taxa recorded at any one site. Habitats with rocky substrates (riffles and rocky pools) supported the richest macroinvertebrate assemblages
- Importantly in the context of the present study, the two off-stream wetland sites sampled had a relatively rich (34 to 35 taxa/episode) and abundant macroinvertebrate assemblage compared to other sites sampled in the wider catchment (Duivenvoorden and Roberts 1996)
- The two low order, secondary stream sites sampled (by Duivenvoorden and Roberts 1996) also had a rich (more than 30 taxa/episode) macroinvertebrate assemblage. This is consistent with observations by BMT WBM elsewhere in the Fitzroy River catchment (WBM 2002), which found that ephemeral streams supported relatively rich and abundant macroinvertebrate assemblages within one to three weeks of flow events
- High diversity was often associated with greater habitat heterogeneity
- Macroinvertebrate taxa richness tended to be greatest in the upper reaches of the catchment, whereas most sites in the lower reaches were generally comprised of taxa that are more tolerant of environmental change
- Sandy pool habitats generally contained a lower richness and abundance of macroinvertebrates than edge and riffle habitats within the study area
- In addition to a low diversity (only bivalve and oligochaetes), bed samples in deep waters > 1 m (e.g. Fitzroy River) also tended have a low abundance of macroinvertebrate fauna
- Habitats with a low micro-habitat diversity, bare edges and/or sandy beds contained the lowest macroinvertebrate richness. This was especially true for ephemeral areas (i.e. those prone to drying).

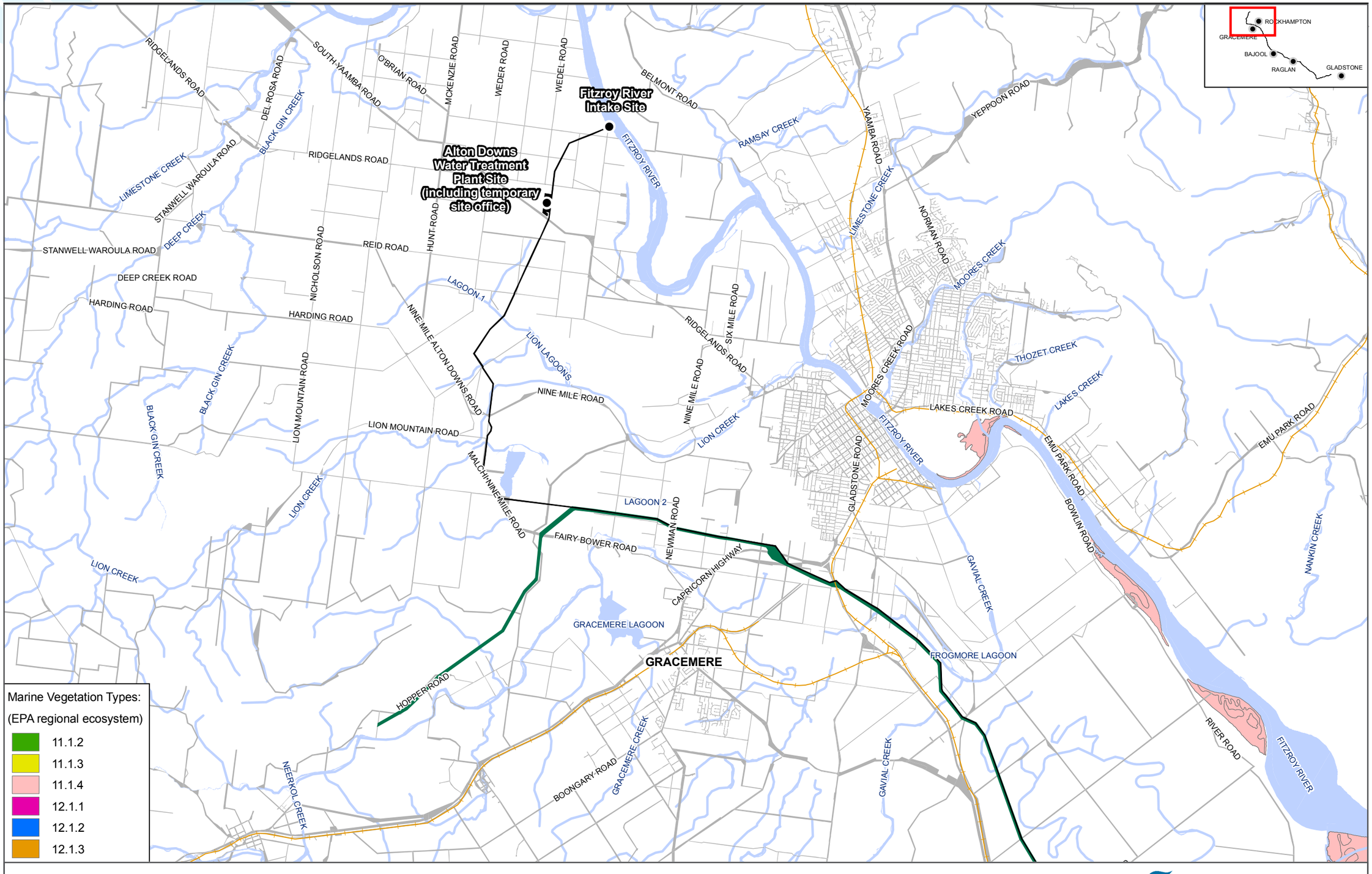
On the basis of SIGNAL scores (see Chessman 2001) for each site, which provide a relative measure of stream health based on macroinvertebrate assemblages, Conrick *et al.* (1997) classified most sites within the Fitzroy River catchment as being in a "moderate" condition. This suggests that, at the time of sampling, macroinvertebrates were in a moderately degraded state. This result possibly reflects habitat degradation resulting from extensive clearing and intensive grazing throughout the Fitzroy River catchment.

Estuarine

Estuarine macroinvertebrate communities found in tidal creeks within the broader region are typically numerically dominated by polychaete worms, molluscs (snails and mussels) and crustaceans (amphipods, isopods, crabs, shrimps and prawns). Surveys by Melzer (2004) throughout the Fitzroy and Gladstone regions identified 49 species, of which bivalve molluscs accounted for the greatest abundance.

Estuarine macroinvertebrates maintain key ecological processes and support the maintenance of coastal bird-life and fisheries (Long *et al.* 2004). From a fisheries perspective, Banana Prawns (*Penaeus merguiensis*) represent the most important commercially harvested shellfish species in the Fitzroy River estuary. The Fitzroy River represents one of seven key stocking areas for the Queensland Banana Prawn Fishery (DPI 2007). Banana Prawns are particularly responsive to variations in freshwater flow, moving to offshore areas when salinity reduces in the estuary (i.e. high freshwater flow). The estuarine habitats within the project area would provide sheltered nursery areas (i.e. mangroves) for this species.

Similarly, estuarine habitats within the project area would also provide nursery habitats, feeding grounds and other ecological functions for the Blue Swimmer Crab (Portunus pelagicus) and Mud Crab (Scylla serrata), which are also significant commercial fisheries species within the Fitzroy River estuary and wider region.



Gladstone - Fitzroy Pipeline Project

Figure 8.6 - Mapped Marine Vegetation within the Vicinity of the Project Area

Sheet 1 of 4

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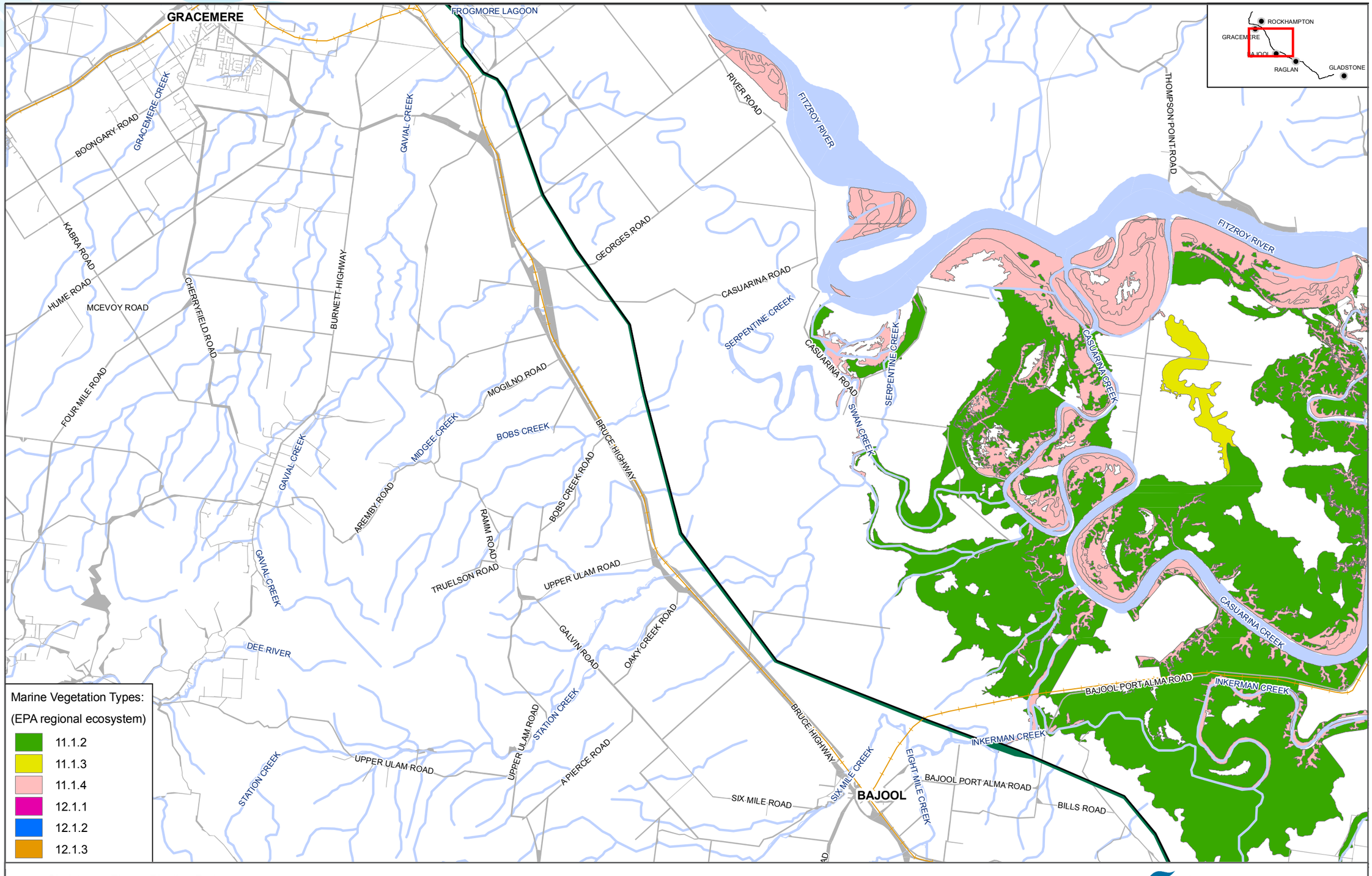

Gladstone - Fitzroy Pipeline Project

Figure 8.6 - Mapped Marine Vegetation within the Vicinity of the Project Area

Sheet 2 of 4

The Right of Way
Project Infrastructure
Railway Line
Road Reserve
Waterways
LGA Boundary
SGIC
GSDA

0 2 4 6 8 km

1:100,000 at A3

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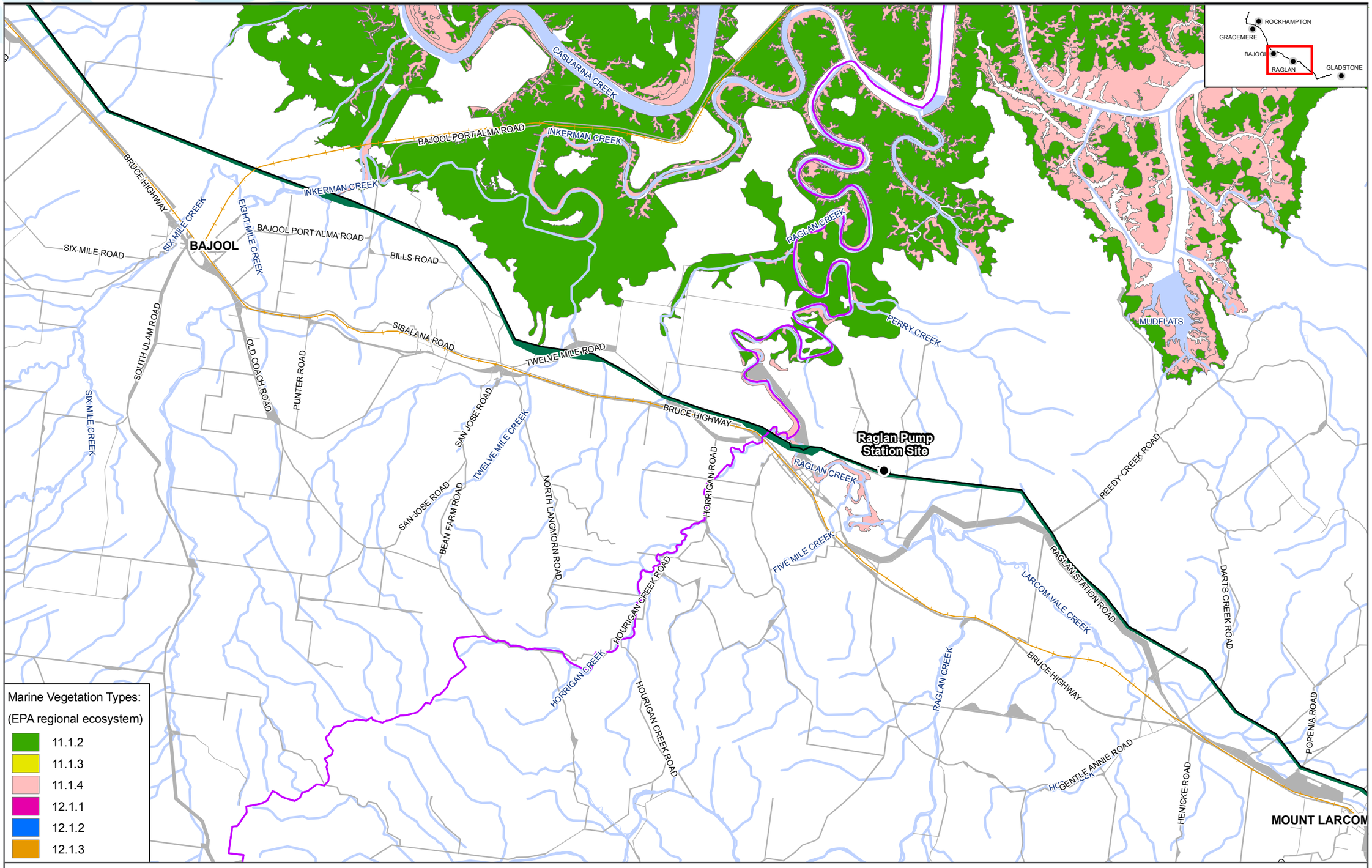
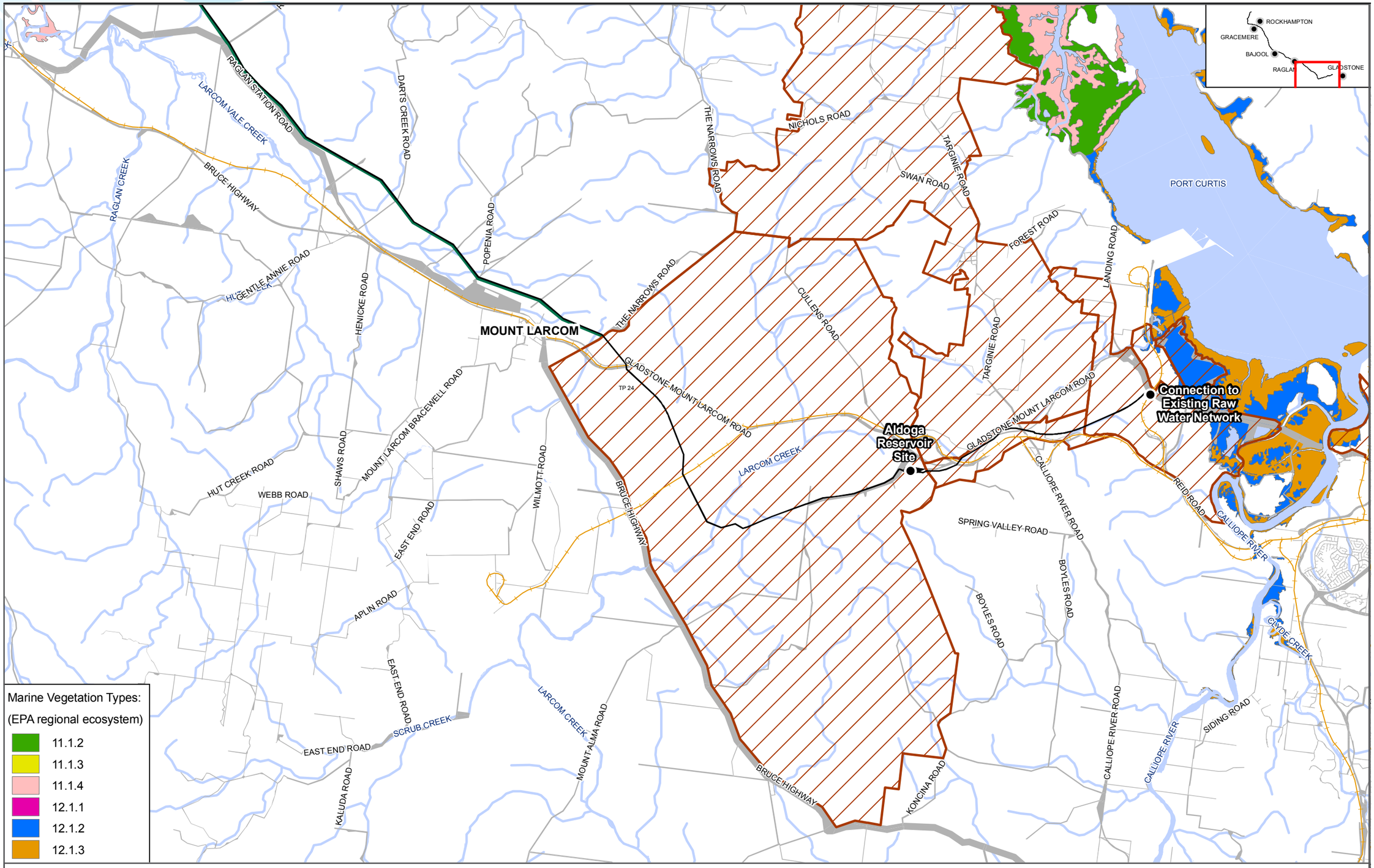
Gladstone Area Water Board

ARUP





While every care is taken to ensure the accuracy of this data, the Gladstone Area Water Board (GAWB) makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the plan being inaccurate or incomplete in any way and for any reason. It should also be noted that final survey of the pipeline alignment and SGIC boundary are yet to occur and may result in changes to the alignments depicted here.

Table 8.7 Freshwater Macroinvertebrate Fauna Likely to be Present within the Project Area
Source Conrick et al. (1997) lower Fitzroy Data and URS (2007)

Phylum/sub-phylum	Order/class	Family	Common name
Annelida	Nematodes		
	Oligochaetes		Blood Worms
	Hirudinea	Richardsonianidae	Aquatic Leeches
Mollusca	Gastropoda	Hydriidae	Freshwater Mussels
		Planorbidae	Freshwater Snails
		Thiaridae	Freshwater Snails
		Hydriobiidae	Freshwater Snails
		Lymnaeidae	Freshwater Snails
		Viviparidae	Freshwater Snails
		Physidae	Freshwater Snails
		Ancylidae	Freshwater Snails
	Bivalvia	Corbiculidae	Freshwater Bivalve
Arachnida	Arachnida	Hydrchnidae	Water Mites
Crustacea	Decapoda	Atyidae	Freshwater Shrimp
		Palaemonidae	Freshwater Prawns
		Parastacidae	Freshwater Crayfish*
	Copepoda		
	Ostracoda		Seed Shrimp
	Cladocera		Water Fleas
	Isopoda	Cirolanidae	Slaters/Pill Bugs
Insecta	Ephemeroptera	Baetidae	Mayflies
		Caenidae	
		Leptophlebiidae	
	Odonata	Coenagrionidae	Damselflies
		Aechnidae	Dragonflies
		Libellulidae	Dragonflies
	Hemiptera	Corixidae	Water Boatmen
		Notonectidae	Back Swimmers

Phylum/sub-phylum	Order/class	Family	Common name
		Pleidae	Pygmy Back Swimmers
		Veliidae	Small Water Striders
		Mesoveliidae	Water Striders
		Naucoridae	Creeping Water Bugs
		Gerridae	
	Coleoptera	Dytiscidae	Predacious Diving Beetles
		Haliplidae	Crawling Water Beetles
		Hydrophilidae	Scavenger Water Beetles
		Hydraenidae	Minute Rove Beetles
	Diptera	Chironomidae	Biting Midges
		Culicidae	Mosquitoes
		Ceratopogonidae	
	Trichoptera	Leptoceridae	
		Ecnomidae	
		Hydroptilidae	
		Calamoceratidae	

** Macroinvertebrates of recreational fisheries significance.*

Conservation Values

There are no Aquatic or Marine macroinvertebrate species listed under Commonwealth (EPBC Act) or State (NC Act, *Fisheries Act 1994*) legislation known or likely to occur within the project area or Fitzroy River catchment.

One Aquatic invertebrate taxa is listed as a 'Priority Species' for the Brigalow Belt South bioregion (QEPA 2005); namely spiny freshwater crayfish of the genus *Euastacus* (all species)[3]. Elsewhere, members of this genus typically contain species with extremely limited geographical distributions and highly specific habitat requirements (typically highland, rainforest streams; a habitat type that is not represented within the project area or surrounds). The ecology of *Euastacus* within the bioregion is poorly known. For this reason, it is uncertain what species occur in the catchment, and the location (if any) of important habitats of these species.

Fisheries Values

Freshwater streams within the project area and surrounds provide suitable habitat for freshwater crayfish (*Cherax* spp.), which are of direct recreational fisheries importance. Freshwater crayfish occur in a wide range of habitats, including farm dams, wetlands, ephemeral streams and rivers. Recreational anglers target crayfish using either collapsible traps or baited lines.

The estuarine creeks within the project area would support several macroinvertebrate species of direct economic significance, including crabs (Mud Crab (*Scylla serrata) and* Blue Swimmer Crab (*Portunus pelagicus)*), and penaeid prawns (particularly Banana Prawns (*Penaeus merguiensis)*). Project area waterways also discharge into the Fitzroy estuary and Great Barrier Reef Marine Park, which have very high fisheries habitat values at regional to national scales.

[3] Note – no aquatic invertebrate species are listed for the Central Queensland coast bioregion.

8.5.5.2 Fitzroy to Bajool

There is no available information on Aquatic macroinvertebrates specific to this section of the project area. It is likely that most of the freshwater taxa discussed above for the broader catchment would occur in the project area. Floodplain wetlands, ephemeral streams and the littoral edge habitat of the Fitzroy River are likely to support relatively rich and abundant macroinvertebrate communities. The more permanent waters of Gavial Creek may provide refuge for Aquatic taxa that are intolerant of pool drying. Based on patterns observed in similar habitats elsewhere in the catchment, it is likely that the deepwater 'bed' habitat of the Fitzroy River at the intake would not support a particularly rich or abundant macroinvertebrate assemblage.

8.5.5.3 Bajool to Gladstone

The proposed pipeline alignment within this section of the project area traverses both freshwater and estuarine habitats. URS (2007) examined the Aquatic macroinvertebrate fauna at one site on Larcom Creek, and found a relatively depauperate assemblage (11 families) that was numerically dominated by shrimps from the family Atyidae. BMT WBM is unaware of any other surveys in this section of the project area.

Estuarine habitats within this section of the project area occur at Raglan Creek, Horrigan Creek and Inkerman Creek. The habitat types present within and adjacent to these waterways are known elsewhere to be important habitats for several crustacean species of commercial significance (i.e. Banana Prawns, Mud Crabs, Blue Swimmer Crabs). The area of mangroves and saltmarsh habitats within this section of the project area (particularly Raglan Creek) is quite extensive (see Section 8.5.4), and it possible that this area has high fisheries habitat values at a local scale.

8.5.6 Fish

8.5.6.1 General

The freshwater fish fauna of the lower Fitzroy River catchment is well studied (see Marsden and Power 2007 for a review). Marsden and Power (2007) suggest that there is a total of 34 freshwater fish species within the lower Fitzroy River and catchment areas within close proximity to the project area. A review of database records by Pusey *et al.* (2004) lists 44 freshwater fish species within the Fitzroy, Dawson and Comet Rivers. A search of the Queensland EPA Wildlife Online database (QEPA, 2007), identified 32 species within the project area. Considering all identified sources, a total of 45 fish species are known or likely to occur within the project area and immediate surrounds.

Table 8.8 lists freshwater fish species previously recorded within the project area and surrounds. 22 native families and two exotic families were represented by the 45 species known or likely to occur in the project area. The family Eleotridae (gudgeon) represented the most speciose family with a total of eight species, followed by Terapontidae (Grunters) and Plotosidae (Eel-tailed Catfishes).

Most species known or likely to occur in the project area can be broadly described as common and widespread (Pusey *et al.* 2004). The exceptions to this are the Southern Saratoga (*Scleropages leichardti*) and Leathery Grunter (*Scortum hillii*), which are both thought to be locally endemic to the Fitzroy River catchment.

Pusey *et al.* (2004) identifies several known or likely translocated species within the Fitzroy River catchment: Mary River Cod (*Maccullochella peelii*), Silver Perch (*Bidyanus bidyanus*) and the Sooty Grunter (*Hephaestus fuliginosus*). With the possible exception of Sooty Grunter, it is thought that these introductions have failed. Note also that the ndangered Lungfish (*Neoceratodus forsteri)* was also translocated into the Fitzroy over 100 years ago but it is thought that the attempt also failed (Kemp 2005).

Three exotic species (i.e. those introduced from other countries) have been recorded in the catchments of the project area, namely; the Goldfish (*Carassius auratus**), Guppy (*Poecilia reticulate**) and the Eastern Gambusia or Mosquito Fish (*Gambusia holbrooki**). Due to the impact that exotic fish species can have on native species and Aquatic habitat, these species are considered noxious. Eastern Gambusia are declared a pest species under the *Fisheries Act 1994* (Qld) and *Fisheries Regulation 1995* (Qld).

Conservation Values

In terms of species of conservation significance, only one fish species previously recorded in the project area, Mary River Cod (*Maccullochella peelii*), is specifically protected under legislation (Table 8.9). This species is listed as Endangered under the EPBC Act, and is fully protected under the *Fisheries Act 1994* (Qld). This species has been translocated into the Fitzroy River catchment, although it is thought that the translocation attempt failed (Pusey *et al.* 2004). Note that the Wildlife Online (QEPA, 2007) database and the EPBC Act Protected Matters Report (DEWHA, 2007) did not identify any listed fish species within the project area.

Several fish species within the wider catchment are also considered as Threatened or near/potentially-Threatened, but are not specifically protected under legislation. These species are listed under a variety of non-statutory conservation schemes including Australian Society for Fish Biology (2001), International Union for the Conservation of Nature (IUCN) Red List, and listings of Priority taxa under the BAMM methodology (QEPA 2002). Six fish species that have been recorded within the project area are listed in at least one of these schemes (Table 8.9). Details on each of these species are provided below.

Southern Saratoga (Scleropages leichardti)

The Australian Society for Fish Biology (ASFB) lists Southern Saratoga as lower risk – near-Threatened, however it is not specifically protected under Commonwealth or State legislation. This species is known to favour large, slow flowing turbid streams (Allen 1989; Pusey *et al.* 2004), similar to habitat conditions found in the Fitzroy River at the extraction point. The other sections of the project area do not appear to represent optimal habitat for this species.

Purple-spotted Gudgeon (Mogurnda adspersa)

Inland and southern Australian populations of Purple-spotted Gudgeon have suffered large declines, and in these areas it is considered Threatened. The population status in southern Queensland coastal streams remains secure (Pusey *et al.* 2004) and is not specifically protected under legislation. This species has a widespread by patchy distribution, and may occur throughout most waterways, particularly larger streams more so than ephemeral drainages, in the project area.

Rendahl's Tandan (Porochilus rendahli)

This species is listed as a priority species by the Queensland EPA (2002). There is very little known about the population status and ecology of this species, hence it is difficult to assess its present day conservation status (Pusey *et al.* 2004). It is known to occur in both riverine and floodplain wetland habitats, and may therefore occur throughout most waterways within the Fitzroy to Bajool section of the project area.

Leathery Grunter (Scortum hillii)

Leathery Grunter, which was recorded throughout the study area in low numbers, has a restricted geographic distribution, and is thought to be endemic to the Fitzroy River system. As a consequence of its restricted geographic range, this species is classified as uncertain by the Queensland Department of Primary Industries (Wager 1993) and the ASFB, and poorly known under the Action Plan Conservation Status Listing (Wager and Jackson 1993). The habitat preferences of this species are not well understood. BMT WBM has recorded this species in perennial riverine habitats such as those found in the Fitzroy River within the project area, as well as turbid pools within ephemeral streams. This species is not known to occur in tidal waters.

Silver Perch (Bidyanus bidyanus)

Silver Perch is a non-indigenous native fish of conservation significance that has been stocked in the Fitzroy River catchment. This species is not specifically protected under Commonwealth or State legislation. The ASFB lists Silver Perch as Vulnerable. This species is not known to have established in the catchment (Pusey *et al.* 2004).

Jungle Perch (Kuhlia rupestris)

Jungle Perch is listed as a priority species by the Queensland EPA (2002). This species prefers rainforest riverine streams, but can also occur in other habitats such as lowland floodplain billabongs. This species may occur throughout the project area, although it is considered that this represents a marginal habitat for this species.

In general, the large, permanent waterholes (particularly the Fitzroy River at the intake site) located in the project area would provide suitable habitat for most of the above fish species of conservation significance, including the Mary River Cod. The more ephemeral, sandy streams within the project area would also represent movement corridors and temporary habitats during times of higher flow conditions.

Table 8.8 Freshwater Fish Species Recorded within the Project Area and Immediate Surrounds. Y = preferred habitat; P = possible/marginal habitat; N = habitat not suitable.

Scientific name	Common name	Catchment records	Project area distribution	Origin[2]	Primary habitat (spawning)	Migratory pattern	Habitat requirements	Permanent streams	Small ephemeral streams	Lagoons/ billabongs	Estuaries
Osteoglossidae											
Scleropages leichardti	Southern Saratoga	Fitzroy[2 & 14]	Section 1 only[a]	Native	Freshwater	Non-Migratory	Open turbid water, slow-moving rivers and pools, mouthbrooder.[1 & 9] Snags undercut banks and overhanging vegetation	Y	P/N	P/N	N
Megalopidae											
Megalops cyprinoides	Oxeye Herring	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Marine/ Freshwater (Marine)	Catadromous	Habitat generalist, but typically more abundant in open waters, highly fecund with pelagic eggs[1]	Y	P	P	Y
Anguillidae											
Anguilla obscura	Pacific Short-Finned Eel	Fitzroy[2]	Section 1 & 2[c]	Native				Y	P	P	Y
Anguilla reinhardtii	Long-Finned Eel	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater (Marine)	Catadromous	Generalist, but usually more common in rivers than lakes[4]	Y	P	P	Y
Clupeidae											
Nematalosa erebi	Bony Bream	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater	Potamodromous	Open water generalist, common in rivers and lakes[8]	Y	Y	Y	N
Ariidae											
Arius graeffei	Lesser Salmon Catfish	Fitzroy[2 & 14], Calliope[2]	Section 1 only[a, b & c]	Native	Freshwater/Estuarine (Freshwater)	Anadromous	Fresh, estuarine and coastal waters, demersal habitats, mouthbrooder[1]	Y	P/N	P	Y
Plotosidae											
Neosilurus ater	Black Catfish	Fitzroy[2 & 14]	Section 1 only[b & c]	Native possible	Freshwater	Potamodromous	Near bottom of lakes and slow-flowing rivers with rocky bottom[1]	Y	P	P	Y
Neosilurus hyrtlii	Hyrtl's Catfish	Fitzroy[2 & 14], Calliope[2]	Section 1 only[a, b & c]	Native	Freshwater	Potamodromous	Generalist, clear-flowing streams to turbid pools.[10]	Y	Y	Y	N
Porochilus rendahli	Rendahl's Catfish	Fitzroy[2 & 14]	Section 1 only[b & c]	Native	Freshwater	Potamodromous	Mud bottoms of lowland lagoons, flowing creeks and backwaters near Aquatic vegetation[13]	Y	Y	Y	N
Tandanus tandanus	Eel-tailed Catfish	Fitzroy[2 & 14], Calliope[2]	Section 1 only[b & c]	Native	Freshwater	Non-Migratory	Near bottom of lakes and slow-flowing rivers with rocky bottom[5]	Y	P/N	P	N
Retropinnidae											
Retropinna semoni	Australian Smelt	Fitzroy[2]	Section 1 only[a & c]	Native possible	Freshwater	Potamodromous	Slow moving streams or still waters, eggs laid amongst Aquatic vegetation[2]	Y	P	P	N
Hemiramphidae											
Arrhamphus sclerolepis	Snub-Nosed Garfish	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater/ Marine (Estuaries, can breed in freshwater)	Unknown	Open water, typically associated with Aquatic vegetation[2]	Y	P	P	Y
Belonidae											
Strongylura krefftii	Freshwater Longtom	Fitzroy[2 & 14]	Section 1 only[a, b & c]	Native	Freshwater	Potamodromous	Open water in larger streams[9]	Y	N	P	Y
Atherinidae											
Craterocephalus marjoriae	Marjorie's Hardyhead	Fitzroy[2]	Section 1 & 2[c]	Native possible	Freshwater	Non-Migratory	Schooling species, common in shallow waters.[11]	Y	P	P	N
Craterocephalus stercusmuscarum	Flyspecked Hardyhead	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater	Non-Migratory	Schooling species, common in shallow waters[11]	Y	P	P	N

Scientific name	Common name	Catchment records	Project area distribution	Origin[2]	Primary habitat (spawning)	Migratory pattern	Habitat requirements	Permanent streams	Small ephemeral streams	Lagoons/ billabongs	Estuaries
Melanotaeniidae											
Melanotaenia duboulayi	Duboulay's Rainbowfish	Fitzroy[2]	Section 1 & 2 [c]	Native possible				Y	Y	Y	N
Melanotaenia splendida splendida	Eastern Rainbowfish	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2 [a, b & c]	Native	Freshwater	Potamodromous	Creeks, rivers and ponds, particularly near snags and weed beds[9]	Y	Y	Y	N
Pseudomugilidae											
Pseudomugil signifer	Pacific Blue-eye	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2 [a, b & c]	Native	Freshwater	Amphidromous	Clear, fast-flowing streams, particularly the lower reaches[1] and estuaries.[9] Spawns in vegetation[1]	Y	Y	Y	Y
Synbranchidae											
Ophisternon spp.	Swamp Eel	Fitzroy[2 & 14]	Section 1 only [b & c]	Native	Freshwater/ Estuarine	Unknown	Benthic environments within shallow streams with little to no flow. Preferably areas with high portion of finer substrate with organic littler and in stream cover[2]	Y	P/N	P/N	Y
Scorpaenidae											
Notesthes robusta	Bullrout	Fitzroy[2 & 14], Calliope[2]	Section 1 only [a, b & c]	Native	Freshwater	Diadromous	Still or gentle flowing waters, with a rock, mud or gravel substrate, Aquatic vegetation and woody debris[2]	Y	P	P	Y
Chandidae											
Ambassis agassizii	Agassiz's Glassfish	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2 [a, b & c]	Native	Freshwater	Non-Migratory	Rivers, creeks, ponds and swamps near snags and Aquatic vegetation. [12] Eggs adhere to vegetation	Y	Y	Y	N
Centropomidae											
Lates calcarifer	Barramundi	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2 [a, b & c]	Native	Freshwater (Marine)		Rivers, large creeks, billabongs with connection to coastal swamps	Y	P/N	P/N	Y
Percichthyidae											
Maccullochella peelii	Mary River Cod	Fitzroy[2]	Section 1 only [c]	Translocated –failed/ uncertain				Y	P/N	P/N	N
Macquaria ambigua	Golden Perch/Yellowbelly	Fitzroy[2 & 14]	Section 1 only [a, b & c]	Native	Freshwater	Potamodromous	Turbid streams, from headwaters to estuaries[1]	Y	P	P	Y
Terapontidae											
Amniataba percoides	Barred Grunter	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2 [a, b & c]	Native	Freshwater	Non-Migratory	Creeks, ponds, clear or turbid, from headwaters to estuaries[1]	Y	Y	Y	Y
Bidyanus bidyanus	Silver Perch	Fitzroy[2]	Section 1 only [a & c]	Translocated –failed/ uncertain	Freshwater	Potamodromous	Generalist, prefers flowing waters, spawns on rocky substrates[1]	Y	P/N	P/N	N
Hephaestus fuliginosus	Sooty Grunter	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2 [b & c]	Translocated –failed/ uncertain				Y	Y	Y	P/N
Leiopotherapon unicolor	Spangled Perch	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2 [a, b & c]	Native	Freshwater	Potamodromous	Creeks, ponds, clear or turbid, from headwaters to estuaries.[1] Spawns in shallows on soft substrates	Y	Y	Y	N
Scortum hillii	Leathery Grunter	Fitzroy[2 & 14]	Section 1 only [a, b & c]	Native	Freshwater	Potamodromous	Flowing, still, clear and turbid waters.[1] Lays pelagic eggs[1]	Y	P	P	N
Kuhliidae											
Kuhlia rupestris	Jungle Perch	Fitzroy[2]	Section 2 only [a & c]	Native	Estuarine (Marine)	Catadromous	Fast flowing rainforest streams and rivers, occasionally in billabongs.[2]	Y/P	N	P	N

Scientific name	Common name	Catchment records	Project area distribution	Origin[2]	Primary habitat (spawning)	Migratory pattern	Habitat requirements	Permanent streams	Small ephemeral streams	Lagoons/ billabongs	Estuaries
Apogonidae											
Glossamia aprion	Mouth Almighty	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater	Non-Migratory	Still waters with Aquatic vegetation, from near tidal reaches to headwaters, mouthbrooder[12]	Y	P	Y	N
Mugilidae											
Mugil cephalus	Sea Mullet	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater (Marine)	Catadromous	Deep gentle flowing rivers[2]	Y	P	N	Y
Myxus petardi	Freshwater Mullet		Section 1 only[a]		Freshwater (Marine)	Catadromous	Deep gentle flowing rivers[2]	Y	P	N	Y
Gobiidae											
Glossogobius giuris	Flathead Goby	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[c]	Native							
Redigobius bikolanus	Speckled Goby	Fitzroy[2 & 14], Calliope[2]	Section 1 only[b & c]	Native	Freshwater	Amphidromous	With both lentic and lotic systems across a range of substrates[2]	Y	P	P	P/N
Eleotridae											
Gobiomorphus australis	Striped Gudgeon	Fitzroy[2], Calliope[2]	Section 1 & 2[a & c]	Native	Freshwater	Amphidromous	Small coastal streams and rivers, floodplain wetlands and estuaries	Y	Y	Y	Y
Hypseleotris compressa	Empire Gudgeon	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater	Amphidromous	Lower reaches of coastal rivers and streams, juveniles commonly occur in estuaries[3]	Y	Y	Y	Y
Hypseleotris galii	Firetail Gudgeon	Fitzroy[2], Calliope[2]	Section 1 & 2[a & c]	Native possible	Freshwater	Non-Migratory	Common around Aquatic vegetation in lakes, dams and streams[1]	Y	Y	Y	N
Hypseleotris klunzingeri	Western Carp Gudgeon	Fitzroy[2 & 14]	Section 1 only[a, b & c]	Native	Freshwater	Non-Migratory	Common around Aquatic vegetation in lakes, dams and streams[1]	Y	Y	Y	N
Hypseleotris spp. A	Midgley's Carp Gudgeon	Fitzroy[2 & 14], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater	Non-Migratory	Typically occurs around Aquatic vegetation, schools in caves and sheltered areas[1]	Y	Y	Y	N
Oxyeleotris lineolata	Sleepy Cod	Fitzroy[2 & 14]	Section 1 only[a, b & c]	Native	Freshwater	Non-Migratory	Shaded slow moving creeks, adhesive eggs on hard surfaces[1]	Y	Y	Y	N
Philypnodon grandiceps	Flathead Gudgeon	Fitzroy[2 & 14]	Section 1 only[b & c]	Native	Freshwater	Amphidromous	Aquatic vegetation and muddy bottoms in sluggish streams, ponds and estuaries.[1] Spawning sites include logs, rocks and tree roots	Y	Y	Y	Y
Mogurnda adspersa	Southern Purple-spotted Gudgeon	Fitzroy[2], Calliope[2]	Section 1 & 2[a, b & c]	Native	Freshwater	Non-Migratory	Slow moving creeks, spawns on hard substrate[3]	Y	P	P	N
Cyprinidae											
Carassius auratus	Goldfish	Fitzroy[2 & 14]	Section 1 only[b & c]	Alien	Freshwater	Unknown	Aquatic vegetation or rock for eggs to adhere too	Y	P	P	N
Poeciliidae											
Gambusia holbrooki	Eastern Gambusia	Fitzroy[2 & 14]	Section 1 & 2[a, b & c]	Alien	Freshwater	Non-Migratory	Most common in slow-flowing waters near weed beds[6]	Y	Y	Y	P
Poecilia reticulata	Guppy	Fitzroy[2]	Section 1 & 2[a & c]	Alien	Freshwater	Non-Migratory	Most common in slow-flowing waters near weed beds[6]	Y	Y	P	N

Data source: [1](Merrick and Schmida 1984); [2](Kemp 1993); [3](Larson and Hoese 1996); [4](Beumer 1996); [5](Pollard et al. 1996); [6](McDowell 1996b); [7](Allen 1996); [8](Briggs and McDowall 1996); [9](Allen 1989); [10](Pollard et al. 1996); [11](Ivantsoff and Crowley 1996); [12](Merrick and Schmida 1984; Pollard 1996); [13](Unmack, 1999 #2067); [14](Marsden and Power 2007)

Y = preferred habitat; P = possible/marginal habitat; N = habitat not suitable

Table 8.9 Fish Species of Conservation Concern Listed in Table 8.8

Species of significance	Conservation status	Habitat requirements	Potential locations in project area	Wildlife online records
Known/likely species				
Southern Saratoga (*Scleropages leichardti*)	Lower risk – near-Threatened (ASFB 2001)	Open turbid water, slow-moving rivers and pools, snags undercut banks and overhanging vegetation	Fitzroy River. The small creeks elsewhere do not represent preferred habitat, and it is likely to be uncommon/absent in these smaller drainages. This species is restricted to the Fitzroy catchment (Section 1 only)	Section 1 only
Purple-spotted Gudgeon (*Mogurnda adspersa*)	Restricted (ASFB 2001)	Slow moving creeks among Aquatic vegetation, requires hard substrate for spawning (Larson and Hoese 1996; Merrick and Schmida 1984)	Reportedly widespread but not abundant in the Fitzroy and Calliope Rivers (Pusey *et al*. 2004). Highly likely to occur within slow-flowing pools and lagoons within the project area, but not likely to be common in ephemeral streams	Section 1 & 2
Rendahl's Tandan (*Porochilus rendahli*)	Listed (QEPA 2002)	Mud bottoms of lowland lagoons, flowing creeks and backwaters near Aquatic vegetation	This species is likely to occur throughout the project area, including ephemeral streams	Section 1 only
Leathery Grunter (*Scortum hillii*)	Uncertain (ASFB 2001)	Flowing, still, clear and turbid waters	Fitzroy River. The small creeks elsewhere do not represent preferred habitat, although this species may occasionally occur in more permanent pools within these streams in low numbers. This species is restricted to the Fitzroy catchment (Section 1 only)	Section 1 only
Species not likely to occur in project area				
Mary River/Murray Cod (*Maccullochella peelii*)	Protected – *Fisheries Act* Endangered – *EBPC Act* Critically Endangered (ASFB 2001)	Slow flowing turbid waters of streams and rivers at low elevations, also fast-moving, clear, rocky upland streams	This species has been translocated into the Fitzroy River, but it is thought that translocations failed	Section 1 & 2
Silver Perch (*Bidyanus bidyanus*)	Vulnerable (ASFB 2001)	Rivers, lakes and reservoirs, preferring areas of rapid flow	This species has been translocated into the Fitzroy River, but it is thought that translocations failed	Section 1 only
Jungle Perch (*Kuhlia rupestris*)	Listed (QEPA 2002)	Depths to approximately 1 m, species has an extreme movement pattern	This species prefers rainforest riverine streams, but can also occur in other habitats. May occur in the Fitzroy River. The small creeks elsewhere do not represent preferred habitat, although this species may occasionally occur in more permanent pools within these streams in low numbers.	Section 2 only

Note: Non Statutory Conservational Schemes (a) IUCN – International Union for the Conservation of Nature and Natural Resources "Red List"; (b) ASFB – Australian Society for Fish Biology "Conservation Status of Australian Fishes 2001"; (c) BAMM – Biodiversity Assessment and Mapping Methodology – Appendix detailing Priority Taxa (QEPA 2002)

Fisheries Significance

The Coastal Habitat Resource Information System (CHRIS) (DPIF 2007) provides commercial fisheries catch data over a grid system (30-minute grid), which covers the state of Queensland. Two 30-minute grid sections (Q29 and Q30) incorporate the whole project area (excluding Fitzroy River, which is declared as closed to commercial fishing under the *Fisheries Regulation 1995* (Qld)). No commercial catch data were reported for these grids. Note however that due to privacy considerations, catch data are not reported in instances where there are less than five operators within a grid section. It is therefore possible that low levels of commercial fishing effort are expended in the project area. It is highly unlikely that minor streams and waterbodies within the project area would be regularly fished by commercial operators.

No systematic data is available on recreational fishing catch and effort in the freshwater reaches of the project area and surrounding areas. Anecdotal reports suggest that the most popular recreational fishing locations within the broader area occur in the lower reaches of the Fitzroy River. It is notable that there are closures to recreational fishing within 200 to 400 m of the barrage.

Several of the tidal waterways (e.g. Raglan Creek and Inkerman Creek), and large, deeper waterholes (e.g. Twelve Mile Creek) particularly those accessible by public roads, are utilised by recreational anglers. Physical access constraints are likely to pose a significant restriction to fishing opportunities within most other streams in the project area.

Several fish species known or likely to occur in the project area are of direct economic importance, as they form either part of a commercial fishery or are targeted by recreational anglers for consumption, sport or bait. Based on discussions with local residents and information from the wider catchment, Barramundi is likely to be the most targeted and commonly caught species by recreational anglers, although other species such as Long-finned Eels, Sea Mullet, Yellowbelly Perch, Eel-tailed Catfish and Silver Perch are also targeted in freshwater reaches. A list of fish species of economic significance known or likely to occur in the project area is provided in Table 8.10.

Table 8.10 Species of Economic Significance in Freshwater Reaches of the Project Area and Surrounds

Scientific name	Common name	Fisheries significance
Anguilla reinhardtii	Long-finned Eel	Commercial / recreational
Strongylura krefftii	Freshwater Longtom	Recreational
Lates calcarifer	Barramundi	Commercial / recreational
Nematalosa erebi	Bony Bream	Recreational
Oxyeleotris lineolata	Sleepy Cod	Recreational
Arrhamphus sclerolepis	Snub-nosed Garfish	Recreational
Megalops cyprinoides	Oxeye Herring	Recreational
Mugil cephalus	Sea Mullet	Recreational
Myxus petardi	Freshwater Mullet	Recreational
Scleropages leichardti	Southern Saratoga	Recreational
Macquaria ambigua	Golden Perch/Yellowbelly	Recreational
Tandanus tandanus	Eel-tailed Catfish	Recreational
Amniataba percoides	Barred Grunter	Recreational
Bidyanus bidyanus	Silver Perch	Recreational
Leiopotherapon unicolor	Spangled Perch	Recreational

Migratory and spawning patterns

Many of the fish species that occur within the lower Fitzroy River catchment are known to undergo some form of migration, usually for reproduction and spawning (refer to Table 8.8). Such migrations can be broadly classified into the following four categories.

- *Catadromous species*. Fish that migrate from freshwater to the sea to breed. This includes (but not limited to):
  - Long-finned Eel (*Anguilla reinhardtii*). Adult eels migrate downstream in December to April, and are thought to spawn in the deep waters of the Coral Sea (Beumer 1996)
  - Sea Mullet (*Mugil cephalus*). Sea Mullet migrate offshore in winter to spawn (Merrick and Schmida 1984, Thomson 1996)
  - Barramundi (*Lates calcarifer*). Barrumundi migrate to salt water (river mouths or Marine bays) to spawn from September to March
- *Anadromous species*. Fish that migrate from the sea to freshwater to breed. Only one anadromous species has been recorded in the catchment, the Lesser Salmon or Blue Catfish (*Arius graeffei*). Populations of the Salmon Catfish that inhabit estuarine and coastal waters are known to undertake extensive anadromous migrations into fresh-waters to spawn (Pollard and Rimmer 1996). This species is also known to be capable of inhabiting freshwaters for its entire lifecycle, although it is unknown whether this species can spawn in estuarine waters (Pollard and Rimmer 1996)
- *Amphidromous species*. Fish that migrate between the sea and freshwater, but not to breed. For example, Striped Gudgeon (*Gobiomorphus australis*), Pacific Blue-eye (*Pseudomugil signifier*), and Spangled Perch (*Leiopotherapon unicolor*) may occur in estuaries, but all are essentially freshwater species
- *Potamodromous species*. Fish that migrate wholly within freshwater. 11 fish species recorded in the Fitzroy to Bajool section of the project area are known to live their entire lifecycle in freshwaters. However, several species are known to migrate upstream to spawn, including Bony Bream (*Nematalosa erebi*), Australian Smelt (*Retropinna semoni*), Freshwater Longtom (*Strongylura krefftii*) and Spangled Perch (*Leiopotherapon unicolor*). It is possible that some of the other Gudgeon species also undertake limited movements during their lifecycle.

Note that the construction of the Fitzroy River Barrage, which was undertaken in 1970 to supply water to the City of Rockhampton, is thought to represent a major impediment to the movement patterns of fish (and other Aquatic biota). The barrage, despite having a functioning fishway since 1997, reduces the number of fish that can migrate upstream, including Barramundi. Sawynok (2002) suggests that the combined impacts of barrages, weirs and ponded pastures in the catchment effectively isolates approximately 80 percent of the original extent of available habitat, except during major flooding events when these structures are overtopped. Supplementary stocking of Barramundi is now undertaken upstream of the barrage.

8.5.6.2 Fitzroy to Bajool

Project area waterways in the Fitzroy to Bajool section could, from time to time, represent potential habitat for most fish species listed in Table 8.8. The actual habitat value of project area waterways will however depend on a number of factors, such as biogenic habitat structure (e.g. presence of macrophytes and snags); water permanency and physical dimensions of the waterbody; patterns in connectivity of the waterbody to other waterbodies in space and time; presence of in-stream barriers (natural and man-made); physio-chemical characteristics of the waterbody; and flow characteristics (patterns in space and time).

As discussed in Section 8.5.1.1, several meso-habitat types were represented in the project area, namely:

- Deep perennial riverine habitat (Fitzroy River)
- Floodplain lagoon
- Ephemeral, low order streams
- Tidal/mangrove lined creek.

All these meso-habitats except tidal/mangrove-lined creeks were represented in the Fitzroy to Bajool section. The Fitzroy River at the pipeline intake represents perhaps the most important Aquatic habitat for fish of economic (e.g. Barramundi, Yellowbelly and Southern Saratoga) and conservation significance (all the 'likely' species listed in Table 8.9). This site represents permanent refugia, and contains a diverse range of micro-habitats (snags, some rock and backwaters) of importance for fish spawning, shelter, and feeding sites. This site also forms a locally important fishing area.

The floodplain lagoons (Lagoons 1 and 2) in this section also represent potentially good quality fish habitats, and as discussed earlier, these wetlands connect to the Fitzroy River during large flood events. Floodplain lagoons are known to represent important refugia during prolonged dry weather conditions and a source of fish (and macroinvertebrate) propagules during flood conditions. Given the small size and shallow depths of these lagoons, it is unlikely that these lagoons would contain large numbers of larger bodied fish species (e.g. Southern Saratoga, Yellowbelly, Barramundi) during prolonged drought conditions, although during wetter periods these lagoons may represent good quality fisheries habitats. Purple-spotted Gudgeon and Agasizzi's Glassfish are likely to be present.

The ephemeral drainages (Lion Creek and Station Creek) are likely to represent temporary habitat movement corridors for most fish species during certain flow conditions. However, no large, permanent waterbodies are known to occur on the creeks upstream of the project area, limiting the values of these waterways as fish habitats. The semi-permanent in-stream pools on Gavial Creek represent potential fish refugia during low and zero flow conditions.

8.5.6.3 Bajool to Gladstone

Tidal Creeks

The Bajool to Gladstone section of the project area intersects tidal creeks at two main points, namely Inkerman Creek and Raglan Creek. Raglan Creek and Inkerman Creek are mangrove-lined tidal creeks that supports habitat types that are of importance to fisheries productivity. Mangrove-lined creeks are known to represent potential nursery habitats and feeding areas for many fish and nekton-benthic species (prawns, crabs etc.). It should be noted that when considering the fisheries habitat value of an area, it is important to consider the spatial organisation of habitat patches and types (i.e. degree of fragmentation), together with other attributes such as structural complexity and size of habitat patches, and the degree of tidal inundation/flushing. On this basis, the following broad conclusions are applicable to habitat values of the two creeks:

- Extensive areas of inter-tidal habitat are present in the project area, including well-flushed mangals, tidal channels with undercut banks, and mud flats in places. These inter-tidal environments provide shelter and/or foraging areas for fish and nektobenthos during high tide
- Saltmarsh plants. Saltmarsh communities within the project area are inundated tidally during high water spiring events and are known from case studies elsewhere to provide functional habitats and foraging areas for a range of fish (typically small-bodied, non-commercial species) and crustaceans (including penaeid prawns and non-commercial crab species) of indirect and direct fisheries value (Morton *et al.* 1987, Mousalli and Connolly 1998)
- It is notable that there are no seagrass meadows situated at or directly adjacent to the project area, most likely a consequence of the turbid nature of waters in this area.

Based on this, it can be concluded that the two tidal creeks provide a range of structurally complex habitats for fish and crustaceans of commercial and non-commercial significance. These environments would contribute to the fisheries productivity of the Fitzroy-Gladstone region, and are likely to represent important fisheries habitats at a highly localised scale. However, given their small area, it is unlikely that the project area waterways have a high value at broad spatial scales (i.e. scales measured at 100s of metres to kilometres).

No listed fish species of conservation significance are known or likely to occur in the project area tidal creeks.

Freshwater Habitats

The freshwater habitats within this section of the project area are mostly low-order ephemeral drainages (i.e. Marble, Pelican, Larcom Vale and Sandy Creeks). These drainages would be expected to have similar functional fish habitat values as the ephemeral drainages described in Section 8.5.6.2.

The largest freshwater waterbodies in this section of the project area were situated on Twelve Mile Creek and Larcom Creek. As discussed in Section 8.5.1.3, Twelve Mile Creek is heavily disturbed by cattle and presently has limited habitat diversity. Nonetheless, the permanent pools within the watercourse would provide Aquatic refugia for many fish species, possibly including larger-bodied fish species such as Yellowbelly and Eels. This creek also occurs near and drains into the high quality fisheries habitats of Raglan Creek, potentially increasing its fish habitat values for catadromous species.

Larcom Creek also represents a fish refugia, and contains a wide diversity of micro-habitats. This waterway is not situated in the Fitzroy catchment and is therefore not known to be within the geographic range of several large-bodied fish species, such as Southern Saratoga, Leathery Grunter and Yellowbelly. Nonetheless, it would support suitable habitat for species of conservation significance such as Purple-spotted Gudgeon, Agasizzi's Glassfish and possibly Rendahl's Tandan.

8.5.7 Freshwater Turtles

8.5.7.1 General

Five species of freshwater turtle are known to occur within the broader catchment in which the project area is located, namely: Broad-shelled River Turtle (*Chelodina expansa*), Eastern Snake-necked Turtle (*Chelodina longicollis*), Krefft's River Turtle (*Emydura krefftii*), Fitzroy River Turtle (*Rheodytes leukops*) and Saw-shelled Turtle (*Elseya latisternum*). Most of these species are widespread and abundant throughout the broader region, the exception being the Fitzroy River Turtle, which is restricted to the Fitzroy River catchment (Table 8.11).

Table 8.11 Freshwater Turtle Species Known to Occur in the Catchment of the Project Area

Scientific name	Common name	Project area distribution	Conservation status
Chelidae			
Chelodina expansa	Broad-shelled River Turtle	Sections 1 & 2	Common
Chelodina longicollis	Eastern Snake-necked Turtle	Sections 1 & 2	Common
Emydura krefftii	Krefft's River Turtle	Sections 1 & 2	Common
Rheodytes leukops	Fitzroy River Turtle	Sections 1 & 2	Vulnerable
Elseya latisternum	Saw-shelled Turtle	Sections 1 & 2	Common

The Fitzroy River Turtle is listed as Vulnerable under both Commonwealth (EPBC Act) and State (Queensland NC Act) legislation. The distribution of this species is wholly confined to the Fitzroy River and its tributaries, occurring in permanent freshwater riverine reaches and large, isolated, permanent waterholes (Cogger 2000). Habitats favoured by the Fitzroy River Turtle include both deep, large pools and shallow, fast-flowing waters with gravel, rock or sandy substrates. They prefer clear water and are often associated with submerged logs and undercut banks (Cann 1998).

A combination of threatening processes has contributed to the conservation status of the Fitzroy River Turtle and continues to be a source of ongoing pressure. The most significant threats for this species are: nest predation by feral animals (e.g. foxes and pigs); waterway pollution and siltation; riparian modifications from grazing, agriculture, mining and timber harvesting; and the construction of weirs reducing the amount of suitable habitat (i.e. prefers well-oxygenated, flowing water) (Cogger *et al.* 1993).

A number of additional key ecological requirements for the Fitzroy River Turtle are present at Aquatic sites within the project area. These include nesting habitats (i.e. sand or gravel stream banks) and food resources (e.g. Aquatic insects, Aquatic macrophytes and terrestrial plant material) (Cogger *et al.* 1993). Despite the lack of preferred habitat (i.e. well-oxygenated, flowing water), the project area could support the Fitzroy River Turtle but is not considered to represent areas of core habitat.

8.5.7.2 Fitzroy to Bajool

Shells of the Krefft's River Turtle (*Emydura krefftii*) were observed at three locations within the Fitzroy to Bajool section of the project area during the field investigations conducted for this EIS. This strongly suggests that these particular locations, Lagoon 2, Gavial Creek and Frogmore Lagoon, represent Aquatic habitat that is utilised by this species. Although limited data is available, studies elsewhere in Queensland suggest that *Emydura* spp. often represent the numerically dominant turtle species. For example, surveys near Walla Weir in the Burnett River indicate that Krefft's River Turtle represented approximately 93 percent of the total turtle catch (Limpus *et al.* 1997). Unpublished observations by BMT WBM field staff also indicate that *Emydura* spp. are relatively common in Queensland catchments.

Most of this section of the project area represents marginal habitat for the Vulnerable Fitzroy River Turtle. As discussed in this section, this species prefers permanent freshwater riverine reaches and large, isolated permanent waterholes. Within the project area, the Fitzroy River at the extraction point, and possibly Gavial Creek and the two off-stream lagoons (Lagoons 1 and 2), represent potential but low quality (i.e. not typically fast-flowing or clear waters) habitat for this species.

8.5.7.3 Bajool to Gladstone

Shells of the Krefft's River Turtle (*Emydura krefftii*) were observed at one location within the Bajool to Gladstone section of the project area, Larcom Creek, during field investigations conducted for this EIS. It is likely that this species, together with the other three common and widespread species, occurs in waterbodies throughout the project area.

Most of this section of the project area represents marginal habitat for the Vulnerable Fitzroy River Turtle. As discussed above, this species prefers permanent freshwater riverine reaches and large, isolated permanent waterholes. Within the project area, the larger freshwater waterbodies (Twelve Mile Creek and Larcom Creek) represent only marginal habitat for this species as their waters are typically not clear or fast-flowing.

8.5.8 Marine Megafauna

8.5.8.1 Fitzroy to Bajool

There are no Marine areas in this section of the project area.

Within the Fitzroy to Bajool section of the project area populations of Estuarine Crocodile have been reported (Britton 2007), primarily in the Fitzroy River. See below for further details on this species.

8.5.8.2 Bajool to Gladstone

There are four species of Marine turtle occurring within the Central Queensland coastal region (GBRMPA 1993). These species include the Green Turtle (*Chelonia mydas*), Flatback Turtle (*Natator depressa*), Loggerhead Turtle (*Caretta caretta*) and Hawksbill Turtle (*Eretmochylus imbricata*). Marine turtles are protected under the NC Act, with the Loggerhead and Olive Ridley Turtles listed as Endangered, and the Green, Hawksbill and Flatback Turtles listed as Vulnerable. (All of these marine turtle species are protected under the EPBC Act) The most likely turtle to inhabit nearshore areas close to the Fitzroy River is the Green Turtle (*Chelonia mydas*), which is listed as Vulnerable under the EPBC Act, and is also listed as a Migratory and Marine species under the EPBC Act.

Dugongs have a global IUCN listing of Vulnerable to extinction (IUCN 1996), they are listed Threatened, Migratory and Marine species under the EPBC Act and the Queensland dugong population is considered as Vulnerable under the NC Act. Dugongs are not likely to occur in the estuarine areas of the project area.

The most common species in the coastal region is the Green Turtle. Green Turtles are known to feed directly on seagrasses and algae (Kuiper-Linley *et al.* 2007), while Loggerhead Turtles are known to feed on bivalve molluscs from seagrasses and hard bottom areas (Limpus *et al.* 1994). Dugongs feed almost exclusively on certain seagrass species. Changes to seagrass (and/or reef communities for some turtles) can therefore impact on turtles and dugongs. No seagrass or major reef communities exist within the estuary reaches of the project area. While their distribution is not physically limited to areas where, for example, seagrasses grow, marine turtles and dugongs are likely to be only transient visitors (if at all) to these creeks.

The project area does not contain suitable nesting sites for marine turtles. The project area contains mangrove-lined creeks, whereas turtles typically nest in sandy beach/dune environments, where they can excavate a nest for their eggs. No particular sites are known as major nesting areas, since nesting intensity is highly variable between years.

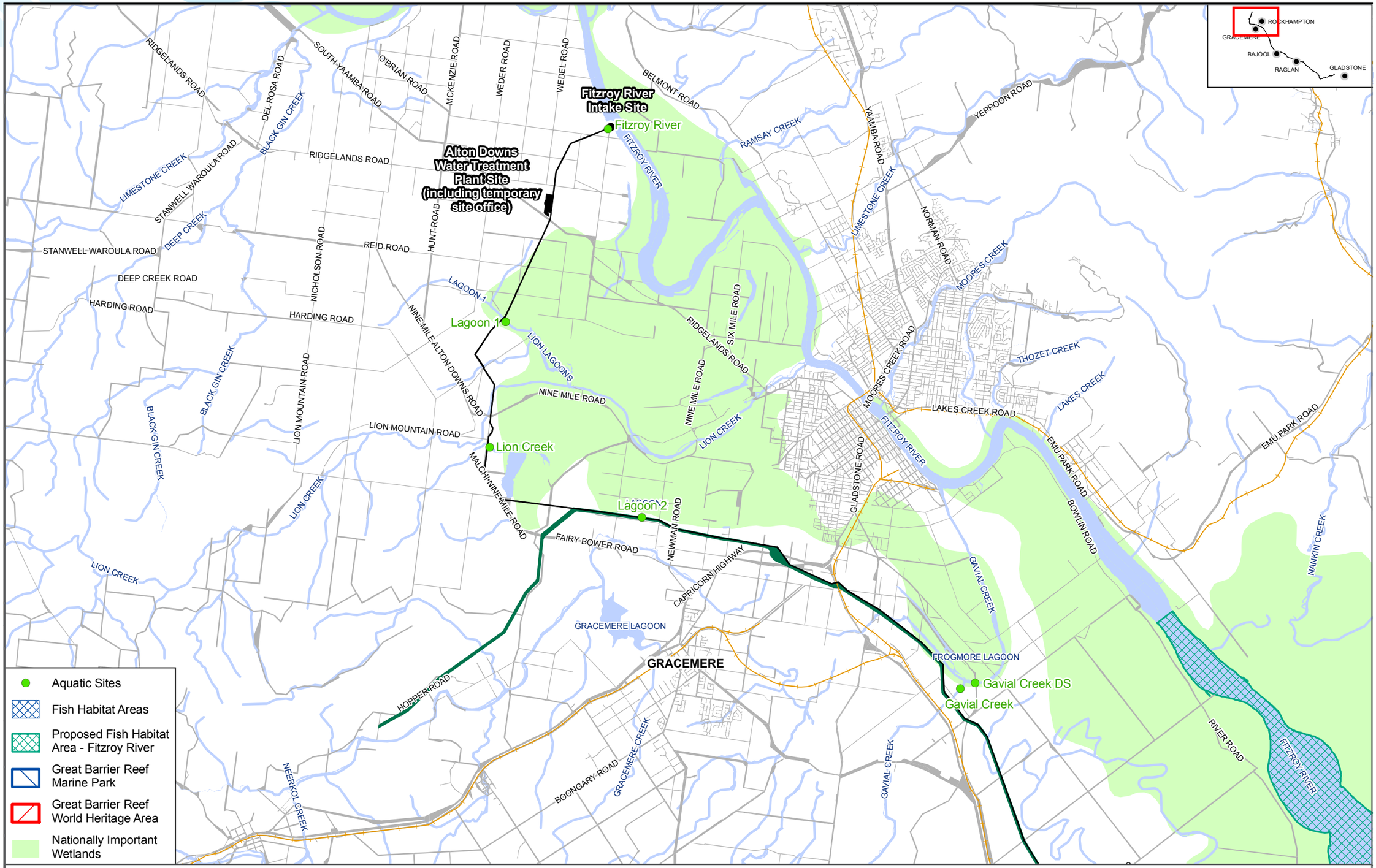
The marine megafauna species most likely to occur in the project area is the Estuarine Crocodile (*Crocodylus porosus*). The Estuarine Crocodile is listed as Vulnerable under Queensland's NC Act, and as a 'listed Migratory species' under the EPBC Act. The species is widely distributed within tropical Australia, with the project area situated towards the southern extent of its range. The Estuarine Crocodile inhabits coastal rivers and creeks through to upper reaches of freshwater rivers, beyond any tidal influences including isolated lagoons and billabongs, which can be permanent or seasonal. The species generally inhabit areas with a high accessibility to feeding areas and potential nesting environments.

Within the Bajool to Gladstone section of the project area, Raglan Creek, Twelve Mile Creek and Inkerman Creek represent areas likely to be inhabited by the Estuarine Crocodile.

8.5.9 Summary of Key Aquatic Ecology Values

A number of areas of Aquatic conservation estate are located in the project region, and the wider region, some shown in Figure 8.7, and include the following features:

- Great Barrier Reef Marine Park (GBRMP). The GBRMP is administered under the *Great Barrier Reef Marine Park Act 1975* (Cth), and its associated regulations and plans. The GBRMP is located approximately 49 km downstream of the northern most extent of the project area on the Fitzroy River. The southern extent of the project area is approximately 9 km from the protected Narrows estuarine area, which is part of the GBRMP. The waters adjacent to the Fitzroy River mouth are zoned general use. The closest habitat protection zone is located within the Narrows, located more than 9 km south of the project area
- Great Barrier Reef World Heritage Area (GBRWHA). The GBRWHA is specifically protected under the provisions of the Commonwealth EPBC Act. The GBRWHA boundary is located coincident with the GBRMP boundary
- Ramsar listed wetlands. The closest Ramsar wetland aggregation to the project area is Shoalwater and Corio Bays Ramsar site, located 46 km north of the Fitzroy River mouth. Specific protection of the wetland is provided by the Commonwealth under the provisions of the EPBC Act
- Wetlands of National Significance. Three wetlands within or adjacent to (downstream) the project area are listed under the Directory of Important Wetlands in Australia (Environment Australia 2001): Fitzroy River Floodplain wetlands (within the Fitzroy to Bajool section); Fitzroy River delta wetlands (within the Fitzroy to Bajool section); and GBRMP (discussed above). Designation in the directory does not afford specific protection to the wetland under Commonwealth or State legislation



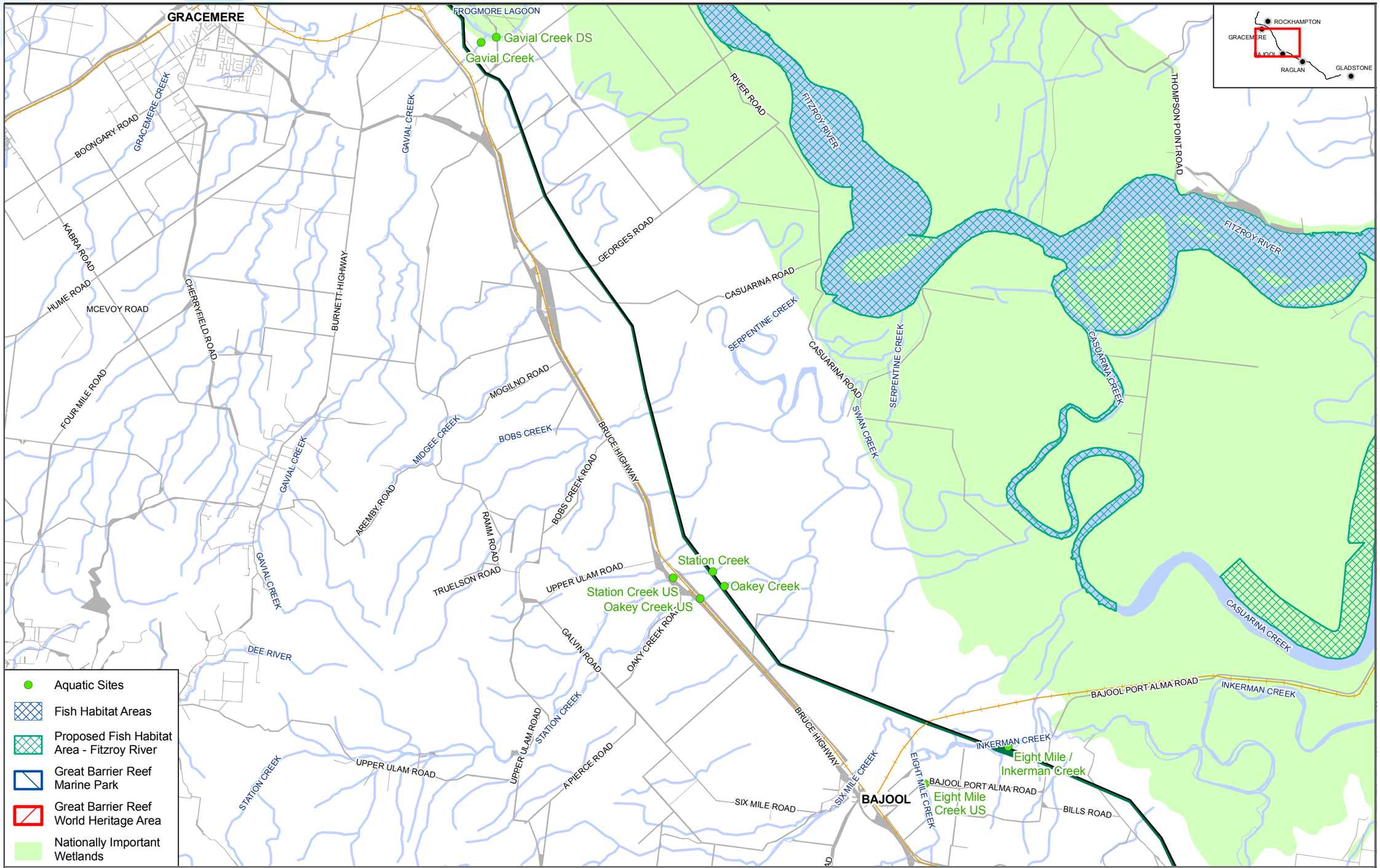
Gladstone - Fitzroy Pipeline Project

Figure 8.7 - Areas of Aquatic Conservation Estate

Sheet 1 of 4

Gladstone Area Water Board

ARUP



Gladstone - Fitzroy Pipeline Project

Figure 8.7 - Areas of Aquatic Conservation Estate

Sheet 2 of 4

The Right of Way
Project Infrastructure
Railway Line
Road Reserve
Waterways
LGA Boundary
SGIC
GSDA

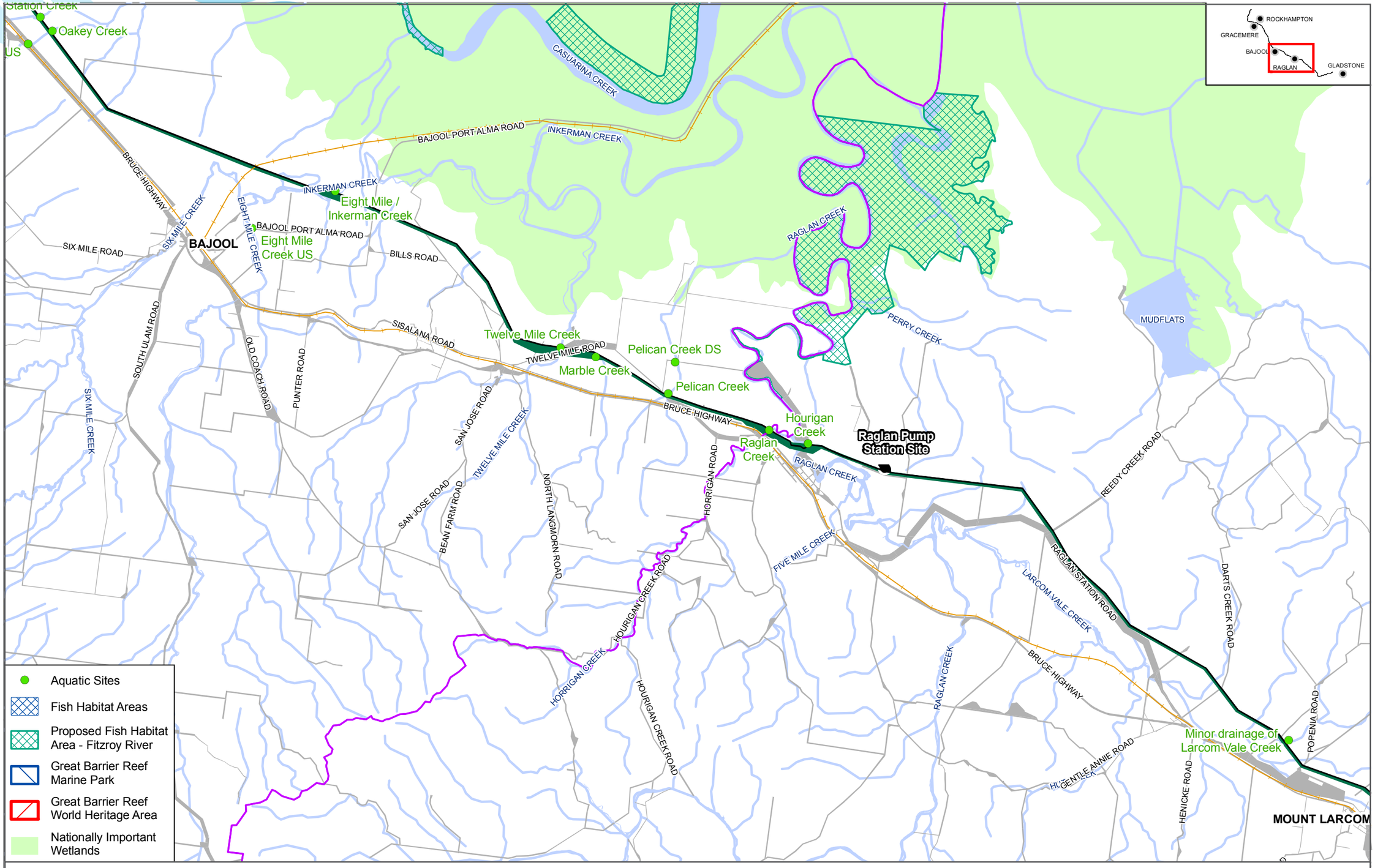
0 2 4 6 8 km

1:100,000 at A3

N

Gladstone Area Water Board

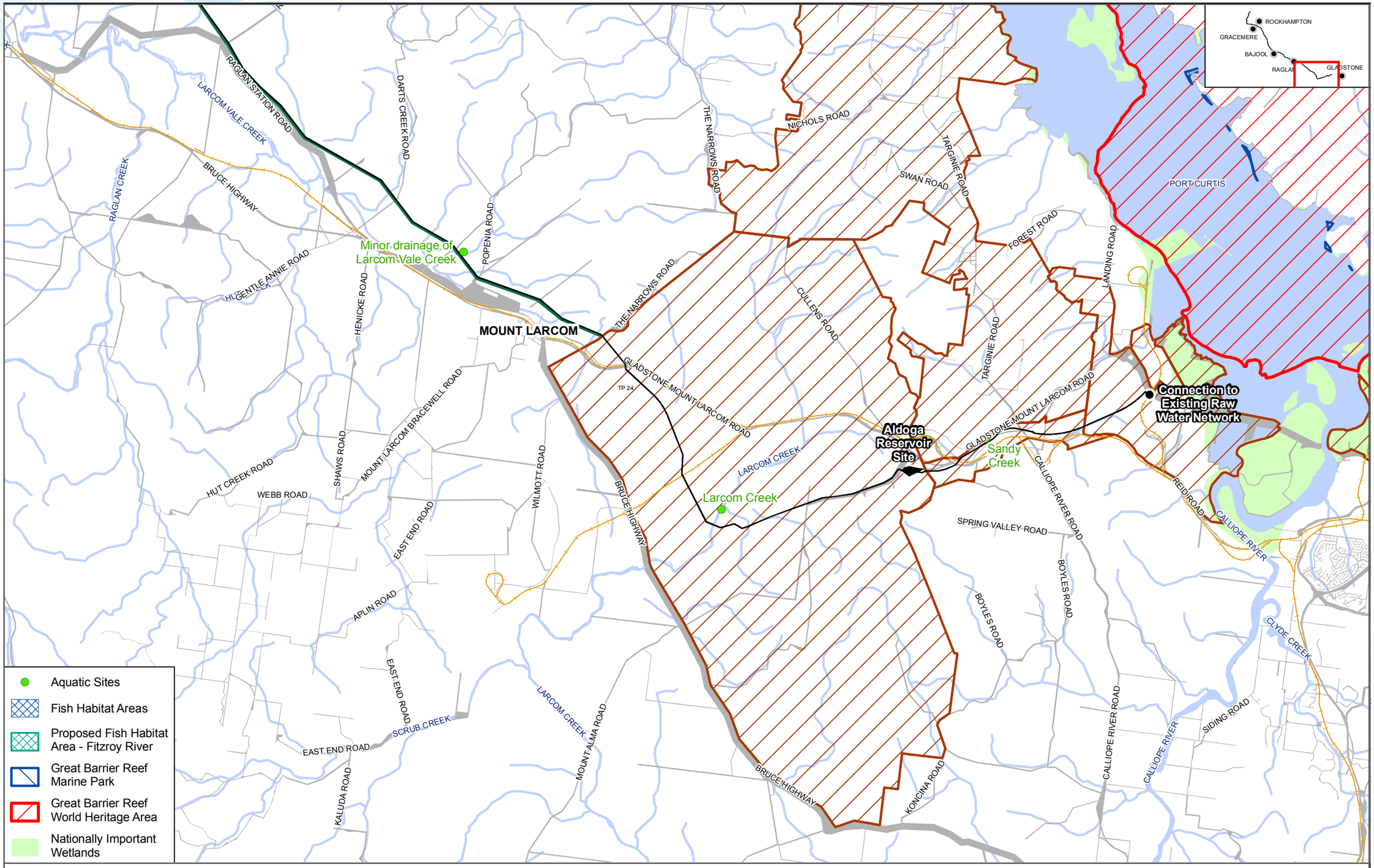
ARUP



Gladstone - Fitzroy Pipeline Project

Figure 8.7 - Areas of Aquatic Conservation Estate

Sheet 3 of 4



Gladstone - Fitzroy Pipeline Project

Figure 8.7 - Areas of Aquatic Conservation Estate

Sheet 4 of 4

- Dugong Protection Areas (DPAs) are declared in legislation under the NC Act and as Special Management Areas under the *GBRMP Regulations 1983* and the *GBRMP Zoning Plan 2003*. No DPAs occur in the wider region. The closest DPAs to the project area are Shoalwater Bay and Port Clinto DPA (north of the project area), and Rodd's Bay (south of the project area), both of which are located at more than 20 km from the project area
- Fish Habitat Areas (FHAs). FHAs are administered by Queensland Fisheries under the *Fisheries Act 1994* (Qld). The closest FHA to the project area is the Cawarral Creek FHA (FHA 050), located northeast of Rockhampton at Emu Park, approximately 30 km from the northern extent of the project area.

8.5.9.1 Fitzroy to Bajool

The Fitzroy River at the intake point is located within the weir pool formed by the Fitzroy River barrage. This site represents the largest waterbody within the project area, and has a number of inherent functional ecological values, including:

- Permanent refugia for Aquatic fauna that are intolerant of pool drying
- A movement corridor for Aquatic fauna, linking the high value estuarine and freshwater reaches
- Preferred habitat for fish species of conservation significance, including the Saratoga and Leathery Grunter, which are both endemic to the Fitzroy River catchment
- An important habitat for freshwater fish species of fisheries significance (recreational and commercial), and a locally important recreational fishing area (note that commercial fishing is prohibited at this site)
- Potential habitat for the Fitzroy River Turtle and the Saltwater Crocodile.

Several off-stream lagoons (oxbow lakes) also occur within the project area. These environments can represent important Aquatic habitats for many Aquatic invertebrate and fish species, and can have higher biodiversity values than other meso-habitat types. It is unlikely that the lagoons within the project area support habitat for listed Aquatic fauna species due to their small size, absence of optimal habitat for these species, and historical (clearing) and ongoing pressures from adjacent catchment land uses.

Most other natural waterways and drainages within the project area are ephemeral streams. Some of the more permanent waterbodies (e.g. creeks) could support seasonal refugia for fish and other Aquatic fauna species. During and shortly after flow, these drainages can also support relatively rich and abundant macroinvertebrate and fish communities. It is unlikely that the ephemeral streams within this section of the project area support important habitat for listed Aquatic fauna species due to their small size, absence of optimal habitat for these species, and historical (clearing) and ongoing pressures from adjacent catchment land uses.

8.5.9.2 Bajool to Gladstone

The most significant Aquatic habitat within this section of the project area is Raglan Creek. This waterway contains well developed mangrove areas that are likely to represent locally important habitat for species of direct economic (fisheries) significance (e.g. Mud Crabs, Banana Prawns, juvenile life-stages of many fish species). This site is also a locally important recreational fishing area apparent through evident fishing and boat ramps. The only listed marine fauna species that could potentially occur within the project area is the Saltwater Crocodile.

Inkerman Creek is also an estuarine creek system containing mangroves and saltmarsh vegetation. This creek system would have similar functional properties to Raglan Creek, albeit perhaps to a lesser degree given the smaller size of the waterway.

Most other natural waterways and drainages within the project area are ephemeral streams. These would have similar Aquatic habitat values as those described for the Fitzroy to Bajool section of the project area, and are unlikely to represent important habitat for listed Aquatic fauna species, although some fish species of conservation significance (e.g. Agassiz's Glassfish and perhaps Purple-spotted Gudgeon) may occur in places, particularly in more permanent waterbodies such as Larcom Creek.

Table 8.12 Aquatic Habitat Values of Each Waterway within the Project Area

Site	Meso-habitat type	Conservation values	Fisheries values
Fitzroy River	Large permanent pool habitat within natural defined channels	Habitat for numerous fish species of conservation value, none of which are protected under legislation	Presence of Fitzroy barrage greatly reduces habitat values to catadromous species (i.e. most commercially significant species)
Lagoon 1 and Lagoon 2 (Part of the Lion, Lotus and Lower Gracemere Lagoon complex)	Semi-permanent floodplain lagoons	Potential habitat for several fish species of conservation significance, none of which are protected under legislation	Links to Fitzroy River (above the barrage) during large floods. During non-flood periods, particularly during drought, small size likely to limit fisheries values of these lagoons
Lion Creek	Ephemeral drainage	Marginal, temporary habitat (during flows) for several fish species of conservation significance (except during floods), none of which are protected under legislation	Links to Fitzroy River (above the barrage) during large floods. During non-flood periods, particularly during drought, small size likely to limit fisheries values of these lagoons.
Gavial Creek	In-channel semi-permanent pools	Marginal, temporary habitat (during flows) for several fish species of conservation significance (except during floods), none of which are protected under legislation	Creek links to several off-stream wetlands of high fisheries significance (i.e. Frogmore, Woolwash and Bates Lagoons) during floods, and ultimately to the lower Fitzroy River (estuarine sections). During non-flood periods may represent refugia of limited fisheries value
Serpentine Creek	Ephemeral drainage (note – not a core sampling site)	Marginal, temporary habitat (during flows) for several fish species of conservation significance (except during floods), none of which are protected under legislation	Links to Fitzroy River (downstream of the barrage) during large floods. However, presence of lat least five in-stream barriers greatly reduces connectivity and therefore fisheries values. During non-flood periods, particularly during drought, small size likely to limit fisheries values of these lagoons
Dingo, Station and Oakey Creeks	Ephemeral drainages	As for Gavial Creek	Links to Fitzroy River (downstream of the barrage) during large floods. During non-flood periods, particularly during drought, small size likely to limit fisheries values of these lagoons
Inkerman Creek	Macro-tidal watercourses within defined channels completely draining during tidal cycles	Part of Fitzroy River delta wetland area and contains small areas of protected marine plants (mangroves and saltmarsh)	Links to Fitzroy River (downstream of the barrage) during large floods. During non-flood periods, particularly during drought, small size likely to limit fisheries values of these lagoons. Fish kills reported in the creek due to pool drying and lack of permanent refugia, which is isolated by the Bajool Weir (Veitch and Sawynok 2005)
Twelve Mile Creek	Large permanent pool on muddy substrate with a slight brackish intrusion	Potential habitat for several fish species of conservation significance, none of which are protected under legislation	Discharges into brackish lagoon on the Fitzroy River delta, which Veitch and Sawynok (2005) suggests is the key juvenile Barramundi habitat in central Queensland. This lagoon is located approximately 1.24 km downstream from project area

Site	Meso-habitat type	Conservation values	Fisheries values
Raglan Creek	Macro-tidal watercourses within defined channels completely draining during tidal cycles	Provides habitats for a range of marine and freshwater species and is one of the least impacted and more important wetland systems in the Great Barrier Reef catchment	Drains into the lower reaches of the Fitzroy River, extensive in-stream habitat that is import to fishery resources within the area. Blacks Hole and Pelican Lagoon provide important habitat for Barramundi. Culvert and causeway effect fish migration during periods of low flow
Unnamed tributary of Larcom Vale Creek	Ephemeral drainages with a natural defined channel	Marginal, temporary habitat (during flows) for several fish species of conservation significance (except during floods), none of which are protected under legislation	During non-flood periods, particularly during drought, small size likely to limit fisheries value
Larcom Creek	Large freshwater permanent pool on muddy substrate	Marginal, temporary habitat (during flows) for several fish species of conservation significance (except during floods), none of which are protected under legislation	During non-flood periods, particularly during drought, small size likely to limit fisheries values of these lagoons
Sandy Creek	Ephemeral drainages with a natural defined channel	Marginal, temporary habitat (during flows) for several fish species of conservation significance (except during floods), none of which are protected under legislation.	During non-flood periods, particularly during drought, small size likely to limit fisheries value

8.6 Assessments of Impacts

Potential impacting processes to Aquatic flora, fauna and their habitat resulting from the construction and operation phases of the Gladstone-Fitzroy Pipeline project are:

Construction phase

- Vegetation clearing and channel disturbance
- Water quality modifications
- Creation of in-stream barriers (i.e. culverts)
- Creation of new mosquito and biting midge breeding sites.

Operational phase

- Alterations to habitat, both surrounding the intake pipe and within the Fitzroy River weir pool
- Translocation of exotic species, especially the noxious Water Hyacinth* (*Eichhornia crassipes*) from the Fitzroy River
- Water treatment plant (WTP) operational impacts.

Operational phase impacts are described in further detail in Section 8.6.3.

For all potential impacts (i.e. residual impacts) considered in this section, the levels of impact described in Table 8.13 were considered in assigning significance to the environmental impacts identified. Definitions of the duration of temporal impacts used in the assessment are also provided in Table 8.14.

Table 8.13 Impact Significance Criteria for Aquatic Flora and Fauna

Impact level	Scale of impact	Assessment criteria (must meet the criteria of one or more impact categories)		
		Habitat impact	Species impacts	Ecosystem impacts
Major adverse	Moderate (or greater) impacts at a national or state scale	> 60% of habitat removed	Mortality of a protected species, likely to cause local extinction	Total ecosystem collapse
High adverse	Minor impact at national or state scale, moderate (or greater) impact at a regional scale	30–60 % of habitat removed	Mortality of a protected species affects recruitment and the capacity to increase in numbers	Measurable impact to ecosystem function: some functions are lost, declining or increasing outside an historical range, or facilitate new species to appear
Moderate adverse	Major or high (medium- to long-term) impact at a local scale	5–30% of habitat removed	Mortality within some species causes impacts at the maximum acceptable level.	Measurable change to ecosystem components but no loss of functions (no loss of components)
Minor adverse	Moderate or high (short-term) impact at a site-specific scale, or minor impact at a local	< 5% of habitat removed	Protected species affected but no impact on population status (e.g. stress or behavioural change to individuals)	Keystone species not affected and minor changes in relative abundance of other species
Negligible	Negligible impact at local, regional, state and national scales, or minor impact at (or below) a site-specific scale	< 1% of habitat removed	No impact to protected species	Possible changes but within the range of natural variation
Beneficial	Any scale	Habitat creation	Improvement in population status of protected species	Ecosystem improvements (e.g. rehabilitation)

Table 8.14 Definitions of Temporal Impacts

Relative Duration	Definition
Permanent	Period in excess of 50 years
Long-term	From 20 to 50 years
Medium-term	From seven to 20 years
Short-term	From one to seven years
Temporary	Up to one year

8.6.1 General Design Considerations

Note that early in the impact assessment process, the key potential threats from an Aquatic and marine flora and fauna perspective were identified. These are generally applicable throughout the project area and primarily include the potential impacts of the pipeline on stream habitat integrity, flows and Aquatic fauna passage. The key mitigation measure in the detailed design for optioneering phase was the consideration of environmental values in the selection of construction and creek crossing methods. Where possible, trenchless methods have been selected for creek crossings at ecologically significant or sensitive watercourses. The construction method for each of the main watercourses in the study area and factors considered in method selection are described in Table 2.3 of Chapter 2, Project Description. Where trenchless methods will be used in construction, there are a number of general impacts that are avoided or minimised. These include:

- Vegetation clearing and channel disturbance
- Water quality modifications
- Creation of in-stream barriers.

8.6.2 General Construction Impacts

8.6.2.1 Physical and Vegetation Disturbance

Construction works throughout the project area will involve the physical disturbance to stream and wetland habitats and surrounding vegetation. These issues are considered together here.

Physical Disturbance

Impacts to Aquatic habitats and resident biota may occur as a result of a number of construction activities. These are listed below.

- The clearing of vegetation at and adjacent to drainage environments within the ROW (see Vegetation Removal below)
- Grading (stripping) of top-soil within the ROW
- The construction of temporary tracks within and adjacent to drainages. This could potentially include the removal of banks considered too steep for access, construction of temporary culverts and removal of vegetation and fill materials placed on tracks. Access tracks will endeavour to avoid watercourse crossings where practical
- Compaction, erosion and sediment release of bed and bank material associated with the use of construction plant and light vehicles within the ROW corridor
- Trenching will be used to lay the pipeline at most (all but three) creek crossings, particularly the more ephemeral stream environments and in areas where tunnelling is not feasible. Trenching will involve the installation of sheet piled coffer dams on both sides of the trench (to prevent the ingress of stream waters), excavation of a trench using a backhoe or other excavating machine, placement of the pipeline within the trench, and the subsequent filling of the trench (with parent bed material) and burial of the pipeline. Disturbance to bed and bank environments will occur as a result of the excavation, removal and subsequent re-filling of the pipeline trench
- Installation of the pipeline using micro-tunnelling methods is recommended to occur at three creek crossings. Tunnelling will involve drilling a hole beneath the surface and pulling the pipe through the drill hole. Tunnelling is the proposed method for laying the pipeline at the three major tidal and/or high-value drainages intersected by the pipeline, including Inkerman, Raglan and Horrigan Creeks. Note that at Raglan Creek micro-tunnelling will only occur for the actual creek section of the crossing, with the crossing still incorporating some trenching methods in some riparian/mangrove areas
- Temporary stockpiling of material from boring, directional drilling and trenching
- Excavation from borrow pits to supply material for pipeline padding, hard-stands and road base.

Vegetation Removal

Note that the impacts of vegetation clearing are considered in the context of vegetation community species values in Chapter 6, Terrestrial Flora. The issues raised in the vegetation assessment are relevant to this assessment of impacts to Aquatic habitats. Additional construction phase factors are also relevant to Aquatic habitats, flora and fauna, and are considered here.

Vegetation clearing will be required for the ROW access corridor, generally 30 m in width, extending the 115 km of pipeline length. This area will be utilised for stockpiling of soil and vegetation, and access tracks associated with construction. Whilst the selection of the ROW has endeavoured to avoid areas of remnant vegetation and other notable fauna habitats, there are several sections within the project area where such values could not be avoided (e.g. due to positioning within the SGIC, topographical constraints or existing development). The total width of the ROW will be reduced for short distances within environmentally sensitive areas, particularly Raglan Creek, to minimise vegetation disturbance.

There will be direct disturbance to bed and bank habitats at Aquatic sites where trenching is proposed, and at sites where there will be the construction/operation of vehicle crossing points. The nature and magnitude of potential impacts to Aquatic habitats and biota will depend on whether water is present at the time of works.

In the absence of effective on-site management, the removal or modification of vegetation can lead to a range of effects, most notably an increase in rates of erosion and consequent deposition of sediments into drainages, creeks and wetlands. Catchment waterways are already under stress from sediment loading, as evidenced by the high turbidity values and presence of large sand bars throughout most of the project area waterways. While these waterways are already heavily impacted by sedimentation and high turbidity, the proposal could result in further localised impacts to Aquatic flora and fauna values if not appropriately managed.

The loss of riparian (and catchment) vegetation could also lead to a loss of several Aquatic ecosystem services at a local scale, including:

- Shading the waterway, which controls in-stream primary productivity and water temperatures (Bunn *et al.* 1998, Davies *et al.* 2004)
- Restricting the development of weeds in the understorey and within the stream (Bunn *et al.* 1998)
- Stabilising the bed and banks (Bunn 1998)
- Providing important physical habitat structure (fallen timber) for Aquatic fauna (Brooks *et al.* 2006, Cottingham *et al.* 2003).

While vegetation clearing will be minimised as far as possible, there will be areas in the riparian corridor that could, in the absence of management intervention, lead to impacts to Aquatic habitat values.

8.6.2.2 Construction Phase Water Quality Modifications

Chapter 9, Water Resources and Water Quality, provides a discussion on the potential water quality impacts associated with the project. In summary, the key potential impacting processes include:

- An increase in suspended sediments due to removal of vegetation, and the physical disturbance of catchment soils, as well as bed and bank sediments
- Disturbance of potential acid sulfate soils and generation of acid runoff
- Disturbance and remobilisation of organically enriched wetland sediments, and subsequent reduction in dissolved oxygen due to increase in biological oxygen demand (BOD)
- Release of contaminants (oils, greases and other chemicals) by machinery.

Turbidity

During the construction phase topsoil and sediment removed from the ROW and the open trench will be temporarily stored onsite. Potential impacts to Aquatic flora and fauna and their habitats exist if these sediments were to enter adjacent waterways via surface water runoff. Remobilisation of stream sediments due to in-stream works (i.e. trenching, coffer dam construction) could also lead to temporary increases in Total Suspended Solids (TSS) concentrations.

When assessing the risk of impacts to resident Aquatic flora and fauna communities (and their habitat), it is important to consider background turbidity conditions at the site. If works were to be undertaken during floods when suspended sediment concentrations are usually high (Noble and Rummenie 1996), for example, it is unlikely that Aquatic ecology impacts would be detectable. During low flow periods, particularly in catchments with sandy soils, turbidity is often lower (WBM 2002), hence impacts to Aquatic ecology could occur. During zero flow conditions within residual in-stream pools, turbidity is often elevated due to the deposition and resuspension (by wind, stock or other animals) of fine silty sediments, as was noted within most sites within the project area in the present study. Background turbidity at off-stream wetlands can vary over a range of spatial and temporal scales in response to flood conditions, stock access and substrate conditions.

The construction and removal of coffer dams is likely to mobilise bed sediments, resulting in the generation of turbid waters. Sites that are most likely to be susceptible to increased turbidity are those that contain submergent macrophytes or typically have low background turbidity concentrations (i.e. Twelve Mile and Larcom Creeks and Lagoon 2). Note that the southern section of the project area (Bajool to Gladstone section) has a more extensive submergent macrophyte cover. An additional main site where trenching is proposed that contains surface waters during non-flow (or dry) conditions is Lagoon 1. At the time of sampling this site already had very high turbidity due to the use of the waterbody by cattle. It is therefore unlikely that this waterbody would contain Aquatic biota that would be sensitive to elevated turbidity levels.

Mobilisation of Organic Sediments

Trenching is proposed through a number of Aquatic habitats, of which the ones most likely to contain surface water during construction include Lagoons 1 and 2, as well as Twelve Mile, Pelican, Horrigan and Larcom Creeks. Mobilisation of organically enriched sediments (likely to be derived mainly from cattle faeces and/or terrestrial and estuarine plant material) within these habitats is expected to result in some localised oxygen depletion as a result of biological oxygen demand, which may be associated with asphyxiation of sensitive macroinvertebrates and fish. Note that cattle are often already present at many of these waterbodies and probably already regularly mobilise Aquatic sediments at these locations. In these instances, impacts as a result of the project would be expected to be negligible.

Acid Sulfate Soils (ASS)

Potential acid sulfate soils (PASS) occur on coastal plains that are within 5 m above sea level. Their impacts are considered in detail elsewhere in this EIS (see Chapter 5, Soils and Contaminated Land). Large sections of the project area have been identified as likely to contain PASS based on the preliminary ASS investigation (Golder Associates, 2007) (Refer to Chapter 5, Soils and Contaminated Land). In particular, areas surrounding Raglan, Bajool to Midgee, Rocklands, west of Archer Park and the Fitzroy River will require further investigations (as part of the detailed ASS investigation to be completed prior to the commencement of construction) as actionable levels of acidity have been detected or no investigations have yet taken place. Trenching works associated construction could expose PASS, resulting in impacts to Aquatic flora and fauna.

Toxicants

The impacts of construction are likely to be restricted to the vicinity of works. However, the introduction of contaminants, such as fuels and chemicals that may be associated with machinery operation, may pose a risk to downstream communities. Many chemicals, such as petrol and diesel fuel, drilling lubricants and pesticides, are particularly toxic to freshwater and estuarine macroinvertebrate taxa. All water quality risks (contaminants and suspended sediments) are primarily footprint effects, which will reduce quickly downstream, particularly in low or no flow conditions. In high flows there is a greater likelihood that sediment will be mobilised but it will then be mixed with the catchment runoff. There is therefore little risk of these impacts reaching downstream to estuarine areas, which represent particularly sensitive environments.

8.6.2.3 Construction Phase Barriers

As discussed in Section 8.6.2.1, in-channel construction works will result in the creation of temporary barriers, namely:

- Temporary road crossings with pipe culverts will be constructed at most of the waterways to enable construction equipment access, excluding the major waterways that will be accessed from both sides (e.g. Raglan, Horrigan and Inkerman Creeks). Temporary creek crossings will be removed on completion and the creek profiles will be restored
- Permanent creek crossings, if required at minor creeks, will generally be left as a gravel causeway without permanent culverts
- Temporary coffer dams will be constructed around pipeline trenches and at the intake site during construction. For the pipeline trenches, a pipe will pass through the coffer dam walls, thereby linking upstream and downstream environments (should flows occur at the time of construction). In the Fitzroy River, a large coffer dam will surround the intake structure during construction.

Construction of temporary or waterway barriers may require a permit under the *Fisheries Act 1994* (Qld), or in some cases self-assessment, dependent on the detailed design for construction of the structure and the nature (including freshwater/tidal and stream order) of the waterway. Additional development approval triggers (e.g. within the *Water Act 2000*) may also be relevant, dependent on the location and detailed design for construction of the structure.

As discussed in Section 8.5.6.1, numerous fish species undertake migrations as part of their lifecycle and/or movements as part of their day-to-day foraging activities. At present, most of the major drainages within the project area are impacted by artificial in-stream barriers (e.g. Raglan and Inkerman Creeks and Fitzroy River), which are thought to represent a major stress on local fish communities (see Veitch and Sawynok 2005). Most other drainages within the project area are ephemeral in nature, especially in the Fitzroy to Bajool section, containing running water only seasonally and not necessarily every year. For most of the time these drainages consist of occasional disconnected pools, with no opportunity for broad-scale migrations/movements. Pools become connected only following sustained rainfall events, allowing the passage of fish and other Aquatic fauna in and out of the project area. There are also several permanent and large freshwater pool environments, where barriers would be of greatest concern.

Even though the pipes and culverts will allow some movement under certain (low flow) conditions, both types of structures have the potential to restrict Aquatic fauna movement patterns in the short-term (Table 8.15). This will not represent a key risk in the more ephemeral drainages, particularly if works are undertaken during the dry season when surface water is either absent or restricted to isolated pools. There is a risk that in-stream barriers could restrict migratory movement patterns during low to medium flow periods (i.e. when water levels are below bank-full height). The key migratory period for most freshwater fish species occurs in spring and summer, which is coincident with both (i) periods of high flow and (ii) increasing water temperature.

Table 8.15 Impacting Processes Associated with Culverts (Source: Fairfull and Witheridge 2003)

Potential effect	Cause
Turbulence	Excessive water turbulence from the culvert
Flow velocities	Excessive flow velocities within the culvert
Physical barriers	Inadequate flow depth within the culvert Debris blockage of the culvert. Excessive variation in water level across the culvert outlet (waterfall effect)
Habitat modifications	Excessive culvert length and a lack of Aquatic habitat and "rest" areas within the culvert
Behavioural	Inadequate lighting within the culvert

8.6.2.4 Creation of New Mosquito and Midge Breeding Habitat

Management of mosquitoes and biting midges is necessary for the purposes of public health and community wellbeing. Local councils within the project area have mosquito/midge control programmes in place.

Mosquitoes lay eggs on the surface of water, on damp ground, on vegetation at the edges of waterholes, on the damp edges of natural containers such as tree-hole cavities and rock pools, and man-made containers such as tyres or rainwater tanks (LQAQ 2002). Biting midge larvae mostly inhabit wet soil conditions including stream and wetland margins, floating or emergent vegetation and crab holes (Rey 1964). Following the life cycles of these insects, outbreaks usually occur within one or two weeks after rain events.

During construction of the project, excavated areas (e.g. borrow pits and the pipeline trench) and disturbed soils may provide areas for water to pool. Construction therefore has the potential to create new habitats for mosquito and biting midge breeding, however, these effects are expected to be temporary and also very small in relation to the abundant availability of suitable breeding habitat that already exists within the project area.

8.6.3 General Operational Impacts

8.6.3.1 Operational Phase Impacts Associated with Water Extraction

Operational phase impacts are primarily located at the intake site on the Fitzroy River and are discussed in detail in Section 8.6.4, which addresses impacts specific to the Fitzroy to Bajool section of the project area. In brief, impacts may occur in the vicinity of the intake due to:

- Entrainment of biota within the pipeline
- Bed or bank scouring at the intake.

As mentioned above, further details relating to these impacts, including extraction details, ecological effects and significance are described in Section 8.6.4.

8.6.3.2 Operational Phase Translocation of Exotic and Pest species

A number of exotic Aquatic plant and fauna species, including noxious and pest species, occur in the Fitzroy River. Based on catchment records, together with the results of EIS surveys, at least nine introduced Aquatic macrophyte species have been recorded in the Fitzroy River catchment (Table 8.4). Of the species listed in Table 8.4, one is listed as a declared pest species; Water Hyacinth (*Eichhornia crassipes**). This species is a Class 2 declared plant under the *Land Act 1994*. Water Hyacinth was recorded in large numbers at the proposed pipeline intake point on the southern banks of the Fitzroy River.

From an Aquatic fauna perspective, there are also:

- Three exotic fish species known to occur in the catchment. The most abundant and widespread of these species is Eastern Gambusia (*Gambusia holbrooki**). Eastern Gambusia is a highly adaptable species, tolerating broad temperature (less than 0 to 44˚C) and salinity (0 to 35 ppt) ranges. Eastern Gambusia is the only declared noxious fish (under schedule 5A of the *Fisheries Regulation 1995 (Qld)) known from the project area*
- A range of native insect species that are considered to be pests from a human health perspective, including biting midges (*Ceratopogonidae*) and mosquitoes (*Culicidae*).

The range of propagules sizes for a number of common Fitzroy River fish species is summarised in Table 8.16. All of the propagules listed are smaller than 10 mm and could enter the intake structure, which is surrounded by only a coarse trash screen (approximately 50 mm aperture) to filter incoming waters.

Scour valve outlets along the pipeline will occasionally release water into local waterways, which would probably occur every few years. In the absence of management intervention, there is a risk that this would facilitate the transfer of these species into the recipient waterway. All of the noxious and pest species, and probably most other introduced species, have been recorded throughout all of the project area catchments. Therefore, should pest species (or their propagules) survive the journey from the intake, this would not result in introduction of new species to the recipient waterway. However, there is a risk that the transfer of pest species could lead to an increase in the abundance of these species in the recipient waterway.

It should be noted that some algae can disperse aerially, which means that if favourable environmental conditions exist for a species, it could naturally colonise waterways in adjacent catchments over time. Conversely, if a species is translocated into a waterway, and the waterway has environmental conditions outside its physiological tolerance range, then it will not survive. Therefore, in the long-term, environmental conditions within the waterway will ultimately determine the species composition and structure of Aquatic communities.

Table 8.16 Reproductive Mode and Propagule Size of Common Representative Fish Species in the Fitzroy River Catchment

Common name	Reproductive mode	Propagule size (mm)*
Long-finned Eel	Coral sea – egg type unknown	Length at hatching approximately 2.5 mm. Early stage Glass Eels in freshwaters = 46-65 mm
Eel-tailed Catfish	Freshwater – benthic non-adhesive eggs	Egg size (water hardened) = 3.1–3.4 mm. Length at hatching = 7–7.4 mm
Eastern Gambusia*	Freshwater – live-bearer	Length at hatching = 9.5 mm**
Pacific Blue-eye	Freshwater or marine – benthic adhesive eggs	Egg size (water hardened) up to 1.8 mm. Length at hatching = 5.5 mm
Purple-spotted Gudgeon	Freshwater – benthic adhesive eggs	Egg size (water hardened) = 2.0–3.8 mm long, 1.1–1.3 mm wide. Length at hatching = 5.5 mm
Empire Gudgeon	Freshwater – benthic eggs	Egg size (water hardened) = 0.26–0.28 mm. Length at hatching = 1.0 mm
Firetail Gudgeon/Migley's Carp Gudgeon	Freshwater – benthic adhesive eggs	Egg size (water hardened) = 0.8–1.0 mm. Length at hatching = 2.1–4.0 mm
Western Carp Gudgeon	Freshwater – benthic adhesive eggs	Egg size intra-ovarian = 0.45 mm, water hardened unknown. Length at hatching = 1.76–2.10 mm
Striped Gudgeon	Freshwater – benthic eggs	Unknown
Flat-headed Gudgeon	Freshwater – benthic adhesive eggs	Egg size (water hardened) = 1.5–2.2 mm long, 0.7–0.9 mm wide. Length at hatching = 3.7–3.9 mm
* (Pusey *et al.* 2004) unless noted otherwise; ** Meffe (1990)		

8.6.4 Fitzroy to Bajool Section

Table 8.17 summarises the specific impacts relevant to the Fitzroy to Bajool section of the project area.

Table 8.17 Summary of Potential Impacts in the Fitzroy to Bajool Section

Impact	Effect
Construction phase	
Bank and bed disturbance	• Physical habitat disturbance • Sediment resuspension and oxygen depletion
Vegetation clearing	• Loss of macrophytes and macroinvertebrates
In-stream barriers	• Restricted and/or interrupted fauna (fish) movements
Water quality changes	• Increased turbidity, oxygen depletion, exposure of potential acid sulfate soils
Operational phase	
Impacts at the intake	• Entrainment of biota • Disturbance to physical habitat

8.6.4.1 Construction Phase Impacts

Trenching will be undertaken at all creek crossings in the Fitzroy to Bajool section of the project area, including in the ephemeral waterways Lion, Gavial, Station and Oakey Creeks, as well as two off-stream wetlands, referred to here as Lagoons 1 and 2. During non-flow periods, there is limited potential for direct impacts to Aquatic flora and fauna communities at the ephemeral waterways, however, the two wetlands are most likely to contain water during construction. If construction is undertaken during periods of flow, a range of Aquatic macroinvertebrates will have colonised the waterways, and these will be lost within the construction zone. Most fish and any semi-Aquatic fauna such as turtles are likely to avoid the construction area and therefore unlikely to be directly impacted. As noted in the baseline section, no listed Aquatic fauna species are known or likely to occur in these ephemeral waterways. There is a low risk of impacts to Aquatic macrophytes associated with construction-related habitat disturbance, noting that water quality and passage issues are considered separately below.

There also exists the potential for highly localised impacts (measured in metres to 10s of metres) to bed and bank structure as a result of these activities (i.e. bed and bank erosion, slumping and bed aggradation), which could lead to impacts to Aquatic fauna during flow periods. Mitigation strategies will be undertaken to minimise such impacts.

Due to the large width of the two unnamed lagoons within the pipeline corridor (Lagoons 1 and 2), tunnelling is not considered feasible in these locations. In these locations the pipeline will therefore be laid using trenching methods. As discussed in Section 8.5.1.2, these lagoons contained water at the time of site inspections, and are likely to represent locally important Aquatic refugia to a range of Aquatic macrophytes, macroinvertebrates, freshwater fish and turtles. No species listed as Threatened under legislation are likely to occur here, however the lagoons could provide a locally important refugia for fish species of conservation significance (i.e. Southern Saratoga, Purple-spotted Gudgeon, Renhahl's Tandan and Leathey Grunter) and possibly economic significance (i.e. Long-finned Eel and Eel-tailed Catfish).

Because the trench would intersect submergent sections of Lagoon 1, there would be direct disturbance and loss of Aquatic macrophytes and macroinvertebrates within the footprint of the coffer dams and trench. As discussed in Section 8.6.2.2, disturbance of bed sediments could also lead to water quality impacts (resuspension of bed sediments and most likely oxygen depletion due to an increase in biological oxygen demand) that could have lagoon-wide impacts to resident Aquatic fauna.

At the time of site inspections (undertaken during prolonged drought conditions), the pipeline alignment at Lagoon 2 traversed the dry upper banks of the wetland. If construction avoided wet areas of the lagoon, it would be expected that there is little risk of Aquatic ecosystem impacts. However, should construction be undertaken when the wetland is full or near bank-full depth, direct disturbance of Aquatic biota and water quality impacts would be expected, similar to that described above for Lagoon 1.

Some water quality impacts are expected. Sites that are most likely to be susceptible to increased turbidity are those that contain submergent macrophytes or typically have low background turbidity concentrations (e.g. Lagoon 2). The only sites where trenching is proposed, that also contain surface waters during non-flow conditions, are Lagoons 1 and 2. The construction and removal of coffer dams at these locations is likely to mobilise bed sediments, resulting in the generation of turbid waters. At the time of sampling, Lagoon 1 already had very high turbidity due to the use of the waterbody by cattle. It is therefore unlikely that this waterbody would contain Aquatic biota that would be sensitive to elevated turbidity levels.

As discussed previously, trenching will occur at all creek crossings in this section of the project area and may mobilise organic sediments, particularly at Lagoon 1. It is noted, however, that there already exists some disturbance of bed sediments by cattle at Lagoon 1, which is likely to have caused the high turbidity and possibly the low dissolved oxygen concentrations recorded in the present study. Consequently, it is considered unlikely that biota that is reliant on high dissolved oxygen concentrations would occur here. However, the degree of bed disturbance due to trenching may be greater than currently occurs as a result of cattle disturbance, and consequently there is potentially a higher risk of impact to Aquatic biota. PASS are likely to occur on lands within this section of the study area and may be disturbed during construction.

In terms of in-stream barriers, the construction of the sheet pile coffer dam around the water intake structure within the Fitzroy River represents a potential risk to fish trapped within the pool formed by the dam walls.

8.6.4.2 Operational Phase Impacts at the Intake

This section considers the impacts of pump and intake operation in the vicinity of the intake. Note that the potential impacts of inter-basin transfer of pest species is considered in Section 8.6.3.2. Also, that impacts of water extraction on environmental flow requirements within the Fitzroy River are not considered as part of the scope of the EIS ToR.

Impacts to habitats and biota may occur in the vicinity of the intake due to:

- Impingement or entrainment of biota within the pipeline
- Mechanical damage to bed and bank structure (scouring) at the intake.

Water will be extracted at an average rate of 1,141 L/second. Entrainment of biota will occur where current velocities generated by pumping exceed the swimming speed of biota. At the head of the intake ports, current velocities are expected to be approximately 0.6 m/second, which exceeds the swimming speed of some small-bodied fish, invertebrates and probably all planktonic and non-motile (e.g. plants) biota.

There are no empirical data describing densities of different life-forms (e.g. juvenile fish, phytoplankton, zooplankton, nektonic invertebrates etc.) within the Fitzroy River at the intake point. It would be expected that densities would vary markedly over time (i.e. seasonal, inter-annual) and space (e.g. differences at different positions in the water column, proximity to the bed). Assuming a constant algal biomass (chlorophyll *a*) of 9 µg/L (DNRW 2008), up to 0.89 kg of algae could be entrained daily, based on a constant extraction rate of 1,141 L/second. The biomass of Aquatic fauna (mostly zooplankton grazers) entrained would be expected to be lower than the algal biomass.

As well as the entrainment of small-bodied species, there is also a risk that larger bodied species of fish, turtles and other semi-Aquatic biota could be impinged or entrapped on the intake screen. In the absence of management intervention, this would represent not only a localised ecological impact, but also potentially reduce the operational efficiency of the intake.

8.6.5 Bajool to Gladstone Section

Table 8.18 summarises the specific impacts relevant to the Bajool to Gladstone section of the project area.

Table 8.18 Summary of Impacts in the Bajool to Gladstone Section

Impact	Effect
Construction phase	
Bank and bed disturbance	• Physical habitat disturbance • Sediment resuspension and oxygen depletion
Vegetation clearing	• Loss of macrophytes and macroinvertebrates
Water quality changes	• Increased turbidity, oxygen depletion, exposure of potential acid sulfate soils
In-stream barriers	• Restricted and/or interrupted fauna (fish) movements
Operational phase	
Species translocation	• Translocation of exotic and pest species

8.6.5.1 Construction Phase Impacts

Physical and Vegetation Disturbance

The nature and activities relating to the physical and vegetation disturbance as a result of the project is discussed in Section 8.6.2.1, and is broadly applicable in this section of the corridor. This section of the project area includes remnant areas of both terrestrial (see Chapter 6, Terrestrial Flora) and marine vegetation (see Section 8.5.4.3). Of particular note are:

- *Raglan Creek.* This tidal creek contains large areas of mangroves, which are of high fisheries value
- *Inkerman Creek.* This tidal creek contains large areas of mangroves and saltmarsh, which are of high fisheries value
- *Marble, Horrigan, Larcom and Sandy Creeks and minor tributaries of Larcom Vale Creek.* They contain remnant riparian vegetation of varying degrees of disturbance and complexity.

Also of interest is the freshwater pool habitat in Raglan Creek, located downstream of several drainages that are intersected by the corridor.

Trenching in ephemeral drainages and creeks is expected to result in a similar range and magnitude of impacts to those outlined in Section 8.6.2.1. Within this section of the project area, these locations include Twelve Mile, Marble, Pelican, Larcom Vale, Larcom and Sandy Creeks. Micro-tunnelling will be the construction method used at three waterways, namely Raglan, Horrigan, and Inkerman Creeks. At these three creek crossings, there will be highly localised disturbance of catchment vegetation and little direct physical disturbance of waterways. At Raglan Creek some trenching will still occur in bank areas resulting in some clearing of estuarine vegetation, mainly the Grey Mangrove (*Avicennia marina*). However, the ROW at Raglan Creek will be reduced to minimise vegetation disturbances. The loss of this vegetation is expected to result in highly localised impacts to estuarine ecosystems within the footprint. Detectable impacts to fisheries productivity at Raglan Creek at an estuary-wide scale are not expected, although ecological functions at this scale could be impeded (i.e. loss of nursery habitat values and bank stabilisation impacts).

There will be highly localised disturbance of catchment vegetation and little direct physical disturbance of waterways and wetlands where directional drilling is to be undertaken. At these sites, the most notable construction-related impact would be the installation and operation of temporary vehicle crossing points. These temporary crossing points will be located in areas with limited riparian and catchment vegetation in most cases, however, impacts could occur to fish and other Aquatic flora and fauna passage. Furthermore, and as discussed above, Aquatic macrophytes and macroinvertebrates within the footprint of the crossing point will be temporarily lost, whereas most fish would likely avoid the disturbance area during flow periods.

Water Quality Modifications

The nature of water quality impacting processes in the Bajool to Gladstone section of the project area are expected to be broadly similar to those described in Section 8.6.2.2. Impacts include:

- *Turbidity impacts.* Compared to the Fitzroy to Bajool section, this section of the project area contains a larger number of waterways with Aquatic macrophytes (i.e. the submergent Hornwort (*Ceratophyllum demersum*) present within Larcom Creek; the floating macrophyte *Nymphaea* spp. was recorded at Twelve Mile Creek and Larcom Creek). Therefore, compared to the Fitzroy to Bajool section, waterbodies in this section of the project area, particularly Larcom and Raglan Creeks, may be more susceptible to turbidity impacts
- *Acid Sulfate Soils (ASS).* Large sections of the project area have been identified as likely to contain PASS based on the preliminary ASS investigation (Golder Associates, 2007) (Refer to Chapter 5, Soils and Contaminated Land). In particular, areas surrounding Raglan, Bajool to Midgee, Rocklands, west of Archer Park and the Fitzroy River will require further investigations as actionable levels of acidity have been detected or no investigations have yet taken place. Trenching works associated construction could expose PASS, resulting in impacts to Aquatic flora and fauna.

8.7 Mitigation

8.7.1 Construction Phase Mitigation Measures

8.7.1.1 Physical and Vegetation Disturbance

Vegetation clearing and bank/bed disturbance will be minimised where possible, which will be aided, for example, by undertaking works along existing tracks where possible (e.g. Inkerman Creek) and reducing the corridor width in sensitive areas (e.g. Raglan Creek).

Additional measures that would reduce the impacts of vegetation removal and sediment disturbance are:

- Appropriate management to contain disturbed sediments
- Monitoring and controlling the encroachment of weeds in areas where vegetation has been removed
- Where possible, replanting vegetation after construction completion, which would be particularly beneficial to the long-term stability of stream banks.

Any small areas of ponded water resulting from local rainfall or flooding (e.g.. within borrow pits) will be emptied within a few days to avoid breeding of biting insects.

8.7.1.2 Water Quality Modifications

A range of measures will be implemented to minimise potential water quality impacts, particularly in regard to turbidity, toxicants and the disturbance of PASS. These measures are detailed in full in Chapter 9, Water Resources and Water Quality, and in the Planning Environmental Management Plan (EMP) (see Chapter 20, Planning Environmental Management Plan) and are summarised here:

- Water leaving the work sites will be of similar quality to that of receiving waters and efforts will be made to ensure contaminants do not leave the site
- Construction activities will be conducted in a manner so as to minimise disturbance to stream/wetland banks and beds
- Disturbed sediments will be contained to minimise the occurrence of elevated turbidity
- Where disturbance of PASS is unavoidable, soils will be treated appropriately and the generation of acid runoff will be minimised (or avoided).

8.7.1.3 In-stream Barriers and Fauna (Fish and Turtle) Management

In-stream works will be timed in a manner that minimises impacts to Aquatic fauna. In this regard, in-stream construction works should avoid spring and summer months, where possible, as this represents the wet season when creeks are most likely to be flowing and the critical migratory period of most Australian freshwater fish. If the works result in the temporary isolation of pools for any period of time, and they become susceptible to drying or poor water quality, then any resident native fish that are trapped will be relocated to areas away from impacts.

Protocols will be developed and implemented to relocate any trapped fish and turtles to nearby suitable habitats, as follows:

- Wildlife handlers will follow the *Australian National Health and Medical Council's Australian Code of Practice for the Care and Use of Animals for Scientific Purposes 2004* when dealing with injured turtles
- A permit to interfere with wildlife (fish and turtles) from the Queensland EPA will be required for the wildlife handling activities as will the appropriate Animal Ethics Permit from the Department of Primary Industries.

8.7.1.4 Creation of New Mosquito and Midge Breeding Habitat

Rehabilitation of construction areas following construction will prevent pooling of water where possible and checks will be undertaken as part of the Construction EMP to minimise the potential for new breeding sites to persist for greater than one week.

8.7.2 Operational Phase Mitigation Measures

8.7.2.1 Impacts Associated with Water Extraction

Measures that may be implemented to prevent bed scour and reduce the potential for macroinvertebrate and fish entrainment include:

- Placing the intake at a depth that will prevent bed scour
- Provision of an adequate distance between the pump and the intake screens to reduce the risk of fauna being impinged on the intake screens (i.e. reduced flow velocity)
- Design of the intake will include adequate scour protection by using suitable rock/grout construction
- Monitor operation of the intake point for impacts on Aquatic flora and fauna.

8.7.2.2 Translocation of Exotic and Pest Species

Donor waters will be screened at the intake using a coarse (approximately 50 mm) trash screen. This will only prevent the entrainment of Aquatic flora and fauna larger than this screen size. Smaller flora and fauna will still be entrained (e.g. invertebrates, small bodied fish, zooplankton viable flora propagules). Flora and fauna that are entrained and collected with intake waters are not expected to survive the water treatment process at the WTP. At the entry to the WTP, there will be a 5 mm mesh. Treatment at the WTP is comprised of a combination of flocculation, clarification, chlorination and possibly filtration. Chlorination, in particular, is aimed at preventing algal growth within the pipeline. Therefore, the concentrations that will be used are likely to be lethal to any flora and fauna that might remain after the physical removal of solids from the intake waters (i.e. through clarification/filtration).

In the event that flora propagules (such as water hyacinth seeds) remain viable in the residue from the WTP (i.e. prior to chlorination), these would not have the opportunity to spread to other waterways as the residue will be taken offsite and will not enter waterways.

8.8 Residual Impacts

The assessment of potential impacts, taking into account the mitigation measures that will be implemented, is detailed below for each type of impact (Table 8.19).

8.8.1 General Construction Impacts

8.8.1.1 Physical and Vegetation Disturbance

For the ephemeral drainages, **minor adverse** impacts to Aquatic habitats and flora and fauna communities are expected as a result of construction (i.e. trenching) activities. At sites where micro-tunnelling will be undertaken, vegetation clearing and disturbance would result in **negligible** to **minor adverse** impacts to Aquatic habitats, and flora and fauna communities. Notable exceptions include Raglan Creek, Lagoon 1 and Lagoon 2.

Due to the disturbance of bed sediments, **moderate adverse** impacts are expected within Lagoon 1, which could be measurable over time scales of days to years (depending on length of time to recolonise the lagoon via overland flooding). If construction works at Lagoon 2 are undertaken when the lagoon is full or near full, **minor** to **moderate adverse** impacts may occur depending on the length of time of submergence, and sediment geochemistry (particularly the amount of organic material present) within the disturbance footprint at the time of works. At Raglan Creek, vegetation clearing and disturbance would result in **minor** to **moderate adverse** impacts to Aquatic habitats, and flora and fauna communities.

8.8.1.2 Construction Phase Water Quality Modifications

Through the implementation of the mitigation measures, most water quality modifications to turbidity, toxicants, sediment mobilisation and the disturbance of potential ASS are expected to have **negligible** to **minor adverse** impacts to Aquatic environments. Impacts would therefore be short-term with a rapid recovery in days to months, depending on flow conditions and recruitment strategies of constituent species.

Some **minor** to **moderate adverse** general water quality impacts are expected at some specific waterways, particularly Lagoons 1 and 2, as well as at Twelve Mile and Larcom Creeks. This is mostly associated with the mobilisation of organic sediments. Recovery for these localised impacts would be expected to be measured in weeks and years, depending again on flow conditions and recruitment strategies of constituent species.

8.8.1.3 Construction Phase Barriers

During the construction phase temporary construction of culverts and/or temporary stream crossing will generally result in an impact to Aquatic fauna of **minor adverse** significance. This is based on the following: (i) none of the EVR fauna species are known or likely to occur here, nor are any species Migratory; and (ii) impacts would be of a temporary nature, recovering in days to weeks. Note that under higher flows, the entire Fitzroy River delta may be inundated by flood waters providing opportunities for broad-scale fish movements throughout the project area. Under such conditions, small in-stream barriers are unlikely to represent a significant barrier to fish movements.

8.8.1.4 Creation of New Mosquito and Midge Breeding Habitat

In the context of existing waterbodies within the project area, the contribution of the project to breeding sites for mosquitoes and biting midges is expected to be **negligible**.

8.8.2 General Operational Impacts

8.8.2.1 Water Extraction Activities at the Intake

With the implementation of the mitigation strategies, it would be expected that the impacts to Aquatic ecosystems would be localised and minor. Overall, **minor adverse** impacts are expected for the potential impacting process occurring at the intake site during the operational phase of the project.

8.8.2.2 Translocation of Exotic Species

A range of Aquatic flora and fauna species will likely be entrained at the intake (e.g. invertebrates, small bodied fish, zooplankton, viable flora propagules) but are not expected to survive the water treatment process at the WTP. Therefore, the risk of translocating pest fish, Aquatic macrophytes and nuisance insects (biting midges and mosquitoes) is considered to be very low. The resultant residual impacts are expected to be of **negligible** to **minor adverse** significance.

8.9 Cumulative and Interactive Impacts

There are several other pipeline projects within the SGIC which have the potential to result in cumulative and interactive impacts to Aquatic ecological values. These projects will likely result in many of the same impacting processes as identified in this chapter across the width of the SGIC (approximately 100 m). From an Aquatic ecology perspective, the key issues identified in the project area are:

- Clearing of riparian vegetation, particularly within the vicinity of high ecological value estuarine wetland areas such as those surrounding Raglan Creek. It is possible that future pipeline projects in this area could result in clearing of estuarine wetland vegetation, with subsequent impacts to ecosystem values
- Introduction of weeds due to additional construction and operation activities
- Increased habitat fragmentation due to the construction of additional vehicle creek crossing points. Given that construction activities will not occur all at one time, there is potential for future projects to result in cumulative effects to Aquatic fauna movements over the life of future construction activities
- Related to the above point, there is greater potential for additional water quality impacts associated with further pipeline construction activities.

It is not expected that these cumulative and interactive effects would have major, detectable impacts to listed Threatened Aquatic flora and fauna populations, communities and their habitats within the project area. There is a need however to ensure future additional pipeline works in the SGIC take into account the findings of the present study, and are aware of the management principles and guidelines outlined in the EMP developed for this project (see Chapter 20, Planning Environmental Management Plan).

8.10 Summary and Conclusions

The project area and surrounds have a range of values from an Aquatic ecology perspective (see summary in Section 8.5.9). Most significant Aquatic ecology features will not be directly or indirectly affected by the proposed pipeline. There are very few listed Threatened species and communities within the project area, reflecting in part extensive historical and ongoing anthropogenic disturbances, particularly those associated with land clearing. Detectable impacts to Threatened Aquatic species associated with the project assessed as **negligible**.

In terms of Aquatic ecology, the construction of the pipeline, ROW and operational impacts will have an overall environmental impact that has been referred to in this chapter as **minor adverse**. However, despite the application of best management strategies, **moderate (localised) adverse** impacts could occur at Lagoon 1, which may experience water quality impacts due to trenching, including sediment resuspension, and mobilisation of organic sediments. EMPs have been proposed which address these issues. Refinement of construction techniques at Lagoon 1 may reduce the impacts in this area to **minor adverse**.

Table 8.19 Summary of Key Impacts and Mitigation Measures – Aquatic Flora and Fauna

EIS area: Aquatic flora and fauna Feature/activity	Current value + substitutable Y:N	Description of impact		
		Description in words	Mitigation inherent in design/ standard practice mitigation	Residual impact using significance criteria
Disturbance of listed Threatened fauna and their habitat	Natural features; Protected Not substitutable	Fitzroy River Turtle – unlikely to occur in project area. Estuarine creeks represent marginal habitats for listed estuarine fauna. No other Threatened Aquatic fauna known or likely to occur in project area. Impacts therefore not expected.	Avoidance of high value Aquatic habitats in the detailed design for construction phase.	Negligible
Disturbance of wetland (Lagoon 1) due to trenching	Natural ecosystem Substitutable	Short-term water quality impact may result in temporary loss of Aquatic fauna. Possible increase in weeds. Disturbance of bed and bank habitats.	Appropriate management practices to minimise disturbance of bed sediments. Avoidance of works during periods when water levels are high.	Moderate –ve, D, T, MT-ST
Clearing of remnant estuarine vegetation	Natural ecosystem Not substitutable	Minor clearing at Raglan Creek. Possible increase in weeds.	Appropriate management practices to minimise disturbance of marine vegetation.	Minor –ve, D, T, MT-ST
In-stream barrier impacts to fauna movements	Natural ecosystem Substitutable	Construction of temporary road crossings on several ephemeral streams.	Crossing design allows passage of Aquatic fauna. Temporary works only.	Minor –ve, D, T, ST
Entrainment and impingement at intake site	Natural ecosystem with high ecological values	Impingement and entrainment of Aquatic flora and fauna.	Positioning of intake off the stream bed and banks. Low flow rates will minimise risk of impingement and trash screen will prevent entrainment of large-bodied fauna.	Minor –ve, D, T, ST

Key
Significance Criteria: Major, High, Moderate, Minor, Negligible
+ve = positive impacts; -ve = negative impacts
D = direct; I = indirect
C = cumulative; P = permanent; T = temporary
ST = short-term; MT = medium-term; LT = long-term.

Relative Duration of Environmental Effects

Temporary:	Up to one year
Short-term:	From one to seven years
Medium-term:	From seven to 20 years
Long-term:	From 20 to 50 years
Permanent:	Period in excess of 50 years

8.11 Glossary

Aggrading	Deposition of sediment in the bed of a stream or waterbody.
Aquatic	Living or existing within or on water.
Catchment	The area of land which collects and transfers rainwater into a waterway.
Concentration	The strength or amount of substance in a known volume or mass.
Conductivity	Relative ability of material to allow the passage of electricity (also electrical conductivity).
Current	Water movements that result in the horizontal transport of water masses.
Dissolved Oxygen	The amount of oxygen dissolved in solution (expressed as % Saturation or mg/L).
Diversity	See species diversity.
Dugong Protection Areas (DPAs)	Marine protected areas designated for the protection of dugongs and/or dugong habitat (e.g. boating and fishing restrictions generally apply).
Entrainment	Capture of organisms by the current generated by pumping.
Ephemeral	A waterbody that exists for only a short amount of time following rainfall.
Erosion	The removal of sediment from the bed or banks of a waterway.
Filamentous Algae	Fine thread-like algae.
Fish Habitat Areas	Defined inshore or estuarine areas valuable for sustaining local and regional fish stocks, and are specifically protected under the *Fisheries Act 1994*.
Great Barrier Reef World Heritage Area (GBRWHA)	The world's largest World Heritage Area, signifying universal natural and cultural heritage.
Great Barrier Reef Marine Park (GBRMP)	Approximately 98 percent of the GBRWHA is within the GBRMP, managed by the Australian Government.
Impingement	Trapping of biota on the intake screen.
Littoral	Edge or near-shore habitats.
Macroinvertebrate	A general term referring to invertebrate fauna (i.e. do not possess a backbone) that are greater than 1 mm in size.
Macrophyte	Emergent wetland plant.
Macro-tidal	Tidal waters with a tidal-range greater than 4 m.
Noxious	Generally refers to noxious weeds, which are plants (typically introduced species) that have been declared by authorities to be harmful to industry or environmental values.
Periphyton	A complex matrix of algae, cyanobacteria and microbes attached to submerged surfaces in Aquatic ecosystems.
Perrenial	Refers to a permanent stream (i.e. is wet during periods of no rainfall).
Phytoplankton	Planktonic plant-like organisms.
Plankton	Those organisms free-floating or drifting in open water (particularly in large waterbodies like the ocean).
Ramsar Site	Wetland areas designated for inclusion in the List of Wetlands of International Significance because they meet one or more of the Ramsar criteria (i.e. Ramsar Convention).
Redox	Oxidation Reduction Potential, a measure of a water system's capacity to either gain or release electrons, which has implications for the types of biota that water can sustain.
Riparian	Relating to or living or located on the banks or a river or stream.
Runoff	That portion of rainfall that is not immediately absorbed into or retained by the soil (e.g. overland flow).
Salinity	The total amount of dissolved salts in water.
Sampling	The procedure used to collect a sample.
Sediment	Particulate matter at the bottom of the water column of streams, rivers, estuaries and other water bodies.
Sessile	An organism that is fixed in place.
Species Diversity	The number of species in a given area.
Suspended Sediment	Particles in suspension in flowing or static water.
Total Suspended	The total concentration of filterable solids present in suspension.
Solids (TSS) Turbidity	A measure of the ability of light to pass through water. Units of measurement are Nephelometric Turbidity Units (NTU).
Water Column	The water from surface to bottom of a particular point.
Zooplankton	Planktonic animals.

8.12 References

Allen, G. R. (1989) 'Freshwater Fishes of Australia.' (T.F.H. Publications, Inc.: Brookvale, N.S.W.)

Allen, G. R. (1996) Family Melanotaeniidae, Rainbowfishes. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 134-140. (Reed Books: Chatswood, NSW)

Arthington, A. (1996) Recovery Plan for the Oxleyan Pygmy Perch, *Nannoperca oxleyana*. Centre for Catchment and In-stream Research Griffith University, Final Report to the Australian Nature Conservation Agency.

Australian Society for Fish Biology (2001). Conservation Status of Australian Fishes - 2001, Australian Society for Fish Biology Threatened Species Committee Report.

Beumer, J. P. (1996) Family Anguillidae, Freshwater eels. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 39-43. (Reed Books: Chatswood, NSW)

Briggs, I. C., McDowall, R. M. (1996) Family Clupeidae, Herrings. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 44-47. (Reed Books: Chatswood, NSW)

Brooks, A., Abbe, T., Cohen, T., Marsh, N., Mika, S., Boulton, A., Broderick, T., Borg, D., Rutherford, I. (2006) 'Design guideline for the reintroduction of wood into Australian streams.' Land & Water Australia, Canberra.

Bunn, S. E. (1998) Riparian influences on ecosystem function in the Brisbane River. In 'Moreton Bay and Catchment'. (Eds IR Tibbetts, NJ Hall and WC Dennison) pp. 131-142. (School of Marine Science, University of Queensland: Brisbane)

Bunn, S. E., Davies, P. M., Kellaway, D. M., Prosser, I. (1998) Influence of invasive macrophytes on channel morphology and hydrology in an open tropical lowland stream, and potential control by riparian shading. *Freshwater Biology* 39, 171-178.

Byron, G., Toop, J., Long, P. (1992) The impacts of catchment developemnt on the fish fauna of the Fitzroy River system. In 'Fitzroy Catchment Symposium, 12-13th November 1992'. Central Queensland Universiuty, Rockhamptom. (Eds LJ Duivenvoorden, DF Yule, LE Fairweather and AG Lawrie)

Cann, J. (1998). Australian freshwater turtles. Beaumont Publishing, Singapore.

Chessman, B. C. (2001) 'SIGNAL-2 A scoring System for Macro-invertebrates ('Water Bugs') in Australian Rivers – User Manual.' NSW Department of Land and Water Conservation, Sydney.

Choy, S., Marshall, C. (1999) 'An Assessment of the Ecological Condition of the Burnett River using Macroinvertebrates as Bioindicators. Freshwater Biological Monitoring Report No. 12.' Water Monitoring Group, Department of Natural Resources, Brisbane.

Cogger, D. (2000) Reptiles and Amphibians of Australia, 6th edition. Reed New Holland Publishers, Sydney.

Cogger, H. G., Cameron, E., Sadlier, R. & Eggler, P. (1993). The Action Plan for Australian Reptiles. Australian Nature Conservation Agency, Canberra.

Conrick, D. (2001) 'Assessment of the Ecological Health of Streams in the Bowen/Broken Rivers Catchmnent Based on the Aquatic Macroinvertebrate Community and Water Quality, and the Impact of Newlands Coal Mine on the Aquatic Environment.' Freshwater Biological Monitoring – Department of Natural Resources, Brisbane.

Conrick, D., Choy, S., Stowar, M. (1997) 'River Health: An Overview of the Fitzroy River Catchment. Freshwater Biological Monitoring Report No. 2.' Water Monitoring Group, Department of Natural Resources, Brisbane.

Cottingham, P., Bunn, S., P., P., Lovett, S. (Eds) (2003) 'River and Riparian Land Management, Technical Guideline Update No. 3. Managing wood in streams.' (Land & Water Australia: Canberra)

CRCCH (2004) Focus Catchments: Fitzroy River. CRC for Catchment Hydrology Information Brochure (C. Carroll ed., Natural Resources, Mines and Energy Queensland), Cooperative Research Centre for Catchment Hydrology, Rockhampton.

Davies, P., Cook, B., Rutherford, K., Walshe, T. (2004) 'River and Riparian Land Management, Technical Guideline No. 5. Managing high in-stream temperatures using riparian vegetation.' Land & Water Australia, Canberra.

DEC (2007) Threatened Species Website: Species, populations and ecological communities of NSW. NSW State Government Department of Environment and Conservation, Sydney. http://Threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10059

DEWHA (2007) EPBC Act Protected Matters Report. Report for the project area generated by the Protected Matters Online Database. Australian Government Department of Environment and Water Resources.
http://www.environment.gov.au/erin/ert/epbc/index.html

DNR (1998) 'Draft Fitzroy Basin Water Allocation and Management Plan.' DNR.

DNR (Ed.) (2001) 'Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual.' (State of Queensland, Department of Natural Resources: Brisbane)

DNRW (2008) Historical Water Quality Monitoring Data for the Fitzroy River: 'Watershed' Online Resource. Queensland Government Department of Natural Resources and Water. http://www.nrw.qld.gov.au/watershed

DPI (2007) Stock Assessment of the Queensland Banana Prawn Fishery. Queensland State Government Department of Primary Industries and Fisheries.

Duivenvoorden, L. J., Roberts, D. T. (1996) Aquatic Invertebrates. *Downstream Effects of Land Use in the Fitzroy Catchment: November 1993–December 1996 (Summary Report)*, 59-65.

Duivenvoorden, L.J. (1992) The River Dee: Aquatic Flora and Acid Mine Discharge. In Yezdani, H. (Editor) Water Weeds Management in Queensland: Proceedings of a workshop held at Queensland University of Technology, Brisbane. p. 187 - 200.

Enertrade (2006) Central Queensland Gas Pipeline Environmental Impact Study, Report prepared by Enertrade.

Environment Australia (2001). A Directory of Important Wetlands in Australia. Canberra, Australian Government Press.

Fairfull, S., Witheridge, G. (2003) 'Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings.' NSW Fisheries, Cronulla.

GAWB (2006) Fitzroy River Water Infrastructure Corridor Investigation Report. Gladstone Area Water Board Rockhampton Corridor Investigation Report. Prepared by RLMS for Gladstone Area Water Board.

GBRMPA (1993) Marine Turtles of the Great Barrier Reef World heritage Area. Government of Australian, Great Barrier Reef Marine Park Authority.

Golder Associates (2007) Preliminary ASS investigation for the Gladstone-Fitzroy Pipeline project. Prepared by Golder Associates for the Gladstone Area Water Board.

Henderson, R. J. F. (2002). Queensland Plants: Names and Distribution. Brisbane, Queensland Herbarium Environmental Protection Agency.

HLA Envirosciences (2007) Vegetation and fauna Habitat Assessment: Stanwell - Gladstone Sate Development Area (GSDA) Infrastructure Corridor. Prepared by HLA Envirosciences on behalf of the Coordinator General, Brisbane.

HLA (2006) Flora and Fauna Assessmnet: Gladstone Pacific Nickel Slurry Pipeline, Report prepared by HLA, for RLMS, Brisbane.

IUCN (1996) International Union for the Conservation of Nature Red List of Threatened Animals, (Baillie, J. and Groombridge, B. eds.). International Union for the Conservation of Nature.

Ivantsoff, W., Crowley, L. E. L. M. (1996) Family Antherinidae, Silversides or Hardyheads. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 123–133. (Reed Books: Chatswood, NSW)

Kemp, A. (1993) Unusual oviposition site for *Neoceratodus forsteri* (Osteichthyes: Dipnoi). *Copeia* 1993, 240–242.

Kemp, A. (2005) The biology of the australian lungfish, *Neoceratodus forsteri* (krefft 1870). *Journal of Morphology* 190, 181–198.

Kuiper-Linley, M., Johnson, C. R., Lanyon, J. M. (2007) Effects of simulated green turtle regrazing on seagrass abundance, growth and nutritional status in Moreton Bay, south-east Queensland, Australia. *Marine and Freshwater Research* 58, 492–503.

Larson, H. K., Hoese, D. F. (1996) Family Gobiidae, subfamilies Eleotridinae and Butinae, Gudgeons. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 200–219. (Reed Books: Chatswood, NSW)

Limpus, C. J., Couper, P. J., Read, M. A. (1994) The green turtle *Chelonia mydas* in Queensland: Population structure in a warm temperate feeding area. In)

Limpus, C. J., Limpus, D. J., Hamann, M. (1997) 'Freshwater Turtle Populations in the Area to be Flooded by the Walla Weir, Burnett River: Baseline Study.' Queensland Department of Environment, Brisbane.

Long, B., Robert, R., *et al.* (2004) Monitoring Seagrass Beds at Fisherman Island, Moreton Bay, Queensland. CSIRO Division of Fisheries.

Long, P. E., Berghuis, A. P. (1996) Fisheries. In 'Downstream Effects of Land Use in the Fitzroy Catchment: November 1993–December 1996 (Summary Report)'. Brisbane. (Eds RM Noble, LJ Duivenvoorden, SK Rummenie, PE Long and LD Fabbro) pp. 66–78. (State of Queensland, Department of Natural Resources)

Marsden, T., Power, T. (2007) 'Proposal of Raising of the Eden Bann and Construction of Rockwood Weir. An assessmenmt of potential requirements for fish passage. Queensland Department of Primary Industries and Fisheries.

McDowell, R. M. (1996a) Family Galaxiidae, Galaxiids. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 52–77. (Reed Books: Chatswood, NSW)

McDowell, R. M. (1996b) Family Poeciliidae, Livebearers. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 116–122. (Reed Books: Chatswood, NSW)

Meffe, G. K. (1990) Offspring size variation in Eastern Gambusia (*Gambusia holbrooki*: Poeciliidae) from contrasting thermal environments. *Copeia*, Vol 1 (1990) No.2, pp 10-18.

Melzer, A (2004) Macrobenthic community Structure. In New coastal science for the Fitzroy estuary, February 2004. A brochure published by the Coastal CRC, Queensland.

Merrick, J. R., Schmida, G. E. (1984) 'Australian Freshwater Fishes: Biology and Management.' (Griffin Press Limited: Netley, South Australia).

Metzeling, L., Chessman, B., Hardwick, R., Wong, V. (2003) Rapid assessment of rivers using macroinvertebrates: the role of experience, and comparisons with quantitative methods. *Hydrobiologia* 510, 39–52.

Morton, R. M., Pollack, B. R., Beumer, J. P. (1987) The occurrence and diet of fishes in a tidal inlet to a saltmarsh in southern Moreton Bay, Queensland. *Australian Journal of Ecology* 12, 217–237.

Mousalli, A., Connolly, R. (1998) Fish use of the inudated waters of a subtropical saltmarsh-mangrove complex in southeast Queensland. In 'Moreton Bay and Catchment'. Brisbane. (Eds IR tibbetts, NJ Hall and WC Dennison) pp. 471–472. (University of Queensland)

Noble, R. M., Rummenie, S. K. (1996) Physical and chemical water quality. In 'Downstream Effects of Land Use in the Fitzroy Catchment: November 1993–December 1996 (Summary Report)'. (Eds RM Noble, LJ Duivenvoorden, SK Rummenie, PE Long and LD Fabbro) pp. 17–43. (State of Queensland, Department of Natural Resources: Brisbane)

Pollard, D. A. and M. A. Rimmer (1996). Family Ariidae, Salmon or fork-tailed catfish. Freshwater Fishes of South-Eastern Australia. R. M. McDowell. Chatswood, NSW, Reed Books: 107-111.

Pollard, D. A. (1996) Family Apogonidae, Cardinalfishes and mouthbrooders. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 181–182. (Reed Books: Chatswood, NSW)

Pollard, D. A., Davis, T. L. O., Llewellyn, L. C. (1996) Family Plotsidae, Eel-tailed catfish. In 'Freshwater Fishes of South-Eastern Australia'. (Ed. RM McDowell) pp. 109–113. (Reed Books: Chatswood, NSW)

Pusey, B., Kennard, M., Arthington, A. (2004) 'Freshwater Fishes of North-Eastern Australia.' (CSIRO Publishing: Collingwood)

QEPA (2007) Wildlife Online: an online wildlife database. Queensland Government Environmental Protection Agency. https://www.epa.qld.gov.au/nature_conservation/wildlife/wildlife_online/

QEPA (2003) Brigalow Belt: Fauna Expert Panel Report. Biodiversity Panning Assessment. Queensland State Government Environmental protection Agency, Brisbane.

QEPA (2002) Aquatic Biodiversity Assessment and Mapping Methodology. Queensland Government Environmental Protection Agency, Brisbane.

QEPA (1999). Water Quality Sampling Manual. For use in testing for compliance with the Environmental Protection Act 1994. Brisbane, Queensland EPA: 52.

QWP (2006) Helping Wetlands in Southern Fitzroy Floodplain: Information Bulletin No.1. The Queensland Wetlands Programme - Great Barrier Reef Wetlands Protection Programme, together with the Fitzroy Basin Association, Rockhampton.

Sattler, P. S. and R. D. Williams, Eds. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Brisbane, Environmental Protection Agency.

Sawynok (2002) Barramundi Nursery Areas in Central Queensland. Natural heritage Trust Project Reports 982209 and 2012207, Rockhampton Queensland.

Thomson, J. M. (1996). Family Mugilidae, Grey mullets. Freshwater Fishes of South-Eastern Australia. R. M. McDowell. Chatswood, NSW, Reed Books: 191-197.

Wager, R. (1993) 'The Distribution and Conservation Status of Queensland Freshwater Fishes.' Department of Primary Industries, Information Series QI93001, Brisbane.

Wager, R., Jackson, P. (1993) 'The Action Plan for Freshwater Fishes.' Queensland Department of Primary Industries, prepared for Australian Nature Conservation Agency, Brisbane.

WBM (2002) 'Impacts of Mining on the Aquatic Ecology of the Bowen Basin Streams.' Report prepared on behalf of Ausralian Coal Association, Brisbane.

Unmack, P. J. (1999) Biogeography of Australian Freshwater Fishes. Master of Science thesis, Arizona State University.

URS (2007) Gladstone Nickel Project Environmental Impact Statement: Flora and Fauna Appendix. Prepared for Gladstone Pacific Nickel Ltd., Queensland.

Veitch, V. and Sawynok, B. (2005) Freshwater Wetlands and Fish. Importance of Freshwater Wetlands to Marine Fisheries Resources in the Great Barrier Reef. Report prepared by Sunfish Queensland Inc on behalf of Great Barrier Reef Marine Park Authority, January 2005.