14 Water Resources

14.1 Introduction

14.1.1 Background and scope

The project is known to cross a large number of water bodies including rivers, ephemeral streams, wetlands and groundwater aquifers. This chapter is concerned specifically with the waterways and groundwater aquifers that lie on the project and evaluates the impacts of the project to the water quality of these water bodies as a result of the construction, operation and decommissioning of the project.

The overall assessment approach has been carried out to meet the TOR and generally follows the procedure below:

1. collection of background information on waterways likely to be affected by the project
2. evaluate limitations in existing information
3. review legislation and guidelines which govern water quality
4. review and characterise the water quality of the affected waterways
5. evaluate the possible impacts arising from the design, construction, operational and decommissioning phases of the project
6. propose mitigation measures which can be implemented during the different phases of the project to ensure that impact to water quality is reduced
7. evaluate the residual impacts to water quality taking into account appropriate legislative standards and guidelines.

This assessment will broadly be divided as follows: surface water quality, and groundwater quality. In investigating surface water the focus will be the rivers, ephemeral streams and tidal streams within the rail corridor. Groundwater will focus on the aquifer system below ground. Existing data sources have been primarily used in this assessment and there are some limitations to this assessment due to lack of up to date and more detailed site specific information on location of groundwater aquifers.

In reviewing the impacts from the project, the impacts during the design, construction, operational and decommissioning stage will be addressed. The construction and decommissioning phases have the greatest potential for short-term impacts on water quality within the waterways; both surface and groundwater. The risk of large sediment loads being discharged into receiving waterways without appropriate mitigation measures is an example. These sediment loads have the potential for both direct impacts (e.g. increased turbidity, habitat smothering) associated with the sediment, but also impacts associated with the pollutants (e.g. nutrients, heavy metals) that can be attached to eroded sediment particles and conveyed into downstream waterways. Another risk associated with construction works is spills from construction vehicles.

The potential for detrimental impacts in the operational phase is reduced, with the principal risks being increased loads of gross pollutants and spills from rail accidents.

Mitigation is possible to reduce the risk of these impacts. These will take the form of an Erosion and Sediment Control Program (ESCP) for the construction phase and a range of Water Sensitive Urban Design (WSUD) techniques and devices for the operational phase.

The selection of the preferred route for the project from a water quality perspective has focussed on the number of creek crossings and on the length of the corridor in close proximity to the waterways. While mitigation can reduce water quality impacts for any of the options, reducing the number of crossings and the length of the corridor in close proximity to the waterways has been a key consideration in terms of minimising the potential water quality impacts and the cost of mitigation.

14.1.2 Aims

There are essentially three parts to the impact assessment process: establishing baseline data, utilising that information to predict the impacts of the development on existing local conditions and developing appropriate mitigation measures. The specific aims of the baseline investigations were to describe:

- existing surface and groundwater in terms of physical, chemical and biological characteristics
- existing surface drainage patterns, flows history of flooding including extent, levels and frequency and present water uses
- environmental values of the surface waterways of the affected area in terms of:
  - values identified in the *Environmental Protection (Water) Policy*
  - physical integrity, fluvial processes and morphology of watercourses, including riparian zone vegetation and form
  - hydrology of waterways and groundwater
- existing and other potential surface and groundwater users and holders of Quarry Material Allocation Notices in the project area
- any Water Resources Plans relevant to the affected catchments.

14.1.3 Relevant legislation and policy

Federally, the National Water Quality Management Strategy sets objectives for the preservation of water quality within the ANZECC 2000 guidelines for fresh and marine water quality. Within the State of Queensland, the *Water Act 2000* legislates the extraction of water and alteration of water courses. The *Environmental Protection Act 1994* (EP Act) regulates water quality issues under the *Environment Protection (Water) Policy 1997* and defines Environmentally Relevant Activities requiring assessment and licensing. A range of guidelines and policies specific to management of water quality are also important in discussing obligations under Queensland legislation.

Water Resource Plans (*Water Act 2000*)

The water resource planning process is designed to plan for the allocation and sustainable management of water to meet Queensland's future water requirements. Water Resource Plans (WRPs) are structured under the *Water Act 2000* to deliver new levels of sustainability for river ecosystems and certainty for water users. A water resource plan details what the government aims to achieve for a catchment's social, economic and environmental needs. They are developed through detailed technical and scientific assessment as well as extensive community consultation. Generally, a water resource plan will apply to a catchment's rivers, lakes, dams and springs and, if necessary, underground water and overland flow. A plan is developed by assessing the size and nature of the resource so we can ensure that water allocation occurs within sustainable limits. There are two WRPs affecting the project area. The Mary Basin WRP affects the project area from Ewan Maddock dam (near Landsborough) to Nambour. The Moreton WRP affects the township of Landsborough. The objectives of each of the plans are shown below:

Water Resource (Mary Basin) Plan 2006

The purposes of this plan are:

(a) for both surface and sub-artesian water, the following:

- (i) to define the availability of water in the plan area
- (ii) to provide a framework for sustainably managing water and the taking of water
- (iii) to identify priorities and mechanisms for dealing with future water requirements
- (iv) to provide a framework for reversing, where practicable, degradation that has occurred in natural ecosystems

(b) for surface water only, to provide a framework for establishing water allocations.

Water Resource (Moreton) Plan 2007

The following are the purposes of this plan:

(a) to define the availability of water in the plan area

(b) to provide a framework for sustainably managing water and the taking of water

(c) to identify priorities and mechanisms for dealing with future water requirements

(d) to provide a framework for reversing, where practicable, degradation that has occurred in natural ecosystems

(e) to provide a framework for:

- (i) establishing water allocations to take surface water
- (ii) granting and amending water entitlements for groundwater
- (iii) granting water entitlements for overland flow water.

National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) has been jointly developed since 1992 by the Australian government in cooperation with State and territory governments. The main policy objective of the NWQMS is to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development. As part of this strategy, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) were developed and remain the default guideline for water quality values where local or regional guidelines have not been developed.

Environmental Protection Act 1994

Section 319 of the *Environmental Protection Act 1994* (EP Act) imposes a general duty of care, which specifies that a person must not undertake any activity that may harm the environment without taking reasonable and practical measures to prevent or minimise the harm. In Queensland, the EP Act and subordinate legislation the *Environmental Protection (Water) Policy 1997* form the framework that regulates activities likely to affect both surface and groundwater. Within this framework the key focus is to establish the Environmental Values (EV) attached to the watercourses and subsequently to determine the Water Quality Objectives (WQO) required to protect the EVs. EVs have been established for much of SEQ and cover the waterways of concern to this project.

Queensland Water Quality Guidelines

Surface water

The Queensland Water Quality Guidelines (QWQG) developed by the Department of Environment and Resource Management are technical guidelines for the protection of aquatic ecosystems. These guidelines aim to further the goals of the NWQMS. The QWQG identifies three levels of ecosystem conditions for which different levels of protection can be applied:

- level 1 – high conservation/ecological value systems
- level 2 – slightly to moderately disturbed systems
- level 3 – highly disturbed systems.

In setting Water Quality Objectives (WQOs) for aquatic ecosystems, the QWQG (Environment Protection Agency, 2006) represents the most locally accredited guideline information. Under the process outlined in the *Environmental Protection (Water) Policy 1997*, these guidelines therefore take precedence over broader guidelines such as the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000).

Seven major regions are defined in the QWQG that include SEQ coastline, which is then divided into sub-regions.

The QWQG provide regional and sub regional guidelines for physio-chemical indicators, regional guidelines for biological indicators (adapted from the Ecosystem Health Monitoring Program (EHMP)) and regional guidelines for riparian zones (also adapted from EHMP).

Water quality objectives for SEQ waters are provided below in **Table 14.1.3a**. The water types shown in this table include those applicable to the project (i.e. lowland streams and upland streams). The parameters in **Table 14.1.3a** include key physio-chemical indicators for the protection of aquatic ecosystems. However, for a number of indicators, notably toxicants, there is little or no applicable information for Queensland. For these indicators the ANZECC guidelines remain the principal source of information.

Table 14.1.3a: Regional Guideline Values for Physio-Chemical Indicators - Central Coast Region (Department of Environment and Resource Management, 2006)

Water type	Amm N	Oxid N	Org N	Total N	Filt R P	Total P	Chl-a	DO(%Sat)		Turbidity (NTU)	Secchi	SS	pH	
	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	upper	lower	NTU	M	mg/l	lower	upper
Upland streams	10	15	225	250	15	30	n/a	90	110	25	n/a	n/a	6.5	7.5
Lowland streams	20	60	420	500	20	50	5	85	110	50	n/a	10	6.5	8

The QWQG provide guidelines for the protection of riparian zones which is linked to water quality. Table 14.1.3b shows the guidelines for upland and lowland freshwater areas.

Table 14.1.3.b: South East Region Guidelines for Riparian Areas[1]

Water Type	Riparian Function		
	Ecological Processes	Habitat	Bed and Bank Stability
	Perennial	Perennial	Perennial
Tannin stained and coastal fresh-waters	Maintain or restore vegetation to achieve: ▪ 70% canopy shade in streams less than 10m wide ▪ shade over near-bank areas in wider streams. This will achieve: ▪ moderation of temperature and dissolved oxygen extremes ▪ transformation of diffuse nitrogen inputs.	Eradicate weeds and maintain or restore: ▪ in-stream debris, riffles and pools ▪ native trees, shrubs and ground cover on the banks. This also assists in maintaining biodiversity.	Maintain or restore bank vegetation. Manage cattle access.
Estuarine	Maintain or restore marine plants to achieve: ▪ shade over near-bank areas ▪ moderation of temperature and dissolved oxygen extremes ▪ organic cycling of leaf litter for nutrients and energy ▪ transformation of diffuse nitrogen inputs.	Eradicate weeds and maintain or restore: ▪ in-stream debris ▪ marine plants, trees, shrubs and ground cover on the banks.	Maintain or restore bank vegetation to minimise erosion.
Coastal foreshores	Maintain or restore marine plants to achieve: ▪ shade over near-bank areas; ▪ moderation of temperature and dissolved oxygen extremes; ▪ organic cycling of leaf litter for nutrients and energy; and ▪ transformation of diffuse nitrogen.	Eradicate weeds and maintain or restore marine plants, trees, shrubs, and ground cover, and restore tidal regimes where appropriate.	Maintain or restore shoreline vegetation (such as mangroves, salt marshes and seagrass) to minimise erosion.

1 Queensland Water Quality Guidelines, 2006

Schedule 1 of the EPP (Water)

Schedule 1 of the EPP (Water) was updated in 2006 to include the following policy amendment: The *Environmental Protection (Water) Amendment Policy (No. 1) 2006 - Subordinate Legislation 2006 No. 30 (EP Water Amendment Policy)*. This amendment policy establishes environmental values and water quality objectives for riverine (freshwater), estuarine and coastal waters in the following areas:

- Moreton Bay/SEQ
- Mary River Basin/Great Sandy Region
- Douglas Shire waters.

As part of the amendment, EVs and WQOs have been scheduled for the waterways within the project area. The following documents provide scheduled EVs and WQOs applicable to the project area:

- Maroochy River: environmental values and water quality objectives: Basin No. 141 (part) including all tributaries of the Maroochy River (Department of Environment and Resource Management, 2006a)
- Pumicestone Passage: environmental values and water quality objectives: Basin No. 141: (part) including waters of Bribie Island and Bells, Coochin, Dux, Elimbah, Mellum, Ningi and Tibrogargan Creeks (Department of Environment and Resource Management, 2006b).

These documents also refer to a number of guidelines, codes and other reference sources on water quality. In particular, the QWQG provides more detailed information on water types, water quality indicators, derivation of local water quality guidelines, application during flood events and predicting and assessing compliance.

Table 14.1.3c lists the identified EVs for protection for the principal waterways within the project area. The corresponding scheduled water quality objectives to the aquatic ecosystem EV (slightly to moderately disturbed level of protection – level two) are provided in **Table 14.1.3d**.

Groundwater

The EVs and WQOs for waters of the Mooloolah River catchment provide WQOs relating to groundwaters for the protection of aquatic ecosystems. In particular, it specifies that, where groundwaters and surface waters interact, groundwater quality should not compromise the quality of surface waters.

More specifically, the ANZECC guidelines are also another source of groundwater guidance. The ANZECC guidelines stipulate a framework for identifying the environmental value of groundwater. This framework is based on the identification of an existing or potential beneficial use of a groundwater resource (ANZECC, 1995). The specific water quality and potential long-term value of the groundwater resource dictates the beneficial use classification.

Table 14.1.3c: Scheduled environmental values

Waterway	Environmental Value													
	Aquatic ecosystems	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Cultural and spiritual values	Industrial use	Aquaculture	Drinking water	Irrigation	Stock water	Farm supply	Oystering	Seagrass
Pumicestone Passage (freshwater tributaries)	✓	✓	✓	✓	✓	✓				✓	✓	✓		
Petrie Creek (freshwater)	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		
Paynter Creek (freshwater)	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓		
Eudlo Creek (freshwater)	✓		✓	✓	✓	✓	✓			✓	✓	✓		
Other freshwater tributaries	✓	✓	✓	✓	✓	✓				✓	✓	✓		
Groundwaters	✓								✓	✓	✓	✓		

Table 14.1.3d: Scheduled water quality objectives

Water type	TN mg/L	TP mg/L	Turb NTU	DO %Sat	Chl a µg/L	TSS mg/L	NOx mg/L	NH3 mg/L	Org N mg/L	FRP mg/L	pH
Wallum/tannin-stained and coastal streams	0.50	0.050	50	85 - 100	5	6	0.06	0.02	0.42	0.02	6.5 – 8.0

The ANZECC guidelines further stipulate that the proponent of an activity likely to impact on a groundwater resource will be responsible for maintaining the resource at or above its beneficial use classification. The beneficial use classification follows five broad categories:

- ecosystem protection
- recreation and aesthetics
- raw water for drinking water supply
- agricultural water
- industrial water.

Further to the ANZECC guidelines, direction on what constitutes good quality drinking water is provided by the Australian Drinking Water Guidelines (2004) developed by the National Health and Medical Research Council (NHMRC) and Natural Resource Management Ministerial Council (NRMMC).

14.2 Methodology

14.2.1 Review of existing information

Surface water quality

For the project, the infrastructure cross-flow control is assumed to be achieved through hydraulic structures such as bridge or culverts. Separate preliminary design techniques were used depending on the nature of the flood flow (regional or local):

- Regional flooding from major creeks has previously been studied, and GIS layers of the 100 year ARI design flood are available from the council. These GIS layers are produced by hydraulic computer models, which accurately predict statistically based design flood events. Approximate design water levels, which the rail embankment must exceed, are extracted from the comparison of the lateral flood extents and the Digital Elevation Model (DEM). The spread of regional flooding in both urban and rural areas generally affects properties and businesses over a large area. As a preliminary assessment, the only consistent means to prevent increasing damage is to bridge the entire floodplain at the location of the railway crossing. The length of bridge required to cross the major floodplains was calculated in this way.
- Local drainage flow paths cross the project. They correspond to the runoff concentrated at the bottom of catchment gullies before they merge with downstream creek flows. All the crossing locations with a significant upstream catchment (> 1ha) were identified using the DEM. As a preliminary assessment, the crossing structures (pipes or culverts) at these locations are sized based solely on the peak flow and a proposed design afflux (0.3m) using standard hydraulic equations for culverts flowing full. Design peak flows are derived using the rational method from the catchment characteristics determined from the DEM and aerial photographs. The proposed design afflux is assumed to be insignificant in most cases, as the location of existing buildings and the land steepness limit the afflux area of influence.

Although the assessment of the required flood structures is only preliminary, it uses the techniques most adapted to the available information and the project time frame. Further and more advanced analyses, which could include hydraulic modelling, will be required at the detailed design stage to optimise the flood crossing structures.

The methodology adopted for water quality incorporates a review of the following information:

- water quality assessment information from the Ecosystem Health Monitoring Program (EHMP) undertaken by the SEQ Healthy Waterways Partnership
- water quality monitoring data collected in late 2007 and early 2008 by BMT WBM as part of their aquatic surveys undertaken for this project.

Where appropriate, comparison against the Queensland Water Quality Guidelines (Department of Environment and Resource Management, 2006) for lowland streams has been undertaken. These guidelines set annual median objectives against selected environmental values and in particular the protection of the aquatic ecosystems. For indicators not considered in these guidelines (e.g. metals), the ANZECC 2000 Guidelines remain the principal source of information. Freshwater trigger values for slightly to moderately disturbed systems have been used as a comparison.

Groundwater

No previous hydrogeological analysis has been performed within the project area. This desktop study has been carried out based on the Department of Environment and Resource Management groundwater database. Information provided by this database incorporates registered groundwater bores facilities only. The project area includes boreholes created from 2004 to 2007.

A review of the Department of Environment and Resource Management's groundwater database (GWDB) has been carried out to assess information on the location, yields and lithology of registered groundwater bores. The groundwater quality has only been recorded for some of the bores facilities.

In order to target the search from GWDB, a groundwater study zone has been confined to the project area. Results from this search were used to describe a rough hydrogeological context of this area.

14.2.2 Field investigations

Surface water

As part of BMT WBM's aquatic surveys undertaken for this project, the following water quality sampling regime was initiated:

A detailed analys of selected water quality parameters was undertaken at 4 core sample sites. The core sites were selected on the basis that they were representative of different aquatic habitats and waterways to be affected by the project, and/or contain features of high conservation significance from an aquatic ecology perspective (e.g. represent habitat for threatened fish species).

At each core site, the following sampling was undertaken:

- A data logger was deployed for two weeks to measure water temperature, electrical conductivity/salinity, pH, dissolved oxygen and turbidity at 15 minute intervals.
- Water quality sampling and laboratory analysis were undertaken on four occasions (two in the dry season and two in the wet season) to measure total and dissolved metals (aluminium, arsenic, chromium, copper, lead, nickel and zinc), total suspended solids, and nutrients (ammonia, nitrate, nitrite, organic nitrogen, total nitrogen, ortho-phosphate and total phosphorus).

The locations of the core sampling sites (5, 7, 11 and 13) are shown in **Figure 14.2a**. Sites 5, 7, 11 and 13 are located on South Mooloolah River, Eudlo Creek, Paynter Creek and Petrie Creek respectively.

Groundwater

There is no specific field investigation which has been carried out for this study. Based on the available information, a brief hydrogeological context has been described.

14.2.3 Limitations of study

A key impact from developments near waterways is the potential for increased sediment laden runoff into waterways. The exact methodologies regarding construction of the project are not known, hence it is difficult to quantify the extent of the impacts on water resources in the project area.

However, the proposed mitigation measures are designed to cater for any impacts regardless of whether they are minor or major. The construction EMP will also be a document subject to ongoing monitoring and review to ensure that adverse impacts are being managed appropriately.

Surface water

This impact assessment study utilises the data sets mentioned to understand the state of the existing environment. This information is far from comprehensive both spatially and temporally, but provides a sufficient indication of the sensitivity of waterways to development within them. Data is insufficient or non existent at many locations to enable the calculation of long-term trends. Limitations relating to the snap shot nature of this sampling should be considered when interpreting these results.

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 14.2b** 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. This may slightly skew the water quality results obtained.

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

Figure 14.2b: Average monthly rainfall

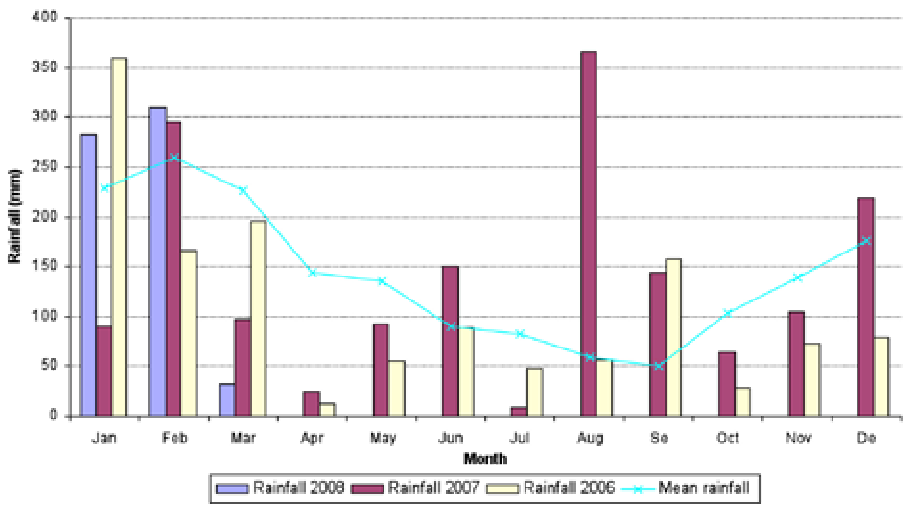
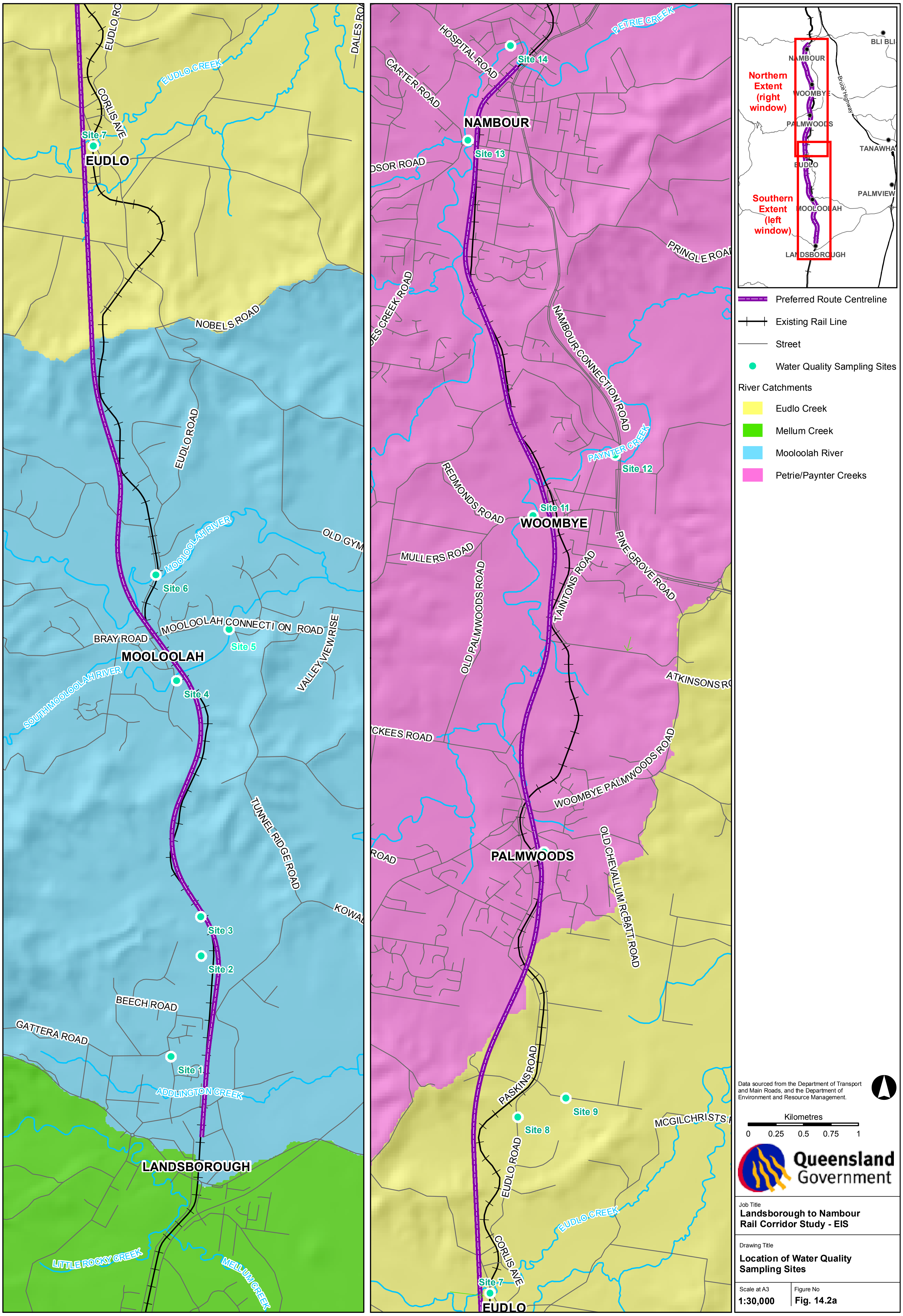


Figure 14.2a: Location of Water Quality Sampling Sites



Groundwater

The data used for this assessment is based on the existing Department of Environment and Resource Management groundwater database which has been developed for the purposes of monitoring groundwater that is accessed for various water supply purposes. The Department of Environment and Resource Management holds data on registered groundwater facilities that include information on lithology, yield, water levels and basic water quality.

The Department of Environment and Resource Management have indicated 78 registered bore facilities in the project area, whilst information has been compiled for only 48 of them. This data is useful in determining the presence of groundwater, however, it is not extensive enough to determine the extent of groundwater resources and the linkages between groundwater and surface water. The groundwater level and water quality data from this dataset are based on private groundwater drilling programs that are irregular and therefore may not be characteristic of the groundwater environment.

14.2.4 Assessment of impacts

The methods used to assess the level of impacts on waterways and water quality are based on the current health of waterways as determined through the Ecosystem Health Monitoring Program (EHMP) and site specific monitoring which overall is considered useful in providing a snapshot of the state of waterways. Potential impacts to water resources were then identified and mitigation methodologies determined to reduce or alleviate potential impacts. Finally, an assessment is made of the residual impact using the significance criteria shown in **Table 14.2.4**. The significance criteria have been made specific to water resources.

Table 14.2.4: Impact significance criteria for water resources

Significance	Criteria for water resources
High adverse	Minor to moderate impact at a national or State scale, and/or moderate (or above) impact at a regional scale, which results in > 30% loss of riparian vegetation and results in stream bank erosion causing some slumping of the banks. Change in surface water quality with breaches to some parameters as documented in the ANZECC Water Quality Guidelines and medium to long term ecosystem collapse. Medium to long term change in groundwater quality rendering it unsuitable for an extended period for its current beneficial usage. Alteration to existing drainage near site area and/or change to channel or bank. Change in groundwater table level with unacceptable changes to bore water pressure.
Moderate adverse	Major or high (medium to long-term) impact at site-specific scale, and/or high (short-term) or moderate impact at local scale, and/or minor impact at regional scale, which results in 10–30% of riparian vegetation removal and some localised scouring and potential for undermining bank stability. Short-term change in water quality with a few breaches of the ANZECC Water Quality Guidelines. Change in groundwater quality affecting water usage for a matter of days. Short-term change to groundwater table level affecting pressure in existing nearby bores.
Low adverse	Moderate or high (short-term) impact at site-specific scale, or minor impact at local scale, which results in <10% of riparian vegetation removal and potential for some short-term turbidity increases. Short-term water quality changes where ANZECC water quality guidelines are only exceeded within an initial mixing zone. Groundwater quality is only affected for a matter of hours and temporary changes to groundwater table resulting in slight changes in bore water pressure.
Negligible	Negligible impact at local, regional, State or national scale, or minor impact at or below a site-specific scale, which results in < 1% removal of riparian vegetation and/or no notable changes to surface water quality, groundwater quality, surface water drainage and/or groundwater levels.
Beneficial	The effects of a project can also be beneficial from an ecological perspective, and result in water quality improvements to either surface or groundwater. Revegetation activities proposed could improve current riparian habitat and reduce erosion capacity of the site.

14.3 Description of environmental conditions

14.3.1 Surface water

The following named watercourses pass through the project area (listed south to north):

- Mellum Creek (Pumicestone Passage Catchment)
- Addlington Creek (Flows into Ewen Maddock dam – tributary of Mooloolah River)
- South Mooloolah River (tributary of Mooloolah River)
- Mooloolah River
- Acrobat Creek (tributary of Eudlo Creek)
- Eudlo Creek (tributary of the Maroochy River)
- Paynter Creek (tributary of the Maroochy River)
- Petrie Creek (tributary of the Maroochy River).

Many of these waterways are significant from an ecological, recreational and visual perspective. The mouth of the Maroochy River which Eudlo, Paynter and Petrie Creek flow into is a Fish Habitat Area (FHA). The Ewen Maddock dam water resource catchment area also partially covers the southern end of the project area. Pumicestone Passage, which Mellum Creek flows into, is one of four passage type estuaries in Queensland. Its mangrove fringed wetland contains extensive seagrass meadows and is a valuable nursery area for commercial and recreational fisheries. Of international significance, the Passage is listed under the Ramsar Convention as an important feeding and roosting site for migratory birds. The project does not cross Mellum Creek at any stage, nor does it affect the Mellum Creek / Pumicestone Passage catchment (which is to the south of the project).

A search of the Department of Environment and Resource Management water permits was conducted to ascertain the level of surface water usage in the project area. A total of 164 permits were recorded. These included: riparian water access, license to take water, license to interfere by impounding flow and license to interfere with the course of flow. Most licenses relate to irrigation. These licenses were scattered along each of the major waterways affected by the preferred route for the proposed rail corridor. The break down is as follows:

- South Moolooah River – 3
- Mooloolah River – 36
- Eudlo Creek – 26
- Paynter Creek – 48
- Petrie Creek – 45.

Ecosystem Health Monitoring Program (EHMP)

The SEQ Healthy Waterways EHMP monitors catchments and waterways on a monthly basis and provides an annual overview of the health of SEQ waterways. Monitoring is undertaken on a catchment wide basis with assessments of both freshwater and estuarine waterways.

The project area traverses three river catchments, namely:

- Pumicestone Passage catchment
- Mooloolah River catchment
- Maroochy River catchment.

Details of each of the catchments and their 2007 EHMP assessment are provided.

Pumicestone catchment

Catchment map (Source – SEQ Healthy Waterways Program)

Catchment facts

- total area: 789km²
- stream network length: 1,481 km
- local councils: former Caboolture (pop. 121,135), Caloundra (pop. 82,905) – now part of Moreton Bay Regional Council and Sunshine Coast Regional Council (SCRC) respectively
- dominant land uses: pine plantations, forestry, native bush, grazing, agriculture
- Pumicestone Passage receiving inflows from numerous small creeks on the mainland and Bribie Island
- most of Pumicestone Passage part of the Moreton Bay Marine Park
- tidal flushing of the southern passage from Deception Bay dominates the estuary, with a net northern movement of water through the passage
- during flood events, catchment runoff dominating water quality within the passage.

Freshwater results

- 2007 Report Card (Pumicestone Catchment): C-
- streams generally in fair condition
- physical/chemical indicator lower than in previous years
- although no data available for the nutrient cycling indicator in autumn, spring results for this indicator considered poor, as per previous year.

Estuarine results

- 2007 Report Card (Pumicestone Passage - Marine): B-
- fair water quality throughout most of the zone with generally poorer water quality found in the northern reaches
- Phytoplankton abundance increased in the southern reaches compared to 2006
- intact and stable natural habitats throughout with extensive mangrove forests and stable seagrass meadows.

Mooloolah catchment

Catchment map (Source – SEQ Healthy Waterways Program)

Catchment facts

- total area: 223km[2]
- stream network length: 322 km
- local councils: former Caloundra (pop. 82,905), Maroochy (pop. 136,461) – now SCRC
- dominant land uses: native bush, grazing, rural residential, managed forests
- lower estuarine reaches extensively modified for urban development and canal estates
- Ewen Maddock dam draining into the Mooloolah River
- Riparian vegetation in the upper catchment in good condition.

Freshwater results

- 2007 Report Card (Mooloolah Catchment): B+
- streams generally in very good condition
- excellent results for the nutrient cycling indicator
- consistent results between seasons.

Estuarine results

- 2007 Report Card (Mooloolah Estuary): B
- consistently good to excellent water quality throughout the estuary due to strong tidal flushing and no nutrient point source discharges
- lower freshwater inputs from the catchment resulting in higher salinity levels in the upper reaches compared with 2006
- highly impacted riparian habitat in the lower reaches, some intact natural habitat remaining in the upper reaches.

Maroochy catchment

Catchment map (Source – SEQ Healthy Waterways Program)

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Catchment facts

- total area: 636 km^2
- stream network length: 438 km
- local councils: former Maroochy (pop. 136,461), Noosa (pop. 46,461) – now SCRC
- dominant land uses: native bush, grazing, intensive agriculture, urban
- most of the catchment cleared for agricultural and urban uses
- Cooloolabin and Wappa dams impound streams above the South Maroochy River.

Freshwater results

- 2007 Report Card (Maroochy Catchment): C-
- streams generally in fair condition
- improvement in the annual score for the aquatic macro-invertebrate indicator largely offset by a decline in the fish indicator
- low scores for the nutrient cycling indicator in spring and the aquatic macro-invertebrate indicator in autumn.

Estuarine results

- 2007 Report Card (Maroochy Estuary): C-
- lower nutrient levels recorded in the upper reaches compared to 2006
- lower freshwater inputs from the catchment resulting in higher salinity levels in the upper reaches compared to 2006
- impacted riparian habitat due to urbanisation in the lower reaches, good riparian habitat in the middle reaches, extensive agriculture and modified habitat in the upper reaches.

Surface water quality sampling results

Water quality parameters were measured at many sites within the project area. At four sites a data logger was deployed for a two week period over a wet and dry season. At various other sites in-situ data was collected (**Table 14.3.1a**). Summaries of the data logger results for site five (South Mooloolah River), site seven (Eudlo Creek), site 11 (Paynter Creek) and site 13 (Petrie Creek) are shown in **Table 14.3.1b** to **Table 14.3.1e** respectively.

A summary of the laboratory analysis results from a dry season event are provided in **Table 14.3.1f** and **Table 14.3.1g** for metals and nutrients respectively. All the samples were taken on 5 December 2007. A summary of the laboratory analysis results from a wet season event are provided in **Table 14.3.1h** and **Table 14.3.1i** for metals and nutrients respectively. All the samples were taken on 3 January 2008.

In terms of dissolved oxygen, the data logger results for all sites lie below the objectives (85% to 110% saturation) on a median basis. Results from the South Mooloolah River are only slightly below the objectives while the Eudlo Creek site appears to show signs of significant oxygen deficiency over the two week duration which is a potential issue for general aquatic ecosystem health. Paynter Creek and Petrie Creek recorded levels in between these two waterways (approximately 65%).

The turbidity data from the logger at sites five (South Mooloolah River), seven (Eudlo Creek) and 11 (Paynter Creek) has some potentially spurious high readings that require verification. However, from the data available, sampling at Petrie Creek shows very low turbidity (< 10%) consistently. Paynter Creek and Eudlo Creek sites show relatively low median turbidity levels that comply with the objectives, but did experience some large spikes. While the South Mooloolah River results show consistently higher turbidity levels that exceed twice the Queensland objective (50 Nephelometric Turbidity Units (NTU)).

In terms of nutrients, levels were predictably elevated under the wet weather conditions and showed general non compliance against the Queensland objectives. Under dry conditions, phosphorus was particularly elevated at the South Mooloolah River site and to a lesser degree in Petrie Creek. Compliance of total nitrogen was recorded at all the sites but with high levels of bio-available forms in both Paynter Creek and Petrie Creek.

From the total metal results that are above the detectable limits, the following observations have been made with comparison to the freshwater ANZECC guidelines.

- Total aluminium levels under wet and dry events at all four sites are above the ANZECC trigger value (0.055 mg/L).
- Metal concentration in general increased in the wet weather event. The most notable increases were in the South Mooloolah River.
- Total copper levels were above the ANZECC trigger value (0.0014 mg/L) at the South Mooloolah River and Petrie Creek sites under dry conditions and at all sites under wet conditions.
- Total zinc levels at all four sites under both events were above the ANZECC trigger value (0.0014 mg/L).

In summary, the sampling undertaken by BMT WBM concurs with findings from the EHMP assessments. Variations in water quality are shown across the waterways in the project area but the surface water quality in the project area is generally fair to good.

Table 14.3.1a: In-situ physiochemical water quality parameters collected during September 2007 field investigations

Location		Site, Date		Temp	Conductivity	Salinity	pH	ORP	DO	DO	Turbidity
		Time		C	uS/cm	ppt		mV	%	mg/L	NTU
ANZECC Guideline Values					125-2200		6.5-8.0		85-110		6-50
Drainages of Ewen Maddock Dam	Addlington Creek	1	Min	16.36	239	0.04	6.5	188	56	5.5	44.3
		13.9.07	Max	16.39	239	0.04	6.5	234	62.4	6	47.1
		7:20	Av.	16.37	239	0.04	6.5	205.3	58.4	5.7	46
	Minor Drainage of Ewen Maddock dam	2	Min	18.89	85	0	6	273	15.4	2	37.2
		28.9.07	Max	19	87	0	6	274	16	2.1	370
		9:00	Av.	18.95	86	0	6	273.5	15.7	2.1	203.6
	Minor Drainage of Ewen Maddock dam	3	Min	18.3	96	0	5.9	211	32.8	2.7	109
		28.9.07	Max	18.71	97	0	5.9	308	40.2	3.6	145
		10:10	Av.	18.48	97	0	5.9	247	35.5	3.3	126.2
Drainages of South Mooloolah River	Unnamed drainages of Mooloolah River	4	Min	16.96	533	0.17	7.2	100	78.1	7.6	40.3
		13.9.07	Max	16.99	547	0.19	7.2	147	81.7	7.8	46
		11:00	Av.	16.97	538	0.18	7.2	118.7	79.4	7.7	42.6
	South Mooloolah River	5	Min	15.56	605	0.21	7.2	116	40.2	4	22.3
		24.9.07	Max	15.68	615	0.23	7.4	134	63.4	6.1	64
		8:40	Av.	15.61	610	0.21	7.3	125.6	47.4	4.6	33
	Unnamed drainages of Mooloolah River	6	Min	16.64	388	0.11	7.8	6	88.1	8.5	24.6
		25.9.07	Max	16.7	392	0.12	7.8	157	92	8.9	31.2
			Av.	16.67	391	0.12	7.8	70.3	89.5	8.7	28.6
Drainages of Eudlo Creek	Eudlo Creek	7	Min	19.2	296	0.07	7.2	84	67.8	6.3	79.3
		25.9.07	Max	19.35	296	0.13	7.2	126	71.8	6.6	127.5
		13:47	Av.	19.27	296	0.10	7.2	106.3	70.1	6.4	98.9
	Unnamed drainages of Eudlo Creek	8	Min	18.22	209	0.04	6.6	189	30.2	2.6	113.2
		27.9.07	Max	21.62	233	0.06	6.7	206	40.5	3.6	134.1
		14:30	Av.	19.92	221	0.05	6.7	197.5	35.4	3.1	123.7
	Unnamed drainages of Eudlo Creek	9	Min	18.46	149	0	6.3	189	70	6.5	179.3
		25.9.07	Max	20.44	149	0.03	6.6	218	73.1	6.6	217.4
		17:30	Av.	19.45	149	0.02	6.4	203.5	71.6	6.6	198.4
Drainages of Paynter Creek	Unnamed drainages of Paynter Creek	10	Min	19.63	118	0	6.1	148	73.7	6.7	49.2
		13.9.07	Max	19.76	121	0.01	6.1	170	77.3	7	69.3
		15:51	Av.	19.69	119	0.01	6.1	158.3	75	6.8	58.4
	Paynter Creek	11	Min	19	185	0.02	7	107	60.4	5.6	37.7
		27.9.07	Max	19.03	215	0.04	7	120	61	5.6	135.4
			Av.	19.01	198	0.03	7	113	60.7	5.6	78.8
	Paynter Creek	12	Min	18.66	182	0.03	6.9	89	59.6	5.6	31.9
		27.9.07	Max	18.69	193	0.04	7	95	60.3	5.6	32.6
		7:40	Av.	18.68	188	0.04	6.9	92	60	5.6	32.3

Table 14.3.1a: continued

Location		Site, Date		Temp	Conductivity	Salinity	pH	ORP	DO	DO	Turbidity
		Time		C	uS/cm	ppt		mV	%	mg/L	NTU
ANZECC Guideline Values					125-2200		6.5-8.0		85-110		6-50
Drainages of Petrie Creek	Petrie Creek	13	Min	19.77	354	0.11	7.3	197	66.4	5.6	162.9
		26.9.07	Max	21.99	356	0.11	7.3	201	70.1	6.1	164.5
		13:10	Av.	20.88	355	0.11	7.3	199	68.3	5.9	163.7
	Petrie Creek	14	Min	17.69	348	0.09	7.5	222	80.3	7.7	14
		26.9.07	Max	17.72	366	0.1	7.5	224	80.7	7.7	17.8
		8:00	Av.	17.71	357	0.1	7.5	223	80.5	7.7	15.9

Table 14.3.1b: Data logger results from Site 5 (South Mooloolah River 28/12/07 to 11/01/08)

	Temperature (°C)	Conductivity (mS/cm)	Salinity (g/L)	DO (% sat)	DO (mg/L)	Depth (m)	pH	Turbidity (NTU)
Minimum	20.3	0.073	0.04	46	4.17	0.50	6.7	33
20th Percentile	20.9	0.165	0.08	62	5.36	0.56	6.8	53
Median	21.8	0.222	0.11	79	6.82	0.60	6.9	107
80th Percentile	23.2	0.307	0.15	87	7.63	0.63	7.0	158
Maximum	23.6	0.383	0.19	100	9.01	0.77	7.2	2474

Table 14.3.1c: Data logger results from Site 7 (Eudlo Creek 12/11/07 to 28/12/07)

	Temperature (°C)	Conductivity (mS/cm)	Salinity (g/L)	DO (% sat)	DO (mg/L)	Depth (m)	pH	Turbidity (NTU)
Minimum	21.0	0.072	0.03	17	1.45	0.46	6.7	6
20th Percentile	22.1	0.200	0.10	42	3.64	0.54	6.9	12
Median	22.8	0.245	0.12	52	4.43	0.58	7.0	19
80th Percentile	23.6	0.269	0.13	62	5.29	0.62	7.0	55
Maximum	25.6	0.309	0.15	95	8.28	0.67	7.4	2480

Table 14.3.1d: Data logger results from Site 11 (Paynter Creek 11/01/08 to 22/02/08)

	Temperature (°C)	Conductivity (mS/cm)	Salinity (g/L)	DO (% sat)	DO (mg/L)	Depth (m)	pH	Turbidity (NTU)
Minimum	22.1	0.132	0.06	60	5.16	0.59	6.7	6
20th Percentile	22.7	0.151	0.07	64	5.47	0.65	6.8	9
Median	23.1	0.168	0.08	68	5.86	1.095	6.8	19
80th Percentile	23.9	0.193	0.09	109	9.03	1.182	6.8	36
Maximum	24.7	0.211	0.1	124	10.43	1.229	6.9	2476

Table 14.3.1e: Data logger results from Site 13 (Petrie Creek 22/02/08 to 06/03/08)

	Temperature (°C)	Conductivity (mS/cm)	Salinity (g/L)	DO (% sat)	DO (mg/L)	Depth (m)	pH	Turbidity (NTU)
Minimum	21.03	0.262	0.13	5	0.15	10.708	7.25	0
20th Percentile	21.6	0.299	0.15	6	0.16	10.775	7.34	3
Median	22.82	0.312	0.16	65	5.43	10.84	7.4	5
80th Percentile	24.56	0.321	72	71	6.02	10.863	7.43	7
Maximum	26.02	0.334	75.7	80	6.77	10.887	7.51	74

Table 14.3.1f: Analytical dry season results (Metals - 5 December 2007)

Parameter	Units	Site 5	Site 7	Site 11	Site 13
Aluminium - Dissolved	mg/L	<0.004	<0.004	<0.004	<0.004
Arsenic - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001
Cadmium - Dissolved	mg/L	<0.0005	<0.0005	<0.0005	<0.0005
Chromium - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001
Copper - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001
Lead - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001
Manganese - Dissolved	mg/L	0.25	0.57	0.43	0.07
Nickel - Dissolved	mg/L	<0.003	<0.003	<0.003	<0.003
Silver - Dissolved	mg/L	<0.002	<0.002	<0.002	<0.002
Zinc - Dissolved	mg/L	0.033	0.041	0.062	0.058
Aluminium - Total	mg/L	0.06	0.16	0.06	0.44
Arsenic - Total	mg/L	<0.001	<0.001	<0.001	<0.001
Cadmium - Total	mg/L	<0.0005	<0.0005	<0.0005	<0.0005
Chromium - Total	mg/L	<0.001	<0.001	<0.001	<0.001
Copper - Total	mg/L	0.002	0.001	<0.001	0.002
Lead - Total	mg/L	<0.001	<0.001	<0.001	<0.001
Manganese - Total	mg/L	0.29	0.65	0.49	0.095
Nickel - Total	mg/L	0.003	<0.003	<0.003	<0.003
Silver - Total	mg/L	<0.0012	<0.0012	<0.0012	<0.0012
Zinc - Total	mg/L	0.023	0.025	0.02	0.025

Table 14.3.1g: Analytical dry season results (Nutrients and TSS - 5 December 2007)

Parameter	Units	Site 5	Site 7	Site 11	Site 13
Total Phosphorus	mg/L as P	0.16	0.037	0.039	0.065
Filterable Reactive Phosphorus	mg/L as P	0.029	0.006	0.006	0.017
Ammonia Nitrogen	mg/L as N	0.056	0.011	0.035	0.003
Nitrogen Oxides	mg/L as N	0.009	0.028	0.40	0.099
Total Nitrogen	mg/L as N	0.48	0.33	0.45	0.43
Total Suspended Solids	mg/L	4	4	1	8

Table 14.3.1h: Analytical wet season results (Metals – 3 January 2008)

Parameter	Units	Site 5	Site 7	Site 11	Site 13
Aluminium - Dissolved	mg/L	0.2	0.087	0.15	0.12
Arsenic - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001
Cadmium - Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Chromium - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001
Copper - Dissolved	mg/L	0.003	<0.001	0.002	0.002
Lead - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001
Manganese - Dissolved	mg/L	0.04	0.07	0.11	0.048
Nickel - Dissolved	mg/L	<0.003	<0.003	<0.003	<0.003
Silver - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001

Table 14.3.1h: continued

Parameter	Units	Site 5	Site 7	Site 11	Site 13
Zinc - Dissolved	mg/L	0.15	0.11	0.17	0.085
Aluminium - Total	mg/L	11	4.5	4	5.4
Arsenic - Total	mg/L	0.001	<0.001	<0.001	<0.001
Cadmium - Total	mg/L	0.0001	<0.0001	<0.0001	<0.0001
Chromium - Total	mg/L	0.009	0.005	0.005	0.009
Copper - Total	mg/L	0.004	0.002	0.003	0.004
Lead - Total	mg/L	0.002	<0.001	<0.001	<0.001
Manganese - Total	mg/L	0.11	0.12	0.17	0.12
Nickel - Total	mg/L	0.007	0.004	0.005	0.008
Silver - Total	mg/L	<0.001	<0.001	<0.001	<0.001
Zinc - Total	mg/L	0.038	0.053	0.037	0.03

Table 14.3.1i: Analytical wet season results (Nutrients and TSS – 3 January 2008)

Parameter	Units	Site 5	Site 7	Site 11	Site 13
Total Phosphorus	mg/L as P	0.15	0.077	0.12	0.16
Filterable Reactive Phosphorus	mg/L as P	0.050	0.016	0.032	0.072
Ammonia Nitrogen	mg/L as N	0.028	0.022	0.007	0.020
Nitrogen Oxides	mg/L as N	0.064	0.13	0.069	0.14
Total Nitrogen	mg/L as N	0.89	0.54	0.72	0.91
Total Suspended Solids	mg/L	16	13	13	14

Surface water hydrology and flooding

As previously mentioned the project traverses six major waterways. The physical properties of these are discussed briefly below:

Addlington Creek

The project crosses Addlington Creek 600 metres to the north of Landsborough station and downstream of Addlington Street. A second crossing is made approximately 300 metres to the north. The crossings are in an upstream part of the creek catchment. Combined, they account for 110 m³/s during the 100 year ARI design flood, discharging from a 3.3 km² upstream catchment.

Depending on the proximity of existing properties, if a 300 mm afflux is acceptable, culverts adding up to 55 m² of opening area will be required to convey Addlington Creek flows.

Another significant flowpath to account for, with 2.1 km² to 2.8 km² of catchment area at the proposed rail crossing, occurs between Park Court and Dularcha Drive. The 100 year ARI design flows from 67 m³/s to 84 m³/s will require between 34 m² and 42 m² of culvert opening area. Aside from these significant crossings, approximately eight cross-drainage structures are required to accommodate small flowpaths.

The physical integrity of the waterways in this area is variable. All waterways are well vegetated at the point where the project crosses the waterway. The major waterways (Addlington Creek branches) are well vegetated with RE12.3.2 (Flooded gum alluvial forest). Due to their proximity to residential development, weed incursion is prominent in Addlington Creek. The five minor waterways within Dularcha National Park are also well vegetated with the same vegetation, however, those waterways towards the north of the park are more representative of RE12.3.1 (riparian rainforest). The presence of vegetation has maintained good bank structure and erosion is limited to the intermittent patches of disturbance at periods of high flow. These waterways are known to provide good habitat for native frogs and fish.

South Mooloolah River and Mooloolah River

The project includes the two major floodplains of Mooloolah River and South Mooloolah River. The size of the respective catchments is approximately 6.7 km² and 1.4 km² at the crossing. Due to the geometry of the floodplains, the lateral spread of the 100 year ARI design flood is significant. Each floodway shall be bridged to avoid upstream negative impacts, the South Mooloolah River bridge is approximately 50 metres long whilst the Mooloolah River bridge is approximately 290 metres long and traverses the floodplain to the north of the station.

In addition to the major bridges, five minor waterways are affected to the south of the structure and eight to the north (to The Pinch Lane). One of these waterways will require a minor realignment. Cross-drainage structures are required to accommodate small flowpaths. The total culvert opening area required in this location is about 43 m².

The waterways in the area around Mooloolah and north to The Pinch Lane are generally highly modified systems. The major waterways of South Mooloolah and Mooloolah River still maintain some remnant vegetation cover, but it is limited to a 40 metres corridor (10 – 20 metres either side of the waterway). The vegetation represents RE12.3.1 (riparian rainforest). Smaller waterways generally contain less vegetation (i.e. a 10 m strip or scattered trees) with a high density of weeds. The integrity of the banks of the major waterways is reasonable and erosion is limited to small areas of disturbance. The condition of the banks along minor waterways is generally poor. The South Mooloolah and Mooloolah Rivers are known to support significant fauna species, including the Giant Barred Frog (*Mixophyes iteratus*).

Eudlo Creek

The size of the Eudlo Creek catchment is approximately 25.7 km^2 at the crossing of the project. Due to the geometry of the floodplains, the lateral spread of the 100 year ARI design flood is significant. Assuming that the entire floodway should be bridged to avoid upstream negative impacts, the length of bridge is approximately 600 metres to the south of the station and 210 metres to the north of the Eudlo station.

In addition to the major bridges, between 10 and 13 cross-drainage structures are required to accommodate small flowpaths. The total culvert opening area required in this location is about 35 m^2.

The waterways in the area around Eudlo are generally highly modified systems until the rail reaches Eudlo Creek National Park. Eudlo Creek itself is largely devoid of remnant vegetation. In its original form the creek would have represented RE12.3.2 with intermittent patches of RE12.3.1, but current habitat values of this section of Eudlo Creek are limited. Smaller waterways are in a similar condition, with the exception of those in Eudlo Creek National Park. The integrity of the banks of the major and minor waterways that are not vegetated is generally poor and in most areas the banks have visible signs of erosion and collapse. The aquatic habitat values in this area are limited to those areas in the national park.

Paynter Creek

The size of the Paynter Creek catchment is approximately 34.7 km^2 at the crossing of the project. Due to the geometry of the floodplains, the lateral spread of the 100 year ARI design flood is significant. Assuming that the entire floodway should be bridged to avoid upstream negative impacts, the length of the bridge is approximately 800 metres north of the Palmwoods station with an additional 250 metres on the eastern bank of Paynter Creek (near Taintons Road) to the south of Woombye station. Another small bridge exists just to the north of Woombye station, which is 100 metres long.

In addition to the major bridges, between two and three cross-drainage structures are required to accommodate small flow paths. The total culvert opening area required in this location is approximately 40 m^2.

The waterways in the area around Palmwoods to Woombye are generally highly modified systems. The major waterway of Paynter Creek still maintains some remnant vegetation cover, but it is limited to a 40 metres corridor (10 – 20 metres either side of the waterway). The vegetation represents RE12.3.2 (Flooded Gum alluvial forest) with intermittent patches of RE12.3.1 (riparian rainforest). Smaller waterways generally contain less vegetation (i.e. a 10 m strip or scattered trees) with a high density of weeds. The integrity of the banks of the major waterways is reasonable and erosion is limited to small areas of disturbance. The condition of the banks along minor waterways is generally poor. The creek is noted to support a high number of native fish and Platypus (*Ornithorhynchus anatinus*).

Petrie Creek

The project runs parallel to Petrie Creek for approximately 2.8 km. The project encroaches in the Petrie Creek floodplain. The rail will be a conglomeration of structure and embankment, to ensure the continuation of overall conveyance as well as lateral flow transfers. The sections of the project crossing the 100 year ARI predicted flood areas will be bridged. The cumulative length of bridge is approximately 360 metres.

In addition to the major bridges approximately ten cross-drainage structures are required to accommodate small flowpaths. The total culvert opening area required in this location is approximately 45 m^2.

The waterways in the area around Nambour are generally highly modified systems. Petrie Creek itself is a mix of remnant vegetation and non-remnant vegetation dominated by weeds. In its original form the creek would have represented RE12.3.2 with intermittent patches of RE12.3.1, but current habitat values of this section of Petrie Creek are limited to areas still supporting vegetation.

Smaller waterways are in a similar condition. The integrity of the banks of the major and minor waterways that are not vegetated is generally poor and in most areas the banks have visible signs of erosion and collapse. The habitat value at this site is limited, but the creek has high value as a local wildlife movement corridor given that the majority of the creek line is vegetated to some extent.

14.3.2 Groundwater

A total of 78 registered groundwater bores have been indentified with all bores classified as sub-artesian. The spatial distribution of bores identified in the Department of Environment and Resource Management database (**Figure 14.3a**) is likely the result of:

- potential for groundwater supply from the aquifer
- population density and properties
- land use.

Of the bores identified, 17 are abandoned and destroyed and though 61 are existing, the Department of Environment and Resource Management database provides information for only 48 of them (**Table 14.3.2a**). At present, no accurate groundwater level data is available for most of the alignment. However, the review of aerial photography notes ponding water at various locations at an elevation of 30 – 35 metres AHD. The groundwater table is also likely to rise with topography and will be variable on a seasonal basis. Perched water is likely to be encountered at higher elevations, particularly during the winter months.

The presence of groundwater bores in the project area indicates the importance of the groundwater resources to the local community. Areas of groundwater are also important from a biological diversity perspective. Groundwater Dependent Ecosystems (GDE) take into account ecosystems that rely on groundwater to exist, and can potentially include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps.

The level of groundwater dependence of these systems varies from complete reliance to partial reliance during certain periods. For example, a vegetation community may rely on underlying groundwater resources during periods of drought. The degree and nature of dependency will influence the extent to which the GDEs are affected by changes to the groundwater system. Changes to the groundwater system that may induce impacts on GDEs are often related to flow / flux (rate and volume of water supply), groundwater level, pressure (the potentiometric head of the aquifer and its expression in groundwater discharge areas) and groundwater quality. The response of ecosystems to change in these attributes is variable. There may be a threshold response in some cases, whereby an ecosystem collapses completely if conditions change to a critical level.

Detailed hydrological studies are required to determine the full extent of the interaction between the groundwater, GDEs and surface water systems, especially in terms of identifying discharge and recharge areas. Recharge zones are typically at higher altitudes but can occur wherever water enters an aquifer, such as from rain, river and reservoir leakage, or from irrigation. Discharge zones can occur anywhere; discharge occurs not only in springs and in wetlands at low altitude, but also from bores and high-altitude springs. Hence recharge zones in the project area are likely to be located on the ridgelines to the south and north of Mooloolah (near Rose Road and The Pinch Lane). The project is known to traverse a small area of wetland (RE12.3.5) to the north of Palmwoods. This area is likely to be a groundwater discharge location. It is anticipated that groundwater relating to alluvium areas will have a greater extent of interaction with surface waters due to the higher permeability of the aquifer.

Table 14.3.2a: Groundwater facilities in the project area

Facility	GDA94 Coordinates		Date Drilled
Number	Easting	Northing	
117674	497816	7053868	22/03/2004
117789	495549	7051560	22/02/2004
117791	495190	7051190	24/02/2004
121079	498286	7049991	16/04/2004
121082	495442	7043407	16/04/2004
121086	498231	7053406	19/04/2004
121093	496491	7046668	19/04/2004
121117	496382	7041315	21/04/2004
121131	497928	7045130	22/04/2004
121132	496133	7041500	22/04/2004
121135	497016	7047099	22/04/2004
121163	498287	7046576	27/04/2004
121175	496020	7049314	28/04/2004
121176	496133	7041438	28/04/2004
121236	494808	7040638	6/05/2004
121238	494808	7040822	6/05/2004
121635	494808	7040853	25/08/2004
121664	496354	7041407	31/08/2004
121667	498177	7043838	31/08/2004
121709	497762	7044023	13/09/2004
121751	495356	7051067	28/09/2004
121861	494946	7040792	22/10/2004
121862	495439	7050114	25/10/2004
121864	494665	7050298	25/10/2004
121870	498037	7051130	26/10/2004
127009	495073	7041111	6/01/2005
127010	495166	7040658	6/01/2005
127014	494726	7040280	6/01/2005
127015	495891	7051129	6/01/2005
127059	497169	7036708	28/01/2005
127165	498296	7046318	2/03/2005
127296	494718	7048960	22/03/2005
127299	496081	7045369	23/03/2005
127301	497993	7040260	23/03/2005
127530	497223	7045511	17/08/2005

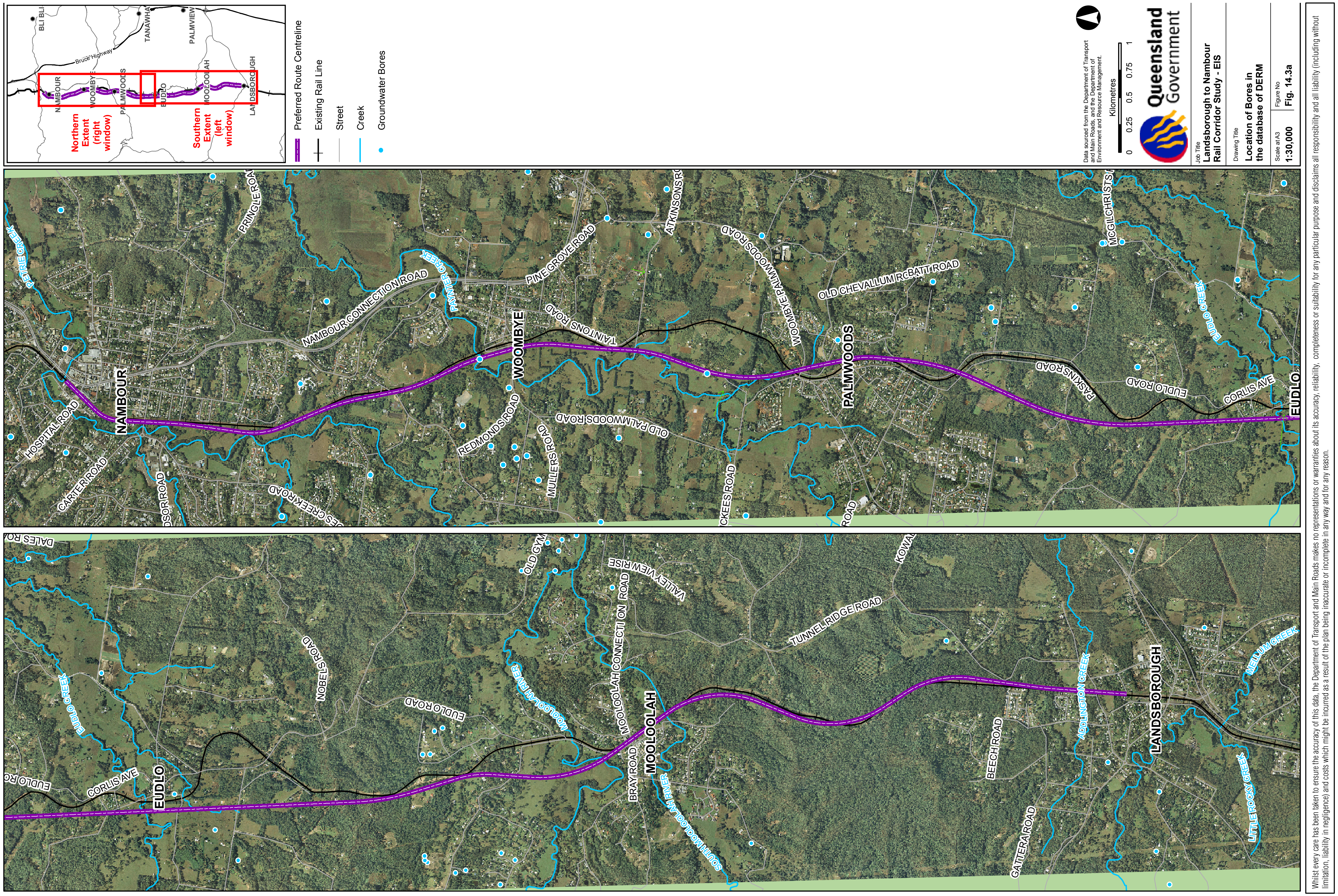

Figure 14.3a: Location of Bores in NRW Database

Table 14.3.2a: continued

Facility	GDA94 Coordinates		Date Drilled
Number	Easting	Northing	
127557	497212	7045691	1/09/2005
127566	496877	7044450	12/09/2005
127635	495050	7041206	4/11/2005
127650	496861	7047245	24/11/2005
127705	495230	7040785	28/02/2006
127725	494613	7041024	14/03/2006
127785	498067	7040362	19/04/2006
135133	498177	7040792	12/09/2006
135179	495164	7043198	29/09/2006
135259	497706	7049684	15/11/2006
135281	496620	7046710	18/12/2006
135411	495146	7041462	16/03/2007
135428	496626	7045942	19/03/2007

Groundwater quality

The ANZECC guidelines stipulate beneficial use classifications for groundwater resources. The beneficial use classification follows five broad categories:

- ecosystem protection
- recreation and aesthetics
- raw water for drinking water supply
- agricultural water
- industrial water.

The beneficial use category for groundwater in the project area has been determined based on a review of hydrogeological data, land use data and current groundwater usage as agricultural water. This indicates that the majority of groundwater drawn from the aquifer is used for irrigation for agricultural purposes. No groundwater quality sampling was undertaken for the project, hence, no comparison with ANZECC guidelines is made.

Based on GWDB analysis and geological setting of the area, groundwater seems to occur within two aquifer units: Sandstone basement rocks and tertiary and quaternary alluvial sediments.

Basement rock aquifers

Landsborough sandstone (RJl) and Nambour formation (RBJw) geological units can be associated within a single hydrogeological unit called the basement rock aquifer. Both geological units are mainly composed of sandstone, shale and siltstone, hence their hydrogeological properties are similar. The basement rock is overlaid by clay deposit conferring a confined condition to the aquifer. The thickness of the clay varies from 1 to 18 meters providing a protective layer to the aquifer. This generally acts to reduce the exposure of the groundwater to pollution. According to the information available, the basement rock could contain fractures but their density and frequency are not recorded in the GWDB.

Generally a fractured zone will provide a high water yield, conversely this zone is more sensitive regarding pollutant exposure and groundwater level decrease during disturbance. On the whole, this aquifer seems to be the most productive in this area with a total of 42 bore facilities identified as having sandstone basement rock (**Table 14.3.2b**).

Tertiary and quaternary alluvial sediments

The tertiary and quaternary alluvial sediments (Qa) called alluvium are composed of clay, silt and flood plain deposits. This type of aquifer is associated with the main rivers encountered within the project area and their tributaries. The distribution of permeable aquifers is related to the geomorphological characteristics and the proportion of permeable material composing the aquifer. According to the GWDB, the alluvium seems to contain a large proportion of clay conferring to this aquifer a low permeability but it is not confined. This permeability can result in exposure of the groundwater to pollutants. Only two bores have been identified within this aquifer (**Table 14.3.2b**). This may result from:

- poor aquifer quality due to relation with surface water and different pollutant exposure (e.g. agricultural practice)
- low yield due to the large clay composition.

Some information regarding groundwater quality is also provided by GWDB. A 'potable' groundwater supply indicates that the bore facility can be used for drinking water. Although the use of the water cannot be confirmed, it can be noted that the groundwater quality in the locality is good and could be used for the consumption of local residents. Although the groundwater is potable and suitable for residential purposes, it is mainly used for agriculture.

Table 14.3.2b: Groundwater occurrence and quality within the project area

Facility Number	Target Aquifer	Groundwater Quality
117674	Basalt	-
117789	Basement Rock	Potable
117791	Basement Rock	Potable
121079	Basement Rock	-
121082	Basement Rock	-
121086	Basalt	-
121093	Basement Rock	-
121117	Basalt	-
121131	Basement Rock	-
121132	Basement Rock	-

Table 14.3.2b: continued

Facility Number	Target Aquifer	Groundwater Quality
121135	Basement Rock	-
121163	Basement Rock	-
121175	Basement Rock	Potable
121176	Basement Rock	Potable
121236	Basement Rock	-
121238	Basement Rock	-
121635	Basement Rock	Potable
121664	Basement Rock	Potable
121667	Basement Rock	Potable
121709	Basement Rock	Potable
121751	Basement Rock	-
121861	Alluvium	Potable
121862	Basement Rock	Potable
121864	Basement Rock	Potable
121870	Basement Rock	-
127009	Basement Rock	Potable
127010	Basement Rock	Potable
127014	Basement Rock	-
127015	Basement Rock	Potable
127059	Basement Rock	-
127165	Basement Rock	Potable
127296	Basement Rock	Potable
127299	Basement Rock	-
127301	Basement Rock	Potable
127530	Basement Rock	-
127557	Basement Rock	Potable
127566	Alluvium	Potable
127635	Basement Rock	Potable
127650	Basement Rock	-
127705	Basement Rock	-
127725	Basement Rock	Potable
127785	Basement Rock	-
135133	Basement Rock	-
135179	Basement Rock	-
135259	Basement Rock	-
135281	Basement Rock	-
135411	Basement Rock	-
135428	Basement Rock	-

(-) Data unavailable

Groundwater levels and yields

Broad trends in groundwater levels and yield for the two aquifers can be interpreted based on the results of the GWDB as follows. **Figures 14.3b** and **14.3c** show the depth and yields of the bores known in the project area.

Basement rock aquifers

Depth to groundwater within the basement rock varies spatially across the project area from 48 to 2 meters below ground level (mbgl) with an average of 8 mbgl (**Table 14.3.2c**). Being confined, the groundwater level is above the top of the aquifer. No monitoring results are known at this stage of the study which means that no hydrographs are available to assess seasonal variation in groundwater levels. It is also not possible to determine flow directions as water level contours are not available.

In order to assess fluctuations in water levels responding to a rainfall event, groundwater level monitoring is recommended. Groundwater yields in the basement rock are generally low ranging from 0.06 to 4.55 L/s with an average of 0.98 L/s (**Table 14.3.2c**). Variations to this rate may relate to changes in permeability associated with geological structures. It is not possible to comment on the sustainability of the current uses of the aquifer without having historical data regarding groundwater levels and groundwater quality.

Tertiary and quaternary alluvial sediments

Only two data points are available regarding the alluvium groundwater. The depth to groundwater is relatively shallow, 3 and 5 mbgl (**Table 14.3.2c**). No monitoring results are known at this stage of the study. It is also not possible to determine flow directions as water level contours are not available. Though this aquifer seems to be less used by the population than the sandstone formation, it is recommended to carry out groundwater level monitoring in order to assess fluctuations in water levels after a rainfall event. Recorded groundwater yields in the alluvium are 0.32 and 0.44 L/s (**Table 14.3.2c**). It is not possible to comment on the sustainability of the current uses of the aquifer without having historical data regarding groundwater levels and groundwater quality.

Table 14.3.2c: Groundwater levels and yields within the project area

Facility Number	Target Aquifer	SWL (mbgl)	Groundwater RL (mAHD)	Yield L/s
117674	Basalt	-20	3	-
117789	Basement Rock	-6	31	0.5
117791	Basement Rock	-10	12	0.15
121079	Basement Rock	-5	33	1.11
121082	Basement Rock	-3	23	3
121086	Basalt	-	-	0.2
121093	Basement Rock	-20	11	0.3
121117	Basalt	-	-	0.22
121131	Basement Rock	-	-	3
121132	Basement Rock	-4	33	1.5
121135	Basement Rock	-25	-6	0.06
121163	Basement Rock	-9	6	2.53
121175	Basement Rock	-	-	0.13
121176	Basement Rock	-	-	0.13
121236	Basement Rock	-6	35	0.43
121238	Basement Rock	-2	44	0.61
121635	Basement Rock	-2	45	1
121664	Basement Rock	-17	25	0.45
121667	Basement Rock	-	-	4.55
121709	Basement Rock	-5	26	1.35
121751	Basement Rock	-3	23	0.8
121861	Alluvium	-5	38	0.32
121862	Basement Rock	-14	12	0.45
121864	Basement Rock	-48	20	0.26
121870	Basement Rock	-2	68	1.17
127009	Basement Rock	-4	40	0.55
127010	Basement Rock	-2	37	0.66
127014	Basement Rock	-20	23	0.27
127015	Basement Rock	-3	16	1
127059	Basement Rock	-2	28	1.25
127165	Basement Rock	-5	10	0.75
127296	Basement Rock	-3	21	0.3
127299	Basement Rock	-5	17	1.5
127301	Basement Rock	-3	25	0.7

Table 14.3.2c: continued

Facility Number	Target Aquifer	SWL (mbgl)	Groundwater RL (mAHD)	Yield L/s
127530	Basement Rock	-4	20	1.35
127557	Basement Rock	-4	24	1.48
127566	Alluvium	-3.03	17.97	0.44
127635	Basement Rock	-7	50	0.43
127650	Basement Rock	-15.5	11.5	0.22
127705	Basement Rock	-2	37	1
127725	Basement Rock	-7	46	0.43
127785	Basement Rock	-3	25	1
135133	Basement Rock	-2	30	0.6
135179	Basement Rock	-15	26	0.43
135259	Basement Rock	-2	38	2
135281	Basement Rock	-5.5	18.5	1.26
135411	Basement Rock	-20	27	0.4
135428	Basement Rock	-9	11	0.4

(-) Data unavailable

14.4 Information provided by the community

Throughout the project, there has been on-going community consultation. Details of activities and information releases are discussed in **Chapter 1, Introduction, Section 1.9**. Issues raised through feedback on the Route Identification Report and in the 'Township Options' consultation are captured in **Table 14.4.**

Table 14.4: Issues raised during community consultation

Issues Raised	Response	Section
Flooding concerns in Eudlo, Mooloolah, Palmwoods, Woombye	The design of the project has taken into consideration flood levels up to ARI100. Areas where the rail passes over floodplains will be built on structure (i.e. Mooloolah River, Eudlo Creek and Paynter Creek). In other areas culverts will be used to facilitate the flow of water through the project area.	**Chapter 14, Section 14.5.2**
Retention of riparian vegetation, particularly Paynter Creek	The importance of riparian vegetation in maintaining water quality and habitat values has been recognised. Bridges have been included in the design of the project to traverse major waterways in the project area. The height of these bridges varies and therefore the extent of vegetation retained under the bridges varies, but generally encompasses groundcover and shrub species. The bridge from Palmwoods north approx. 800 m ranges from 8 to 14 m high. The second bridge at Paynter Creek will be located to the east of the creek and crosses a small tributary. It may necessitate some clearing on the eastern bank. In this location the retention of small shrubs and groundcover will be possible as the bridge is 2 – 2.8 m high. Weed management will need to be ongoing in these areas.	**Chapter 13 Section 13.5.1, Chapter 14 Section 14.5.1 and Chapter 21 Section 21.14**
Flood resilience of roads and flood access, particularly Neill Rd at Mooloolah	The aim of the project has been to improve or at least not worsen the current flooding situation. New or redirected roads will be designed to satisfy current requirements for flooding for the level of road hierarchy.	Chapter 21 Section 21.7

14.5 Assessment of potential impacts and mitigation measures

This assessment of impacts aims to address the water resource values described in **Section 14.3** 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 14.1.3**). 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 water resources, this policy specifically encompasses surface and groundwater water quality.

The project crosses six major waterways and numerous minor streams and/or ephemeral drainages, and is located in close proximity to a considerable length of Petrie Creek. Construction 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 preferred route for 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 follows 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 **Chapter 13, Nature conservation: Aquatic biology, Table 13.5.**

Key potential project threats from a water resources 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 integrity, as well as to water quality. Potential impacting processes to surface water and groundwater resources primarily result from the construction of the project and the decommissioning of the existing railway, as follows:

- vegetation clearing and channel disturbance
- surface water quality modifications
- groundwater quality modifications
- reduction in groundwater resources
- alteration in surface water flows.

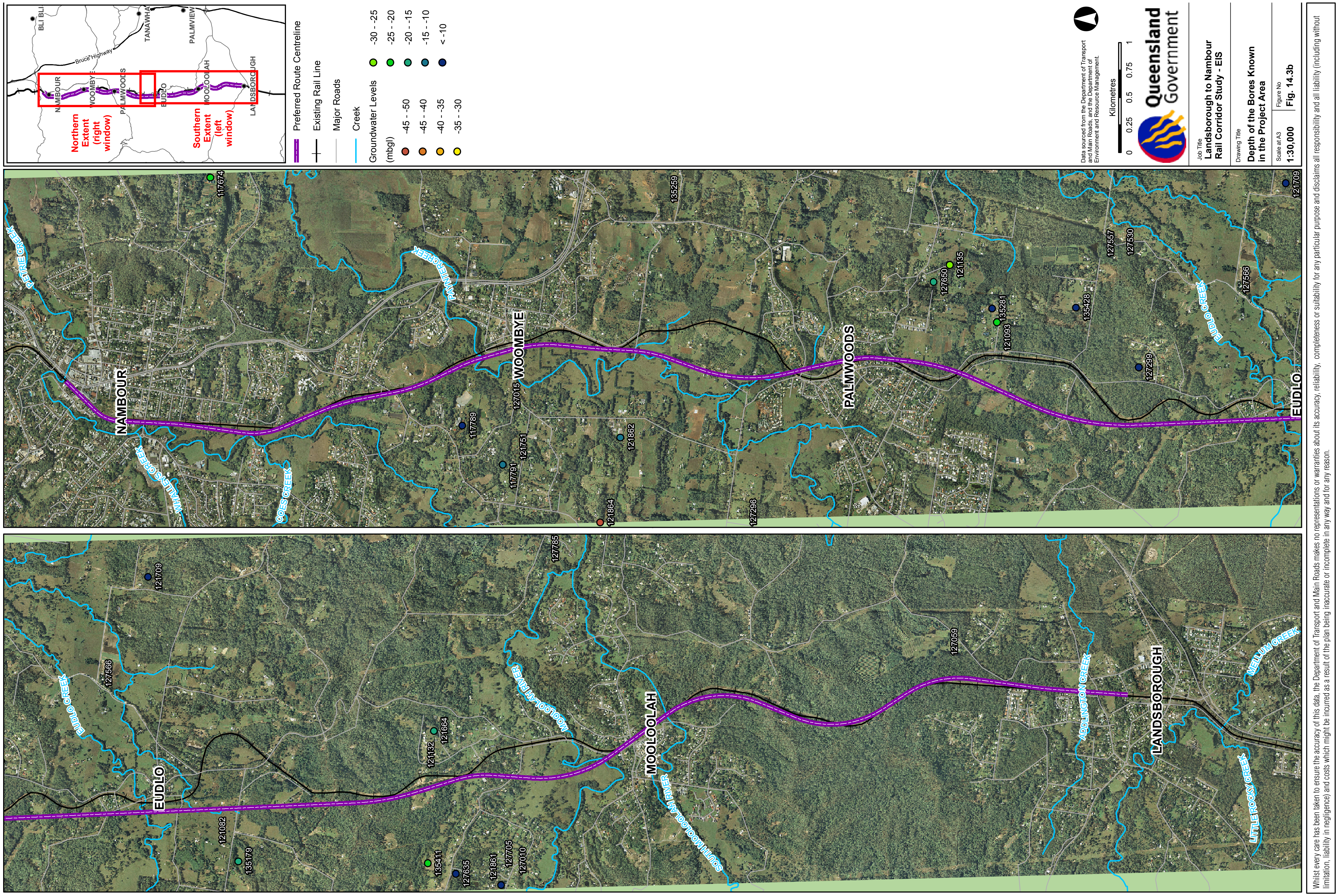

Figure 14.3b: Depth of Bores Known in the project area

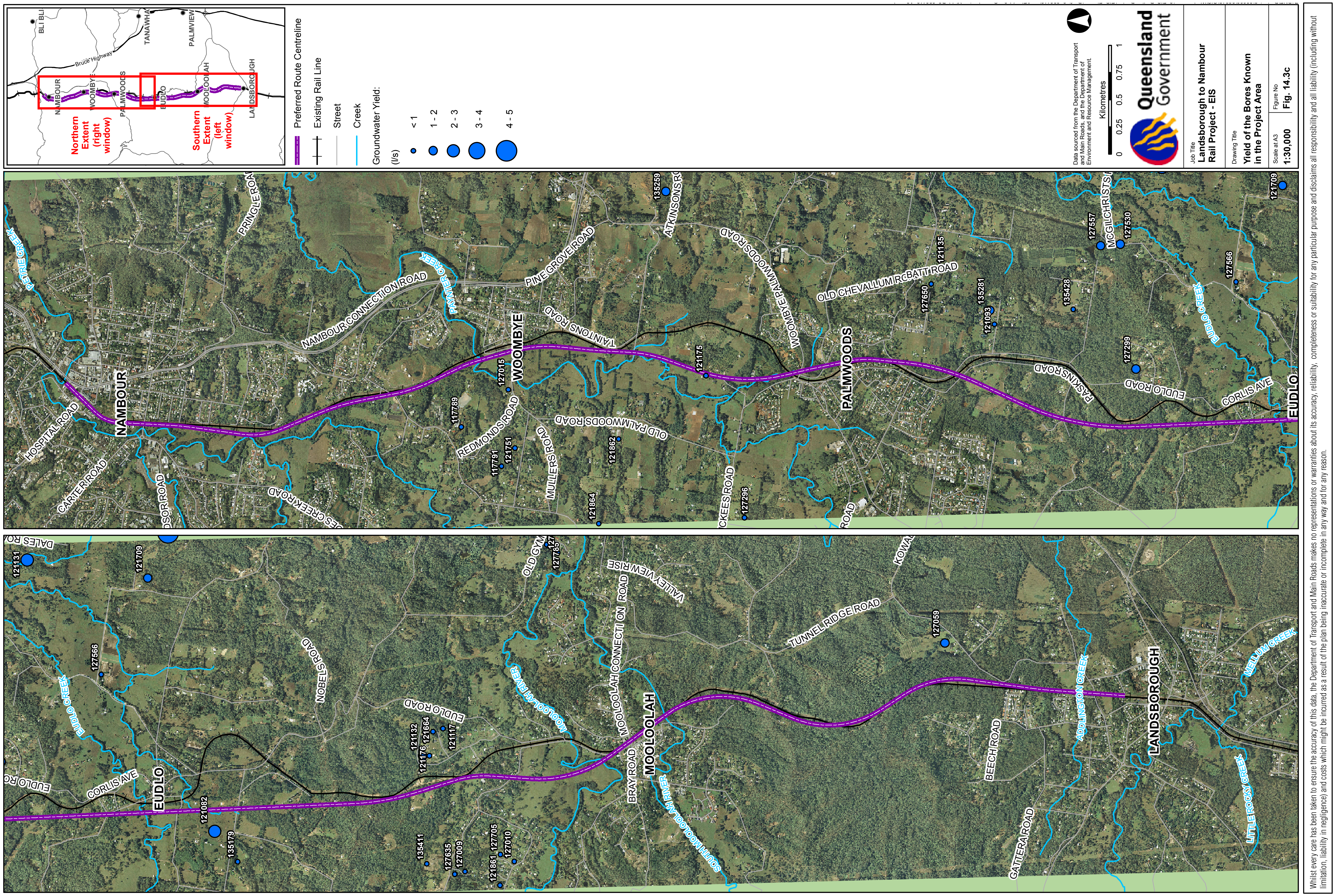

Figure 14.3c: Yield of the Bores Known in the Study project area

14.5.1 Vegetation clearing and channel disturbance

Potential impact

Riparian vegetation is an important component to maintaining good water quality and therefore preserving the health of the aquatic ecosystem. Riparian vegetation is known to reduce stream velocities, maintain the stability of the banks, prevent erosion and sedimentation, filter pollutants from stormwater runoff, lower water temperatures, lower direct light penetration which can perpetuate algal blooms and the growth of aquatic weed species and provide spawning habitat for fish communities.

Undertaking engineering works near waterways has the potential to reduce the amount of riparian vegetation or the diversity of riparian communities. As stated in **Chapter 13, Aquatic biology**, approximately 5.23 ha of riparian vegetation will be removed. If this impact is not appropriately managed the follow on water quality impacts could have wide reaching effects on the catchments that are experiencing the reduced vegetation coverage. While some disturbance or removal of riparian vegetation is inevitable, rehabilitation and revegetation strategies can be adopted to ensure that the overall impact on water quality can be considerably reduced.

Construction phase impacts

Construction activities are likely to have the greatest impact on riparian vegetation. This impact to riparian vegetation communities can be both direct and indirect.

Direct impacts include the direct removal of riparian vegetation and as stated this could comprise up to 5.23 ha of riparian vegetation. This value may be exceeded in reality, given that the construction of the rail link will require access and construction corridors to over 50 waterway crossings for the project. Establishing access tracks and safe working conditions are likely to impact riparian vegetation communities.

The follow on impact from the loss of vegetation is both local and far reaching. The local effect is likely to be deterioration in water quality due to the increased sediment runoff resulting from erosion. Another impact on riparian vegetation communities could be from the increased potential for the spread of exotic weed species which could be transferred from other areas in which the construction vehicles operate.

Operational phase impacts

During the operational phase, the impact to riparian vegetation is likely to be minimal. Operation of the rail track will require some maintenance activities that have the potential to indirectly affect riparian vegetation communities by increasing the risk of spills and accidents. Similarly to the construction impacts, there is the risk of spread of exotic vegetation that could undermine the quality of riparian vegetation communities.

Decommissioning of existing railway phase impacts

Decommissioning of the existing railway has activities associated with it that may be similar in effect to the construction stage given that machinery will be required to remove existing crossings.

Proposed mitigation

Design

Ecological data on riparian vegetation 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 preliminary 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.
- 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:

- undertaking of in-channel works 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 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**) to be put in place prior to commencement of construction
- construction personnel not to release sediment, debris or material into the stream or stream channel
- restoration of the worksite after the completion of works and replanting vegetation in areas not required for the operational phase, which would be a beneficial impact to the long term stability of stream banks
- monitoring and controlling the encroachment of weeds in areas where vegetation has been removed
- reporting any environmental incident that results in physio-chemical changes to water quality of physical habitat structure of riparian, littoral and in-stream environment
- following a reportable incident, the restoration and repair of the habitat to its natural state or as directed by the regulatory authority.

A specific section on aquatic habitat management has been included in the EMP 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 VM Act 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 to replace areas of remnant regional ecosystems removed by the proposed railway development

Offsets will be in line with the *Policy for Vegetation Management Offsets* of the Department of Environment and Resource Management, which is triggered under the *Vegetation Management Act 1999*. Refer to **Section 11.6** for more information regarding offset requirements. The extent of offsets and offset areas will be defined 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 should 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
- management of areas under bridges, including replanting and on-going weed management
- 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 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 it is considered that vegetation clearing and other physical disturbances will result in impacts of **low adverse** significance.

14.5.2 Surface water quality modifications

Potential impact

There is a potential for impacts to water quality of water resources during the project 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 (riparian vegetation removal is discussed in **Section 14.5.1**)
- the release of toxicants (oils, greases and other chemicals) by machinery or the failure to adhere to EMP measures.

Construction phase impacts

A key impact during the construction phase is the potential for increased sediment runoff resulting from disturbance to soil and vegetation near waterways. Construction activities are expected to be relatively invasive involving excavation works and disturbance to stream beds. Impacts would be an increase in suspended sediments and toxicants, however, they could be of longer duration and include greater volumes of material, if serious destabilisation occurs. Waterways along this section of the rail corridor already exhibit evidence of some erosion, so it will be important to minimise further unnecessary disturbance to banks.

Excavation activities may result in the disturbance and exposure of Acid sulfate soils (ASS) which can then impact on water quality. Alluvial plains associated with Petrie Creek and Paytner Creek are designated ASS risk zones, but further testing needs to be undertaken to determine their presence and extent. Effects of ASS disturbance include:

- damage or death of aquatic fauna and flora
- a long-term change in aquatic plant communities and their composition
- the release of iron, aluminium and heavy metals into surface water, which reduces water quality
- health impacts for humans caused by drinking or bathing in water
- damage to infrastructure which is subject to corrosion from acidic water
- slumping of structures built on material containing ASS, as this soil type generally has a low-bearing capacity.

Construction of the project will require substantial quantities of water for dust suppression (not quantifiable at present), landscaping, surface stabilisation or compaction purposes. Due to the lack of town water supply for some of the rail corridor, supply for construction purposes is likely to be sought from non-potable sources such as existing waterways, private dams or quarry/extraction sites. Water from non-potable sources may have poor water quality, and if run-off from the construction site occurs at a high velocity, it may contribute to lowering water quality in the catchment.

Operational phase impacts

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.

Decommissioning of existing railway phase impacts

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 14.5.1**, 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 bioretention basin 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).
- Detailed design should identify areas that may require additional scour protection during construction. This may include the use of rock, jute matting or similar.

- Further geological investigations, including acid sulfate soils (ASS), shall be undertaken prior to detailed design and dealt with appropriately with regards to management of erosion prone areas and ASS areas.
- Detailed hydrological investigations are required to determine the size and location of stormwater management devices.

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 to follow the natural contour of the terrain, where possible and avoid steep slopes, wet or rocky areas and highly erosive soils
- access ways to be delineated with sediment and erosion control fencing and incorporate earthen bunds every 5 – 10 metres where slope is an issue
- silt fences to 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 to protect against unexpected erosion and a mobile spill kit to be available on site
- catch-drains 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 to be avoided during wet weather
- construction activities to be conducted in a manner, so as to minimise disturbance to stream banks and beds
- operation not to occur outside of construction zone
- no clearing, operation of machinery or personnel access to occur within 3 metres of the high bank of the waterway
- re-fuelling of machinery not to be undertaken less than 30 metres from the waterway and fuel to be stored at least 50 metres from the waterway
- topsoil stripped from the site to 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.) to be implemented and maintained to ensure potential contaminants are prevented from surface or subsurface leakage from the construction site
- water leaving the work sites to be monitored and to be of similar quality to that of the receiving waters and efforts to be made to ensure contaminants do not leave the site
- stockpiles 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 to be cleaned up
- earthen bunds or sediment fences to delineate the toe of any stockpiles
- earthen bunds or sediment fences to delineate the boundary of any temporary unsealed roads constructed to deal with traffic movement (construction or public)
- construction staff to be trained in emergency response measures
- construction staff to be trained in appropriate waste management (Waste Management Plan, **Chapter 22, Environmental management plans**) to prevent litter entering waterways
- rehabilitation of areas required for construction but not required during operation to be undertaken as soon as possible.

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. Corrosion of materials within the rail corridor (e.g. the rails themselves or steal reinforcements that may be used on sleepers) may also contribute to toxic leachate. 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 the following mitigation measures:

- the condition of the rail and all associated stormwater management devices to be monitored regularly
- the rail to be maintained as necessary, i.e. corroding sleepers and track replaced

- the stormwater management devices to be maintained as required including replacement of filter medium and weed management in bioretention basins
- monitoring of quality of water exiting stormwater management devices
- 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 of all major waterways affected by the project
- 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 be **negligible** to **low adverse**.

Overall the impact on water resources is expected to be low and largely restricted to the construction phase of the project. Hence, the users of surface water resources may experience a temporary decline in water quality (mainly due to sedimentation) but this impact will be managed so as not to be ongoing.

14.5.3 Groundwater quality modifications

Potential impact

Earthworks activities which cause a decrease in water level beneath areas with ASS have the potential to cause sulfide minerals in the soil. These kinds of minerals oxidise and infiltrate acidity, arsenic and metals into groundwater. This may lead to the situation where groundwater beneath new urban developments becomes unsuitable for irrigation or other uses (*Guidance for groundwater management in urban areas on acid sulfate soils*). Additionally, the discharge of acidic contaminated groundwater in the vicinity of wetlands or waterways can affect aquatic ecosystems and may make these water features unsuitable for recreational use.

The impact associated with spill or leaching of contaminants (fuel or liquid chemicals) resulting from servicing of equipment depends of the geological setting of the exposed area. According to the Department of Environment and Resource Management database, most of bore logs identified a clay deposit within the first ground meters of the project area. A clay layer acts as an impermeable barrier, capturing any contaminants and preventing leakage into groundwater. On the other hand, the railway design can also cross alluvium that is more sensitive to contaminant exposure. If a spill occurs where there is interaction with this aquifer, groundwater quality may be reduced. The impact to groundwater quality is likely to be localized and temporary if management strategies are adopted. However, the likelihood of disturbance with groundwater is considered unlikely due to the large expansive clay layer within the project area.

The project is located in the vicinity of two known bores situated at Palmwoods and Woombye. The borehole at Palmwoods is identified as Facility Number 121175. It is associated with basement rock and is potable. It has a very low yield of 0.13L / s. The bore is utilised by an agricultural property on Spackman Lane, Palmwoods. The project will traverse the bore on embankment. It is likely that the extraction point will need to be shifted prior to construction of the rail. There is no data associated with the bore to the north of Woombye station. The bore appears to be associated with Paynter Creek and is located under a structure. It is assumed that this water extraction exercise will be able to continue to operate, post-construction. Water quality may be affected during the construction phase.

Decommissioning of the existing railway will likely involve dismantling and removing the railway track, including sleepers, rail, overhead wiring and signalling equipment. Then the ballast will be levelled and bridges that are not likely to be used for other purposes will be removed. Buried cable will likely remain in the ground. There may be possible impacts to groundwater from degradation of the remaining structure. The risk of groundwater contamination is reduced by the presence of clay layer acting as confining barrier. However, it is important to note that if the contaminant concentration increases over the time, it may become harmful.

Proposed mitigation

Design

The ANZECC guidelines stipulate that the proponent of an activity likely to impact a groundwater resource will be responsible for maintaining the resource at or above its beneficial use classification. For the project area, the beneficial use classification is 'agricultural water'. Mitigation measures associated with potential impacts regarding the construction, the operation and the decommissioning of the railway project are presented in the following section. 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).
- Further geological investigations, including ASS shall be undertaken prior to detailed design and dealt with appropriately with regards to management of alluvium areas and ASS areas.
- Detailed hydrological investigations are required to determine the location of high risk areas in terms of impacts to groundwater quality.

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:

- sensitive areas where groundwater is close to the surface, i.e. discharge or recharge areas to be excluded from the construction zone as far as possible
- relocation of groundwater extraction points where appropriate, e.g. Spackman Lane, Palmwoods
- site access to follow the natural contour of the terrain, where possible; avoid steep slopes, wet or rocky areas and highly erosive soils
- access ways to be delineated with sediment and erosion control fencing and incorporate earthen bunds every 5 – 10 metres where slope is an issue
- catch-drains to be used to intercept and divert run-off around the area of impact
- groundwater quality to be determined before works commence to enable establishment of baseline data.

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 to be avoided during wet weather
- operation not to occur outside of construction zone
- re-fuelling of machinery not to be undertaken less than 30 metres from discharge / recharge areas and fuel to be stored at least 50 metres from discharge / recharge areas
- control measures for the storage and handling of chemicals (e.g. fuels, oils etc.) to be implemented and maintained to ensure potential contaminants are prevented from surface or subsurface leakage from the construction site
- water leaving the work sites to be monitored and to be of similar quality to that of the receiving waters and efforts to be made to ensure contaminants do not leave the site
- construction staff to be trained in emergency response measures
- rehabilitation of areas required for construction but not required during operation to be undertaken as soon as possible
- monitoring of groundwater quality, such that changes that are recognised can be mitigated.

Operational impacts

Once the rail has been constructed, the risk to groundwater quality will be decreased. The area of disturbed land will be reduced, so that there is less chance of disruption to aquifers. 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. Corrosion of materials within the rail corridor (e.g. the rails themselves or steal reinforcements that may be used on sleepers) may also contribute to toxic leachate. 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 the following mitigation measures:

- the condition of the rail and all associated stormwater management devices to be monitored regularly
- the rail to be maintained as necessary, i.e. corroding sleepers and track replaced
- the stormwater management devices will be maintained as required including replacement of filter medium and weed management in bioretention basins
- monitoring of quality of water exiting stormwater management devices

- correct use of herbicides as described in the Weed Management Plan in the EMP (**Chapter 22, Environmental management plans**)
- regular water quality monitoring of all major aquifers affected by the project
- 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 further away from the disturbance area. They may, however have highly localised impacts in sensitive areas affected by alluvium aquifers. Through the implementation of the mitigation methods, most groundwater quality modifications associated with ASS and toxicants are expected to be **negligible** to **low adverse**.

Overall the impact on water resources is expected to be low and largely restricted to the construction phase of the project. Hence, the users of surface water resources may experience a temporary decline in water quality (mainly due to sedimentation) but this impact will be managed so as not to be ongoing.

14.5.4 Reduction in groundwater resources

Potential impact

Cuttings and tunnels proposed for the project have the potential to draw down the natural ground water level. If this were to occur it would have a negative impact on abstraction from existing groundwater wells, on ground water dependant ecosystems (GDE), springs and groundwater dependent creek flows.

Water for construction purposes may be extracted from groundwater bores in the vicinity of the railway. This may result in impacts on local users and their water supply bores and environmental water requirements of groundwater dependant ecosystems (GDE). Groundwater extraction could result in lowering of the water level in supply bores impacting on water supply requirements of local users. GDE depend on groundwater availability for maintaining ecosystem features and processes. A decline in the water level attributed to groundwater extraction could impact on the continued health of these ecosystems.

Vegetation clearance will occur during the construction period. It is not anticipated that maintenance activity associated with the railway would require native vegetation removal. A gap in vegetation along the entire easement may act as a groundwater recharge corridor.

Extensive vegetation clearance has been known to facilitate increased recharge aquifers whereby the volume of rainfall infiltrating the soil is increased.

The likelihood of rising groundwater level in extreme cases may lead to development of dry land salinity. If deep rooted vegetation is removed, excess recharge can occur increasing the height of the water table. Where saline water rises within two metres of the surface, water can be taken up by plants or can evaporate through the soil. Evaporation results in the dissolved salts being left behind and concentrated as deposits at the soil surface.

Increased recharge and dry land salinity associated with vegetation removal is unlikely for the following reasons:

- The railway corridor is a long and narrow area. Any reduced and subsequent mounding in the region along the railway alignment would quickly dissipate to adjacent regions.
- Where the clay layer is prevalent, it would act as an effective aquiclude (low permeability unit), significantly limiting recharge to any underlying aquifers.
- Minimisation of vegetation removal and revegetation shall be implemented as required.

Proposed mitigation

Design

The ANZECC guidelines stipulate that the proponent of an activity likely to impact a groundwater resource will be responsible for maintaining the resource at or above its beneficial use classification. For the project area, the beneficial use classification is 'agricultural water'. Mitigation measures associated with potential impacts regarding the construction, the operation and the decommissioning of the railway project are presented below. These design measures should be carried through to detailed design:

- The design aims to minimise the removal of vegetation as far as possible.
- Further geological investigations shall be undertaken prior to detailed design and dealt with appropriately with regards to management of alluvium aquifer areas.
- Detailed hydrological investigations are required to determine the location of high risk areas in terms of impacts to groundwater draw down. The vertical alignment of the rail may be altered slightly to stay above ground water level.
- The requirement for groundwater extraction shall be avoided, however, if deemed necessary (at detailed design stage), a water permit is to be sought from the Department of Environment and Resource Management.

Construction

A range of mitigation measures are to be implemented to minimise potential impacts on groundwater levels. These measures primarily focus on the construction and decommissioning phases of the project when impacts are most likely to occur, particularly in regard to draw down on groundwater resources. 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 location of discharge / recharge areas shall be identified on the ground and measures for the impact zone shall be established. The appropriate measures for each site will change with site conditions, however, recommended mitigation measures include:

- delineation of construction zone with exclusion fencing to prevent unnecessary clearing of vegetation
- sensitive areas where groundwater is close to the surface, i.e. discharge or recharge areas to be excluded from the construction zone as far as possible
- groundwater levels to be determined before works commence to enable establishment of baseline data
- the amount of water that can be drawn out of the aquifer to be pre-determined and to represent an amount that ensures minimal impact on other users and the ecological values of the aquifer.

During construction works

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

- earthworks to be avoided during wet weather
- operation not to occur outside of construction zone
- transferring water intercepted by cuttings and recharging groundwater down slope of cuttings
- lining tunnels to prevent inflow and consequent draw down of the water table
- minimisation of groundwater use
- monitoring of groundwater levels, such that changes from baseline scenarios are recognised and can be mitigated
- warning to contractors when nearing the specified / permitted amount
- cessation of groundwater extraction once the amount specified / permitted is reached
- rehabilitation of areas required for construction but not required during operation shall be undertaken as soon as possible.

Operational impacts

Once the rail has been constructed, the risk to groundwater supply will be decreased. The area of disturbed land will be reduced, so that there is less chance of disruption to aquifers. Operational impacts from running of trains are anticipated to be minimal. The risk of operational groundwater supply impacts will be minimised through the application of the following measures:

- the condition of the rail and all associated stormwater management devices to be monitored regularly
- regular monitoring of all major aquifers affected by the project to ensure no ongoing impacts
- pruning of native vegetation to maintain access and ensure safety of rail operators as opposed to clearing.

Decommissioning of existing rail

Refer to 'construction' mitigation measures.

Residual impact

Through the implementation of the mitigation methods, most groundwater level modifications are expected to be negligible to low adverse.

14.5.5 Alteration in surface water flows

Potential impact

As the railway represents linear infrastructure, it has not been possible to avoid traversing floodplains or major waterways. The project crosses several floodplains with the most significant of these being located in the vicinity of Mooloolah River, Eudlo Creek, Paynter Creek and Petrie Creek.

The addition of civil structures in flow paths or floodways generally increases upstream water levels due to energy losses from turbulence around structure walls, increased friction from higher velocities in the structure narrow sections, and longer streamlines due to contraction and expansion effects. However, councils development policies control and limit residual impacts. The final design is a compromise between the infrastructure cost and the predicted resulting afflux, i.e. the shorter the bridge, the cheaper the solution but the higher the negative impacts upstream.

When crossing a floodplain is unavoidable, the following crossing locations can provide opportunities to improve the design:

- the upstream side of the floodplain
- perpendicular to the creek and the main floodways
- at the floodplain narrowest section
- where velocities are low
- where the upstream landuse can tolerate flood level increases.

Specifically, embankments running in the floodplain parallel to the creek and floodways should be avoided. Lateral flow transfer occurs in floodplain, and such infrastructure arrangements produce high affluxes.

There is potential for the development of rail infrastructure to interfere with existing hydrological and flooding patterns, if these areas are not considered during the design stage of the project. These impacts may be temporary or permanent. Temporary impacts could occur during the construction phase where the use of temporary stream barriers may be required to facilitate the construction of a waterway crossing. Permanent impacts would result from the placement or design of the rail, such that it essentially acts as a dam. In a worst case scenario, it may be possible for the rail structure to cause or exacerbate flooding by creating a permanent barrier to natural or existing water movement across the landscape. Conversely, there is also the potential for flood events to cause damage to the rail infrastructure.

The impacts of barriers on aquatic biology are discussed in detail in **Chapter 13, Section 13.5.3**.

Proposed mitigation

Design

It is a requirement for the project to comply with the current ARI 100 flood levels, such that it is built to withstand a flood event that may only occur every 100 years. It is also a requirement that the project does not result in worsening of existing flooding conditions. Historical hydrological and flood data collated during desktop and field based assessment was utilised to inform the preliminary design of the project. As aforementioned, due to the linear nature of the corridor, it is not possible to avoid crossing waterways and impacting floodplains, hence mitigation measures are necessary to minimise impacts on these areas. Strategies employed during the preliminary 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 has integrated a system of bridges and culverts to allow the continuation of water movement.
- Within each of the significant floodplains (Mooloolah River, Eudlo Creek, Paynter Creek and Petrie Creek), the rail has been designed to be built on structure to cater for natural water movement through these areas.
- Major waterways have been treated with bridges, where possible, to minimise interference with water movement patterns.
- 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 and the use of temporary barriers.
- The length of bridges has been calculated based on peak flows and extent of flooding during this time, such that the rail will not interfere with peak flood flows and the operation of the rail will continue.
- The number and size of culverts in any location has been calculated based on peak flows and extent of flooding during this time, such that the rail will not interfere with peak flood flows and the operation of the rail will continue.
- 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, where crossings are unavoidable.
- No major waterway shall be redirected as a result of the project. Although some smaller ephemeral drainage lines will be redirected, this occurrence has been kept to a minimum.
- The necessity for stormwater management devices to collect any excess water and treat stormwater run-off shall be investigated prior to detailed design.
- Advanced hydrological modelling shall be undertaken at the design stage to optimise the design solution. Existing models are available at the local council, and could be modified to include the proposed route geometry. The modelling exercise would also assist in confirming that the railway levels are above the design flood level criteria.

During detailed design, the dimensions of bridges and culverts will be refined to reflect the most current data available at the time. It is anticipated that further hydrological studies will be undertaken for the detailed design stage.

Construction

Hydrological impacts that may occur during the construction phase are largely a result of temporary in-stream barriers that may cause issues upstream or downstream. There is also an opportunity for the construction activities to be impacted during flood events. Mitigation measures that must be put in place to manage these impacts have been included in the EMP (**Chapter 22, Environmental management plans**). Suggested measures include:

- avoid in-stream works where possible
- the length of time that in-stream barriers are in place to be minimised by careful management of the construction process
- undertaking of in-channel works 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.

- stormwater management devices to be used during construction where necessary and to be monitored throughout the construction phase to ensure their effectiveness
- monitoring both long and short term weather forecasts during the construction period
- postpone construction work during periods of cyclones, severe storms and other extreme climatic events
- a disaster management plan and an emergency management plan should be prepared for the project construction
- restoration of the worksite after the completion of works and replanting vegetation in areas not required for the operational phase, which would be a beneficial impact to the long term stability of stream banks.

The construction phase must be overseen by an environmental officer who will monitor contractor activity for compliance with the 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 hydrological issues management issues on site.

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:

- water crossings are maintained adequately
- the natural stream flow and velocity at water crossings 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)
- stormwater management devices are monitored and maintained regularly.

Decommissioning of existing railway

Refer to 'construction' mitigation measures.

Residual impact

With the implementation of the mitigation strategies, it is considered alteration in surface water flows will result in impacts that are **negligible** or **low adverse** significance.

14.6 Summary and conclusions

The project crosses over 50 waterways many of which are perennial in nature. Potential impacts associated with the project are mostly related to construction impacts, disturbance of the ground surface near waterways and unsustainable use of groundwater resources which can be readily mitigated through good site practice and adherence to the EMP. 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 14.6**.

Taking into account the localised nature of all potential impacts to water resource values of the project area, it is considered that the overall impact of the project on water resources is of **low adverse** significance.

Table 14.6: Summary of impacts to water resources and mitigation strategies

Potential impact	Mitigation strategy	Residual impact significance
Riparian vegetation	▪ minimise riparian vegetation removal ▪ minimise works in riparian, bank or in-stream areas ▪ monitor and control weed encroachment in cleared area, or revegetate if possible.	Low adverse
Alterations to surface water quality	▪ further investigations into geology and acid sulphate soils (ASS) ▪ stormwater management devices ▪ erosion and sediment control measures are implemented ▪ stabilisation of exposed/disturbed soils ▪ manage fuel and chemical handling, storage, distribution and spill response during construction ▪ use bunded areas to store harmful substances ▪ rehabilitation of disturbed areas ▪ regular water quality monitoring.	Negligible to low adverse
Alterations to groundwater quality	▪ further investigations into geology and ASS ▪ further investigations into the location of aquifers and water quality ▪ relocation of extraction points where necessary ▪ manage fuel and chemical handling, storage, distribution and spill response during construction ▪ manage railway degradation ▪ carry out groundwater quality monitoring to detect any possible contamination.	Negligible to low adverse
Alterations of groundwater levels	▪ further investigations into geology ▪ further investigations into the location of aquifers and water levels ▪ manage groundwater usage ▪ carry out groundwater quality monitoring to detect any significant change in levels.	Negligible to low adverse
Alterations to surface water flows	▪ implementation of bridges and culverts to allow continued water movement ▪ rail on structure over flood plains ▪ rail designed to ARI100 standards ▪ minimise use of in-stream barriers during construction ▪ implementation of stormwater management devices.	Negligible to low adverse