13 Nature Conservation: Aquatic Biology

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13.1 Introduction

13.1.1 Background and scope

The project is located within the three catchments of Pumicestone, Mooloolah and Maroochy (from south to north) and traverses a number of major waterways and minor drainage lines. Major waterways from Landsborough to Nambour include: Addlington Creek, South Mooloolah River, Mooloolah River, Eudlo Creek, Paynter Creek and Petrie Creek. The condition of the waterways varies, but generally speaking the condition of the waterways is better in the southern portion of the site (between Landsborough and Palmwoods) due to more expansive riparian vegetation and a lower density of development.

This report presents a description of existing (baseline) aquatic flora and fauna conditions within the project area, together with an assessment of the key potential impacts associated with the project and an outline of the strategies that will be implemented to mitigate these potential impacts. The key ecological functional groups considered are:

- aquatic macrophytes and habitats
- macroinvertebrates
- fish (freshwater)
- turtles (freshwater).

Note that this section does not consider semi-aquatic mammals (e.g. platypus, water rat etc.) or amphibians, which are addressed in **Chapter 12, Terrestrial fauna.**

13.1.2 Aims

The aims of the baseline fauna investigations were to identify the aquatic fauna occurring in areas that would be potentially impacted by the project. Specifically, in order to address the terms of reference, the aims of this study are to:

- identify aquatic fauna or flora present, or likely to be present including fish species, aquatic invertebrates and aquatic macrophytes
- provide a description of the distribution, and other patterns, of aquatic flora and fauna
- describe aquatic fauna habitat requirements and the sensitivity of aquatic flora to changes in flow regime, water levels and water quality
- describe aquatic substrate and stream type, including extent of tidal influence and common levels such as Highest Astronomical Tide and Mean High Water Spring Tide
- identify the key aquatic ecology constraints and potential impacts of the proposal
- describe methods used to mitigate impacts on aquatic ecosystems with particular focus on: stream diversions, stream crossings, construction timing (to avoid spawning periods) and methodology (to minimise discharges and disruption), rehabilitation and offsets, creation of biting insect habitat and monitoring of aquatic health.

13.1.3 Relevant legislation and policy

There are several pieces of relevant Queensland and Commonwealth legislation and policies that need to be considered for relevance to aquatic ecosystems. This legislation refers either directly to the watercourse and water resource (*Water Act 2000*) or to species of flora and fauna that may rely on these resources for habitat requirements. These are listed in **Table 13.1.3.**

Table 13.1.3: Relevant Commonwealth and State legislation

Legislation/ Policy	Implications	Level
Environment Protection Biodiversity Conservation Act 1999 (EPBC Act)	This Act aims to protect Threatened species. It requires referral to the federal government for development that may impact listed species.	Commonwealth
Nature Conservation Act 1992 (NC Act) (and Regulations and Conservation Plans)	This Act aims to protect Threatened species and recognised conservation areas. It requires application to the Department of Environment and Resource Management for the take of Threatened fauna species.	Queensland
Land Protection (Pest and Stock Route Management) Act 2002 (LP Act)	This Act defines noxious pests (including aquatic plants), which are formally referred to in the Act as Declared Pests. It requires management of some Declared Pests.	Queensland
Fisheries Act 1994	Protects fisheries habitat and certain fish species of conservation significance or concern. This Act requires assessment of temporary or permanent barriers to fish movement.	Queensland
Fisheries Regulation 1995	This Act defines noxious fish, which are formally referred to as Declared Pests.	Queensland
Water Act 2000	This Act governs water allocations from waterways and ground water sources. It also protects the physical features of the waterways themselves, in terms of bed, banks and riparian vegetation. Clearing of riparian vegetation or alteration of the watercourse requires assessment under this law.	Queensland

13.2 Methodology

13.2.1 Review of existing information

Information pertaining to the project area was available due to work that has already been carried out in the region by various government and private bodies for other projects. Some of this information was able to be utilised in a desktop review of the project area.

Information review

The information review considered a range of relevant published studies, consultancy reports and data sources, including but not limited to:

- existing water quality data for the project area and catchment, including the Ecosystem Health Monitoring Program (EHMP), the Department of Environment and Resource Management Watershed Database and the Mooloolah and Maroochy State of Rivers (SOR) reports
- various information sources that describe structural habitat characteristics and aquatic ecology for the catchments, including the above mentioned SOR and EHMP reports
- Mary Basin catchment Water Resource Planning (WRP) technical reports and appendices
- freshwater fish records for the Mooloolah and Maroochy River catchments documented in various publications, EHMP 2007, EHMP 2004, Pusey et al. 2004.)

All data was reviewed, and wherever relevant, used as supplementary data for comparison with the results of the current survey.

Spatial data

Several GIS datasets were assessed, including:

- rectified aerial photography of the project area and surrounds
- cadastre
- Regional Ecosystem (RE) vegetation mapping (Version 5.0 with December 2006 amendments)
- Biodiversity Planning Assessment (BPA) mapping (Version 3.4 – March 2005)
- Ramsar wetland areas
- Department of Environment and Resource Management estate (National Parks, Conservation Parks etc).

Public databases

Public access databases with restricted location 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, namely:

- Wildlife Online is a Queensland internet database of the Department of Environment and Resource Management accessible to the public which stores records of plant collections and fauna sightings (and other groups including algae, fungi etc.) for a search area defined by the user. EVR and other notable species can be selected from the search outputs.
- EPBC Act Protected Matters Report is a Commonwealth Department of Environment and Water Resources internet-based database. It lists matters of national environmental significance, or other matters protected by the EPBC Act, that are likely to occur within a search area defined by the user. These include EPBC Act listed EVR species, migratory and other notable species of national environmental significance, including Ramsar wetlands, World and National Heritage places and other relevant Commonwealth lands.
- Coastal Habitat Resources Information System (CHRIS) is a Queensland Department of Primary Industries and Fisheries database providing information on commercial fisheries catches and protected coastal habitat areas.

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

13.2.2 Field investigations

The project area defined for the future upgrade of the Northern Coast Line between Landsborough and Nambour is approximately 3 km wide, extending approximately 22 km from Landsborough to Nambour. The average width of the project within this project area is approximately 60 m. The major catchments represented in the project area are the Maroochy River Catchment to the north and the Mooloolah River Catchment to the south. Together these catchments drain an approximate combined total area of 859 km^2, which includes South Mooloolah River, Eudlo Creek, Paynter Creek and Petrie Creek. The project area traverses the Pumicestone (Mellum Creek) catchments, Mooloolah and Maroochy. The main drainage within the project area is the Mooloolah River, which is situated in the Mooloolah Catchment. Other main drainages include Eudlo, Petrie and Paynter Creeks, which are located in the Maroochy Catchment. Addlington Creek is included in the Pumicestone catchment.

Aquatic habitats, flora, fauna and in-situ water quality surveys were undertaken to provide detailed site-specific information on the distribution and patterns of aquatic ecology values within the project area. Sampling was conducted at sites within and adjacent to the project, and was repeated on two occasions, September 2007 and January 2008, to encompass potential seasonal differences in aquatic communities.

Sampling sites and timing

Five main drainages were investigated within the project area, namely drainages of Ewen Maddock Dam (Addlington Creek and tributaries), South Mooloolah River, Eudlo Creek, Paynter Creek and Petrie Creek. Within these drainage systems a total of 14 sites (**Figure 13.2a and Table 13.2.2**) were selected for field surveys. Site selection was based on the following criteria:

- sites which were considered to be representative of the range of aquatic meso-habitat types found within each major drainage and the project area generally
- sites which were representative of habitats favoured by the key Threatened species potentially occurring within the project area (e.g. 'wallum' habitat, which is favoured by Oxleyan Pygmy Perch (*Nannoperca oxleyana*) and Honey Blue Eye (*Pseudomugil mellis*)).

Table 13.2.2: Summary of Samples Sites within the Project Area

Catchment	Sub-Catchment	Site No:	Drainage Name	Stream Order[1]
Mooloolah	Mooloolah River	1	Addlington Creek	2
		2	Minor drainage into Ewen Maddock Dam	1
		3	Minor drainage into Ewen Maddock Dam	1
		4	Unnamed tributary of Mooloolah River	4
		5	South Mooloolah River	4
		6	Unnamed tributary of Mooloolah River	4
Maroochy	Eudlo Creek	7	Eudlo Creek	3
		8	Unnamed tributary of Eudlo Creek	1
		9	Unnamed tributary of Eudlo Creek	2
	Paynter Creek	10	Unnamed tributary of Paynter Creek	1
		11	Paynter Creek	4
		12	Paynter Creek	4
	Petrie Creek	13	Petrie Creek	5
		14	Petrie Creek	5

1 Stream Order is a numerical ordering classification of each watercourse segment according to its position within a catchment (refer to Glossary for diagrammatic representation)

Aquatic habitat and macrophyte methods

A general description of the habitat characteristics of each site was undertaken, documenting riparian vegetation characteristics, stream substrate composition and profile, adjacent land uses and overall condition.

At each site, 50 m long transects (tape measures) were placed parallel to the stream on each bank. The area bound by the tapes represented the site. The location of site boundaries and significant features (e.g. trees) were recorded with a hand-held GPS to allow re-positioning of the site boundaries for repeat sampling.

The aquatic habitat and macrophyte sampling methodology was adapted from Arthington (1996) and incorporated two related methods. The first is based on five adjacent, evenly spaced, in-stream transects running parallel to the banks with: two bank transects, a centre-of-stream transect and two remaining transects either side of the centre of stream transect. Four random points were selected along each of the five transects, totalling 20 sampling points.

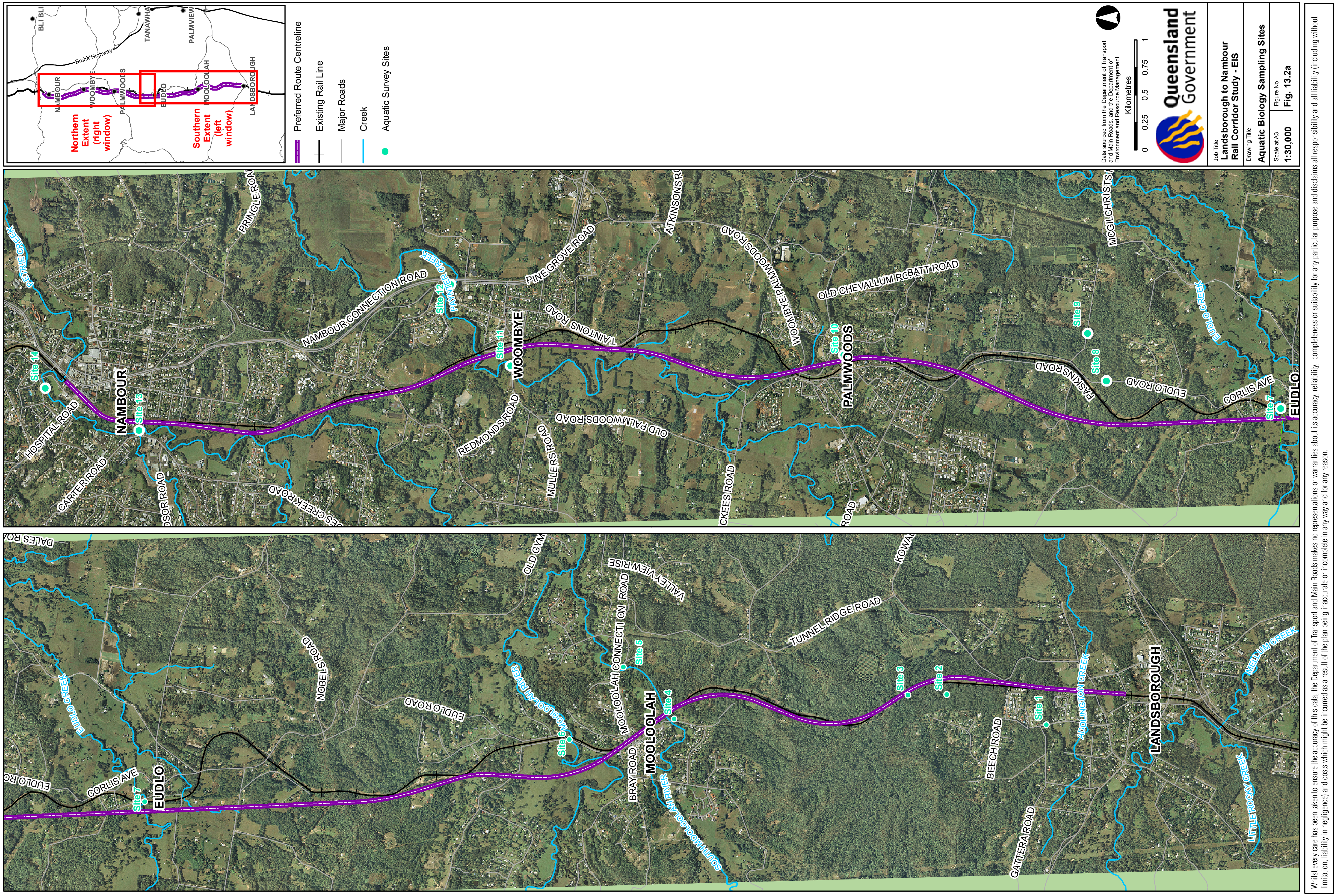


Figure 13.2a: Acquatic Biology Sampling Sites

The following parameters were measured within 1 m^2 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 (>15 cm diameter)
- percentage cover of small woody debris (<15 cm diameter).

The second method estimated the percentage cover of the following attributes along the banks on either side of the stream, excluding terrestrial vegetation except for the immediate riparian strip:

- canopy cover
- aquatic macrophytes
- filamentous algae
- periphyton
- overhanging vegetation
- submerged vegetation
- emergent vegetation
- leaf litter
- large woody debris (>15 cm diameter)
- small woody debris (<15 cm diameter)
- undercut banks
- overhanging roots.

Macrophyte surveys were conducted using visual observations and, if necessary, by hand collecting samples for identification. Similarly, substrate composition was estimated by eye from hand picked samples in shallow areas and by an extended scoop in deeper sections.

Fish

In order to adequately sample the range of fish species present, a number of sampling methods were utilised during surveys. These included the following sampling apparatus:

- **Gill nets** (25, 50, 75 mm stretched mesh, 2.5 m drop, 30 m wide) - multi-panel gill nets were set oblique to the shore for two-hour soak times, field operators 'sat' on these nets so that any animals captured were immediately released from the net.
- **Baited box traps** (0.5 mm mesh) - baited box traps were used at all sites, and represented the key trapping techniques for small bodied Endangered, Vulnerable or Rare (EVR) species. Fifteen collapsible, baited baitfish traps were deployed across the range of microhabitat types present. All traps were deployed for approximately one hour.
- **Fyke net** - where stream dimensions permitted, a fyke net was set for two hours with the entrance facing downstream, parallel to the bank. The dimension of the net was approximately 5 m long with a single 1 m entrance and dual wings.
- **Push seine net** (3 m long, 2 m high, 5 mm stretched mesh) - a push seine net was used to sample small fish. Numerous hauls were undertaken within each microhabitat types present, depending on channel dimensions and the number of snags present.
- **Scissor seine net** (2 m long, 2 m drop, 0.5 mm mesh) - a scissor seine net was used to sample small fish. Three 10 m hauls were conducted in each microhabitat at each site where waterway dimensions permitted.

Gear types appropriate to the characteristics of each site were used. Consequently not all sampling methods were deployed at each site. For example, a push seine net and a scissor seine net were not applicable in deep streams.

All fish caught were identified and counted. A proportion of individuals were measured and wounds, lesions or deformities were recorded if present. Native fish were released alive, whilst any introduced fish species collected were euthanised. When identification was difficult in the field, one or two specimens were retained for identification in the laboratory.

Water quality

In-situ measurements of selected physical water quality parameters were undertaken at all sites, coinciding with aquatic flora and fauna sampling (i.e. 14 sites sampled on two occasions, September 2007 and January 2008).

Sampling procedures followed those outlined in the QEPA (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 (^oC)
- conductivity (uS/cm)
- total dissolved salinity (g/L)
- dissolved oxygen (mg/L and % saturation)
- pH
- reduction-oxidation (Redox) potential (mV)
- turbidity (NTU).

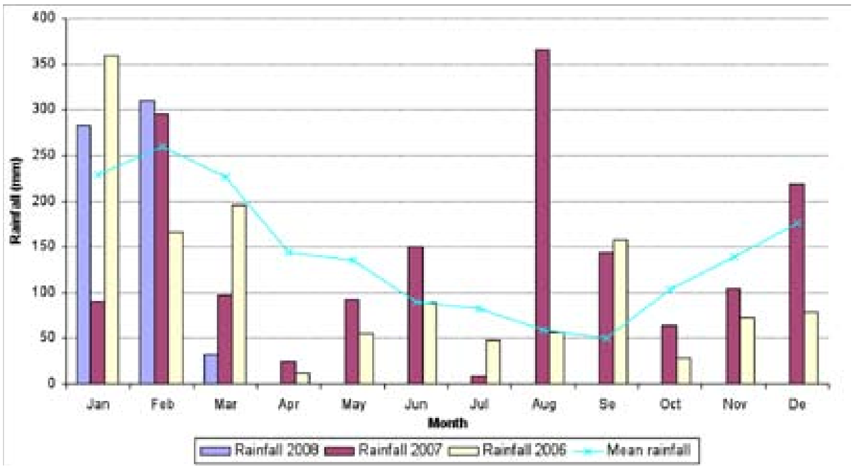
13.2.3 Limitations of study

Flora and fauna sampling was conducted on two occasions and, hence, encompassed some temporal variation. However, fish communities, in particular, can show marked variation in composition, richness and abundance at various time scales (e.g. seasonally, annually etc.). It is probable that not all species occurring in the area were detected. Variability in fish communities is thought to be linked to a number of factors, including inter-annual changes in seasonal flow and drought conditions, seasonal trends in fish movements (which occur in response to changes in water temperature and flows), and biological interactions (i.e. food availability, predation, competition etc.).

Although the region had experienced drought conditions during the past few years, the months prior to the sampling events had experienced higher than average rainfall.

Figure 13.2b illustrates the total and average monthly rainfall in the 27 months leading up to the completion of all baseline sampling[2]. Consequently, waterways within the project area were experiencing high flows during the sampling times and conditions could be considered to be representative of wet climatic periods. Prior to these rainfall events the project area and wider region had been experiencing severe drought conditions.

Figure 13.2b: Total and mean monthly rainfall over the two years leading up to the study (Data from Bureau of Meteorology Nambour weather station)



13.2.4 Assessment of impacts

The primary potential impacting processes of the project, in regard to aquatic flora, fauna and their habitats, were identified and described with specific references to the key aquatic ecology survey sites and adjacent areas. Each of these aquatic ecology impacts was assessed and assigned one of the significance criteria described in **Table 13.2.4a**. These terms are used throughout the impact assessment. Definitions of the duration of temporal impacts used in the assessment are also provided in **Table 13.2.4b**.

Following the assignment of the significance levels to the various impacts, the impact assessment proposes the mitigation methodologies that could be implemented to reduce or alleviate potential impacts. The significance of any residual potential impacts (i.e. after mitigation) were also assessed and assigned their resultant significance level.

Table 13.2.4a: Significance criteria for aquatic ecology impact assessment

Significance	Description
High Adverse	Impact a major problem. These impacts are likely to be important considerations adversely affecting species or the aquatic habitat of species of National importance (as identified in the EPBC Act, or State significance (as identified in the Nature Conservation (Wildlife) Regulation 2006). Impacts are to the extent that the Threatened species is removed indefinitely or known habitat can no longer function to provide essential resources for the Threatened species. In a more general sense, a high adverse impact can be defined as an impact on a significant area of habitat such that the result is that the abundance and / or diversity of aquatic flora and fauna species is decimated. These impacts are concerns to the project, depending upon the relative importance attached to the issue during the decision making process. Mitigation measures and detailed design work will not remove the impacts upon the affected Threatened species. Adverse residual impacts would predominate.

2 *Rainfall at Nambour weather station; average based on 54 years of rainfall data (BoM)*

Table 13.2.4a: continued

Significance	Description
Moderate Adverse	Impact moderate. These impacts are likely to be important at a national, State or local (as identified within local laws or local planning scheme codes or guidelines) scale. Impacts are to the extent that the aquatic habitat of the Threatened species is reduced in size or quality and / or there are ongoing activities that are likely to have adverse implications for the Threatened species in the long-term. Ongoing activities may include: increased water activities (e.g. boating and recreation), fishing, water extraction, release of contaminants etc. In a more general sense, a moderate adverse impact can be defined as an impact on a significant area of habitat such that the result is a noticeable reduction in the abundance and / or diversity of aquatic flora and fauna. These impacts represent issues where adverse outcomes would be experienced, but mitigation measures and detailed design work can ameliorate some of the consequences upon Threatened species and their aquatic habitats. Some residual impacts would still arise. The cumulative impacts of such issues may lead to an increase in the overall impacts upon a particular area or on a particular resource and hence may become key decision making issues.
Low Adverse	Impact recognisable but acceptable. These impacts are likely to be important only at a local scale and are unlikely to be of significant importance in the decision making process. Impacts are minor or short term and can be ameliorated by detailed design work and mitigation measures. Residual impacts are minimal or non-existent and do not cause a decline in aquatic flora and fauna diversity or abundance or affect the ability of a Threatened species to exist. These impacts are generally of relevance for enhancing the subsequent design of the project and in the consideration of mitigation or compensation measures.
Negligible	Minimal change. No impacts or those which are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error.
Beneficial	Impacts beneficial to the environment. There is an increase in the area or quality of habitat affected by the proposal and / or the ability of a riverine community to provide ecosystem services is enhanced. Similarly, an existing threatening activity or process is ameliorated. These impacts are large a result of mitigation measures.

Table 13.2.4b: Definitions of temporal scale of impacts

Relative Duration	Definition
Permanent	Period in excess of 50 years
Long-term	From 20-50 years
Medium term	From 7-20 years
Short term	From 1-7 years
Temporary	Up to 1 year

13.3 Description of environmental conditions

The project area incorporates three catchment areas and numerous creeks and drainage lines, as described in the following section. These waterways traverse a variety of land uses including conservation, rural, rural residential, residential and small townships. As such the extent and quality of the riparian zones varies significantly. The diversity and abundance of aquatic flora and fauna across the project area was expected to vary between catchments, as a reflection of riparian zone condition and water quality. Generally, the Mooloolah catchment was anticipated to have higher quality habitat because of the larger areas of remnant vegetation still present within the catchment. Field survey effort was evenly distributed throughout the project area, to provide a representation of the aquatic ecosystems in each of the major waterways potentially affected by the project.

Based on the results of both the review of existing information and field investigations, this section describes the existing environmental conditions in terms of the aquatic ecology values of the project area. These specifically include:

- aquatic habitats
- aquatic macrophytes
- freshwater fish
- macro-invertebrates
- aquatic flora and fauna species of conservation or other special significance.

13.3.1 Aquatic habitats

Overview

The project area traverses the mid and upper reaches of three southeast Queensland catchments, namely, the Pumicestone, Mooloolah and Maroochy catchments. The total area of each catchment within the project area was 2.88, 22.09 and 41.37 km^2, respectively (**Table 13.3.1**). Based on the SEQ catchment digital terrain model and stream order mapping (WBM 2005), a total of 163.4 km of stream length have been mapped within the project area, most of which are minor drainages (stream orders 1 and 2) (**Table 13.3.1, Figure 13.3a**).

Five main drainage systems traverse the project area, including Petrie Creek, Paynter Creek, Eudlo Creek, Mooloolah River and minor drainages of Ewen Maddock Dam. Mellum Creek represents the principle drainage for the Pumicestone catchment within the southern end of the project area. However, drainages of this waterway do not intersect the proposed rail corridor within the project area.

Table 13.3.1: Stream order lengths (km) and area data for the project area and associated sub catchments

	Pumicestone Catchment		Mooloolah River Catchment		Maroochy River Catchment				Total	
	Mellum Creek Sub-Catchment		Mooloolah River Sub-Catchment		Eudlo Creek Sub-Catchment		Petrie/Paynter Creeks Sub-Catchment			
	Project area	Total	Project area	Total	Project area	Total	Project area	Total	Project area	Total
Area (km^2)	2.88	276	22.09	223	15.43	79	25.94	120	66.34	698
Stream order 1	3.21	261	24.28	238	18.79	96	31.02	142	77.3	737
Stream order 2	0.85	152	14.32	115	8.71	50	12.36	71	36.24	388
Stream order 3	3.25	69	3.64	58	10.21	33	4.29	32	21.39	192
Stream order 4	0	55	9.42	45	1.11	7	13.45	34	23.98	141
Stream order 5	0	21	0	35	0	12	4.52	17	4.52	85
Stream order total length	7.30	558	51.67	491	38.83	198	65.63	296	163.43	1543

Habitat types

The following broad aquatic habitat features occur within the project area:

- *Semi-perennial freshwater rivers and streams* are commonly restricted to the main arms of the 5 larger drainage systems characterised by stream orders of 3 to 5 (i.e. Eudlo Creek, South Mooloolah River etc.). At the time of sampling these were generally semi-contiguous to continuous low flowing pool environments and interspersed with areas of glide and riffle habitat. During periods of low rainfall, some streams may not flow but contain contiguous pools.
- *Low order ephemeral streams and drainages* are well represented throughout the project area, with many currently containing temporary pools as a result of recent flood events. Aquatic habitat features vary in response to flow conditions, potentially including temporal run, glide, riffle and pool habitats during periods of prolonged rainfall, and isolated pools during low flow periods.
- *Palustrine wetlands* were mainly recorded at and adjacent to Dularcha National Park.

Each of these aquatic habitat features contains a range of meso-habitat (and micro-habitat) types, including the following:

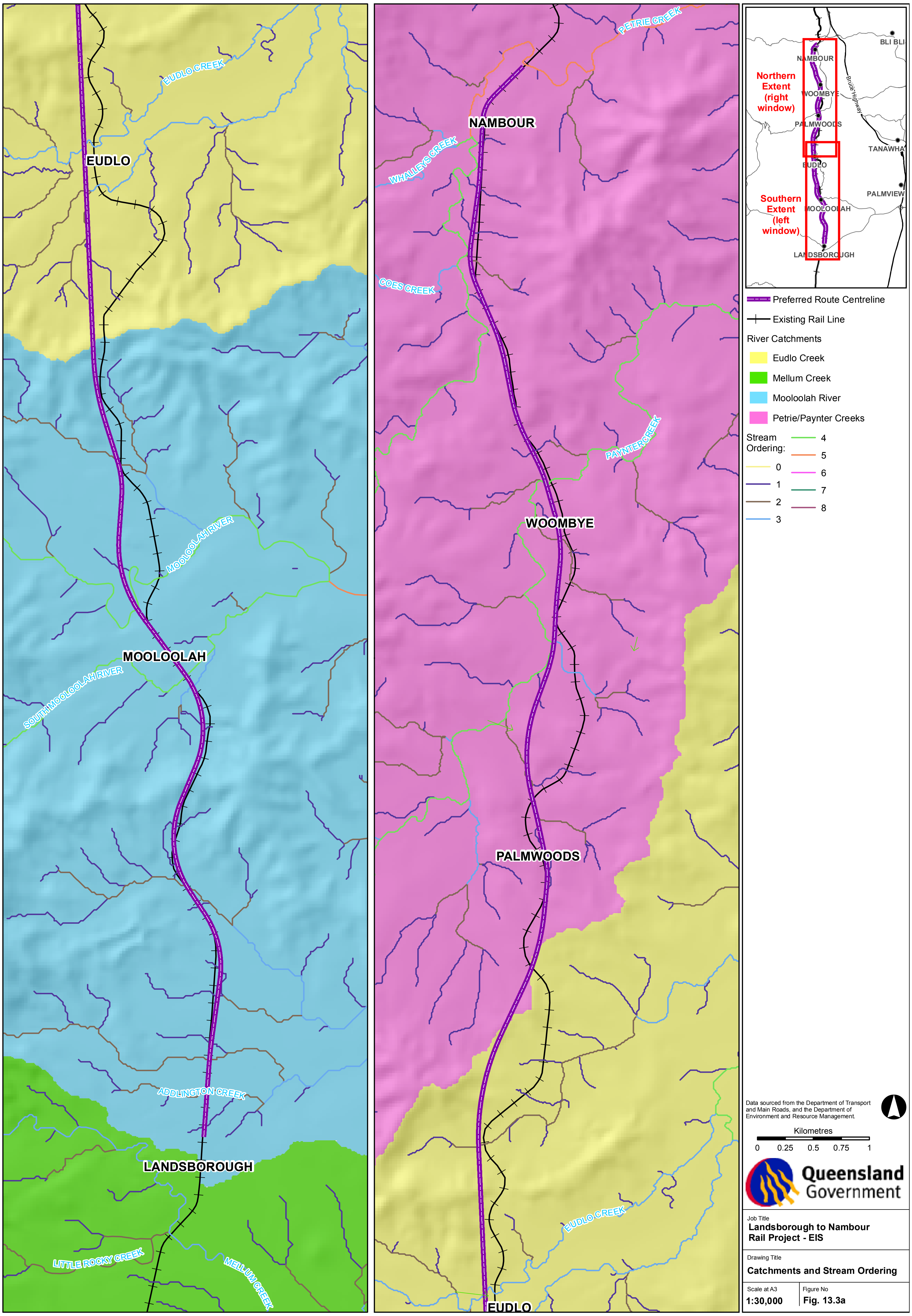
- permanent/semi-permanent pools within natural defined channels
- ephemeral low-order drainages with defined channels
- run habitats

During the period of sampling this habitat type was well represented within the project area due to the relatively high rainfall prior to the sampling period.

- riffle habitats, which were also well represented throughout the project area
- low-lying wetland environments.

At the time of sampling, low-lying wetland environments were well represented in Dularcha National Park, reflecting the high rainfall experienced prior to sampling.

Figure 13.3a: Catchments and Stream Ordering



Whilst every care has been taken to ensure the accuracy of this data, the Department of Transport and Main Roads 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) and costs which might be incurred as a result of the plan being inaccurate or incomplete in any way and for any reason.

Catchment condition

The Ecosystem Health Monitoring Program (EHMP) monitors the health of southeast Queensland waterways. Assessments incorporate a number of stream health indicators including, water quality, nutrient cycling, aquatic habitat condition, fish and macro-invertebrates. Data are integrated to give an aquatic ecosystem health score for each catchment. Findings of the 2006 EHMP assessments of the freshwater reaches of the Maroochy and Mooloolah catchments (i.e. northern and southern sections of the project area, respectively) can be summarised as follows:

- *Maroochy catchment* - overall score of C- , streams generally in fair condition, nutrient cycling was poor, water quality, ecosystem processes and fish indicators are good.
- *Mooloolah catchment* - overall score of B, streams generally in good condition, riparian vegetation in the upper catchment in good condition, all other indicators, apart from nutrient cycling score well.

Queensland State of the Rivers reporting (Eberhand and Manen 2000; Fawns 2000) for the Mooloolah and Maroochy catchments indicate that:

- bank stability was rated as unstable to stable (20-60%) in the Mooloolah catchment and stable to very stable (60-80% or greater) in the Maroochy catchment
- stream bed stability was unstable to stable (20-80%) throughout the project area
- channel diversity was rated very low (< 20%) throughout much of the project area, though patches of low to moderate (20-60%) channel diversity occur
- within the project area, the condition of riparian vegetation range from very poor to poor (0- 40%) for the Mooloolah catchment and poor to good (40-80%) for the Maroochy catchment
- aquatic vegetation condition was mostly rated as very poor (< 20%) throughout the project area
- within the project area, aquatic habitat condition was generally rated as very poor to moderate (0-60%) for the Mooloolah catchment and good to very good (60-80% or greater) for the Maroochy catchment
- overall, the waters within and adjacent to the project area have been degraded by catchment clearing and ongoing human disturbances, though good quality habitat does occur in some places
- stream condition within the project area was rated as poor to good (20-80%).

Site-specific aquatic habitat features

Field surveys revealed a number of key conditions of micro-habitats in the creeks within the project area:

- Aquatic macrophyte cover was consistently low at most sampling sites.
- Wetted stream width ranged from 2 to 8 m for all sites, with the exception of Site 13 on Petrie Creek, which had a mean width of 17 m.
- Mean water depth was variable among sites, ranging from 0.2 - 1.6 m.
- Most sites had a high cover (typically >15%) of large and small woody debris, root cover and leaf litter.
- Over-stream riparian vegetation cover was generally high throughout the project area, typically ≥ 50% at most sites, except at Sites 10, 13 and 14 where cover was < 20%.
- Generally, substrates were moderately compacted at all sites, with sediments composed of a mixture of sand and mud. Substrates at Sites 14, 4 and 7 were also comprised of a high proportion of coarse gravel, cobbles and rocks.

Overall, these habitat features were consistent (within each site) between the September 2007 and January 2008 surveys, with a few main exceptions:

- Mean water depth and wetted stream width increased by a maximum of 0.2 m and 0.5 m, respectively, due to rainfall that occurred prior to the January 2008 survey.
- Water turbidity and stream flow were also higher in January 2008 at most sites.

There was an increase in debris, particularly leaf litter and small and large woody debris, in January 2008 along the banks of some creeks.

Water quality

The water quality of waterways within the project area is described in detail in **Chapter 14, Water resources.** In brief, most water quality parameters are typically within or below the ANZECC/ARMCANZ (2000) guideline values for slightly disturbed lowland rivers in South-east Australia. The main exceptions to this are dissolved oxygen and turbidity.

Dissolved oxygen can be highly variable throughout the project area, ranging from hypoxic (low) conditions to saturated (high) levels. Hypoxic conditions in the ephemeral stream generally occur during periods of no flow (e.g. streams in Dularcha National Park). During water quality investigations for this EIS, dissolved oxygen concentrations were typically below the ANZECC/ARMCANZ (2000) guideline values (85-110% saturation). In contrast, turbidity levels throughout the project area were generally elevated. This is partly associated with the project area catchments having received substantial rainfall prior to water quality sampling. The resultant run-off and localised flooding within the region caused an extended period of elevated turbidity levels.

Both low dissolved oxygen and turbid conditions can influence aquatic flora and fauna communities. With regard to fauna, such conditions can exclude sensitive species, whilst favouring more opportunistic species (e.g. exotic fish species). Although submergent aquatic macrophytes may be able to tolerate turbid conditions for short periods of time, they typically prefer clear waters that enable sufficient light penetration.

It should be noted that the pH in a number of minor drainages was slightly acidic (i.e. less than the relevant guideline value of 6.5). These included the two minor drainages in Dularcha National Park that drain into Ewen Maddock Dam (Sites 2 and 3) and an unnamed drainage of Paynter Creek (Site 10). The low pH at these waterbodies is likely due to high levels of dissolved organic matter derived from surrounding vegetation (tannins and lignins) and is a key habitat condition favourable by EVR fish species that occur within the broader region.

13.3.2 Wetlands

No Ramsar or Nationally Important (Environment Australia 2001) wetlands were recorded within the project area. The Moreton Bay aggregation is the closest Ramsar site, located at the most downstream extent of the Pumicestone catchment (i.e. estuarine sections of Pumicestone Passage). Note that Mellum Creek, located in the southern sections of the project area, ultimately discharges into the Moreton Bay Aggregation ~18 km downstream of the project area.

Two nationally important wetland areas (Environment Australia 2001; DEWHA Online Australian Wetlands Database) occur to the east of the project area, namely: Lower Mooloolah River; and Coolum Creek / Lower Maroochy River. These wetlands are located in estuarine environments downstream (approximately 14 and 12 km, respectively) of the project area (**Figure 13.3b**). They are considered to have a high value to wildlife and ecosystems, particularly through the provision of refuge habitat (Environment Australia 2001). Project area drainages that ultimately discharge into these wetland systems include Petrie Creek, Paynter Creek, Eudlo Creek and the Mooloolah River.

13.3.3 Aquatic macrophytes

Aquatic macrophyte richness

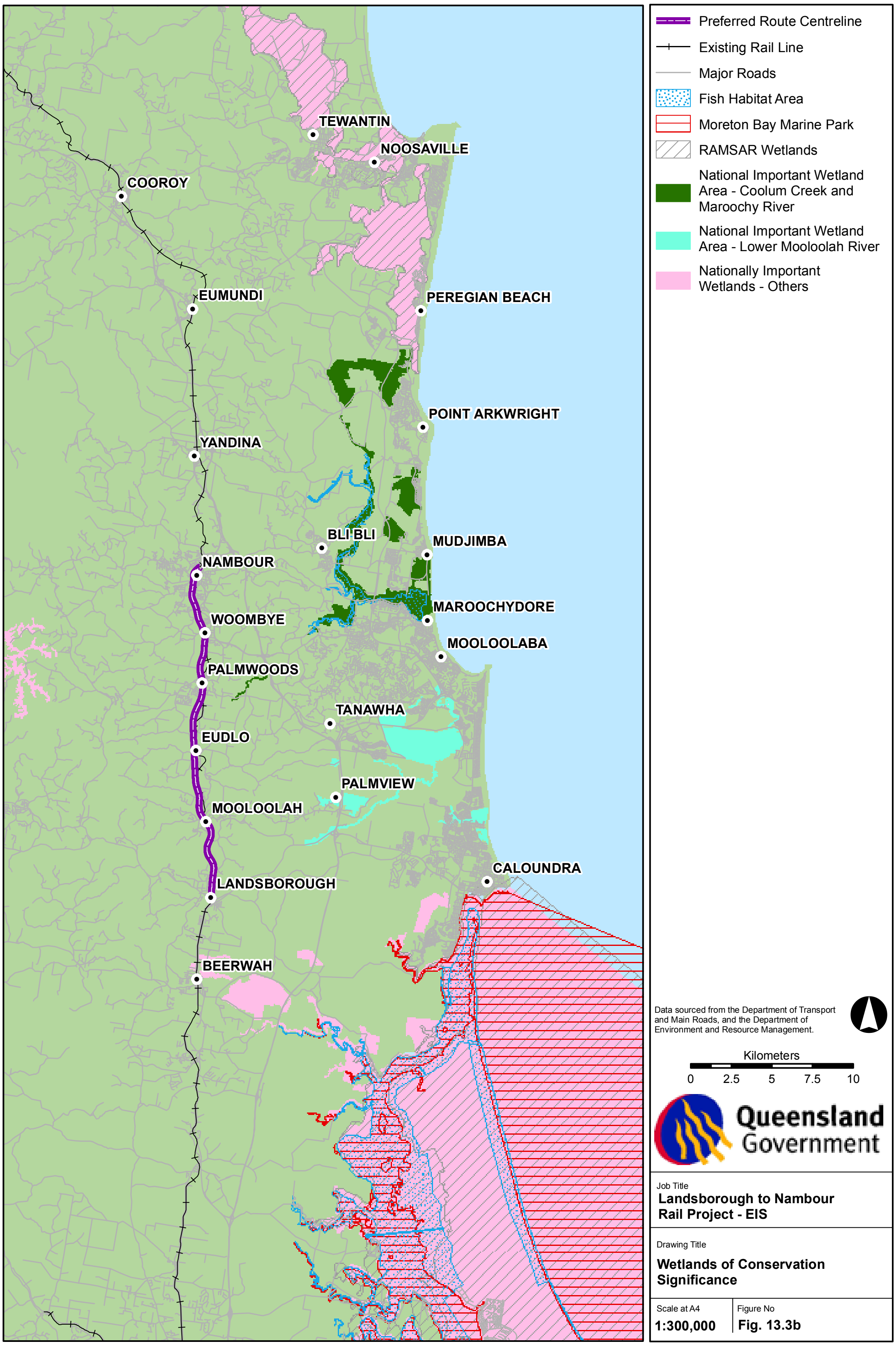
Surveys recorded a paucity of aquatic macrophytes within the project area (refer **Table 13.3.3**). However, it is acknowledged that significant rainfall prior to the survey may have resulted in the loss of some aquatic vegetation. Aquatic macrophytes were observed at approximately one third of the sampling sites (Sites 2, 5, 7, 10 and 14).

Aquatic macrophyte species richness at these five sites was low, with a total of 12 species recorded in the project area. These results conform with the State of the Rivers reporting for the project area catchments, which also found limited freshwater aquatic vegetation. The maximum number recorded at a site (Site 10) was eight species. The comparatively higher species richness at Site 10 is most likely due to a relatively open canopy of overhanging riparian vegetation, in contrast to the heavy shading at the majority of other survey sites.

Table 13.3.3: Aquatic macrophytes recorded by BMT WBM

Scientific Name		Common Name	Life-form	Origin
Amaryllidaceae	*Crinum pedunculatum*	River/Swamp Lily	Emergent	Native
Asteraceae	*Gymnocoronis spilanthoides*	Senegal Tea	Emergent	Introduced
Cyperaceae	*Cyperus exaltatus*	Giant Sedge	Emergent	Native
	Cyperus spp		Emergent	
	Cyperus polystachyos	Bunchy Sedge	Emergent	Introduced
	Cyperus involucratus			Native
	Schoenoplectus mucronatus		Emergent	Native
Hydrocharitaceae	*Egeria densa*	Dense Waterweed	Submerged	Introduced
Nymphaeaceae	*Nymphaea violacea*	Native Waterlily	Floating	Native
Philydraceae	*Philydrum lanuginosum*	Frogsmouth	Emergent	Native
Poaceae	*Setaria pumila subs pumila*	Bristlegrass	Emergent	Introduced
	Urochloa mutica	Para Grass	Emergent	Introduced
Polygonaceae	*Persicaria strigosa*	Prickly Smartweed	Emergent	Native
	Persicaria spp		Emergent	
Potamogetaceae	*Potamogeton pectinatus*	Fennel Pondweed	Submerged	Native
Typhaceae	*Typha orientalis*		Emergent	Native

Figure 13.3b: Wetlands of Conservation Significance



Whilst every care has been taken to ensure the accuracy of this data, the Department of Transport and Main Roads 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) and costs which might be incurred as a result of the plan being inaccurate or incomplete in any way and for any reason.

Aquatic flora community structure

The aquatic macrophyte communities that were observed during the survey consisted of emergent, submerged and floating life-forms. Emergent macrophyte species were the dominant life-form recorded, with the number of emergent species being threefold that of submerged and floating species combined. Emergent macrophytes were generally restricted to the shallow littoral margins, and were recorded at all five sites that had aquatic flora present.

The introduced weed species Para Grass (*Urochloa mutica*) was the most widespread species, while species belonging to the Cyperaceae were also well-represented. Submerged macrophytes were observed at two survey sites, and included the native species Fennel Pondweed (*Potamogeton pectinatus*) and the introduced weed species Dense Waterweed (*Egeria densa*). Instream cover of these submerged species was low. Only one floating species was observed at a single survey site, namely the Native Waterlily (*Nymphaea violacea*). Submerged and floating macrophyte growth is likely to be inhibited by a number of factors that are typical of the survey sites, including:

- water quality, in particular high turbidity
- high levels of shading by riparian vegetation
- a highly variable flow regime, including fluctuating water levels and flow velocities
- habitat degradation due to disturbance.

Species of conservation significance

None of the aquatic macrophyte species that were observed in the survey are listed as Rare and/or Threatened species. This is in accord with a review of the EPBC Act Protected Matters Report (DEWR 2007) and a search of the Wildlife Online Database (Department of Environment and Resource Management 2007) that did not reveal aquatic flora of conservation significance within the project area.

Exotic species

Introduced weed species were commonly observed at survey sites, forming approximately one third of the aquatic macrophyte flora. None of these introduced species are declared weeds under the *Land Protection (Pest and Stock Route Management) Act 2002*. Of the five sites with macrophytes present, Site 2 was the only site at which exotic weed species were not present.

13.3.4 Freshwater fish

Community composition

A total of 24 freshwater fish species[3] have previously been recorded within the catchments traversed by the project area (Pusey et. al 2004, BMT WBM 2007). These are shown in **Table 13.3.4a**. This number includes:

- at least eighteen species native to the catchment, most of which can be broadly described as common and widespread

The exceptions to this are Oxleyan Pygmy Perch (*Nannoperca oxleyana*), Honey Blue-eye (*Pseudomulig mellis*) and the Ornate Rainbowfish (*Rhadinocentrus ornatus*).

- three exotic species, namely: Swordtail (*Xiphophorus helleri*), Platy (*Xiphophorus maculatus*) 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 is declared a pest species under the *Fisheries Act 1994* and Fisheries Regulation 1995.

No species are considered to be restricted (endemic) to the Pumicestone, Mooloolah or Maroochy catchment areas. Overall, the family Eleotridae (gudgeons) represents the most species rich freshwater fish family (6 species), whereas the remaining native fish families are represented by one or two species.

In the present study 15 species, representing 8 families were collected across 14 sampling sites. In total, 8 families were recorded within the project area during both sampling episodes. The most species rich families were the Eleotridinae (gudgeons), which was represented by 5 species, followed by the Melanotaeniidae (rainbowfish) and the exotic family Poeciliidae, which were each represented by 2 species.

Observations on abundance and distribution were:

- The native Ornate Rainbowfish (*Rhadinocentrus ornatus*) was the most abundant species collected. This species was found at nine (9) sites and represented 80% of the total catch. The high overall relative abundances of this species reflected the large catches from drainages of the South Mooloolah River, Eudlo Creek and Paynter Creek. Notably, this species was not recorded elsewhere in the project area, possibly indicating the disjunct nature of populations of this species.
- The Eleotridinae family was the most widely distributed, with species recorded in all five drainage systems surveyed within the project area. Firetail Gudgeon (*Hypseleotris galii*), Empire Gudgeon (*Hypseleotris compressa*) and Western Carp Gudgeon (*Hypseleotris klunzingeri*) were all relatively common throughout the project area.
- Agassiz's Glassfish (*Ambassis agassizii*), Spangled Perch (*Leiopotherapon unicolour*) and Australian Smelt (*Retropinna semoni*) were recorded in relatively low numbers. For example, Agassiz's Glassfish was only recorded at one site in the northern section of the project area, whilst Spangled Perch was only recorded at sites within larger water bodies.
- The introduced pest species Eastern Gambusia (*Gambusia holbrooki*) and Swordtail (*Xiphophorus helleri*) had a patchy distribution within the project area. Swordtail was the second most abundant species collected overall. This species was recorded within all main creeks and drainages, with the highest abundances recorded within Melaleuca swamp habitats.

3 *Species that spend most of their lifecycle in freshwater, or are dependent on freshwater for part of their life cycle.*

Table 13.3.4a: Freshwater fish species identified within the broader region (Pusey et.al 2004)

Family	Species	Common Name	Origin	Migratory Pattern	Habitat Requirements
Osteoglossidae:	*Scleropages leichardti*	Southern Saratoga	Translocated	Non-migratory	Open turbid water, slow-moving rivers and pools, mouthbrooder.[1,9] Snags undercut banks and overhanging vegetation.
Anguillidae:	*Anguilla reinhardtii*	Long Finned Eel	Native	Catadromous	Generalist, but more common in rivers than lakes.[4]
	Anguilla australis	Short Finned Eel	Native	Catadromous	Generalist, but usually more common in rivers than lakes.[4]
Ariidae:	*Arius graeffei*	Lesser Salmon Catfish	Native	Anadromous	Fresh, estuarine and coastal waters, demersal habitats, mouthbrooder.[1]
Plotosidae:	*Tandanus tandanus*	Eel-tail Catfish	Native	Non-migratory	Near bottom of lakes and slow-flowing rivers with rocky bottom.[5]
Melanotaeniidae:	*Melanotaenia doublyi*	Duboulay's Rainbowfish	Native	Non-migratory	Lotic and lentic habitats.
	Rhadinocentrus ornatus	Ornate Rainbowfish	Native	Non-migratory	Coastal waterbodies, with dense emergent and submerged marginal vegetation, leaf litter beds, undercut banks and submerged woody debris.
Scorpaenidae:	*Notesthes robusta*	Bullrout	Native	Diadromous	Still or gentle flowing waters, with a rock, mud or gravel substrate, aquatic vegetation and woody debris.[2]
Chandidae:	*Ambassis agassizi*	Agassiz's Glassfish	Native	Non-migratory	Rivers, creeks, ponds and swamps near snags and aquatic vegetation.[7] Eggs adhere to vegetation.
Percichtyidae:	*Macquaria novemaculeata*	Australian Bass	Native	Catadromous	Lakes, rivers and small stream, with cover provided by aquatic vegetation in rocky or gravel-bottomed pools.
Teraponidae:	*Leioptherapon unicolor*	Spangled Perch	Native	Potamodromous	Creeks, ponds, clear or turbid, from headwaters to estuaries.[1] Spawns in shallows on soft substrates.
Mugilidae:	*Mugil cephalus*	Sea Mullet	Native	Catadromous	Deep gentle flowing rivers.[2]
	Myxus petardi	Freshwater Mullet	Native	Catadromous	Deep gentle flowing rivers.[2]
Eleotridae:	*Mogurnda adspersa*	Purple-spotted Gudgeon	Native	Non-migratory	Slow moving creeks, spawns on hard substrate.[3]
	Hyperseleotris galii	Firetail Gudgeon	Native	Non-migratory	Common around aquatic vegetation in lakes, dams and streams.[1]
	Hypseleotris klunzingeri	Western Carp Gudgeon	Native	Non-migratory	Common around aquatic vegetation in lakes, dams and streams.[1]
	Hypseleotris sp. A	Midgley's Gudgeon	Native	Freshwater	Non-migratory Typically occurs around aquatic vegetation, schools in caves and sheltered areas.[1]
	Hypseleotris compressa	Empire Gudgeon	Native	Amphidromous	Lower reaches of coastal rivers and streams, juveniles commonly occur in estuaries.[3]
	Gobiomorphus australis	Striped Gudgeon	Native	Amphidromous	Small coastal streams and rivers, floodplain wetlands and estuaries

Table 13.3.4a: continued

Family	Species	Common Name	Origin	Migratory Pattern	Habitat Requirements
Poecillidae:	*Xiphophorus helleri*	Swordtail	Alien	Non-migratory	Warmer waters near the edges of creeks and drains among weeds. Species knows as "Livebearers"
	Xiphophorus maculatus	Platy	Alien	Non-migratory	Warmer static waters. Species knows as "Livebearers"
	Gambusia holbrooki	Eastern Gambusia	Alien	Non-migratory	Most common in slow-flowing waters near weed beds.[6]
Pseudomugilidae:	*Psedulugil mellis*	Honey Blue-eye	Native	Non-migratory	Slow flowing, tannin-stained, slightly acidic waters.
Nannopercidae:	*Nannoperca oxleyana*	Oxleyan Pygmy Perch	Native	Non-migratory	Slow flowing, tannin-stained, slightly acidic waters.

Species of conservation significance

Two small bodied fish species of conservation significance that are protected under legislation are known to occur within the broader region, namely Oxleyan Pygmy Perch (*Nannoperca oxleyana*) and Honey Blue-eye (*Pseudomugil mellis*). Under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), Oxleyan Pygmy Perch is listed as Endangered, whereas Honey Blue-eye is listed as Vulnerable. Both species are listed as Vulnerable under the *Nature Conservation (Wildlife) Regulation 1994*, and Endangered under the IUCN Red List and the Australian Society of Fish Biology (2000) listing.

There have been no records of these species occurring within the Mooloolah or Maroochy catchments, though both species have been identified at various locations within the Pumicestone catchment including Mellum Creek, which traverses the southern section of the project area. Both species have also been recorded at various locations within Noosa catchment to the north of the project area. The absence of either species within the Mooloolah and Maroochy catchments may be a consequence of limited survey effort as both catchments contain the preferred habitat for these species and are within their geographic range. Refer to **Table 13.3.4b** for previous records of the species.

As both species have been recorded in Mellum Creek, it is possible that habitats within the project area may represent movement corridors for these species throughout the wider region. Based on snapshot water quality measurements undertaken in the recent surveys, it appears that pH and conductivity values were within the known tolerance range of the two species at several locations within the project area, specifically at the drainages of Ewen Maddock Dam, as well as Eudlo and Paynter Creek drainages. However, limited dissolved oxygen concentrations would likely exclude Honey Blue-eye.

At the time of sampling most aquatic habitats within the project area were characterised by moderately flowing streams, which are not typically associated with these species. No areas of wallum, their preferred habitat, were recorded within the project area. However, various stream sections along minor drainages of Ewen Maddock Dam were represented by lentic and low flowing waters fringed with dense emergent macrophytes amongst stands of melaleuca. Such environments represent potential habitat for Oxleyan Pygmy Perch with downstream environments of Ewen Maddock Dam also containing permanent areas of ideal habitat. It is possible that Oxleyan Pygmy Perch may occasionally inhabit these drainages.

Table 13.3.4b: Localities and habitat conditions known to support Oxleyan Pygmy Perch and Honey Blue-eye

	Oxleyan Pygmy Perch	Honey Blue-eye
Localities (SEQ region)	Searys Ck, Carland Ck, Noosa River and tributaries, Coondoo/Tiana Ck, Mellum Ck, trib of Blue Gum Ck, Burpengary Ck, Marcus Ck D, Coochin Creek E	Big Tuan Ck, Lake Cooloola, Noosa River, Marcus Ck, Scrubby Ck, Kangaroo Ck, Schnapper Ck, Carland Ck, Mellum Ck, Tibrogargan Ck D
Localities (Project area)	No records of species occurring within the area though preferred habitat is present in a few locations.	No records of species occurring within the area though preferred habitat is present in a few locations.
Localities not recorded by Arthington (1996); Arthington and Marshall (1993)	Waraba Ck, Tibrogargan Ck, Coonowrin Ck, Obi Obi Ck; Mooloola R., Tingalpa Ck, Currumbin Ck D	Seary Ck, Lake Freshwater, Kin Kin Ck, Castaways Ck, Obi Obi Ck, Mooloola River, Coochin Ck, Coonowrin Ck, Waraba Ck, Tingalpa Ck, Currumbin Ck D
Water QualityA,B	pH 4.2 - 7.2 Conductivity <330 S/cm DO > 2 mg/L Clear, tannin stained waters	pH 4.4 - 6.8 Conductivity <900 S/cm DO > 6.8 mg/L Clear, tannin stained waters
Habitat	Wallum habitat, often with Melaleuca Structurally complex habitats: 60-80% aquatic plant cover (typically sedges) Undercut banks Leaf litter or fallen timber Low flow environments	Wallum habitat High aquatic plant cover, typically sedges Low flow environments (<0.3 m/sec)

A Pusey et al. (2004); B = EPBC Act database; C = Arthington (1996); D = Arthington and Marshall (1993); E = AGFA records

There are an additional four fish species known or likely to occur within the project area, which are considered to be Threatened or near Threatened under various non-statutory conservation classifications (i.e. not protected under Commonwealth or State legislation) (Table 13.3.4c):

- **Southern Saratoga** - Southern Saratoga have previously been stocked in Ewen Maddock Dam. The Australian Society of Fish Biology lists this translocated species as Lower Risk – near Threatened. This species is known to favour large, slow flowing turbid streams (Allen 1989; Pusey et al. 2004; Kennard et al. 2004), which are not represented by any of the project area waterways that are connected to Ewen Maddock Dam.
- **Purple-spotted Gudgeon** - Southern and inland 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). This species was not recorded in the project area in the present study, but has a patchy distribution and been recorded in the project area catchments by Pusey et al. (2004).
- **Ornate Rainbowfish** - Recorded within the current survey in high numbers in the South Mooloolah River and Paynter Creek drainage systems. This species has a similar geographic distribution to Oxleyan Pygmy Perch but has a broader set of habitat requirements, being found in both acid lakes (Merrick and Schmida 1984; Allen 1989; Allen 1996) and clear mountain streams (WBM 1999). Classified as "potentially Threatened" by the Queensland Department of Primary Industries (Wager 1993), due to both a reduction in the number of suitable habitats throughout its geographic range and a range of threatening processes.
- **Agasizzi's Glassfish** - Listed under the IUCN as Data Deficient. Populations have suffered a large reduction in distribution and abundance in the Murray-Darling system (Wager and Jackson 1993), however, Queensland coastal populations of this species are considered secure and its conservation status in this bioregion should not be considered to be elevated (Pusey et al. 2004). This species is patchily distributed within the region (BMT WBM 2006) and was only recorded in Petrie Creek in the present study.

Table 13.3.4c: Fish of conservation concern known or likely to occur within the wider region

Species	EPBC Act 1999	NC Regulation 1994	Non-regulatory Schemes*
Oxleyan Pygmy Perch	Endangered	Vulnerable	IUCN - Endangered ASFB - Endangered BAMM - EVR
Honey Blue-eye	Vulnerable	Vulnerable	IUCN - Endangered ASFB - Endangered BAMM - EVR
Purple-spotted Gudgeon	Not listed	Not listed	IUCN – Not listed ASFB - Lower Risk, least concern BAMM – Restricted
Ornate Rainbowfish	Not listed	Not listed	IUCN – Not listed ASFB – Not listed BAMM – Listed
Agasizzi's Glassfish	Not listed	Not listed	IUCN – Data Deficient ASFB – Not listed BAMM – Not listed
Southern Saratoga	Not listed	Not listed	IUCN – Not listed ASFB – Lower risk, near Threatened BAMM – Listed

IUCN = International Union for the Conservation of Nature and Natural Resources "Red List", ASFB = Australian Society for Fish Biology "Conservation Status of Australian Fishers, 2001", BAMM = Biodiversity Assessment and Mapping Methodology (Appendix Detailing Priority Taxa, QEPA 2002).

Fisheries significance

Eudlo and Petrie Creek (Sites 7 and 13) were the only sites where native, large-bodied fish of potential fisheries significance were recorded (i.e. Spangled Perch, Freshwater Eels and Freshwater Catfish). These species, together with Australian Bass, are likely to occur throughout all the larger streams within the project area (Paynter, Petrie and Eudlo Creeks and both branches of the Mooloolah River).

Ewen Maddock Dam, immediately downstream of the project area, has been stocked with Australian Bass, Southern Saratoga, Spangled Perch, Golden Perch (*Macquaria ambigua*), Freshwater Catfish, Freshwater Eels (*Anguilla spp.*) and possibly Mary River Cod (*Maccullochella peelii mariensis*). The dam is the key recreational fisheries resource within the immediate vicinity of the project area. Within the project area, there is likely to be some recreational fishing effort at Paynter, Petrie and Eudlo Creeks and both branches of the Mooloolah River, although fishing effort is expected to be low compared to levels in the coastal and estuarine reaches of the these catchments.

Note that there is no commercial catch data for the project area.

Migratory requirements

Many of the fish species that occur in the project area are known to undergo some form of migration, usually for reproduction and spawning, or other in-stream movements for activities such as foraging (refer **Table 13.3.4a**). Such migrations, as they relate to the current project area, can be broadly classified into the following five categories:

- *Catadromous* - Fish that migrate to from freshwater to the sea to breed. Most migratory species likely to occur within the project area are catadromous, including Long-finned Eel, Short-finned Eel, Australian Bass, Sea Mullet and Freshwater Mullet.
- *Anadromous* - Fish that migrate from the sea to freshwater to breed. Only one anadromous species, the Lesser Salmon Catfish has been recorded in the project area and/or surrounds.
- *Amphidromous* - Fish species that migrate at some stage in their lifecycle between freshwater and the sea but not for breeding purposes. For example, Striped and Empire Gudgeons may occur in estuaries but are essentially freshwater species.
- *Potamodromous* - Fish that migrate wholly within freshwater, typically migrating upstream to breed. The Spangled Perch is the only fish listed for the project area that undertakes this form of migration.
- *Diadromous* - This group includes the Bullrout, which regularly migrates between freshwater and the sea.

13.3.5 Macro-invertebrates

Community composition

It is expected that the project area provides habitat for diverse and productive freshwater macro-invertebrate communities. However, limited information is available as fauna have generally only been identified to family level in most catchment-wide assessments (Department of Environment and Resource Management, 2005). In reference to the Maroochy catchment, which incorporates most sites in the project area, the sites have been affected by riparian disturbance and nutrient inputs. This is likely to have modified macro-invertebrate habitats through increased aquatic or emergent plant growth and favoured species that prefer vegetated habitats.

A list of macro-invertebrate taxa that are known to occur in freshwater reaches of the Maroochy, Mooloolah and Pumicestone catchments is provided in (**Table 13.3.5a**). The project area is wholly within the freshwater reaches of these catchments, hence, all taxa listed are likely to occur within the project area.

Table 13.3.5a: Freshwater macro-invertebrates recorded in the Maroochy, Mooloolah and Pumicestone catchments (From EHMP 2007)

Class	Order	Taxa	Catchment		
			Maroochy	Moolooah	Pumicestone
Arachnida	Acariformes	Acarina	✓	✓	✓
	Araneae	Araneae	✓	✓	✓
Bivalvia	Paleoheterodonta	Hyriidae			✓
		Sphaeriidae	✓	✓	
Branchiopoda	Cladocera	Cladocera	✓	✓	✓
Copepoda		Copepoda	✓	✓	✓
Gastropoda	Basmmatophora	Ancylidae	✓	✓	✓
		Physidae	✓	✓	
		Planorbidae	✓		✓
	Mesogastropoda	Hydrobiidae	✓	✓	
		Thiaridae	✓		
		Hirudinidae			✓
Hydrozoa	Hydroida	Hydridae			✓
Insecta	Coleoptera	Dytiscidae	✓	✓	✓
		Elmidae	✓	✓	✓
		Gyrinidae		✓	
		Hydraenidae	✓	✓	✓
		Hydrochidae	✓		✓
		Hydrophilidae	✓	✓	✓
		Hygrobiidae			✓
		Noteridae			✓
		Psephenidae		✓	
		Scirtidae	✓	✓	✓
		Staphylinidae		✓	✓
	Collembola	Collembola		✓	✓
	Diptera	Ceratopogonidae	✓	✓	✓
		Chaoboridae			✓
		Culicidae	✓	✓	✓
		Chirinominae	✓	✓	✓
		Orthocladiinae	✓	✓	
		Tanypodinae	✓	✓	✓
		Stratiomyidae		✓	
		Tipulidae		✓	
	Ephemeroptera	Baetidae		✓	✓
		Caenidae		✓	
		Leptophlebiidae	✓	✓	✓
	Hemiptera	Corixidae	✓	✓	✓

Table 13.3.5a: continued

Class	Order	Taxa	Catchment		
			Maroochy	Moolooah	Pumicestone
		Gelastocoridae		✓	
		Gerridae	✓	✓	✓
		Hydrometridae	✓	✓	✓
		Mesoveliidae		✓	✓
		Notonectidae	✓	✓	✓
		Ochteridae		✓	
		Pleidae		✓	
		Veliidae	✓	✓	✓
	Lepidoptera	Pyralidae	✓		✓
	Megaloptera	Sialidae		✓	
	Odonata	Macromiidae		✓	
	Anisoptera	Aeshnidae		✓	✓
		Austrocorduliidae		✓	
		Cordulephyidae	✓		
		Gomphidae	✓	✓	
		Hemicorduliidae	✓	✓	✓
		Libellulidae	✓	✓	✓
		Lindeniidae	✓	✓	
		Synthemistidae	✓		
	Zygoptera	Coenagrionidae	✓	✓	✓
		Isostictidae	✓	✓	✓
		Megapodagrionidae	✓	✓	
		Synlestidae		✓	
	Trichoptera	Clamoceratidae		✓	
		Calocidae		✓	
		Ecnomidae	✓	✓	
		Hydropsychidae		✓	
		Hydroptilidae			✓
		Leptoceridae	✓	✓	✓
Malacostraca	Decapoda	Atyidae	✓	✓	✓
		Palaemonidae	✓	✓	✓
		Parastacidae	✓	✓	✓
	Isopoda	Sphaeromatidae	✓		✓
Nematoda		Nematoda	✓		✓
Oligochaeta		Oligochaeta	✓	✓	✓
Ostracoda		Ostracoda	✓	✓	✓
Platyhelminthes	Temnocephalidea	Temnocephalidea	✓		✓
Polychaeta		Polychaeta			✓
Turbellaria	Seriata	Dugesiidae			✓

Species of conservation significance

No Threatened aquatic macro-invertebrate species listed under Commonwealth (*Environment Protection and Biodiversity Conservation Act 1999*) or State (*Nature Conservation (Wildlife) Regulation 2006; Fisheries Act 1992*) legislation are known or likely to occur within the project area. The BAMM Priority Species for the Southeast Queensland (SEQ) region (Department of Environment and Resource Management 2005) and the IUCN Red list identify several aquatic invertebrate species of regional or local significance within the wider region **(Table 13.3.5b)**.

Several Spiny Crayfish (*Euastacus spp.*) that occur in the wider region have a habitat preference for highland streams. The Land Yabby (*Cherax punctatus*) is known from the Mary River catchment only (which occurs to the north of the project area) and the project area does not contain the preferred habitat for this species. The rail corridor does not intersect high altitude streams, therefore these species are unlikely to occur in the project area. Most of the remaining aquatic invertebrate species of conservation concern are unlikely to occur within the project area as they are typically associated with coastal wallum environments, which are not represented within the project area.

In addition to species of conservation significance, macro-invertebrate communities in the project area are generally important in controlling processes that maintain aquatic ecosystems, and are therefore considered to have high ecological values. With the exception of freshwater crayfish (*Cherax spp.*), which are of recreational importance, the project area does not support preferred habitat of macro-invertebrates species of direct fisheries significance.

Table 13.3.5b: Aquatic invertebrates of conservation significance within the wider geographic region

Species	Common Name	Listing	Habitat type	Distribution and Know Localities
Euastacus hystricosus	Giant Spiny Crayfish	BAMM, IUCN	Streams in wet sclerophyll and rainforests at elevations > 550 m a.s.l.	Conondale Range and Maleny areas west of Nambour. Occurs in the Mary River system and is known from a tributary of the Brisbane River.[1]
Euastacus jagara	freshwater crayfish	BAMM, IUCN	High altitude rainforest streams.	Known only from Mistake Mountains, approximately 50 km SW of Ipswich, including tributaries of the Brisbane River with rainforest stream banks.[1]
Euastacus maidae	freshwater crayfish	BAMM, IUCN	Known only from high altitude rainforest streams.	Known only from rainforest at the upper reaches of Currumbin Creek, west of Coolangatta.[1]
Euastacus setosus	Mount Glorious Crayfish	BAMM, IUCN	Known only from high altitude rainforest streams.	Known only from a small area in the Maiala National Park near Mount Glorious, north-west of Brisbane.[1]
Euastacus sulcatus	freshwater crayfish	BAMM	Small shallow highland streams, altitudes > 300m. Prefer rocky or sandy bottoms with leaf litter, banks shaded by rainforest or wet sclerophyll woodland.	Upper Richmond River in northern NSW, north to the Lamington Plateau and west to the Condamine River system.[1]
Euastacus urospinosus	freshwater crayfish	BAMM, IUCN	Rainforest, > 240 m altitude.	Known only from limited area, Conondale and Blackall Ranges, SE QLD.[2]
Euastacus valentulus	freshwater crayfish	BAMM	Small flowing tributaries, with rock rubble or gravel substrates, bordered by coastal rainforest or wet sclerophyll forest.	Known only from limited area, ranges from Currumbin Creek SE QLD, south to Ballina area, NSW.[2]
Cherax punctatus	Land Yabby	BAMM	Burrows found on clay hillsides independent of open water or the water table.	Known only from limited area, Mary River catchment, SE QLD.[2]
Cherax robustus	Sand Yabby	BAMM	Coastal sand dune wetlands, acid water, burrows connected to open water or water table.	Known only from limited area, Fraser Island and Cooloola to N Stradbroke Island, SE QLD.[2]
Tenuibranchiurus glypticus	Swamp Crayfish	BAMM	Coastal freshwater wetlands.	Known only from limited area, Woodgate to Brisbane.[2]
Griseargiolestes albescens	Coastal Flatwing Damselfly	BAMM	Coastal freshwater wetlands.	SEQ, NNSW.[4]
Petalura litorea	Dragonfly	BAMM	Coastal freshwater wetlands.	SEQ, NNSW.[3]

1 Crandall, Keith A. 1999. Euastacus. Version 05 October 1999 (under construction). http://tolweb.org/Euastacus/7705/1999.10.05 in The Tree of Life Web Project, http://tolweb.org/; 2 Australian Faunal Directory; 3 ABRS Species Bank; 4 Australian National Insect Collection, CSIRO Entomology

13.3.6 Freshwater turtles

Three species of freshwater turtle are known to occur within the project area, including the Saw-shelled Turtle (*Elseya latisternum*), Eastern Snake-necked Turtle (*Chelodina longicollis*) and Krefft's River Turtle (*Emydura macquarii kreftii*) (**Table 13.3.6**). Both Saw-shelled and Krefft's River turtles were observed during the aquatic surveys undertaken for this EIS (at Eudlo and Petrie Creeks, respectively).

All freshwater turtle species known to occur within the project area are typically widespread and abundant throughout the broader region. None are listed as Threatened species under the EPBC Act or NC Act.

Although limited data are available, studies elsewhere in Queensland suggest that *Emydura* spp. often represents the numerically dominant turtle species. For example, surveys near Walla Walla on the Burnett River (north of the project area) indicate that Krefft's River Turtle represented ~93% of the total turtle catch (Limpus et al. 1997). Unpublished observations by BMT WBM field staff also indicate that *Emydura* spp. are relatively common on Queensland catchments. These characteristics are influenced by the generalist ecological nature of these species (e.g. in terms of food and habitat requirements etc.).

Table 13.3.6: Freshwater Turtle species known to occur within the project area

Scientific Name	Common Name	Conservation Status
Elseya latisternum	Saw-shelled Turtle	Common
Chelodina longicollis	Eastern Snake-necked Turtle	Common
Emydura macquarii kreftii	Krefft's River Turtle	Common

13.4 Information provided by the community

Throughout the project there has been on-going community consultation. Details of activities and information releases is discussed in **Chapter 1, Section 1.9.** There were no issues regarding aquatic biology raised through feedback on the Route Identification Report and in the 'Township Options' consultation.

13.5 Assessment of potential impacts and mitigation measures

This assessment of impacts aims to address the aquatic ecology values described in **Section 13.3** that may potentially be affected by the project, with a specific focus on aspects of the impact assessment relating to relevant legislation (as outlined in **Section 13.1.3**). The mitigation and compensatory measures proposed also take into account the commitment of the Department of Transport and Main Roads to adhere to a policy of 'no net loss of biodiversity' in support of ecologically sustainable development. In terms of aquatic ecology, this policy specifically encompasses aquatic flora, fauna and their habitats.

The project crosses six waterways, excluding minor streams and/or ephemeral drainages, and is located in close proximity to a considerable length of Petrie Creek. Upgrade works will occur along the full length of the project. Consistent with environmental best practice, a risk-based mitigation hierarchy was adopted to minimise impacts to ecological values. In order of preference, these included: (1) realignment of the project to avoid intersecting sensitive habitats where feasible (note that due to the linear nature of the corridor it is not possible to avoid waterway crossings); (2) bridge crossings with no in-stream sections; (3) bridge crossing with in-stream sections; and less preferably (4) open bottom box culverts (5) closed bottom box culverts. By implementing these broad mitigation options, most of the impacts are avoided or minimised.

Only one of the major waterway crossings follow the existing railway (i.e. South Mooloolah River), where the bridge will be widened. New crossings away from the existing railway will be constructed across Mooloolah River (bridge), Eudlo Creek (bridge), a tributary of Eudlo Creek in Eudlo Creek National Park (culvert) and Paynter Creek (bridge). In locations where there are culverts, they will be extended or replaced, if necessary. Where culverts are replaced, the new culverts will be suitable to convey fauna movement as necessary. Associated with the construction of the new crossings will be the decommissioning of the respective existing crossing on each waterway. A complete list of culverts and bridges (south to north) is shown in **Table 13.5.**

Key potential threats from an aquatic flora and fauna perspective were identified early in the impact assessment process to provide information assisting the selection of the project. Most potential impacts are generally applicable throughout the project area and primarily include impacts to riparian and stream habitat integrity, as well as to aquatic fauna passage. Potential impacting processes to aquatic flora, fauna and their habitat primarily result from the construction of the project and the decommissioning of the existing railway, as follows:

- vegetation clearing and physical disturbance
- water quality modification
- creation of in-stream barriers (i.e. culverts and other structures)
- creation of habitats favouring pest species.

Table 13.5: Waterways and crossings

ID	Location	Values	Existing	Proposed
1	Small tributary of Addlington Creek, just north of Landsborough station (Chainage 82000)	First order. Poor habitat quality with little opportunity for linkages.	Culvert	Culvert
2	Addlington Creek (south) (Chainage 82325)	Marginal habitat with a local linkage potential.	Culvert	Upgrade culvert for fauna movement (0.75 m x 1.5 m, 2 culverts)
3	Addlington Creek (north) (Chainage 82600)	Good habitat and local linkage potential. Known habitat for Giant Barred Frog (*Mixophyes iteratus*).	Culvert	Project to use large culvert with fauna sensitive design, particularly for frog species. A bridge was investigated for this location, but the topography of the site meant that the bridge would not achieve the desired fauna passage because the headstock would be too close to the existing ground level. A culvert can achieve a larger area for the passage of native fauna, particularly frogs. Fauna furniture will be used to enhance the culvert conditions.
4	Small tributary to Addlington Creek (north) (Chainage 82750)	Poor habitat and little opportunity for linkages.	Culvert	Culvert.
5	Small tributary in Dularcha NP (south) (Chainage 83175)	Riparian rainforest and potential habitat for significant fish species, i.e. Honey Blue Eye and Oxleyan Pygmy Perch.	Culvert	Upgrade or remove existing culvert to reinstate more natural water flow and fauna movement. New culvert for aquatic fauna movement (3 m x 3 m).
6	Small tributary in Dularcha NP (mid) (Chainage 83400)	First order waterway. No connectivity outside of National park.	Culvert	Upgrade or remove existing culvert to reinstate more natural water flow and fauna movement. Realignment of creek may be necessary.
7	Small tributary in Dularcha NP (mid) (Chainage 83900)	First order waterway. Connectivity can be catered for with waterway to north.	Culvert	Culvert.
8	Small tributary in Dularcha NP (mid) (Chainage 84260)	Good habitat and linkage connecting off site.	Culvert	Upgrade culvert for fauna movement (3 m x 3 m).
9	Small tributary in Dularcha NP (north) (Chainage 84450)	Good habitat and connectivity within the park.	Culvert	Removal of existing culvert to reinstate natural channel. Realignment of creek through a culvert suitable for fauna movement (2 m x 2 m).
10	Tributary of South Mooloolah River (Chainage 85500)	First order waterway. Good quality habitat and linkages.	Culvert	Removal of existing culvert to reinstate natural channel. Culvert. Linkage provided at 13.
11	Tributary of South Mooloolah River (Chainage 85575)	First order waterway. Good quality habitat and linkages.	Culvert	Removal of existing culvert to reinstate natural channel. Culvert. Linkage provided at 13.
12	Tributary of South Mooloolah River (Chainage 85700)	Good quality habitat and linkages to east.	Culvert	Upgrade or remove existing culvert to reinstate more natural water flow and fauna movement. New culvert for fauna movement (2 m x 2 m).
13	Tributary of South Mooloolah River (Chainage 85800)	First order waterway. Good quality habitat and linkages.	Culvert	Removal of existing culvert to reinstate natural channel. Culvert. Linkage provided at 12.
14	Tributary of South Mooloolah River (Chainage 86100)	Riparian rainforest. Good quality habitat and linkages. Habitat for *M. iteratus*.	Bridge	Remove existing bridge. Project to use bridge with fauna sensitive design, particularly for frog species.

Table 13.5: continued

ID	Location	Values	Existing	Proposed
15	South Mooloolah River (Chainage 86300)	Riparian rainforest. Good quality habitat and linkages. Habitat for *M. iteratus*.	Bridge	Replace with bridge with fauna sensitive design, particularly for frog species.
16	Tributary of Mooloolah River (Chainage 86525)	Mostly piped under residential development. No habitat or linkages.	Culvert	Culvert.
17	Mooloolah River (87000 - 87220)	Riparian rainforest. Good quality habitat and linkages. Habitat for *M. iteratus*. There are three minor tributaries with limited habitat value that will also be spanned by this bridge.	Bridge	Remove existing bridge. Project to use bridge with fauna sensitive design, particularly for frog species. Bridge is required due to flooding constraints.
18	Small tributaries of Mooloolah River (double crossing) (Chainage 87290)	First order waterways with limited riparian habitat and with no vital wildlife link.	None	Culvert.
19	Small tributaries of Mooloolah River (double crossing) (Chainage 87400)	First order waterways with limited riparian habitat and with no vital wildlife link.	None	Culvert.
20	Small tributaries of Mooloolah River (double crossing) (Chainage 87600)	First order waterways with limited riparian habitat and with no vital wildlife link.	None	Culvert.
21	Small tributary of Mooloolah River (Chainage 87750)	First order waterways with limited riparian habitat and with no vital wildlife link.	None	Culvert.
22	Small drain between two dams (Chainage 88000)	First order waterways with limited riparian habitat and with no vital wildlife link.	None	Culvert.
23	Tributary to Mooloolah River (Chainage 88350)	Third order waterway with limited riparian habitat, but opportunity to become a significant wildlife link.	Culvert	Upgrade or remove existing culvert to reinstate more natural water flow and fauna movement. New culvert for fauna movement (3 m x 3 m).
24	Small drainage before tunnel (Chainage 88700)	First order waterways with good riparian habitat but with no vital wildlife link to east.	Culvert	Culvert.
25	Small drainage before tunnel (Chainage 88900)	First order waterways with good riparian habitat but with no vital wildlife link to east.	Culvert	Culvert.
26	Small drainage before tunnel (Chainage 89350)	First order waterways with good riparian habitat but with no vital wildlife link to east.	Culvert	Culvert or redirected, depends on extent of earthworks for cut and cover.
27	Small drainage (Chainage 89850)	First order waterways with good riparian habitat but with no vital wildlife link to east.	Culvert	Culvert.
28	Small tributary of Eudlo Creek (Chainage 90300)	First order waterways with good riparian habitat and wildlife link to east but only small area before road.	None	Culvert.
29	Eudlo Creek (multi-crossing from Logwoods Road to Highlands Road) (Chainage 90400 – 90950)	Major waterway. Habitat limited to close proximity to banks. Riparian wildlife corridor.	None	Rail will be on structure through this section.

Table 13.5: continued

ID	Location	Values	Existing	Proposed
30	Eudlo Creek (single crossing)	Major waterway. Habitat limited to close proximity to banks. Riparian wildlife corridor.	Bridge	Remove existing bridge. Project to use bridge with fauna sensitive design.
31	Drainage north of Eudlo Creek (Chainage 91400)	First order waterways with limited riparian habitat and patchy vegetation.	None	Rail will be on structure through this section.
32	Drainage north of Eudlo Creek (Chainage 91750)	First order waterways with limited riparian habitat and patchy vegetation.	None	Culvert.
33	Drainage north of Eudlo Creek (Chainage 92000)	First order waterways with limited riparian habitat and patchy vegetation.	None	Culvert.
34	Tributary of Eudlo Creek, Eudlo Creek National Park – double crossing (Chainage 92640)	Riparian rainforest. Good quality habitat and linkages. Habitat for M. iteratus.	Culvert	Fauna movement is highly important in this area. A bebo arch underpass will be installed to allow wet and dry passage (3 x 3m).
35	Tributary of Eudlo Creek, Eudlo Creek National Park (Chainage 92925)	Riparian rainforest. Good quality habitat and linkages. Habitat for M. iteratus.	Culvert	The earthworks will be prohibitive of fauna movement. Connectivity has been maintained to the north and south.
36	Tributary of Eudlo Creek, Eudlo Creek National Park (Chainage 93150)	Riparian rainforest. Good quality habitat and linkages. Habitat for M. iteratus.	Culvert	A bridge has been ruled out here because there is an existing culvert to the east of the project, which will be maintained for road. A fauna sensitive culvert will be designed for this location (2 m x 2 m).
37	Drainage lines north of Toby Court – double crossing (Chainage 93450)	Marginal riparian habitat and fragmented vegetation.	None	Culvert.
38	Drainage line south of Paskins Road (Chainage 93950)	Marginal riparian habitat and fragmented vegetation.	None	Culvert.
39	Drainage line into Kolora Park, Palmwood (Chainage 95450)	Habitat is marginal and there is no link provided to large habitat areas.	None	The drainage line may need to be realigned where Eudlo Road crosses the project. The drainage line will pass through a culvert at the station. The rail is on structure over Kolora Park.
40	Paynter Creek (multi-crossing north of Palmwoods station) (Chainage 95500 – 96375)	Habitat is marginal and the area is surrounded by residential development.	None	The rail is on structure in this location due to flooding.
41	Drainage line associated with Paynter Creek (Chainage 96800 - 96900)	Limited habitat value and no potential linkage.	None	Culvert. There may be a requirement for realignment of the waterway.
42	Paynter Creek (north) (multi-crossings) (Chainage 97100 – 97400)	Habitat is marginal and the area is surrounded by residential development. The Creek has value as a wildlife corridor.	None	The rail is on structure in this location due to flooding.
43	Tributary to Paynter Creek (Chainage 97520)	Limited habitat value and no potential link. Conveys water to dam.	None	Culvert.
44	Tributary to Paynter Creek, Woombye (Chainage 98250)	Limited habitat value and no potential linkage.	None	Culvert. This culvert needs to be suitable for the movement of cattle (3 m x 5 m).

Table 13.5: continued

ID	Location	Values	Existing	Proposed
45	Tributary to Paynter Creek, Woombye (Chainage 98400)	Limited habitat value and no potential linkage.	None	Culvert.
46	Paynter Creek, Woombye (Chainage 98800)	Major waterway. Habitat limited to close proximity to banks. Riparian wildlife corridor.	Bridge	Remove existing bridge. Project to use bridge with fauna sensitive design.
47	Tributary to Paynter Creek, Woombye (Chainage 99100)	Riparian rainforest. Good quality habitat and linkages.	Culvert	Upgrade or remove existing culvert to reinstate more natural water flow and fauna movement. New culvert for fauna movement (3 m x 3 m).
48	Tributary to Petrie Creek (Chainage 99950)	First order waterway. Good habitat and link to habitat to east.	Culvert	Upgrade existing culvert to allow fauna movement (2 m x 2 m).
49	Tributary to Petrie Creek (Chainage 100080 to 100160)	First order waterway. Good habitat and link to habitat to east.	Culvert	Two culverts.
50	Tributary to Petrie Creek (Chainage 100300)	First order waterway. Poor habitat and weak link.	Culvert	Culvert.
51	Tributary to Petrie Creek (Chainage 100500)	First order waterway. Poor habitat and no link.	Culvert	Culvert.
52	Tributary to Petrie Creek (Chainage 100950)	First order waterway. Poor habitat and no link.	Culvert	The rail will be on structure through this area due to flood requirements.
53	Tributary to Petrie Creek (Chainage 101300)	First order waterway. Poor habitat and no link.	Culvert	Rail will be on structure through this section.
54	Tributary to Petrie Creek (Chainage 101600)	First order waterway. Poor habitat and no link.	Culvert	Culvert.

13.5.1 Vegetation clearing and physical disturbance

Potential impact

Construction works throughout the project area will involve the physical disturbance to aquatic habitats and surrounding vegetation, which are considered together here.

Physical disturbance will impact aquatic habitats and resident flora and fauna as a result of a number of construction activities, including:

- the clearing of vegetation at and adjacent to aquatic habitats within the proposed corridor
- construction of permanent and temporary access tracks within the corridor, which could potentially include grading (stripping) of top-soil, removal of vegetation and placement of fill materials on tracks where necessary
- compaction, erosion and sediment release of bank materials associated with the use of construction plant and vehicles within the corridor
- the disturbance and release of bed or bank sediments through the installation of in-stream structures (e.g. bridge pylons, culverts etc.).

The project will result in a rail corridor that stretches 22 km between Landsborough and Nambour. The width of the corridor will allow for the safe construction of four tracks and will vary depending on terrain and design. There are areas of earthworks involving cuttings and embankments and also areas where the rail will be required to be built on structure (e.g. over waterways and flood prone areas). The narrowest parts of the corridor will be where the rail is on structure or where sensitive areas require minimisation of clearing. The footprint may be wider at stations or within areas of difficult topography.

Whilst the selection of the project has endeavoured to avoid areas of remnant vegetation and notable fauna habitats (discussed further in **Chapter 11, Terrestrial flora** and **Chapter 12, Terrestrial fauna**), there are several sections that could not be avoided (i.e. considering both the linear nature of the corridor and topographical or existing development constraints). The project crosses the Mooloolah River at a point where there is no mapped remnant vegetation. The total amount of riparian vegetation lost along each of these waterways is:

- Addlington Creek – 0.28 ha (RE 12.3.2)
- Dularcha NP (waterways) – 0.68 ha (RE 12.3.2) and 0.51 ha (RE12.3.1)

- South Mooloolah River – 0.18 ha (RE 12.3.1)
- Eudlo Creek – 0.92 ha (RE 12.3.2)
- Paynter Creek – 1.09 ha (RE 12.3.2) and 0.37 ha (RE 12.3.1)
- Petrie Creek – 1.2 ha (RE 12.3.2).

A total of 5.23 ha of riparian vegetation will be cleared due to the construction of the rail corridor. Of these waterways, three have been recognised as habitat for EPBC Act listed Giant Barred Frog (*Mixophyes iteratus*), i.e. Addlington Creek, South Mooloolah River and Eudlo Creek. This is discussed further in **Chapter 12, Terrestrial fauna**. The project is on lengthy structure over the Eudlo Creek and Paynter Creek floodplains.

Note that the impacts of vegetation clearing in the design stage of the project are considered in **Chapter 11, Terrestrial flora** of this EIS and provided specific input into the selection of the project for the rail corridor. Each of the major waterway crossings have been discussed in **Chapter 21, Special management areas.**

In the absence of effective on-site management, vegetation and bed or bank disturbance can lead to a range of effects, most notably an increase in rates of erosion and consequent deposition of sediment into waterways. This could result in localised impacts to aquatic flora and fauna values if not appropriately managed.

The loss of riparian (and catchment) vegetation could also lead to the loss of several ecosystem services at a local scale, potentially impacting aquatic communities. These services include:

- shading of the waterway, which controls in-stream primary productivity and water temperature (Bunn 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 (e.g. woody debris) for aquatic fauna (Brooks et al. 2006; Cottingham et al. 2003).

Direct disturbance to aquatic ecology values as a result of riparian vegetation removal and physical channel disturbance will be greatest at the waterways where new crossings are constructed (refer to **Table 13.5**). Riparian vegetation clearing and channel disturbance will occur to a lesser extent at all other waterways to facilitate widening of the existing corridor and crossings.

The physical disturbance impacts described will also occur at locations where existing waterway crossings are removed / decommissioned (refer to **Table 13.5**). Specifically, access to and removal of existing structures will result in the physical disturbance of stream channel beds and banks. Some vegetation clearing will also occur to facilitate access to and/or within the existing rail corridor.

Proposed mitigation

Design

Ecological data collated during desktop and field based assessment was utilised to inform the preliminary design of the project. Due to the linear nature of the corridor, it is not possible to avoid crossing waterways and impacting riparian vegetation in some form. The mitigation measures are necessary to minimise these impacts. Strategies employed during the design phase to reduce the potential impacts on riparian vegetation are listed below. These strategies will be carried over into the detailed design phase, where applicable:

- The project aligns waterway crossings with existing crossings, where it does not significantly depart from the overall design objectives (e.g. providing a shorter, straighter rail alignment).
- The project has avoided crossing of long sections of waterways where possible.
- The project has been located to minimise the number of crossings on each waterway, where possible. However, multiple perpendicular crossings are preferred to crossing of long sections.
- In-stream disturbance impacts should be reduced through the widening of existing bridges and/or culverts, rather than establishing a new structure.
- The use of bridges rather than culverts at major waterway crossings is a key design strategy that will minimise the need for in-stream works.
- Design of bridges such that works are avoided within riparian, littoral and in-stream environments, where possible.

During detailed design, the amount of remnant vegetation to be cleared will be refined to the exact areas required for the construction of the rail. Clearing will be minimised where possible through the minimisation of the construction zone, use of retaining walls and steepening of batters and cuttings where possible. The offsets required under the VMA, will be further refined and identified during this stage.

Construction

Due to the linear nature of the rail corridor, it is not possible to avoid impacting on areas of riparian vegetation completely. In places where clearing of riparian vegetation will occur, clearing will need to be managed to ensure it is limited to that which is necessary and minimise harm to areas of retained vegetation. The mitigation of vegetation clearing is addressed in **Section 11.5, Chapter 11, Terrestrial flora.**

The construction phase must be overseen by an environmental officer who will monitor contractor activity for compliance with the Environmental Management Plan (EMP), and liaise regularly with the on-site construction supervisor. Liaison will incorporate an induction for all site workers, where details of the EMP will be discussed. This will help to increase the awareness of aquatic habitat management issues on site. The EMP will incorporate mitigation measures as listed:

- In-channel works will be undertaken during winter and early spring. This period is typically the time of year when rainfall is lowest, and also avoids the late spring to late summer period which is a critical spawning and migration period for most native fish species.
- Construction methods are to avoid removing sediment or other substrate material from a stream or stream channel.
- Erosion and sediment control measures (as outlined in **Chapter 5, Geology and soils**) shall be put in place prior to commencement of construction.
- Construction personnel are not to release sediment, debris or material into the stream or stream channel.
- The worksite will be restored after the completion of works and vegetation replanted in areas not required for the operational phase, which would be a beneficial impact to the long term stability of stream banks.
- The encroachment of weeds will be monitored and controlled in areas where vegetation has been removed.
- Any environmental incident that results in physio-chemical changes to water quality of physical habitat structure of riparian, littoral and in-stream environment will be reported.
- Following a reportable incident, the habitat will be restored and repaired to its natural state or as directed by the regulatory authority.

A specific section on aquatic habitat management has been included in the EMP (**Chapter 22, Environmental management plans**) for the project to address this issue. The successful implementation of these measures will ensure that overall impacts to water quality are expected to be minimal. It is likely that construction of the bridges will necessitate a Riverine Permit under the *Water Act 2000*.

Operation

Once the rail has been constructed there will be no further requirement for clearing of riparian vegetation. The rail corridor will be maintained on a regular basis through weed management and pruning of overhanging vegetation. During the operational phase, the focus on riparian vegetation will shift to the management of the rehabilitation program. The location and securing of areas required for offsetting remnant vegetation as per the VMA will be undertaken prior to operation. These areas will be the focus of the Vegetation Management Plan (VMP). Mitigation will be as follows:

- Management of vegetation offsets will replace areas of remnant regional ecosystems removed by the proposed railway development. Offsets will be in line with the policy of the Department of Environment and Resource Management for Vegetation Management Offsets, which is triggered under the *Vegetation Management Act 1999*. Refer to **Section 11.6** for more information regarding offset requirements. The final extent of offsets required and offset areas will be finalised during the detailed design phase in conjunction with Ecofund.
- Any weeds in the corridor that have been introduced or exacerbated as a result of the works will be controlled and/or removed with the aim being to leave the site in equivalent condition (or better, in terms of weeds) prior to construction. The environmental officer shall take before and after photographs and site notes to verify the condition of the site.
- Weed establishment will be prevented on bare ground and in areas of revegetation.
- Areas under bridges will be managed, including replanting and on-going weed management.
- Areas necessary for construction, but not required for the operational phase of the railway, will be rehabilitated. For example, areas disturbed by construction of the bridges. Rehabilitation will aim to re-establish the original regional ecosystems present prior to disturbance.
- Rehabilitation shall be more specifically addressed within the VMP for detailed design, particularly: progressive staging of rehabilitation, recommended native species, incorporation of Threatened flora, recommended planting densities, incorporation of understorey where canopy species are excluded by structure and monitoring.
- The operational phase will be overseen by an environmental officer, who will periodically monitor weed cover, replanting success and report necessary maintenance to operational management.

Decommissioning of existing railway

General mitigation strategies to reduce impacts associated with vegetation clearing and physical disturbance for decommissioning works will follow those outlined for the construction phase of the project. As part of the decommissioning of existing waterway crossings, the rehabilitation of stream banks and riparian vegetation (e.g. through removal of weeds and revegetation of riparian areas) will improve aquatic habitats, in turn benefiting aquatic flora and fauna in the immediate vicinity.

Residual impact

With the implementation of the mitigation strategies, and in other parts of the EIS, it is considered that vegetation clearing and other physical disturbances will result in impacts of **Low Adverse** significance.

13.5.2 Water quality modifications

Potential impact

Note that **Chapter 14, Water resources** provides a detailed discussion on the potential water quality impacts associated with the project. The present section discusses only water quality impacts as they relate to the aquatic ecology values of the project area.

There is a potential for impacts to aquatic flora and fauna (and their habitats) during the construction and/or upgrade of the rail as a result of the following key impacting processes:

- an increase in suspended sediments due to removal of vegetation and the disturbance of bed or bank sediments
- the release of toxicants (oils, greases and other chemicals) by machinery or the failure to adhere to EMP measures.

During the construction phase, topsoil disturbed in the corridor (i.e. through vegetation clearing or creation of access tracks) could enter waterways via surface water runoff, resulting in increased sediment loadings to waterways. This would be expected to result in a deterioration of water quality and possible sediment aggradation, which would present a potential impact to aquatic flora, fauna and their habitats. Remobilisation of stream sediments will also likely occur due to in-stream works (e.g. bridge or culvert construction), which could lead to temporary increases in total suspended solid concentrations.

Aquatic flora and fauna may be susceptible to increased sediment loadings. The deposition of fine sediments may lead to changes in habitat complexity. For example, Mooloolah River and Eudlo Creek were the only waterways surveyed that contained riffle habitat. Sedimentation in these waterways could reduce the availability of this habitat, which could have flow-on effects to aquatic biodiversity values. Additionally, high suspended sediment levels can lead to the smothering or reduced photosynthesis of aquatic macrophytes. In this regard, Paynter Creek had the highest recorded richness of macrophytes and could, therefore, be particularly susceptible. Impacts to aquatic fauna species could also occur as a direct effect (e.g. reduced gill efficiency) or indirectly by altering habitat suitability (e.g. smothering food resources and aquatic vegetation).

In terms of toxicants, the impacts of construction are likely to be restricted to the vicinity of the works. However, the introduction of contaminants, such as fuels and chemicals associated with machinery operation, may also pose a risk to downstream communities. Many chemicals such as petrol, diesel fuel, industrial lubricants and oils are toxic to aquatic fauna, especially sensitive macroinvertebrate taxa including Plecoptera (stoneflies), Ephemoptera (mayflies) and Trichoptera (caddisflies). The risk of toxicant contamination is directly related to the quality of project management. Severe spillage of fuels or other chemicals has the potential to cause floral and faunal mortality and morbidity for many kilometres downstream. However, damaged communities are likely to fully recover over a period of months, assuming appropriate decontamination strategies are implemented.

There is little available information about the effect of rail infrastructure on water quality. It is likely that a number of potential contaminants could be released from trains, including oils and lubricants, which could disperse into downstream environments. Such releases could either occur as a result of a single major incident or multiple small releases from the day to day operations of rail infrastructure. It can be expected that major incidents releasing contaminants into waterways will affect aquatic fauna, in particular the sensitive taxa aforementioned. However, the effects of multiple small releases over extended periods are difficult to quantify and will be highly dependent on the nature of the chemical released.

All aspects of potential construction phase water quality modifications discussed are equally applicable to works associated with the decommissioning of the existing rail crossings on Mooloolah River, Eudlo Creek and a tributary of Eudlo Creek. In brief, the release of contaminants is a risk associated with machinery operation, whilst increased turbidity could be associated sediment disturbance as a result of either clearing to facilitate access or removal of existing structures.

Proposed mitigation

Design

In minimising the number of waterway crossings as outlined in **Section 13.5.1**, there will be less impact to the water quality within the project area. The level of contaminants expected from electric trains is minimal and may include, steel particles, dust, oil and brake oil. The level of contaminants expected from diesel (freight) trains is higher. However, it is still necessary to manage water quality issues at each crossing. The key impact mitigation measures that shall be implemented for management of water quality are listed below. These design measures should be carried through to detailed design:

- In the situations where bridge crossings are constructed, the bridge shall be built with a drainage system that collects stormwater and drains it to either end of the bridge.
- The stormwater from the bridge is either discharged into a filtration system to remove contaminants or discharged down a vegetated slope to the waterway (where the vegetation will filter out contaminants and sediment before it reaches the waterway).

Construction

A range of mitigation measures are to be implemented to minimise potential water quality impacts. These measures primarily focus on the construction and decommissioning phases of the project when water quality modification are most likely to occur, particularly in regard to turbidity and toxicants. These measures follow standard site practices and are detailed in full in the Water Quality EMP (**Chapter 22, Environmental management plans**) and are summarised here as follows:

Site preparation

Prior to the commencement of works the appropriate sediment and erosion mitigation measures for the impact zone shall be established. The appropriate measures for each site will change with site conditions, however, recommended mitigation measures include:

- Site access is to follow the natural contour of the terrain, where possible and to avoid steep slopes, wet or rocky areas and highly erosive soils.
- Access ways are to be delineated with sediment and erosion control fencing and incorporate earthen bunds every 5 – 10 m where slope is an issue.
- Silt fences must be placed on the down-slope boundary of the construction zone. Silt fences should be placed along the contour and not across it to avoid heavy sediment loading.
- Additional materials will protect against unexpected erosion and a mobile spill kit shall be available on site.
- Catch-drains are to be used to intercept and divert run-off around the area of impact.

During construction works

Once the soil erosion and sediment control measures are in place, the construction works can commence. During construction the following protocols should be observed:

- Earthworks are to be avoided during wet weather.
- Construction activities shall be conducted in a manner, so as to minimise disturbance to stream banks and beds.
- Operation is not to occur outside of construction zone.
- No clearing, operation of machinery or personnel access is to occur within 3 m of the high bank of the waterway.
- Re-fuelling of machinery shall not be undertaken less than 30 m from the waterway and fuel should be stored at least 50 m from the waterway.
- Topsoil stripped from the site shall be stockpiled and protected from erosion until re-use during site remediation.
- Control measures for the storage and handling of chemicals (e.g. fuels, oils etc.) shall be implemented and maintained to ensure potential contaminants are prevented from surface or subsurface leakage from the construction site.
- Water leaving the work sites shall be monitored and is to be of similar quality to that of the receiving waters and efforts shall be made to ensure contaminants do not leave the site.
- Stockpiles are to be located on the up-slope side of any excavation and as far as possible from the waterway.
- Any sediment material that is spilled shall be cleaned up.
- Earthen bunds or sediment fences must delineate the toe of any stockpiles.

Operational

Once the rail has been constructed, the risk to water quality will be decreased. The area of disturbed land will be reduced, so that there is less chance of erosion leading to sedimentation. The construction machinery will also move off-site, so that the risk of spills and contaminants entering the water will be reduced. Operational impacts from running of trains are anticipated to be minimal, unless there is a malfunction and oil, grease of fluids leak from the train. The rail corridor will be maintained on a regular basis through weed management, which may require the use of herbicides. The risk of operational water quality impacts will be minimised through the application of:

- implementation of pollution and water quality management systems (discussed in **Chapter 14, Water resources**)
- implementation of sedimentation management practices (QR Limited actively seeks to identify sites where sedimentation problems may occur as a result their activities and implement appropriate management activities to minimise these impacts)
- correct use of herbicides as described in the Weed Management Plan in the EMP (**Chapter 22, Environmental management plans**)
- regular water quality monitoring
- emergency response (QR Limited has emergency response plans and training that are to be utilised when required).

Decommissioning of existing rail

Refer to 'Construction' mitigation measures.

Residual impact

In terms of project works (i.e. construction and decommissioning), all water quality risks are primarily footprint effects, which will reduce quickly downstream, particularly in low flow conditions. They may, however have highly localised impacts in sensitive areas such as Mooloolah River or Paynter Creek. Through the implementation of the mitigation methods, most water quality modifications associated with turbidity and toxicants are expected to have **low adverse** impacts to aquatic environments. The assessment of water quality impacts (refer **Chapter 14, Water resources**) indicates that the impact of the operation of the new rail corridor will be **negligible to low adverse.**

13.5.3 Creation of in-stream barriers

Potential impact

As discussed in **Section 13.3.4**, numerous fish species undertake migrations as an obligatory part of their life-cycle, or movements in their day to day foraging activities. These movement patterns can be prevented by the presence of in-stream barriers, both natural and artificial. Within the project area significant fish movements would most likely occur in all major waterways (i.e. Mooloolah and South Mooloolah Rivers; Addlington, Eudlo, Paynter and Petrie Creeks). Note that broad scale migrations / movements would be limited in the parts of Petrie Creek that are near the rail corridor due to the presence of a weir (i.e. between Sites 13 and 14).

Inappropriate design of both temporary and permanent in-stream structures and/or construction procedures may contribute to the creation, or exacerbation, of in-stream barriers to aquatic fauna passage. Temporary barriers would most likely be associated with the construction and decommissioning stages of the project, whilst permanent barriers would generally be associated with the operational stage of the project. Each of these aspects is detailed further below.

It should be noted that construction of temporary or permanent waterway barriers may require a permit under the *Fisheries Act 1994 (*Qld), or in some cases self-assessment, depending on the final design of the structure and the nature (e.g. freshwater 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 design of a structure.

Temporary barriers

During construction of the rail corridor, it will be necessary to construct bridge pylons and supporting foundations, as well as culverts. Existing waterway crossings within the project will be utilised where possible, requiring similar structures during construction. As such, some temporary works within the waterway channels will be required. Temporary waterway crossings (or partial crossings) may also be required to provide access for construction works (e.g. for machinery). This will involve the placement of construction materials across waterways, which has the potential to restrict aquatic fauna movement patterns in the short term.

Even though pipes and culverts will allow some fauna movements under certain (low flow) conditions, both types of structures have the potential to restrict aquatic fauna movement patterns in the short term. The mechanisms driving such restrictions are summarised in **Table 13.5.3.** 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 13.5.3: Impacting processes associated with culverts (from Fairfull and Witheridge 2003)

Potential Effect	Cause
Turbulence	Excessive water turbulence from culvert.
Flow velocities	Excessive flow velocities within 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.

Potential adverse impacts to fauna passage could occur during decommissioning works if temporary waterway crossings (or partial crossings) are required to provide access for the works (e.g. for construction machinery etc.). These effects are only applicable to the waterways where existing crossings will be decommissioned (i.e. Mooloolah River, Eudlo Creek and the Eudlo Creek tributary) and follow the construction phase in-stream barrier impacts described.

Permanent barriers

Permanent in-stream barriers created by the project represent a higher risk than the temporary works. In this regard, the operation of in-stream barriers could lead to aquatic habitat separation and fragmentation, which could result in a loss of connectivity and viability of aquatic fauna assemblages in the long term. If inappropriately designed, the operation of bridges and culverts can present physical, hydraulic and behavioural barriers to aquatic fauna movements (Cotterall 1998; Fairfull and Witheridge 2003) as described in **Table 13.5.3.**

Overall, the bridge structures tend to have the least potential for impacts to fish passage, particularly if pylons are located outside the channel. By contrast, culverts can significantly alter flow conditions within and immediately adjacent to these crossings, resulting in reduced opportunities for fish passage over a wide range of flow conditions. Barriers to fish movements will eventually lead to habitat fragmentation, which could result in reduced viability of fish populations.

Following the completion of decommissioning works, a localised beneficial impact may be expected. This is due to the long term improvement of fish passage as a result of the removal of any existing in-stream structures (i.e. in-stream barriers such as culverts or bridge supporting structures).

Proposed mitigation

Design

In minimising the number of waterway crossings as outlined in **Section 13.5.1**, there will be less of a requirement for in-stream barriers within the project area. Barriers are created by bridges and culverts, but can be mitigated through the use of careful design. Temporary barriers will often result from construction measures, where a temporary dam or diversion is necessary to construct a culvert or bridge footing. It is important to avoid creating permanent barriers in aquatic ecosystems. There are a number of design principles that have been considered to minimise the impacts of in-stream barrier effects.

These design measures should be carried through to detailed design:

- Bridges will be used as the preferred crossing method on key waterways. The majority of these bridges do not interfere with the main channel and are intended to be bridges with the pylons located outside the main channel to avoid impacts to fish habitat.
- In locations where the rail crossing has the potential to significantly impact the resident *M. iteratus* population, experts have concurred (Hines and Hero, 2008, pers. comm.) that the ultimate design for a bridge is to have the footings of the bridge set back 20 m with a bridge height that allows retention of rainforest understorey at the site. It would also be beneficial to separate the tracks to allow light penetration between tracks.
- Where the use of culverts is unavoidable (including Addlington Creek (north)), culverts have followed best practice design standards (Cotterel 1998; Fairfull and Witheridge 2003). Multi-cell box culverts shall be used in preference to single-cell culverts and pipes. This is preferred because multi-cell culverts maintain the natural area and flow of the waterway (Fairfull and Witheridge 2003). Box culverts with a lower cell (i.e. centre of the structure) also assist in maintaining passage during low flow periods.
- Sub-standard culverts will be replaced, where necessary, i.e. in areas identified as being significant habitat or wildlife corridors. Recommendations for culvert replacement are shown in **Table 13.5**.

Construction

The design of the bridges, with footings setback from the riparian zone and outside of the waterway itself, allows for the use of less destructive construction methods. For example, piers can be constructed and pre-fabricated units can be placed on them. This way riparian vegetation of suitable stature can be retained under the bridge and temporary dams or redirection of the waterway will not be necessary. However, in some locations where this is not possible a range of mitigation measures are to be implemented to minimise potential impacts from the creation of in-stream barriers:

- In-stream works are to be timed in a manner that minimises impacts to aquatic fauna. In this regard, in-stream construction works should avoid the critical Spring-Summer, where possible, as this represents the typical high rainfall period when aquatic habitats are most likely to be flowing. It is also the critical migratory period for most Australian freshwater fish.
- If the works result in the 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 are to be relocated to areas away from impacts.

Operation

Once the rail has been constructed, the risk of creating an in-stream barrier is greatly reduced. There is potential for poorly maintained water crossings to become a barrier. For example, if vegetative matter or rubbish becomes snagged on bridge structures or culverts it may hamper the movement of aquatic organisms (depending on the size of the snag). Generally, once construction is complete the crossing structures will be expected to operate in such a way that retains the flow of water, aquatic flora and fauna through the ecosystem. A monitoring program is to be implemented to ensure that:

- the natural stream flow and velocity is maintained or mimicked as closely as possible
- the surface level of a causeway is the same, or lower than the natural level of the stream bed to reduce interference with flow (especially relevant to culverts)
- habitat within a culvert is as natural as possible (e.g. allow rocks and bed materials to infill the culvert base)
- light penetration is as great as possible.

Decommissioning works

Refer to 'Construction' mitigation measures.

Residual impact

With the implementation of the mitigation strategies presented in this section, and other parts of the EIS, it is considered that the construction and/or decommissioning works of temporary and permanent waterway crossings will generally result in an impact to aquatic fauna of **negligible** to **low adverse** significance. This is based on the following: (i) no EVR fauna species are known or likely to occur within the project area; (ii) impacts that are of a temporary nature will generally recover in a period of days to weeks; and (iii) the decommissioning of the existing railway crossing may result in localised improvements to fauna passage.

13.5.4 Increased occurrence of exotic species

Potential impact

The project is not expected to result in new introductions of exotic flora and fauna species into the project area or surrounds. However, it is possible that, in the absence of management intervention, the proposed works could lead to the creation (or expansion) of suitable habitats for exotic species.

Clearing of vegetation could facilitate the encroachment and increased distribution of exotic macrophytes (e.g. Para Grass, Brittle Grass). In-stream works may also disturb exotic aquatic macrophytes that are able to re-establish elsewhere via stem fragments (e.g. Dense Waterweed). A greater occurrence of exotic macrophytes would likely provide optimal habitat for exotic fish species (e.g. Eastern Gambusia).

Two exotic fish species are widespread throughout the project area, Eastern Gambusia (*Gambusia holbrooki*) and Swordtail (*Xiphophorus helleri*). Both of these species are considered noxious due to the detrimental effects they can have on native species and aquatic habitat. There is the potential for works associated with the project to create opportunities to enhance local populations of these species. For example, surveys in the Brisbane region have previously found that abundances of Eastern Gambusia can be positively linked with the percentage cover of in-stream weeds (Arthington et al. 1983).

Proposed mitigation

Design

In minimising the number of waterway crossings as outlined in **Section 13.5.1**, there will be less of a requirement for disturbance of aquatic habitats within the project area. The infiltration of exotic species into natural ecosystems is often the result of disturbance. Hence, the aim of the preliminary design has been to minimise the opportunity for disturbance. There are a number of design principles that have been considered to minimise the potential of disturbance to aquatic ecosystems and these are all shown in **Sections 13.5.1, 13.5.2 and 13.5.3.** These design measures shall be carried through to detailed design.

Construction

Exotic species are already present within the majority of the waterways in the project area and may potentially respond to additional disturbance. There are a number of construction measures that have been considered to minimise the potential of disturbance to aquatic ecosystems and these are all shown in **Sections 13.5.1, 13.5.2 and 13.5.3.** More specific management during construction should focus on not creating appropriate breeding habitat for the exotic species, i.e. aquatic weeds and shallow ponds. Mitigation measures to be implemented during the construction phase to reduce the risk of providing favourable habitat conditions for exotic fish species (i.e. Eastern Gambusia and Swordtail), include the following:

The risk of in-stream and riparian weeds should be minimised through the implementation of vegetation clearing and revegetation management strategies outlined in **Chapter 11, Terrestrial flora** and the Vegetation Management Plan (VMP) and Weed Management Plan in **Chapter 22, Environmental management plans.**

The creation of shallow ponded waters shall be avoided.

Operation

The most effective mitigation method to manage the intrusion of weeds and exotic species is to ensure that there is a robust cover of native vegetation and associated fauna assemblages, such that exotic species are excluded from the area. Once the new rail has been constructed there will be no further requirement for clearing of riparian vegetation. The rail corridor will be maintained on a regular basis through weed management and pruning of overhanging vegetation. During the operational phase, the focus on riparian vegetation will shift the management of the rehabilitation program. These areas will be the focus of the Vegetation Management Plan (VMP). Mitigation will be as follows:

- management of vegetation offsets to replace areas of remnant regional ecosystems removed by the proposed railway development

Offsets will be in line with the policy of the Department of Environment and Resource Management for Vegetation Management Offsets, which is triggered under the *Vegetation Management Act 1999*. Refer to **Section 11.6** for more information regarding offset requirements. The final extent of offsets required and offset areas will be finalised during the detailed design phase.

- control and/or removal of any weeds in the corridor that have been introduced or exacerbated as a result of the works, with the aim being to leave the site in equivalent condition (or better, in terms of weeds) to prior to construction

The environmental officer shall take before and after photographs and site notes to verify the condition of the site.

- preventing weed establishment on bare ground and in areas of revegetation
- rehabilitation of areas necessary for construction, but not required for the operational phase of the railway

For example, areas disturbed by construction of the bridges. Rehabilitation will aim to re-establish the original regional ecosystems present prior to disturbance.

- rehabilitation to be more specifically addressed within the VMP for detailed design, particularly: progressive staging of rehabilitation, recommended native species, incorporation of Threatened flora, recommended planting densities, incorporation of understorey where canopy species are excluded by structure and monitoring.

Decommissioning works

The most effective mitigation measure regarding encroachment of exotic macrophytes will be the protection and rehabilitation of native vegetation cover associated with waterways. Vegetation rehabilitation measures are detailed further in **Chapter 11, Terrestrial flora** and the relevant EMP. The rehabilitation and revegetation of riparian areas will improve aquatic habitats, and partially compensate the risk of increased occurrences of exotic macrophytes elsewhere.

Residual impact

With the implementation of the mitigation strategies detailed, it is unlikely that the project will result in measurable increases in exotic fish abundances. Any increase in exotic fish abundance will be difficult to associate with the rail project, because the exotic species are already present in the project area and populations are subject to fluctuations. Some increase in the distribution or abundances of exotic macrophytes, however, may be expected to occur. It is therefore considered that the project will result in an impact of low adverse significance.

13.5.5 Creation of new mosquito and biting midge breeding habitat

Potential impact

Mosquitoes and biting midges are aquatic macro-invertebrates that are often required to be managed for the purposes of public health and community wellbeing. The local council (Sunshine Coast Regional Council) has mosquito (incorporating biting midge) control programs in place.

Mosquitoes and biting midges lay eggs on the surface of pooled water and in other damp locations such as damp ground, on aquatic vegetation, on the damp edges of natural containers (e.g. tree-hole cavities, rock-pools) and man-made containers (e.g. tyres, rainwater tanks). Outbreaks usually occur within one to two weeks after a rainfall event.

During the construction and decommissioning phases of the project, disturbed soils and cleared vegetation that is not removed may provide areas for water to pool (e.g. following rainfall). These works therefore have the potential to create new breeding habitats for mosquitoes or biting midges throughout the length of the new corridor and existing rail alignment. However, these effects are expected to be temporary and also very small in relation to the abundant availability of suitable breeding habitat that currently exists (both naturally and artificially) within the project area.

Proposed mitigation

Design

In minimising the number of waterway crossings as outlined in **Section 13.5.1**, there will be less of a requirement for disturbance of aquatic habitats within the project area. The infiltration of mosquitos and biting midges into natural ecosystems is often the result of disturbance. Hence, the aim of the preliminary design has been to minimise the opportunity for disturbance. There are a number of design principles that have been considered to minimise the potential of disturbance to aquatic ecosystems and these are all shown in **Sections 13.5.1, 13.5.2** and **13.5.3.** These design measures should be carried through to detailed design.

Construction

Mosquitos and biting midges are already present within the project area and may potentially respond to additional disturbance. There are a number of construction measures that have been considered to minimise the potential of disturbance to aquatic ecosystems and these are all shown in **Sections 13.5.1, 13.5.2** and **13.5.3**. More specific management during construction should focus on not creating appropriate breeding habitat for the mosquitos and biting midges, i.e. aquatic weeds and shallow ponds. Mitigation measures to be implemented during the construction phase to reduce the risk of providing favourable habitat conditions for exotic fish species (i.e. Eastern Gambusia and Swordtail), include the following:

- The risk of in-stream and riparian weeds shall be minimised through the implementation of vegetation clearing and revegetation management strategies outlined in **Chapter 11, Terrestrial Flora** and the Vegetation Management Plan (VMP) and Weed Management Plan in **Chapter 22, Environmental Management Plans.**
- The creation of shallow ponded waters shall be avoided.

Operation

The most effective mitigation method to manage the intrusion of weeds and exotic species is to ensure that there is a robust cover of native vegetation and associated fauna assemblages, such that mosquitos and biting midges are excluded from the area. Once the new rail has been constructed there will be no further requirement for clearing of riparian vegetation. The rail corridor will be maintained on a regular basis through weed management and pruning of overhanging vegetation. During the operational phase, the focus on riparian vegetation will shift the management of the rehabilitation program. The rehabilitation program is outlined in **Section 13.5.4**. Other mitigation strategies specifically related to the abatement of mosquito and biting midge problems that are to be implemented are:

- Monitoring shall also be utilised to identify areas that could be used as potential breeding sites.
- If breeding areas have been created through disturbance associated with the project, they shall be rectified to establish a natural flow of water.

Decommissioning works

The most effective mitigation measure regarding encroachment of exotic macrophytes will be the protection and rehabilitation of native vegetation cover associated with waterways. Vegetation rehabilitation measures are detailed further in **Chapter 11, Terrestrial flora** and the relevant EMP. The rehabilitation and revegetation of riparian areas will improve aquatic habitats, and partially compensate the risk of increased occurrences of exotic macrophytes elsewhere.

Residual impact

In the context of existing water bodies within the project area, the contribution of the project to providing breeding sites for mosquitoes or biting midges is expected to be **negligible.**

13.6 Summary and conclusions

The project area has a range of values from an aquatic ecology perspective. These include a diversity of aquatic habitats, which support rich and abundant fauna, including fish species of potential conservation significance. Ornate Rainbow fish, for example, are considered to be under pressure from a range of habitat threats but were found to be highly abundant in some of the waterways within the project area.

Most notable aquatic ecology features within the project area will not be directly or indirectly affected by the proposed rail upgrade between Landsborough and Nambour. With the exception of two freshwater fish (Oxleyan Pygmy Perch and Honey Blue-eye), there are no listed Threatened aquatic species or communities within the broader subject area. Note that Oxleyan Pygmy Perch and Honey Blue-eye have been recorded in nearby Mellum Creek (to the south of the project area). This creek is not intersected by the proposed rail corridor. The nearby Ewen Maddock Dam also contains habitats and water quality favoured by Oxleyan Pygmy Perch and Honey Blue-eye. Due to connectivity with the dam, it is considered that Addlington Creek and its tributaries represent potential, though highly marginal (due to the turbid nature of the waters), habitats for these species.

Flow-on impacts from the development to Threatened aquatic species outside the project area are also not expected. Some negligible to low adverse impacts to aquatic habitats, flora and fauna could occur, primarily through temporary alterations to water quality, clearing of vegetation, physical disturbance and in-stream barriers. A summary of the key potential impacts and associated mitigation measures in relation to the aquatic ecology values of the project area is provided in **Table 13.6.**

Taking into account the localised nature of all potential impacts to aquatic ecology values of the project area, together with the unlikelihood of impacts to Threatened aquatic species, it is considered that the overall impact of the project on aquatic flora and fauna is of low **adverse significance.**

Table 13.6: Summary of key potential impacts to aquatic ecology and associated mitigation strategies

Potential Impact	Mitigation Strategy	Residual Impact Significance
Vegetation clearing and physical disturbance of aquatic habitats and surrounds	▪ corridor designed so as to minimise number of waterway crossings ▪ corridor designed to align with existing waterway crossings, where practicable ▪ minimise works in riparian, bank or in-stream areas ▪ contain disturbed sediments ▪ monitor and control weed encroachment in cleared area, or revegetate if possible.	Low Adverse
Water quality modifications, especially increased turbidity and the introduction of contaminants	▪ minimise disturbance to stream bed and banks ▪ install and maintain erosion and sediment controls ▪ store and handle chemicals appropriately and prevent leakage from construction site ▪ water released from site to be of similar quality to receiving waters ▪ ongoing water quality monitoring.	Low Adverse
Creation of in-stream barriers to fauna passage	▪ waterway crossings designed so as to minimise barrier effects ▪ in-stream works timed to avoid key migration periods, when feasible ▪ stream flow patterns will be maintained (or mimicked) as closely as possible ▪ habitats and light penetration within culverts to be as natural as possible.	Negligible to Low Adverse
Increased occurrence of exotic flora and fauna species	▪ minimise vegetation clearing at or adjacent to waterways ▪ protect and rehabilitate native riparian and in-stream vegetation ▪ minimise physical in-stream disturbance and water quality modifications.	Negligible to Low Adverse
Creation of new mosquito or biting midge breeding habitats	▪ prevent or minimise water pooling in areas disturbed by project works.	Negligible

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