# UPGRADING THE PACIFIC HIGHWAY

## Woolgoolga to Ballina Upgrade

## Working paper – Water Quality

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FINAL

UPGRADING THE PACIFIC HIGHWAY

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# Executive summary

This Water Quality Working Paper identifies and assesses potential water quality impacts associated with the Pacific Highway Woolgoolga to Ballina upgrade project (the project). The working paper addresses the relevant Director General's environmental assessments requirements for surface water quality for the project, and discusses the existing water quality and potential impacts of the project during construction and operation. To protect water quality on-site and downstream of the project, impact mitigation measures and environmental safeguards are recommended for the construction and operational phases.

The receiving environments in the study area that are considered to be sensitive are National Park, Marine Parks, nature reserves, state conservations areas, threatened ecological communities, key fish habitats, habitats for threatened fish such as the Oxleyan Pygmy Perch, State Environmental Planning Policy 14 wetlands, Nationally Important Wetlands, aquaculture and commercial fishing areas and the Woodburn Sands aquifer borefields, which supply drinking water to Rous Water. Of these, the regions that would result in the most significant impacts from changes to water quality are the Solitary Islands Marine Park, the Upper Coldstream Wetlands, the Tabbimoble Swamp Nature Reserve, the Rous Water regional water supply catchment, Broadwater National Park, Wardell Heath and habitats of threatened aquatic fish. These regions have been classified as high risk areas for the project.

These and other environmentally sensitive receiving environments (sensitive receiving environment) are unlikely to be affected by the project if appropriate water quality control measures are implemented during the construction and operational phases.

Acid sulfate soils are widespread in low lying parts of the study area. Acid sulfate soil management techniques would need to be adopted during construction to protect the aquatic environment.

During construction, the major risk to water quality would be erosion of soil from disturbed areas during rainfall events, causing sedimentation of waterways, and risk from spills of construction materials. Erosion and sedimentation control measures recommended for the construction phase include diversion drains, construction sedimentation basins, sediment filters, erosion controls, onsite diversion drains, progressive re-vegetation and other best practice management measures.

During the operational phase, the major risk to sensitive receiving environments is from a range of contaminants from highway runoff and accidental spills. To mitigate this risk, it has been recommended that pavement runoff be collected and treated. Proposed water quality control measures include water quality ponds, spill containment basins, and grassed swales.

The existing water quality of rivers and creeks in the study area is variable and available data needs to be supplemented by pre construction monitoring to create a reliable understanding of baseline water quality. A water quality monitoring program is recommended to effectively identify the existing water quality conditions, and the possible cause of any existing issues.

Preliminary locations have been identified and preliminary sizing undertaken for construction phase sedimentation basins and permanent water quality ponds. The methodology and design criteria are discussed in this report and a list of the preliminary proposed basins and ponds is included.

This report concludes that, with implementation of appropriate impact mitigation measures during construction and operational phases, there would be no significant impacts to waterways crossed by the project, or to high risk areas or sensitive receiving environments downstream of the project.

# 1. Introduction

## 1.1. The project

NSW Roads and Maritime Services (RMS) is seeking project approval for the Woolgoolga to Ballina Pacific Highway upgrade project (the project) which is located on the NSW North Coast. The approval is sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The project would upgrade around 155 kilometres of highway, forming a major part of the overall Pacific Highway Upgrade Program. The project would provide a four-lane divided carriageway from around five kilometres north of Woolgoolga to around six kilometres south of Ballina.

The project has been divided into eleven sections between tie-ins with the existing Pacific Highway to aid description, and the impact assessment for the project is described for each of these sections (refer to Table 1-1).

**Table 1-1 Project sections and lengths**

| Project section | Location | Station | | Length (kilometres) |
|---|---|---|---|---|
| | | Start | Finish | |
| 1 | Woolgoolga to Halfway Creek | 0 | 17.0 | 17.0 |
| 2 | Halfway Creek to Glenugie upgrade | 17.0 | 28.7 | 11.7 |
| 3 | Glenugie upgrade to Tyndale | 33.8 | 68.8 | 35.0 |
| 4 | Tyndale to Maclean | 68.8 | 82.0 | 13.2 |
| 5 | Maclean to Iluka Road, Mororo | 82.0 | 96.4 | 14.4 |
| 6 | Iluka Road to Devil's Pulpit upgrade | 96.4 | 105.6 | 9.2 |
| 7 | Devil's Pulpit upgrade to Trustums Hill | 111.1 | 126.4 | 15.3 |
| 8 | Trustums Hill to Broadwater National Park | 126.4 | 137.6 | 11.2 |
| 9 | Broadwater National Park to Richmond River | 137.6 | 145.1 | 7.5 |
| 10 | Richmond River to Coolgardie Road | 145.1 | 158.6 | 13.5 |
| 11 | Coolgardie Road to Ballina bypass | 158.6 | 164.0 | 5.4 |

While the project is for a four-lane motorway standard upgrade, the construction and opening of the project would be staged. Staging could include some sections being constructed and opened initially as a four-lane arterial standard upgrade.

The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit, which are located between Woolgoolga and Ballina, as Glenugie is now complete and Devils Pulpit is under construction. Together with the Glenugie and Devils Pulpit upgrades, the project would complete a total of 164 kilometres of upgraded highway between Woolgoolga and Ballina.

The key features of the project include:

- Around 155 kilometres of motorway standard highway, comprising a four-lane divided carriageway (two lanes in each direction) that can be upgraded to a six-lane divided carriageway in the future, if required
  - Bypasses of Grafton, South Grafton, Ulmarra, Woodburn, Broadwater and Wardell
  - Ten interchanges to provide access to and from the upgraded highway at:
  - Range Road (Corindi)
  - Glenugie (Eight Mile Lane)
  - Tyndale (Sheey's Lane)
  - Maclean (Goodwood Street)
  - Yamba Road (Harwood)
  - Watts Lane (Harwood)
  - Iluka Road (Woombah)
  - Woodburn (Trustums Hill Road)
  - Broadwater (Evans Head Road)
  - Wardell (Coolgardie Road)
- About 40 bridge crossings of waterways or floodplains, including bridges over the Clarence and Richmond rivers
- About 55 overbridge and underpasses structures to maintain access along local roads crossed by the project
- Viaducts located where the project would cross low-lying or flood-prone areas
- Service roads and access roads to maintain connections to existing local roads and properties
- Structures to help wildlife cross above or below the project including crossings for tree-dwelling mammals, dedicated culverts under the highway and over-land fauna bridges
- Rest areas located at around 50 kilometre intervals for both northbound and southbound traffic. These are located at:
  - Tucabia (north and southbound)
  - North of Mororo Road (southbound)
  - South of Old Bagotville Road (north and southbound)
  - Heavy vehicle checking station located near Halfway Creek and at the rest area south of Old Bagotville Road.

The project boundary includes the construction footprint and the permanent elements of the project for the motorway standard upgrade.

In addition to these key features, the project would include construction sedimentation basins, operational water quality basins and construction facilities such as compounds and batching plants.

Construction would be staged from 2013 onwards following project approval, depending on the availability of funding. Construction of the project would generally comprise the conventional techniques employed on most major highway projects, modified for specific environmental or engineering constraints. RMS seeks approval for construction working hours for all day (8am–5pm) on Saturdays and between 6am and 7pm on weekdays.

An indicative outline of construction activities may include:

- Establishment of the construction site and ancillary facilities
- Enabling works, including adjustments to utilities, property adjustments, works to existing drainage and provision of construction access roads
- Clearing and grubbing of vegetation, stripping of topsoil and stockpiling for re-use
- Construction of road cuttings and embankments
- Treating areas of soft soil to stabilise the underlying soil sub-layers
- Installing drainage and bridging structures
- Laying of pavement materials
- Installing pavement markings, signposting, street lighting and progressive landscaping.

The project would not be built in one phase. The project would be delivered in stages as further funding becomes available and to best manage construction and material resources. Stages would be identified that prioritise and target upgrades and works that would best deliver safety and traffic efficiency improvements, and best deliver value for money outcomes.

This working paper assesses the potential impacts of the full motorway standard upgrade for construction and operation. Where there are relevant differences between the full motorway standard upgrade and the initial upgrade to arterial standard, those impacts are also assessed. Impacts are generally identified through the eleven project sections identified above.

Further information on the description of the project and the assessment of other environmental aspects can be found in the main volume of the environmental impact statement.

## 1.2. Scope of this report

This report should be read in conjunction with Biodiversity Working Paper and the Groundwater Working Paper.

This report compiles data from previous studies to provide background information on existing conditions in the project study area relating to waterways and water bodies. It identifies those floodplains and sensitive receiving environments which could be impacted by the project. It also provides an assessment of the existing water quality in the waterways with respect to the default trigger values outlined in the *National Water Quality Management Strategy 2000* (ANZECC/ARMCANZ, 2000).

The report provides an assessment of water quality impacts associated with both the construction and operation of the project. In accordance with the Environmental Assessment Requirements (EARs) issued by the Director-General, it focuses on key areas, including:

- Impacts on surface water quality
- Impact of surface water quality on groundwater (also refer to the Groundwater Working Paper)

- Impacts of surface water quality on the Rous Water Regional Water Supply (also refer to the Groundwater Working Paper)
- Identification and assessment of soil characteristics.

Impact mitigation during the construction phase of the project includes the development of a Soil and Water Management Plan (SWMP), with prevention of erosion using at-source controls and treatment provided by sedimentation basins. The proposed locations and approximate sizing of sedimentation basins are provided in this report.

Impact mitigation during the operational phase involves permanent water quality control features. This report identifies the location and size of the permanent water quality ponds along the project.

Identifying preliminary locations and sizing information for water quality controls early in the project assists in defining the extent of the project boundary required to contain these controls, enabling higher certainty in the accuracy of the design boundary.

This report also outlines a water quality monitoring framework to develop a water quality monitoring plan.

The production of this report has been limited by the following factors:

- The size and location of water quality mitigation measures such as sedimentation basins and water quality ponds are based on the concept design and should be considered to be preliminary values. As the road and drainage designs are developed during the detailed design phase, the locations and sizing of the basins and ponds would need to be reviewed and further developed
- Recent water quality monitoring has not been undertaken for all project sections, thus limiting the available information on existing conditions of waterways. Pre-construction water quality monitoring would need to be undertaken and would be used to develop the detailed design of water quality construction and operation management measures.

## 1.3. Director-General's environmental assessment requirements

The Director-General's and supplementary Director- General's environmental assessment requirements for the project with respect to water quality issues are listed in Table 1-2 and Table 1-3 along with reference to where these issues are addressed in this report.

**Table 1-2 Director-General environmental assessment requirements**

| Topic | Requirements | Where addressed |
|---|---|---|
| Surface water flows | Impacts on surface water flows, quality and quantity, with particular reference to any likely impacts on surrounding water bodies, wetlands and their habitats, including potential indirect impacts on the Solitary Island Marine Park by works in the Arrawarra Creek and Corindi River catchments. | Section 3<br>Section 4<br>Section 5 |
| Groundwater | Groundwater impacts, taking into consideration local impacts at deep cuttings and fill locations, and cumulative impacts on regional hydrology. The assessment shall consider: the extent of drawdown, impacts to groundwater characteristics, quality, quantity, and connectivity, discharge and recharge rates, and implications for surface flows, groundwater users, groundwater dependent ecosystems and wetlands. | 3.1.4, 4.2.9, 4.3.4, Section 5 (In relation to the interaction between surface water quality and groundwater quality only.) |
| Drinking water | Impacts to the Rous Water Regional Water Supply (Woodburn) bore fields drinking water source, taking into account discharge/ recharge rates and groundwater yield, and consideration of the relevant public health and environmental water quality criteria specified in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000*(Australian and New Zealand Environment and Conservation Council) and the *Australian Drinking Water Guidelines 2004* (National Health and Medical Research Council and the Natural Resource Management Ministerial Council). | 3.1.4, 4.2.10, 4.3.5, Section 5 (In relation to the interaction between surface water quality and groundwater quality only.) |
| Soils and properties | identification and assessment of soil characteristics and properties that may impact or be impacted by the proposal | 2.4, 3.1.7, 3.2.4, 4.2.6, Section 5 |
| Soils and properties | Identification and assessment of soft soils, soil contamination, acid sulfate soils, and details of erosion and sedimentation control measures. | 2.5, 3.1.6, 4.2.5, Section 5 |

**Table 1-3 Director-General supplementary environmental assessment requirements**

| Topic | Requirements | Where addressed |
|---|---|---|
| Existing environment and relevant matters of national environmental significance | A description of the existing environment including:<br>Details of relevant baseline conditions to be used to assess the impacts of the action and the performance and effectiveness of proposed mitigation measures, including water quality, road kill data and habitat parameters for relevant areas that support migratory species, listed threatened species and ecological communities | Section 2, Section 5, Appendix A, Appendix C |

## 1.4. Assessment approach

The process of assessing the potential water quality impacts of the project and developing impact mitigation measures has included:

- A review of existing project literature, including the following reports:
    - *North Coast Rivers Independent Enquiry into the North Coast Rivers Final Report* (HRC, 2003)
    - *Corindi River Estuary Tidal Data Collection February – April 2004, Report MHL 1318* (NSW Department of Commerce, 2004)
    - *Woolgoolga to Wells Crossing Concept Design Report, April 2008* (RTA, 2008a)
    - *Iluka Road to Woodburn Preferred Concept Design Report, July 2008* (RTA, 2008b)
    - *Woodburn to Ballina Upgrade Concept Design Report, March 2008* (RTA, 2008c)
    - *Wells Crossing to Iluka Road Concept Design Report, January 2009* (RTA, 2009a)
    - *Pacific Highway Upgrade – Devils Pulpit Section, Technical Working Paper on Water Quality* (RTA, 2010)
- A review of existing conditions using GIS functions to identify the locations of sensitive receiving environments such as national parks, nature reserves, state conservation areas, SEPP No. 14 wetlands, key fish habitat areas, and channels and waterways
- A review of the existing water quality conditions
- Consultation with relevant agencies
- A geographic assessment to determine existing catchments along the project
- An assessment of the catchments based on the proposed project alignment
- An assessment of the impact of construction on water quality
- A review of water quality treatment measures that could be used to mitigate the impact of construction on water quality, following the principles of *Managing Urban Stormwater, Soils and Construction, Volume 2D Main Road Construction.* (NSW Department of Environment and Climate Change, 2008)
- An assessment of the impact of the project during its operation
- A review of water quality treatment measures that could be used to mitigate the impact of the operation of the highway on water quality, based on RMS, Austroads and the NSW Office of Environment and Heritage (OEH) guidelines
- Locating and sizing sedimentation basins and water quality ponds using 12d software and the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC).

## 1.5. Guidelines

The following design guidelines and management procedures are relevant to the assessment of surface water quality determining the existing water conditions along the project, and identifying the appropriate water quality management and impact mitigation measures to be implemented during the construction and operational phases of the project.

### 1.5.1. Water quality guidelines

The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) have formulated the National Water Quality Management Strategy (NWQMS) with the objective of achieving sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development.

The NWQMS contains healthy river guidelines for the protection of lowland river aquatic ecosystems and estuarine aquatic ecosystems. These guidelines have been used to determine the existing condition of rivers along the project.

It should be noted, however, that the ANZECC/ARMCANZ trigger values are not necessarily the most appropriate measures for all waterways on the project, as some threatened aquatic faunae, namely the Oxleyan Pygmy Perch and Purple-Spotted Gudgeon, require conditions that fall outside the trigger ranges for pH. Appropriate trigger values for each water course would need to be determined during detailed design and development of the water quality monitoring plan

### 1.5.2. Construction phase mitigation guidelines

The guidelines listed below seek to minimise land degradation and water pollution from road construction sites in NSW. They have been used to identify appropriate management procedures for construction works, including physical controls to minimise erosion and prevent sediment moving off site during the construction phase of development.

- *Water Policy* (RTA, 1997)
- *Code of Practice for Water Management - Road Development and Management* (RTA, 1999)
- *Environmental Direction: Management of Tannins from Vegetation Mulch* (RMS, 2012)
- *Erosion and Sedimentation Management Procedure* (RTA, 2009b)
- *Guideline for Construction Water Quality Monitoring* (RTA, 2003c)
- *Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze* (RTA, 2005)
- *Managing Urban Stormwater- Soils and Construction*, Volume 1, 4th Edition (Landcom, 2004)
- *Managing Urban Stormwater-Volume 2D Main Road Construction*, (NSW Department of Environment and Climate Change, 2008)
- *Road Design Guideline: Section 8 Erosion and Sedimentation* (RTA, 2003b)
- *Stockpile Site Management Procedures* (RTA, 2001)
- *Technical Guideline: Temporary Stormwater Drainage for Road Construction* (RMS, 2011)
- *Technical Guideline – Environmental Management of Construction Site Dewatering* (RMS, 2011)
- *Guidelines for Riparian Corridors on Waterfront Land* (NSW Office of Water, 2012)
- *Australian Drinking Water Guidelines* (NHMRC, 2011)
- *The NSW Groundwater Quality Protection Policy* (NSW Department of Land and Water Conservation, 1998)

### 1.5.3. Operational phase mitigation guidelines

The objectives of the manuals listed below is to protect waterways and water quality by providing guidance on water management practices and water quality, quantity and conservation issues related to the design, operation and maintenance of the roads and traffic system. They provide guidance on the process of designing permanent water quality treatment trains in a consistent and practicable manner. The design would address the sensitivity of receiving waters and local environment along the project.

- *Water Policy* (RTA, 1997)
- *Code of Practice for Water Management - Road Development and Management* (RTA,1999)
- *AP-R232 Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure* (Austroads, 2003)
- *Managing Urban Stormwater, Environmental Targets Consultation-Draft* (NSW Department of Climate Change and Water, 2007)
- *Procedures for Selecting Treatment Strategies to Control Road Runoff* (RTA, 2003a)
- *AP-R180 Road Runoff and Drainage: Environmental Impacts and Management Options* (Austroads, 2001)
- *Integrated Water Management Guidelines* (VicRoads, 2007)
- *Guidelines for Riparian Corridors on Waterfront Land* (NSW Office of Water, 2012)
- *Australian Drinking Water Guidelines* (NHMRC, 2011)
- *The NSW Groundwater Quality Protection Policy* (NSW Department of Land and Water Conservation, 1998)

# 2. Existing environment

## 2.1. Environmental setting

In the Biodiversity Working Paper a detailed description of the environmental setting of the project is provided. It outlines the national parks, states forests and natures reserves that occur within 10 kilometres of the project, the landscape, land tenure and land use, the key habitats and corridors, and the waterways and wetlands. The Biodiversity Working Paper should be read in conjunction with this report.

## 2.2. Topography

Topographic conditions throughout the project are variable, but can be broadly categorised as either lowland areas or elevated areas.

The project generally traverses the geological sequence of the Clarence-Moreton Basin. This basin is an extensive Mesozoic age sedimentary basin extending from south Queensland to the New South Wales North Coast.

The underlying topography and geology give rise to a variety of soil landscapes, including erosional, transitional and alluvial landscapes

The topography and geology of the throughout the project are detailed further in Section 2 of the Groundwater Working Paper. The Groundwater Working Paper should be read in conjunction with this report.

## 2.3. Catchments

The study area includes numerous creeks and two large river systems (Clarence and Richmond rivers) and their floodplains. Catchments of watercourses crossed by the project range from small unnamed tributaries of less than two square kilometres to the major Clarence and Richmond river systems of around 20,000 square kilometres and 7000 square kilometres respectively.

The study area is characterised by relatively steep catchments (five to 15 per cent) with some steeper catchments characterised by slopes of up to 25 per cent. Floodplain slopes are generally in the order of 0.5 to one per cent gradient. Several of the catchments, such as Corindi River and Halfway, Pheasant, Champions, Tabbimoble and Oaky creeks are predominantly forested, intercepting numerous national parks. Most catchments include cleared areas used for agriculture, grazing and rural residential land uses. These areas are typically in lower areas of the catchment and closer to the existing highway.

Detailed descriptions of the catchments are given in the Hydrology Working Paper which should be read in conjunction with this report.

## 2.4. Soil landscapes

The underlying topography and geology has given rise to a variety of soil landscapes throughout the project. The erodibility of soils along the project has been reviewed using the Milford (1999) and Morand (1994 and 2001) Soil Landscape Maps. Descriptions of the various soil landscapes underlying the project are provided below. There are no published soil landscape maps currently available for the region between Dirty Creek and Tyndale (predominantly Sections 2 to 3) and so information has been taken from RMS reports (RTA 2006 and 2006a). Soil conditions within each of the project sections are summarised in Table 2-1 and are displayed in Appendix F.

### 2.4.1. Erosional landscapes (ne, gu, oi)

Erosional landscapes throughout the project comprise the New Italy (ne), Gulmarrad (gu), and Olive Gap (oi) formations and are present within Sections 4, 6 to 8. These units are generally associated with gently undulating to undulating rises and low hills. Slopes are in the order of two to 35 per cent and soils are typically of a low foundation hazard and highly erodible when cleared of vegetation.

### 2.4.2. Transferral landscapes (mo, pp, bia)

Transferral landscapes throughout the project comprise the Moonee (mo), Pretty Plain (pp) and Billinudgel (bia) formations and are present within Sections 1, 6, 7 and 10. These units are generally associated with undulating rises, low hills, footslopes, drainage plains and fans. Slopes are in the order of zero to 10 per cent and soils are typically highly acidic, highly sodic, highly erodible and of a low bearing strength due to seasonal waterlogging.

### 2.4.3. Alluvial landscapes (ci, bh, cw, du, ep)

Alluvial landscapes throughout the project comprise the Corindi (ci), Brushgrove (bh), Cowper (cw), Dungarubba (du) and Empire Valley (ep) formations and are present within Sections 1, 4, 8 to 11. These units are generally associated with level to very gently undulating alluvial plains, floodplains and river back plains. Slopes are in the order of zero to six per cent and soils are typically highly acidic, highly erodible, of a low bearing strength and subject to flood hazards.

### 2.4.4. Stagnant alluvial landscapes (tm)

Stagnant alluvial landscapes throughout the project comprise the Tabbimoble (tm) formation, which is located within Sections 6 and 7. This unit is associated with stagnant alluvial plains and drainage depressions derived from mixed alluvium within the Tabbimoble lowlands. Slopes are generally around zero to one per cent and soils are moderately erodible and of a low bearing strength due to seasonal waterlogging.

### 2.4.5. Estuarine landscapes (pa, bpa)

Estuarine landscapes throughout the project comprise the Palmers Island (pa) and Burns Point (bpa) formations and are present within Sections 5 and 11. These units are generally associated with deltaic plains and extra tidal flats of the Clarence and Richmond Rivers. Slopes are in the order of zero to three per cent and soils are typically saline, subject to regular flooding and of a low bearing strength. These soil types are also water erosion prone.

### 2.4.6. Aeolian landscapes (il, bj, wa)

Aeolian landscapes throughout the project comprise the Iluka (il), Bundjalung (bj), and Wardell (wa) formations and are present within Sections 8, 9 and 11. These units are generally associated with extremely low level to gently undulating sand sheets, beach ridges and dune fields. Slopes are in the order of zero to five per cent and soils are non-cohesive, highly erodible and of high permeability.

### 2.4.7. Swamp landscapes (np, ev)

Swamp landscapes throughout the project include the Newports Creek (np) and Everlasting (ev) formations and are present within Sections 1 and 4. These units are generally associated with low, level to gently undulating coastal back barrier floodplains, and estuarine backswamps of the Clarence and Richmond Rivers. Slopes are in the order of zero to two per cent and soils are highly acidic, highly sodic, highly saline and of a low bearing strength. These soil types are also water erosion prone.

### 2.4.8. Disturbed landscapes (xx)

Disturbed landscapes throughout the project comprise areas mapped as Disturbed Terrain (xx) and are present within Sections 5, 9 and 10. These units vary from level plains to undulating terrain and comprise land that has been disturbed by human activity, including the use of fill. Landfill includes soil, rock, building refuse and waste material. Subsidence, poor drainage, low fertility and the presence of toxic materials may be typical issues.

### 2.4.9. Dirty Creek to Tyndale

Whilst there are no soil maps available of the region between Dirty Creek and Tyndale, Section 3.9 of the RMS' *Woolgoolga to Wells Crossing Preferred Route Report* (RTA, 2006) provides some information on topography, geology, rock stability and soil issues for the relevant sections between Dirty Creek and Wells Crossing. It outlines the presence of erodible siltstone seams around the Dirty Creek Range, and the presence of soft soils between the Dirty Creek Range and Halfway Creek.

Information on the soils between Wells Crossing and Tyndale is provided in Section 3.6.1 of RMS' *Wells Crossing to Iluka Road Preferred Route Report* (RTA, 2006a). It outlines the presence of soft soils in low lying areas including the Clarence River Floodplain between Grafton and Tyndale.

**Table 2-1 Summary of soil landscapes within the project**

| Section | Soil units present | Description |
|---|---|---|
| 1 | np, ci, mo | Southern portion of section underlain by Swamp and Alluvial landscapes in the lower elevations (i.e. < 10 m), and Transferral landscapes in the higher elevations toward the central portion near the Dirty Creek locality. No published soil landscape mapping available for the northern portion of section. Reported presence of erodible siltstone seams around the Dirty Creek Range |
| 2 | - | No published soil landscape mapping available for section. Reported presence of soft soils. |
| 3 | - | No published soil landscape mapping available for section. Reported presence of soft soils. |
| 4 | ne, bh, cw, ev | No published soil landscape mapping available for the southern portion of section. Northern portion of section underlain by Swamp and Alluvial landscapes in the lower elevations (i.e. < 5 m), and Erosional landscapes in the higher elevations near Maclean. |
| 5 | pa, xx | Section predominately underlain by Estuarine landscapes of the Clarence River Delta and associated floodplains. Disturbed landscapes located on the south bank of the Clarence River at the southern extremity of section. |
| 6 | ne, pp, tm | Section predominately underlain by Erosional landscapes. Transferral landscapes located in the central portion. Stagnant alluvial landscapes located in the northern extremity near the Tabbimoble locality. |
| 7 | tm, ne, pp, gu | Section predominately underlain by Erosional landscapes. Isolated areas of Stagnant alluvial landscapes located in the southern and central portions. Isolated areas of Transferral landscapes located in the northern portion near the New Italy and Trustums Hill localities. |
| 8 | gu, du, oi, il | Section generally underlain by Erosional landscapes in the southern portion, Alluvial landscapes in the central portion and Aeolian Landscapes in the northern portion. Section traverses and isolated area of Erosional landscapes near the northern extremity north-east of the Woodburn locality. |
| 9 | du, il, xx, bj, ep | Section predominately underlain by Aeolian landscapes. Isolated area of Disturbed landscapes located in the southern portion. Swamp landscapes located in the northern extremity of section adjoining the Richmond River (south bank) near the Broadwater locality. |
| 10 | ep, bia, xx | Section predominately underlain by Transferral landscapes. Isolated area of Disturbed landscapes located in the southern portion. Alluvial landscapes located at the southern extremity of section adjoining the Richmond River (north bank). |
| 11 | wa, ep, bpa | Section predominately underlain by Alluvial landscapes. Aeolian landscapes located at southern end of section and generally west of Pimlico Island. Estuarine landscapes located at northern end of section typically west of Emigrant Creek. |

## 2.5. Acid sulfate soils

Acid sulfate soils are soils and sediments containing iron sulfides that, when disturbed and exposed to oxygen, generate sulfuric acid and toxic quantities of aluminium and other heavy metals. The sulfuric acid and heavy metals are produced in forms that can be readily released into the environment, with potential adverse effects on the natural and built environment and human health. Activities that would be undertaken during construction, such as drainage, excavation, dewatering and clearing, pose a significant environmental risk when they are carried out in areas with acid sulfate soils.

The majority of acid sulfate soils are formed by natural processes under specific environmental conditions. This generally limits their occurrence to low lying sections of coastal floodplains, rivers and creeks where surface elevations are less than about five metres Australian Height Datum. New South Wales contains about 600,000 hectares of acid sulfate soils along its coastline, with acid sulfate soils found in every coastal estuary between the Victorian and Queensland borders.

The term acid sulfate soils includes both actual acid sulfate soils  and potential acid sulfate soils. Actual and potential acid sulfate soils can occur together within the same soil profile, with actual acid sulfate soils usually overlying potential acid sulfate soils horizons. Based on the definitions included in the *Acid Sulfate Soil Management Advisory Committee Manual* (ASSMAC, 1998), actual acid sulfate soils are soils containing highly acidic soil horizons, or layers resulting from the previous oxidation of soil materials that are rich in iron sulfides, and can usually be identified by the presence of pale yellow mottles or coatings of jarosite. Potential acid sulfate soils are soils containing iron sulfides or sulfidic material that have not been exposed to the atmosphere but will become highly acidic when oxidised due to disturbance. The oxidation of iron sulfide in potential acid sulfate soils S as a result of disturbance (such as excavation) or lowering the groundwater table can lead to actual acid sulfate soils conditions.

Acid sulfate soils occur extensively across the floodplains of the Clarence and Richmond Rivers either as actual acid sulfate soils or potential acid sulfate soils. The regional extents of acid sulfate soils risk areas have been mapped based on the Department of Infrastructure, Planning and Natural Resources' (DIPNR) (Now NSW Office of Environment and Heritage) *Acid Sulfate Soils Maps (DIPNR, 1998)*. Figures are provided in the Groundwater Working Paper. These regions generally correspond to areas where the groundwater table is within three metres of the surface. Activities such as drainage, excavation, dewatering and clearing pose a substantial environmental risk within these areas if not managed effectively. A summary of the risk of acid sulfate soils occurring in each section of the project is provided in Table 2-2.

**Table 2-2 Summary of risk of occurrence of acid sulfate soil in the project (DIPNR, 2012)**

| Section | Risk of occurrence | Proportion of section (%) | Description |
|---|---|---|---|
| 1 | No known occurrence | 65 | Majority of section mapped as having no known occurrence of acid sulfate soils. Areas of low and high probability of occurrence mapped for the lowland coastal plains in the southern portion of section near the Arrawarra and Corindi Beach localities. |
| 2 | No known occurrence | 100 | Entire section mapped as having no known occurrence of acid sulfate soils. Section is located within elevated terrain where acid sulfate soils are not expected to occur. |

| Section | Risk of occurrence | Proportion of section (%) | Description |
|---|---|---|---|
| 3 | No known occurrence | 80 | Majority of section mapped as having no known occurrence of acid sulfate soils. Section traverses several isolated areas of low and high probability of occurrence in the southern and central portions. |
| 4 | High probability | 65 | Majority of section mapped as having a high probability of occurrence. Isolated areas of no known occurrence located in the central and northern portions near the Maclean locality. |
| 5 | High probability | 100 | Entire section mapped as having a high probability of occurrence. |
| 6 | No known occurrence | 100 | Entire section mapped as having no known occurrence of acid sulfate soils. Section is located within elevated terrain where acid sulfate soils are not expected to occur. Area of low probability of occurrence noted to be mapped immediately west of the section in the southern portion. |
| 7 | No known occurrence | 95 | Majority of section mapped as having no known occurrence of acid sulfate soils. Isolated areas of low and high probability located in the northern portion of section on both the eastern and western sides of the project. |
| 8 | High probability | 80 | Majority of section mapped as having a high probability of occurrence and is located close to the boundary of low and high probability areas to the north of Woodburn. Southern extremity of section mapped as having no known occurrence of acid sulfate soils. |
| 9 | High probability | 60 | Majority of section mapped as having a high probability of occurrence. Southern portion of section mapped as having a low probability of occurrence. |
| 10 | Low probability | 55 | Majority of section mapped as having a low probability of occurrence. Northern portion of section mapped as having no known occurrence of acid sulfate soils. |
| 11 | High probability | 85 | Majority of section mapped as having a high probability of occurrence. Southern extremity of section mapped as having a low probability of occurrence. |

## 2.6. Rainfall and climate

### 2.6.1. Woolgoolga to Wells Crossing

Climate data were obtained from NSW Bureau of Meteorology for weather stations at Woolgoolga and Halfway Creek. The mean annual rainfall in Woolgoolga is 1575 millimetres. The highest rainfall occurs between December and April, with the most rain failing March. At Halfway Creek the mean annual rainfall is 1229 millimetres. The highest rainfall occurs between December and March with February being the wettest month on average.

### 2.6.2. Wells crossing to Iluka Road

Climatic data were obtained from the NSW Bureau of Meteorology weather stations at Grafton, Yamba and Glenugie. In general, the recorded temperatures are similar at all stations, however, the inland stations of Grafton and Glenugie show greater daily temperature variation than Yamba, which is subject to the moderating effect of the coast. Rainfall fluctuates seasonally, with greater rainfall in the summer and autumn months and less rainfall during late winter and early spring. Generally, Yamba experiences greater total rainfall per annum and more rainy days than Grafton and Glenugie. Mean annual rainfall ranges from 1051 millimetres in Grafton to1459 millimetres in Yamba.

### 2.6.3. Iluka Road to Woodburn

The study area is heavily influenced by coastal weather patterns. The overall climate is warm to sub-tropical, with high annual rainfall. The wettest seasons are summer and autumn, while there is a pronounced dry season between July and December. Mean annual rainfall figures for the study area range from about 1600 millimetres along the coast, to about 1000 millimetres at Casino. At Woodburn mean annual rainfall is 1360 millimetres. The most intense summer rain events, which can exceed 500 millimetres, are usually associated with the influence of tropical cyclone systems. Similarly, heavy winter rainfall events are usually associated with intense offshore low pressure systems. Information on local air quality is limited. (RTA, 2008b)

### 2.6.4. Woodburn to Ballina

The study area lies on the coast and the local climates is heavily influence by offshore meteorological activity. The study are has a warm to sub-tropical climate and high rainfall, which provides an ideal situation for a great variety of agricultural and horticultural pursuits. There is a pronounced summer to autumn wet season and a marked dry season between July and December. The mean annual rainfall ranges from about 1650 millimetres along the coast about 1480 millimetres at Broadwater. High summer rainfalls, sometimes great than 500 millimetres results from southward extensions of tropical cyclones, whilst the periods of high rainfall in winter derive from intense offshore low-pressure systems (RTA, 2005c).

## 2.7. Highway use

Traffic volume along the Pacific Highway through the project area is forecast to grow by about 42 per cent from 2012 to 2036. By 2036, an annual average daily traffic volume of around 30,000 vehicles is expected between Woolgoolga and Ballina.

The Pacific Highway is a designated dangerous goods route. Dangerous goods that might be transported in significant quantities on the Pacific Highway include flammable and combustible petroleum products (petrol and diesel); liquefied petroleum gas and toxic gases (eg ammonia and chlorine); corrosive materials (acids and alkalis); other toxic materials (eg pesticides); and nitrogen-based fertilisers or bulk explosives.

## 2.8. Sensitive receiving environments

A sensitive receiving environment is one that has a high conservation value, or supports human uses of water that are particularly sensitive to degraded water quality (NSW Department of Environment and Climate Change, 2008). In the context of this project, sensitive receiving environments are considered to be:

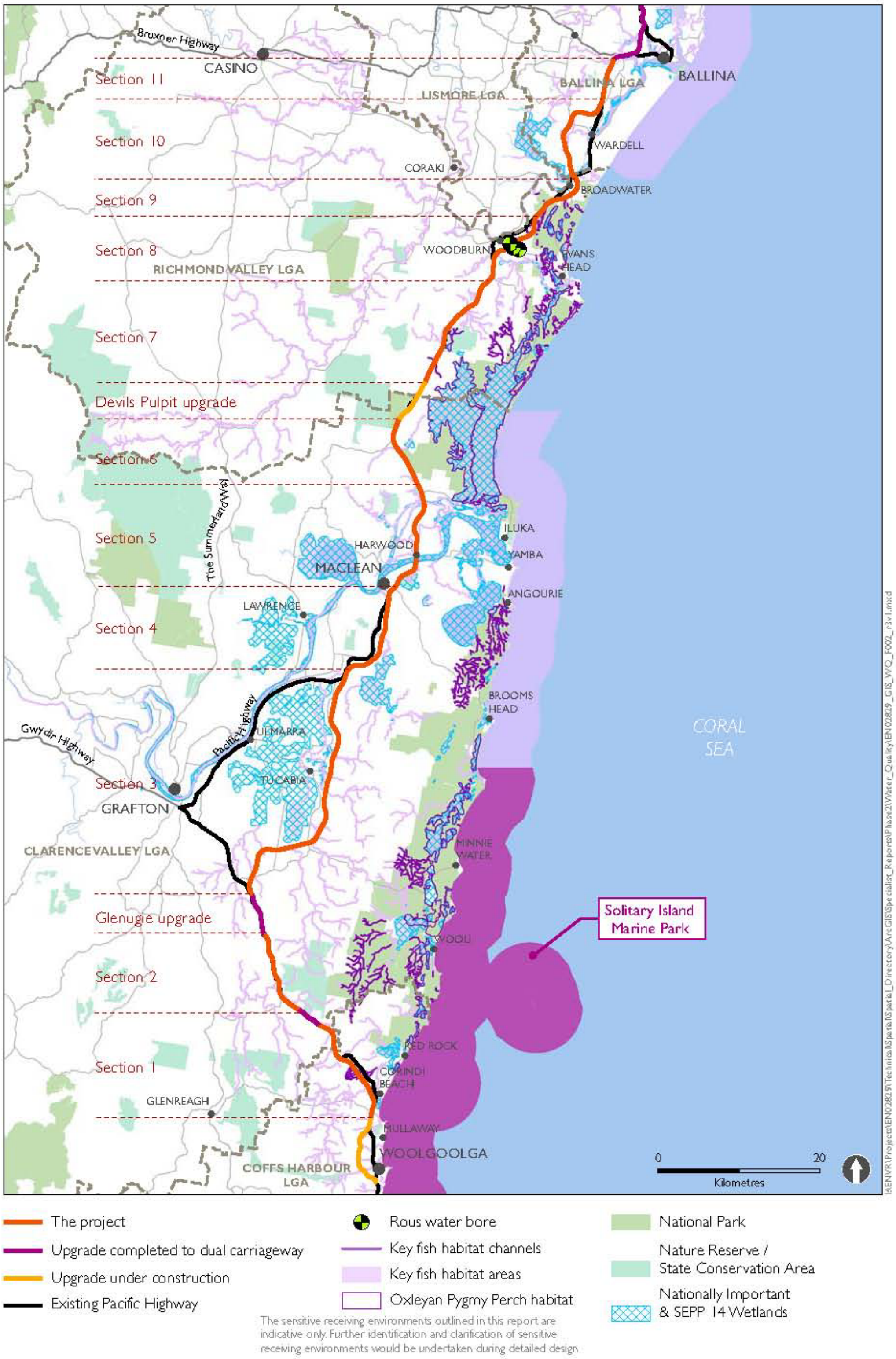
- Nationally Important Wetlands and State Environmental Planning Policy No 14 (SEPP) wetlands as shown in Section 2.8.1
- National parks, marine parks, nature reserves and state conservations areas as shown in Table 2-6 of Section 2.8.2
- Threatened ecological communities associated with aquatic ecosystems, as identified in the Biodiversity Working Paper, and discussed further in Section 2.8.3
- Known and potential habitats for threatened fish, as identified in the Biodiversity Working Paper, and discussed further in Section 2.8.6
- Key fish habitats as identified by the NSW Department of Primary Industry (DPI) and discussed further in Section 2.8.4
- Recreational swimming areas
- Areas that contribute to drinking water catchments, such as the Rous Water supply catchment
- Areas that are available & or used for aquaculture and commercial fishing as identified in the Land Use Working Paper (RMS, 2012) and discussed further in Section 2.8.8.

Sensitive receiving environments located along or adjacent to the project boundary are shown graphically in Figure 2-1 and on the more detailed plans in Appendix D. The sensitive receiving environments that are currently identified in each section of the project are also summarised in Table 2-12 to Table 2-22 in Section 2.11 of this report.

The type, number and locations of sensitive receiving environments outlined in this report are indicative only. Further identification and clarification of sensitive receiving environments would be undertaken during the development of the detailed design, through planned monitoring programs and as further information become available.

A discussion of these sensitive receiving environments is provided in the next sections.

**Figure 2-1 Sensitive receiving environments**



### 2.8.1. Nationally important and SEPP 14 wetlands

Rivers and creek provide a broad range of habitat for wide diversity of aquatic plant and animal species, as well as supporting a range of ecological processes. Many of the freshwater rivers and creeks in the region are influenced by tidal flows that support freshwater and estuarine flora and fauna. A list of important wetlands is detailed in Table 2-4 and SEPP 14 wetlands in Table 2-5.

The project traverses the major river catchments of the Clarence and Richmond River. Eight Nationally Important Wetlands (Environment Australia, 2001) are located adjacent to the project. Most of these wetlands are recharged or fed by the Clarence River Catchment.

Further detail of Nationally Important and SEPP 14 wetlands are given in Section 3 of the Biodiversity Working Paper. Table 2-3 Important wetlands in the region

**Table 2-4 Nationally Important wetlands in the region**

| Wetlands | Type | Land Use | Area (ha) |
|---|---|---|---|
| The Broadwater | Offstream tidal waterbody of the Clarence Estuary | Forestry, agriculture | 2800 |
| Bundjalung National Park | Coastal dunal wetland | National Park | 17738 |
| Clarence River Estuary | Estuary and SEPP 14 | Fishery and agriculture | 1700 |
| Cowans Pond Reserve | Open water body | Conservation, particularly for water birds | 5 |
| Everlasting Swamp | Freshwater meadow and seasonal swamp | Agriculture and forestry | 1930 |
| Upper Coldstream | Coastal floodplain swamps | Agriculture and forestry | 1995 |

**Table 2-5 SEPP 14 wetlands in the region**

| Project Section | Wetland Identification | Details |
|---|---|---|
| Section 1 | No.314 | Located about 60 m east of the project near Corindi Beach. |
| | No.315 | Associated with Arrawarra Gully outside the project. |
| Section 3 | No. 287 | Located about 600 m downstream of the project crossing of Champions Creek. |
| | No. 289 | Associated with Chaffin Creek and located about 450 m downstream and to the west of the project. |
| | No. 292 | Part of the Upper Coldstream Wetlands, associated with Coldstream River and Pillar Valley Creek, located downstream and to the west of the alignment. |
| Section 4 | No.232 | Located on the eastern side of the upstream reaches of Shark Creek, upstream of the alignment. |
| Section 5 | No. 220a | Located to the south east of the corridor south of Harwood Bridge and associated with James Creek which flows through this wetland into a portion of Yaegl Nature Reserve. |
| | No.153c | Located around 400 m upstream and west of the project crossing of North Arm of the Clarence River. |

| Project Section | Wetland Identification | Details |
|---|---|---|
| Section 6 | No.153a | Located on Tabbimoble Creek about 1 km downstream and east of the project. |
| | No.153 | Located about 4.5km to the east of the project mostly within the Bundjalung National Park and Devils Pulpit State Forest and extends between the north arm of the Clarence River in the south and the Evans River in the north, extending between Section 6 and 7 of the project. |
| Section 7 | No.161 | Located about 260 m east of the project in the Tabbimoble Swamp Nature Reserve. |
| Section 8 | No 133 and 134 | Located at the interface of the Tuckombil Canal and Evans river, about 500m downstream and to the east of the alignment. There are numerous SEPP 14 wetlands along the length of Evans River. |
| Section 9 | No. 121 | Located within the Broadwater National Park, to the east of the alignment. |
| | No.119 | Located at Tuckean Broadwater, and dominated by mangroves (namely the species *Avicennia marina* and *Aegiceras corniculatum)*. The aquatic and riparian habitat of the Tuckean Broadwater is considered to be ecologically significant. |
| | No. 119a | Within the Richmond River, to the west of the alignment |
| Section 10 | No.118 and 118a | Located on the northern banks of the Richmond River, either side of the project. |
| Section 11 | No.108 | In the location of the alignment at Duck Creek. |
| | No. 95 | On either side of the existing highway at Emigrant Creek, outside the project boundary. |

### 2.8.2. National parks, marine parks, nature reserves and state conservation areas

A number of national parks and nature reserves occur in the bioregion; those within 10 km of the project are described in Table 2-6. These have been considered in the context of the distribution and extent of conserved habitat for listed species, communities and populations that may be affected by the project and the importance of maintaining connectivity within the landscape with conservation reserves.

The project is located near a number of conservation reserves managed by the National Parks and Wildlife Service including Yuraygir State Conservation Area (which adjoins Yuraygir National Park), Mororo Creek Nature Reserve, Yaegl Nature Reserve, Bundjalung National Park, Tabbimoble Swamp Nature Reserve and Broadwater National Park. The largest area of national park potentially affected by the project is Broadwater National Park which comprises a total area of 4055 hectares. From previous studies, it is understood that there are currently no treatment controls along the entire length of the existing Pacific Highway through Broadwater National Park. Sections 8 and 9 of the project duplicate the existing highway adjoining Broadwater National Park and some strip acquisition of land is required in this location.

The Solitary Islands Marine Park managed by the Marine Parks Authority is a coastal reserve located between Coffs Harbour and Sandon. The park includes a number of small creeks and estuaries that discharge directly into the coast at this location. Of these, the project crosses upstream of the tidal influences (extent of the marine park) of Arrawarra Gully, Corindi River, Cassons Creek, Redbank Creek. The project is near to the upper reaches of Blackadder Gully.

Dirty Creek also flows to the marine park, but this occurs a long distance from the highway. In general, the designated marine reserve is downstream of the highway.

### Table 2-6: National parks and reserves within 10 km of the project

| Project section | National park or reserve name | Description | Total area (ha) |
|---|---|---|---|
| 1 | Coffs Coast Regional Park | Coastal Protection Zone (7a) protected under Coffs Harbour LEP, occupying a coastal strip adjacent to Wedding Bells State Forest and Garby Nature Reserve. Includes coastal dune systems, rainforests, and heathlands. | 388 |
| 1 | Sherwood Nature Reserve | Located about 40 km south of Grafton. The reserve is bordered by Conglomerate and Wedding Bells state forests and includes elevated plateaus with perched swamps and also pockets of littoral rainforest to the southwest (NPWS, 2009a). Contains important population of the national listed Square-fruited Ironbark. | 5942 |
| 1-4 | Yuraygir National Park | Borders the coastline to the east of the existing highway extending from Red Rock in the south to near the mouth of the Clarence River. Characterised by coastal dunes, heathlands and open forest. Pockets of littoral rainforest and wet sclerophyll forest also occur. | 36,374 |
| 1-2 | Yuraygir State Conservation Area | To the east of the existing Pacific Highway, around Halfway Creek and adjacent to the western border of Yuraygir National Park. Pockets of littoral rainforest and wet and dry sclerophyll forest occur. | 3136 |
| 4 | Woodford Island Nature Reserve | Located west of the Clarence River between Tyndale and Maclean. | 373 |
| 4 | Munro Island Nature Reserve | Located on the Clarence River near Sportsman Creek. The area of the reserve is variable due to fluvial processes that change the size of the island (NPWS, 2009). The reserve is one of only three that protect estuarine intertidal habitats of the North Coast Bioregion (NPWS, 2009). | 14 |
| 4 | Everlasting Swamp State Conservation Area | Located to the west of Munro Island Nature Reserve and the Clarence River it is the largest coastal floodplain swamp in NSW and is a significant habitat for water birds at a state, national and international level. | 457 |
| 4-5 | Yaegl Nature Reserve | Located immediately adjacent to the existing Pacific Highway. James Creek traverses the reserve and a SEPP 14 wetland (known as Farlows Swamp or the Maclean Wetlands), is protected by the reserve (NPWS, 2009a). These wetlands include a large area of remnant floodplain paperbark forest that is not well represented in the NSW reserve system (NPWS, 2009a). | 312 |
| 4-5 | Clarence Estuary Nature Reserve | Located on the Clarence River to the west of Yamba. Established to protect the Clarence estuary foreshore, SEPP 14 coastal wetlands and a small area of littoral rainforest (NPWS 2007). | 132 |
| 5-6 | Chatsworth Hill State Conservation | Located to the west of Mororo Creek Nature reserve on the Richmond Range (NPWS, 2009b). The Reserve supports shrubby dry sclerophyll forest, wet sclerophyll forest and | 519 |

| Project section | National park or reserve name | Description | Total area (ha) |
|---|---|---|---|
| | Area | swamp sclerophyll forest. | |
| 5-6 | Mororo Creek Nature Reserve | Located on the Clarence River floodplain near Chatsworth Hill State Conservation Area and adjacent to the west of the existing Pacific Highway. This reserve and Chatsworth Hill State Conservation Area provide an important wildlife corridor between the coastal floodplain and the hinterland (NPWS, 2009b). The reserve supports shrubby dry sclerophyll forest, wet sclerophyll forest and swamp sclerophyll forest. | 79 |
| 5-8 | Bundjalung National Park | The northernmost limit of the park occurs to the east of Tuckombil Canal, near the Evans River, and extends as far south as the Clarence River.<br>The national park includes SEPP 14 wetlands and supports freshwater lagoons, mangrove mudflats and rare rainforests. | 21,195 |
| 6-7 | Bundjalung State Conservation Area | Located to the west of the existing Pacific Highway and situated close to Tabbimoble State Forest and Doubleduke State Forest. | 4869 |
| 7 | Jackywalbin State Conservation Area | Located to the west of the existing Pacific Highway, contiguous with Doubleduke State Forest and Tabbimoble State Forest. | 660 |
| 7 | Tabbimoble Swamp Nature Reserve | Located to the east of the existing Pacific Highway and contiguous with Bundjalung National Park to the east. It conserves wetlands, littoral rainforest, and wet and dry sclerophyll forest. | 1075 |
| 7-8 | Yarringully Nature Reserve | Located to the west of the project and to the north of the Yarringully State Conservation Area. | 287 |
| 7-8 | Yarringully State Conservation Area | Bounded by Bungawalbin Creek which separates the area from Yarringully Nature Reserve. | 237 |
| 8-9 | Broadwater National Park | Located between Broadwater in the north, and Woodburn in the south. The existing Pacific Highway bisects the western portion of the park. It supports heath, wetland and creek habitats. | 4055 |
| 9 | Tuckean Nature Reserve | Located west of the study area, between Broadwater and Wardell, the reserve forms part of a regional network of protected wetlands, including nearby<br>Ballina Nature Reserve. | 1037 |
| 10-11 | Uralba Nature Reserve | Located to the west of the project just south of Ballina, on the Blackwell Range. The reserve protects remnants of sub-tropical rainforest known as ‘Big Scrub’. | 155 |
| 10-11 | Victoria Park Nature Reserve | Located on the Alstonville Plateau to the west of the project. Also a ‘Big Scrub’ remnant. | 17 |
| 10-11 | Little Pimlico Island Nature Reserve | In the Richmond River west of Wardell, the reserve supports wetlands and littoral rainforest of state significance. It also contains rainforest elements representative of the ‘Big Scrub’ at their southern limit. | 6 |
| 11 | Richmond River Nature Reserve | Located east of Duck Creek, near Ballina, on the north-facing bank of the Richmond River estuary. The reserve contains significant wetland and coastal vegetation communities that | 253 |

| Project section | National park or reserve name | Description | Total area (ha) |
|---|---|---|---|
| | | provide significant habitat for birds, including those protected under international conservation agreements. | |

### 2.8.3. Threatened ecological communities

Vegetation characteristics of five threatened ecological communities relating to aquatic ecosystems listed under the *NSW Threatened Species Conservation Act 1995* (TSC Act) have been identified in Table 2-7. All of these are listed under Schedule 1 part 3 of the Act as endangered. Lowland rainforest in subtropical Australia has also been listed as a Critically Endangered Ecological Community under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The distribution of listed ecological communities in the region is widespread and extensive, although heavily fragmented and largely confined to the coastal and floodplain habitats being traversed by the project, many of which have been cleared for agriculture and coastal development. It should be noted that these are not shown on the figures in Appendix D that show sensitive receiving environments, and the water quality design does not incorporate additional mitigation in these areas associated with sensitive receiving environments, however this would need to be reviewed and threatened ecological communities would need to be included as sensitive receiving environments during detailed design.

Further detail on threatened ecological communities is given in Section 3 of the Biodiversity Working Paper.

**Table 2-7 Descriptions and distribution of threatened ecological communities**

| No | Threatened Ecological Community | Status | Distribution |
|---|---|---|---|
| 1 | Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin & South East Corner bioregions | Endangered (TSC Act) | Sections 3, 4, 8 and 9 |
| 2 | Sub-tropical coastal floodplain forest of the NSW North Coast bioregion | Endangered (TSC Act) | All sections |
| 3 | Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions | Endangered (TSC Act) | All sections except section 11 |
| 4 | Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions | Endangered (TSC Act) | Sections 1, 3-5, and 8-11 |
| 5 | Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion<br>Lowland Rainforest of Sub-tropical Australia | Endangered (TSC Act)<br>Critically Endangered (EPBC Act) | Sections 3, and 8-11 |

### 2.8.4. Key fish habitats

Key fish habitats are defined by the NSW Department of Primary Industries are those aquatic habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species (DPI, unknown date).

### Table 2-8 NSW Department of Primary Industries definition of key fish habitats

| What is included | What is not included |
|---|---|
| Oceanic, bay, inlet and estuarine habitats up to the level defined by High Water Solstice Spring tides (so called 'King tides' or Highest Astronomical Tide). | Unmapped gullies and first and second order streams* |
| Intermittently closing and opening lakes and lagoons up to the level at which they would naturally break out to the sea (which may be 2 or 3 metres above mean sea level). | Farm dams constructed on unmapped gullies and first and second order streams. |
| Permanently flowing rivers and creeks including those where the flow is modified by upstream dam(s), up to the top of the natural bank regardless of whether the channel has been physically modified. | Purpose built irrigation and other water supply channels and off-stream storages. |
| Intermittently flowing rivers and creeks that retain water in a series of disconnected pools after flow ceases including those where the flow is modified by upstream dam(s), up to the top of the natural bank regardless of whether the channel has been physically modified. | Irrigation, agricultural or urban drains. |
| Billabongs, lakes, lagoons, wetlands associated with other permanent fish habitats (eg permanent rivers and creeks, estuaries etc). | Urban ponds including water pollution control ponds and detention basins. |
| Weir pools and dams, up to full supply level, where the weir/dam is across a natural stream channel or waterway. | Sections of streams that have been concrete lined or piped (but not including where an otherwise natural stream passes through culverts). |
| Flood channels or flood runners that may normally be dry but would be used by fish to move/migrate across or along floodplains between habitats during high flow events. | Purpose-built salt evaporation ponds or basins. |
| Mound springs | Purpose-built aquaculture ponds. |
| Any waterbody, regardless of whether or not it may be listed under the heading 'What is not included?' below, if it is known to support or could be confidently expected (based on predictive modelling) to support threatened species, threatened populations or threatened communities listed under the provisions of Part 7A of the *Fisheries Management Act 1994*. | Intermittent lagoons or wetlands filled from localised runoff and not otherwise hydrologically connected to other permanent habitats such as rivers, creeks, estuaries and ocean. |
| | Canal estates. |

*(based on the Strahler method of stream ordering) as determined from the largest scale topographic map produced for the area concerned (i.e. use 1:25,000 rather than 1:50:000 and use 1:50:000 rather than 1:100,000 and include all depicted streams). Note that this methodology only applies to 'gaining systems' – those where streams are coming together and becoming progressively larger.

In 2007, the NSW Department of Primary Industries identified 'key fish habitats' across the state and published maps outlining the habitats. The maps show that key fish habitats extend along the majority of the NSW north coast in the area of the project and include all named waterways in the region of the project.

The key fish habitats for the project, as currently defined by the NSW Department of Primary Industries and from investigations undertaken for the Biodiversity Working Paper, are listed in Table 2-9. In the context of this project, these key fish habitats are classified as sensitive receiving environments.

Further details of aquatic habitats are given in Section 3 of the Biodiversity Working Paper

**Table 2-9 Location of key fish habitats crossing or near the project**

| Section | Key fish habitats present |
|---|---|
| 1 | Arrawarra Gully, Corindi River, Cassons Creek, Blackadder Gully, Cassons Creek, Redbank Creek, Dirty Creek, Dundoo Creek, Halfway Creek, unnamed tributary to Redbank Creek at Ch 6650 |
| 2 | Halfway Creek, Wells Crossing Creek, Glenugie Creek and all unnamed waterbodies. |
| 3 | Pheasant Creek, Coldstream River, Black Snake Creek, Pillar Valley Creek, Chaffin Creek, Champions Creek, unnamed tributary of Glenugie Creek at Ch 39700, unnamed tributary of Pillar Valley Creek at Ch 48000, unnamed tributary of Chaffin Creek at Ch 54600 |
| 4 | South Arm (Clarence River), Edwards Creek, Shark Creek. |
| 5 | James Creek, Clarence River, Serpentine Channel, North Arm (Clarence River), Mororo Creek, all unnamed waterbodies, including the unnamed tributary of James Creek at Ch 84400. |
| 6 | Mororo Creek, Nyrang Creek, Tabbimoble Creek, all unnamed waterbodies. |
| 7 | Tabbimoble Floodway No. 1, Nortons Gully, Oaky Creek, all unnamed water bodies including waterways at Ch 114000, 121700 to 122400 and 124500 |
| 8 | Tuckombil Canal, Rocky Mouth Creek, Macdonalds Creek, the unnamed waterways at Ch 134700 and 136450. |
| 9 | Montis Gully, Eversons Creek, all unnamed waterbodies including the tributary of Montis Gully at Ch 141850. |
| 10 | Richmond River, Tuckean Swamp and Broadwater, unnamed tributaries of Bingal Creek at Ch 149250, 150600 and153900. |
| 11 | Duck Creek, Emigrant Creek. |

### 2.8.5. Class 1 and 2 waterways

Class 1 and 2 waterways are considered to be sensitive receiving environments. The definition of class 1 and 2 waterways is given in Table 2-10 (Fairfull and Witheridge, 2003).The waterways on the project that are currently understood to be classified as class 1 or class 3 have been given previously in Table 2-8.

**Table 2-10 Characteristics of waterway types**

| Classification | Characteristics of waterway type |
|---|---|
| Class 1<br>Major fish habitat | Major permanently or intermittently flowing waterway (eg river or major creek), habitat of a threatened fish species. |
| Class 2<br>Moderate fish habitat | Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi - permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area. |

### 2.8.6. Threatened fish

Six listed species are known to occur in the broader region of the study area which are a federally listed species under the EPBC Act and in NSW, under the FM Act. These are the Oxleyan Pygmy Perch (*Nannoperca oxleyana*), Eastern (Freshwater) Cod (*Maccullochella ikei*), Purple-spotted Gudgeon (*Morgunda adspersa*), Black Cod (*epinephelus daemilii*), Estuary Cod (*Epinephelus coioides)* and Green Sawfish (*Pristis zijstron*). However, only the Oxleyan Pygmy Perch was observed during targeted surveys within and near the project boundary. A total of 26 Oxleyan Pygmy Perch individuals have been recorded from several studies in Section 6, 7 and 8 of the project. In Section 6, three individuals were found at a small dam situated at Tabbimoble Floodway 2, and three individuals were found downstream of the confluence of Tabbimoble 2 and 3. In Section 7, 17 individuals were recorded within an unnamed ephemeral stream near station 114.0. In Section 8, two individuals were recorded at Broadwater National Park/McDonalds Creek, and one individual was found at the upstream extent of an unnamed ephemeral stream near station 134.7. Many other water courses within the project boundary have also been identified as potential habitat for Oxleyan Pygmy Perch even if it has not been recorded, as the species appears to disperse principally during floods, when it can easily migrate from one swampy area to another. Potential habitat is present within the project boundary for the endangered Purple-Spotted Gudgeon and Eastern Freshwater Cod.

Appendix D maps the Oxleyan Pygmy Perch habitats along the project and Appendix G provides a table of waterways identifying associated known or potential threatened fish.

Further detail of threatened fish is given in Section 3 of the Biodiversity Working Paper.

### 2.8.7. Drinking water catchment

Rous Water operates two groundwater sources: one from bores in the Woodburn Sands aquifer and one tapping the Alstonville Plateau groundwater source (Innovation Planning Australia, 2009). The Woodburn Sands aquifer underlies the northern portion of the project boundary, from station 131.4 through to the end of the corridor at station 165.2 and beyond past Ballina. The Woodburn Borefield is about two kilometres southeast of Woodburn Township and the project boundary crosses the borefield at station 132.3. Three bores are operational and are installed into the Woodburn Sand aquifer (Coffey, 2006). Refer to the Groundwater Working Paper for further information. Project areas overlying the Woodburn Sand aquifer, between station 131.1 and 134.0 are deemed to be within sensitive receiving environments.

### 2.8.8. Aquaculture and commercial fishing areas

Areas that are available and or used for aquaculture and commercial fishing, as identified in the Land Use Working Paper (RMS, 2012), would be considered as sensitive receiving environments in the detailed design. It should be noted that these are not shown on the figures in Appendix D and the water quality design does not incorporate additional mitigation in these areas. However, during detailed design, these areas would be included as sensitive receiving environments during detailed design.

## 2.9. High risk areas

Where a number of sensitive receiving environments are located in a single region and where there would be severe implications from changes in surface water quality to the receiving environment, the region has been defined as a high risk area. These areas have been reviewed in Section 5.

## 2.10. Existing water quality

The water quality review is made in accordance with default trigger values for chemical and physical stressors for the protection of aquatic ecosystems in slightly disturbed estuarine and lowland river ecosystems in south-eastern Australia (ANZECC/ARMCANZ, 2000). Table 2-11 outlines the default trigger values for chemical and physical stressors. It should be noted, however, that the ANZECC/ARMCANZ trigger values are not necessarily the most appropriate measures for all waterways on the project, as some threatened aquatic faunae, namely the Oxleyan Pygmy Perch and Purple-Spotted Gudgeon, require conditions that fall outside the trigger ranges for pH. Appropriate trigger values for each water course would need to be determined during detailed design and development of the water quality monitoring plan.

**Table 2-11 Default trigger values for protection of aquatic ecosystems (ANZECC, 2000)**

| Water quality parameter | Trigger values – Lowland River | Trigger values – Estuarine |
|---|---|---|
| Temperature ($^{o}$C) | N/A | N/A |
| Turbidity (NTU) | 6-50 NTU | 0.5-10 NTU |
| Total nitrogen | 0.5 mg/L | 0.3 mg/L |
| Total phosphorous | 0.05 mg/L | 0.03 mg/L |
| Dissolved oxygen (mg/L) | N/A | N/A |
| Dissolved oxygen (% saturation) | 85-110% saturation | 80-110% saturation |
| Electrical conductivity (mS/cm) | 0.125-2.2 mS/cm | N/A |
| Salinity (ppt) | N/A | N/A |
| pH | 6.5-8.0 | 7.0-8.5 |
| Oxidation Reduction Potential (mV) | N/A | N/A |

*Note: N/A indicates no trigger values applicable for these parameters*

Existing water quality monitoring data for waterways within each section was reviewed. Generally the data included was recorded during previous investigations in the area. Raw data has been collected in some sections by SKM in 2007 and 2010 and has been included to provide an indication of water quality at that time. It should be noted that for the majority of waterways in the study area, water quality data are greater than 5 years old and conditions may have changed, or the location of monitoring may not be near the proposed crossing of the waterway. More accurate water quality will be collected through pre-construction monitoring. A review of the data generally indicates that the existing water quality for waterways crossing the project is variable and in many locations the water quality does not comply with the ANZECC/ARMCANZ guidelines.

The review of water quality for waterways potentially impacted by the project is summarised below. The detailed water quality sampling results are provided in Appendix A.

### 2.10.1. Section 1 – Woolgoolga to Halfway Creek

To assess the existing water quality conditions in Section 1, the results of samples collected in 2007 from Arrawarra Creek (part of the Solitary Islands Marine Park), Corindi River, Blackadder Gully, Cassons Creek and Redbank Creek (RTA, 2008a) were reviewed. The results are outlined in Table A - 1 in Appendix A. Dirty Creek and Dundoo Creek did not have any available sampling results.

The sampling results indicate that water quality in Section 1 waterways is generally poor, with the exception of Corindi River. All waterways sampled, other than Corindi River, had low pH levels that did not meet ANZECC/ARMCANZ (2000) lower guideline limit of 6.5 (refer to Table 2-18). This is possibly due to the presence of acid sulfate soil. The same samples also show consistently low dissolved oxygen levels. Redbank Creek and Blackadder Gully had high turbidity levels that exceeded the upper guideline limit of 50 nephelometric turbidity units (NTU), which are likely to reflect the presence of stock in the waterways at the time of sampling.

The Corindi River, its floodplain and a number of minor creeks are located north of Woolgoolga. Water quality in Corindi River and its tributary creeks is generally good. Water in the creeks tends to be tannic and brown in colour, due to staining from tannins in the native vegetation, and has low dissolved oxygen levels. The creeks are seasonally dry. Water quality is impacted by agricultural land use in some areas.

Manly Hydraulics Laboratory (NSW Department of Commerce, 2004) undertook the Corindi River estuary tidal data collection study. This involved collecting a number of water quality samples and testing for density, temperature, salinity, dissolved oxygen, pH, turbidity and chlorophyll-*a*. The study concluded that water quality in the Corindi River estuary was typical of an estuary and the parameters were all within the acceptable limits recommended by the ANZECC/ARMCANZ water quality guidelines for fresh and marine waters.

The Healthy Rivers Commission of NSW (HRC) (HRC, 2003) identified that water quality in the Corindi River and Arrawarra Creek was ‘better than average’, however bank erosion was identified as an issue.

### 2.10.2. Section 2 – Halfway Creek to Glenugie upgrade

To assess the existing water quality conditions in Section 2, the results of wet and dry weather samples taken from Glenugie Creek in 2007 (RTA, 2008b) were reviewed. The results are provided in Table A - 2 in Appendix A. The water quality of Glenugie Creek was sampled once during dry weather and classified as poor, with the sample failing to meet ANZECC/ARMCANZ guideline values for protection of aquatic ecosystems for all parameters measured. The poor water quality results recorded are likely to reflect the low flow and stagnant nature of the waterway at the time of sampling, in addition to excessive macrophyte growth and oxidation of organic matter (RTA, 2008b). Water quality during wet weather was substantially better, meeting all ANZECC/ARMCANZ (2000) recommended trigger values.

HRC (HRC, 2003) identified that water quality in Halfway Creek was relatively good, although road maintenance and poorly designed existing creek crossings have contributed to major soil and stream bank erosion (RTA, 2005a).

### 2.10.3. Section 3 – Interchange at Glenugie to Tyndale

The project crosses the upstream reaches of a number of waterways in Section 3, including Pheasant Creek, Coldstream River, Pillar Valley Creek, Chaffin Creek and Champions Creek. These waterways were sampled between 2005 and 2007 during wet and dry conditions to assess the existing water quality (RTA, 2009a). The results are outlined in Table A - 3 in Appendix A. Black Snake Creek also crosses the project boundary. However no water quality samples were collected from this waterway.

The water quality of waterways in Section 3 of the project exceeded recommended trigger values during both dry and wet weather. The creeks within Section 3 generally have low flows and often have no flow in their upstream reaches after periods of dry weather. This results in low dissolved oxygen levels, low pH and elevated turbidity, with water quality failing to meet the ANZECC/ARMCANZ (2000) guidelines for protection of aquatic ecosystems (RTA, 2009a).

Poor water quality is already known to occur throughout the section of the study area including black water events within the Coldstream River which has resulted in fish kills. Black water events can occur naturally due to the breakdown of large quantities of organic material and can result in low dissolved oxygen levels which can cause stress and eventual death of fish.

The majority of Section 3 is characterised by rural land uses, including grazing pastures, which may contribute to poor water quality. The low dissolved oxygen and pH levels at the majority of sites may also be related to the presence of acid sulfate soil.

### 2.10.4. Section 4 – Tyndale to Maclean

Section 4 of the project runs adjacent to the South Arm of Clarence River and also crosses this waterway. It crosses Edwards Creek and Shark Creek and runs in close proximity to a SEPP 14 Wetland No. 232. The results from water quality sampling undertaken for this section are provided in Table A - 4 in Appendix A.

A number of sites were sampled in 2007 during either wet or dry weather (RTA, 2009a). The results of this sampling indicated that the water quality in these streams is generally poor and fails to meet the ANZECC/ARMCANZ (2000) guidelines. Reasons for poor water quality include low flow, modified channels including floodgates, exotic weeds, acid sulfate soil and associated drainage from surrounding sugar cane fields in Edwards Creek, and agricultural runoff and bank erosion around Shark Creek and South Arm (RTA, 2009a).

Anecdotal evidence suggests poor water quality also occurs in Section 4 due to the use of floodgates and 'cane drains'. Drains and flood gate systems can accumulate acid (from surrounding acid sulfate soils) and other poor water quality conditions which can be flushed into downstream environments after rain. This water quality can have very high acidity, toxic metals and low dissolved oxygen levels.

### 2.10.5. Section 5 – Maclean to Iluka Road

Section 5 crosses the main waterways of the James Creek, Clarence River (at Harwood Bridge), Serpentine Channel and North Arm (upstream of Clarence River). These are tidally influenced waterways that exhibit estuarine water quality characteristics, although upstream reaches of James Creek are freshwater. The results from water quality sampling undertaken for this section in 2005-2007 during wet and dry conditions (RTA, 2009a) are provided in Table A - 5 in Appendix A. The results indicate that water quality was generally good, except in Serpentine Channel which failed to meet the ANZECC/ARMCANZ (2000) guidelines for turbidity, pH and dissolved oxygen during dry and wet weather. The North Arm generally had good water quality, with the exception of elevated turbidity levels during wet weather, which are likely to be the result of catchment runoff.

Anecdotal evidence suggests poor water quality also occurs in Section 5 due to the use of floodgates and 'cane drains'. Drains and flood gate systems can accumulate acid (from surrounding acid sulfate soils) and other poor water quality conditions which can be flushed into downstream environments after rain. This water quality can have very high acidity, toxic metals and low dissolved oxygen levels.

The *New South Wales State of the Beaches 2009–2010: Far North Coast region* (DECCW, 2011) provides further water quality analysis in the region. The sampling points, however, are about six kilometres upstream and 17 kilometres downstream of the project and so the data is not a relevant reference for this project.

### 2.10.6. Section 6 – Iluka Road to Devils Pulpit upgrade

Section 6 crosses the main waterways of Nyrang Creek and Tabbimoble Creek. Tabbimoble Creek is estuarine downstream of the weir and freshwater upstream. The results of water quality sampling undertaken for these creeks in 2007 (RTA, 2009a) and 2009 (RTA, 2010) are provided in Table A - 6 in Appendix A. The results of this sampling indicated that Nyrang Creek failed to meet the ANZECC/ARMCANZ (2000) lowland river default trigger values for due to elevated turbidity, low dissolved oxygen and electrical conductivity. Sampling was undertaken following rainfall and exceedences are not uncommon following wet weather; when conductivity can be lower due to dilution with rainwater and elevated turbidity (and subsequently low dissolved oxygen). Tabbimoble Creek failed to meet guidelines for electrical conductivity and dissolved oxygen. Tabbimoble Creek was also found to have high levels of aluminium, which could be a result of acid leaching from acid sulfate soil in the area.

### 2.10.7. Section 7 – Devils Pulpit upgrade to Trustums Hill

Along Section 7 of the project, the waterways are typically freshwater, unnamed and small (mostly first to third order streams). Most are ephemeral and only flow after heavy or prolonged rainfall.

For the *Iluka Road to Woodburn Concept Design Report* (RTA, 2006b), a review of existing water quality data was undertaken and relevant government and non-government agencies were approached regarding available background information. However, it is apparent that the smaller freshwater watercourses in the study area are very poorly studied, and as a consequence there is an absence of adequate baseline physico-chemical water quality data for the small freshwater creeks throughout the study area.

Water quality monitoring was undertaken in 2005 at four locations within Section 7 as part of the *Iluka Road to Woodburn Concept Design Report* (RTA, 2006b), and the results are given in Table A - 7 of Appendix A.

The southern-most site, SW10, was located near the township of New Italy and the existing Pacific Highway and was selected to represent the catchment characteristics and potential water quality constraints associated rural residences and rural roads. It was found to be less than one metre wide and to have very low flows. It was found to exhibit a very high total nitrogen concentration and high levels of total dissolved solids and total oils and greases, potentially associated with the impacts of rural residences and minor roads (RTA, 2006b).

Sites SW11 and SW12 were located south of the intersection with the existing Pacific High and Whites Road. The fourth site, SW13, was located south of the intersection with the existing Pacific Highway and Nortons Road These sites were chosen to represent the catchment characteristics and potential water quality constraints associated with smaller creeks and channels draining the costal floodplain (RTA, 2006b). SW12 and SW13 also represented areas of potential or actual acid sulfate soils. These sites were found to be larger bodies of water with no visible current.

In general, sampling and analysis showed that water quality of most of the surveyed creeks does not comply with the relevant ANZECC/ARMCANZ (2000) water quality guideline trigger values for pH, dissolved oxygen and total nitrogen. However the observed low levels of dissolved oxygen and high levels of total nitrogen may be influenced by the low flows observed during the drought conditions in September 2005, which may limit entrainment of oxygen and result in stagnation and the concentration of nutrients (RTA, 2006b). Monitoring also showed low levels of total suspend solids (TSS), indicating that catchment activities and processes are not contributing substantial quantities of particulate material to the creeks under the low flow conditions at the time of monitoring. However, TSS levels may be elevated under higher flow conditions. Field observations noted visible oils and greases in the creek.

### 2.10.8. Section 8 – Trustums Hill to Broadwater National Park

Towards the south of Section 8, the project crosses Tuckombil Canal. The Canal connects the Rocky Mouth Creek, 500 metres upstream of the project, to the upper reaches of the Evans River, about one kilometre downstream of the project. The Evans River flows to the ocean at Evans Head.

Rous Water operates three bores in the middle of Section 8, located to the east of Woodburn near the Woodburn Evans Head Road. The region around the bores is a floodplain and contains a number of cane drains but does not include any named or mapped waterways

Towards the north of Section 8, the project crosses McDonalds Creek. McDonalds Creek flows about 1100 metres form this point to the Richmond River.

Section 8 of the project also runs within close proximity of the Broadwater National Park. The *Woodburn to Ballina Concept Stormwater Management Plan for Broadwater National Park* (RTA, 2007) states that the existing Pacific Highway does not have any runoff treatment controls. All pavement runoff drains directly into the Broadwater National Park. In that report the existing catchment was modelled using MUSIC. The results show existing loads of Total Suspended Solids to be 33 700 kilograms per year, Total Phosphorus to be 71.5 kilograms per year and Total Nitrogen to be 513 kilograms per year.

The *Woodburn to Ballina Route Options Development Report – Stage 1* (RTA, 2005b) and the *Woodburn to Ballina Preferred Route Report* (RTA, 2005c) state that water quality sampling has been undertaken by a variety of organisations within and in close proximity to the study area. The majority of the water quality sampling that has been undertaken in the area has occurred as part of the Lower Richmond Water Quality Monitoring Program, Manly Hydraulics Lab Monitoring Program and as part of the long term monitoring by Richmond River City Council. The reports results indicate that Tuckombil Canal has high salinity levels and extremely low dissolved oxygen. The reports also state that the Rocky Mouth Creek suffers from very low pH and dissolved oxygen levels. The *Iluka Road to Woodburn Concept Design Report* states that both Rocky Mouth Creek and Tuckombil Canal have highly variable water quality and are both subject to acidic influxes from acid sulfate soils in the catchment. Both watercourses have a history of fish kills, and are subject to tidal influence (RTA, 2006b). Water quality monitoring of Tuckombil Canal was undertaken in 2005 as part of that report and the results are given in Appendix A. Monitoring showed elevated electrical conductivity results that substantially exceeded the relevant ANZECC/ARMCANZ (2000) range, which can be attributed to tidal influence. The monitoring also showed phosphorus levels in exceedance of the relevant ANZECC/ARMCANZ (2000) trigger value. All the sites monitored during that study showed low levels of total suspend solids (TSS), indicating that catchment activities and processes are not contributing substantial quantities of particulate material to the creeks under the low flow conditions at the time of monitoring. However, TSS levels may be elevated under higher flow conditions. Tuckombil Canal was also monitored in September 2010 by SKM and at the time, the canal exhibited slightly elevated turbidity (11.6NTU) and low dissolved oxygen (70 per cent saturation), failing to comply with the estuarine default trigger values.

Water quality monitoring is currently being undertaken by Richmond River County Council at two sites in the region, using real-time data loggers. One is located on the Tuckombil Canal, east of the existing Pacific Highway at Woodburn, and one is located on Rocky Mouth Creek upstream on the upstream side of the floodgates. The results reflect the descriptions given in the afore-mentioned RTA reports and are included in Table A - 9 and Table A - 10 in Appendix A (Richmond River County Council, 2012).

The *New South Wales State of the Beaches 2009–2010: Far North Coast region* (DECCW, 2011) provides further water quality analysis in the region. The sampling points, however, are about 14km from the project, at the outlet of the Evans River near Evans Head, and so the data is not a relevant reference for this project.

The water quality of Evans River was reviewed in 2002 as part of the Evans River Estuary Management Study and Plan (Richmond Valley Council, 2002). Although dated, the relevant findings include:

- Most upstream sections of the estuary are predisposed to poor water quality due to naturally poor tidal flushing and local Acid Sulfate Soil runoff
- Water quality in the Evans River depends on the condition of the fabri-dam (which has been placed across the upper reaches of the river at Woodburn to retard the flow of fresh water into the Evans River and, the flow of saltwater back into the Richmond River), as well as the water quality of the Richmond River and Rocky Mouth Creek, which may be contributing
- Catchment-based nutrient inputs into the estuary are relatively low, with no additional significant point source loads. However, due to poor tidal flushing and a small dry weather baseflow, the river is very sensitive to continuous (i.e. dry weather) pollutant loading
- Due to the additional inputs through Tuckombil Canal, the Evans River receives catchment runoff pollutants (such as nutrients, sediment and bacteria) equivalent to a catchment, which is twice its size
- On average, the Evans River receives nearly 20 tonnes of phosphorus and over 300 tonnes of nitrogen per year, with nearly all of this being discharged to the ocean during floods or ebb tide flows. Only a small amount of phosphorus would remain trapped within the estuary attached to fine sediments
- Rocky Mouth Creek upstream of the Tuckombil Canal junction can be a source of poor water quality (eg low pH and low dissolved oxygen), which is advected into the Evans River (Tuckombil Canal) during each ebb tide when the fabri-dam is down
- Water quality has rarely been measured in the Evans River, and the data that is available was collected on an opportunity basis, or in response to an incident, such as an estuary-wide fish kill.

### 2.10.9. Section 9 – Broadwater National Park to Richmond River

At the northern end of Section 9, the Tuckean Broadwater flows into the Richmond River from the upstream Tuckean Swamp. Montis Gully flows adjacent to the upgrade for about 850 metres before flowing a further 1100 metres to the Richmond River. Eversons Creek also flows next to the project for around 900 metres and then continues for about 1000 metres to the Richmond River.

The *Woodburn to Ballina Route Options Development Report – Stage 1* (RTA, 2005b) and the *Woodburn to Ballina Preferred Route Report* (RTA, 2005c) state that water quality sampling has been undertaken by a variety organisations within and in close proximity to the study area. The majority of the water quality sampling that has been undertaken in the area has occurred as part of the Lower Richmond Water Quality Monitoring Program, Manly Hydraulics Lab Monitoring Program and as part of the long term monitoring by Richmond River City Council. The reports state that state that the Tuckean Broadwater has very low pH levels, extremely low dissolved oxygen levels and high turbidity levels, failing to meet most of the default trigger values for the protection of aquatic ecosystems

Water quality monitoring is being undertaken by Richmond River County Council at four sites in the region, using real-time data loggers. Site 1 is located at Bagotville in the Tuckean Broadwater downstream of Bagotville Barrage, Site 2 is located upstream of Bagotville Barrage in the Tuckean Swamp, and Sites 3 and 4 are in the upstream sections of the Tuckean Swamp. This data also shows low salinity, dissolved oxygen and pH levels in these waters. Further information is given in Table A - 11 to Table A - 14 in Appendix A.

### 2.10.10. Section 10 – Richmond River to Coolgardie Road

In Section 10, the project crosses the Richmond River and, Saltwater Creek, a tributary of the Richmond River. At the northern extent of Section 10, the project crosses Randals Creek.

The *Woodburn to Ballina Route Options Development Report – Stage 1* (RTA, 2005b) and the *Woodburn to Ballina Preferred Route Report* (RTA, 2005c) state that water quality sampling has been undertaken by a variety organisations within and in close proximity to the study area. The majority of the water quality sampling that has been undertaken in the area has occurred as part of the Lower Richmond Water Quality Monitoring Program, Manly Hydraulics Lab Monitoring Program and as part of the long term monitoring by Richmond River City Council. The reports state that the Richmond River shows neutral pH levels in the river in the northern part of Section 10 near Wardell, and low levels of dissolved oxygen.

The reports also state that cane cultivation in the area of the Richmond River has resulted in the construction of a network of channels with tidal gates preventing backflow from the river up the channels. As a result, the water table has lowered and exposed acid sulfate soil, which cause significant quantities of sulphuric acid to be realised into the Richmond River.

The *Ballina Shire Council State of the Environment Report* states that water quality in the Richmond River is affected by acidic water associated with acid sulfate soils, sewage discharge related to poorly managed onsite systems, sediment loads and the resale of deoxygenated water in the river from the deterioration of inundated vegetation (Ballina Shire Council, 2010). It also reports that the NSW Department of Industry and Investment identified that deoxygenated water leaving flood plains and poor management of flood gates are a main contributor to fish kills in the river.

NSW Office of Water provides information on river water quality (NSW Office of Water, 2012a). For Richmond River sites in this area, the monitoring was last undertaken in 1995 and therefore not suitable to provide an understanding of existing water quality.

### 2.10.11. Section 11 – Coolgardie Road to Ballina Bypass

Section 11 of the project crosses the Duck Creek and extends near to the crossing with Emigrant Creek.

The *Woodburn to Ballina Route Options Development Report – Stage 1* (RTA, 2005b) and the *Woodburn to Ballina Preferred Route Report* (RTA, 2005c) state that water quality sampling has been undertaken by a variety organisations within and in close proximity to the study area. The majority of the water quality sampling that has been undertaken in the area has occurred as part of the Lower Richmond Water Quality Monitoring Program, Manly Hydraulics Lab Monitoring Program and as part of the long term monitoring by Richmond River City Council. The reports indicate that the issues of concern within the study area are very low pH and dissolved oxygen levels and elevated turbidity levels at a number of sites.

The *New South Wales State of the Beaches 2009–2010: Far North Coast region* (DECCW, 2011) provides further water quality analysis in the region. The sampling points, however, are about 10km from the project, at the mouth of the outlet of the Richmond River in Ballina, and so the data is not a relevant reference for this project.

Water quality data was also compiled and reported for the region, including sites on Duck Creek and Emigrant Creek, by the EPA in 1996 (EPA, 1996) but the age of this data means it is no longer a suitable reference for this project. Duck Creek was monitored by SKM in September 2010 at the proposed crossing. The water quality at this time failed to comply with the trigger values for protection of estuarine aquatic ecosystems due to slightly elevated turbidity (10.4NTU) and low dissolved oxygen (64 per cent saturation).

Rous Water Rous Water monitors the quality of water within streams and waterways in their regional water supply catchment areas. This includes 12 locations in the northern section of Emigrant Creek that feeds the Emigrant Creek Dam. The data from this monitoring program is not relevant, however, as it is only the southern, downstream section of Emigrant Creek that is in the vicinity of the project.

The results of these programs indicate that the waterways in this project section are degraded and have poor water quality.

## 2.11. Summary of existing conditions in each section

Table 2-12 to Table 2-22 provide a summary of relevant existing conditions for each of the project sections. These tables also describe the presence of acid sulfate soil and soil erodibility for each section.

**Table 2-12 Water courses and soil conditions relevant to Section 1**

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Arrawarra Gully, Corindi River, Blackadder Gully, Cassons Creek, Redbank Creek, Dirty Creek, Dundoo Creek, Halfway Creek<br>• Corindi River, Cassons Creek and Blackadder Creek form part of the Corindi River floodplain.<br>• Arrawarra Gully, Corindi River, Blackadder Gully, Cassons Creek, Redbank Creek and Dirty Creek flow to the Solitary Islands Marine Park. |
| **Key fish habitats** | • All of the above, plus an unnamed tributary of Redbank Creek at station 6.7 |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • Arrawarra Gully, Corindi River, Cassons Creek, Redbank Creek, Halfway Creek, unnamed tributary of Redbank Creek at station 6.7 |
| **Description** | • Creeks are primarily lowland freshwater systems. |
| **Acid sulfate soil** | • The majority of Section 1 is mapped as having no known occurrence of acid sulfate soil. There are areas of low and high probabilities of occurrence mapped for the lowland coastal plains in the southern portion of the route near the Arrawarra and Corindi Beach localities. |
| **Soil erodibility** | • Areas of highly erodible and water erosion prone landscapes |
| **SEPP 14 and Nationally Important wetlands** | • There is a SEPP14 wetland (No. 314) located 60 metres east of the project near Corindi Beach. |
| **High risk areas** | • Solitary Islands Marine Park |

**Table 2-13 Water courses and soil conditions relevant to Section 2**

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Halfway Creek, Wells Crossing Creek, Glenugie Creek |
| **Key fish habitats** | • All named waterways, plus all unnamed waterbodies. |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • All named waterways, plus all unnamed waterbodies |
| **Description** | • Primarily lowland freshwater systems. |
| **Acid sulfate soil** | • No known occurrence of acid sulfate soil. |
| **Soil erodibility** | • Assumed to be highly erodible. |
| **SEPP 14 and Nationally Important wetlands** | • N/A |

**Table 2-14 Water courses and soil conditions relevant to Section 3**

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Pheasant Creek, Coldstream River, Black Snake Creek, Pillar Valley Creek, Chaffin Creek, Champions Creek. |
| **Key fish habitats** | • All named waterways, plus unnamed tributary of Glenugie Creek at station 39.7, unnamed tributary of Pillar Valley Creek at station 48.0, unnamed tributary of Chaffin Creek at station 54.6 |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • Coldstream River, Black Snake Creek, Pillar Valley Creek, Chaffin Creek. |
| **Description** | • Waterways are primarily lowland freshwater systems.<br>• Coldstream Creek, Chaffin Creek and Champions Creek have estuarine properties downstream and lowland river characteristics upstream. |
| **acid sulfate soil** | • Majority of the project section is mapped as having no known occurrence of acid sulfate soil.<br>• Route traverses several isolated areas of low and high probability of occurrence in the southern and central portions. |
| **Soil erodibility** | • Assumed to be highly erodible. |
| **SEPP 14 and Nationally Important wetlands** | • The alignment of the project runs adjacent to the southern boundary of Crows Nest Swamp.<br>• SEPP 14 wetland (No. 287) is located about 600 metres downstream from the proposed crossing of Champions Creek.<br>• The SEPP 14 wetland (No. 289) associated with Chaffin Creek is located about 450 metres to the west of the project.<br>• The SEPP 14 wetland (No. 292) is part of the Upper Coldstream Wetlands, associated with Coldstream River and Pillar Valley Creek, located downstream and to the west of the alignment. |
| **High risk areas** | • Upper Coldstream Wetlands |

**Table 2-15 Water courses and soil conditions relevant to Section 4**

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • South Arm (Clarence River), Edwards Creek, Shark Creek. |
| **Key fish habitats** | • South Arm (Clarence River), Shark Creek. |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • N/A |
| **Description** | • Tidally influenced estuarine systems dominated by saline conditions, although the upstream reaches of Shark Creek are considered to be a lowland freshwater ecosystem. |
| **Acid sulfate soil** | • Majority of section is mapped as having a high probability of occurrence. Isolated areas of no known occurrence located in the central and northern portions near the Maclean locality. |
| **Soil erodibility** | • Areas of highly erodible and water erosion prone landscapes. |
| **SEPP 14 and** | • The alignment near Shark Creek is in close proximity to SEPP 14 |

| | |
|---|---|
| **Nationally Important wetlands** | wetland no. 232 which is located on the eastern side of the upstream reaches of Shark Creek, upstream of the project. |

**Table 2-16 Water courses and soil conditions relevant to Section 5**

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • James Creek, Nyrang Creek, Clarence River, Serpentine Channel, North Arm (Clarence River), Mororo Creek. |
| **Key fish habitats** | • All named waterways plus all unnamed waterbodies, including the unnamed tributary of James Creek at station 84.4. |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • Clarence River |
| **Description** | • The Clarence River is the largest river on the NSW coast. Waterways in this project section are mainly tidally influenced estuarine systems dominated by saline conditions with estuarine water quality characteristics. |
| **Acid sulfate soil** | • High probability of acid sulfate soil along entire section. |
| **Soil erodibility** | • Areas of water erosion prone landscapes. |
| **SEPP 14 and Nationally Important wetlands** | • The project runs adjacent to SEPP 14 wetland no. 220a which is located to the south east of the section. James Creek flows through this wetland which extends into Yaegl Nature Reserve (primarily consisting of an estuarine back swamp).<br>• SEPP 14 wetland no.153c is located about 400 metres west of the project crossing of North Arm. |

**Table 2-17 Water courses and soil conditions relevant to Section 6**

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Mororo Creek, Tabbimoble Creek |
| **Key fish habitats** | • All named waterways and unnamed waterbodies. |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • All named waterways and unnamed waterbodies. |
| **Description** | • Tabbimoble Creek is estuarine downstream of the weir and freshwater upstream. |
| **Acid sulfate soil** | • The entire project section is mapped as having no known occurrence of acid sulfate soil. However an area of low probability of occurrence is located immediately west of the route in the southern portion. |
| **Soil erodibility** | • Areas or highly erodible and moderately erodible landscapes. |
| **SEPP 14 and Nationally Important wetlands** | • There is a SEPP 14 wetland no. 153a located on Tabbimoble Creek about one kilometre east of the project.<br>• The SEPP 14 wetland no. 153 is located about 4.5 kilometres to the east |

| | |
|---|---|
| | of the project, mostly within the Bundjalung National Park and Devils Pulpit State Forest, and extends between the North Arm of the Clarence River in the south and the Evans River in the north. |

**Table 2-18 Water courses and soil conditions relevant to Section 7**

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Tabbimoble Floodway No. 1, Nortons Gully, Oaky Creek. |
| **Key fish habitats** | • All named waterways and unnamed water bodies including waterways at stations 114.0, 121.7 to 122.4 and 124.5 |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • All named waterways and unnamed waterbodies. |
| **Description** | • Waterways in Section 7 are typically freshwater and small. Many are ephemeral and flow only after heavy or prolonged rainfall. |
| **Acid sulfate soil** | • The majority of the project section has no known occurrence of acid sulfate soil. Isolated areas of low and high probability are located in the northern portion of the project on both the eastern and western sides. |
| **Soil erodibility** | • Areas of highly erodible and moderately erodible landscapes. |
| **SEPP 14 and Nationally Important wetlands** | • SEPP 14 wetland no. 161 is located about 260 metres east of the project |
| **High risk areas** | • Tabbimoble Swamp Nature Reserve |

**Table 2-19 Water courses and soil conditions relevant to Section 8**

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Tuckombil Canal (becomes Evans River), Rocky Mouth Creek, Macdonalds Creek |
| **Key fish habitats** | • Tuckombil Canal, Rocky Mouth Creek, Macdonalds Creek, the unnamed waterways at station 134.7 and 136.5. |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • As per the key fish habitats. |
| **Description** | • Waterways in Section 8 are typically freshwater and small creeks. Many are ephemeral and flow only after heavy or prolonged rainfall. Tuckombil Canal is a flood control structure to direct waters from the Richmond Floodplain to the ocean via Evans River and is subject to tidal influences. |
| **Acid sulfate soil** | • The majority of Section 8 is mapped as having a high probability of occurrence and is located close to the boundary of low and high probability areas to the north of Woodburn<br>• Southern extremity of the route is mapped as having no known occurrence of acid sulfate soil |
| **Soil erodibility** | • Areas of highly erodible landscapes. |
| **SEPP 14 and** | • The project runs adjacent to Broadwater National Park which contains a |

| | |
|---|---|
| **Nationally Important wetlands** | number of SEPP 14 wetlands. |
| **High risk areas** | • The Rous Water borefields are located in this project section to the east of Woodburn |

### Table 2-20 Water courses and soil conditions relevant to Section 9

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Montis Gully, Eversons Creek |
| **Key fish habitats** | • All named waterways plus all unnamed waterbodies, including the unnamed tributary of Montis Gully at station 141.9. |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • Broadwater National Park and all unnamed waterbodies, including the unnamed tributary of Montis Gully at station 141.9. |
| **Description** | • With the exception of Richmond River, waterways in Section 9 are typically freshwater and small<br>• Richmond River is a large tidal river |
| **Acid sulfate soil** | • The majority of the project section is mapped as having a high probability of occurrence. Southern portion of project section mapped as having a low probability of occurrence.<br>• Cane cultivation around the Richmond River has exposed acid sulfate soil |
| **Soil erodibility** | • Areas of highly erodible and water erosion prone landscapes. |
| **SEPP 14 and Nationally Important wetlands** | • The project runs through Broadwater National Park which contains a number of SEPP 14 wetlands including SEPP 14 No. 121. |
| **High risk areas** | • Broadwater National Park |

### Table 2-21 Water courses and soil conditions relevant to Section 10

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Tuckean Swamp and Tuckean Broadwater (upstream of Richmond River), Richmond River, Saltwater Creek, Randals Creek. |
| **Key fish habitats** | • Tuckean Swamp and Tuckean Broadwater (upstream of Richmond River), Richmond River, unnamed tributaries of Bingal Creek at stations 149.3, 150.600 and 153.9. |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • Tuckean Swamp, Tuckean Broadwater and Richmond River. |
| **Description** | • The project in this project section crosses a wide floodplain. |
| **Acid sulfate soil** | • The majority of the project section is mapped as having a low probability of occurrence. Northern portion of route mapped as having no known occurrence of acid sulfate soil.<br>• Cane cultivation around the Richmond River has exposed acid sulfate |

| | |
|---|---|
| | soil |
| **Soil erodibility** | • Areas of highly erodible landscapes. |
| **SEPP 14 and Nationally Important wetlands** | • SEPP 14 wetland No.119 mangroves are located at Tuckean Broadwater (700 metres upstream from the proposed crossing at Richmond River)<br>• SEPP 14 wetlands no.118 and 118a are located on the northern banks of the Richmond River, along either side of the project |
| **High risk areas** | • Wardell Heath |

### Table 2-22 Water courses and soil conditions relevant to Section 11

| | |
|---|---|
| **Named waterways crossing or near to the alignment** | • Duck Creek, Emigrant Creek |
| **Key fish habitats** | • Duck Creek, Emigrant Creek. |
| **Mapped, recorded or potential habitats of threatened aquatic species** | • N/A |
| **Description** | • Creeks in Section 11 are located on a floodplain and while they are freshwater in their upstream reaches, they are estuarine in the proximity of the proposed alignment and subject to tidal influences |
| **Acid sulfate soils** | • Majority of project section mapped as having a high probability of occurrence<br>• Southern extremity of route mapped as having a low probability of occurrence |
| **Soil erodibility** | • Areas of highly erodible and water erosion prone landscapes. |
| **SEPP 14 and Nationally Important wetlands** | • SEPP 14 wetlands no. 108 and 95 are located around Duck Creek and Emigrant Creek respectively, which are directly affected by the project |

# 3. Impact assessment

## 3.1. Potential construction impacts

The construction phase of the project presents a high risk to downstream water quality if management measures are not implemented, monitored and maintained throughout the construction process. The risks are presented during rainfall and wind events, when sediments or pollutants resulting from construction can flow or be blow to sensitive receiving environments. The highest risk to water quality would occur through the following activities:

- Works in waterways such as bridge pier construction
- Installation of culverts
- Stockpiling of topsoil and vegetation
- Transportation of cut or fill materials
- Movement of heavy vehicles across exposed earth including along haulage routes
- Removal of riparian vegetation
- Earthworks, including stripping of vegetation and topsoil, excavation or raising
- Realignment of waterways and creek beds
- Construction of drainage infrastructure
- Spills from construction equipments
- Blasting
- Construction in steep areas
- Construction in highly erodible areas
- Construction in contaminated land
- Construction in acid sulfate soil
- Construction in areas upstream of sensitive receiving environments
- Contamination from concrete batch plants, chemical storage areas and washdown locations
- Construction in drinking water catchments.

These activities expose soils and, without proper management, may result in sediments and associated pollutants being washed during rainfall events or being blown into downstream watercourses, with consequent degradation of water quality.

The impact of unmitigated construction activities on receiving surface waters could include:

- Increased sediment loads from exposed soil during rainfall events and dust blown off site, causing high sediment loads to be washed or deposited into downstream waterways, with the potential to (Flaxmann,1967):
  - Smother aquatic life and inhibit photosynthesis conditions for aquatic and riparian flora
  - Impact breeding and spawning conditions of aquatic fauna
  - Change water temperature conditions due to reduced light penetration
  - Affect the ecosystems of downstream sensitive waterways, wetlands and floodplains

  - o Increase turbidity levels in water supply catchments above the design levels of the water treatment infrastructure
  - o Detract from the visual aesthetics of clear waterways
  - o Reduce visibility in recreational areas which may result in the inability to see accidents during swimming and reduced enjoyment during swimming and boating
  - o Cause excessive wear of sprinkler nozzle heads and fittings in irrigation systems drawing water from the waterway
- Increased levels of nutrients, metals and other pollutants, transported via sediment to downstream water courses
- Chemicals, oils, grease and petroleum hydrocarbon spills from construction machinery directly polluting downstream waterways
- Increased levels of litter from construction activities polluting downstream watercourses
- Contamination of waterways as a result of disturbance of contaminated land
- Acidification of receiving waters as a result of disturbance of acid sulfate soils during construction
- Tannin leachate from clearing and mulching.

Sections 3.1.1 to 3.1.13 analysis these water quality impacts in further detail and Section 5 reviews the impact of the project on water quality in high risk locations along the project. Measures to minimise erosion, sedimentation and pollution during construction are outlined in Section 4.2 and Appendix B of this report, and would be further detailed in a SWMP to be developed as part of the Construction Environmental Management Plan (. These measures would address the potential impacts detailed in this report and reduce risks to acceptable levels.

### 3.1.1. Impact of water quality changes on fish habitats

The Biodiversity Working Paper analyses the key impacts and mitigation requirements for aquatic species and habitats. A summary is provided here, relevant to water quality.

Changes in water quality have the potential to impact upon aquatic ecosystems, particularly fish. Throughout the study area there are 32 fish and decapods species and the potential for three threatened species (Oxleyan Pygmy Perch, Purple-Spotted Gudgeon, and Eastern (Freshwater) Cod. While impacts are relevant to all fish species, the discussion below is focussed upon threatened fish species that occur or have potential to occur within the study area (Oxleyan Pygmy Perch, Purple-Spotted Gudgeon & Eastern Freshwater Cod).

Oxleyan Pygmy Perch and Purple-Spotted Gudgeon Both have similar and specific habitat requirements. The water quality requirements include:

- Physical parameters: pH 3 – 5.
- Conductivity < 350µS/cm.
- Dissolved oxygen > 2mg/L.
- Low turbidity (tannin stained).

A key point to note is the low pH levels identified with the habitat. Both species are sensitive to any changes in these water conditions and the associated habitat. There is potential for a change at known and potential sites during both the construction and operational phases of the project. In particular, any increase in total suspended solids, reduction in dissolved oxygen and/or change in pH beyond the tolerance limits of Oxleyan Pygmy Perch is considered to represent an unacceptable change.

The potential impacts from the project on threatened fish subject species is discussed in Table 3-1. There is potential to minimise the likely impacts through appropriate and targeted mitigation and management actions during construction and operation and this is discussed in Section 4.2.18 and in more detail in the Biodiversity Working Paper.

**Table 3-1 Likely impacts on threatened fish subject species**

| Species | Water quality conditions associated with habitat | Likely impacts |
|---|---|---|
| Oxleyan Pygmy Perch | The species is restricted to aquatic habitats with suitable physicochemical water quality conditions, specifically acidic waters (pH 4.4-6.8) with low conductivity (90 to 830µS/cm). | The project would result in changes to potential aquatic habitat within the study area.<br><br>Potential impacts may result from changes to the water quality parameters preferred by this species |
| Purple-spotted Gudgeon | The species is restricted to aquatic habitats with suitable physicochemical water quality conditions, specifically waters with a pH ranging from 5.6 to 8.8, conductivity of 72 to 4,295µS/cm, dissolved oxygen between 0.6 and 12.8mg/L and low turbidity. | Construction of the project would result in short term impacts on immediate downstream reaches. Potential impacts may result from changes to the water quality parameters preferred by this species |
| Eastern Freshwater Cod | Water quality associated with areas of large woody debris (snags) and intact riparian vegetation. Potential habitat was observed in the middle section of Coldstream River, Chaffin Creek and Pillar Valley Creek. | Construction of the project would result in short term impacts on immediate downstream reaches associated with potential sediment input during high rainfall events. Potential habitat identified in Section 3 |

### 3.1.2. Impacts of water quality changes on sensitive receiving environments

Increased levels of turbidity, sediment deposition, decreased dissolved oxygen changed pH levels in waterways downstream of the project as a result of construction activities could have an adverse impact on the health of aquatic environments in natural areas such as Nationally Important and SEPP 15 wetlands, the Solitary Island Marine Park, national parks, marine parks, conservation areas, threatened ecological communities, key fish habitats, habitats of threatened aquatic fauna, recreational swimming areas and drinking water catchments. Without mitigation, impacts in these areas could be significant and include loss of biodiversity, reductions in populations of species and or loss of species. It is for this reason that these areas have been classified as sensitive receiving environments (refer to Section 2.8). Mitigation measures specific to sensitive receiving environments during the construction phases are given in Section 4.2.19.

### 3.1.3. Impacts of changes to surface water quantity on water quality

Changes to flow regimes can impact water quality in waterways by changing the volumes and flow rates of water. A reduction in flow and volume of water could lead to stagnation of a waterway. It may also lead to changes in levels of turbidity, nitrogen and phosphorus. These changes may affect the balance of aquatic ecosystems. Changes to flow regimes can also potentially expose Potential Acid Sulfate Soils (PASS) if ground waters are reduced.

Construction of the project could change the proportion of pervious areas in a catchment, altering the flow patterns of the catchment. The change in pervious area would generally be small in comparison to the overall catchment area and so the impact would not be significant.

Temporary diversions of offsite flow, excavations and embankments could also alter flow patterns and change the shape of the catchment. As these changes would be temporary during the construction phase, the impacts would not be significant. A discussion of the construction impacts of changes to flow regimes on waterway and farm dam hydrology, due to permanent diversions of flow and other changes to the catchment, is covered in the Flooding and Hydrology Working Paper

Mitigation measures for the changes to surface watery quality due to water quantity during the construction phases are given in Section 4.2.8.

### 3.1.4. Impacts of surface water on groundwater including drinking water sources

In general, construction impacts could result in changes to relative groundwater levels and potentially to groundwater quality. The Groundwater Working Paper covers these subjects in detail and should be read in conjunction with this paper.

Potential risks to groundwater quality from surface water during construction include:

- Contamination by hydrocarbons from accidental fuel and chemical spills during construction activities, refuelling or through storage facilities
- Contaminants contained in turbid runoff from unpaved surfaces.

Intersection of the water table during excavation works is likely at a number of locations and this will result in groundwater ingress and mixing with surface water. Localised diversions, or dewatering, may be required.

Infiltration of surface water from site runoff to groundwater sources is also possible. This process of infiltration is generally effective in filtering polluting particles and sediment. Hence the risk of contamination of groundwater from any pollutants bound in particulate form in the surface water, such as heavy metals, is generally low. Further, low density pollutants such as insoluble hydrocarbons (oils, tars, petroleum products) will be preferentially retained in the soil profile and will not penetrate to the water table. However, mitigation would still be required in areas where the water table is high or in high risk areas such as the Rous Water Regional Water Supply catchment as there is the potential for long-term accumulation of contaminants in the upper soil profile to represent a long term contamination risk. Mitigation measures would be adequately designed to ensure that these contaminants (pollutants bound in particulate form) are removed prior to discharge to the receiving environment.

Soluble pollutants, however, such as acids and alkalis, salts and nitrates, as well as soluble hydrocarbons, will infiltrate through soils into the groundwater source and may be an issue as the solute would not be removed by the infiltration process. Under certain pH conditions, metals may also become soluble and could infiltrate groundwater. In these areas chemical treatment may be necessary. This should be considered during the detailed design of sedimentation basins.

Mitigation measures to account for these circumstances are required during construction and are given in Section 4.2.9.

**Groundwater dependent ecosystems**

One of the implications of impacts to groundwater quality included the potential contamination of groundwater dependent ecosystems in the study area. The impacts to groundwater dependent ecosystems are covered in Section 4 of the Biodiversity Working Paper.

**Rous Water Regional Water Supply catchment**

The major implication of surface water quality affecting groundwater quality is the potential contamination of drinking water sources. In Section 8 of the project, there are three groundwater bores operated by Rous Water Regional Water Supply, located east of Woodburn in the Richmond Valley. This water supply source draws raw water from the Woodburn Sands aquifer system. The bores generally provide a suitable quality of raw water such that with appropriate treatment, the bores can function effectively as a drinking water supply source The Woodburn Sands aquifer is an unconfined coastal sands aquifer, with the water table typically located within two metres of the ground surface. If unmitigated, construction between station 131.1 and 134.0 may result in contamination of this groundwater source with a range of pollutants including sediments, nutrients, hydrocarbons, metals, and pathogens, through direct intersection or infiltration, as discussed previously. Furthermore, the setting of the borefield is in a high risk area for the presence of acid sulfate soils (as identified in Sections 2.5 and 3.1.6). Any decrease in pH of the ground water, either through de-watering leading to acid production or allowing infiltration of acid water into the ground water system, would create an elevated risk of dissolved metal contaminants in the Woodburn Sand aquifer system and therefore the Woodburn water supply bores. The implication of any contamination would be that water drawn from the bores may not be for use by Rous Water without additional treatment to that which is currently provided.

There is currently no water quality mitigation for the existing road runoff in this area, which has the potential to flow into the area of the bores after rainfall events. Rous Water believes that the level of mitigation associated with the existing operational design is inadequate. During construction, the existing road would still be in operation whilst additional activities are taking place in the catchment, resulting in an overall increased risk to water quality. Mitigation to prevent or minimise the impact of construction on the Rous Water groundwater source from contamination by surface water during construction would be required, and details of this are provided in Section 5.4. With installation of these mitigation measures, risks to the water quality of the groundwater supply would be reduced. As construction proceeds, the risk to the groundwater supply would be further reduced as the filled road sections provide an additional buffer between the road and the water table.

Refer to the Groundwater Working Paper for full details of groundwater impacts and impacts to the Rous Water groundwater source.

### 3.1.5. Impact on water quality due to works in waterways

Temporary diversions of waterways during construction, the construction of permanent waterway diversions and the construction of in-stream structures in waterways may all disturb the bed and banks of the waterway and may result in soil and streambank erosion, leading to high volumes of sediment entering and polluting the waterways. The implication of these effects could include damage to aquatic plants and degraded aquatic habitats in the vicinity of the works, which would be highly detrimental to threatened aquatic species such as the Oxleyan Pygmy Perch.

There are a number of bridges to be constructed over waterways along the length of the project, and in some cases, construction of these bridges will involve construction within the waterway. A list is given in Table 3-2

A permanent waterway diversion will be constructed in Section 3 at Picaninny Creek at approximate station 35.9 at the interchange with Eight Mile Lane. At Halfway Creek in Section 2, the highway is close to the creek alignment in some areas and a temporary or permanent creek diversion may be required.

At station 143.6 in Section 9, a permanent waterway diversion of Eversons Creek will also be constructed, in order to divert the course of the creek to the eastern side of the project. In this area, Eversons Creek is not mapped as a key fish habitat.

In addition, temporary waterway diversions may be undertaken during construction of the numerous culverts along the length of the project. Mitigation to protect water quality during works within or near waterways is included in Section 4.2.12.

**Table 3-2 Bridges to be constructed at waterways**

| Section | Station | Bridge location |
|---|---|---|
| 1 | 3.6 | Corindi Creek |
| 1 | 4.0 | Corindi Floodplain |
| 2 | 4.7 | Cassons Creek |
| 2 | 20.7 | Halfway Creek |
| 3 | 36.4 | Pheasant Ck |
| 3 | 42.6 | Coldstream River 1 |
| 3 | 43.2 | Coldstream River 2 |
| 3 | 44.0 | Coldstream River 3 |
| 3 | 46.1 | Pillar Valley Creek 1 - twin bridges |
| 3 | 46.4 | Pillar Valley Creek 2 - twin bridges |
| 3 | 46.7 | Pillar Valley Creek 3 - twin bridges |
| 3 | 47.7 | Pillar Valley Creek 4 - twin bridges |
| 3 | 52.5 | Chaffin Creek |
| 3 | 57.1 | Champions Creek |
| 4 | 74.8 | Shark Creek |
| 4 | 80.2 | Edwards Creek |
| 5 | 86.2 | Clarence River - Harwood bridge |
| 5 | 89.4 | Serpentine Channel |
| 5 | 94.0 | Clarence River North Arm |
| 6 | 101.6 | Tabbimoble Creek |
| 6 | 102.9 | Tabbimoble Overflow |
| 6 | 102.9 | Tabbimoble Overflow |
| 7 | 115.3 | Tabbimoble Floodway No.1 |

| Section | Station | Bridge location |
|---|---|---|
| 8 | 130.2 | Tuckombil Canal |
| 8 | 131.1 | Woodburn Floodway Viaduct 1 |
| 8 | 136.7 | McDonalds Creek |
| 9 | 143.6 | |
| 10 | 145.3 | Richmond River |
| 11 | 164.7 | Emigrant Creek – Smith Drive |

### 3.1.6. Impact of acid sulfate soil on water quality

Table 2-2 listed the areas of actual or potential acid sulfate soil soils and sediments containing iron sulphides along the project boundary. Construction activities such as drainage, excavation, dewatering and clearing pose a significant environmental risk when they are carried out in the areas identified as having acid sulfate soil. The activities could disturb and expose acid sulfate soil to oxygen, which could generate sulphuric acid and toxic quantities of aluminium and other heavy metals. These could be readily released into the surrounding environment, polluting surface water and groundwater.

The implication of acid sulfate soils entering water bodies include changes to pH levels and the potential for habitat degradation, fish disease or kills, losses in food resources, lowered potential for fish migration and recruitment, disturbance to water plant communities and secondary effects on water quality (Stone *et al.* 1998).

The Rous Water Regional Water Supply catchment is located in a high risk area for the presence of acid sulfate soils. Infiltration of acid water into the ground water system would create an elevated risk of dissolved metal contaminants in the Woodburn Sand aquifer system and therefore the Woodburn water supply bores.

Measures for management of acid sulfate soils during construction are given in Section 4.2.5.

### 3.1.7. Influence of soil erodibility

Throughout the project, there are erosional, transitional and alluvial landscapes containing soils that are often highly erodible with low bearing strength. A description of the existing conditions was given in Section 2.4 and figures are provided in Appendix F. Table 3-2 lists the locations of soils landscapes that are highly erodible, moderately erodible and water erosion prone.

In areas where erodibility is moderate or high, if mitigation measures aren't established during construction, sediment would be more easily eroded and transported into waterways than in areas where soil is not as erodible, potentially increasing the turbidity of waterways above the ANZECC/ARMCANZ trigger levels, with resulting implication on aquatic plants, fauna and habitats visual amenity, as detailed in Section 3.1

**Table 3-3 Location of highly erodible, moderately erodible and erosion prone landscapes**

| Project section | Highly erodible (eg alluvial, transferral, erosional, aeolian landscapes.) | Moderately erodible (eg Stagnant alluvial.) | Water erosion prone (eg estuarine, swamp) |
|---|---|---|---|
| 1 | Southern portion of section in the lower elevations (i.e. < 10 m).<br>Higher elevations toward the central portion, near the Dirty Creek locality. | | Southern portion of section in the lower elevations (i.e. < 10 m). |
| 2 | Assumed predominant throughout. | | |
| 3 | Assumed predominant throughout. | | |
| 4 | Northern portion in the lower elevations (i.e. < 5 m).<br>Higher elevations near Maclean. | | Northern portion in the lower elevations (i.e. < 5 m). |
| 5 | | | Clarence River Delta and associated floodplains. |
| 6 | Predominant throughout.<br>Central portion. | Northern extremity near Tabbimoble. | |
| 7 | Predominant throughout.<br>Isolated areas in the northern portion near New Italy and Trustums Hill. | Isolated areas in the southern and central portions. | |
| 8 | Predominant throughout. | | |
| 9 | Predominant throughout. | | Northern extremity of section adjoining the Richmond River (south bank) near the Broadwater locality |
| 10 | Predominant throughout.<br>Southern extremity of section adjoining the Richmond River (north bank). | | |
| 11 | Predominantly underlain throughout.<br>Southern end of section and generally west of Pimlico Island. | | Northern end of section typically west of Emigrant Creek. |

### 3.1.8. Impact of large excavations and embankment construction

Construction of large excavations and embankments, exceeding a single bench, pose an elevated risk to water quality in downstream waterways through the increased likelihood of movement of sediment off steep slopes. If mitigation measures aren't established during construction, sediment would be more easily eroded and transported into waterways than flat areas, potentially increasing the turbidity of waterways above the ANZECC/ARMCANZ trigger levels, with resulting implication on visual amenity, aquatic plants, fauna and habitats, as detailed in Section 3.1.

A review of the project has been undertaken to identify areas where large excavations will take place. The results are given in Table 3-4. Sections 1, 3, 4, 8, 9 and 10 all include areas of large excavation, with Section 3 of the project posing the highest risk to water quality due to the size and number of such earthworks.

**Table 3-4 Large earthworks and impacts on water quality**

| Section | Location of large excavations | Location of large embankment | Risk to water quality |
|---|---|---|---|
| 1 | 7400 - 8000 at Dirty creek | 8500-8700 | M |
| 2 | - | - | L |
| 3 | 54000-54300<br>59500-59900<br>66700-66900 at Bondi Hill<br>67600-67900<br>68100-68600 | 66900-67200 at Bondi Hill | H |
| 4 | 69100-39400<br>76000-76400<br>76600-76800 at Green Hill | - | H |
| 5 | - | - | L |
| 6 | - | - | L |
| 7 | - | - | L |
| 8 | 128300-128800 Woodburn interchange | - | M |
| 9 | 146100 | - | M |
| 10 | 147500-147600<br>147800-148100 | - | M |
| 11 | - | - | L |

### 3.1.9. Impact of high proportions of cut and fill area in a catchment

Catchments with a high proportion of batter areas pose an elevated risk to downstream water quality due to high levels of soil handling and exposure. In these cases, the size of the excavations and batters may not be large, but they may make up a large portion of the catchment. Large exposed areas within a catchment increase the potential for sediment transport to downstream waterways, potentially increasing the turbidity of waterways above the ANZECC/ARMCANZ trigger levels, with resulting implication on visual amenity, aquatic plants, fauna and habitats, as detailed in Section 3.1.

A review has been undertaken to determine the level of risk based on the proportion of batter area in a road catchment. Where the area of batters is more than 30 per cent of the catchment, the water quality risks are deemed to be elevated.

For each of the project sections, the number of high risk catchments, with batters areas greater than 30 per cent of the catchment area, was calculated. The proportion of high risk catchments in each section of the project was then calculated. Table 3-5 gives the results of the review. It can be seen that Sections 1 to 4 and Sections 6, 7 and 11 of the project have a low proportion of batters and so pose low risk to water quality. At the other end of the scale, 91% of catchments in Section 5 have a large proportion of batters. In this area, the impact to water quality could be significant. Sections 8 to 10 present medium impacts to water quality.

**Table 3-5 Sections with elevated risks due to large proportion of batters**

| Project section | Proportion of catchments within the section that have large batter area. | Risk to water quality |
|---|---|---|
| 1 | 3% | L |
| 2 | 0% | L |
| 3 | 5% | L |
| 4 | 9% | L |
| 5 | 91% | H |
| 6 | 0% | L |
| 7 | 0% | L |
| 8 | 36% | M |
| 9 | 28% | M |
| 10 | 27% | M |
| 11 | 0% | L |

### 3.1.10. Impact of road gradient on water quality

During construction, the gradient of the road affects the amount of sediment that could be washed to downstream waterways. A larger gradient would result in larger volumes of sediment. Without appropriate management measures, the impact on downstream waterways would be increased levels of turbidity.

An analysis of the gradient of the proposed road has been undertaken, the results of which are given in Table 3-6. The majority of the proposed project has a gradient of less than one per cent. There are no areas where road catchments have gradients larger than five per cent. In general, the gradient of the proposed road poses a low risk to water quality, with the exception of Section 1 of the project where slightly higher gradients may elevate the risk slightly and should be managed accordingly.

**Table 3-6 Road gradients and impact on water quality**

| Section | Proportion of road catchment with longitudinal slope of < 1% | Proportion of road catchment with longitudinal slope of 1 – 5% | Proportion of road catchment with longitudinal slope > 5% | Risk to water quality |
|---|---|---|---|---|
| 1 | 57% | 43% | 0% | M |
| 2 | 97% | 3% | 0% | L |
| 3 | 80% | 20% | 0% | L |
| 4 | 77% | 23% | 0% | L |
| 5 | 90% | 10% | 0% | L |
| 6 | 78% | 22% | 0% | L |
| 7 | 74% | 26% | 0% | L |
| 8 | 97% | 3% | 0% | L |

| Section | Proportion of road catchment with longitudinal slope of < 1% | Proportion of road catchment with longitudinal slope of 1 – 5% | Proportion of road catchment with longitudinal slope > 5% | Risk to water quality |
|---|---|---|---|---|
| 9 | 68% | 32% | 0% | L |
| 10 | 66% | 34% | 0% | L |
| 11 | 100% | 0% | 0% | L |

### 3.1.11. Impact of stockpile sites on water quality

Storage of earthwork materials, mulch and vegetation would be done using stockpiles. There are a number of sites along the project that are currently being considered for stockpiling materials. Indicative sites are listed in Table 3-7, however there may be some temporary stockpiling at some locations, prior to materials being moved to approved sites. Stockpiling of earthworks, particularly stockpiling of Potential Acid Sulfate Soils (PASS) causes a risk to downstream water quality during rainfall if the stockpiles are not managed appropriately. Sediments from the stockpiles could wash into waterways, increasing levels of turbidity if no controls are in place.

Stockpiling vegetation from cutting of trees and slashing of shrubs causes a risk of tannins leaching into waterways, and increased loads of organics in waterways. According to RMS' *Environmental Direction: Management of Tannins from Vegetation Mulch* (RMS, 2012) the main concern with the discharge of water that is high in tannins is that it may increase the biological oxygen demand (BOD) of the receiving environment, which may in turn result in a decrease in available dissolved oxygen. The Direction states that a lack of dissolved oxygen is identified as the main cause of about 80 per cent of fish kills in NSW rivers and estuaries. Once discharged to the environment, tannins may also reduce visibility and light penetration and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

Stockpiles of vegetation are more likely to be required in heavily vegetated areas, such as Section 2 and Section 7 of the project.

**Table 3-7 Key risk areas for water quality due to stockpile sites**

| Section | Location | Description of stockpile site |
|---|---|---|
| 1 | 2500 LHS | Stockpile site |
| | 3300 - 3400 RHS | Stockpile site |
| | 5250 to 5400 RHS | Materials processing and stockpile site |
| | 7400 to 7650 RHS | Materials processing and stockpiling |
| | 9550 to 9650 LHS | Stockpile site |
| | 9450 to 9650 LHS | Satellite site compound and Stockpile site |
| 2 | 17550 - 18150 LHS | Stockpile site |
| | 19100 - 19850 RHS | Satellite site compound and stockpile site |
| | 21750 to 22250 | Satellite compound and stockpile site |
| | 23600 - 24050 LHS | Stockpile site |
| | 25750 to 25950 | Stockpile site |

| Section | Location | Description of stockpile site |
|---|---|---|
| 3 | 45600 to 46000 | Materials processing and stockpile site (1ha), batch plant (0.5ha), and workshop (0.5ha). |
| | 49500 to 49600 | Site compound and stock pile site |
| | 51400 - 51500 RHS | Stockpile site |
| | 52000 RHS | Materials processing and stockpile site |
| | 56150 to 56400 RHS | Stockpile site |
| | 61150 - 61500 RHS | Stockpile site |
| 4 | 77100 RHS | Stockpile site |
| | 77150 to 77250 LHS | Stockpile site |
| | 79550 to 80000 LHS | Site compound (1ha), batch plant (0.5ha), workshop and stockpiles. |
| | 80650 - 80850 RHS | Stockpile site |
| 5 | 85950 to 86100 LHS | Stockpile area |
| | 85900 to 86200 LHS | Site compound (1ha) and stockpile area |
| | 86000 RHS | Stockpile area |
| | 90980 - 91000 LHS | Stockpile sites |
| | 90750 and 90950 | Stockpile sites |
| 6 | 98250 - 98450 RHS | Stockpile site |
| | 100200 - 100700 RHS | Materials processing and stockpile site. |
| | 102900 to 103700 LHS | Stockpile site |
| | 105600 - 106000 RHS | Satellite compound and stockpile site. |
| 7 | 114250 to 114450 | Site compound and stockpile area. |
| | 114200 - 114450 LHS | Site compound and stockpile area. |
| | 125300 - 125600 LHS | Satellite compound, workshop (0.5ha) and stockpile site. |
| 8 | 131400 to 132200 RHS | Site compound workshop (0.5ha) and stockpile site. |
| | 132000 - 132200 LHS | RMS site office and stockpile site. |
| | 132300 - 132400 LHS | Stockpile site |
| | 135000 to 135200 RHS | Site compound (1ha), batch plant (0.5ha) and stockpile site. |
| 9 | 137500 - 137900 RHS | Site compound workshop (0.5ha) and stockpile site. |
| 10 | 152650 - 152800 LHS | RMS site office and stockpile site. |
| | 156150 to 156600 RHS | Site compound (1ha), batch plant (0.5ha), workshop (0.5ha), vehicle parking and stockpile site. |
| 11 | 159800 - 160050 | Stockpile sites |
| | 163700 to 164400 | Satellite compound and stockpile site. |
| | 7400 to 7650 RHS | Materials processing and stockpiling. |
| | 9550 to 9650 LHS | Stockpile site |
| | 9450 to 9650 LHS | Satellite site compound and stockpile site. |

### 3.1.12. Impact of construction spills on water quality

Dangerous goods and hazardous materials that may be used during construction include, but may not be limited to diesel fuels, oils, greases and lubricants, petrol, gases (oxy-Acetylene), bitumen, paints and epoxies, curing compounds, herbicides and hydrated lime. Some of these hazardous materials would be stored at the construction work sites. Spills of these materials could come about from negligence or accidents, the consequences of which could be highly detrimental to aquatic ecosystems if washed into a downstream waterway in a rain event. The quantities required are not expected to pose a significant off-site risk, although mitigation would still be required and is outlined in Section 4.2.7.

### 3.1.13. Impact of contaminated land on water quality

An assessment of contaminated land has been undertaken and the results are given in Chapter 9 of the *Woolgoolga to Ballina Pacific Highway Upgrade Environmental Impact Statement.* The EIS notes areas where contaminated land is likely to exist and the related impact of this during construction. In terms of water quality, the impact of construction in contaminated land would be the contamination of surface water through disturbance and mobilisation of contaminants. Further assessment of contaminated land would be carried out during detailed design.

### 3.1.14. Impact of site compounds and materials processing sites

Site compounds and materials processing sites are likely to include sites and activities that have a high potential to impact downstream water quality, if unmitigated, through spills of pollutants flowing to downstream watercourses. These include:

- Storage of chemicals and other hazardous materials
- Processing of construction materials
- Batch plants
- Vehicle washdown areas
- Vehicle refuelling areas
- High frequency of vehicle movements.

The potential locations of site compounds are given in Table 3-7. In order to minimise the transport of sediments and pollutants from site compounds, the sites are best located on flat ground that do not require vegetation clearance, away from overland flowpaths and in areas of high topography with minimal upstream catchment.

### 3.1.15. Impacts of borrow sources

There are two borrow sources proposed along the project. These include Lang Hill at station 134.7 and a site west of Wardell at station 152.2. Borrow sources have the potential to significantly impact surface runoff quality through contamination with dissolved and suspended materials. The most common surface-water contaminant from borrow pits is sediment produced by soil erosion from the disturbed land.

The potential borrow source at Lang Hill, is adjacent to an unnamed waterway that has potential Oxleyan Pygmy Perch habitat. The borrow source site is anticipated to generate around 500,000 cubic metres of earthworks for use on the project. There is a high risk that sediments could be transported into the waterway, affecting the water quality (such as suspended solids and pH) of the waterway, and altering the habitat so that it is no longer suitable to Oxleyan Pygmy Perch and causing stress or death of any Oxleyan Pygmy Perch present. The habitat could be severely impacted if mitigation measures are not implemented during construction. Refer to Section 4.2.21 for mitigation measures for borrow sources.

## 3.2. Potential operational impacts

During the operational phase of the project, the roads would be sealed and the embankments landscaped. It is assumed that the exposed topsoil would be significantly reduced along the highway and therefore little or no risk of soil erosion and transport of eroded sediments to waterways. (Where there is still exposed topsoil, impacts and mitigation would be in line with the construction phase recommendations). Water quality risks during operation would instead be associated with the runoff of pollutants from the new road surface, with pollutant sources including atmospheric deposition, vehicles and motorists.

### 3.2.1. Impacts on surface water quality

During operation, the main potential impact of the project on water quality would be associated with the runoff from stormwater and direct deposition of airborne particles, causing acute or chronic contamination of water quality in downstream waterways that receive discharged stormwater during rainfall events. Specific impacts are further detailed in Sections 3.2.2, 3.2.3, 3.2.4, of this report. Section 5 reviews the impacts of changes to water quality in high risk locations along the project.

A literature review undertaken for the Tintenbar to Ewingsdale (T2E) project (RTA, 2008e) references the Construction Industry Research and Information Association report on Control of Pollution from Highway Drainage Discharges (Luker and Montague, 1994) for pollutants that are likely to be present in highway drainage. These include sediments, hydrocarbons, metals, microbials and others. These deposits build up on road surfaces and pavement areas (including rest areas) during dry weather and get washed off and transported to downstream waterways during rainfall periods. Other pollutants in the atmosphere, derived from local and regional sources, are also deposited and build up on the widened road pavement and contribute to operational impacts on water quality.

The literature review for T2E also investigated pollutant loads. A number of references were compared, but the values derived by Fletcher et al (2004) were adopted for modelling due to the fact that the report was commission by the NSW Department of Environment and Climate Change to find suitable event mean concentration values for total nitrogen, total phosphorus and total suspended solids for water quality modelling in NSW. Fletcher et al conducted an exhaustive review of Australian and worldwide stormwater quality monitoring studies. From this, recommended modelling ranges for each water quality parameter were determined. Values relevant to the stormwater runoff from the proposal are given in Table 3-8.

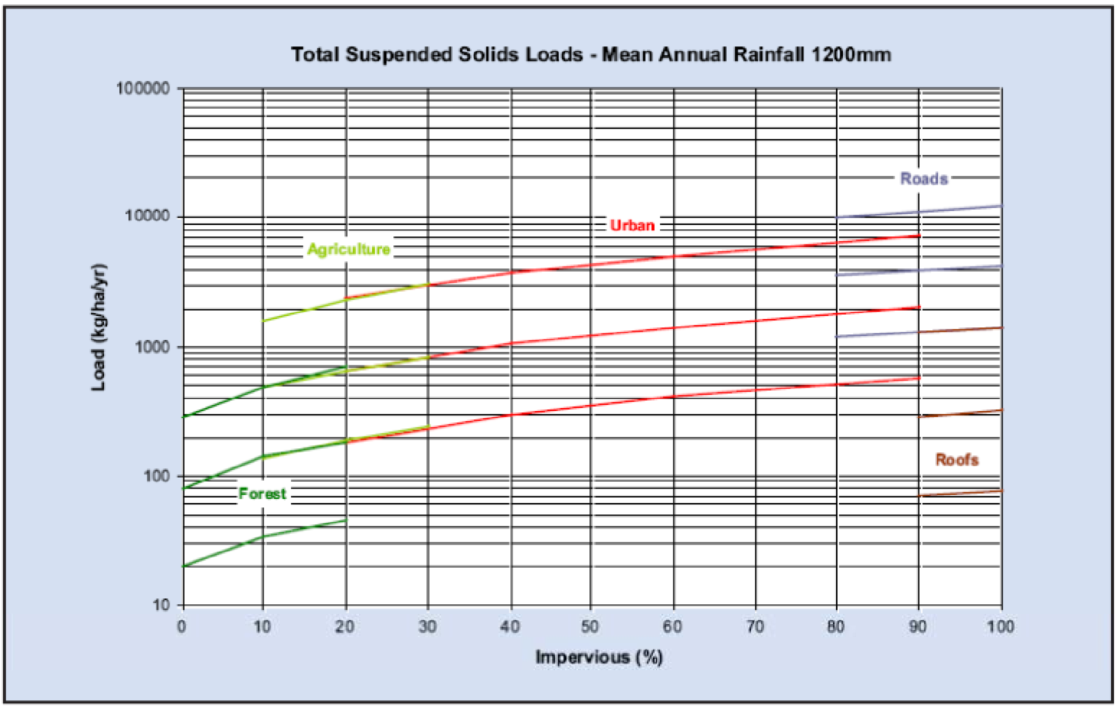
**Table 3-8 Recommended wet weather event mean concentration of various stormwater contaminants**

| Contaminant | Wet weather concentration (mg/L) | | |
|---|---|---|---|
| | Lower | Typical | Upper |
| TSS | 90 | 270 | 800 |

| Contaminant | Wet weather concentration (mg/L) | | |
|---|---|---|---|
| | Lower | Typical | Upper |
| TP | 0.15 | 0.5 | 1.5 |
| TN | 1 | 2.2 | 5 |
| Faecal coliforms | 1700 | 700 | 30000 |
| Zinc | 0.1 | 0.4 | 1.5 |
| Lead | 0.02 | 0.12 | 0.7 |
| Copper | 0.03 | 0.095 | 0.3 |
| Cadmium | 0.001 | 0.03 | 0.08 |
| Oil and Grease | 3 | 17 | 100 |

Fletcher et al derived pollutant load estimates for a range of land uses and impervious areas, and for mean annual rainfalls of 600, 1200 and 1800 millimetres per year using the MUSIC model. An example is given in Figure 3-1. Mean annual loads are highly dependent on volume of runoff and the specific concentration of contaminant in the runoff. As result, the mean annual loads would vary along the length of the project due to the variable rainfall conditions. At Woodburn, in the region of the Woodburn aquifer and the Rous Water Bores, the mean annual rainfall is 1360 millimetres. Interpolating information from the graphs of Fletcher et al provides an upper estimate of about 3800 kilogram of TSS, 20 kilograms of TP and 60 kg of TN in the road runoff from one hectare of road in a single year. A more accurate assessment of the contaminant loads would be determined during the detailed design modelling.

Figure 3-1 Example graph showing relationship between rainfall, impervious area and catchment characteristics (Fletcher et al, 2004)




The T2E literature review (RTA, 2008e) found that there is a correlation between the volume of traffic on a road and the pollutant load generated from that road, with increased traffic volumes resulting in increased pollutants loads. It references work done by Dricsoll et al (1990) which found that highways with traffic loads less than 30,000 vehicles per day generated less than 50 per cent of the pollutant loads generated by highways with greater than 30,000 vehicles per day.

Pollutant loading along the road corridor comprising the project would increase relative to existing levels due to population growth and the associated increases in traffic volumes already occurring along the Pacific Highway. Similar to the T2E project, traffic volume along the Pacific Highway through the project area is forecast to grow by about 42 per cent from 2012 to 2036. By 2036, an annual average daily traffic volume of around 30,000 vehicles is expected between Woolgoolga and Ballina. In addition to future traffic increases, the impervious area of the new road will be larger than existing, providing a greater surface area for accumulation of contaminants and increased road runoff.

During the operational stage, there is also a risk of accidental spillage of petroleum, chemicals or other hazardous materials as a result of vehicle leakage or accidents on the highway. Spills of this nature would pollute downstream waterways if unmitigated.

Pollutants deposited by motorists, such as non-biodegradable garbage and food wastes, could also impact water quality during operation of the project by washing into downstream watercourses and affecting aquatic conditions.

Unless such pollutants are retained by water quality control structures prior to entering waterways, they could adversely affect downstream water quality. The T2E literature review (RTA, 2008e) found that untreated road runoff is likely to have negative eco-toxicological effects and if these are to be minimised then treatment needs to focus on the first flush and specifically on the removal of suspended solids (to eliminate bound heavy metals), zinc and copper. These control structures are particularly important upstream of waterways that have been identified as sensitive receiving environments, as defined in Section 2.11. Mitigation is detailed in Section 5.

### 3.2.2. Impact of surface water on groundwater sources and drinking water

The key potential operational risk to groundwater quality during project operation is contamination of the aquifer by hydrocarbons from accidental fuel and chemical spills, as infiltration of surface water from site runoff to groundwater sources is possible. Contamination of this groundwater source with a range of pollutants including sediments, nutrients, hydrocarbons, metals, and pathogens could mean that water drawn from the bores may not be suitable for use as drinking water without additional treatment to that which is currently provided. Impacts on groundwater are discussed in further detail in the Groundwater Working Paper.

In the region of the Rous Water bores, infiltration is currently protected by a natural clay layer above the main aquifer that acts to impede recharge in the immediate vicinity of the borefield. This clay, however is leaky and locally exhibits preferential recharge to the sands below. Further, where drainage channels have been constructed in adjoining irrigated paddocks, this clay layer may have been breached, thereby enhancing recharge to the aquifer in these areas.

The process of infiltration is generally effective in preventing polluting particles and sediments reaching the groundwater source, hence the short term risk of contamination of groundwater from any pollutants in surface water bound to particulates, such as heavy metals, is low. During operation, most pollutants would be of this nature, or would be insoluble hydrocarbons like oils, tars and petroleum from vehicles accidents and spills that are preferentially retained at the surface. However, mitigation would still be required for this process in areas where the water table is high or in high risk areas such as the Rous Water Regional Water Supply catchment as there is the potential for long-term accumulation of contaminants in the upper soil profile to represent a long term contamination risk. Mitigation measures would be adequately designed to ensure that these contaminants (pollutants bound in particulate form) are removed prior to discharge to the receiving environment.

For soluble pollutants, such as acids and alkalies, salts and nitrates and soluble hydrocarbons, infiltration into the groundwater source may be an issue as the solute would not be removed by the infiltration process. This should be considered during the detailed design of water quality ponds.

There is currently no water quality mitigation for the existing road runoff, which has the potential to flow into the area of the bores after rainfall events. Rous Water believes that the level of mitigation associated with the existing operational design is inadequate. During operation, it is expected that traffic numbers would increase over time, further increasing the risk of contamination of the groundwater. Mitigation to prevent or minimise the impact of operation on the Rous Water groundwater source from contamination by surface water would be required, and details of this are provided in Section 5.4. Once these mitigation measures are operational, the risks to the water quality of the groundwater supply would be reduced from the existing situation.

### 3.2.3. Impact on water quality due to works in waterways

Permanent in-stream structures, diversions, basin discharge and new culverts may change the characteristics of waterways by changing flow rates and flowpaths, leading to scour or deposition of sediment.

If bridge deck drainage systems discharge directly into underlying water bodies, the receiving water body could be polluted with contaminants washed off the bridge deck surface. Contaminates may be deposited from traffic, the atmosphere or through accidental spills. If the underlying water body is considered to be a sensitive receiving environment then the impact of this could be significant, causing acute or chronic contamination of water quality in downstream waterways that receive discharged stormwater during rainfall events.

Mitigation measures for works within waterways are given in Section 4.3.6.

### 3.2.4. Impact of soil characteristics, properties and other features

If fill material, slope and landscape treatments are inappropriately selected, ongoing erosion of embankments could occur. Similarly if the design of batters is too steep, ongoing erosion of the roadway or road shoulder could also occur, particularly in areas of high erodibility identified in Section 3.1.7. This would result in increased sedimentation and increased turbidity in downstream waterways, with impacts as listed in Section 3.1. Mitigation is covered in Section 4.3.

# 4. Mitigation and management

## 4.1. Water quality objectives

The key water quality objective is to protect downstream environments from the potential impacts of surface runoff during the construction and operational phases of the project. This is consistent with the ANZECC (2000) guidelines and objectives for water quality.

To achieve this water quality objective, the following is required:

- Development of a stormwater management strategy to manage the quality of stormwater generated during construction and operation of the project as close to its source as possible. This would include devices to treat construction runoff and operational stormwater, having the least practicable change to the existing water regime
- Integration of the construction and operational phases of the stormwater management strategy so that the total investment in drainage infrastructure would be optimised. Access to all devices would be required to facilitate inspection and maintenance during both the construction and operational phase. The operational water quality ponds would also be capable of containing accidental spills that may occur on the highway
- Where possible, existing environmental features (such as natural channels) would be preserved, natural flow variability (including natural wetting and drying cycles) would be maintained and wetland and riparian vegetation would be maintained
- Water quality in the Woodburn Sands aquifer, which supplies drinking water to Rous Water, would be maintained.

## 4.2. Construction measures

The overall erosion and sediment control objective for the project is primarily to prevent or reduce erosion and sedimentation impacts during construction. Where erosion does occur, the aim would be to capture it as close to the source as practicable.

Impacts to water quality would be managed within the area bounded by the highway construction footprint, incorporating the construction of the highway itself and also all associated areas, including (but not limited to):

- Access and haulage tracks
- Borrow pits
- Earthworks stockpile and storage areas
- Vegetation stockpile areas
- Materials processing areas
- Compound areas, such as the Contractor's and the Principal's facilities
- Washdown facilities
- Concrete and asphalt batching areas
- Temporary sediment ponds.

The impact mitigation strategy would include a mix of procedural, on-site management, design and physical controls.

### 4.2.1. Procedural measures

A SWMP would be developed to manage disturbed excavated and imported materials and prevent erosion, sedimentation and water quality impacts throughout construction. It would be applicable to all activities during the construction phases of the project. The key objective of the plan is to minimise impacts on water quality.

A soil conservationist from the RMS Erosion, Sedimentation and Soil Conservation Consultancy Services Register would be engaged during detailed design to develop an Erosion and Sedimentation Management Report to inform the SWMP. The SWMP would be prepared and implemented in consultation with relevant government departments and councils as part of the construction environmental management plan. The SWMP would include the following items relevant to water quality:

- Erosion and Sediment Control Plans for all stages of construction
- Consideration of soil erodibility
- At-source erosion controls (for example check dams)
- Sedimentation basin construction and management
- Protection of waterways
- Acid sulfate soil issues
- Management of stockpiles
- Tannin leachate management control
- Batch plant/ chemical water quality controls
- Water quality monitoring and checklists
- Detailed consideration of measures to prevent, where possible, or minimise any water quality impacts.

Site specific erosion sedimentation control plans would detail the controls required throughout all stages of construction. These would be in the form of a set of plans and would describe the following:

- Erosion and sediment control measures required before clearing and grubbing of the site
- Appropriate controls before the removal of topsoil and commencement of earthworks for the formation within the catchment area of each structure
- How upstream water would be managed so it is not polluted
- Scour protection measures for haul roads and access tracks when these are an erosion hazard due to their steepness, soil erodibility or potential for concentrating runoff flow
- Methods for tree removal in intermittent watercourses, leaving grasses and small understory species undisturbed wherever possible
- Methods for stabilising temporary drains
- Methods to minimise erosion of all exposed areas, including (but not limited to) large batters and excavations

- Methods of constructing batters to assist the retention of topsoil on the batter slopes
- Temporary sediment trapping measures in median areas at regular intervals
- Measures to minimise erosion and control sedimentation from stockpiles Methods of maintenance of erosion and sediment control structures including measures to restore their capacity
- Inspection and maintenance requirements for all erosion and sediment controls, including the timing and frequency of inspection and maintenance.

All measures would be in accordance with the relevant guidelines listed previously. In addition, the requirements of relevant RMS specifications would be met, including but not limited to:

- RMS QA Specification G36 – Environmental Protection (Management System)
- RMS QA Specification G38 – Soil and Water Management (Soil and Water Management Plan)
- RMS QA Specification G39 – Soil and Water Management (Erosion and Sediment Control Plan)
- RMS QA Specification G40 – Clearing and Grubbing.

### 4.2.2. On-site management controls

Construction activities should be managed to minimise erosion potential and associated water quality risks, including:

- Minimising exposure of topsoil
- Minimising the extent of disturbed areas
- Minimising stockpiling
- Minimising the lengths of slopes through the use of diversion drains to reduce water velocity over disturbed areas
- Early installation of physical controls, including cross drainage to convey clean water around or through the site
- Progressive rehabilitation of works areas throughout construction and early stages of operation, including permanent revegetation or temporary protection such as spray mulching or the use of temporary cover crops.

### 4.2.3. Design considerations

Consideration would be given to the impact of construction on water quality during the design phase of the project. The relevant RMS design guidelines listed in Section 1.5.2.would be followed. The design and construction of works within riparian corridors would be undertaken in accordance with the controlled activities listed under the *Water Management Act 2000* that are detailed in the NSW Office of Water guidelines listed in Section 1.5.2.

The concept design for water quality includes the design of sedimentation basins as part of a treatment train to protect water quality during construction. Sedimentation basins have been located along the project to collect and treat construction runoff prior to discharge into downstream waterways. The rationale and methodology used for locating and sizing sedimentation basins is detailed in Section 6.1. The methodology includes increased design requirements for basins discharging to sensitive receiving environments. During the detailed design, additional protection measures would be developed, including the primary erosion sedimentation control plans and refinement of the sedimentation basins and associated treatment train.

Also, during detailed design batters and retaining structures designed using appropriate slope gradients to minimise erosion of selected covering topsoil where possible. If this is not possible, terracing should be considered.

Where cuttings are to be benched, benches would be diverted onto contours as part of the detailed design, and flow would be designed to spread at the source in preference to concentrating the flow and treating it further down the treatment train, with consideration of site constraints.

Flow discharge points would be designed with erosion controls, such as rock lining, to slow flow velocities. For example, basin spillways would incorporate rock lining to avoid scour downstream of the spillway.

### 4.2.4. Physical measures

Physical controls that would be used to reduce the risk of water quality degradation due to erosion and sedimentation during construction would include:

- Sediment fences and filters to intercept and filter small volumes of non-concentrated construction runoff
- Rock check dams that are built across a swale or diversion channel to reduce the velocity of flow in the channel, thus reducing erosion of the channel bed and trapping sediment
- Level spreaders to convert erosive, concentrated flow into sheet flow
- Onsite diversion drains to collect construction runoff and direct it away from unstable and/or exposed soil to treatment facilities
- Offsite diversion drains to collect clean runoff from upstream of the construction area and divert it around or through the site without it mixing with construction runoff
- Lining of channels and other concentrated flowpaths
- Sedimentation basins to capture sediment and associated pollutants in construction runoff (details of the rationale and methodology for locating and sizing sedimentation basins is detailed in Section 6.1)
- Specific measures and procedures for works within waterways such as the use of silt barriers and temporary creek diversions. Details of some of these measures are covered in detail *Technical Guideline - Temporary Stormwater Drainage for Main Road Construction* (RMS, 2011) and NSW Office of Water guidelines for in-stream works and watercourse crossings (NSW Office of Water, 2010a and 2010c).

Further details on the required controls and procedures are provided in Appendix B. Indicative locations and sizing of temporary sedimentation basins for the construction phase for each of the project sections are presented in Table D-1 and the figures in Appendix D.

The details provided on the location and sizes of these sedimentation basins are preliminary and indicative only. As more information becomes available and changes to the design are considered during detailed design, the requirement for each of these basins will be reassessed. Depending on the results of the analysis, some of the basins may no longer being included in the design. The current basin locations provide information for leasing or purchasing the land, and other planning purposes.

### 4.2.5. Measures for management of acid sulfate soils

Acid sulfate soils would be managed in accordance with the relevant guidelines, including:

- Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze (RTA, 2005)
- The Environmental Guidelines - Acid Sulfate Soils (EPA, 1998)
- Acid Sulfate Soil Manual (ASSMAC, 1998)
- Acid Sulfate Soils Assessment Guidelines (ASSMAC, 1998a)
- Waste Classification Guidelines Part 4: Acid Sulfate Soils Part 4 (DECC, 2008).

An Acid Sulfate Soil Management Plan to address acid sulfate soils issues would be included with the construction environmental management plan. The Acid Sulfate Soils Management Plan would include measures to deal with the unexpected discovery of actual or potential acid sulfate soils. A site specific acid sulfate management plan for the identified recharge area associated with the Woodburn bores would be included. Should acid sulfate soils be detected where excavation is required, works would proceed according to the Acid Sulfate Soils Management Plan and would involve:

- Capping of exposed surfaces with clean fill to prevent oxidation
- Placing excavated acid sulfate soils separately in a lined, bunded and covered area
- Neutralising acid sulfate soils for reuse (where appropriate) by using additives such as lime
- Disposing of acid sulfate soils where necessary in accordance with the relevant guidelines.

Where it is identified that a sedimentation basin is located in acid sulfate soils, the basin would be reviewed during detailed design. The basin depth may be reduced to avoid excavation into the acid sulfate soil layer. The minimum allowable depth would be in accordance with the Blue Book (Landcom, 2004 and DECC, 2008) with the volume of the basin would be maintained by increasing its footprint. Alternatively, clay capping / lining of the basin could be provided where shallower, larger basins are not feasible. If this is not possible, work would be undertaken in accordance with the listed guidelines.

### 4.2.6. Measures to address highly erodible soils

Highly erodible soils exist throughout the project. The types of soil landscapes present were discussed in Section 2.4 and the locations of highly erodible soils have been identified in Section 3.1.7. To mitigate the potential impacts associated with construction in areas of highly erodible soils, the procedural controls identified in Section 4.2.1 would be implemented, together with the on-site management controls identified in Section 4.2.2, the design controls identified in Section 4.2.3 and the physical controls identified in Section 4.2.4 and Appendix B. The primary erosion sedimentation control plans would indicate regions of highly erodible soils and would indicated increased usage of sediment fences in these areas to increase the interception of sediments before they reach sedimentation basins. . In addition, sedimentation basins would be designed to include sediment storage capacity sufficient for the increased sediment loading in these areas.

### 4.2.7. Prevention management of spills

An Emergency Spill Plan would be developed and incorporated in the construction environmental management plan. This would include measures to avoid spills of fuels, chemicals, and fluids into any waterways. The storage, handling and use of the materials would be undertaken in accordance with *the Occupational Health and Safety Act 2000* and Workcover's *Storage and Handling of Dangerous Goods Code of Practice* (Workcover, 2005).

Preventative management procedures would include:

- Bunded storage facilities for chemicals
- Bunded areas for refuelling and washdown
- Locating storage areas away from areas of known near-surface groundwater supplies, in areas where the water table is more than five metres below the surface, otherwise the areas are to be lined if they are located over a shallow groundwater source less than two metres deep
- Sedimentation basins with sufficient storage capacity to capture spills
- Spill kits
- Training of staff.

### 4.2.8. Mitigation of the potential impact of changes to water quantity

Construction sequencing and temporary diversions of water during construction should be developed and designed to consider the impact of change on flow regimes and to minimise these changes throughout the full phase of construction.

### 4.2.9. Mitigation of surface water infiltration to groundwater sources

To minimise the risk of surface water infiltration to groundwater sources, the procedural controls identified in Section 4.2.1 would be implemented, together with the on-site management controls identified in Section 4.2.2, the design controls identified in Section 4.2.3 and the physical controls identified in Section 4.2.4 and Appendix B. In addition, where the water table is identified as being within two metres of the base of a sedimentation basin, the basin would be lined. Similarly, stockpiles, washdown, batch plants, refuelling and chemical storage sites would be lined if they are to be located over a shallow groundwater source. If practical, it would be preferable to locate these sites in areas where the water table is more than five metres below the surface. Further consideration of this would be undertaken during detailed design, as well the identification of the basins and sites that require lining.

### 4.2.10. Mitigation of potential impacts on drinking water catchment

Refer to Section 5.4 for full construction mitigation measures.

### 4.2.11. Mitigation of risks associated with intersecting groundwater

Where groundwater is released from groundwater sources due to road cuttings intersecting the water table, recharge of the water table is the preferred option of managing groundwater. It would be facilitated by collection of the groundwater in grassed swales for infiltration back to the groundwater source. Where possible, these swales would divert the groundwater around the construction area so that the groundwater does not further mix with construction runoff.

If recharging is not suitable, then discharging groundwater would be collected in the surface water system. Treatment of the mixed runoff would occur in basins prior to discharge into natural waterways. If discharging to downstream groundwater, then effects of mounding would be mitigated. This would be investigated further during detailed design.

Dewatering should be undertaken in line with RMS' *Technical Guideline – Environmental Management of Construction Site Dewatering* (RMS, 2011a) and in accordance with any licence conditions. Refer to the Groundwater Working Paper for more information.

### 4.2.12. Impact mitigation for works in waterways

Specific measures and procedures for works within waterways such as the use of silt barriers and temporary creek diversions would be implemented. Consideration would be given to fish passage in consultation with Department of Primary Industries (Fisheries). Details of some of these measures are given in the *Technical Guideline - Temporary Stormwater Drainage for Main Road Construction* (RMS, 2011). All works within waterways would be undertaken in line with the design principles for culverts and bridges outlined in the Biodiversity Working Paper.

Any works within a waterway, the banks of a waterway or the area extending a nominated distance from the top of bank (usually 40 metres) will be coordinated with the NSW Office of Water.

### 4.2.13. Impact mitigation for large excavations and embankment construction

To mitigate the impacts of the construction of large excavations and embankments, the procedural controls identified in Section 4.2.1 would be implemented, together with the construction sequencing controls identified in Section 4.2.2, the design controls identified in Section 4.2.3 and the physical controls identified in Section 4.2.4 and Appendix B. In addition, the erosion sedimentation control plans should highlight large excavations and embankments. Sedimentation basins would be sized to treat the additional sediment loads of catchments containing larger excavation and would generally be larger in volume than those not treating large excavation or embankments.

### 4.2.14. Impact mitigation in areas of high proportions of cut and fill

Where there is a high proportion of cut and fill areas in a catchment, such as in Section 5, 8, 9 and 10, the risk to water quality becomes elevated. To mitigate the impacts of this, the procedural controls identified in Section 4.2.1 would be implemented, together with the on-site management controls identified in Section 4.2.2, the design controls identified in Section 4.2.3 and the physical controls identified in Section 4.2.4 and Appendix B.

### 4.2.15. Impact mitigation for areas of steep road gradient

In general, the road gradient is not steep across the project. Section 1 of the project poses a moderate risk with slightly larger gradients. To mitigate the impacts of this, the procedural controls identified in Section 4.2.1 would be implemented, together with the on-site management controls identified in Section 4.2.2, the design controls identified in Section 4.2.3 and the physical controls identified in Section 4.2.4 and Appendix B. In addition in steep areas, the length between sediment fences and other physical controls would be decreased to reduce rill erosion. Locations of sediment fences would be detailed in the primary erosion sedimentation control plans.

### 4.2.16. Impact mitigation for stockpile sites

The maintenance of established stockpile sites during construction would be in accordance with RMS' *Stockpile Site Management Procedures* (RTA, 2001). To mitigate the impacts of stockpiling earth materials and vegetation, the procedural controls identified in Section 4.2.1 would be implemented, together with the construction sequencing controls identified in Section 4.2.2, the design controls identified in Section 4.2.3 and the physical controls identified in Section 4.2.4 and Appendix B. Also, mitigation of tannin leaching from mulch stockpiles into waterways would be in line with *Environmental Direction - Management of Tannins from Vegetation Mulch* (RMS, 2012). These and additional recommendations include:

- Development of a detailed erosion sedimentation control plan
- Locating stockpiles away from overland flowpaths and in areas of high topography with minimal upstream catchment
- Diverting runoff around stockpiles sites
- Minimising the number and size of stockpiles
- Locate stockpiles away from areas of known near-surface groundwater supplies, in areas where the water table is more than five metres below the surface, otherwise areas are to be lined if they are to be located over a shallow groundwater source less than two metres deep
- Treating stockpiles at the source by as per the Blue Book (Landcom, 2004 and DECC, 2008) requirements, or otherwise treating with a stockpile-specific sedimentation basin and monitoring the sedimentation basin for parameters such as dissolved oxygen levels and organics to determine suitable discharge to the environment (such basins would be considered during detailed design).
- Lining, bunding and covering stockpiles of PASS, in accordance with relevant guidelines outlined in Section 4.2.5
- Consideration during detailed design of locating stockpile sites away from areas where the mitigated stockpile site could still result in downstream impacts to sensitive receiving environments and high risk areas including threatened fish habitats.

### 4.2.17. Mitigation of impacts associated with contaminated land

Mitigation of the potential impacts associated with contaminated land is addressed in the Chapter 9 of the *Woolgoolga to Ballina Pacific Highway Upgrade Environmental Impact Statement.*

### 4.2.18. Mitigation of impacts on key fish habitats

To mitigate the impacts of construction on key fish habitats, the procedural controls identified in Section 4.2.1 would be implemented, together with the on-site management controls identified in Section 4.2.2, the design controls identified in Section 4.2.3 and the physical controls identified in Section 4.2.4 and Appendix B. Key fish habitats are considered to be sensitive receiving environments, hence the additional impact mitigation measures outlined in Section 4.2.19 would also be included. Fish passage must be considered for all waterways.

Increased flow velocities that cause scour downstream of discharge points and detrimental consequences to fish habitats would be mitigated through the design of erosion controls at spillways. The erosion control should be designed to suit the flow velocities. A typical detail of a rock lined spillway is given in Appendix C. The rock lining slows the flow velocity to avoid scour downstream of the spillway.

All works within waterways would be undertaken following the procedures outlined in RMS' *Technical Guideline - Temporary Stormwater Drainage for Main Road Construction* (RMS, 2011). This includes the provision of temporary culverts or other crossings during construction prior to the construction of the permanent crossing.

For mitigation of impacts to water quality that in habitats of threatened aquatic species, refer to Section 5.7.

### 4.2.19. Impact mitigation for sensitive receiving environments

Where construction takes place in areas that will affect sensitive receiving environments, additional impact mitigation would be required over areas that are not considered to be sensitive. Sensitive receiving environments were identified in Section 2.8 and include Nationally Important and SEPP 15 wetlands, the Solitary Island Marine Park, national parks, marine parks, conservation areas, threatened ecological communities, key fish habitats, habitats of threatened aquatic fauna and drinking water catchments.

In sensitive receiving environments, the procedural controls, on-site management controls, design and physical controls should all be carefully considered in line with the recommendations of this report.

Sediment basins would be provided upstream of discharge to all sensitive receiving environments. In these areas, the design criteria of sedimentation basins would be made more stringent to increase the treatment provided to construction runoff prior to its release to the sensitive environment. The key design consideration for sizing sedimentation basins is the *rainfall percentile*. For sensitive receiving environments identified in Section 2.8 , the capacity of the basin would be designed to contain all runoff expected from the 85$^{th}$ percentile, five-day rainfall depth. Where the receiving environment is not deemed not to be sensitive, the 80$^{th}$ percentile, five-day rainfall depth is appropriate (Landcom, 2004). This reduces the average annual overflow frequency from six to eight spills per year to four to six spills per year (DECC, 2008). During detailed design, the 90th percentile, five-day rainfall depth design parameter would also be examined and considered for areas identified as high-risk sensitive receiving environments, such the Solitary Island Marine Park and Rous Water borefields (high risk areas are listed in Section 5). Detailed information on the design methodology is provided in Section 5. Table 4-1 identifies the proportion of basins in each project section that have been designed to the 85$^{th}$ percentile, five-day rainfall depth to protect sensitive receiving environments.  All basins in sections 1, 2, 3, 5, 6, 7, 8, 10 and 11 have been designed to the 85$^{th}$ percentile, five-day rainfall depth, and the majority of basins in section 4 and 8 have been designed to the 85$^{th}$ percentile, five-day rainfall depth.

Identification of high risk areas would continue through the detailed design process. For example, site specific soil testing during detailed design may identify areas of particularly poor soil conditions, while further ecological assessment may find additional areas that could be considered sensitive. In these areas, the water quality design would be reviewed and additional controls may be required. This would be investigated further during detailed design.

**Table 4-1 Sedimentation basins in sensitive areas**

| Section | Proportion of sedimentation basins designed for sensitive receiving environments using the 85th percentile, five-day rainfall depth |
|---|---|
| 1 | 100% |
| 2 | 100% |
| 3 | 100% |
| 4 | 82% |
| 5 | 100% |
| 6 | 100% |
| 7 | 100% |
| 8 | 86% |
| 9 | 100% |
| 10 | 100% |
| 11 | 100% |

### 4.2.20. Impact mitigation for site compounds and materials processing sites

Management of runoff through or from site compounds would be included in the erosion sedimentation control plan. In general, mitigation would be similar to general construction site mitigation, implementing prevention management of spills as outlined in Section 4.2.7, as well as additional factors, such as:

- Restricting vehicle movements to designated pathways where feasible.
- Paving areas that would be exposed for extended periods, such as carparks and main access roads, where feasible.
- Diverting offsite runoff around sites where required.
- Locating chemical or other hazardous material storage areas away from areas of known near-surface groundwater supplies, in areas where the water table is more than five metres below the surface, otherwise areas are to be lined if they are to be located over a shallow groundwater source less than two metres deep
- If the above local controls are not implemented, and where required, treating onsite runoff with a construction or compound-specific sediment basin and monitoring the sediment basin for parameters such as dissolved oxygen levels and organics to determine suitable discharge to the environment (such basins would be considered during detailed design).
- Consideration during detailed design of locating ancillary facilities away from areas where the mitigated site could still result in downstream impacts to sensitive receiving environments and high risk areas including threatened fish habitats.

### 4.2.21. Impact mitigation for borrow source sites

Mitigation of borrow source sites (particularly Lang Hill) would be in line with Volume 2E of the Blue Book which covers water management of mines and quarries. In addition to the prescribed Blue Book controls, the procedural controls identified in Section 4.2.1 would be implemented, together with the construction sequencing controls identified in Section 4.2.2, the design controls identified in Section 4.2.3 and the physical controls identified in Section 4.2.4 and Appendix B. Where borrow pits are located within 50 metres of a sensitive receiving environment, such as a national park the mitigation measures required for sensitive receiving environments (Refer to Section 4.2.19) would also be implemented. Where the sensitive receiving environment is a key fish habitat, the additional mitigation measures outlines in Sections 4.2.18 and 5.7 would be implemented. The following

These and additional recommendations include:

- Development of detailed site specific erosion sediment control plans for borrow sources.
- Diverting upstream runoff around borrow sources.
- Treating runoff from borrow sources at the source as per the Blue Book (Landcom, 2004 and DECC, 2008) requirements, or otherwise treating with a site-specific sedimentation basin and monitoring the sedimentation basin for parameters such as dissolved oxygen levels, pH and organics to determine suitable discharge to the environment (such basins would be considered during detailed design).
- Consideration during detailed design of locating borrow sites away from areas where the mitigated borrow site could still result in downstream impacts to sensitive receiving environments and high risk areas including threatened fish habitats.

Mitigation for the borrow source at Lang Hill, at station 135.0, would be detailed in a site-specific erosion sediment plan which would cover construction and rehabilitation of the site. Runoff from the site would be treated by a sedimentation basin. The required water quality parameters for the basins discharging into this area would be determined during detailed design based on pre-construction water quality monitoring. These would be included in the EPL. Discharges from the sediment basins during construction that do not meet the water quality parameters for Oxleyan Pygmy Perch habitat should not be discharged into the waterway but rather sprayed into adjacent open grass areas or used for construction purposes such as dust suppression to avoid changing water depth and physico-chemical conditions in the potential Oxleyan Pygmy Perch Habitat. If it is not feasible to irrigate to land to completely re-use sediment basin water, then as a last resort discharge water from sedimentation basins to Oxleyan Pygmy Perch waterways will be treated to ensure it has the correct pH of less than 5.5 and total suspended solids of less than 50mg/L.

The sedimentation has not been included in the concept design but would be designed during the detailed design phase using an 85$^{th}$ percentile, five-day rainfall depth design parameter, increased from the 80$^{th}$ percentile value used in non sensitive receiving environment areas. It is anticipated that this would be sufficient; however, as outlined in Section 4.2.19, during detailed design the 90th percentile design parameter would be examined and considered for sizing the sedimentation basin located in this area.

### 4.2.22. Construction water quality monitoring

RMS guidelines detail the requirements for water quality monitoring that would be undertaken during the pre-construction, and construction stages of the project. This is explained further in Appendix E. It should be read in conjunction with Section 5.2 of the Groundwater Working Paper.

### 4.2.23. Effectiveness of construction mitigation measures

The proposed measures detailed in this report are in line with industry standards such as Blue Book (Landcom, 2004 and DECC, 2008). The measures contained in the Blue Book are based on field experience and have been previously demonstrated to be effective in mitigation during construction. Strict conformance with the requirements of the Blue Book during the construction period would be required to ensure that the predicted effectiveness is achieved.

## 4.3. Operational measures

The ANZECC/ARMCANZ (2000) guidelines indicate that several physical-chemical and toxicant parameters need to be controlled to prevent adverse changes to water quality and maintain the required protection level for aquatic ecosystems during operation of the project. Runoff from road surfaces typically contains nutrients (total phosphorus and nitrogen), suspended solids, oils and greases, petroleum hydrocarbons and several heavy metals (including copper, lead, zinc, cadmium and chromium), all of which may result in harm to aquatic ecosystems when concentrations exceed certain levels. A future increase in traffic volumes is likely to cause a corresponding increase in pollutant inflows from the Pacific Highway to waterways.

A large proportion of the pollutants in run-off from the road surface would be bound to particles and can therefore be controlled by water quality ponds, wetlands and grassed swales placed alongside the carriageway. These controls would protect water quality by intercepting road run-off and allowing the pollutants to settle out or be filtered before the run-off enters the environment.

### 4.3.1. Design controls

Consideration would be given to the impact of operation on water quality during the design phase. The relevant RMS design guidelines listed in Section  would be followed. The design of works within riparian corridors would be undertaken in accordance with the controlled activities listed under the *Water Management Act 2000* and detailed in the NSW Office of Water guidelines listed in Section 1.5.2.

For the operational phase of the project, rainfall runoff and accidental spills would be treated and contained through the provision of a water quality treatment train combining grassed swales leading to permanent water quality ponds or spill containment basins. For the concept design, the design strategy has included the use of swales and water quality ponds. Generally in fill areas, grassed swales would be designed at the toe of the fill batter to capture and treat road runoff. Where the swale discharges into a sensitive receiving environment, a spill basin would be included in the design. In floodplain areas, in particular, grassed swales would be used as the predominant method of water quality control. Where swales are not feasible, such as in steep areas or areas of cut, water quality ponds would be used to treat the pavement runoff. The rationale, methodology and design criteria used for locating and sizing water quality ponds for the concept design are detailed further in Section 6.2.

The detailed design would also include the following features:

- Design of the physical water treatment structures and controls listed in Section 4.3.2, such as detailed consideration of water quality ponds, spills basins, grassed swales and biofiltration swales in order to meet the target guidelines in section 6.2.2. The detailed design would determine what control measures are required to meet the target guidelines, with consideration of design constraints, other potential impacts and acquisition constraints.
- Design of highway pavement drainage to discharge to water quality control points, such as water quality ponds.
- The selection of fill material for road embankments to minimise the risk of ongoing erosion.

- Cut batters and retaining structures would be designed and maintained to minimise the risk of erosion of the roadway or road shoulder. This is especially important in the areas of high erodibility identified in Section 2.11 and Section 3.1.7.
- Structures in waterways would be designed to prevent ongoing downstream erosion or scour.
- Flow discharge points would be designed with erosion controls, such as rock lining, to slow flow velocities. For example, basin spillways would incorporate rock lining to avoid scour downstream of the spillway.

### 4.3.2. Physical water quality controls

Typical details of the operational water quality controls, including water quality ponds, spill basins and swales with rock check dams, are shown in Appendix C. Details are included herein.

**Water quality ponds**

Water quality ponds would provide the function of trapping the finer sediments and associated contaminants before stormwater is discharged into the receiving waterways. The ponds would treat road pavement and batter runoff collected by the pavement drainage network. They operate by reducing the flow velocities and promoting the settlement of suspended sediment contained in stormwater runoff. Measures would also be incorporated into the design of the ponds to enable the containment of accidental spills such as petroleum hydrocarbons that have a density lower than water.

A number of operational water quality ponds would be converted from proposed temporary sedimentation basins used during the construction phase. Basins and ponds that are to be used both for construction and operational phases would be designed according to the maximum size requirements (usually the construction phase basins) and the one design would be maintained for both phases.

Maintenance access to water quality ponds would be provided. Access from the main carriageway would only be permitted if access from a side road or service road is not available. Fencing of ponds could be required and would be subject to a risk assessment.

Indicative locations and sizing of permanent water quality ponds for each of the eleven project sections are presented in Table D-1. Figures showing the pond and basin locations are provided in Appendix D. The location and sizes of these water quality ponds and sedimentation basins are preliminary and indicative only. As more information becomes available during detailed design, the requirement for each of these ponds and basins will be reassessed, which may result in some of the basins no longer being included in the design. The current pond and basin locations provide information for leasing or purchasing the land, and other planning purposes.

**Containment of accidental spills**

All water quality ponds would incorporate features to contain accidental spills. Specifically, the ponds would provide this containment through an appropriate baffle arrangement with an underflow or “Ellis” pipes at the outlet end of the pond. To prevent spillages from reaching downstream ecosystems and waterways these measures would be designed to accommodate accidental spills to a volume of 40,000L.

For sensitive areas along the project where pavement runoff discharges to waterways without flowing into a water quality basin, a spill basin would be required to protect the sensitive receiving environments against any accidental spill from the highway. These sensitive areas have been identified in Section 2.8.

The water quality ponds would be effective in capturing insoluble particles, such as hydrocarbons, which are the most common form of spills on highways. Heavy metals, which are typically bound to particles in the environment, would also be captured in water quality ponds. If, however, an accident occurred while it was raining and it resulted in a spill of a soluble material, the material could pass through the water quality pond or spill basin with rainfall overflows. Although it is unlikely that these events would occur simultaneously, overflow containing the soluble spill material could be harmful to the downstream environmental. To mitigate this, provision for additional mitigation measures should be provided during smaller storm events that contain the runoff in the water quality pond until pumping can be undertaken by the emergency response maintenance team. If a spill was to occur during dry weather, highway maintenance procedures would clean up the spill prior to it flowing to basins or out of basins and there would be no concern to downstream receivers.

Typical spill basin details are shown in Appendix C.

### Grassed swales

Along the majority of the project, a considerable number of diversion drains would be designed to intercept offsite or clean water that is flowing towards the road and divert this water to cross drainage structures where it can be directed past the road, without mixing with road runoff. Where feasible, grassed swales would also be used as a water quality mitigation method. Often this would be at the base of fill areas where gutters on the road are not used, in order to provide effective water quality treatment to the road runoff. As swales are grass lined, they filter suspended solids and their associated pollutants, facilitated by the interaction between the flow and the vegetation along the length of the swale. In addition the vegetation acts to spread and slow flow velocities, which aids the deposition of sediments. Swales do not, however, provide spill containment – this will be managed through water quality ponds or spill containment basins.

Maintenance of the swales would be required to ensure that grades are maintained and that grass is kept at a length of 200 to 300 millimetres. Weeds, rubbish and sediment would need to be regularly removed.

In some sections of the project where available space is constricted and a higher level of water quality treatment is required than what would be provided by a typical swale, a swale with a rock check dams could be included in the design. Rock check dams retain small volumes of water, increasing the proportion of sediment settling from the runoff and improving nitrogen and phosphorous removal. Typical details of a swale with a rock check dam are shown in Appendix C.

In some areas where the grades are steeper, grassed swales are inappropriate and drains would be appropriately lined or would have adequate erosion protection such as rock lining.

### Biofiltration swales

There may be opportunities to include biofiltration swales during detailed design. These swales provide both conveyance of stormwater flows and treatment through filtration to remove coarse to medium sediments. A typical biofiltration system consists of a vegetated swale or pond, overlaying a filter medium (usually soil-based) with a perforated drainage pipe at the bottom. A typical biofiltration swale design is illustrated in Figure 4-1.

The decision to incorporate biofiltration swales would include consideration of:

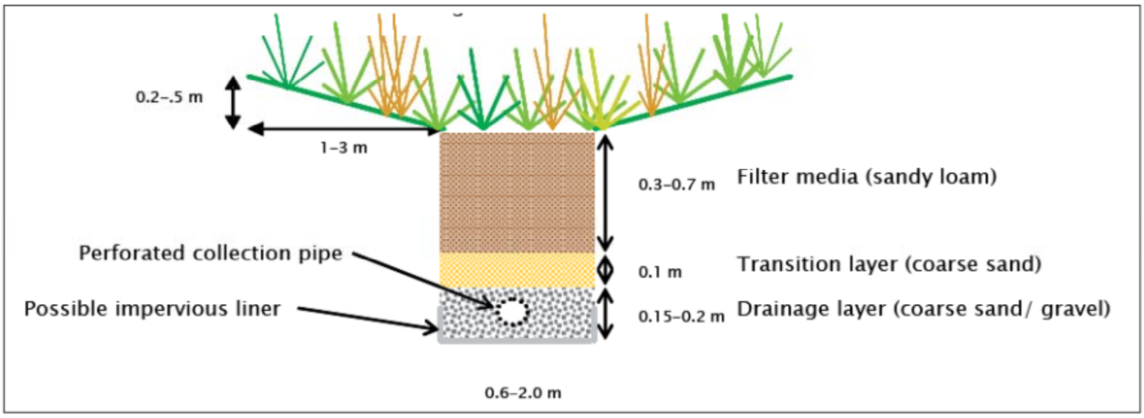
- Whether or not treatment requirements can be met by a standard grass swale
- The topography, as the swale gradient cannot be overly steep.

- Whether there is adequate space for the construction and operation of the swale.
- Whether the biofiltration swale can be constructed without the need for excessive clearing of vegetation and without impacts on heritage, operational road safety, environment and heritage.
- Whether the longitudinal topography allows the subsurface collection pipe to resurface.
- Whether the proposed measure can be safely accessed and maintained.

Biofiltration swales would require a higher level of maintenance than grassed swales to prevent the filtration media from becoming clogged with fine sediment. The following elements would need to be maintained (Upper Parramatta River Catchment Trust, 2003):

- Flow to and through the system to prevent blockages.
- Surface vegetation.
- Prevention of undesired overgrowth and weeds.
- Removal of accumulated sediments.
- Removal of debris and litter.

**Figure 4-1 Example of a biofiltration swale (Landcom, 2009)**




### 4.3.3. Procedural water quality controls

A SWMP would be prepared and implemented and would include:

- Details of all the water management controls.
- A maintenance and inspection program for operational controls.
- Checklists for recording all maintenance activities.
- Operational phase monitoring (further information is provided in Appendix E).

### 4.3.4. Intersection of groundwater

In locations of significant cuts that intersect the pre-existing water table (refer to the Groundwater Working Paper for locations), recharge of the water table would be the preferred option of managing groundwater. It would be facilitated by collection of the groundwater in grassed swales for infiltration back to the groundwater source. No treatment of the groundwater would be required. If recharging is not suitable, then discharging groundwater would be collected in the surface water system. Treatment of the mixed runoff would occur in water quality ponds prior to discharge into natural waterways. If discharging to downstream groundwater, then effects of mounding should be mitigated. This would be investigated further during detailed design.

### 4.3.5. Mitigation of potential impacts on drinking water catchment

Refer to Section 5.4.

### 4.3.6. Mitigation of works in waterways

Bridge deck drainage systems would be devised during the detailed design phase of the project to discharge to the highway pavement drainage system and avoid direct discharge into sensitive receiving environments. The location of operational basins and other water quality treatment measures to treat bridge deck drainage would be further considered during detailed design.

### 4.3.7. Effectiveness of operational mitigation measures

The proposed measures detailed in this report are have been modelled using the industry established MUSIC model developed by eWater Catchment Hydrology CRC. The modelling undertaken in the MUSIC model is based on algorithms that have been previously demonstrated to be effective in mitigation during highway operation. Strict conformance with the appropriate ongoing maintenance of these controls is required to ensure the predicted effectiveness is achieved.

# 5. Impacts and mitigation in high risk areas

Along the length of the project there are numerous areas that are defined as sensitive receiving environments (see Section 2.8). Where a number of sensitive receiving environments are located in a single region and or where there would be severe implications of changes in surface water quality to the receiving environment, the region has been defined as a high risk area. The regions have been selected following discussions with specialists of various disciplines and relevant agencies, and include:

- The Solitary Islands Marine Park in Section 1
- Upper Coldstream Wetlands in Section 3
- Tabbimoble Swamp Nature Reserve in Section 7
- The Rous Water borefields in Section 8
- The Broadwater national park and associated wetlands in Section 9
- Wardell Heath in Section 10
- Various areas where the project would discharge to or within 50 metres of a known or potential habitat of a threatened aquatic species.

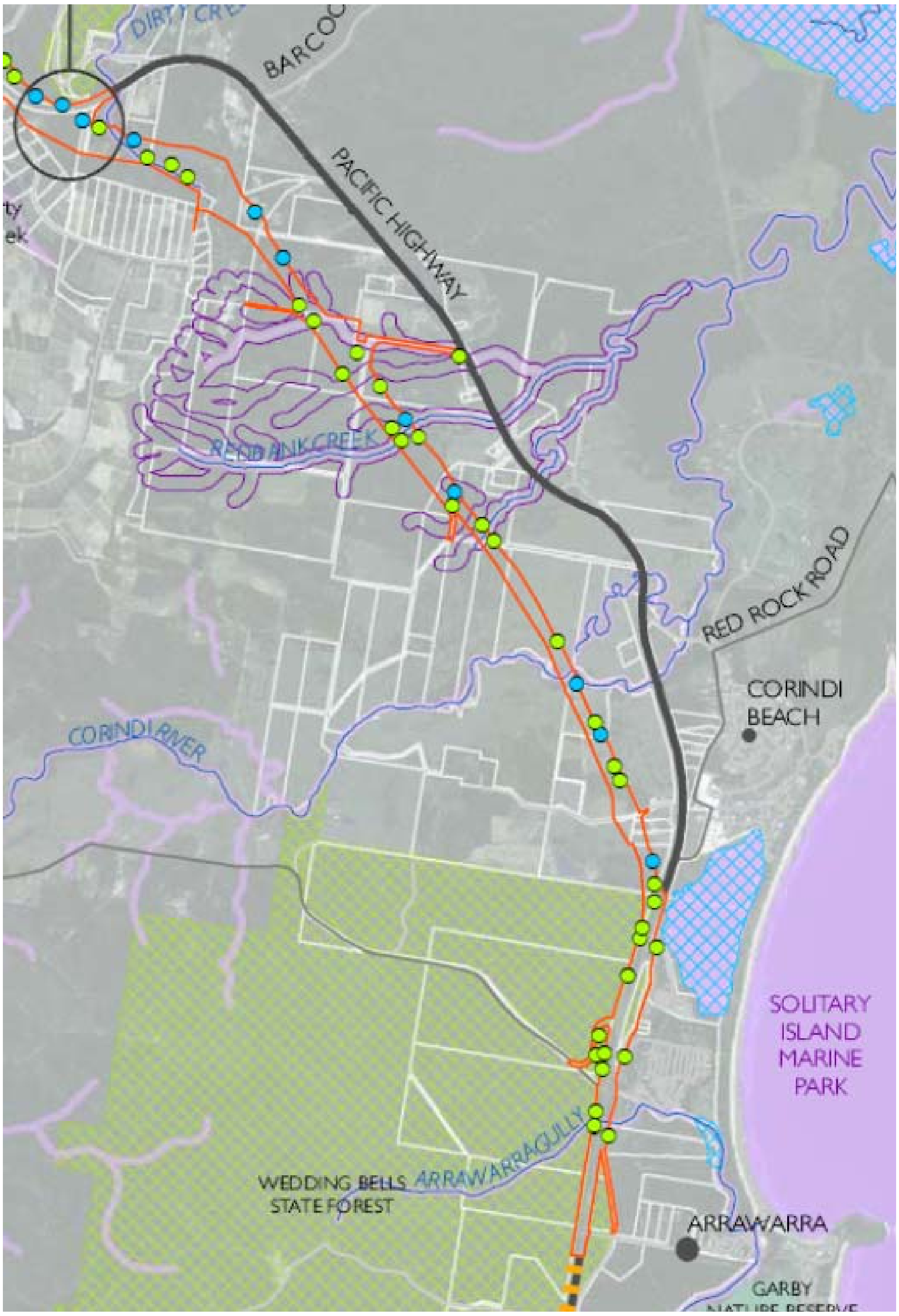
The previous sections of this report have discussed the existing water quality in waterways and the impacts to water quality caused by naturally occurring factors, such as soil erodibility and acid sulfate soils. The report has also discussed the general impact of factors within the proposed design, including construction of large excavations and large batters, steep road gradients, construction near waterways, realigning waterways, stockpiles and site compounds. Section 4 outlined general mitigation strategies to reduce the risks of these impacts to the water quality of downstream environments.

This section of the report details the specific risks to these 'high risk areas', that would cause the general impacts discussed in Section 3 but would result in more significant environmental implications. In these areas, the previous mitigation measures outlined in Section 4 would be implemented, where relevant. This section of the report summarises these and details *additional* mitigation measures to those given in Section 4 that are to be implemented during construction and operation in these high risk areas.

## 5.1. Solitary Islands Marine Park

The Solitary Islands Marine Park has significant ecological value and is a key fish habitat. The consequences of degraded water quality entering the marine park would be significant. The project area that could potentially impact the marine park extends from the start of the project in Section 1 north to station 9.5 near Dirty Creek. The marine park is closest to the project at approximate station 1.0. As the project continues northwards, it diverges away from the marine park so that the crossing at Dirty Creek is over seven kilometres upstream from the marine park and impacts of the project would be less significant. Refer to Figure 5-1.

**Figure 5-1 Region of the Solitary Island Marine Park in Section 1**




Within the Marine Park catchment, areas of erodible soils occur at the intersections with the Arrawarra Gully, (directly upstream of the marine park), the Corindi River (about 800 metres upstream) and Redbank Creek (over three kilometres upstream). The impact of soil erodibility within the Arrawarra Gully will be more significant than that of Corindi River and Redbank creek due to the close proximity to the marine park. As a result additional mitigation would be required around Arrawarra Gully. The mitigation would be detailed in the principal erosion sedimentation control plans. The plans would highlight the areas of erodible soils and provide mitigation measures. It would include increased usage of sediment fences in this area to increase the interception of sediments before they reach the sedimentation basin that would be designed to capture and treat runoff from the area, as well as other erosion and sediment control measures in accordance with the Blue Book (Landcom, 2004 and DECC, 2008). The erosion sedimentation control plan would be reviewed and approved by RMS prior to construction. This mitigation would reduce the impact of erodible soils around the Arrawarra Gully on the water quality of the marine park to an acceptable level.

Acid sulfate soils are mapped as having a high probability of occurrence, between one and three metres below the ground surface at Arrawarra Gully and between stations 1.0 and 2.0. However, construction in these areas is in fill with removal of topsoil only, therefore the risk of disturbing the acid sulfate soils during general construction and impacting water quality in the Marine Park is low. Construction of the three sedimentations basins near Arrawarra Gully, however, may expose acid sulfate soils. During detailed design the depth of the three sedimentation basins around Arrawarra Gully would be reviewed and, if possible within the site constraints, would be reduced to the minimum depth specified by the Blue Book (Landcom, 2004 and DECC, 2008) whilst retaining the required volume. If this is not possible, the standard measures for management of acid sulfate soils outlined in Section 4.2.5 would be implemented.

From Corindi River to Cassons creek there is a high probability of occurrence of ASS in depths greater than 3 metres. The road alignment in these areas is on fill and therefore there is no risk of disturbance. Bridge piers for Cassons Creek are only one metre deep and so pose limited risk of exposing ASS. However the construction of bridge piers at Corindi Creek and the Corindi River floodplain would be between five and eight metres deep, exposing ASS. Mitigation would be required and the standard measures for management of ASS outlined in Section 4.2.5 would be implemented for this construction work. In general, construction of these bridges would pose a risk to the water quality of the immediate waterway below, and mitigation would be implemented in line with the RMS procedures for working within waterways, detailed in Section 4.2.12, thus reducing the downstream impact the water quality of the Marine Park to an acceptable level.

The design includes a large batter between station 8.5 and 8.7 near Dirty Creek and a road gradient that is relatively steep in the same vicinity, between station 8.0 and 9.0. Mitigation would be required to protect the receiving waterways and would be detailed in the site specific erosion and sediment control plans. The plans would highlight the large batter and steep gradient and would detail mitigation measures. It would include increased usage of sediment fences in this area to increase the interception of sediments before they reach the sedimentation basin that would be designed to capture and treat runoff from the area, and other measures including, but not limited to, temporary cover of exposed batters. This, combined with the long distance of about 15 kilometres between the project and the Marine Park, would result in an insignificant impact on the downstream Marine Park.

Stockpile sites are planned for this region at approximate stations 2.5, 3.3 to 3.4 (180 metres from Corindi River), 5.2 to 5.3 (250 metres from Redbank Creek) and 7.4 to 7.7 (750m from a tributary of Redbank Creek). The latter two sites could also be used for material processing. Mitigation in these areas would be required due to the sensitive nature of the creeks and rivers and their proximity to mapped Oxleyan Pygmy Perch habitats. It would be provided in line with the management measures detailed for stockpile sites in Section 4.2.16 and material processing sites in Section 4.2.20 and the measures to prevent spills detailed in Section 4.2.7,.  During detailed design, consideration should be given to the distance between these materials processing sites and

Redbank and Pillar Valley Creek respective, and appropriate controls implemented or alternative areas selected for the purpose that would further minimise any impact on the marine park.

If runoff from the construction or operational highway were to be discharged without mitigation, the impact on the water quality of the marine park would be significant, although the impact would decrease towards the north of the region as the flowpath distance between the highway and the marine park increased. Mitigation against this during the construction phase of the project has been incorporated into the concept design. The concept design for water quality includes the design of sedimentation basins as part of a treatment train to protect water quality during construction. Sedimentation basins have been located along the region to collect and treat construction runoff prior to discharge into downstream waterways. Because the region has been defined as an sensitive receiving environment the basins have been design using an 85$^{th}$ percentile, five-day rainfall depth design parameter, increased from the 80$^{th}$ percentile value used in non sensitive receiving environment areas. It is anticipated that this would be sufficient, however, as outlined in Section 4.2.19, during detailed design the 90th percentile design parameter would be examined and considered for sizing the sedimentation basins located in this high risk region.

Mitigation during the operational phase of the project has been incorporated into the concept design. For the detailed design, rainfall runoff and accidental spills would be treated and contained through the provision of grassed swales, rock check dams, water quality ponds, spill basins or a combination of these. The detailed design would determine what control measures are required to meet the target criteria given in Section 6.2.2, with consideration of design constraints, other potential impacts and acquisition constraints. Meeting the target criteria along the full length of highway would result in there being no significant impact on the water quality of the Marine Park.

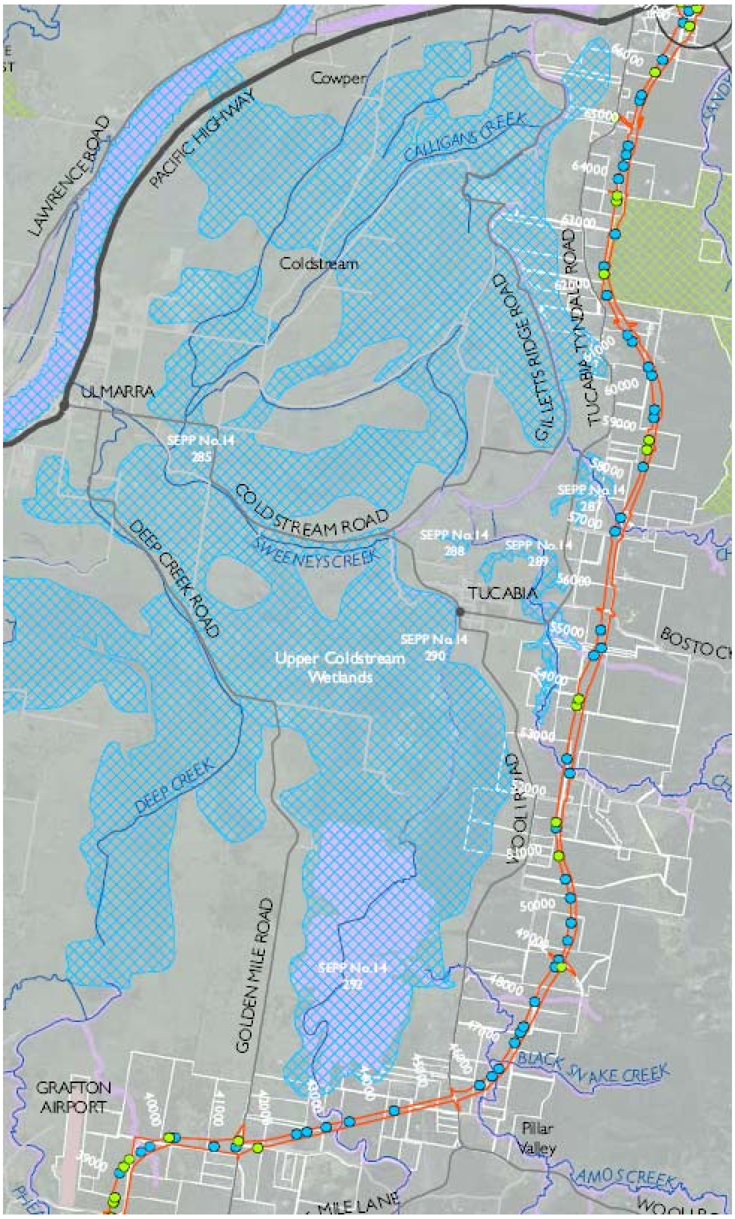
## 5.2. Upper Coldstream Wetlands

The Upper Coldstream Wetlands lie directly to the west of the project, between stations 39.0 and 66.0 in Section 3. A plan of the region is show in Figure 5-2. The wetlands are a key fish habitat, are listed as National Important and contain a number of listed as SEPP 14 wetlands. However, these wetlands do not support habitat for any listed threatened fish species.

The Wetland receives flows from the Coldstream River, Pillar Valley Creek, Black Snake Creek, Chaffin Creek, Champions Creek a number of unnamed waterways, including an unnamed tributary o f Glenugie Creek at station 39.7, an unnamed tributary of Pillar Valley Creek at station 48.0, and an unnamed tributary of Champions Creek at station 54.6. All these waterways cross the project.

Erodibility of soils in the region is not currently known, but there is a high probability of acid sulfate soils occurring between one and three metres deep around the waterway crossings of Coldstream River, Pillar Valley Creek, Black Snake Creek, Chaffin Creek and Champions Creek. The construction of bridge piers at these waterways will require work within potential acid sulfate soils. Likewise, the construction of sediment basins may expose acid sulfate soils. Much of the alignment in this section is in areas of cut, which may expose acid sulfate soils around these waterways. Away from these waterways, there are no known occurrences of acid sulfate soils in the region. During detailed design, the depth of the sedimentation basins near the waterway crossings of Coldstream River, Pillar Valley Creek, Black Snake Creek, Chaffin Creek and Champions Creek would be reviewed and, if possible within the site constraints, would be reduced to the minimum depth specified by the Blue Book (Landcom, 2004 and DECC, 2008) while retaining the required volume. Acid sulfate soils mitigation around the waterways would be required during construction of the bridges in line with the measures in Section 4.2.5

**Figure 5-2 Region of the Upper Coldstream Wetlands in Section3**




The construction of these bridges (nine in total within the region) poses a risk to the water quality of the immediate waterway and the downstream Upper Coldstream Wetlands, as activities may disturb the bed and banks of the waterway resulting in soil and streambank erosion and high volumes of sediment entering and polluting the waterways. Mitigation would be implemented in line with the RMS procedures for working within waterways, detailed in Section 4.2.12.

Large excavations will be undertaken between stations 54.0 and 54.3, as well as between stations 59.5 and 59.9. While neither of these excavations is close to named waterways, runoff would still eventually run to the Upper Coldstream Wetlands via overland flow paths. Mitigation would be required to protect the Wetland from increased sediment loads being transports from the large excavations and would be detailed in the site specific erosion sedimentation control plans. The plans would highlight the large excavations and would detail mitigation measures. It would include increased usage of sediment fences in this area to increase the interception of sediments before they reach the sedimentation basins, and other measures including, but not limited to, temporary cover of exposed batters. The erosion sedimentation control plans would be reviewed and approved by RMS prior to construction.

Stockpile sites are proposed for stations:

- 45.6 to 46.0, which is 400 metres from Pillar Valley Creek, area is also planned to contain a materials processing area, batch plant and workshop
- 49.5 to 49.6, area is also planned to contain a site compound, area is not within close proximity to named or mapped waterways
- 51.4 to 51.5, area is not within close proximity to named or mapped waterways
- 52.0, area is also planned to contain a materials stockpiling site, area is not within close proximity to named or mapped waterways
- 56.2 to 56.4, area is not within close proximity to named or mapped waterways
- 61.2 to 61.5, area is not within close proximity to named or mapped waterways.

Mitigation to protect water quality would be provided in line with the management measures detailed for stockpile sites in Section 4.2.16 and site compound and materials procession sites in Section 4.2.20 and the measures to prevent spills detailed in Section 4.2.7.

During detailed design, consideration should be given to the distance between the materials processing site (between stations 45.6 and 46.0) and Pillar Valley Creek, and appropriate controls or an alternative area selected for the purpose that would further minimise any impact on Upper Coldstream Wetlands.

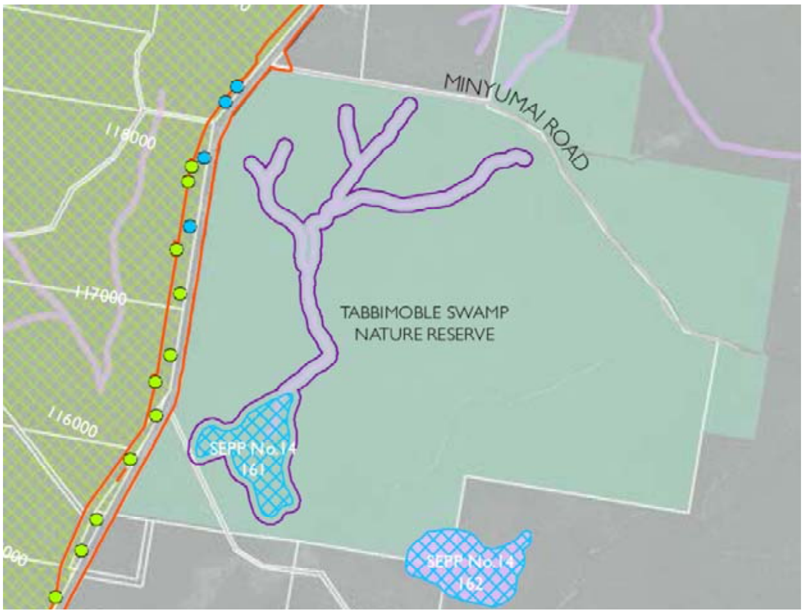
Throughout this region, if runoff from the construction or operational highway were to be discharged without treatment, the impact on the water quality of the Upper Coldstream Wetlands would be significant, due to the proximity of the project to the Wetlands. Mitigation against this during the construction phase of the project has been incorporated into the concept design. The concept design for water quality includes the design of sedimentation basins as part of a treatment train to protect water quality during construction. Sedimentation basins have been located along the region to collect and treat construction runoff prior to discharge into downstream waterways. Because the region has contains multiples sensitive receiving environment the basins in this region have been designed using an 85$^{th}$ percentile, five-day rainfall depth design parameter, increased from the 80$^{th}$ percentile parameter used in non sensitive receiving environment areas. It is anticipated that this would be sufficient, however, as outlined in Section 4.2.19, during detailed design the 90th percentile design parameter would be examined and considered for sizing the sedimentation basins located in this high risk region.

Mitigation during the operational phase of the project has been incorporated into the concept design. For the detailed design, rainfall runoff and accidental spills would be treated and contained through the provision of grassed swales, rock check dams, water quality ponds, spill basins or a combination of these. The detailed design would determine what control measures are required to meet the target criteria given in Section 6.2.2, with consideration of design constraints, other potential impacts and acquisition constraints. Meeting the target criteria along the full length of highway would result in there being no significant impact on the water quality of the Upper Coldstream Wetlands.

## 5.3. Tabbimoble Swamp Nature Reserve

Tabbimoble Swamp has significant ecological value and therefore the implications of impacts to water quality in the region from station 115.0 to 119.0 in Section 7 would be high. A plan of the region is show in Figure 5-3. The swamp is a mapped OPP habitat and a SEPP 14 wetland. As such it is considered to be a sensitive receiving environment.

**Figure 5-3 Region of the Tabbimoble Swamp Nature Reserve in Section 7**




There is no known occurrence of acid sulfate soils in the area, however the soil conditions along the alignment within the region are mapped as being highly erodible, posing an increased risk of sedimentation to the downstream aquatic habitats and therefore requiring mitigation to reduce this risk. The mitigation would be detailed in the site specific erosion and sediment control plans. The plans would highlight this area of erodible soils and would provide mitigation measures including increased usage of sediment fences to increase the interception of sediments before they reach the sedimentation basin. Sedimentation basins would be designed to capture and treat runoff from the area, sized to take into account the erodibility of the soil. The erosion sedimentation control plan would be reviewed and approved by RMS prior to construction. This mitigation would reduce the impact of erodible soils on the water quality of the nature reserve to an acceptable level.

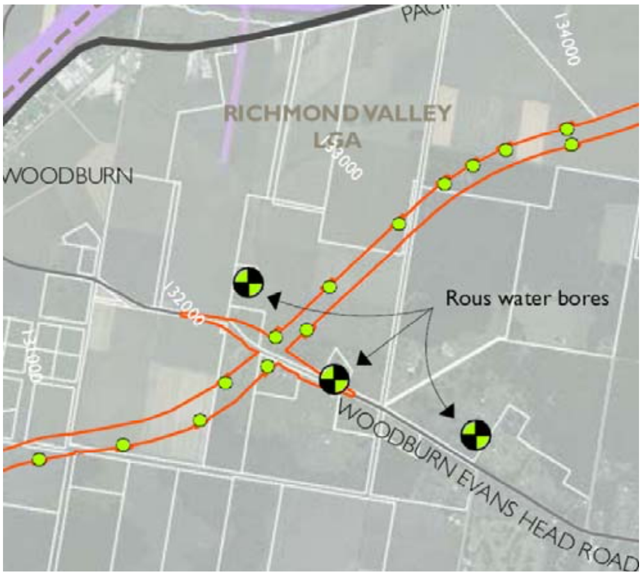
The design does not include any large excavations or batters and the road gradient is not steep in this area. There are no waterways crossing the project and no stockpile sites. These factors reduce the risk posed by construction to the water quality of the swamp. However, unmitigated construction runoff is not acceptable due to the value of the receiving environment, and therefore mitigation during construction has been included in the concept design. In it, sedimentation basins are part of a treatment train to collect and treat construction runoff prior to discharge. Because the region has been defined as a sensitive receiving environment the basins have been design using an 85$^{th}$ percentile, five-day rainfall depth design parameter, increased from the 80$^{th}$ percentile value used in non sensitive receiving environment areas. It is anticipated that this would be sufficient; however, as outlined in Section 4.2.19, during detailed design the 90th percentile design parameter would be examined and considered for sizing the sedimentation basins located in this high risk region. The implementation of the detailed design to the agreed design criteria, along with the correct implementation of approved erosion sedimentation control plans would reduce the risk of water quality impacts on the Tabbimoble Nature Reserve during construction to an acceptable level.

Mitigation during the operational phase of the project has also been incorporated into the concept design; however the detailed design would determine the exact type of control measures required to meet the target criteria given in Section 6.2.2, with consideration of design constraints, other potential impacts and acquisition constraints. Meeting the target criteria for the operation of this section would result in there being no significant impact on the water quality within the Tabbimoble Nature Reserve.

## 5.4. Rous Water regional water supply catchment

Construction and operation of the project between stations 131.1 and 134.0 in Section 8 could impact on the water quality of the Rous Water Regional Water Supply. The drinking water catchment of the Rous Water borefields is considered to be a sensitive receiving environment and due to the high implications related to degraded water quality, the region is additionally considered a high risk area. The region is a floodplain and contains a number of cane drains but does not include any named or mapped waterways. A plan of the region is show Figure 5-4. The potential impacts have been discussed in detail in Section 3.1.4 and should be referred to.

**Figure 5-4 Region of the Rous Water regional water supply catchment**



The strategy for mitigation during construction is to remove contaminants prior to discharge to the receiving environment. As such, all construction runoff in this area must be diverted to sedimentation basins for treatment prior to discharge. As the region is considered to be a sensitive receiving environment, basins that discharge to the catchment of the borefield would be designed to the 85$^{th}$ percentile, five-day rainfall depth design parameter (this design methodology is explained further in Section 4.2.19), increased from the 80$^{th}$ percentile value used in non sensitive receiving environment areas. It is anticipated that this would be sufficient, however, as outlined in Section 4.2.19, during detailed design the 90th percentile design parameter would be examined and considered for sizing the sedimentation basins located in this high risk region. No runoff would bypass the basins untreated, regardless of the size of the footprint of the work.

In addition, all sedimentation basins in the borefields would be clay lined or lined with a geosynthetic clay liner to prevent exfiltration or seepage through cracks in the base of the basin. In addition to this and if required, the depth of the basins would be reduced from the standard depth of two metres to the minimum depth specified by the Blue Book (Landcom, 2004 and DECC, 2008) in these areas to avoid penetration of the natural clay layer or to avoid working within areas of known acid sulfate soils, with the volume of the basins maintained by increasing their footprint. Temporary diversion drains used for transporting site runoff during construction would also be lined with an impermeable material to prevent infiltration to the underlying groundwater sources.

Acids sulfate soils have a high probability of occurring to the south of Woodburn Evans Head Road and on the western side of the length of the alignment in this region. Elsewhere there is a low probability of occurrence. The construction in this region is in fill and therefore acid sulfate soil should not be exposed, however the construction of sedimentation basins and the Woodburn Floodway Viaduct 1 at station 131.1 will potentially expose acid sulfate soils. To mitigate acid sulfate soils risks in this area, a site specific acid sulfate soils management plan would be developed for the identified recharge area associated with the Woodburn bores.

There are no large excavations, large batters or steep gradients in this area. However, stockpile sites are planned for this region at approximate stations 131.4 to 132.2 on the eastern side of the alignment, 132.0 to 132.2 on the western side of the alignment, and at stations 132.3 to 132.4. The first two sites are also proposed to also be used for a site compound and site office respectively. Mitigation would be provided in line with the measures for stockpiles sites in Section 4.2.16 and site compounds in Section 4.2.20 and the measures to prevent spills detailed in Section 4.2.7.

During detailed design, consideration would be given to the location of the site compound to assess whether there are suitable locations outside the region, in order to ensure that the risk to the water quality water supply catchments are minimised. In addition, the following construction activities within the borefield catchment, (between station 131.1 and 134.0), would not be permitted:

- Refuelling
- Washdown
- Storage of chemicals or other hazardous substances
- Installation of concrete batch plants.

This mitigation provides an improvement to the existing management of water quality whereby untreated road runoff has the potential to flow into the area of the bores after rainfall events.

The impacts to water quality during operation were analysed in Section 3.2.2 and should be referred to. The strategy for operational mitigation is again to remove contaminants prior to discharge to the receiving environment.  All runoff from the upgrade would be diverted to a water quality treatment control, and spill control would be provided. There would be no runoff from pavements that will discharge without being treated via a water quality pond.

The mitigation currently outlined in the concept design includes an operational treatment process involving swales and spill basins. Detailed design would need to review this, and adopt a similar standard of stormwater treatment controls to those used for the T2E project (RTA, 2008e), within the constraints of this site, to mitigate impacts on the Rous Water regional water supply catchment.

In addition to these measures for the operational phase, all water quality ponds in the region would be clay lined or lined with geosynthetic clay layer to prevent exfiltration or seepage through cracks in the base of the basin. In addition to this, and if required, the depth of the ponds would be reduced from the standard depth of two metres to the minimum depth specified by the Blue Book (Landcom, 2004 and DECC, 2008) in these areas to avoid penetration of the natural clay layer, with the volume of the water quality ponds maintained by increasing their footprint. Permanent channels and swales would also be lined with concrete or other form of impermeable material to prevent contamination of the underlying groundwater.

Finally, during detailed design, consideration may be given to relocating the Rous Water Bores in consultation with Rous Water.

## 5.5. Broadwater National Park

Broadwater National Park is situation to the east of the project and is close the proposed alignment between stations 135.5 and 141.0 in Sections 8 and 9. A plan of the region is show in Figure 5-5 and Figure 5-6. Wetlands in the park are habitat for Oxleyan Pygmy Perch, a number of which are listed SEPP 14 wetlands. The proposed alignment in this area follows the route of the existing highway, which dissects the Broadwater National Park for about 2.5 kilometres. The significant ecological value of the region makes it a high risk area in the context of this project.

There are two waterways crossing the project in this region – Macdonalds Creek at station 136.7 and an unnamed tributary of Macdonalds Creek at station 136.5, however neither of these waterways are within the national park and both are flowing away from the direction of the national park, into Richmond River. Works are required in the waterways crossing at Mcdonalds Creek, and, while this does not pose a risk to the national park itself, the creek is an Oxleyan Pygmy Perch habitat, and therefore the impacts would be mitigated by the procedures detailed in Section 4.2.18. Risks to water quality in the Broadwater National Park are increased by the presence of highly erodible soils along the project alignment, which would need to be mitigated throughout construction, using measures such increased usage of sediment fences to capture sediments prior to treatment in temporary sediment basins, sized specifically to mitigate highly erodible soils in the catchment. The mitigation measures would be clearly detailed in the erosion sedimentation control plans, highlighting the additional requirements for the Broadwater National Park areas, which would be approved by RMS prior to construction. This mitigation would reduce the impact of erodible soils on the water quality of the National Park to an acceptable level.

Around Macdonalds Creek, between stations 136.0 and 137.0, there is a high probability of acid sulfate soils between one and three metres below ground. Construction in this area is in fill, however the basins in the southern edge of the region, to the south of the national park, would potentially expose acid sulfate soils and this would need to be mitigated. During detailed design the depth of these sedimentation basins around Macdonalds Creek would be reviewed and, if possible within the site constraints, would be reduced to the minimum depth specified by the Blue Book (Landcom, 2004 and DECC, 2008) whilst retaining the required volume. If this is not possible, the standard measures for management of acid sulfate soils outlined in Section 4.2.5 would be implemented. There is a low probability of acid sulfate soils elsewhere in the region.

**Figure 5-5 Region of the Broadwater National Park in Section 9**

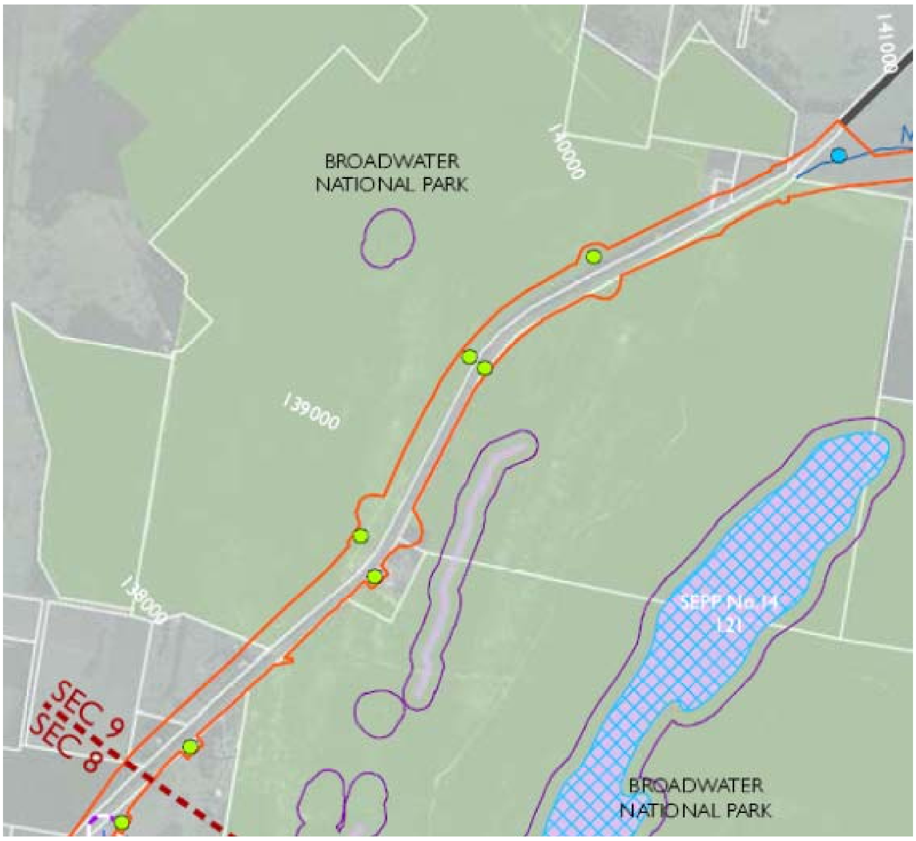


**Figure 5-6 Region of the Broadwater National Park in Section 8**


The design does not include any large excavations or batters and the road gradient is not steep in this area. There is a site compound and stockpile site proposed for the area between stations 137.5 and 137.9, within close proximity to the boundary of the National Park. Mitigation in these areas would be required and would be provided in line with the management measures detailed for stockpile sites in Section 4.2.16 and site compounds in 4.2.20 and the measures to prevent spills detailed in Section 4.2.7. During detailed design, consideration would be given to the location of the site compound to assess whether there are suitable locations outside Broadwater National Park high risk area in order to ensure that the risk to the water quality of the national park are minimised.

Mitigation during construction has been included in the concept design. In it, sedimentation basins are part of a treatment train to collect and treat construction runoff prior to discharge. Because the region has been defined as an sensitive receiving environment the basins have been design using an 85$^{th}$ percentile, five-day rainfall depth design parameter, increased from the 80$^{th}$ percentile value used in non sensitive receiving environment areas. It is anticipated that this would be sufficient, however, as outlined in Section 4.2.19, during detailed design the 90th percentile design parameter would be examined and considered for sizing the sedimentation basins located in this high risk region. The implementation of the detailed design to the agreed design criteria, along with the correct implementation of approved erosion sedimentation control plans and a review of the site compound locations would reduce the risk of water quality impacts on the Broadwater National Park during construction to an acceptable level.

Mitigation during the operational phase of the project has also been incorporated into the concept design and includes a combination of grassed swales and water quality ponds to treat runoff. However, the detailed design would determine the exact type of control measures required to meet the target criteria given in Section 6.2.2, with consideration of design constraints, other potential impacts and acquisition constraints. Meeting the target criteria for the operation of this section would result in there being no significant impact on the water quality within the Broadwater National Park during operation.

## 5.6. Wardell Heath

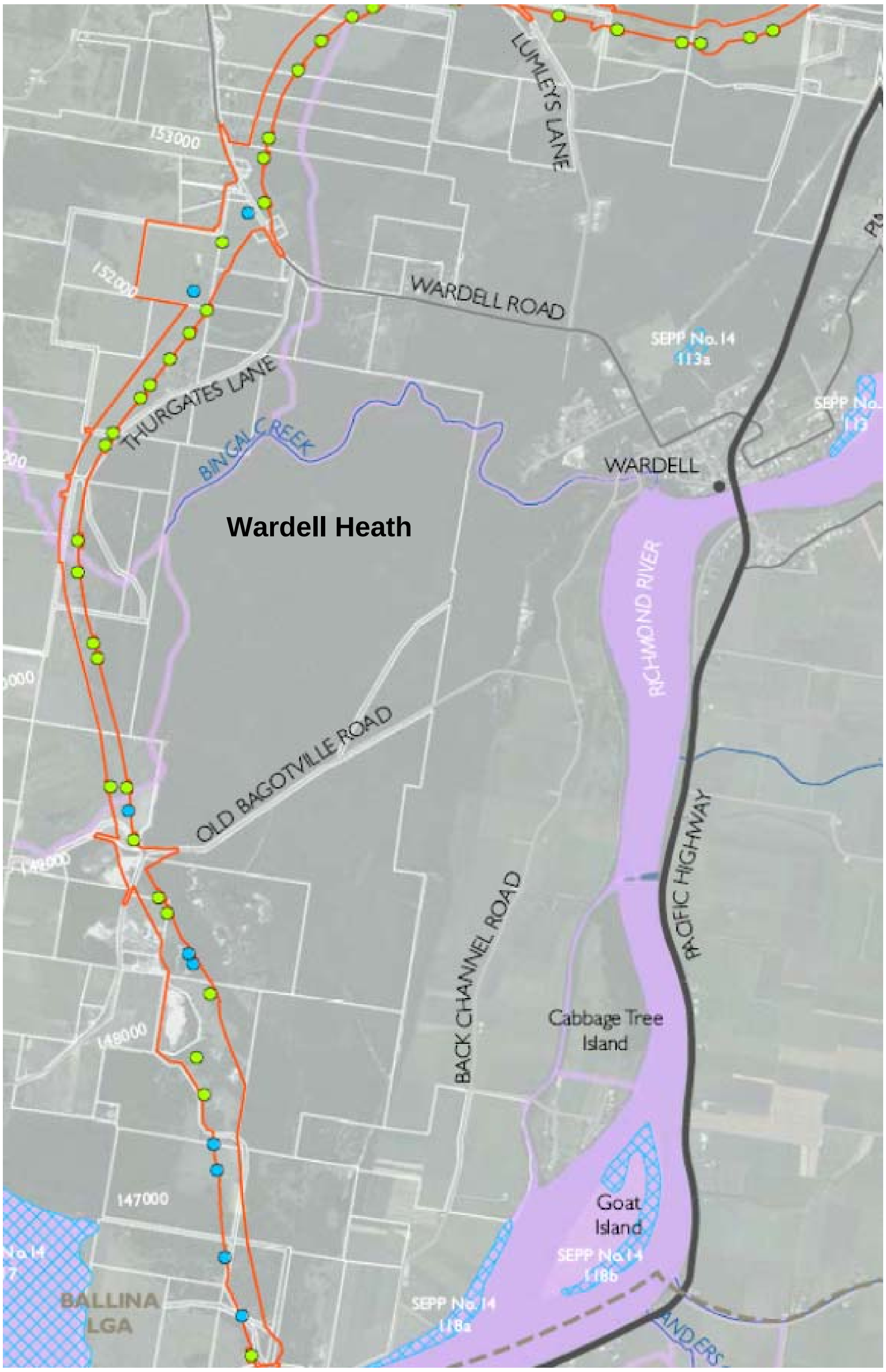
Wardell Heath is located to the east of the project between station 146.0 and 157.0 in Section 10. A plan of the region is show in Figure 5-7. It is deemed to be region of high ecological value, where unmitigated construction could significantly affect the water quality of the region, impacting on the ecosystem. There are three unnamed waterways that cross the alignment in this region (at station 149.3, 150.6 and 153.9), all of which flow to Bingal Creek, which passes through the Heath.

Risks to water quality from construction in this area are increased by highly erodible soils which would need to be mitigated throughout construction. Mitigation would be detailed in the site specific erosion and sediment control plans, which would be approved by RMS prior to construction. The plans would highlight this area of erodible soils and would provide mitigation measures including increased usage of sediment fences to increase the interception of sediments before they reach the sedimentation basin. Sedimentation basins would be designed to capture and treat runoff from the area and sized to take into account the erodibility of the soil. This mitigation would reduce the impact of erodible soils on the water quality of the Heath to an acceptable level.

There is low probability of acid sulfate soils in the area, no major works within waterways and the alignment is not steep, thus limiting risks to water quality from such factors during construction. However, there are two large excavations at station 147.5 to 147.6 and 147.8 to 148.1 that could contribute to increased sediment loads in downstream waterways during construction and hence this would need to be mitigated. Again, mitigation for these large excavations would be managed during construction based on the details outlined in the RMS approved site specific erosion and sediment control plans. The plans would highlight these excavation areas and would provide mitigation measures including increased usage of sediment fences to increase the interception of sediments before they reach the sedimentation basin, and other measures including, but not limited to, temporary cover of exposed batters.

During construction, a site office and stockpile site is proposed for the area between station 152.7 and 152.8, and an additional site compound, batch plant, workshop, vehicle parking and stockpile site is proposed between station 156.2 and 156.6. These areas have a high potential for polluting downstream waterways and would need to be carefully mitigated through the management measures for stockpile sites detailed in Section 4.2.16, the measures to prevent spills detailed in Section 4.2.7, and the mitigation measures for site compounds and materials processing sites detailed in 4.2.20. During detailed design, consideration would be given to the location of these site compounds assess whether there are suitable locations outside the Wardell Heath area in order to ensure that the risks to the water quality of the Heath are minimised.

**Figure 5-7 Region of Wardell Heath in Section 10**




In general, unmitigated construction runoff is not acceptable due to the value of the receiving environment, and therefore mitigation during construction has been included in the concept design. In it, sedimentation basins are part of a treatment train to collect and treat construction runoff prior to discharge. Because the region has been defined as an sensitive receiving environment the basins have been design using an 85th percentile, five-day rainfall depth design parameter, increased from the 80th percentile value used in non sensitive receiving environment areas. It is anticipated that this would be sufficient, however, as outlined in Section 4.2.19, during detailed design the 90th percentile design parameter would be examined and considered for sizing the sedimentation basins located in this high risk region. The implementation of the detailed design to the agreed design criteria, along with the correct implementation of approved erosion sedimentation control plans and a review of the site compound locations would reduce the risk of water quality impacts on the Wardell Heath during construction to an acceptable level.

Mitigation during the operational phase of the project has also been incorporated into the concept design and includes a combination of grassed swales and water quality ponds to treat runoff. However, the detailed design would determine the exact type of control measures required to meet the target criteria given in Section 6.2.2, with consideration of design constraints, other potential impacts and acquisition constraints. Meeting the target criteria for the operation of this section would result in there being no significant impact on the water quality within the Wardell Heath during operation.

## 5.7. Threatened fish

Areas throughout the project where surface water from the construction site or operational highway would discharge to or within 50 metres distance from a known or potential habitat of a threatened fish are considered to be sensitive receiving environments as well as high risk areas. In particular, a borrow source site (Lang Hill) has been identified adjacent to Oxleyan Pygmy Perch habitat at station 134.7. Potential impacts are identified in section 3.1.15 and mitigation measures identified in section 4.2.21.

Section 2.8.6 has described the threatened fish that exist in the region of the project and Appendix D maps the locations of their habitats. The impacts of construction on the water quality of these areas has been analysed in Section 3.1.1. It provides information on the chemical characteristics of threatened fish habitats (particularly in relation to the threatened fish species Oxleyan Pygmy Perch) and the impact of changes to these characteristics. There are a number of naturally acidic environments along the project which are known and potential Oxleyan Pygmy Perch habitats (such as in the Coldstream RIver and MacDonalds Creek), where maintaining the existing water quality (which do not meet the ANZECC/ARMCANZ (2000) guidelines) is crucial to keeping the waterway suitable for Oxleyan Pygmy Perch.

Where work is being carried out in known habitats of threatened fish such as Oxleyan Pygmy Perch or Purple Spotted Gudgeon, it is imperative that the impact mitigation measures detailed in the Biodiversity Working Paper are implemented. The Biodiversity Working Paper details specific measures to avoid and mitigate impacts to protected fish species, in particular the Purple-spotted Gudgeon and Oxleyan Pygmy Perch, and their habitat, and states that such measures are to be documented in the project specific construction environmental management plan. It should be read in conjunction with this report.

In addition to this, mitigation during construction has been included in the concept water quality design. In it, sedimentation basins are part of a treatment train to collect and treat construction runoff prior to discharge into these areas. Because habitats for threatened fish have been defined as sensitive receiving environments the basins have been designed using an 85th percentile, five-day rainfall depth design parameter, increased from the 80th percentile value used in non sensitive receiving environment areas. It is anticipated that this would be sufficient; however, as outlined in Section 4.2.19, during detailed design the 90th percentile design parameter would be examined and considered for sizing the sedimentation basins located in areas that would be discharging into or near habitats of threatened fish.

The required water quality parameters for basins discharging into these areas would be determined during detailed design, with consideration of the individual parameters, such as pH, required to maintain the health of the habitat as identified by baseline monitoring. These would be included in the EPL.

Discharges from sediment basins during construction that do not meet the water quality parameters for Oxleyan Pygmy Perch habitat (as identified through pre-construction water quality monitoring), in particular, should not be discharged into the waterway but rather sprayed into adjacent open grass areas or used for construction purposes such as dust suppression to avoid changing water depth and physico-chemical conditions in potential threatened fish habitat

Where it is not feasible to irrigate to land to completely re-use sediment basin water, then as a last resort discharge water from sedimentation basins to Oxleyan Pygmy Perch waterways will be treated to ensure it has the correct pH of less than 5.5 and total suspended solids of less than 50mg/L.

The locations of potential or known habitats of threatened fish would be finalised during detailed design and would be clearly mapped on the erosion sedimentation control plans. The following activities and installations would not take place within 50 metres upstream of a known or potential habitat of a threatened fish, as shown on the erosion sedimentation control plans:

- Refuelling
- Washdown
- Storage of chemicals or other hazardous substances
- Concrete batch plants
- Materials processing areas
- Site compounds.

The implementation of the management measures here and those outlined in the Biodiversity Working Paper, along with the implementation of the detailed design to the agreed design criteria, would reduce the risk of water quality impacts on threatened fish during construction to an acceptable level.

Mitigation to protect water quality in these areas during the operational phase of the project has also been incorporated into the concept design and includes a combination of grassed swales and water quality ponds to treat runoff. However, the detailed design would again determine the exact type of control measures needed to meet the following requirements with consideration of design constraints, other potential impacts and acquisition constraints:

- The target criteria given in Section 6.2.2
- Other water quality parameters relevant to the health of the receiving threatened fish habitat, as determined during detailed design
- The requirements of the Biodiversity Working Paper.

If these are met, it would result in there being no significant impact to the water quality of threatened fish habitats during operation.

# 6. Design methodology

## 6.1. Construction phase sedimentation basins

### 6.1.1. Locating sedimentation basins

A geographic assessment was undertaken to determine existing catchments along the project, using the 12D modelling software. A further assessment of the catchments was undertaken, based on the proposed upgraded road alignment. The locations of the sedimentation basins have been selected to best capture runoff from these catchments throughout the full construction process, using gravity driven diversion drains to divert runoff to the basins. Where possible, existing natural features have been incorporated into the treatment system. Furthermore, all attempts have been made to avoid properties and sensitive areas when locating sedimentation basins. This will be continued throughout detailed design.

Sections 4, 5, 8, 9 and 11 of the project are situated on floodplains and are relatively flat. In these sections, sedimentation basins have been provided about every 400 metres to ensure onsite diversion drains can be constructed with sufficient grade to convey site runoff to the basins. As the catchment areas for basins located on floodplains are relatively small, the basins would provide a settling period for sediments suspended in runoff during rainfall events. Basins would then overflow as sheet flow with low velocity into the surrounding floodplain, reducing the impact on water quality to an acceptable level.

In locations where sedimentation basins would be used only for the construction stage, additional land outside of the road corridor would be leased for the location of these basins during the construction phase of the project. These temporary basins are mainly situated on floodplains. The flat topography of these areas means that swales would be the most appropriate form of water quality treatment during the operational stage. As such, the sedimentation basins could be removed once construction is complete.

As stated previously, it should be noted that the location and sizes of these sedimentation basins in this report are preliminary only. As more information becomes available and changes to the design are considered during detailed design, the requirement for each of these basins will be reassessed. The analysis may result in some of the basins no longer being included in the design. The current basin locations provide information for leasing or purchasing the land, and other planning purposes.

### 6.1.2. Design criteria for sedimentation basin sizing

The design criteria for the temporary water quality treatment controls used during the construction phase are aimed at achieving the water quality objectives and meeting the performance objectives described in Section 4.1

Typical details of the preliminary sedimentation basins are shown in Appendix C and will be designed as Type C, D or F depending on the site specific soil testing results. The basins must provide a volume to capture a design rainfall depth (settling zone) and an appropriate volume for storage of sediment (storage zone). The settling zone volume is to be estimated using the appropriate design rainfall depth and catchment areas. The storage zone is to be estimated using the Revised Universal Soil Loss Equation (RUSLE). The parameters to be used for sizing the sedimentation basins are outlined in Table 6-1.

A key design consideration for sizing sedimentation basins is the *rainfall percentile*. For sensitive receiving environments identified in Section 2.8 , the capacity of the basin would be designed to contain all runoff expected from the 85$^{th}$ percentile, five-day rainfall depth. Where the receiving environment is not deemed not to be sensitive, the 80$^{th}$ percentile, five-day rainfall depth is appropriate (Landcom, 2004). As outlined in Section 4.2.19, the majority of sedimentation basins will be designed to the five-day 85$^{th}$ percentile value due to downstream sensitive receiving environments.

The criteria listed here may be amended with approval from RMS during detailed design providing the criteria continue to meet the requirement of the Blue Book requirements (Landcom, 2004 and DECC, 2008).

### Table 6-1 Concept design criteria for sizing the sedimentation basins

| Parameter | Value | Comments |
|---|---|---|
| **Rainfall parameters** | | |
| Rainfall depth duration (days) | 5 | 5 day adopted as standard duration. This assumes that five days or less are required following a rainfall event to achieve effective flocculation if necessary, settling and subsequent discharge of the supernatant stormwater |
| Rainfall percentile | 80th or 85th | 85$^{th}$ for sensitive receiving environments with construction duration between 6 months and 3 years, and 80$^{th}$ for all other areas, as per Table 6.1 Volume 2D of Blue Book. |
| Rainfall depth (mm) – 5 day | 40 mm to 55.8mm | The following locations are the closest sites to the project area, obtained from Table 6.3a from the Blue Book.<br><br>Coffs Harbour 80$^{th}$ = 42.7 mm and 85$^{th}$ =55.8 mm<br>Grafton 80$^{th}$ = 29.0 mm and 85$^{th}$ =37.2 mm<br>Lismore 80$^{th}$ = 35.3 mm and 85$^{th}$ =45.2 mm<br><br>Coffs Harbour rainfall depth of 80$^{th}$ = 42.7 mm and 85$^{th}$ = 55.8 mm has been adopted for Sections 1 to 6.<br><br>Modified Lismore rainfall data of 80$^{th}$ = 40 mm and 85$^{th}$ = 50 mm depth has been adopted for Sections 7 to 11. This conservative modification has been applied to take into consideration that Lismore is located further inland from the coastline and project alignment.<br><br>As Grafton is further inland from the project it has not been used. |
| Volumetric runoff coefficient, Cv | 0.64 to 0.74 | 0.8 adopted for expected type of activities on site and compacted surfaces. |
| Rainfall intensity for 2 year ARI, 6 hr duration | 12.8 to 16.3 mm/hr | Varies along the project. Refer to Rainfall erosivity below |
| Rainfall erosivity, R | Approx. 3500 to | Varies along the project:<br>▪ Dirty Creek, Section 1 = 4218 |

| Parameter | Value | Comments |
|---|---|---|
| | 4500 | ▪ Wells Crossing, Section 2: 3835<br>▪ Glenugie, Section 3 = 3539<br>▪ Harwood, Sections 4, 5 and 9 = 3596<br>▪ Woodburn, Sections 7, 8 and 9 = 4218<br>▪ Ballina, Sections 10 and 11 = 4780<br><br>Based on a comparison with Appendix B of the Blue Book, the adopted values are:<br>▪ R= 4500 for Section 1<br>▪ R = 3500 for Sections 2 to 6<br>▪ R = 4500 for Section 7 to 11 |
| **RUSLE parameters** | | |
| Soil/sediment type | C, D or F | Varies along the project .Mainly type F, type D, and small localised pockets of type C. Obtained from the NSW Soil Landscape Maps 1:100,000 sheets, Ref Appendix C of the Blue Book.<br><br>Type D has been adopted for deeper subsoils. |
| Erodibility, k | 0.01 to 0.085 | Varies along the project. Values obtained from the NSW Soil Landscape Maps 1:100,000 sheets, Ref Appendix C of the Blue Book.<br><br>0.06 has been adopted for high erodible soils |
| Hydrologic soil group | D | Appendix F of Blue Book |
| Soil Cover, C | 1 | Corresponding to expected type of activities on site |
| Soil conservation practices, P | 1.3 | Corresponding to expected type of activities on site |
| Length slope factors, LS | Variable | Determined separately for<br>1. main road area<br>2. steeper embankment areas (cut and fill)<br>For item 1 above, <1% adopted as flat area, for 1% to 5% as Mild, and for >5% as Steep.<br>For item 2 above, areas of cut and fill that represent more than 30% of the total catchment area would adopt a higher LS factor for this portion of the area. |
| Sediment Yield Time Period (months) | 2 to 6 | Depending on site constraints. 6 months adopted. |

### 6.1.3. Design methodology for sedimentation basin sizing

Using the above technical criteria, a simplified and consistent method to size sedimentation basins along the project length has been derived that takes into account key elements of each catchment, as listed below. From these key elements, a unit area (i.e. cubic metres per hectare) to estimate the required basin volume has been derived and applied to each catchment area to determine the sedimentation volume.

The five key design elements for each site are as follows:

- Catchment area flowing to sedimentation basins (excludes any diverted offsite runoff).
- Identify if the majority of the catchment is located on a flat, mild or steep area (less than one per cent, one to five per cent, and greater than five per cent.
- Identify if the catchment includes a significant area of cut or fill batters/embankments (greater than 30 per cent of surface area in cut or fill).
- Identify if the downstream waterways are classed as sensitive receiving environments (high for sensitive receiving environments).
- Identify the location of the basin (Section 1, Sections 2-6 or Section 7-11) due to different rainfall erosivity in these sections.

From these key elements, the derived rates to size the basins are shown in Table 6-2.

**Table 6-2 Derived unit rates used to size sedimentation basins ($m^3$/ha)**

| **Longitudinal slope** | **Flat (<1%)** | | | | **Mild (1% to 5%)** | | | | **Steep (>5%)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **% of contributing catchment in steep areas (cut or fill)** | **<30%** | | **>30%** | | **<30%** | | **>30%** | | **<30%** | | **>30%** | |
| Downstream waterways sensitivity and percentile for rainfall depth | low 80% | high 85% | low 80% | high 85% | low 80% | high 85% | low 80% | high 85% | low 80% | high 85% | low 80% | high 85% |
| Estimated basin volume Section 1 ($m^3$/ha) | 500 | 600 | 745 | 850 | 550 | 655 | 780 | 885 | 725 | 830 | 900 | 1000 |
| Estimated basin volume Section 2-6 ($m^3$/ha) | 460 | 565 | 655 | 760 | 505 | 610 | 685 | 790 | 640 | 745 | 770 | 875 |
| Estimated basin volume Section 7-11 ($m^3$/ha) | 470 | 555 | 725 | 805 | 530 | 610 | 760 | 840 | 705 | 785 | 870 | 955 |

This assessment has identified the preliminary locations and space requirements for the construction phase sedimentation basins to inform corridor width requirements. The required volume of each sedimentation basin has been determined according to the maximum catchment area that would drain to the basin during the various stages of the construction and the design parameters identified in Table 6-1. These design parameters are aligned with the requirements detailed in the *Soils and Construction Volume 1* (Landcom, 2004) *and Volume 2* (DECC, 2008)

Indicative locations and sizing of temporary sedimentation basins for the construction phase for each the project sections are presented in Table D-1 and the figures in Appendix D.

## 6.2. Operational phase water quality controls

### 6.2.1. Locating water quality controls

For the operational phase of the project, rainfall runoff and accidental spills would be treated and contained through the provision of grassed swales, rock check dams, water quality ponds, spill basins or a combination of these. The detailed design would determine what control measures are required to meet the target criteria given in Section 6.2.2, with consideration of design constraints, other potential impacts and acquisition constraints.

Generally in fill areas, grassed swales would be designed at the toe of the fill batter to capture and treat road runoff. Where the swale discharges into a sensitive receiving environment, a spill basin would be included in the design. In floodplain areas, in particular, grassed swales would be used as the predominant method of water quality control.

Where swales are not feasible, such as in steep areas or areas of cut, water quality ponds would be used to treat the pavement runoff.

Water quality basins would be placed in the optimal location for treating surface runoff. During detailed design, the location of water quality treatment measures would consider the competing biodiversity requirements of minimising vegetation removal, particularly in locations of potential and known threatened plant species, threatened ecological communities, threatened fauna habitat or in identified regional wildlife corridors. Water quality basins would also consider the design guidelines in the Project Connectivity Strategy (refer to Biodiversity Working Paper).

### 6.2.2. Design criteria for sizing water quality controls

To meet the water quality objectives detailed in Section 4.1 for the operational phase, the Department of Environment, Climate Change and Water (DECCW) design criteria for water quality as described in Managing Urban Stormwater- Council Handbook (EPA, 1997) are proposed to be used as guidelines values. These values are outlined in Table 6-3.

**Table 6-3 Operational water quality control treatment target criteria**

| Pollutant | Minimum reduction of the annual average load |
|---|---|
| Total suspended solids | 80% |
| Total nitrogen | 45% |
| Total phosphorous | 45% |
| Oil and grease | None visible |

### 6.2.3. Design methodology for sizing water quality controls

A strategic assessment of permanent water quality controls has been undertaken using the eWater MUSIC model. This involved setting up simple, site-specific water quality models with typical water quality control measures including water quality ponds and grassed swales. This determined the pond volume required to achieve the pollutant treatment targets for a theoretical catchment equal to one hectare. It also identified locations where treatment using swales would be adequate.

The model was developed for the southern and northern ends of the project in order to consider the variability in rainfall over the length of the alignment. Pluviograph data from Coffs Harbour (station number 59040) and Alstonville (station number 58131) was used. The models were run for 10 years of observed rainfall data from 1996 to 2005 at 1 hour time steps.

Water quality pond volume unit rates were estimated for anticipated ranges of impervious areas within a catchment (typically between 50 and 80 per cent to 80 per cent) at each location. The pond unit rates determined are shown in Table 6-4.

**Table 6-4 Operational phase water quality pond volume requirements per unit area ($m^3$/ha)**

| Catchment imperviousness (%) | Coffs Harbour | Alstonville |
|---|---|---|
| 0-50% | 550 | 540 |
| 50-60% | 560 | 545 |
| 60-70% | 580 | 550 |
| 80-100% | 620 | 570 |

The results indicate that pond volumes required to achieve the water quality objectives would need to range from 540 cubic metres to 620 cubic metres per hectare, depending on the location and impervious area within the catchment. For assessing the pond volume requirements, a median value of 580 cubic metres per hectare was adopted as a constant volume unit rate over the length of the alignment.

In relation to grassed swales, previous experience has shown that the use of grassed swales to manage water quality may be sufficient to provide treatment for total suspended solid and total phosphorus, depending on the space available. However, the criteria for the reduction in total nitrogen may not be met with swales. This may be achieved through the use of sufficient rock check dams. This would be determined during detailed design.

Indicative locations and sizing of permanent water quality ponds for each of the eleven sections are presented in Table D-1 in Appendix D. Where possible, construction stage sedimentation basins have been located and sized so that they can be retained as water quality ponds for the operational phase of the project. As previously stated, it should be noted that the location and sizes of these water quality ponds are preliminary only. As more information becomes available and changes to the design are considered during detailed design, the requirement for each of these basins and ponds will be reassessed. The analysis may result in some of the basins and ponds no longer being included in the design. The current basin and pond locations provide information for leasing or purchasing the land, and other planning purposes.

# 7. Water quality monitoring

Water quality monitoring is recommended to provide assurance of compliance with regulatory requirements and to immediately detect any environmental degradation as a result of the works. The monitoring program will form part of the construction environmental management plan and should be further developed to support the SWMP. It should be undertaken in line with the requirements of RTA's *Guidelines for Construction Water Quality Monitoring* (RTA, 2003c).

A water quality monitoring program effectively identifies potential water pollution problems from the works being undertaken as well as the cause of the problem. It also recommends management methods and remedial actions to address any identified water quality concerns.

Monitoring of water quality is required prior to construction, during construction and during operation of the project.

The objectives of pre-construction monitoring are to:

- Identify parameters for monitoring during construction.
- Determine the indicative existing water quality.

The objectives of construction monitoring are to:

- Identify if any water quality problems are occurring as a result of construction activities.
- Demonstrate compliance with legal and other monitoring requirements including the Environmental Protection Licence.

The objectives of operational phase monitoring are to:

- Assess and manage impacts on the receiving waters as the site stabilises.
- Assist in deciding when the site has stabilised.
- Identify water quality conditions after development.

Details of the requirements for water quality monitoring are provided in Appendix E.

# 8. Conclusions

This report identifies the potential water quality impacts associated with the construction and operation of the Pacific Highway Woolgoolga to Ballina upgrade project.

The region between Woolgoolga and Ballina contains a number of sensitive receiving environments, including rivers, creeks, SEPP 14 wetlands, national parks, marine parks, nature reserves, wildlife habitats and key fish habitats. A number of areas have been classified as high risk due to the potential for significant ecological impacts due to degraded water quality.

Without impact mitigation and management measures in place, the construction of the project could result in detrimental impacts onto surface water quality. This in turn may have adverse effects on key fish habitats, drinking water catchments and other sensitive receiving environments. These impacts would mostly be caused by increased sediment loading through the exposure of soils. Where these soils are highly erodible or contain acid sulphate materials, the environmental risks would be heightened.

During the operational phase of the project, the key issues are pollutants in road runoff and accidental spills, which could cause detrimental environmental impacts by flowing to surrounding surface waters or seeping into the groundwater.

To protect surface water and groundwater quality on-site and downstream of the project boundary, impact mitigation and management measures are recommended for the construction and operational phases of the project. During the construction phase, these measures would include the development of a SWMP that details how construction runoff would be collected, conveyed and treated throughout all stages of the construction process. Techniques to do this would include the use of sedimentation basins, catch and diversion drains, sediment fences and filters, rock check dams and level spreaders, in addition to minimising the exposure of subsoils, minimising stockpiling and progressive revegetation. In addition, works within waterways would be subject to specific mitigation measures.

To protect receiving waterways from ongoing impacts during the operation of the project, permanent water quality controls would be designed and implemented. These would include water quality ponds (with spill containment capabilities), grassed swales and biofiltration swales. Where possible, infrastructure used during the construction phases would be retained or adapted for the operational phase and natural features such as existing channels would be used.

Water quality monitoring would be undertaken prior to construction, during construction and during operation. A monitoring plan would detail the requirements of the monitoring and the procedures required if defined water quality trigger levels for protection of aquatic ecosystems or OEH environmental protection licenses are exceeded.

Through undertaking the preliminary location and sizing of water quality controls at this stage of the project, the extent of the project boundary required can be determined. In developing the detailed design, further modelling and optimisation of the water quality controls would be undertaken. Some of the basins and ponds outlined in this report may not be required. Throughout this refinement process, other solutions that conform to the guidelines and meet the design criteria may be considered. The final design would optimise water quality controls, ease of maintenance and cost, taking into account competing environmental requirements and sites constraints.

Provided adequate water quality controls are implemented, maintained and monitored during the construction and operational phases of this project, there would be no significant impact on waterways crossed by the project or high risk areas and sensitive receiving environments downstream of the project.

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# Appendix A Water quality sampling results

Note: Measurements that exceed the ANZECC/ARMCANZ (2000) default trigger values are highlighted in grey.

### Table A - 1 Water quality results for Section 1 from samples taken in 2007 (Woolgoolga to Halfway Creek) (RTA, 2008a).

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Arrawarra Creek | Corindi River* | | | Blackadder Gully | Cassons Creek | | Redbank Creek | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample point conditions | | DS | DS | DS | US | DS | DS | DS | DS | DS |
| Date | | | | | | | | | | |
| Turbidity | 6-50 NTU | 9 | 8.2 | 7 | 10 | 317 | 6.5 | 7.9 | 28 | 261 |
| Dissolved Oxygen | - (mg/L) | | 3.1 | 3.4 | 3.9 | 3.7 | | low | 1.4 | 2.2 |
| Electrical Conductivity | 0.125-2.2 mS/cm | 160 | 152 | 163 | 176 | 163 | 251 | 252 | 174 | 261 |
| pH | 6.5-8.5 | 5.7 | 6.5 | 6.6 | 6.9 | 6.1 | 6.3 | 6.2 | 5.9 | 6 |

Note: The Corindi River forms part of the Solitary Islands Marine Park
*suspected error with result

### Table A - 2 Water quality results for Section 2 from samples taken in 2007 (Halfway Creek to Glenugie upgrade) (RTA, 2008b).

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Glenugie Creek | |
|---|---|---|---|
| Sample point conditions | | Wet | Dry |
| Date | | 22/08/07 | 5-8/06/07 |
| Turbidity | 6-50 NTU | -* | 94.3 |
| Dissolved Oxygen | 85-110 (% Saturation) | 96.8 | 65.4 |
| Salinity | - | 0.08 | 0* |
| Electrical Conductivity | 0.125-2.2 (mS/cm) | 0.126 | 0* |
| pH | 6.5-8.5 | 6.7 | 6.1 |

*suspected error with result

**Table A - 3 Water quality results for Section 3 from samples taken in 2005 and 2007 (Glenugie interchange to Tyndale) (RTA, 2009a)**

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Pheasant Creek | | | Coldstream River | | | | Pillar Valley Creek | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample point conditions | | Dry | Wet (DS) | Wet (US) | Dry | Dry (US) | Wet (US) | Dry (US) | Dry | Dry (DS) | Wet (DS) |
| Date | | 5-8/06/07 | 22/08/07 | 22/08/07 | 5-8/06/07 | 6/4/05 24/05/05 | 22/08/07 | 6/4/05 24/05/05 | 5-8/06/07 | 5-8/06/07 | 22/08/07 |
| Turbidity | 6-50 NTU | 11 | 107 | -* | 385 | 8 | 75 | 6 | 12 | 8 | -* |
| Dissolved Oxygen | 85-110 (% Saturation) | 94.1 | 93.5 | 98.8 | 94.4 | 72.3 | 79.6 | 44.4 | 66.5 | 23.4 | 78.2 |
| Salinity | - | 0.02 | 0.07 | 0.08 | 0.05 | 0.10 | 0.03 | 0.12 | 0.09 | 0.09 | 0.04 |
| Electrical Conductivity | 0.125-2.2 (mS/cm) | 0.103 | 0.107 | 0.131 | 0.163 | 0.144 | 0.047 | 0.162 | 0.239 | 0.230 | 0.066 |
| pH | 6.5-8.5 | 6.5 | 6.3 | 6.7 | 5.9 | 6.7 | 5.4 | 6.6 | 6.4 | 5.9 | 5.6 |

*suspected error with result

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Chaffin Creek | | | Champions Creek | | |
|---|---|---|---|---|---|---|---|
| Sample point conditions | | Dry | Dry | Dry | Dry | Wet (US) | Wet (DS) |
| Date | | 5-8/06/07 | 22/08/07 | 6/4/05 24/05/05 | 5-8/06/07 | 22/08/07 | 22/08/07 |
| Turbidity | 6-50 NTU | 5 | 57 | 9 | 17 | 49 | 45 |
| Dissolved Oxygen | 85-110 (% Saturation) | 68.0 | 80.8 | 47.1 | 39.6 | 83.0 | 68.1 |
| Salinity | - | 0.09 | 0.04 | 0.15 | 0.06 | 0.04 | 0.04 |
| Electrical Conductivity | 0.125-2.2 (mS/cm) | 0.225 | 0.060 | 0.209 | 0.181 | 0.055 | 0.057 |
| pH | 6.5-8.5 | 6.2 | 5.9 | 6.5 | 6.4 | 5.0 | 5.2 |

### Table A - 4 Water quality results for Section 4 from samples taken in 2007 (Tyndale to Maclean) (RTA, 2009a).

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Estuarine | South Arm Clarence River | | | | | Shark Creek | | | | Edwards Creek | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample point conditions | | Dry | Wet (US) | Wet (US) | Wet (US) | Wet (US) | Dry | Wet (DS) | Wet (US) | Wet (DS) | Dry | Dry |
| Date | | 25-29/06/07 | 22/08/07 | 22/08/07 | 22/08/07 | 21/08/07 | 25-29/06/07 | 22/08/07 | 22/08/07 | 21/08/07 | 25-29/06/07 | 25-29/06/07 |
| Turbidity | 0.5-10 NTU | 4 | 38 | 39 | 46 | 18 | 12 | 35 | 27 | 42 | 3.3 | 7.8 |
| Dissolved Oxygen | 80-110 (% Saturation) | 78.4 | 71.5 | 74.8 | 76.2 | 95.4 | 66.8 | 71.1 | 53.4 | 74.8 | 60.0 | 43.5 |
| Salinity | - | 4.79 | 1.42 | 1.66 | 1.36 | 6.25 | 5.05 | 1.74 | 0.37 | 1.72 | 2.97 | 4.41 |
| Electrical Conductivity | - (mS/cm) | >8.0 | 2.214 | 2.597 | 2.125 | >8.0 | 2.214 | 2.597 | 2.126 | >8.0 | 5.482 | 7.480 |
| pH | 7.0-8.5 | 6.3 | 6.6 | 6.6 | 6.5 | 7.5 | 5.6 | 6.0 | 4.2 | 6.1 | 4.3 | 5.7 |

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Melaleuca Swamp |
|---|---|---|
| Sample point conditions | | Dry |
| Date | | 5-8/06/07 |
| Turbidity | 6-50 NTU | 55.3 |
| Dissolved Oxygen | 85-110 (% Saturation) | 31.6 |
| Salinity | - | 0.25 |
| Electrical Conductivity | 0.125-2.2 (mS/cm) | 0.561 |
| pH | 6.5-8.5 | 5.2 |

### Table A - 5 Water quality results for Section 5 from samples taken in 2005 and 2007 (Maclean to Harwood) (RTA, 2009a)

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Estuarine | James Creek | Clarence River (Maclean Intersection) | Clarence River (Main Bridge Southern Bank) | | | Clarence River (Main Bridge Northern Bank) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample point conditions | | Dry | Dry | Wet (US) | Wet (DS) | Dry | Dry | Wet (US) | Dry (US) | Wet (DS) | Dry (DS) |
| Date | | 5-8/06/07 | 25-29/06/07 | 21/08/07 | 21/08/07 | 25-29/06/07 | 25-29/06/07 | 21/08/07 | 5/04/05 25/05/05 | 21/08/07 | 5/04/05 25/05/05 |
| Turbidity | 0.5-10 NTU | 9.5 | 4.2 | 12 | 19 | 7 | 2 | 9 | 6 | 19 | 6 |
| Dissolved Oxygen | 80-110 (% Saturation) | 80.2 | 81.9 | 99.8 | 92.8 | 83.6 | 84.9 | 99.5 | 88.5 | 101.9 | 87.0 |
| Salinity | - | 16.35 | 6.91 | 12.99 | 13.44 | 12.67 | 12.75 | 12.68 | 15.35 | 12.97 | 20.20 |
| Electrical Conductivity | - (mS/cm) | >8.0 | >8.0 | 20.29 | 21.00 | 21.17 | 21.260 | 19.82 | 25.183 | 20.267 | 21.418 |
| pH | 7.0-8.5 | 7.1 | 6.0 | 8.1 | 8.0 | 6.4 | 6.5 | 7.8 | 7.8 | 7.8 | 7.8 |

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Estuarine | Serpentine Channel (route crossing) | | | | North Arm (Southern Bank) | | North Arm (Northern Bank) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample point conditions | | Dry | Wet | Wet | Wet | Wet | Wet (US) | Wet | Wet | Wet |
| Date | | 25-29/06/07 | 21/08/07 | 21/08/07 | 21/08/07 | 21/08/07 | 25-29/06/07 | 21/08/07 | 21/08/07 | 21/08/07 |
| Turbidity | 0.5-10 NTU | 25 | 100 | 148 | 196 | 33 | 2 | 28 | 30 | 58 |
| Dissolved Oxygen | 80-110 (% Saturation) | 56.7 | 71.5 | 71.2 | 68.7 | 71.0 | 87.9 | 92.1 | 93.8 | 87.8 |
| Salinity | - | 3.07 | 0.23 | 0.76 | 1.74 | 12.85 | 18.51 | 14.05 | 12.50 | 9.66 |
| Electrical Conductivity | - (mS/cm) | 22.060 | 0.112 | 1.184 | 2.717 | 20.240 | 29.910 | 22.943 | 19.030 | 15.093 |
| pH | 7.0-8.5 | 6.0 | 6.6 | 6.7 | 6.7 | 7.7 | 6.7 | 7.7 | 7.0 | 7.5 |

### Table A - 6 Water quality results for Section 6 from samples taken in 2007 and 2009 (Harwood to Devil's Pulpit upgrade) (RTA, 2009a)

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Nyrang Creek | Tabbimoble Creek | |
|---|---|---|---|---|
| Sample point conditions | | Wet | - | - |
| Date | | 21/08/2007 | 7-11/12/09 | 7-11/12/09 |
| Turbidity | 6-50 NTU | 215 | 47 | 16 |
| Dissolved Oxygen | 85-110 (% Saturation) | 57.4 | 23.3 | 7.5 |
| Salinity | - | 0.06 | - | - |
| Electrical conductivity | 0.125-2.2 mS/cm | 0.101 | 0.098 | 0.171 |
| pH | 6.5-8.5 | 6.5 | 5.8 | 5.9 |

### Table A - 7 Water quality results for Section 7 (Iluka Road to Woodburn Upgrade) (RTA, 2006b)

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | SW10 | SW11 | S12 | SW13 |
|---|---|---|---|---|---|
| Sample point conditions | | | | | |
| Date | | | | | |
| Dissolved Oxygen | 85-110 (% Saturation) | 76 | 60 | 65 | 71 |
| Electrical conductivity | 0.125-2.2 mS/cm | 0.63 | 0.15 | 0.19 | 0.31 |
| pH | 6.5-8.0 | 6.5 | 6.4 | 5.2 | 6.2 |
| Total nitrogen | 0.35 mg/L | 5.43 | 0.89 | 0.85 | 1.71 |
| Total phosphorous | 0.025 mg/L | <0.01 | 0.02 | 0.02 | 0.03 |

### Table A - 8 Water quality results for Section 8 (Iluka Road to Woodburn Upgrade) (RTA, 2006b)

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– estuarine | Tuckombil Canal (SW14)l |
|---|---|---|
| Sample point conditions | | Wet |
| Date | | 5-6/9/2005 |
| Dissolved Oxygen | 80-110 (% Saturation) | 102 |
| Electrical conductivity | N/A | 19.9 |
| pH | 7.0-8.5 | 7.0 |
| Total nitrogen | 0.3 mg/L | 0.04 |
| Total phosphorous | 0.03 mg/L | 0.06 |

### Table A - 9 Average monthly water quality results for Section 8 Tuckombil Canal east of the Pacific Highway at Woodburn (Richmond River County Council, 2012)

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– estuarine | Aug 2011 | Jul 2011 | Jun 2011 | May 2011 | Apr 2011 | Mar 2011 |
|---|---|---|---|---|---|---|---|
| Dissolved Oxygen | N/A for mg/L | 6.3[$] | 7.1[$] | 5.7[#] | 3.3* | - | 5[#] |
| Electrical conductivity | N/A | 19 | 13.7 | 7.8 | - | - | 10 |
| pH | 7.0-8.5 | 5.6 | 5.5 | 5.4 | 5.3 | - | 3.1-6.9 |

*Critical to fish

[#]Marginal to fish

[$] Optimal to fish (Optimal is great than 6 mg/L)

**Table A - 10 Average monthly water quality results for Section 8 Rocky Mouth Creek Data logger upstream side of floodgates (Richmond River County Council, 2012)**

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Jan 2012 | Dec 2011 | Nov 2011 | Oct 2011 | Sep 2011 | Aug 2011 |
|---|---|---|---|---|---|---|---|
| Dissolved Oxygen | N/A for mg/L | 3.75* | 4.9# | 5.2# | 5.3# | 4.5# | 6.5$ |
| Electrical | 0.125-2.2 mS/cm | 0.48 | 0.66 | 0.74 | 0.75 | 0.52 | 0.57 |
| pH | 6.5-8.5 | 4.9 | 4.1 | 4.5 | 3.7 | 3.7 | 4.3 |

*Critical to fish
#Marginal to fish
$ Optimal to fish (Optimal is great than 6 mg/L)

**Table A - 11 Average monthly water quality results for Section 9 Site 1 - Data logger located at Bagotville in the Tuckean Broadwater downstream of Bagotville Barrage (Richmond River County Council, 2012)**

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Jan 2012 | Dec 2011 | Nov 2011 | Oct 2011 | Sep 2011 | Aug 2011 |
|---|---|---|---|---|---|---|---|
| Dissolved Oxygen | N/A for mg/L | 1* | 2.3* | 1.97* | 4.1# | 4.7# | 4.4# |
| Electrical | 0.125-2.2 mS/cm | 1.9 | 0.74 | 0.62 | 1.24 | 0.83 | 1.34 |
| pH | 6.5-8.5 | 4.8 | 4.3 | 4.8 | 4.6 | 4.4 | 4.7 |

*Critical to fish (Optimal is great than 6 mg/L)
#Marginal to fish

**Table A - 12 Average monthly water quality results for Section 9 Site 2 -Data logger located upstream of Bagotville Barrage, Tuckean Swamp, NSW (Richmond River County Council, 2012)**

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Jan 2012 | Dec 2011 | Nov 2011 | Oct 2011 | Sep 2011 | Aug 2011 |
|---|---|---|---|---|---|---|---|
| Dissolved Oxygen | N/A for mg/L | - | - | - | - | | |
| Electrical | 0.125-2.2 mS/cm | 0.28 | 0.27 | 0.23 | 0.28 | 0.24 | 0.31 |
| pH | 6.5-8.5 | 4.8 | 4.1 | 4.2 | 4 | 4.3 | 3.7 |

**Table A - 13 Average monthly water quality results for Section 9 Site 3 - Tuckean Swamp (Richmond River County Council, 2012)**

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Jan 2012 | Dec 2011 | Nov 2011 | Oct 2011 | Sep 2011 | Aug 2011 |
|---|---|---|---|---|---|---|---|
| Dissolved Oxygen | N/A for mg/L | - | - | - | - | 8.85[$] | 6.1[$] |
| Electrical | 0.125-2.2 mS/cm | 0.82 | 0.71 | 0.26 | 0.26 | 0.19 | 0.3 |
| pH | 6.5-8.5 | 6.8 | 5.1 | 3.3 | 3.3 | 4.1 | 3.4 |

[$] Optimal to fish (Optimal is great than 6 mg/L)

**Table A - 14 Average monthly water quality results for Section 9 Site 4 - Tuckean Swamp (Richmond River County Council, 2012)**

| Water quality parameter | ANZECC/ARMCANZ (2000) trigger value– Lowland River | Jan 2012 | Dec 2011 | Nov 2011 | Oct 2011 | Sep 2011 | Aug 2011 |
|---|---|---|---|---|---|---|---|
| Dissolved Oxygen | N/A for mg/L | - | - | - | - | - | - |
| Electrical | 0.125-2.2 mS/cm | 0.19 | 0.12 | 0.14 | 0.15 | 0.12 | 0.21 |
| pH | 6.5-8.0 | 6.5 | 5.3 | 4.8 | 5.7 | 5.9 | 5.9 |

# Appendix B Standard construction phase controls

# B.1. Erosion and sediment controls

## B.1.1 Sedimentation basins

Sedimentation basins are used to improve water quality in runoff from a construction site and reduce the environmental impact by intercepting sediment-laden runoff and retaining the sediment. They can also lessen flooding which is associated with a reduction in a stream's capacity caused by deposited sediment.

Basins are used to trap sediments from disturbed areas in locations where the soil type has annual soil loss is greater than 150 $m^3$/year (Section 6 and Appendix M of the Blue Book, Landcom, 2004). For the Woolgoolga to Ballina upgrade project, sedimentation basins are required along the entire length of the project.

Sedimentation basins should be installed prior to any construction activity on a site such as earthworks, and should remain in place until the activity has been completed and the land stabilised, unless remaining for operation. They should be located away from busy construction areas at lower gradients on the construction site just outside of drainage lines, or at some other stormwater collection point where they can trap a high proportion of polluted runoff. Offsite ‘clean’ runoff from undisturbed catchments should be diverted to avoid mixing with the construction runoff so that the required size of the basins is reduced.

Sedimentation basins are used in addition to other on-site control measures such as catch drains, diversion drains, sedimentation traps at stormwater inlets, erosion measures, topsoiling and progressive revegetation. These measures retain a portion of the sediment carried in runoff and the basin is used as an end of line defence before site runoff enters existing creeks and waterways. Subject to the scale of work, in accordance with the POEO Act an Environmental Protection Licence may be required.

A sedimentation basin may be either temporary or permanent in terms of design life. However, there is an over-riding need in both cases for adequate design procedures which should consider flows and estimate a reasonable sediment yield from the contributing catchment.

Storage surface area is a critical design feature, and should be maximised within the site constraints. The distance between the basin inlet and outlet should also be the maximum practical, to ensure optimum retention time and hence optimum sediment trapping efficiency.

Basins can be fitted with a dewatering system, such as low flow outlets, which allows the basin to be discharged between rainfall events. Energy dissipaters or scour protection methods would be used to prevent erosion at all basin outlets to protect natural water courses. Provision for flocculation would normally be required for some basins receiving fine and dispersible soils.

Temporary sedimentation basins have been sized for the project based upon design guidelines detailed in Table 6-1. These guidelines have developed in accordance with Managing Urban Stormwater guidelines (DECCW, 2008 and Landcom, 2004). The minimum depth of the basins would be 0.6 metres, with an average depth of one metre (maximum depth two metres), subject to detailed design refinement, land availability and vegetation clearing. Typical details of the preliminary sedimentation basins are shown in Appendix C and would be designed as Type C, D or F depending on the site specific soil testing results.

### B.1.2 Catch and diversion drains

Either individually or in combination, these structures are used to intercept and direct runoff water to a desired location. By doing so, sheet flow is converted to concentrated flow, and the time of concentration for runoff is decreased. There are two types of drains for clean and dirty runoff used during the construction phase, and they are often used in conjunction with level spreaders and check dams:

- Upslope runoff diversion drains (catch drains). This diversion drain is an earth channel with lining designed to intercept and direct clean runoff from the undisturbed upstream catchment and divert it to an existing waterway, so that it does not mix with the construction runoff.
- Onsite runoff diversion drains. A temporary earth bank located around the perimeter of construction sites or disturbed areas which drain into sedimentation basins.

### B.1.3 Check dams

A check dam is a small, temporary dam built across a swale or diversion channel. Its primary function is to reduce the velocity of flow in the channel and thus reduce erosion of the channel bed. The entrapment of sediment behind these structures is a secondary function. Check dams can be used:

- To protect a grass lined channel during initial establishment of vegetation. A controlled discharge is required through a spillway without adequate erosion control at the downstream end.
- As a supplementary control in a temporary channel.

Check dams can be constructed by using any materials on the site that can withstand the flow of water. Rock, log and sandbag check dams can be the sturdiest, if these materials are correctly placed in position. Wire netting, woven brush and straw bales can also be used.

Although check dams are not primarily intended as sediment trapping devices, larger-sized particles would inevitably accumulate behind them. This sediment should be removed before it accumulates to one-half of the original height of the dam, and placed where it would not be washed back into the drainage system.

### B.1.4 Level spreaders

A level spreader is an excavated outlet constructed at zero grade. It converts an erosive, concentrated flow of runoff into sheet flow, and discharges it at a non-erosive velocity onto an undisturbed area stabilised by vegetation.

Level spreaders may be used as outlets for diversion or perimeter banks or channels, where storm runoff has been intercepted and diverted to stable areas. They should be used only where the spreader can be constructed on undisturbed soil. The area directly below the spreader sill should be uniform in slope and well vegetated, allowing water to spread out as sheet flow.

The cross-sectional area and length of the level spreader would be designed to be sufficient to discharge the design flow from the selected frequency rainfall event.

### B.1.5 Sediment fencing and filters

Sediment fences and filters act as sediment mitigation measures. They can be used for small areas of runoff from disturbed sites that are impracticable to be directed to sedimentation basins by diversion drains. Sediment fences and filters function by intercepting and filtering small volumes of runoff, which mainly occur as sheet flow. They should not be used in concentrated flow paths.

### B.1.6 Material stockpiling

During the construction phase, cut and fill material would generally not be locally stockpiled, but would be removed from the site of excavation and transported directly to the construction face for immediate reuse as compacted fill, or would be transported to the crushing and screening area where it would be processed and then stockpiled in a centralised facility.

Fill or excavated material that cannot be immediately reused would be transported to identified locations within the road corridor to be stockpiled (stored) for reuse in accordance with the RTA stockpile management procedures (2011). Soil stockpile sites would not be located in flood prone areas, they would be situated above the one in 10 year flood level and have effective sediment control works to contain any runoff including cut-off drains, vegetation and silt fences to minimise risk of sediments entering waterways.

Any material found to be unsuitable for reuse would be disposed of in accordance with the *Waste Classification Guidelines* (DECC, 2008a).

### B.1.7 Works within waterways

Where piling is required within a waterway, a silt barrier such as a bund or curtain would be installed either downstream of the work site or around the piles themselves prior to the commencement of works.

To facilitate any excavation work and to minimise the local impact of sediment immobilisation, the waterway flow may be temporarily diverted around the works, by either pumping or channelling the flow. The timing of such works would take into consideration flows and must consider and minimise the interference with the possible migration of fish within the waterway.

Works undertaken within waterways would need to be managed to prevent in stream barriers that would impede future flows or obstruct fish passage in times of flow. Soil sampling would be undertaken to ascertain location and concentration levels of potential acid sulfate soil, as the majority of crossings are located in areas with a high risk of acid sulfate soil. Care should also be taken to minimise the potential impacts of construction to protect the hydrology and habitat values of any dry waterways within the project boundary.

### B.1.8 On site erosion controls

In addition to the water quality controls detailed in above, a large range of erosion management measures are used on construction sites to minimise erosion and consequent sedimentation.

Wherever possible during the clearing stage of the construction works, topsoil cover, grassed drainage lines and shrub cover on the soil surface would be retained to minimise exposure of subsoil and topsoil runoff when construction commences. Where possible, and in accordance with tannin guidelines (RMS, 2012), cleared native vegetation and native mulch would be used to reduce erosion and contain sediment during construction through use of small vegetation filter windrows placed across the contour in drainage lines, below fill batters, below cutting works at the head of cleared minor drainage lines and before the inlet to sedimentation basins and waterways.

Disturbed areas would be progressively re-vegetated or sealed as soon as possible. Where possible, working platforms would be constructed from rock fill so that bare earth is not exposed.

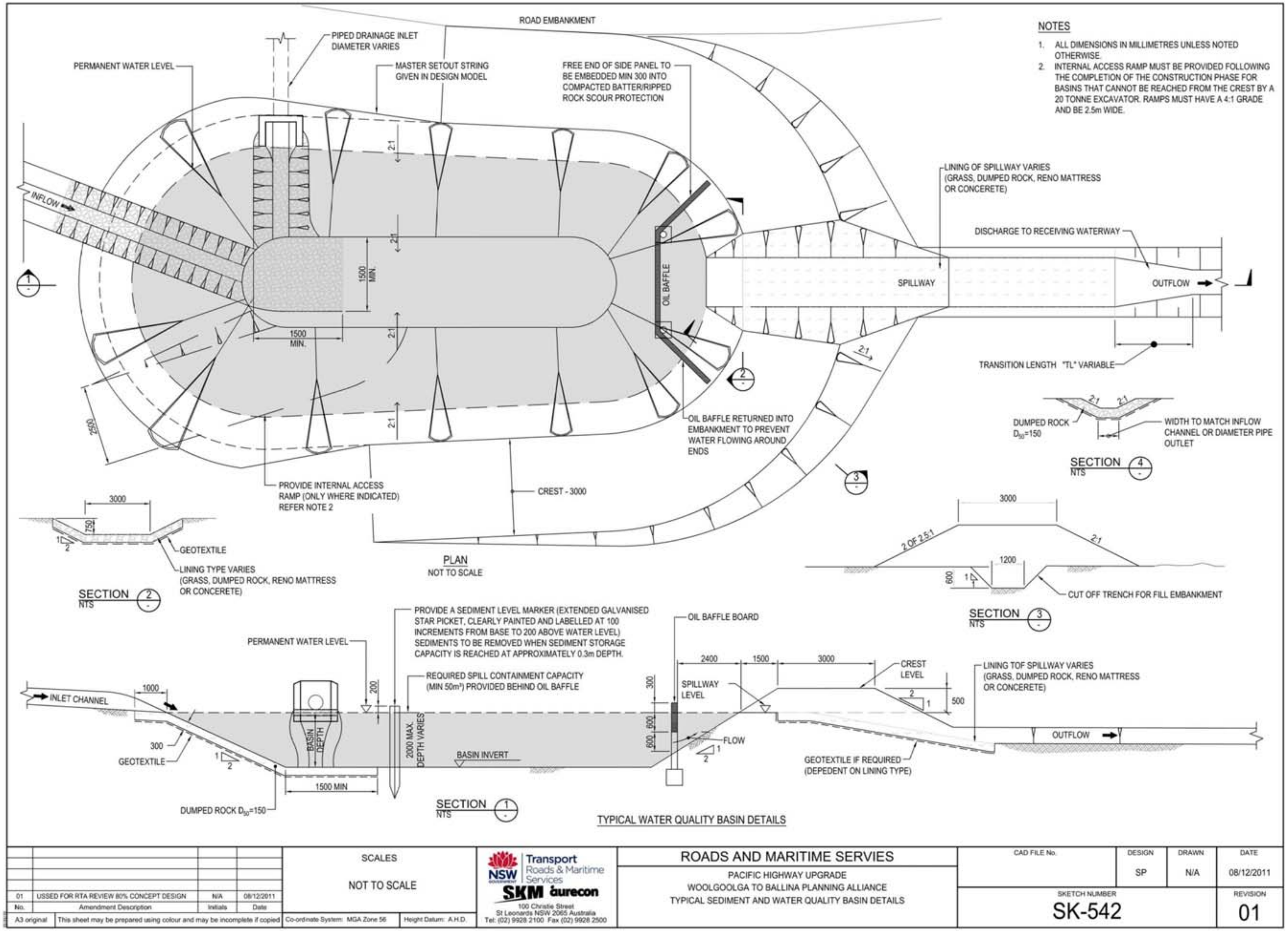
## B.2. Management and maintenance

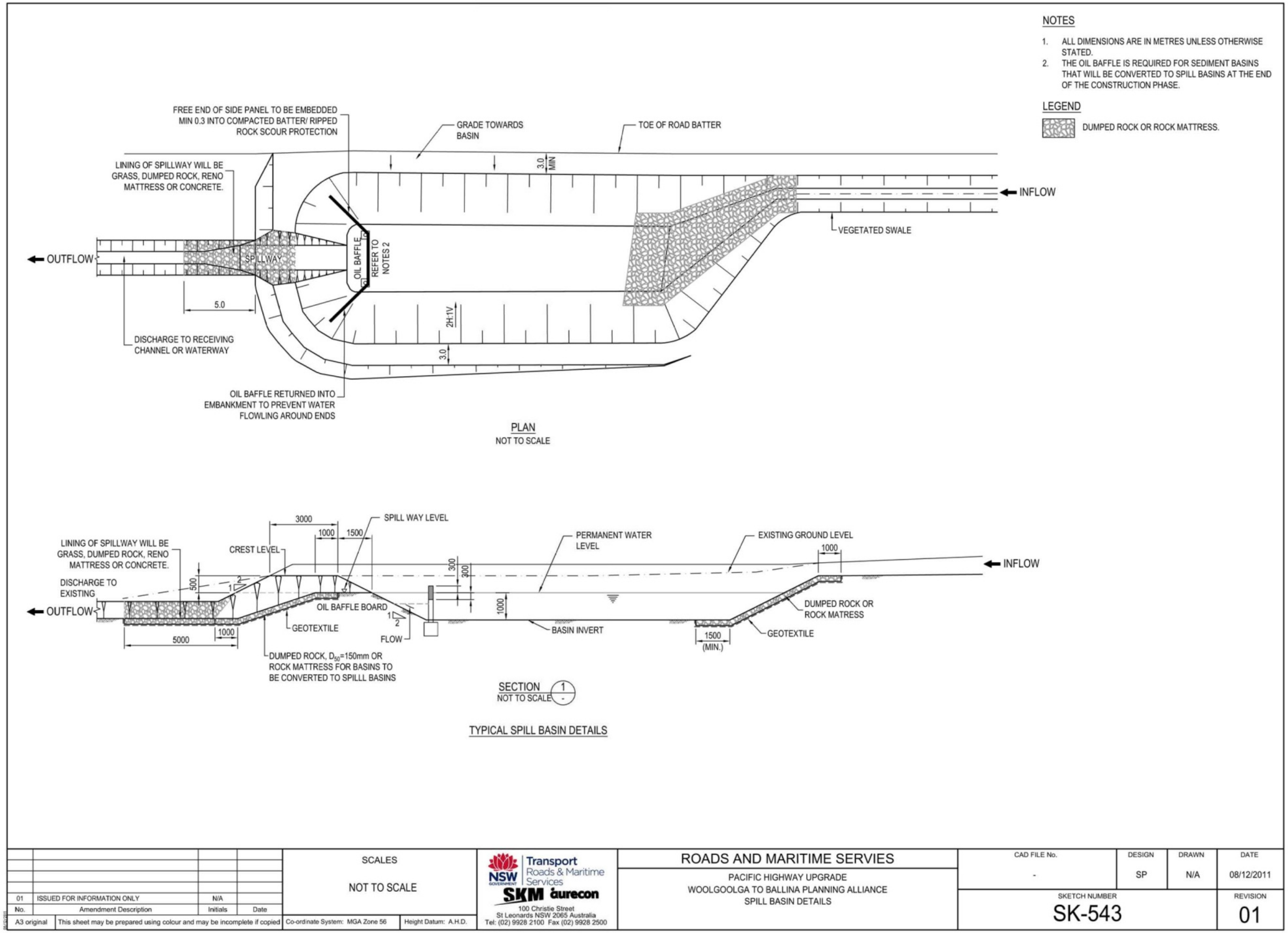
All erosion and sediment control measures would be regularly inspected and maintained. This would include regular engagement of an RMS registered soil conservationist and stormwater management specialist to inspect temporary and permanent erosion and sedimentation control devices, and to ensure the most appropriate controls are implemented and maintained for the duration of construction.

The following management and maintenance procedures for sedimentation basins would be adopted to ensure effective functioning and compliance with the anticipated Environment Protection Licence (EPL) conditions:

- Inspections would be undertaken at regular intervals and following significant rainfall events to assess available water storage capacity, water quality, structural integrity and debris levels, in accordance with the requirements of the Blue Book (Landcom, 2004 and DECC, 2008).
- Liaison would be undertaken during detailed design to ensure the EPL conditions consider the water quality conditions, such as pH levels, favoured by threatened fish, such as Oxleyan Pygmy Perch, in relevant locations along the project.
- Where appropriate, an approved flocculent would be applied to sedimentation basins as early as possible so that early mixing of flocculants occurs. Water quality would be tested prior to discharge in accordance with any EPL requirements. It is anticipated that flocculation will be required for most basins.
- Where excessive sediment has built up in the basin to a point where it exceeds the design sediment storage zone, sediment would be removed and appropriately disposed of.
- Water from sedimentation basins would be utilised for construction purposes such as dust suppression where feasible.
- When sedimentation basins require pumping out rather than discharged via a flow outlet, controlled discharge of basins shall be undertaken in accordance with dewatering guidelines (RMS, 2011a) so that sediment stored within the basin does not become mobilised,.
- Records regarding water quality and functionality or erosion and sediment control devices would be kept, including details of rain events, use of flocculants, discharge, sediment removal and dewatering activities in accordance with the OEH reporting procedures and licence conditions.
- A checklist would be completed when treated water is to be discharged from the basin in accordance with the construction environmental management plan.

# Appendix C Typical details of water quality controls


ROAD EMBANKMENT
NOTES
1. ALL DIMENSIONS IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. INTERNAL ACCESS RAMP MUST BE PROVIDED FOLLOWING THE COMPLETION OF THE CONSTRUCTION PHASE FOR BASINS THAT CANNOT BE REACHED FROM THE CREST BY A 20 TONNE EXCAVATOR. RAMPS MUST HAVE A 4:1 GRADE AND BE 2.5m WIDE.
PIPED DRAINAGE INLET DIAMETER VARIES
PERMANENT WATER LEVEL
MASTER SETOUT STRING GIVEN IN DESIGN MODEL
FREE END OF SIDE PANEL TO BE EMBEDDED MIN 300 INTO COMPACTED BATTER/RIPPED ROCK SCOUR PROTECTION
LINING OF SPILLWAY VARIES (GRASS, DUMPED ROCK, RENO MATTRESS OR CONCRETE)
DISCHARGE TO RECEIVING WATERWAY
INFLOW
OIL BAFFLE
SPILLWAY
OUTFLOW
1500 MIN.
TRANSITION LENGTH "TL" VARIABLE
OIL BAFFLE RETURNED INTO EMBANKMENT TO PREVENT WATER FLOWING AROUND ENDS
DUMPED ROCK $D_{50}$=150
WIDTH TO MATCH INFLOW CHANNEL OR DIAMETER PIPE OUTLET
SECTION 4 NTS
PROVIDE INTERNAL ACCESS RAMP (ONLY WHERE INDICATED) REFER NOTE 2
CREST - 3000
2500
GEOTEXTILE
LINING TYPE VARIES (GRASS, DUMPED ROCK, RENO MATTRESS OR CONCRETE)
SECTION 2 NTS
PLAN
NOT TO SCALE
2 OF 2.5:1
1200
CUT OFF TRENCH FOR FILL EMBANKMENT
SECTION 3 NTS
PROVIDE A SEDIMENT LEVEL MARKER (EXTENDED GALVANISED STAR PICKET, CLEARLY PAINTED AND LABELLED AT 100 INCREMENTS FROM BASE TO 200 ABOVE WATER LEVEL) SEDIMENTS TO BE REMOVED WHEN SEDIMENT STORAGE CAPACITY IS REACHED AT APPROXIMATELY 0.3m DEPTH.
OIL BAFFLE BOARD
REQUIRED SPILL CONTAINMENT CAPACITY (MIN 50m³) PROVIDED BEHIND OIL BAFFLE
INLET CHANNEL
SPILLWAY LEVEL
CREST LEVEL
LINING TOF SPILLWAY VARIES (GRASS, DUMPED ROCK, RENO MATTRESS OR CONCRETE)
BASIN DEPTH
2000 MAX. DEPTH VARIES
BASIN INVERT
FLOW
GEOTEXTILE IF REQUIRED (DEPEDENT ON LINING TYPE)
1500 MIN
DUMPED ROCK $D_{50}$=150
SECTION 1 NTS
TYPICAL WATER QUALITY BASIN DETAILS
01 USSED FOR RTA REVIEW 80% CONCEPT DESIGN N/A 08/12/2011
No. Amendment Description Initials Date
A3 original This sheet may be prepared using colour and may be incomplete if copied
SCALES
NOT TO SCALE
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
Transport Roads & Maritime Services
SKM aurecon
100 Christie Street St Leonards NSW 2065 Australia
Tel: (02) 9928 2100 Fax (02) 9928 2500
ROADS AND MARITIME SERVIES
PACIFIC HIGHWAY UPGRADE
WOOLGOOLGA TO BALLINA PLANNING ALLIANCE
TYPICAL SEDIMENT AND WATER QUALITY BASIN DETAILS
CAD FILE No.
DESIGN SP
DRAWN N/A
DATE 08/12/2011
SKETCH NUMBER SK-542
REVISION 01


NOTES
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. THE OIL BAFFLE IS REQUIRED FOR SEDIMENT BASINS THAT WILL BE CONVERTED TO SPILL BASINS AT THE END OF THE CONSTRUCTION PHASE.
LEGEND
DUMPED ROCK OR ROCK MATTRESS.
FREE END OF SIDE PANEL TO BE EMBEDDED MIN 0.3 INTO COMPACTED BATTER/ RIPPED ROCK SCOUR PROTECTION
GRADE TOWARDS BASIN
TOE OF ROAD BATTER
LINING OF SPILLWAY WILL BE GRASS, DUMPED ROCK, RENO MATTRESS OR CONCRETE.
3.0 MIN
INFLOW
VEGETATED SWALE
OUTFLOW
SPILLWAY
OIL BAFFLE
REFER TO NOTES 2
5.0
2H:1V
3.0
DISCHARGE TO RECEIVING CHANNEL OR WATERWAY
OIL BAFFLE RETURNED INTO EMBANKMENT TO PREVENT WATER FLOWLING AROUND ENDS
PLAN
NOT TO SCALE
3000
1000
1500
SPILL WAY LEVEL
PERMANENT WATER LEVEL
EXISTING GROUND LEVEL
1000
LINING OF SPILLWAY WILL BE GRASS, DUMPED ROCK, RENO MATTRESS OR CONCRETE.
CREST LEVEL
300
300
500
DISCHARGE TO EXISTING
INFLOW
OUTFLOW
OIL BAFFLE BOARD
1000
DUMPED ROCK OR ROCK MATRESS
GEOTEXTILE
FLOW
BASIN INVERT
GEOTEXTILE
1000
5000
1500 (MIN.)
DUMPED ROCK, D50=150mm OR ROCK MATTRESS FOR BASINS TO BE CONVERTED TO SPILLL BASINS
SECTION 1
NOT TO SCALE
TYPICAL SPILL BASIN DETAILS
01 ISSUED FOR INFORMATION ONLY N/A
No. Amendment Description Initials Date
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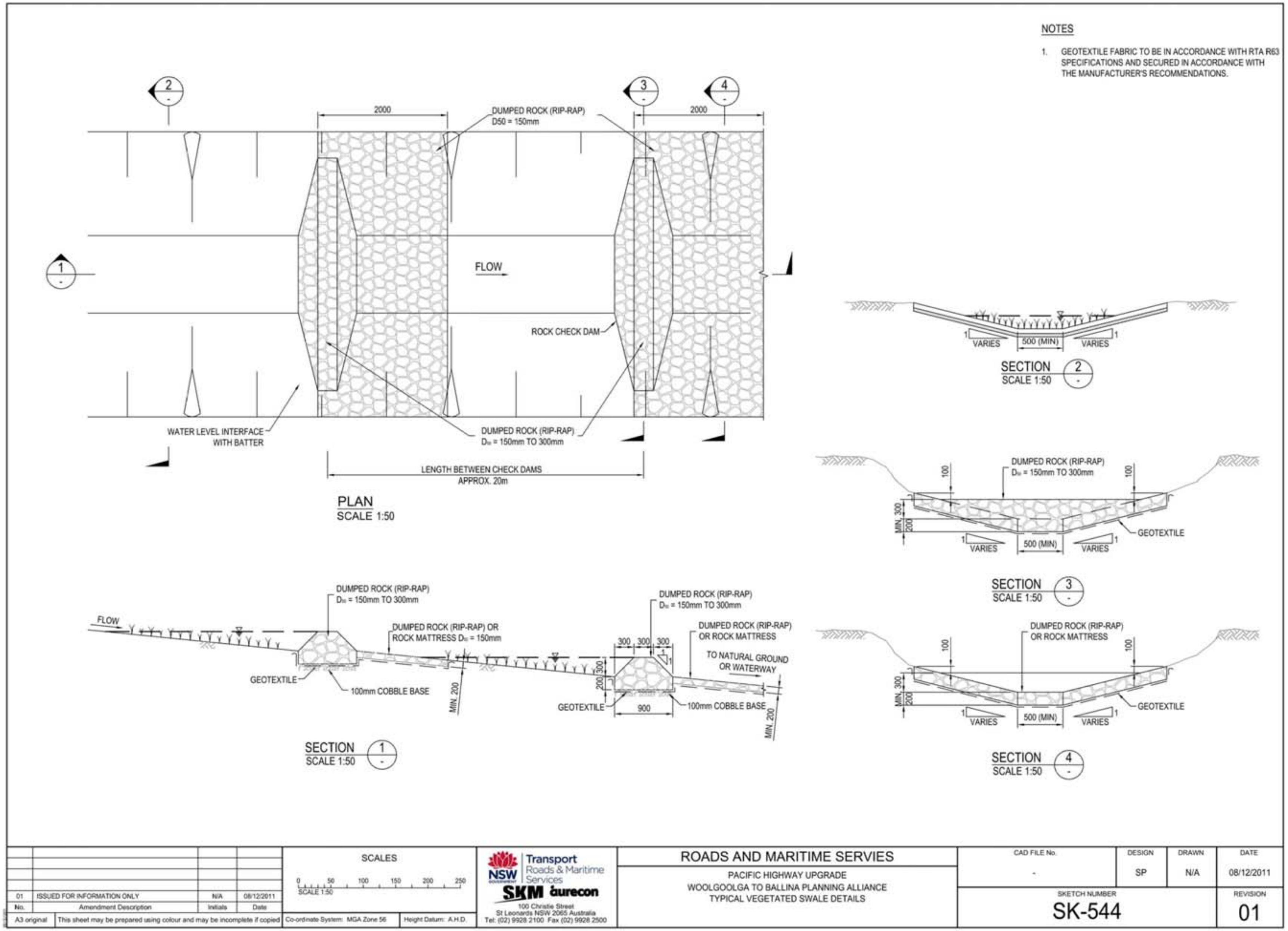
NOT TO SCALE
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
Transport Roads & Maritime Services
SKM aurecon
100 Christie Street St Leonards NSW 2065 Australia Tel: (02) 9928 2100 Fax (02) 9928 2500
ROADS AND MARITIME SERVIES
PACIFIC HIGHWAY UPGRADE
WOOLGOOLGA TO BALLINA PLANNING ALLIANCE
SPILL BASIN DETAILS
CAD FILE No. -
DESIGN SP
DRAWN N/A
DATE 08/12/2011
SKETCH NUMBER SK-543
REVISION 01


NOTES
1. GEOTEXTILE FABRIC TO BE IN ACCORDANCE WITH RTA R63 SPECIFICATIONS AND SECURED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.
2000
DUMPED ROCK (RIP-RAP) D50 = 150mm
FLOW
ROCK CHECK DAM
WATER LEVEL INTERFACE WITH BATTER
DUMPED ROCK (RIP-RAP) D50 = 150mm TO 300mm
LENGTH BETWEEN CHECK DAMS APPROX. 20m
PLAN
SCALE 1:50
VARIES
500 (MIN)
SECTION 2
SCALE 1:50
DUMPED ROCK (RIP-RAP) D50 = 150mm TO 300mm
GEOTEXTILE
SECTION 3
SCALE 1:50
DUMPED ROCK (RIP-RAP) OR ROCK MATTRESS
SECTION 4
SCALE 1:50
DUMPED ROCK (RIP-RAP) OR ROCK MATTRESS D50 = 150mm
100mm COBBLE BASE
TO NATURAL GROUND OR WATERWAY
DUMPED ROCK (RIP-RAP) OR ROCK MATTRESS
MIN. 200
900
SECTION 1
SCALE 1:50
01 ISSUED FOR INFORMATION ONLY N/A 08/12/2011
No. Amendment Description Initials Date
A3 original This sheet may be prepared using colour and may be incomplete if copied
SCALES
SCALE 1:50
Co-ordinate System: MGA Zone 56
Height Datum: A.H.D.
Transport Roads & Maritime Services
SKM aurecon
100 Christie Street St Leonards NSW 2065 Australia
Tel: (02) 9928 2100 Fax (02) 9928 2500
ROADS AND MARITIME SERVIES
PACIFIC HIGHWAY UPGRADE
WOOLGOOLGA TO BALLINA PLANNING ALLIANCE
TYPICAL VEGETATED SWALE DETAILS
CAD FILE No.
DESIGN SP
DRAWN N/A
DATE 08/12/2011
SKETCH NUMBER SK-544
REVISION 01

# Appendix D Sedimentation basins and water quality ponds

# D.1. Sedimentation basins and water quality ponds

A preliminary list of sedimentation basins for the project that are either temporary or to be retained as permanent water quality ponds are shown in Table D - 1. This list is indicative only and will be subject to change at the detailed design stages.

The eleven project sections would be initially upgraded to either a class A or class M standard (as per Table 1 - 1). Basins that have been identified to capture runoff from this stage of the project are referred to in Table D - 1 as required for the initial upgrade. For those sections where the initial upgrade is to class A, a future upgrade would be required to construct the class M. Basins that have been identified to capture runoff from this stage of the project are referred to in Table D - 1 as required for the future upgrade.

Note that this list does not include basins for treatment runoff from rest areas, these basins will be included during detailed design.

**Table D - 1 Proposed indicative sedimentation basins and water quality ponds for the project**

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| **SECTION 1** | | | | | |
| B0.22R | Right | Temporary | 450 | yes | initial |
| B0.27L | Left | Temporary | 750 | yes | initial |
| B0.38L | Left | Temporary | 850 | yes | initial |
| B0.68L | Left | Temporary | 500 | yes | initial |
| B0.77L | Left | Temporary | 1000 | yes | initial |
| B0.78L | Left | Temporary | 300 | yes | initial |
| B0.8R | Right | Temporary | 500 | yes | initial |
| B0.9L | Left | Temporary | 300 | yes | initial |
| B1.35L | Left | Temporary -> Permanent | 900 | yes | initial |
| B1.59R | Right | Temporary | 400 | yes | initial |
| B1.63L | Left | Temporary | 750 | yes | initial |
| B1.71L | Left | Temporary | 500 | yes | initial |
| B1.89R | Right | Temporary | 400 | yes | initial |
| B2.01R | Right | Temporary | 400 | yes | initial |
| B2.17R | Right | Temporary -> Permanent | 2650 | yes | initial |
| B2.77R | Right | Temporary | 1700 | yes | initial |
| B2.87R | Right | Temporary | 850 | yes | initial |
| B3.11R | Right | Temporary -> Permanent | 450 | yes | initial |
| B3.21R | Right | Temporary | 700 | yes | initial |
| B3.51R | Right | Temporary -> Permanent | 900 | yes | initial |
| B3.83R | Right | Temporary | 950 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B4.66R | Right | Temporary | 1050 | yes | initial |
| B4.79R | Right | Temporary | 500 | yes | initial |
| B5.03L | Left | Temporary | 800 | yes | initial |
| B5.11R | Right | Temporary -> Permanent | 2150 | yes | initial |
| B5.56R | Right | Temporary | 850 | yes | initial |
| B5.61L | Left | Temporary | 450 | yes | initial |
| B5.71R | Right | Temporary -> Permanent | 2050 | yes | initial |
| B5.72L | Left | Temporary | 950 | yes | initial |
| B5.83R | Right | Temporary | 1100 | yes | initial |
| B6.01R | Right | Temporary | 1150 | yes | initial |
| B6.23L | Left | Temporary | 750 | yes | initial |
| B6.29R | Right | Temporary | 1650 | yes | initial |
| B6.65L | Left | Temporary | 850 | yes | initial |
| B6.8L | Left | Temporary | 1100 | yes | initial |
| B7.13R | Right | Temporary -> Permanent | 900 | yes | initial |
| B7.52R | Right | Temporary -> Permanent | 6800 | yes | initial |
| B8.03L | Left | Temporary | 2800 | yes | initial |
| B8.17L | Left | Temporary | 1100 | yes | initial |
| B8.36L | Left | Temporary | 800 | yes | initial |
| B8.48R | Right | Temporary -> Permanent | 1750 | yes | initial |
| B8.74R | Right | Temporary | 700 | yes | initial |
| B8.87R | Right | Temporary -> Permanent | 3150 | yes | initial |
| B9.07R | Right | Temporary -> Permanent | 1850 | yes | initial |
| B9.27R | Right | Temporary -> Permanent | 1100 | yes | initial |
| B9.49R | Right | Temporary | 600 | yes | initial |
| B9.62R | Right | Temporary -> Permanent | 1200 | yes | initial |
| B9.97R | Right | Temporary | 1100 | yes | initial |
| B10.26L | Left | Temporary | 950 | yes | initial |
| B10.3R | Right | Temporary -> Permanent | 1400 | yes | initial |
| B10.37L | Left | Temporary -> Permanent | 1800 | yes | initial |
| B10.79L | Left | Temporary | 2300 | yes | initial and future |
| B10.85R | Right | Temporary -> Permanent | 1150 | yes | future |
| B11.12R | Right | Temporary -> Permanent | 2400 | yes | initial |
| B11.7L | Left | Temporary | 450 | yes | initial |
| B11.76R | Right | Temporary -> Permanent | 500 | yes | initial |
| B11.93R | Right | Temporary -> Permanent | 750 | yes | future |
| B12.27L | Left | Temporary -> Permanent | 1850 | yes | initial and future |
| B12.85L | Left | Temporary -> Permanent | 2500 | yes | initial and future |
| B13.22L | Left | Temporary -> Permanent | 1700 | yes | initial and future |
| B13.3R | Right | Temporary | 450 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B13.38R | Right | Temporary | 550 | yes | initial |
| B13.38L | Left | Temporary | 550 | yes | initial and future |
| B13.75L | Left | Temporary -> Permanent | 2250 | yes | initial and future |
| B13.81R | Right | Temporary | 650 | yes | initial |
| B13.89R | Right | Temporary | 450 | yes | initial |
| B14.07L | Left | Temporary -> Permanent | 1750 | yes | initial and future |
| B14.18R | Right | Temporary | 650 | yes | initial |
| B14.24L | Left | Temporary | 850 | yes | initial |
| B14.73L | Left | Temporary | 400 | yes | future |
| B14.84L | Left | Temporary | 750 | yes | future |
| B15.77R | Right | Temporary | 450 | yes | future |
| B15.85L | Right | Temporary | 450 | yes | future |
| B16L | Right | Temporary -> Permanent | 450 | yes | future |
| B17.01L | Left | Temporary | 500 | yes | future |
| SECTION 2 | | | | | |
| B17.47L | Left | Temporary -> Permanent | 800 | yes | future |
| B17.67L | Left | Temporary -> Permanent | 1650 | yes | initial and future |
| B17.77R | Right | Temporary | 800 | yes | initial |
| B18.06R | Right | Temporary | 400 | yes | initial |
| B18.06L | Left | Temporary | 1200 | yes | future |
| B18.44R | Right | Temporary | 1650 | yes | initial |
| B18.73R | Right | Temporary | 800 | yes | initial |
| B18.74L | Left | Temporary | 550 | yes | future |
| B18.83L | Left | Temporary | 900 | yes | initial and future |
| B18.92R | Right | Temporary -> Permanent | 1300 | yes | initial |
| B19.24L | Left | Temporary | 500 | yes | future |
| B19.62L | Left | Temporary | 550 | yes | initial |
| B19.71L | Left | Temporary | 500 | yes | initial |
| B19.92L | Left | Temporary | 450 | yes | initial |
| B20.42R | Right | Temporary | 950 | yes | initial |
| B20.58R | Right | Temporary -> Permanent | 650 | yes | initial |
| B20.66L | Left | Temporary -> Permanent | 1350 | yes | future |
| B20.8R | Right | Temporary -> Permanent | 1150 | yes | initial |
| B20.86L | Left | Temporary | 1400 | yes | future |
| B20.95L | Left | Temporary | 1150 | yes | initial |
| B21.15L | Left | Temporary | 500 | yes | initial |
| B21.37L | Left | Temporary -> Permanent | 1300 | yes | initial and future |
| B22.24L | Left | Temporary | 650 | yes | future |
| B22.32R | Right | Temporary -> Permanent | 2350 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume (m$^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B22.47L | Left | Temporary | 400 | yes | future |
| B22.51L | Left | Temporary -> Permanent | 1200 | yes | initial |
| B22.83L | Left | Temporary | 1200 | yes | initial |
| B23.06L | Right | Temporary | 300 | yes | future |
| B23.17L | Left | Temporary -> Permanent | 2050 | yes | initial |
| B23.71L | Left | Temporary | 550 | yes | initial |
| B23.8L | Left | Temporary | 300 | yes | future |
| B23.81L | Left | Temporary -> Permanent | 1100 | yes | initial |
| B24.46L | Left | Temporary -> Permanent | 1550 | yes | initial |
| B24.48R | Right | Temporary -> Permanent | 350 | yes | initial |
| B24.56L | Left | Temporary | 300 | yes | future |
| B24.66L | Left | Temporary | 550 | yes | future |
| B24.8L | Left | Temporary -> Permanent | 2500 | yes | initial |
| B25.36R | Right | Temporary | 450 | yes | initial |
| B25.48R | Right | Temporary -> Permanent | 1300 | yes | initial |
| B25.57R | Right | Temporary | 1050 | yes | initial |
| B25.9R | Right | Temporary | 700 | yes | initial |
| B26.01R | Right | Temporary | 600 | yes | initial |
| B26.31R | Right | Temporary -> Permanent | 900 | yes | initial |
| B26.44R | Right | Temporary | 450 | yes | initial |
| B26.76R | Right | Temporary | 900 | yes | initial |
| B27.02R | Right | Temporary | 1700 | yes | initial |
| B27.36R | Right | Temporary -> Permanent | 3150 | yes | initial |
| B27.47R | Right | Temporary | 550 | yes | initial |
| B27.76R | Right | Temporary -> Permanent | 1100 | yes | initial |
| B28.36R | Right | Temporary -> Permanent | 2000 | yes | initial |
| SECTION 3 | | | | | |
| B34.54R | Right | Temporary -> Permanent | 2800 | yes | initial |
| B34.89R | Right | Temporary -> Permanent | 2050 | yes | initial |
| B35.01L | Left | Temporary -> Permanent | 300 | yes | initial |
| B35.17R | Right | Temporary -> Permanent | 850 | yes | initial |
| B35.62L | Left | Temporary -> Permanent | 1150 | yes | initial |
| B35.86L | Left | Temporary | 600 | yes | initial |
| B35.91L | Left | Temporary -> Permanent | 600 | yes | initial |
| B36.31L | Left | Temporary -> Permanent | 3750 | yes | initial |
| B36.51L | Left | Temporary -> Permanent | 2250 | yes | initial |
| B37.08L | Left | Temporary | 650 | yes | initial |
| B37.17L | Left | Temporary -> Permanent | 700 | yes | initial |
| B37.43L | Left | Temporary -> Permanent | 2350 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B37.62L | Left | Temporary | 400 | yes | initial |
| B37.86L | Left | Temporary | 450 | yes | initial |
| B38.04L | Left | Temporary -> Permanent | 1000 | yes | initial |
| B38.2L | Left | Temporary | 850 | yes | initial |
| B38.49L | Left | Temporary | 1250 | yes | initial |
| B38.59L | Left | Temporary | 1050 | yes | initial |
| B39.03L | Left | Temporary -> Permanent | 3550 | yes | initial |
| B39.17L | Left | Temporary | 700 | yes | initial |
| B39.33L | Left | Temporary | 850 | yes | initial |
| B39.56L | Left | Temporary -> Permanent | 1900 | yes | initial |
| B39.75L | Left | Temporary -> Permanent | 1800 | yes | initial |
| B40.12L | Left | Temporary | 900 | yes | initial |
| B40.23L | Left | Temporary -> Permanent | 1600 | yes | initial |
| B40.95R | Right | Temporary -> Permanent | 1650 | yes | initial |
| B41.35R | Right | Temporary -> Permanent | 1500 | yes | initial |
| B41.39L | Left | Temporary | 600 | yes | initial |
| B41.74R | Right | Temporary | 550 | yes | initial |
| B42.49L | Left | Temporary -> Permanent | 3650 | yes | initial |
| B42.7L | Left | Temporary -> Permanent | 800 | yes | initial |
| B43.05L | Left | Temporary -> Permanent | 1100 | yes | initial |
| B43.5L | Left | Temporary -> Permanent | 950 | yes | initial |
| B44.35L | Left | Temporary -> Permanent | 4200 | yes | initial |
| B46.03L | Left | Temporary -> Permanent | 2500 | yes | initial |
| B46.32L | Left | Temporary -> Permanent | 950 | yes | initial |
| B46.51L | Left | Temporary -> Permanent | 550 | yes | initial |
| B47.08L | Left | Temporary -> Permanent | 1250 | yes | initial |
| B47.3L | Left | Temporary -> Permanent | 700 | yes | initial |
| B47.43L | Left | Temporary -> Permanent | 1050 | yes | initial |
| B47.93L | Left | Temporary -> Permanent | 2800 | yes | initial |
| B48.69L | Left | Temporary -> Permanent | 1300 | yes | initial |
| B48.74R | Right | Temporary | 300 | yes | initial |
| B48.82L | Left | Temporary -> Permanent | 950 | yes | initial |
| B49.22L | Left | Temporary -> Permanent | 900 | yes | initial |
| B49.56L | Left | Temporary -> Permanent | 850 | yes | initial |
| B50.04L | Left | Temporary -> Permanent | 1900 | yes | initial |
| B50.4L | Left | Temporary -> Permanent | 1450 | yes | initial |
| B50.85L | Left | Temporary | 400 | yes | initial |
| B51.37L | Left | Temporary -> Permanent | 1600 | yes | initial |
| B51.48L | Left | Temporary | 900 | yes | initial |
| B52.41R | Right | Temporary -> Permanent | 4300 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B52.66L | Left | Temporary -> Permanent | 5350 | yes | initial |
| B53.65L | Left | Temporary | 1950 | yes | initial |
| B53.79L | Left | Temporary | 2150 | yes | initial |
| B54.64L | Left | Temporary -> Permanent | 5000 | yes | initial |
| B54.82R | Right | Temporary -> Permanent | 950 | yes | initial |
| B55.13L | Left | Temporary -> Permanent | 1800 | yes | initial |
| B56.98L | Left | Temporary -> Permanent | 4550 | yes | initial |
| B57.25L | Left | Temporary -> Permanent | 3700 | yes | initial |
| B58.29L | Left | Temporary -> Permanent | 950 | yes | initial |
| B58.61L | Left | Temporary | 850 | yes | initial |
| B58.79L | Left | Temporary | 550 | yes | initial |
| B59.22L | Left | Temporary -> Permanent | 1150 | yes | initial |
| B59.38L | Left | Temporary -> Permanent | 4050 | yes | initial |
| B60.04L | Left | Temporary -> Permanent | 1900 | yes | initial |
| B60.21L | Left | Temporary -> Permanent | 900 | yes | initial |
| B60.77L | Left | Temporary -> Permanent | 1800 | yes | initial |
| B60.93L | Left | Temporary -> Permanent | 2000 | yes | initial |
| B61.75L | Left | Temporary -> Permanent | 1800 | yes | initial |
| B62.14L | Left | Temporary | 1100 | yes | initial |
| B62.27L | Left | Temporary -> Permanent | 1600 | yes | initial |
| B62.89R | Right | Temporary -> Permanent | 4450 | yes | initial |
| B63.5L | Left | Temporary | 2000 | yes | initial |
| B63.6L | Left | Temporary | 1000 | yes | initial |
| B63.91L | Left | Temporary -> Permanent | 1700 | yes | initial |
| B64.16L | Left | Temporary -> Permanent | 1200 | yes | initial |
| B64.38L | Left | Temporary -> Permanent | 1100 | yes | initial |
| B64.55L | Left | Temporary -> Permanent | 2300 | yes | initial |
| B65.02L | Left | Temporary | 550 | yes | initial |
| B65.41L | Left | Temporary -> Permanent | 1150 | yes | initial |
| B65.51L | Left | Temporary -> Permanent | 1300 | yes | initial |
| B66L | Left | Temporary | 850 | yes | initial |
| B66.27L | Left | Temporary -> Permanent | 1350 | yes | initial |
| B67.06L | Left | Temporary -> Permanent | 4300 | yes | initial |
| B67.07R | Right | Temporary | 1900 | yes | initial |
| B67.31L | Left | Temporary -> Permanent | 1000 | yes | initial |
| B67.39L | Left | Temporary | 1400 | yes | initial |
| B67.42R | Right | Temporary | 650 | yes | initial |
| B67.53L | Left | Temporary | 800 | yes | initial |
| B67.76L | Left | Temporary | 1950 | yes | initial |
| B67.94L | Left | Temporary | 4150 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B68.11L | Left | Temporary | 1050 | yes | initial |
| B68.36L | Left | Temporary -> Permanent | 3700 | yes | initial |
| B68.48L | Left | Temporary -> Permanent | 900 | yes | initial |
| B68.64L | Left | Temporary | 400 | yes | initial |
| B68.72L | Left | Temporary -> Permanent | 550 | yes | initial |
| B68.92L | Left | Temporary | 1400 | yes | initial |
| B68.98L | Left | Temporary -> Permanent | 500 | yes | initial |
| SECTION 4 | | | | | |
| B69.06L | Left | Temporary | 1650 | no | initial |
| B69.64L | Left | Temporary -> Permanent | 5550 | no | initial |
| B69.94L | Left | Temporary -> Permanent | 2350 | yes | initial |
| B70.42L | Left | Temporary -> Permanent | 1250 | yes | initial |
| B70.74L | Left | Temporary -> Permanent | 800 | yes | initial |
| B70.74R | Right | Temporary | 550 | yes | initial |
| B71.04R | Right | Temporary | 400 | yes | initial |
| B71.07L | Left | Temporary | 600 | yes | initial |
| B71.16R | Right | Temporary | 750 | yes | initial |
| B71.22L | Left | Temporary | 850 | yes | initial |
| B71.79L | Left | Temporary -> Permanent | 750 | yes | initial |
| B71.79R | Right | Temporary | 450 | yes | initial |
| B72.1L | Left | Temporary | 700 | yes | initial |
| B72.1R | Right | Temporary | 450 | yes | initial |
| B72.47R | Right | Temporary | 300 | yes | initial |
| B72.6L | Left | Temporary | 700 | yes | initial |
| B72.76L | Left | Temporary -> Permanent | 500 | yes | initial |
| B72.91R | Right | Temporary | 300 | yes | initial |
| B73.06L | Left | Temporary | 800 | yes | initial |
| B73.21R | Right | Temporary | 500 | yes | initial |
| B73.38L | Left | Temporary -> Permanent | 950 | yes | initial |
| B73.48L | Left | Temporary | 1100 | yes | initial |
| B73.64R | Right | Temporary | 450 | yes | initial |
| B73.99L | Left | Temporary | 1100 | yes | initial |
| B74R | Right | Temporary | 750 | yes | initial |
| B74.37R | Right | Temporary | 600 | yes | initial |
| B74.37L | Left | Temporary | 800 | yes | initial |
| B74.74L | Left | Temporary -> Permanent | 1450 | yes | initial |
| B75.22L | Left | Temporary -> Permanent | 1000 | yes | initial |
| B75.47L | Left | Temporary | 1000 | yes | initial |
| B75.59L | Left | Temporary -> Permanent | 1050 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B75.87L | Left | Temporary -> Permanent | 3750 | no | initial |
| B76.18L | Left | Temporary | 2450 | no | initial |
| B76.46L | Left | Temporary | 1350 | no | initial |
| B76.62L | Left | Temporary | 1500 | no | initial |
| B77.23L | Left | Temporary -> Permanent | 3600 | no | initial |
| B77.36L | Left | Temporary -> Permanent | 1750 | no | initial |
| B77.93L | Left | Temporary | 850 | no | initial |
| B78.02L | Left | Temporary | 1200 | no | initial |
| B78.42R | Right | Temporary -> Permanent | 1700 | yes | initial |
| B78.42L | Left | Temporary | 700 | yes | initial |
| B78.51L | Left | Temporary -> Permanent | 700 | yes | initial |
| B78.83R | Right | Temporary | 1200 | yes | initial |
| B78.84L | Left | Temporary | 500 | yes | initial |
| B79.1L | Left | Temporary | 400 | yes | initial |
| B79.11R | Right | Temporary | 1200 | yes | initial |
| B79.6R | Right | Temporary | 600 | yes | initial |
| B79.89R | Right | Temporary | 950 | yes | initial |
| B79.9L | Left | Temporary | 300 | yes | initial |
| B80.12R | Right | Temporary | 750 | yes | initial |
| B80.13L | Left | Temporary | 350 | yes | initial |
| B80.42L | Left | Temporary -> Permanent | 1750 | yes | initial |
| B80.44R | Right | Temporary -> Permanent | 1850 | yes | initial |
| B80.63L | Left | Temporary -> Permanent | 1850 | yes | initial |
| B80.64R | Right | Temporary -> Permanent | 2450 | yes | initial |
| B81.12R | Right | Temporary -> Permanent | 3000 | yes | initial |

| SECTION 5 | | | | | |
|---|---|---|---|---|---|
| B81.73R | Right | Temporary -> Permanent | 1900 | yes | initial |
| B82.27R | Right | Temporary | 350 | yes | initial |
| B82.4R | Right | Temporary | 650 | yes | initial |
| B82.67R | Right | Temporary | 350 | yes | initial |
| B82.83R | Right | Temporary | 350 | yes | initial |
| B82.94R | Right | Temporary | 350 | yes | initial |
| B83.41R | Right | Temporary | 250 | yes | initial |
| B83.43L | Left | Temporary -> Permanent | 4650 | yes | initial |
| B83.64L | Left | Temporary | 1000 | yes | initial |
| B83.69R | Right | Temporary | 250 | yes | initial |
| B83.92L | Left | Temporary | 1000 | yes | initial |
| B83.92R | Right | Temporary | 500 | yes | initial |
| B84.19R | Right | Temporary | 500 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B84.24L | Left | Temporary | 1000 | yes | initial |
| B84.46L | Left | Temporary | 1000 | yes | initial |
| B84.46R | Right | Temporary | 500 | yes | initial |
| B84.8R | Right | Temporary | 500 | yes | initial |
| B84.81L | Left | Temporary | 1000 | yes | initial |
| B85.13R | Right | Temporary | 500 | yes | initial |
| B85.22L | Left | Temporary | 1200 | yes | initial and future |
| B85.4R | Right | Temporary | 850 | yes | initial and future |
| B85.44L | Left | Temporary | 1000 | yes | initial and future |
| B85.5L | Left | Temporary | 750 | yes | future |
| B85.73L | Left | Temporary | 1450 | yes | initial |
| B85.76R | Right | Temporary | 1950 | yes | initial and future |
| B86.17L | Left | Temporary -> Permanent | 2600 | yes | initial |
| B86.19R | Right | Temporary -> Permanent | 2250 | yes | initial |
| B87.35L | Left | Temporary -> Permanent | 4100 | yes | initial |
| B87.37R | Right | Temporary | 2400 | yes | initial |
| B87.72L | Left | Temporary -> Permanent | 2800 | yes | initial |
| B88.16R | Right | Temporary | 3100 | yes | initial and future |
| B88.18L | Left | Temporary | 2800 | yes | initial |
| B88.59L | Left | Temporary | 2800 | yes | initial |
| B88.6R | Right | Temporary | 1200 | yes | future |
| B88.9R | Right | Temporary | 2000 | yes | initial |
| B89.25L | Left | Temporary | 2150 | yes | initial and future |
| B89.56L | Left | Temporary | 600 | yes | initial and future |
| B89.69R | Right | Temporary | 700 | yes | future |
| B89.69L | Left | Temporary | 700 | yes | initial and future |
| B89.88R | Right | Temporary | 700 | yes | future |
| B90.21L | Left | Temporary | 2150 | yes | initial |
| B90.3R | Right | Temporary | 850 | yes | future |
| B90.65L | Left | Temporary | 2150 | yes | initial |
| B90.72L | Left | Temporary | 1700 | yes | initial |
| B90.73R | Right | Temporary | 450 | yes | future |
| B90.81R | Right | Temporary | 1550 | yes | initial |
| B90.81L | Left | Temporary | 1100 | yes | initial |
| B91.02R | Right | Temporary | 600 | yes | initial and future |
| B91.3L | Left | Temporary | 1200 | yes | initial and future |
| B91.39R | Right | Temporary | 600 | yes | future |
| B91.72L | Left | Temporary | 1050 | yes | initial and future |
| B91.8R | Right | Temporary | 700 | yes | future |
| B92.1L | Left | Temporary | 1150 | yes | initial and future |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B92.19R | Right | Temporary | 550 | yes | future |
| B92.51L | Left | Temporary | 900 | yes | initial and future |
| B92.63R | Right | Temporary | 650 | yes | future |
| B92.9L | Left | Temporary | 2000 | yes | initial and future |
| B93.33R | Right | Temporary | 500 | yes | future |
| B93.35L | Left | Temporary | 1800 | yes | initial and future |
| B93.45R | Right | Temporary | 750 | yes | initial |
| B93.94R | Right | Temporary -> Permanent | 2150 | yes | initial |
| B94.23L | Left | Temporary | 700 | yes | initial |
| B94.25R | Right | Temporary -> Permanent | 1600 | yes | initial |
| B94.44R | Right | Temporary | 700 | yes | initial |
| B94.66R | Right | Temporary -> Permanent | 3550 | yes | initial |
| B94.93L | Left | Temporary | 2600 | yes | initial |
| B95.11L | Left | Temporary | 3850 | yes | initial |
| B95.62R | Right | Temporary | 4600 | yes | initial |
| B95.68L | Left | Temporary | 4600 | yes | initial |
| B95.9L | Left | Temporary -> Permanent | 3800 | yes | initial |

| SECTION 6 | | | | | |
|---|---|---|---|---|---|
| B96.27R | Right | Temporary -> Permanent | 850 | yes | initial |
| B96.65R | Right | Temporary -> Permanent | 450 | yes | initial |
| B96.65L | Left | Temporary | 300 | yes | future |
| B96.89L | Left | Temporary | 400 | yes | future |
| B96.94R | Right | Temporary -> Permanent | 700 | yes | initial |
| B97.02L | Left | Temporary | 1250 | yes | future |
| B97.03R | Right | Temporary | 1950 | yes | initial |
| B97.75L | Left | Temporary -> Permanent | 1300 | yes | initial |
| B98.08L | Left | Temporary | 350 | yes | future |
| B99.04R | Right | Temporary | 2600 | yes | initial |
| B99.05L | Left | Temporary | 1000 | yes | future |
| B99.27L | Left | Temporary | 850 | yes | future |
| B99.29R | Right | Temporary | 1600 | yes | initial |
| B100.35L | Left | Temporary | 1400 | yes | initial and future |
| B100.45L | Left | Temporary | 600 | yes | initial and future |
| B100.7L | Left | Temporary | 350 | yes | initial and future |
| B101.14L | Left | Temporary | 400 | yes | future |
| B101.45R | Right | Temporary -> Permanent | 1950 | yes | initial |
| B101.49L | Left | Temporary | 400 | yes | future |
| B101.75L | Left | Temporary | 1000 | yes | initial and future |
| B102.16L | Left | Temporary | 1300 | yes | future |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B102.78L | Left | Temporary | 1150 | yes | future |
| B102.87R | Right | Temporary | 1150 | yes | initial and future |
| B102.94L | Left | Temporary | 1250 | yes | future |
| B102.99R | Right | Temporary -> Permanent | 2800 | yes | initial |
| B103.72R | Right | Temporary | 450 | yes | initial and future |
| B103.73L | Left | Temporary | 600 | yes | future |
| B103.83L | Left | Temporary | 400 | yes | initial |
| B104.01R | Right | Temporary | 850 | yes | initial and future |
| B104.01L | Left | Temporary | 450 | yes | future |
| B104.4R | Right | Temporary | 300 | yes | initial and future |
| B104.56R | Right | Temporary | 400 | yes | initial and future |
| B104.85R | Right | Temporary | 750 | yes | initial and future |
| B105.08R | Right | Temporary | 550 | yes | initial and future |
| B105.29R | Right | Temporary | 1100 | yes | future |
| B105.4R | Right | Temporary | 1150 | yes | future |

| SECTION 7 | | | | | |
|---|---|---|---|---|---|
| B111.22L | Left | Temporary | 1250 | yes | initial and future |
| B111.82L | Left | Temporary | 1950 | yes | initial and future |
| B112.96L | Left | Temporary | 650 | yes | future |
| B113.22R | Right | Temporary -> Permanent | 1700 | yes | initial |
| B113.25L | Left | Temporary | 1800 | yes | initial |
| B113.41L | Left | Temporary | 450 | yes | future |
| B113.43L | Left | Temporary | 1150 | yes | initial |
| B113.44R | Right | Temporary -> Permanent | 1350 | yes | initial |
| B113.54L | Left | Temporary | 350 | yes | future |
| B113.94L | Left | Temporary | 350 | yes | future |
| B113.96L | Left | Temporary | 650 | yes | initial |
| B113.98R | Right | Temporary -> Permanent | 650 | yes | initial |
| B114.08L | Left | Temporary | 450 | yes | future |
| B114.63L | Left | Temporary | 2250 | yes | initial and future |
| B114.66R | Right | Temporary -> Permanent | 2100 | yes | initial |
| B114.89L | Left | Temporary | 900 | yes | initial and future |
| B115.24L | Left | Temporary | 550 | yes | initial and future |
| B115.47L | Left | Temporary | 1850 | yes | initial and future |
| B115.94L | Left | Temporary | 1300 | yes | initial and future |
| B116.27R | Right | Temporary | 450 | yes | initial |
| B116.49L | Left | Temporary | 1100 | yes | initial |
| B116.68R | Right | Temporary | 1300 | yes | initial and future |
| B117.1R | Right | Temporary | 1600 | yes | initial and future |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B117.39L | Left | Temporary | 2100 | yes | initial |
| B117.55R | Right | Temporary -> Permanent | 800 | yes | initial |
| B117.84L | Left | Temporary | 900 | yes | initial |
| B117.94L | Left | Temporary | 950 | yes | initial |
| B118.03R | Right | Temporary -> Permanent | 600 | yes | initial |
| B118.42L | Left | Temporary -> Permanent | 1250 | yes | initial |
| B118.54L | Left | Temporary -> Permanent | 3200 | yes | initial |
| B119.49L | Left | Temporary | 550 | yes | initial and future |
| B119.74L | Left | Temporary -> Permanent | 1850 | yes | initial |
| B120.14L | Left | Temporary | 2150 | yes | initial and future |
| B120.57L | Left | Temporary -> Permanent | 4250 | yes | initial |
| B120.62R | Right | Temporary | 1050 | yes | initial and future |
| B120.73R | Right | Temporary | 800 | yes | initial and future |
| B120.78L | Left | Temporary | 350 | yes | initial and future |
| B121.52R | Right | Temporary -> Permanent | 3200 | yes | initial |
| B121.55L | Left | Temporary | 450 | yes | initial and future |
| B122.09R | Right | Temporary | 950 | yes | future |
| B122.1L | Left | Temporary | 600 | yes | initial and future |
| B122.24L | Left | Temporary | 350 | yes | initial and future |
| B122.51L | Left | Temporary | 700 | yes | initial and future |
| B122.62L | Left | Temporary -> Permanent | 2350 | yes | future |
| B123.32R | Right | Temporary -> Permanent | 950 | yes | initial |
| B123.54L | Left | Temporary | 1800 | yes | initial |
| B123.62L | Left | Temporary | 450 | yes | initial |
| B123.79L | Left | Temporary | 850 | yes | initial |
| B124.06L | Left | Temporary | 850 | yes | initial |
| B124.44L | Left | Temporary | 700 | yes | initial |
| B124.53L | Left | Temporary -> Permanent | 1850 | yes | initial |
| B125.45L | Left | Temporary | 1500 | yes | initial |
| B125.57L | Left | Temporary | 1200 | yes | initial and future |
| B126.19L | Left | Temporary | 1600 | yes | initial and future |

| SECTION 8 | | | | | |
|---|---|---|---|---|---|
| B126.9R | Right | Temporary -> Permanent | 2300 | no | initial |
| B127.33R | Right | Temporary | 1050 | yes | initial |
| B127.94L | Left | Temporary -> Permanent | 1200 | no | initial |
| B128.06L | Left | Temporary | 800 | no | initial |
| B128.31L | Left | Temporary | 2650 | no | initial |
| B128.89L | Left | Temporary | 4500 | no | initial |
| B129.3L | Left | Temporary -> Permanent | 5500 | no | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B129.61R | Right | Temporary | 1800 | yes | initial |
| B129.94R | Right | Temporary -> Permanent | 1150 | yes | initial |
| B130.3R | Right | Temporary -> Permanent | 1400 | yes | initial |
| B130.67R | Right | Temporary | 650 | yes | initial |
| B130.94R | Right | Temporary | 700 | yes | initial |
| B131.34R | Right | Temporary | 1300 | yes | initial |
| B131.7R | Right | Temporary | 1200 | yes | initial |
| B131.89L | Left | Temporary | 700 | yes | initial |
| B132.09R | Right | Temporary | 1700 | yes | initial |
| B132.21L | Left | Temporary | 1200 | yes | initial |
| B132.34R | Right | Temporary | 1000 | yes | initial |
| B132.55L | Left | Temporary | 800 | yes | initial |
| B132.98L | Left | Temporary | 700 | yes | initial |
| B133.26L | Left | Temporary | 550 | yes | initial |
| B133.42L | Left | Temporary | 450 | yes | initial |
| B133.58L | Left | Temporary | 800 | yes | initial |
| B133.88L | Left | Temporary | 600 | yes | initial |
| B133.88R | Right | Temporary | 750 | yes | initial |
| B134.54L | Left | Temporary | 500 | yes | initial |
| B135.14L | Left | Temporary | 900 | yes | initial |
| B135.24L | Left | Temporary | 500 | yes | initial |
| B135.5L | Left | Temporary | 550 | yes | initial |
| B135.65L | Left | Temporary | 1650 | yes | initial |
| B136.37L | Left | Temporary | 700 | yes | initial |
| B136.58L | Left | Temporary | 650 | yes | initial |
| B136.75R | Right | Temporary | 350 | yes | initial |
| B136.81L | Left | Temporary -> Permanent | 1900 | yes | initial |
| B137.01R | Right | Temporary | 600 | yes | initial |
| B137.13L | Left | Temporary -> Permanent | 5900 | yes | initial |
| B137.43R | Right | Temporary | 500 | yes | initial |
| SECTION 9 | | | | | |
| B137.78R | Right | Temporary | 1000 | yes | initial |
| B138.62R | Right | Temporary | 1000 | yes | initial |
| B138.69L | Left | Temporary | 2600 | yes | initial |
| B139.4R | Right | Temporary | 800 | yes | initial |
| B139.4L | Left | Temporary | 1800 | yes | initial |
| B139.92L | Left | Temporary | 2400 | yes | initial |
| B140.79L | Left | Temporary -> Permanent | 6000 | yes | initial |
| B141.15L | Left | Temporary | 1200 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B141.26L | Left | Temporary | 1800 | yes | initial |
| B141.87L | Left | Temporary | 400 | yes | initial |
| B141.98L | Left | Temporary -> Permanent | 1000 | yes | initial |
| B142.29L | Left | Temporary -> Permanent | 1700 | yes | initial |
| B142.77R | Right | Temporary | 1900 | yes | initial |
| B142.79L | Left | Temporary | 700 | yes | initial |
| B142.79L | Left | Temporary | 1100 | yes | initial |
| B143.31R | Right | Temporary -> Permanent | 1400 | yes | initial |
| B143.49R | Right | Temporary | 600 | yes | initial |
| B144.22R | Right | Temporary -> Permanent | 1300 | yes | initial |
| B144.33R | Right | Temporary -> Permanent | 1100 | yes | initial |
| B144.89R | Right | Temporary | 500 | yes | initial |
| B145.05R | Right | Temporary -> Permanent | 1400 | yes | initial |
| B145.22R | Right | Temporary -> Permanent | 1900 | yes | initial |

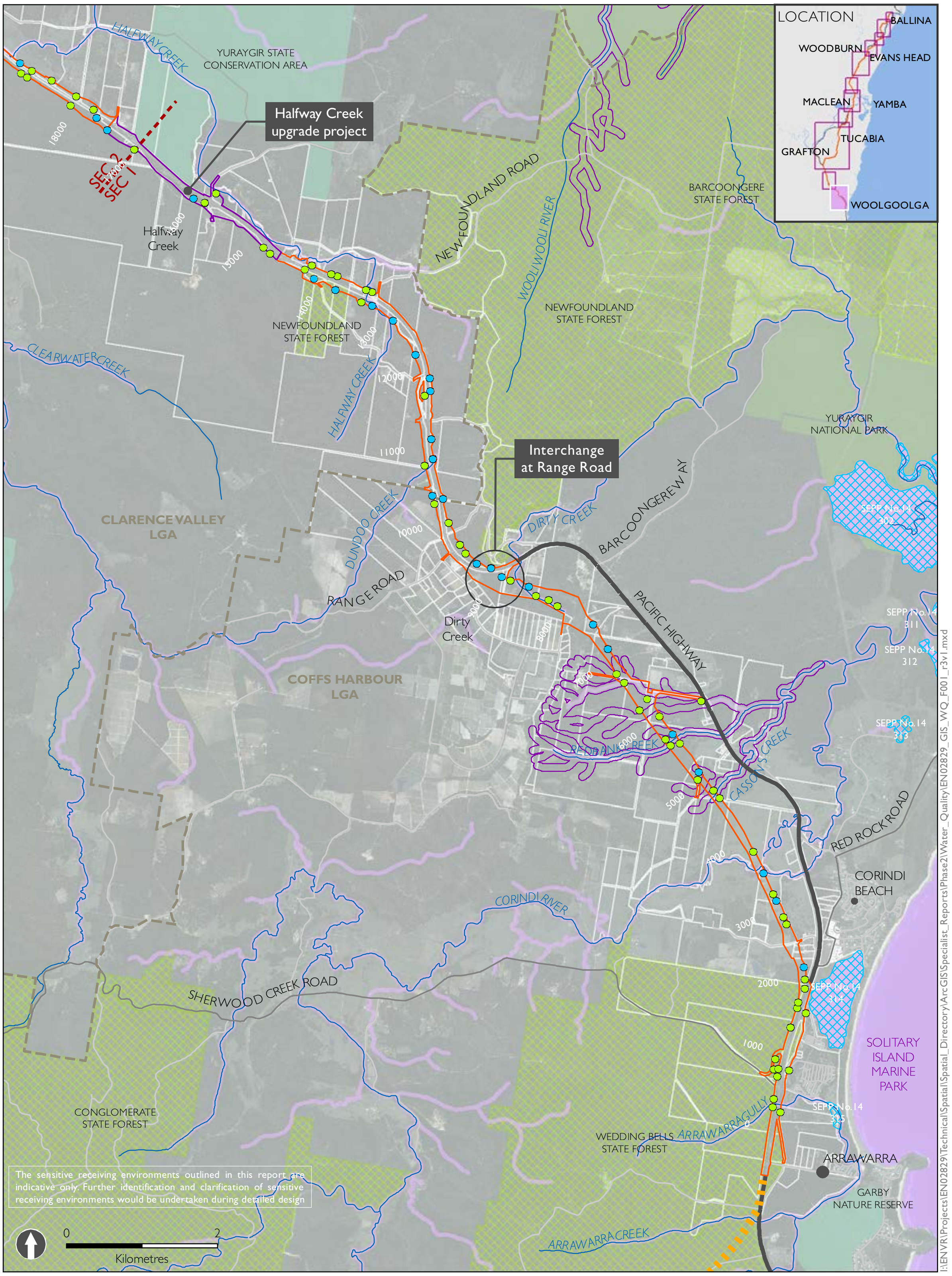
| SECTION 10 | | | | | |
|---|---|---|---|---|---|
| B146.12L | Left | Temporary | 1100 | yes | initial |
| B146.34L | Left | Temporary -> Permanent | 1100 | yes | initial |
| B146.67L | Left | Temporary -> Permanent | 800 | yes | initial |
| B147.13L | Left | Temporary -> Permanent | 2000 | yes | initial |
| B147.27L | Left | Temporary -> Permanent | 4300 | yes | initial |
| B147.55L | Left | Temporary | 2400 | yes | initial |
| B147.76L | Left | Temporary | 1400 | yes | initial |
| B148.08R | Right | Temporary | 5700 | yes | initial |
| B148.26R | Right | Temporary -> Permanent | 500 | yes | initial |
| B148.32R | Right | Temporary -> Permanent | 900 | yes | initial |
| B148.56R | Right | Temporary | 700 | yes | initial |
| B148.66R | Right | Temporary | 1300 | yes | initial |
| B149.01R | Right | Temporary | 700 | yes | initial |
| B149.17R | Right | Temporary -> Permanent | 900 | yes | initial |
| B149.3R | Right | Temporary | 900 | yes | initial |
| B149.32L | Left | Temporary | 800 | yes | initial |
| B150.01R | Right | Temporary | 600 | yes | initial |
| B150.1R | Right | Temporary | 700 | yes | initial |
| B150.5R | Right | Temporary | 500 | yes | initial |
| B150.67R | Right | Temporary | 1500 | yes | initial |
| B151.24R | Right | Temporary | 1200 | yes | initial |
| B151.32R | Right | Temporary | 600 | yes | initial |
| B151.57R | Right | Temporary | 900 | yes | initial |
| B151.65R | Right | Temporary | 700 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B151.83R | Right | Temporary | 500 | yes | initial |
| B152R | Right | Temporary | 1000 | yes | initial |
| B152.15R | Right | Temporary | 700 | yes | initial |
| 152.34L | Left | Temporary -> Permanent | 700 | yes | initial |
| B152.21L | Left | Temporary -> Permanent | 3300 | yes | initial |
| B152.52L | Left | Temporary | 600 | yes | initial |
| B152.72R | Right | Temporary -> Permanent | 800 | yes | initial |
| B152.79R | Right | Temporary | 900 | yes | initial |
| B153.02R | Right | Temporary | 1400 | yes | initial |
| B153.14R | Right | Temporary | 1000 | yes | initial |
| B153.55R | Right | Temporary | 1400 | yes | initial |
| B153.77R | Right | Temporary | 1300 | yes | initial |
| B153.99R | Right | Temporary | 500 | yes | initial |
| B154.12R | Right | Temporary | 2200 | yes | initial |
| B154.61R | Right | Temporary | 2100 | yes | initial |
| B155.18R | Right | Temporary | 900 | yes | initial |
| B155.51R | Right | Temporary | 900 | yes | initial |
| B155.86R | Right | Temporary | 500 | yes | initial |
| B155.96R | Right | Temporary | 700 | yes | initial |
| B156.21R | Right | Temporary | 400 | yes | initial |
| B156.34R | Right | Temporary | 900 | yes | initial |
| B156.89R | Right | Temporary | 1200 | yes | initial |
| B156.98R | Right | Temporary | 400 | yes | initial |
| B157.17R | Right | Temporary | 600 | yes | initial |
| B157.37R | Right | Temporary | 500 | yes | initial |
| B157.45R | Right | Temporary -> Permanent | 1200 | yes | initial |
| B157.6R | Right | Temporary | 1500 | yes | initial |
| B157.69R | Right | Temporary | 600 | yes | initial |
| B157.83R | Right | Temporary | 700 | yes | initial |
| B158.37L | Left | Temporary | 1400 | yes | initial |

| SECTION 11 | | | | | |
|---|---|---|---|---|---|
| B158.8L | Left | Temporary | 900 | yes | initial |
| B158.92L | Left | Temporary | 800 | yes | initial |
| B159.74R | Right | Temporary -> Permanent | 1300 | yes | initial |
| B159.75L | Left | Temporary | 1900 | yes | initial |
| B159.88R | Right | Temporary -> Permanent | 400 | yes | initial |
| B159.95L | Left | Temporary | 300 | yes | initial |
| B160.16L | Left | Temporary | 300 | yes | initial |
| B160.37L | Left | Temporary | 300 | yes | initial |

| Basin name | Side of upgrade | Temporary or permanent | Basin volume ($m^3$) | Sensitive receiving environment | Project staging |
|---|---|---|---|---|---|
| B160.56L | Left | Temporary | 300 | yes | initial |
| B160.75L | Left | Temporary | 300 | yes | initial |
| B161.16L | Left | Temporary | 600 | yes | initial |
| B161.55L | Left | Temporary | 600 | yes | initial |
| B161.96L | Left | Temporary | 600 | yes | initial |
| B162.15L | Left | Temporary | 300 | yes | initial |
| B162.35L | Left | Temporary | 300 | yes | initial |
| B162.57L | Left | Temporary | 300 | yes | initial |
| B162.96L | Left | Temporary | 700 | yes | initial |
| B163.04L | Left | Temporary | 400 | yes | initial |
| B163.58L | Left | Temporary | 600 | yes | initial |
| B163.82R | Right | Temporary | 600 | yes | initial |
| B163.94R | Right | Temporary | 600 | yes | initial |
| B164.13R | Right | Temporary -> Permanent | 800 | yes | initial |

Figure D - 1 Section 1 - Woolgoolga to Halfway Creek - Location of water quality control basins




- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway
- Named waterways
- Permanent basins
- Temporary basins
- Key fish habitat (NSW DPI)
- *Oxleyan Pygmy Perch* habitat (NSW DPI)
- *Oxleyan Pygmy Perch* habitat (from targeted surveys)
- National Park
- Nature Reserve / State Conservation Area
- State Forest
- Nationally Important & SEPP 14 wetlands

Figure D -2 Section 2 - Halfway Creek to Glenugie upgrade - Location of water quality control basins

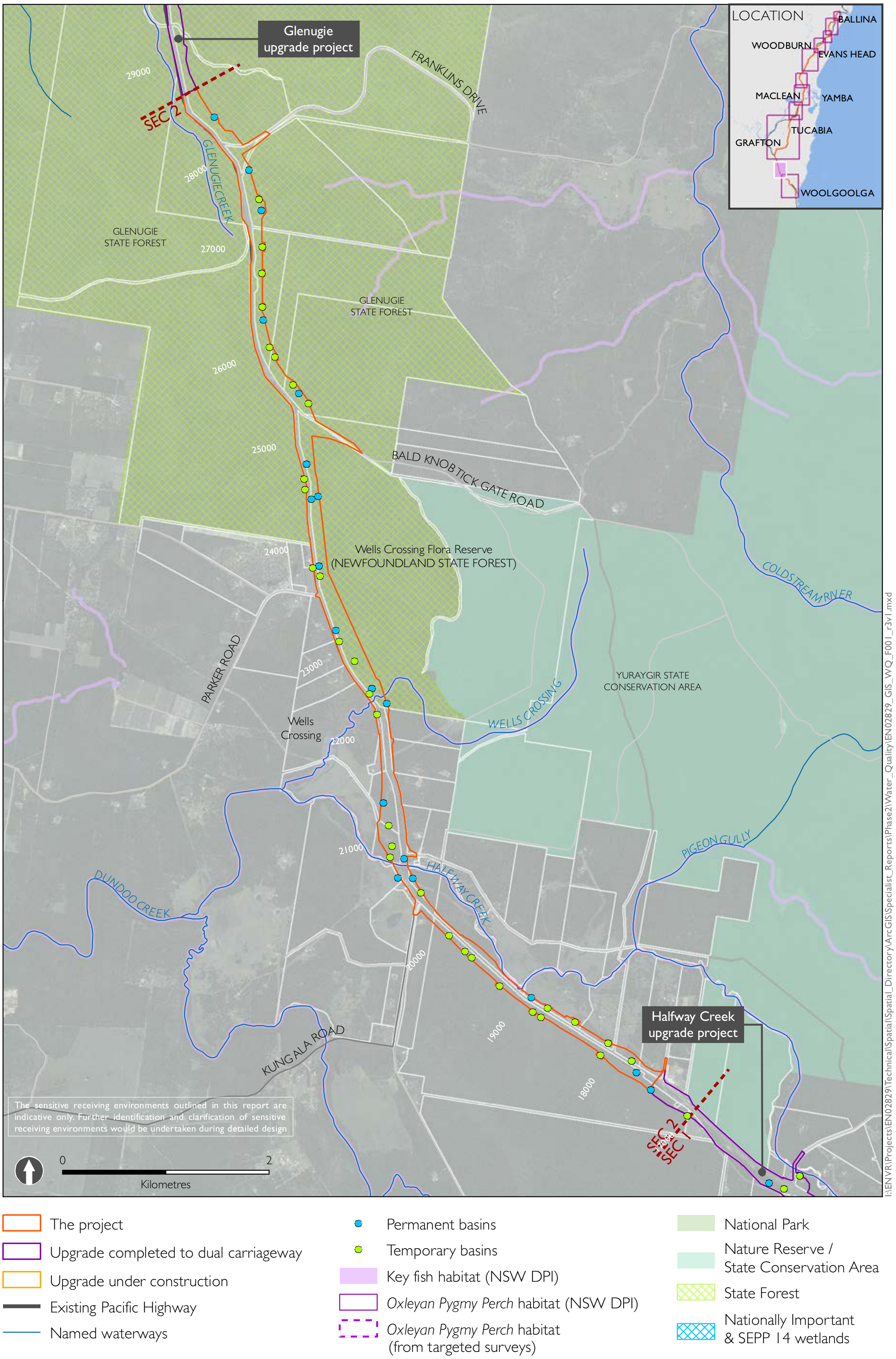
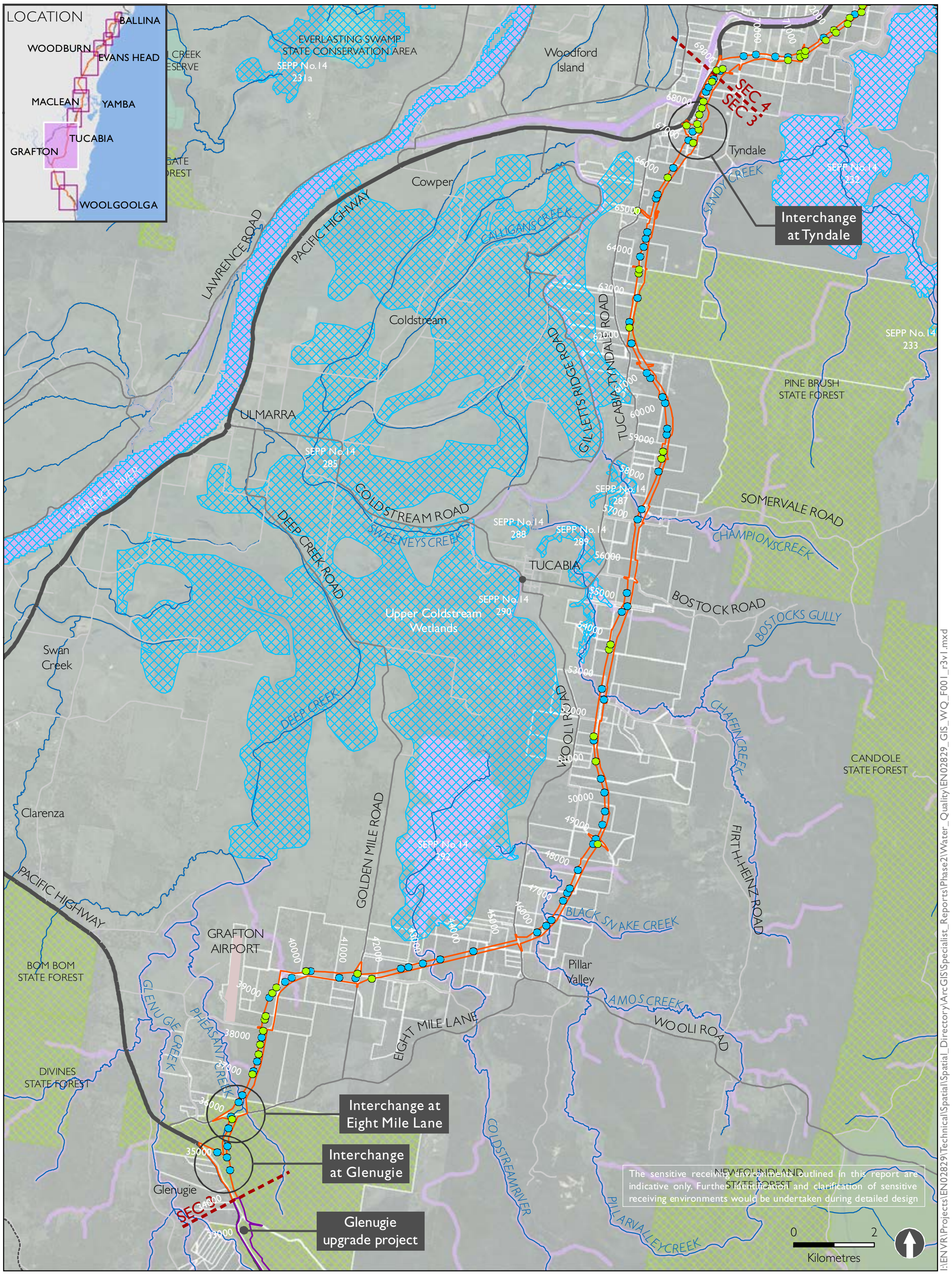
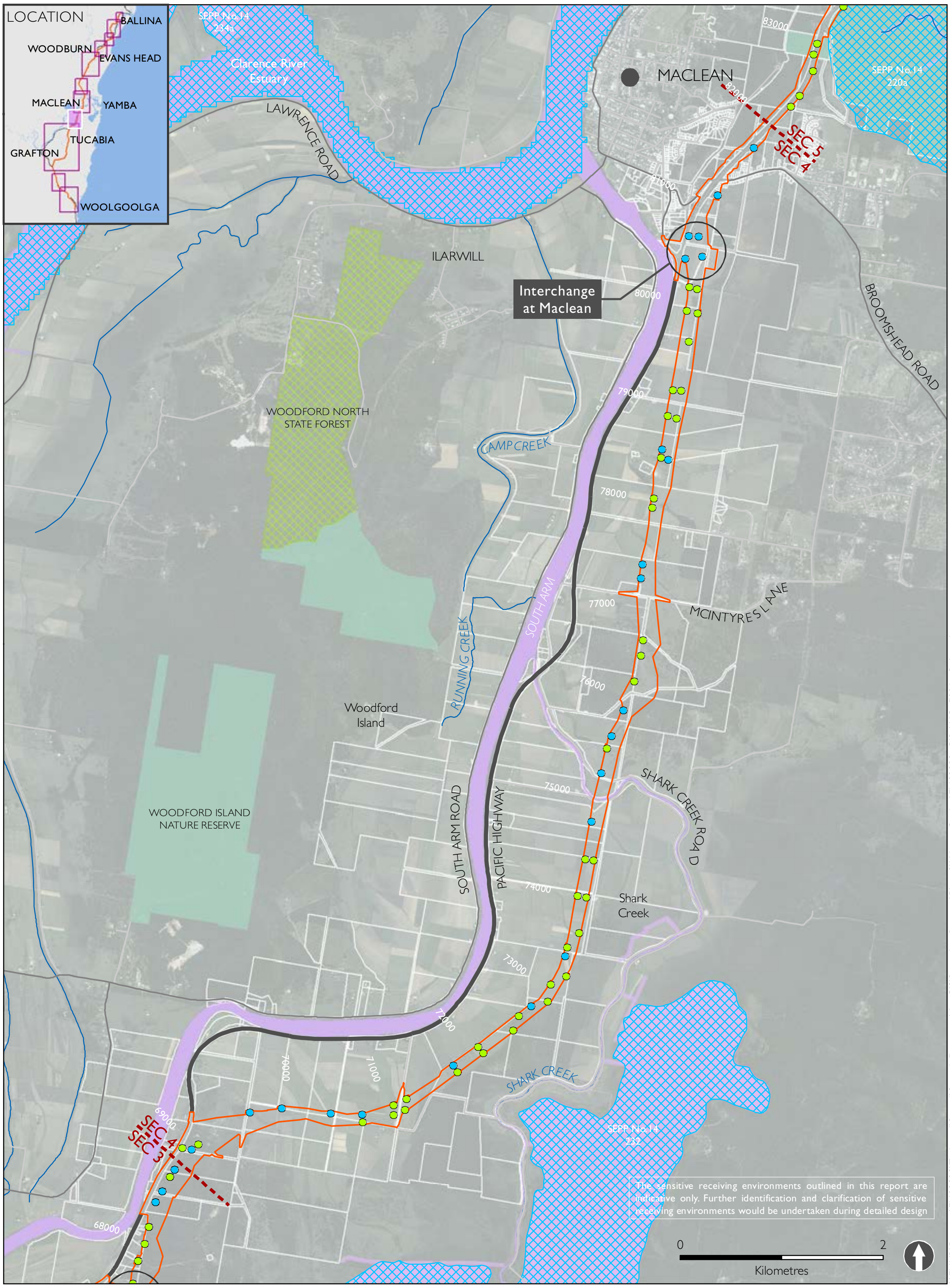


Figure D -3 Section 3 - Glenugie upgrade to Tyndale - Location of water quality control basins




The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Named waterways
Permanent basins
Temporary basins
Key fish habitat (NSW DPI)
*Oxleyan Pygmy Perch* habitat (NSW DPI)
*Oxleyan Pygmy Perch* habitat (from targeted surveys)
National Park
Nature Reserve / State Conservation Area
State Forest
Nationally Important & SEPP 14 wetlands

Figure D -4 Section 4 - Tyndale to Maclean - Location of water quality control basins




The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Named waterways
Permanent basins
Temporary basins
Key fish habitat (NSW DPI)
*Oxleyan Pygmy Perch* habitat (NSW DPI)
*Oxleyan Pygmy Perch* habitat (from targeted surveys)
National Park
Nature Reserve / State Conservation Area
State Forest
Nationally Important & SEPP 14 wetlands

Figure D -5 Section 5 - Maclean to Iluka Road - Location of water quality control basins

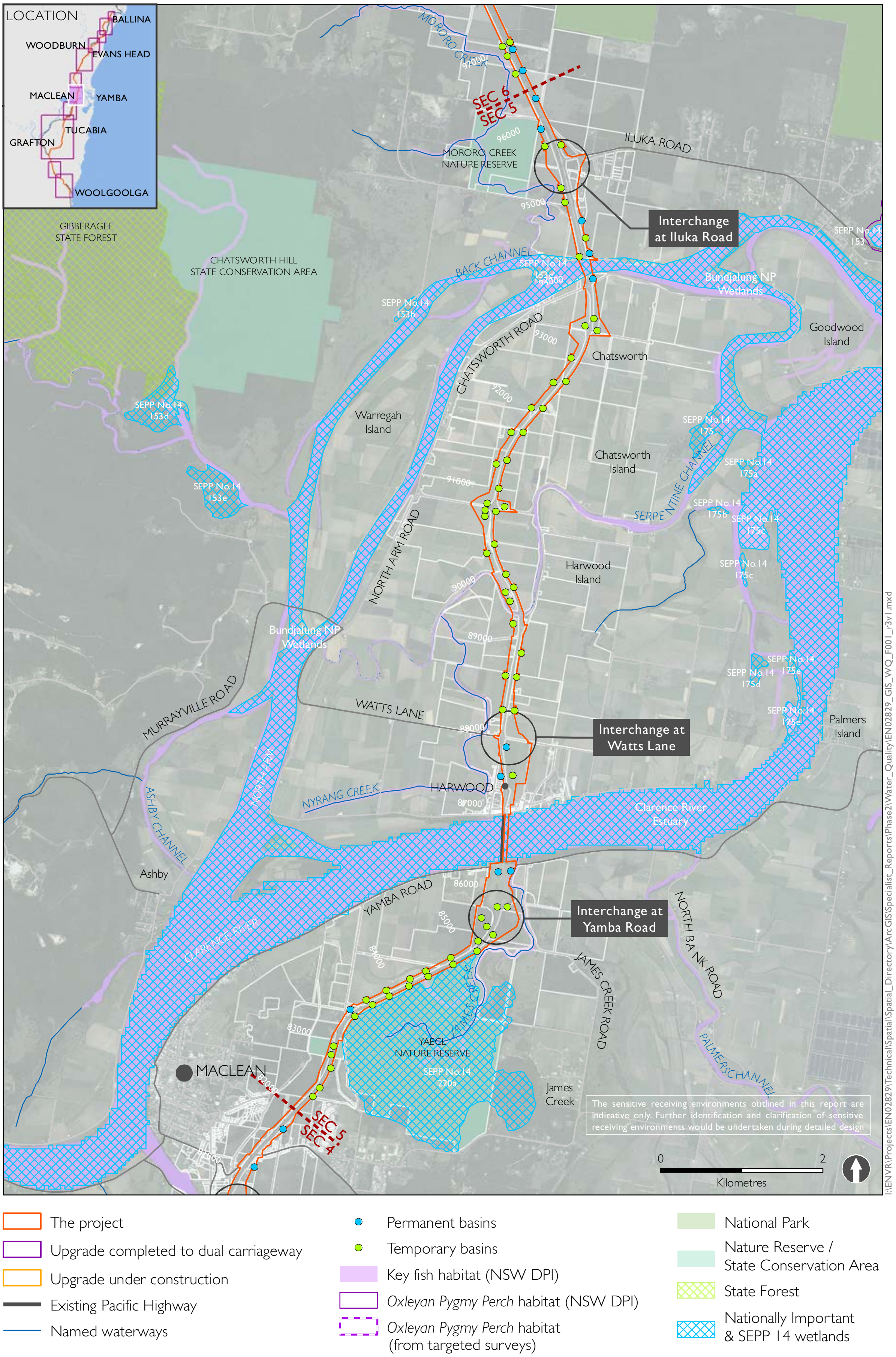
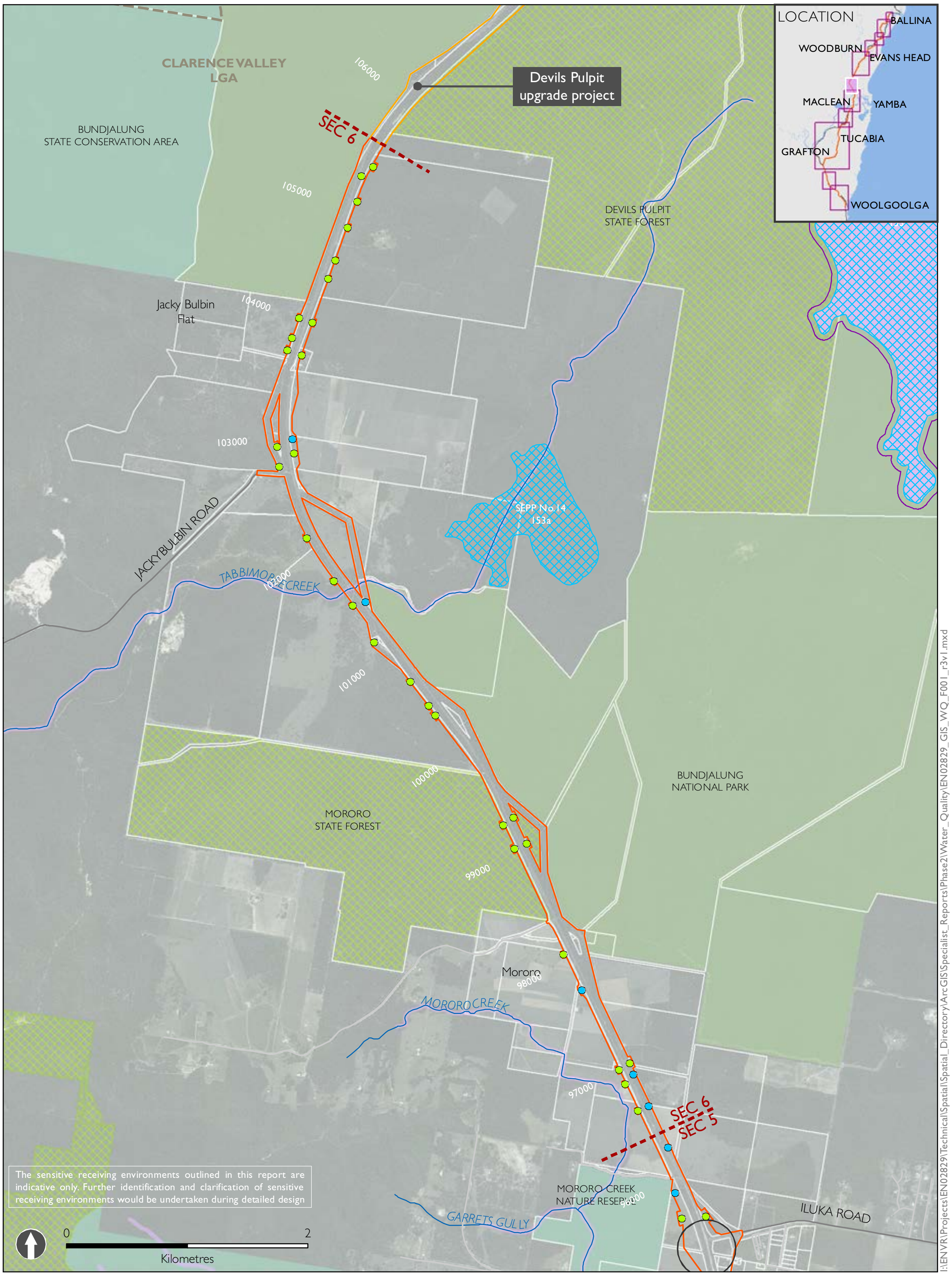
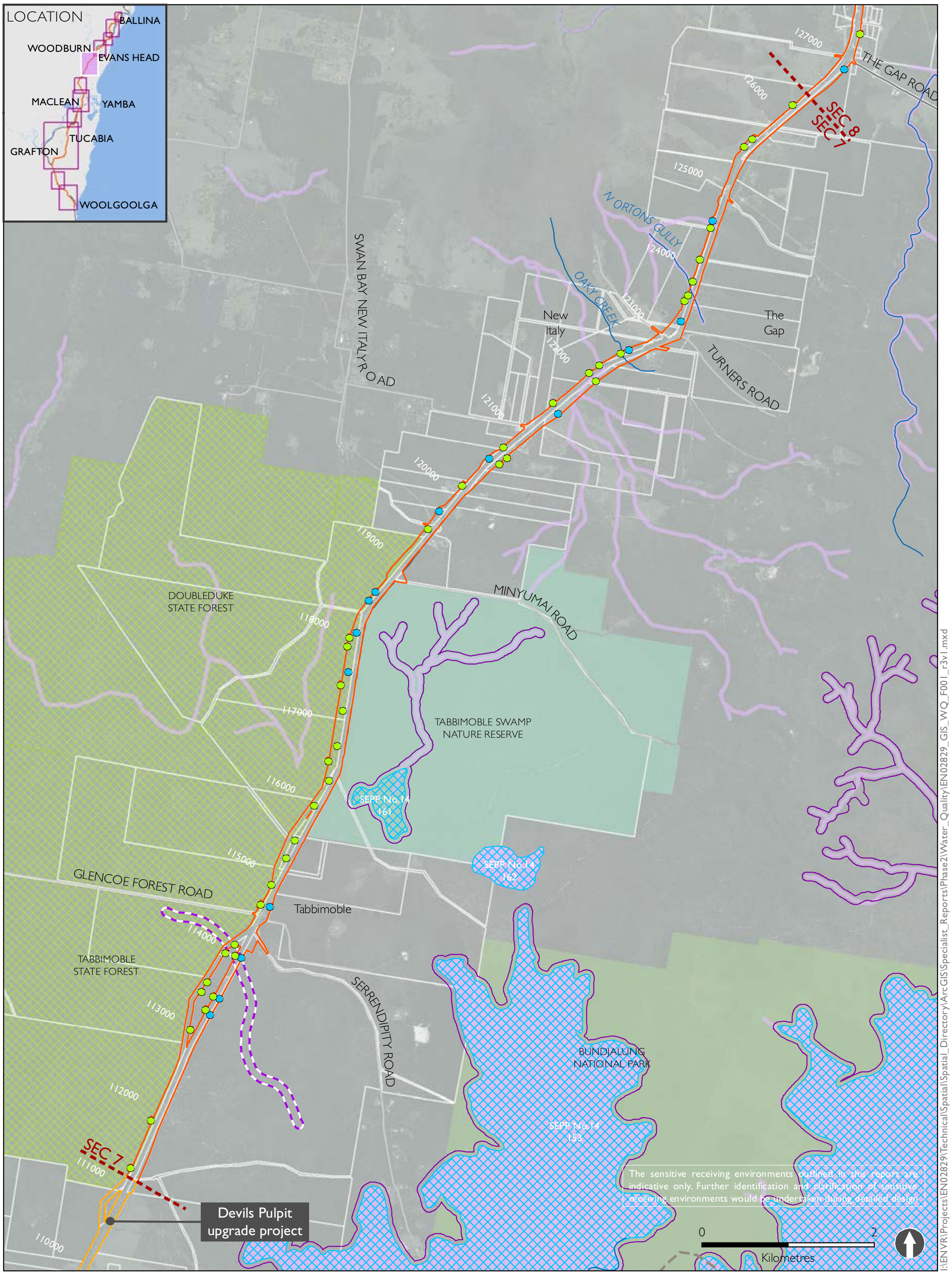


Figure D -6 Section 6 - Iluka Road to Devils Pulpit upgrade - Location of water quality control basins




- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway
- Named waterways
- Permanent basins
- Temporary basins
- Key fish habitat (NSW DPI)
- *Oxleyan Pygmy Perch* habitat (NSW DPI)
- *Oxleyan Pygmy Perch* habitat (from targeted surveys)
- National Park
- Nature Reserve / State Conservation Area
- State Forest
- Nationally Important & SEPP 14 wetlands

Figure D -7 Section 7 - Devils Pulpit upgrade to Trustums Hill - Location of water quality control basins




- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway
- Named waterways
- Permanent basins
- Temporary basins
- Key fish habitat (NSW DPI)
- *Oxleyan Pygmy Perch* habitat (NSW DPI)
- *Oxleyan Pygmy Perch* habitat (from targeted surveys)
- National Park
- Nature Reserve / State Conservation Area
- State Forest
- Nationally Important & SEPP 14 wetlands

Figure D -8 Section 8 - Trustums Hill to Broadwater National Park - Location of water quality control basins

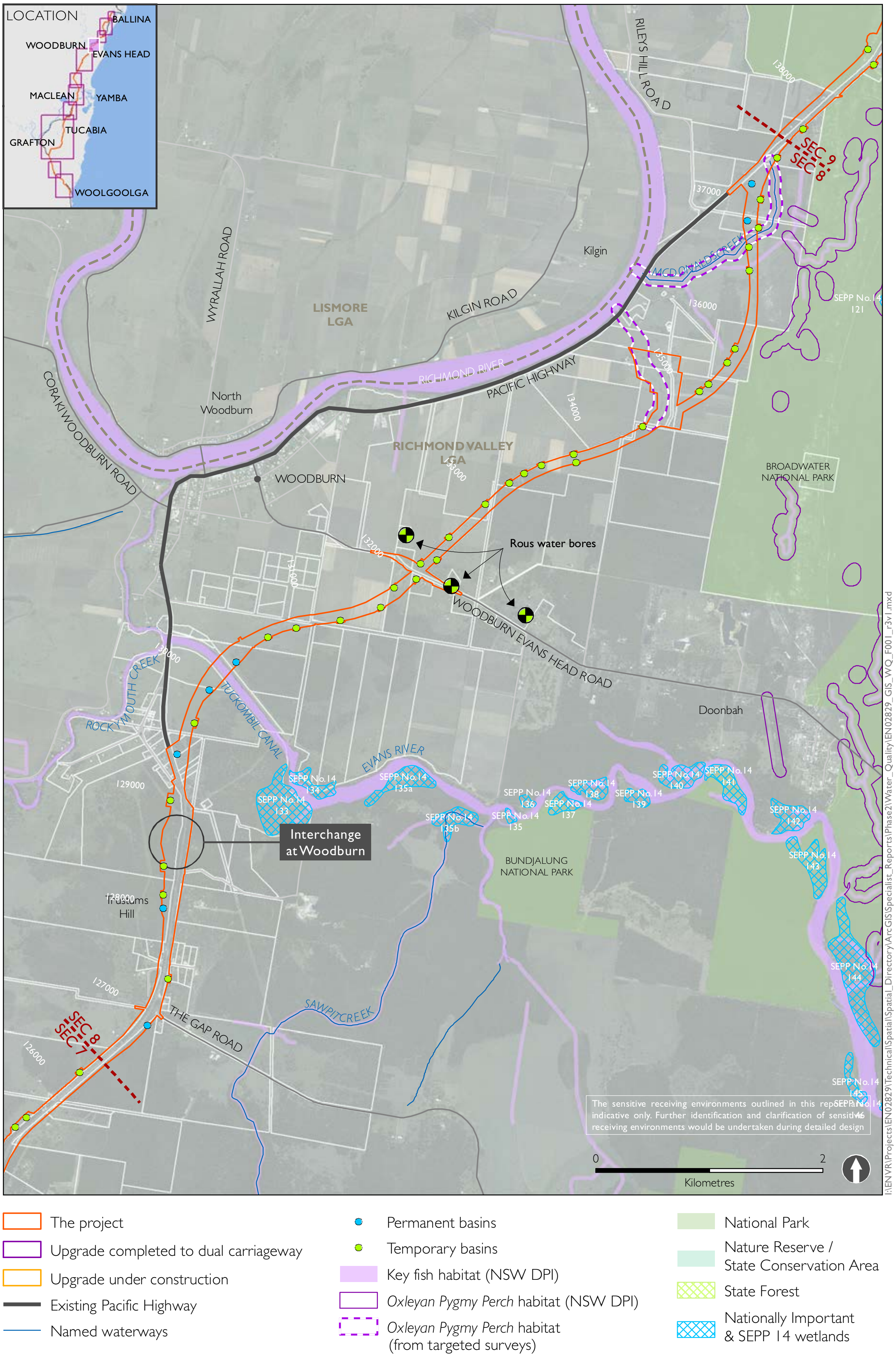
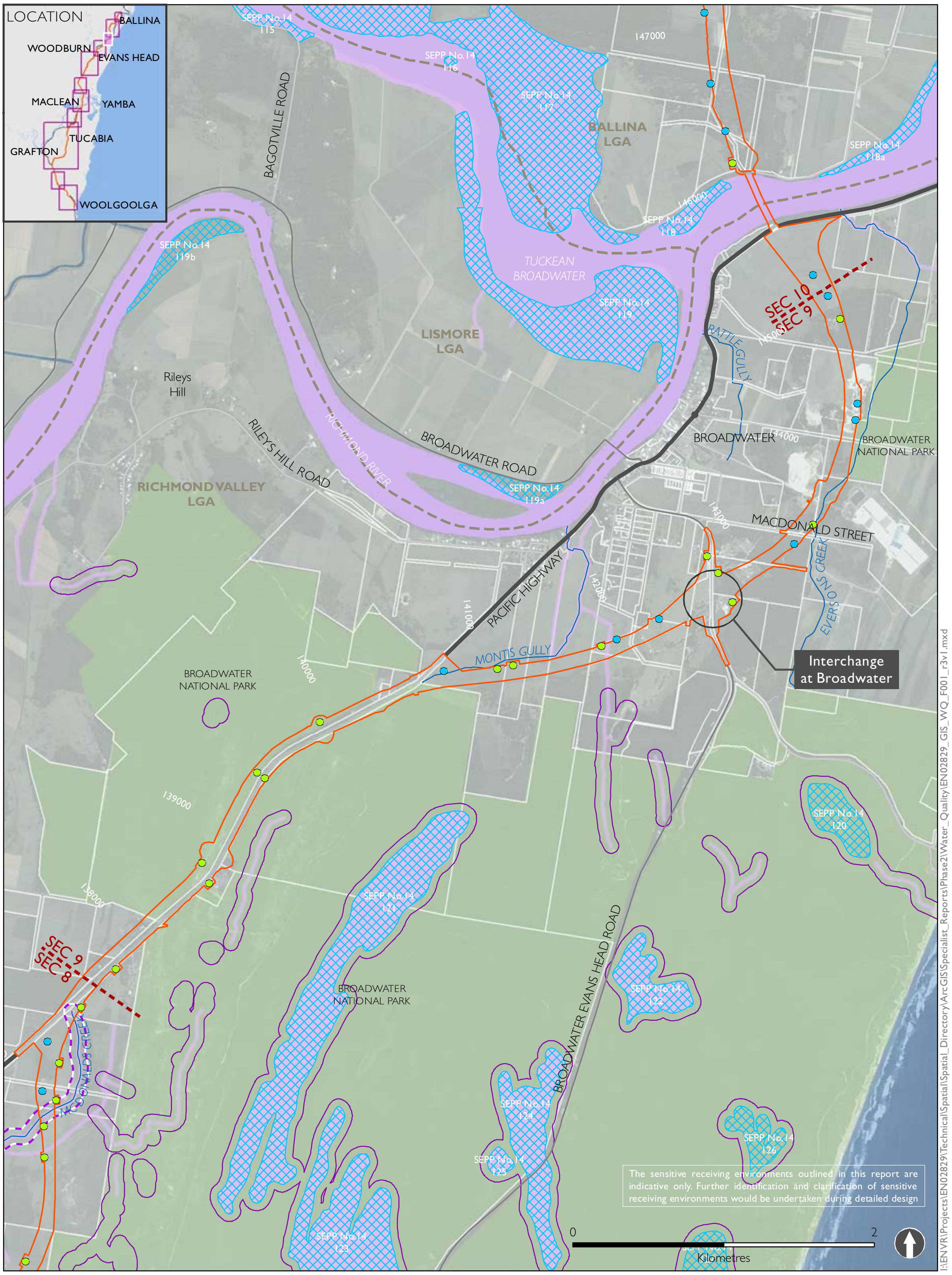
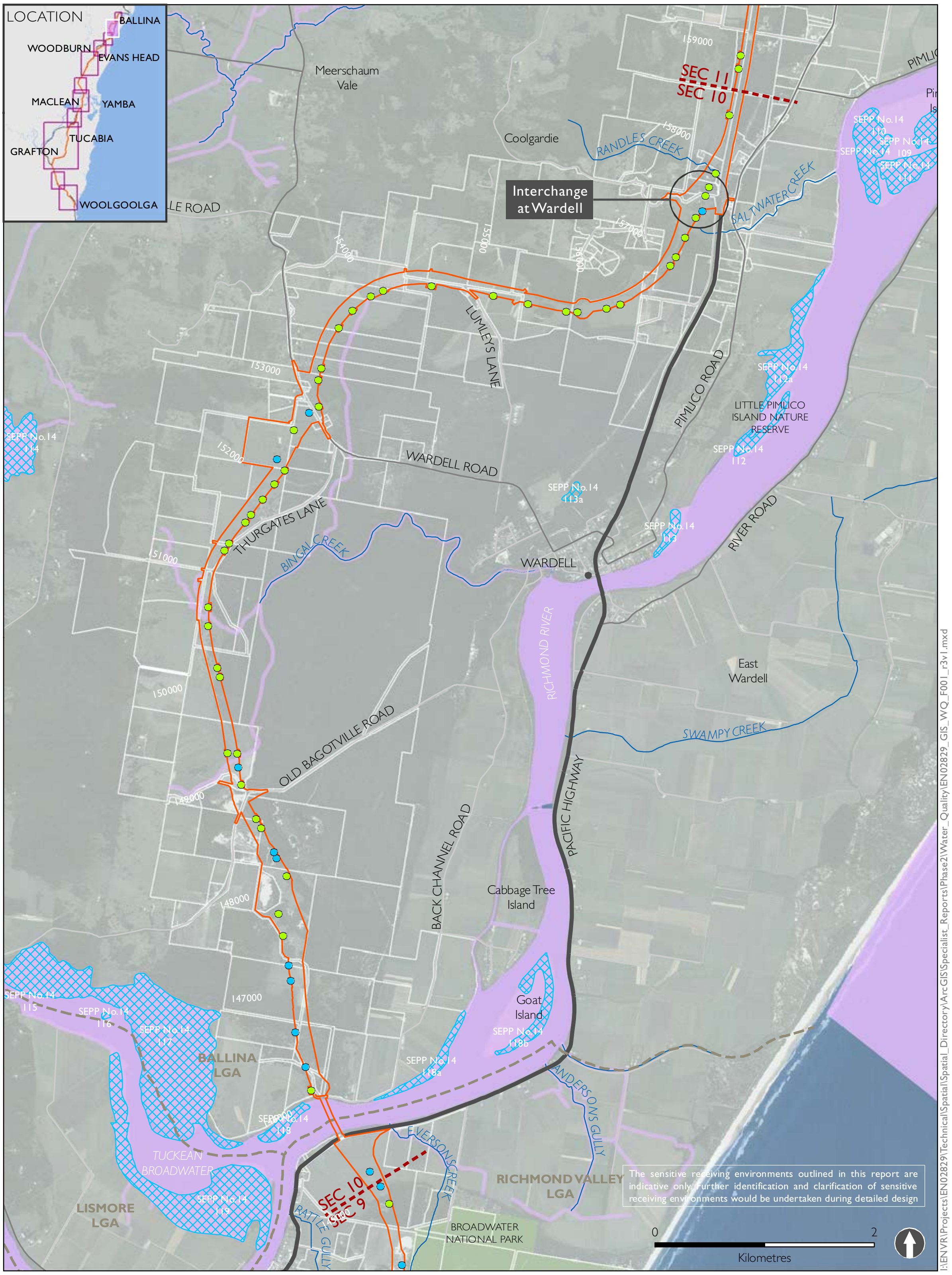


Figure D -9 Section 9 - Broadwater National Park to Richmond River - Location of water quality control basins



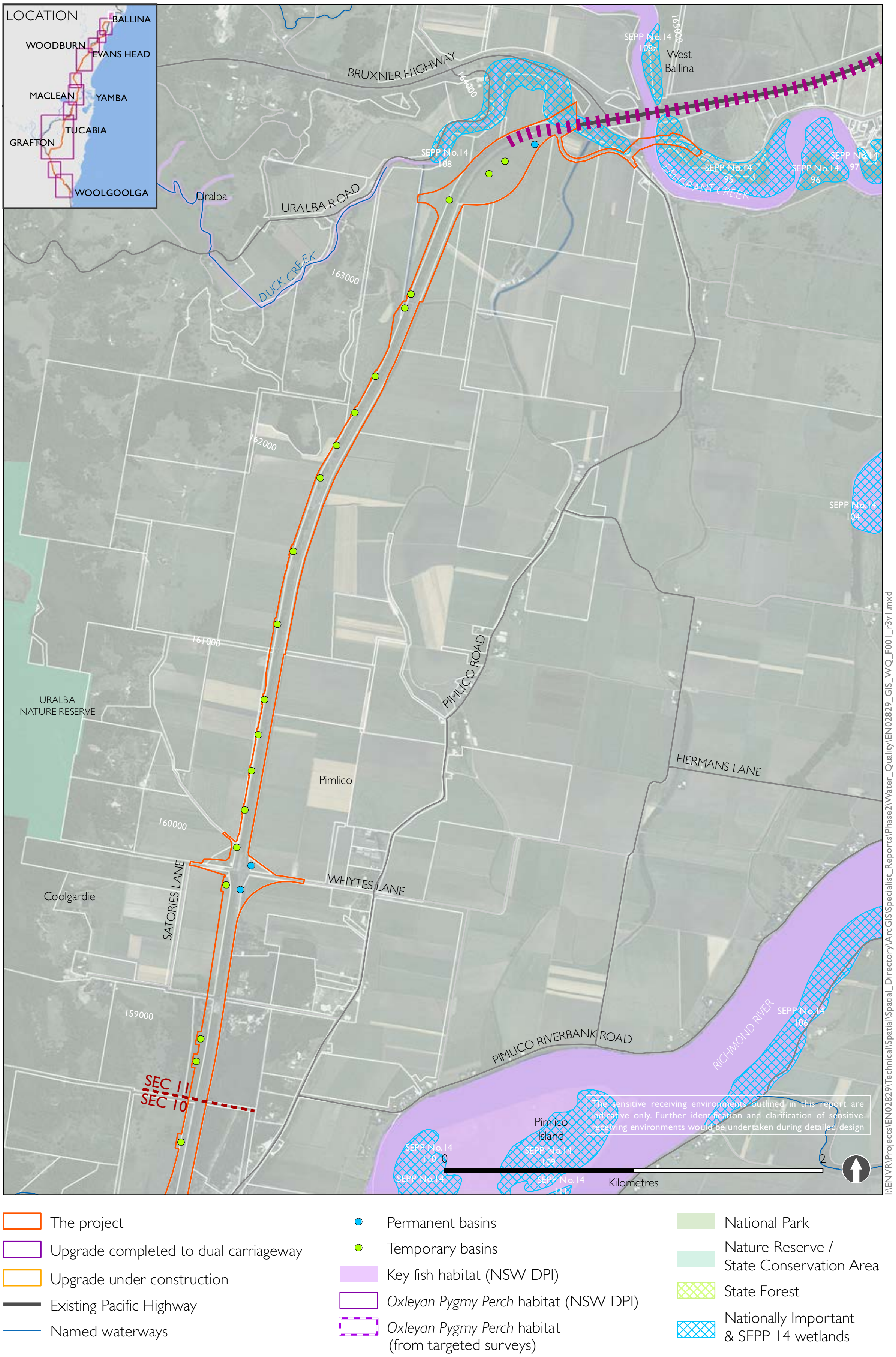

The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Named waterways
Permanent basins
Temporary basins
Key fish habitat (NSW DPI)
*Oxleyan Pygmy Perch* habitat (NSW DPI)
*Oxleyan Pygmy Perch* habitat (from targeted surveys)
National Park
Nature Reserve / State Conservation Area
State Forest
Nationally Important & SEPP 14 wetlands

Figure D-10 Section 10 - Richmond River to Coolgardie Road - Location of water quality control basins




- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway
- Named waterways
- Permanent basins
- Temporary basins
- Key fish habitat (NSW DPI)
- *Oxleyan Pygmy Perch* habitat (NSW DPI)
- *Oxleyan Pygmy Perch* habitat (from targeted surveys)
- National Park
- Nature Reserve / State Conservation Area
- State Forest
- Nationally Important & SEPP 14 wetlands

Figure D-11 Section 11 - Coolgardie Road to Ballina bypass - Location of water quality control basins



# Appendix E Water quality monitoring framework

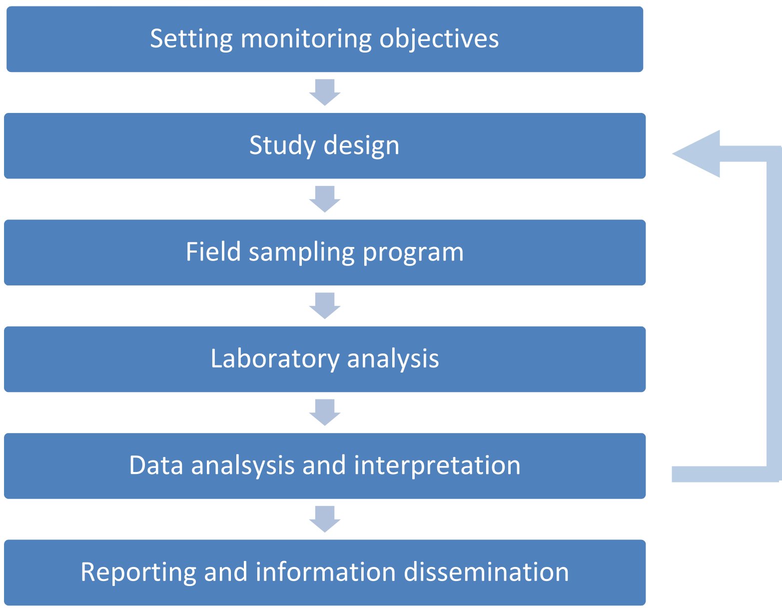
# E.1. Purpose of this framework

This Appendix outlines a surface water quality overview framework to inform the Water Quality Monitoring Plan that would be developed as early as possible, prior to construction. The Groundwater Working Paper (Section 5.2) includes the Groundwater Monitoring Framework that also informs the project Water Quality Monitoring Plan. The surface water and groundwater monitoring plans have been developed together to cover connectivity issues and interactions.

The project Water Quality Monitoring Plan would include details of the monitoring objectives and commitments in relation to baseline data, locations of monitoring sites, the frequency and duration of monitoring and the parameters to be monitored. The monitoring plan would be developed with input from relevant agencies including, but not limited to, the Environmental Protection Authority and Department of Primary Industries.

The monitoring plan would comply with the requirements of Australian Standard *AS/NZS 5667.1 1998 – Water quality Sampling Guidance* and the on the design of sampling programs, sampling techniques and the preservation and handling of samples. It would also comply with ANZECC/ARMCANZ (2000) *Australian Guidelines for Water Quality Monitoring and Reporting*, which provides a framework for designing monitoring programs including setting monitoring program objectives, designing monitoring studies and effective field sampling program, laboratory analysis, analysis and interpretation and reporting etc as per figure below.

**Figure E - 1 ANCECC/ARMCANZ (2000) framework for monitoring programs**



## E.2. Water quality objectives

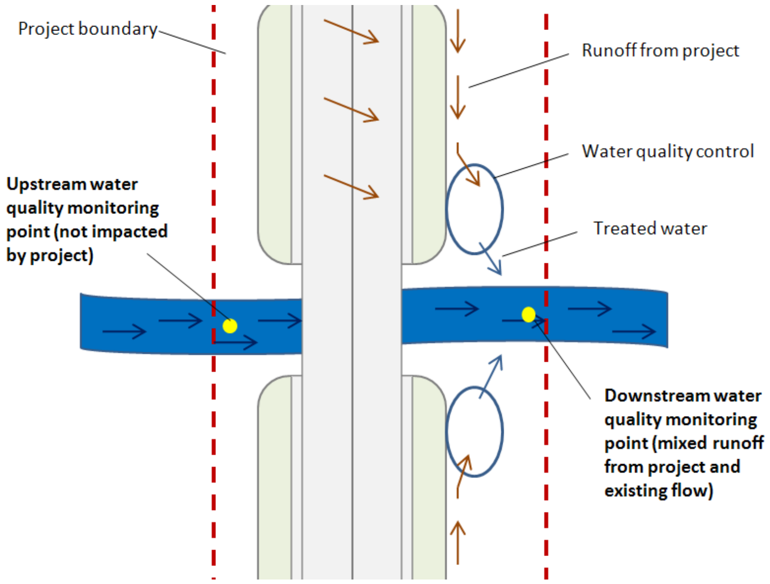
The water quality objectives would be detailed in the Water Quality Monitoring Plan following input from relevant agencies including, but not limited to, the EPA and DPI. It is recommended that the objective for water quality is to cause no net change to receiving waterway quality as a result of construction or operation of the project.

## E.3. Sampling sites

Sampling sites would be selected based on the objectives detailed in the Water Quality Monitoring Plan. Potential locations include all permanent waterways that may potentially be impacted by the project, including named waterways, key fish habitats, Class 1 and 2 waterways and known and potential habitats of threatened fish. Water quality monitoring would consider wet and dry weather condition and different seasons. Sites and sampling times would be selected to be specifically useable for project management purposes, to ensure mitigation of water quality impacts in line with the project water quality objectives. Details would be provided in the water quality monitoring plan.

Figure E - 2 shows a typical detail for the location of water quality monitoring sites. It shows two sampling locations – an upstream point that will not be contaminated by construction, and a point downstream of the site discharge point, where the site runoff mixes with receiving waters.

**Figure E - 2 Typical detail of waterway sampling locations**




In general when sampling is undertaken, a visual inspection of the site condition is required. If the monitoring results or visual inspection give rise to concern, the results will assist to identify the source of the pollution and appropriate management measures to be implemented. Reporting and recording of monitoring is covered in Section E.6

The monitoring locations would not be moved throughout the project. This ensures that each site can be compared over time. Once the project is completed and the site begins to stabilise, the number of monitoring sites would be reduced. Ongoing operational sampling may be required at sites upstream of key sensitive receiving environments.

## E.4. Sampling regime

Existing water quality data, where available, and pre-construction monitoring would be used to determine baseline water quality in each waterway and to determine appropriate site specific parameters for monitoring during the construction works. Site specific indicators may be the result of previous sampling, presence of or likelihood aquatic species (eg threatened fish), etc. Sampling collection is required to comply with the *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW* (EPA 1998).

The Water Quality Monitoring Plan would detail the sampling regime. It would be determined following consultation from relevant agencies including the Environmental Protection Authority and Department of Primary Industries.  Samples should be taken to represent a variety of weather conditions, to provide appropriate baseline water quality information.

The construction phase has the highest potential to impact water quality, particularly as a result of rainfall events, when construction activities could result in the transport of sediment and particulate matter via runoff into receiving waterways downstream of the construction site. Upstream and downstream sampling should be undertaken during the construction phase within 48 hours of a rainfall event. The surface water quality sampling frequency required for each phase of the project is summarised in Table E - 1.

**Table E - 1 Pre construction water quality monitoring frequency**

| Project phase | Sampling frequency per waterway (upstream and downstream of project) |
|---|---|
| Pre-construction | Minimum 12 months of monthly samples in both wet and dry conditions<br><br>During this period, 12 monthly routine samples will be taken for surface water.<br>• 11 samples will be assessed for Type A parameters<br>• 1 sample (dry weather sample - as Type B parameters)<br><br>During this period, 4 wet weather samples are to be taken within 24hrs of a 15mm rain event. The 4 wet weather samples are to be roughly distributed throughout year with 1 from each season.<br>• 3 of these samples will be using type A parameters.<br>• 1 sample using type B parameters.<br><br>Type A, B and C parameters are outlined in Table E - 2. |
| Construction | Wet weather: minimum two samples per month.<br>Dry weather: minimum one sample per month. |
| Operational | One sample per month for at least a year or until results demonstrate construction site has stabilised, then sampling can be discontinued. |

## E.5. Parameters

The Water Quality Monitoring Plan would detail the sampling parameters to be tested in order to satisfy the water quality objectives of the project. It is recommended that the indicators provided in Table E - 2 and Table E - 3 be monitored for the relevant phases of the project; however additional indicators may be required depending on the nature of the site, eg presence of threatened fish species, known water quality issue such as algal blooms, etc. It is worth noting that during construction and operation, additional parameters will require testing in two areas where surface water may interact with groundwater. These are the Rous Water borefields and the Coffs Alluvium, as identified in Figure A2-11 of the Groundwater Working Paper. For pre-construction monitoring, all parameters will be tested in all areas.

Water quality thresholds would be developed prior to construction, either recommended by the Environmental Protection Authority following the provision of an Environmental Protection Licence (EPL), in consultation with Department of Primary Industries (Fisheries) or against the criteria in ANZECC/ARMCANZ (2000) guidelines for protection of aquatic ecosystems - and would be listed in the project Water Quality Monitoring Plan. At monitoring sites identified as potentially impacting bore field sites along the project, supplementary testing would be required to monitor if water quality concerns in the surface water are impacting the local groundwater quality.

As per *AS/NZS 5667.1 1998 – Water Quality Sampling Guidance*, laboratory analysis is required to be undertaken by those registered with the National Association of Testing Authorities (NATA).

**Table E - 2 Sampling parameters for the pre construction phase**

| Parameters | Standard monitoring parameters (Type A) | Additional Metal Monitoring (Type B) |
|---|---|---|
| Dissolved Oxygen | ✓ | ✓ |
| Electrical Conductivity | ✓ | ✓ |
| pH | ✓ | ✓ |
| Temperature | ✓ | ✓ |
| Turbidity | ✓ | ✓ |
| Total suspended Solids | ✓ | ✓ |
| Oils and Grease | ✓ | ✓ |
| Total phosphorus | ✓ | ✓ |
| Total Nitrogen | ✓ | ✓ |
| Cadmium | | ✓ |
| Copper | | ✓ |
| Lead | | ✓ |
| Aluminium | | ✓ |
| Silver | | ✓ |
| Arsenic | | ✓ |
| Chromium | | ✓ |

| Parameters | Standard monitoring parameters (Type A) | Additional Metal Monitoring (Type B) |
|---|---|---|
| Iron | | ✓ |
| Manganese | | ✓ |
| Nickel | | ✓ |
| Selenium | | ✓ |
| Zinc | | ✓ |
| Mercury | | ✓ |
| Magnesium | | ✓ |
| Calcium | | ✓ |

**Table E - 3 Sampling parameters for construction and operational phases**

| Analytes | Construction phase | Operational phase[1] |
|---|---|---|
| pH | ✓ | ✓ |
| Alkalinity | ✓[2] | ✓[2] |
| Temperature | ✓ | ✓ |
| Turbidity | ✓ | ✓ |
| Total Suspended Solids (TSS) | ✓ | ✓ |
| Oils and grease | ✓ | ✓ |
| Electrical Conductivity (EC) | ✓ | ✓ |
| Electrical potential (Eh) | ✓[2] | ✓[2] |
| Dissolved Oxygen (DO) | ✓ | ✓ |
| Ferrous ions | ✓[2] | ✓[2] |
| Total Phosphorous (TP) | | ✓ |
| Total Nitrogen (TN) | | ✓ |
| Sulfate | ✓[2] | ✓[2] |
| Metals | ✓[2] | ✓[2] |
| Major and minor ions | ✓[2] | ✓[2] |

[1] individual sampling parameters may be withdrawn from the sampling program as the site stabilises and the parameter is shown to no longer be a concern over a minimum record of 2 months.
[2]Supplementary surface water monitoring only required in the Rous Water bore field and Coffs Alluvium catchments

## E.6. Reporting and recording

Prior to commencing the design and implementation of the water quality monitoring program, previous relevant water quality monitoring sites and results should be reviewed to determine the appropriateness as a reference site for the monitoring and baseline water quality. The pre-construction water quality monitoring results for each waterway should be assessed against the baseline data (and relevant guidelines), to provide an explanation of differences in the water quality for each waterway that may be useful when interpreting the construction and operational phase monitoring results.

The water quality monitoring program requires results to be routinely submitted to the project manager during the construction phase. These reports should include the following information:

- The date of sample, location of sample, names of staff that collected the sample and name of the client
- A results tables for the upstream and downstream sample results that displays the current sample result, water quality criteria and that clearly highlights any exceedances.
- A discussion of the potential source of pollution for any results that are higher than expected, exceed water quality criteria, or show a significant change in a parameter between the upstream and downstream sample for a site.

Where exceedances to the baseline data are identified, corrective actions would be implemented as soon as possible. High turbidity measurements during construction are a trigger for immediate site management action to mitigate impacts during rainfall events. During construction monitoring, a communication plan should be developed to alert the site manager of noticeable differences in water quality between upstream and downstream sites by way of visual inspection or *in situ* monitoring results.

If an exceedance is recorded at a sampling site during construction, a second sample is required to validate the results. The project manager needs to be notified immediately and further investigations / sampling are required to identify the likely cause and source of the exceedance. As part of this investigation, the factors included in Table E - 4 should be documented. Once the source of pollution is identified, a review of the pollution controls, construction activities and procedures is required to develop corrective actions including changes to pollution controls should be undertaken to mitigate the risk of pollution recurring. All recorded information and actions undertaken to address the pollution should be documented and the requirements of statutory reporting of the exceedance to relevant government agencies should be followed.

**Table E - 4 Exceedance reporting during construction**

| Factor | Reported information |
|---|---|
| Physical observations | Colour, clarity and odour of water |
| Climatic conditions | Climatic conditions at time of sample collection including timing sample was taken in relation to the rainfall event (if sample taken during wet conditions) and total rainfall over the previous week at the site |
| Site differences | Interpretation of any differences between sampling locations that may have an impact on the assessment of the data |

During operation of the project, monitoring records are to be provided to RMS for record keeping purposes.

# Appendix F Soil landscapes

Figure F - 1 Section 1 - Woolgoolga to Halfway Creek - Soil landscapes

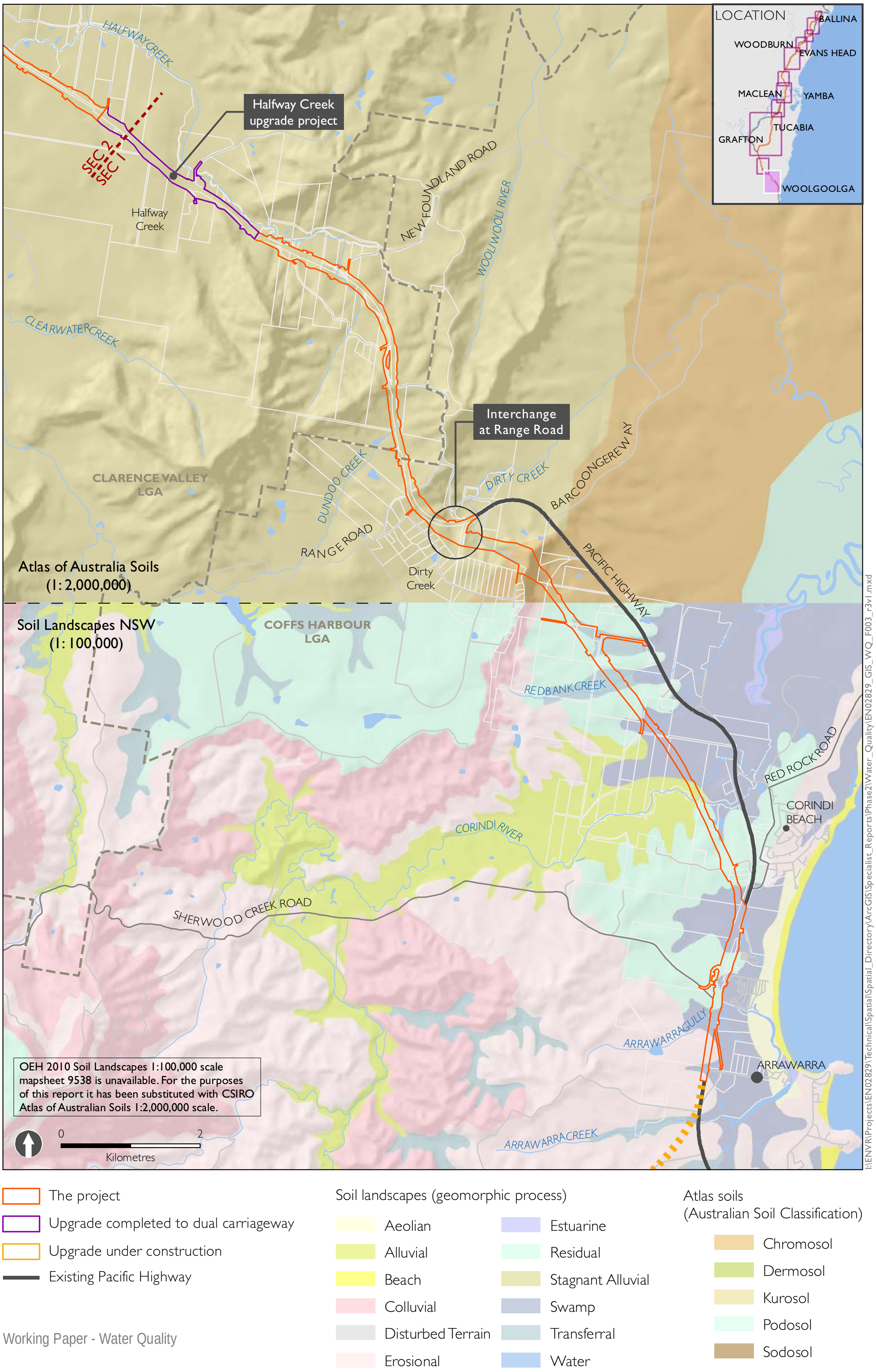
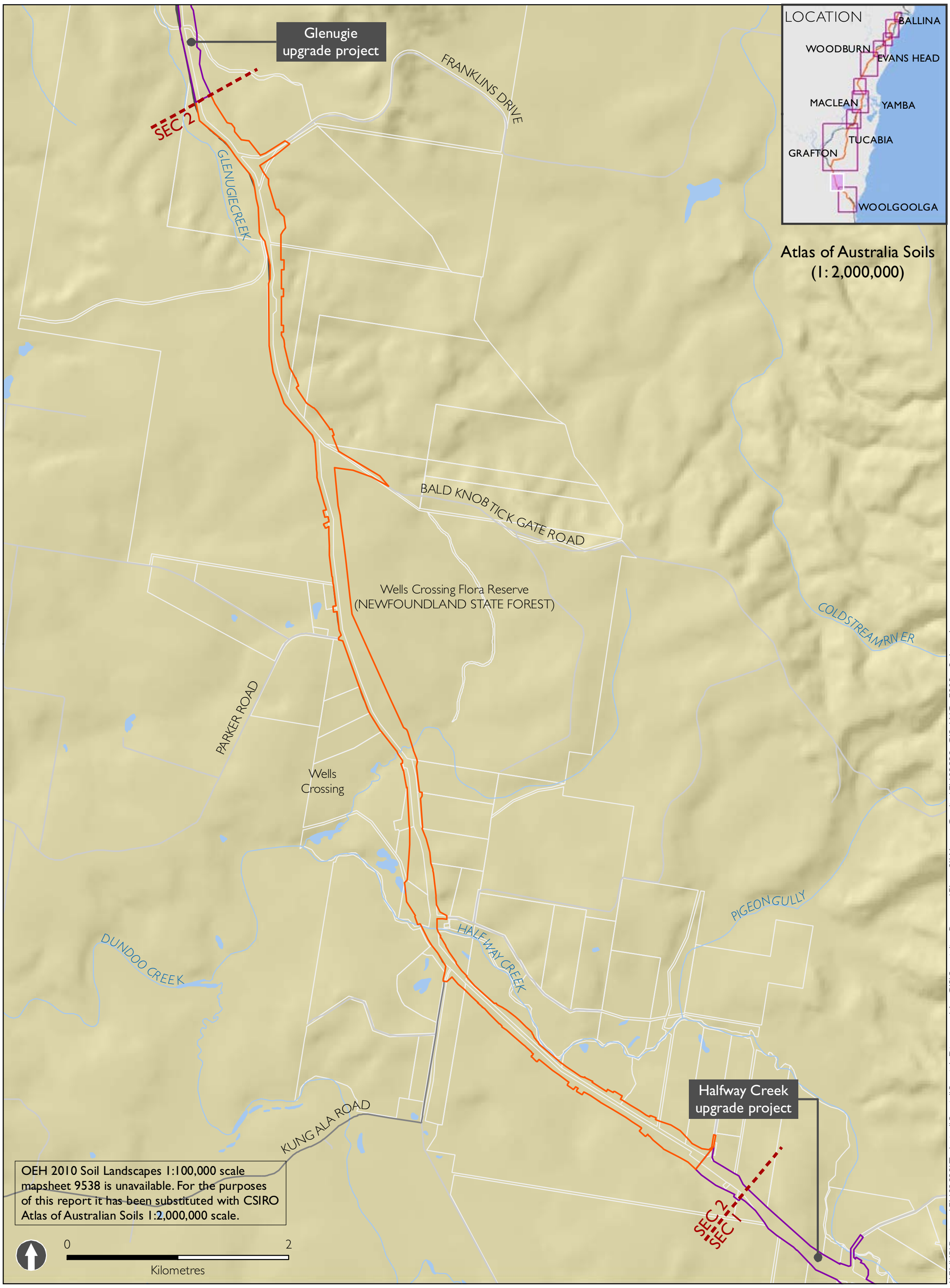


Figure F -2 Section 2 - Halfway Creek to Glenugie upgrade - Soil landscapes




The project

Upgrade completed to dual carriageway

Upgrade under construction

Existing Pacific Highway

Atlas soils
(Australian Soil Classification)

Chromosol

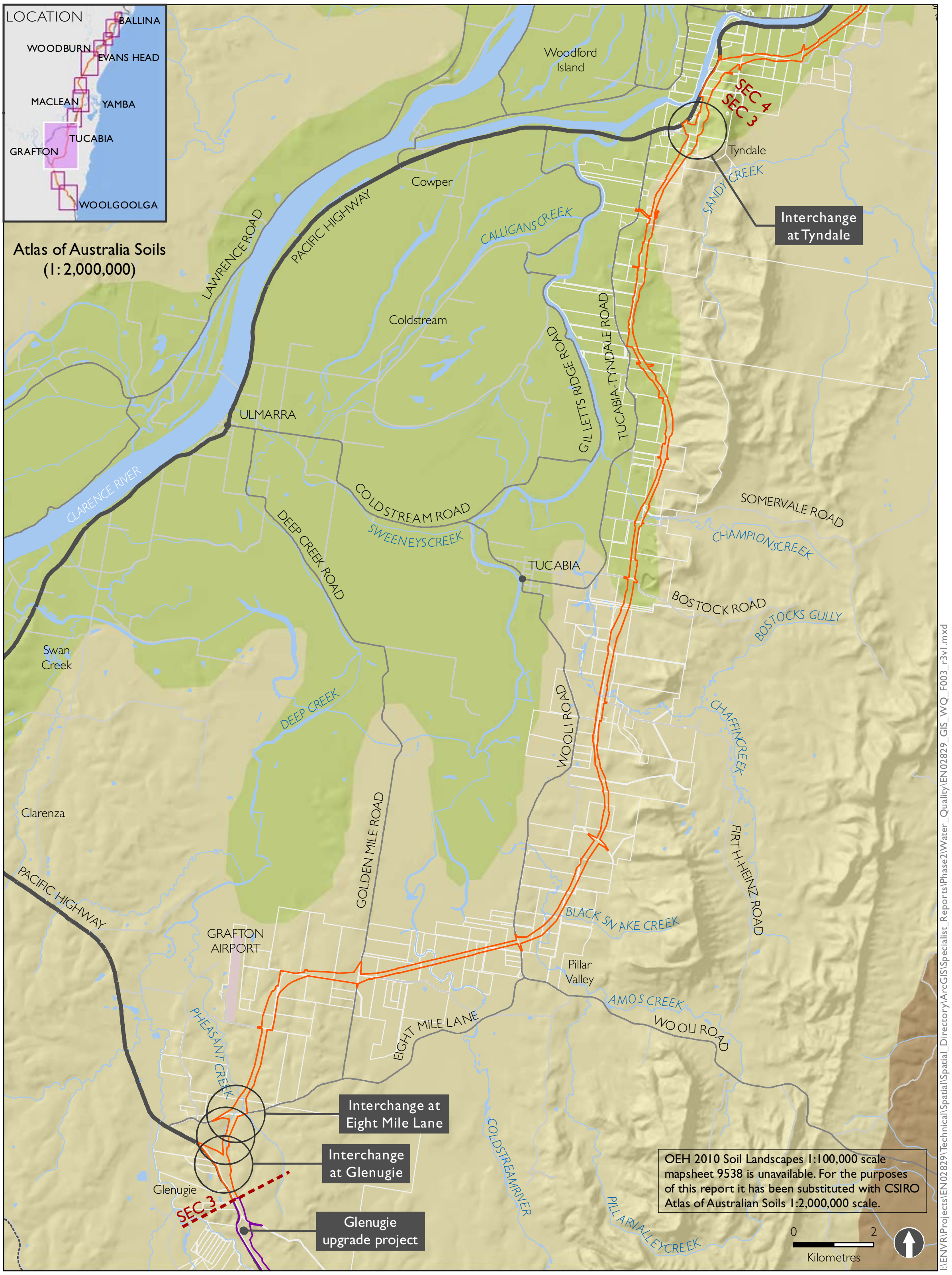
Dermosol

Kurosol

Podosol

Sodosol

Figure F -3 Section 3 - Glenugie upgrade to Tyndale - Soil landscapes




The project

Upgrade completed to dual carriageway

Upgrade under construction

Existing Pacific Highway

Atlas soils
(Australian Soil Classification)

Chromosol

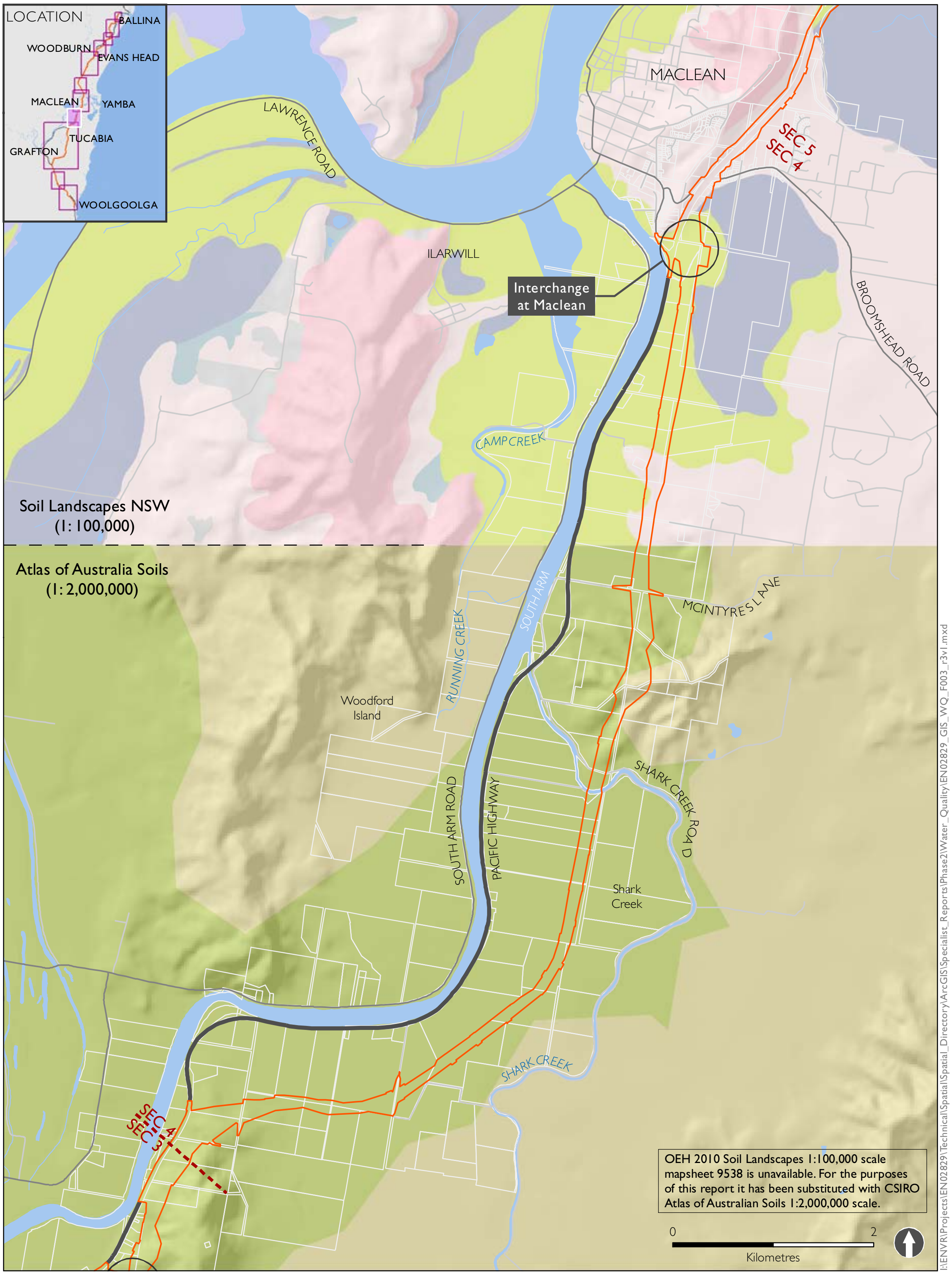
Dermosol

Kurosol

Podosol

Sodosol

Figure F -4 Section 4 - Tyndale to Maclean - Soil landscapes




The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway

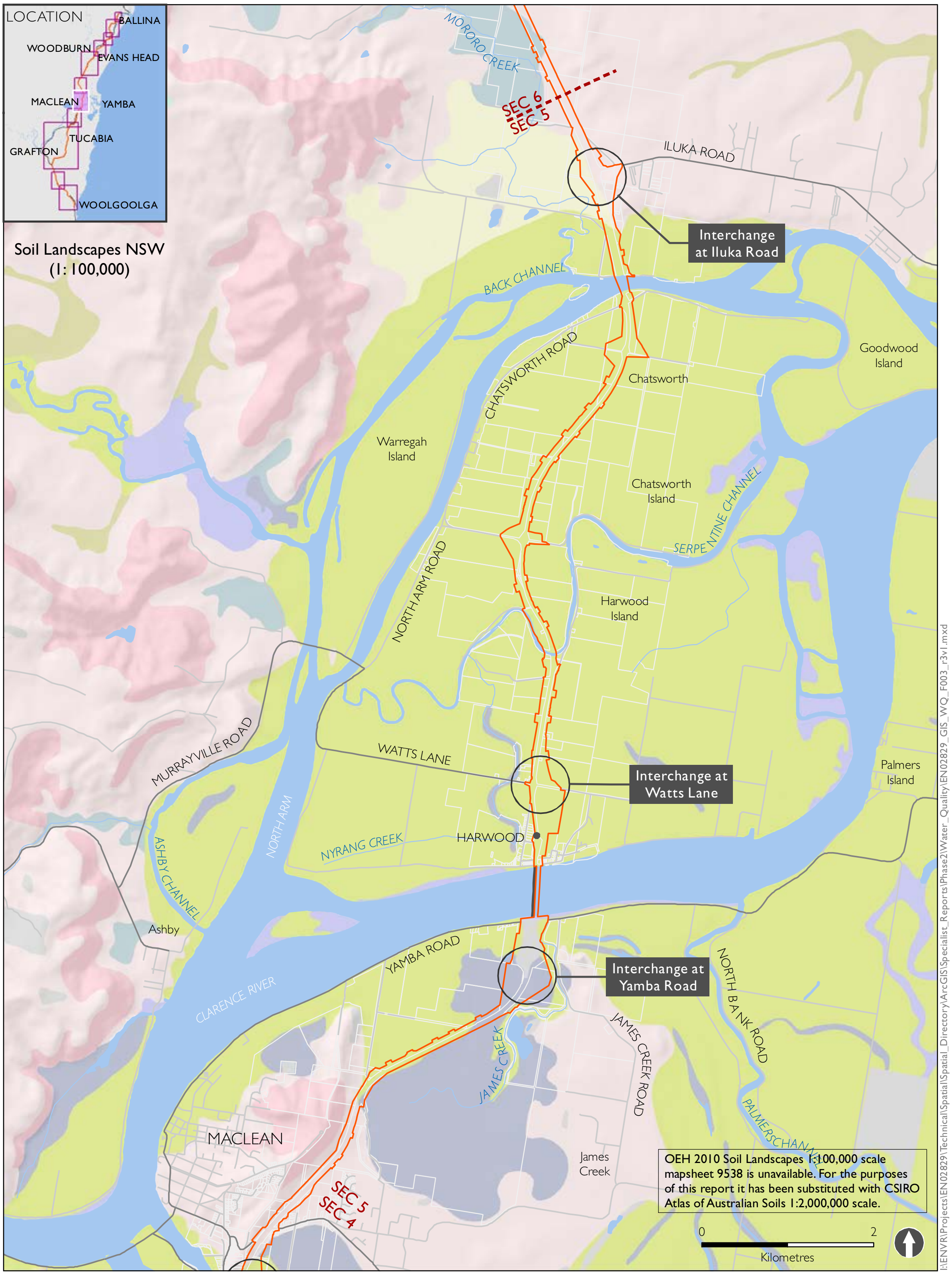
Soil landscapes (geomorphic process)

Aeolian
Alluvial
Beach
Colluvial
Disturbed Terrain
Erosional
Estuarine
Residual
Stagnant Alluvial
Swamp
Transferral
Water

Atlas soils
(Australian Soil Classification)

Chromosol
Dermosol
Kurosol
Podosol
Sodosol

Figure F -5 Section 5 - Maclean to Iluka Road - Soil landscapes




- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway

Soil landscapes (geomorphic process)

- Aeolian
- Alluvial
- Beach
- Colluvial
- Disturbed Terrain
- Erosional
- Estuarine
- Residual
- Stagnant Alluvial
- Swamp
- Transferral
- Water

Figure F -6 Section 6 - Iluka Road to Devils Pulpit upgrade - Soil landscapes

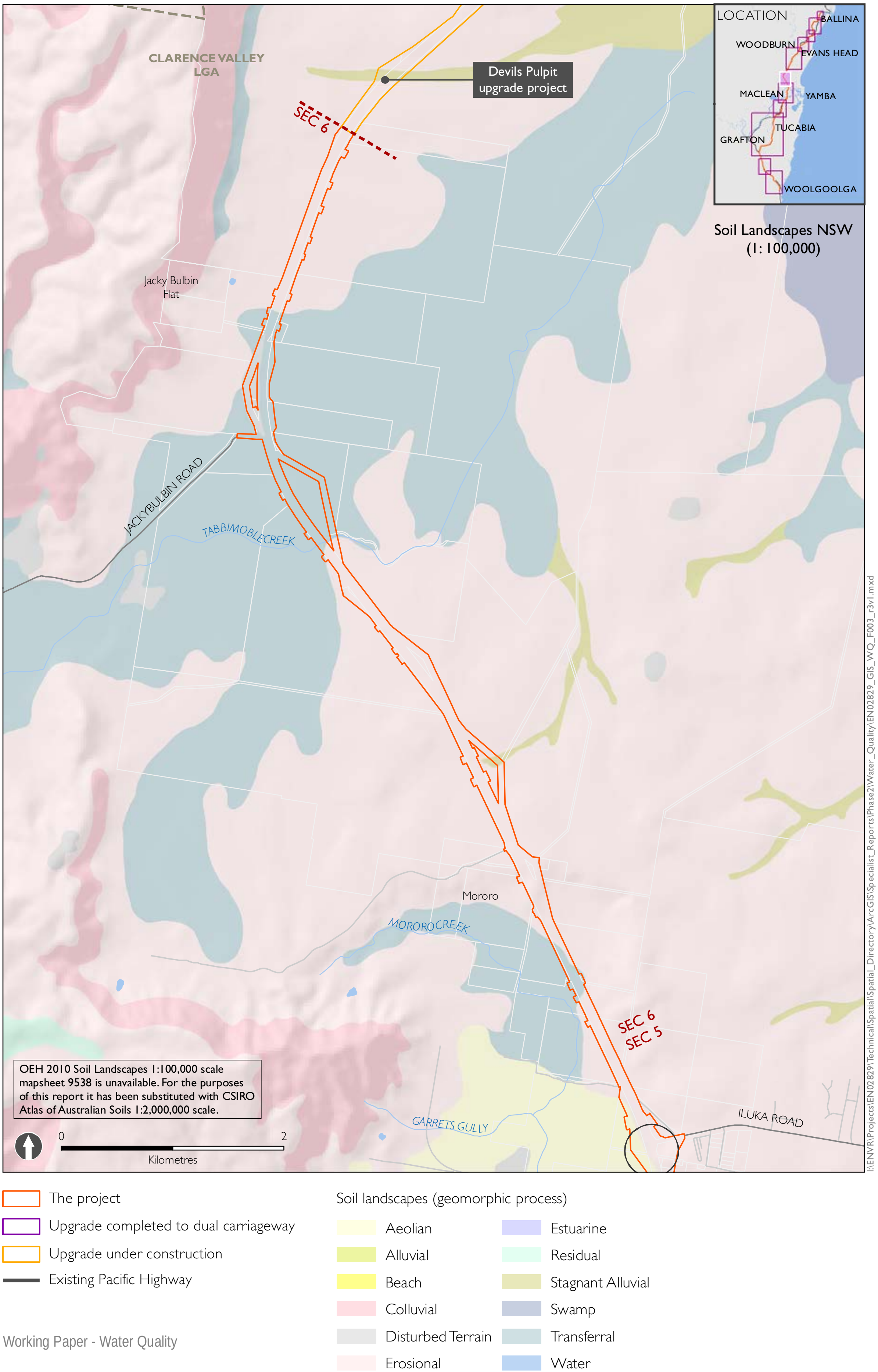
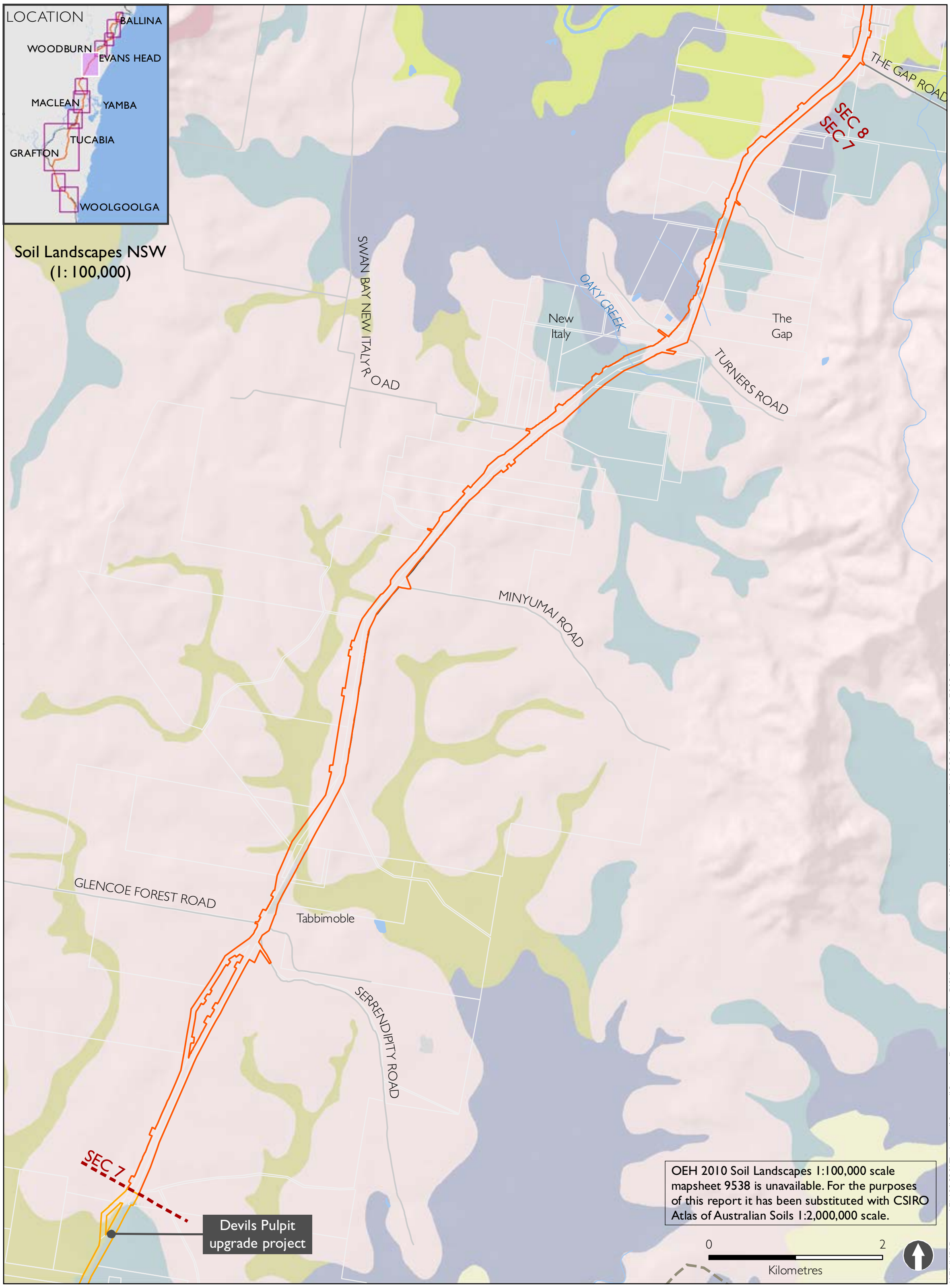


Figure F -7 Section 7 - Devils Pulpit upgrade to Trustums Hill - Soil landscapes

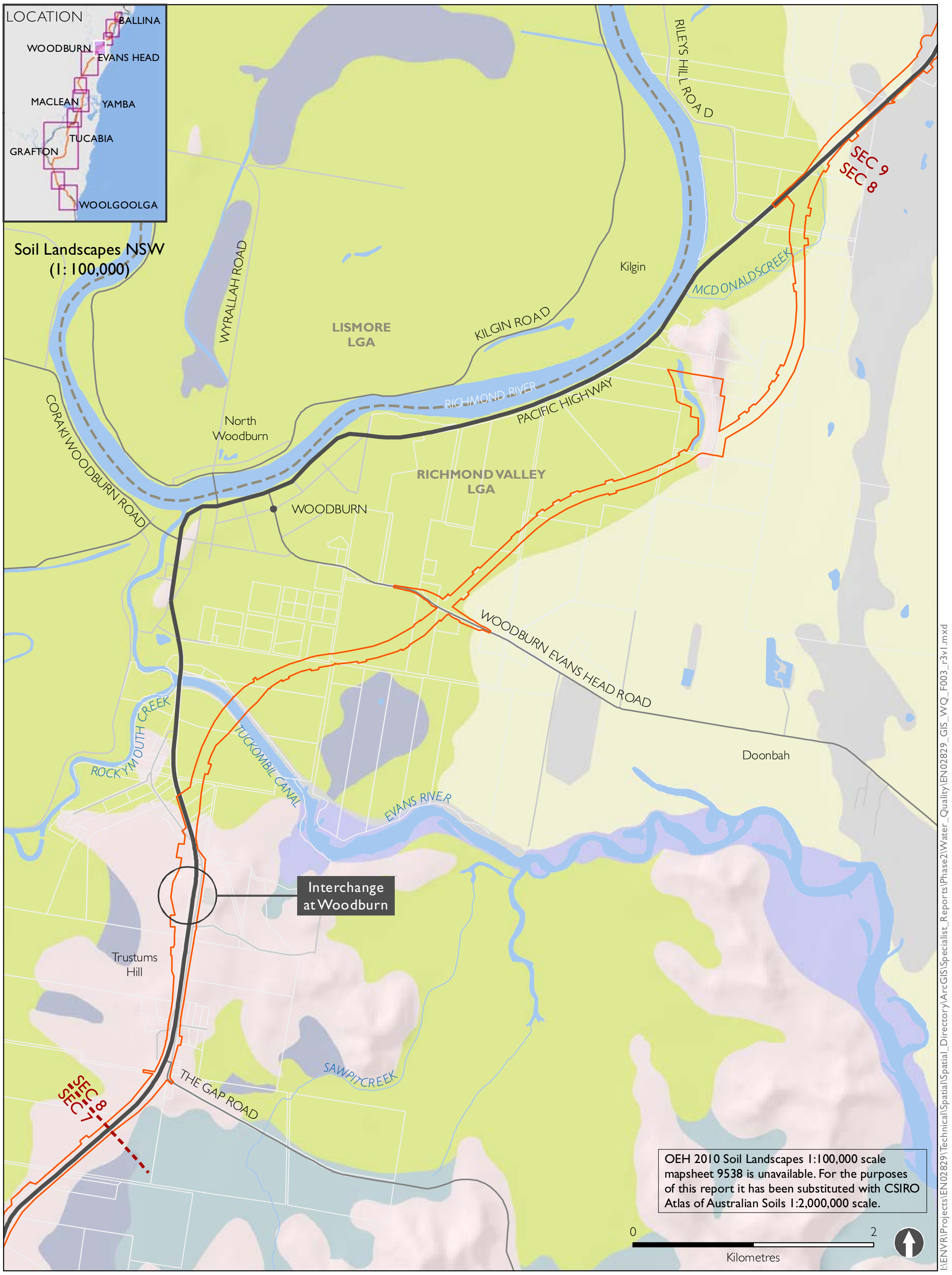



The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway

Soil landscapes (geomorphic process)

| | |
|---|---|
| Aeolian | Estuarine |
| Alluvial | Residual |
| Beach | Stagnant Alluvial |
| Colluvial | Swamp |
| Disturbed Terrain | Transferral |
| Erosional | Water |

Figure F -8 Section 8 - Trustums Hill to Broadwater National Park - Soil landscapes




The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway

Soil landscapes (geomorphic process)

Aeolian
Alluvial
Beach
Colluvial
Disturbed Terrain
Erosional
Estuarine
Residual
Stagnant Alluvial
Swamp
Transferral
Water

Figure F -9 Section 9 - Broadwater National Park to Richmond River - Soil landscapes


- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway

Soil landscapes (geomorphic process)

- Aeolian
- Alluvial
- Beach
- Colluvial
- Disturbed Terrain
- Erosional
- Estuarine
- Residual
- Stagnant Alluvial
- Swamp
- Transferral
- Water

Figure F -10 Section 10 - Richmond River to Coolgardie Road - Soil landscapes

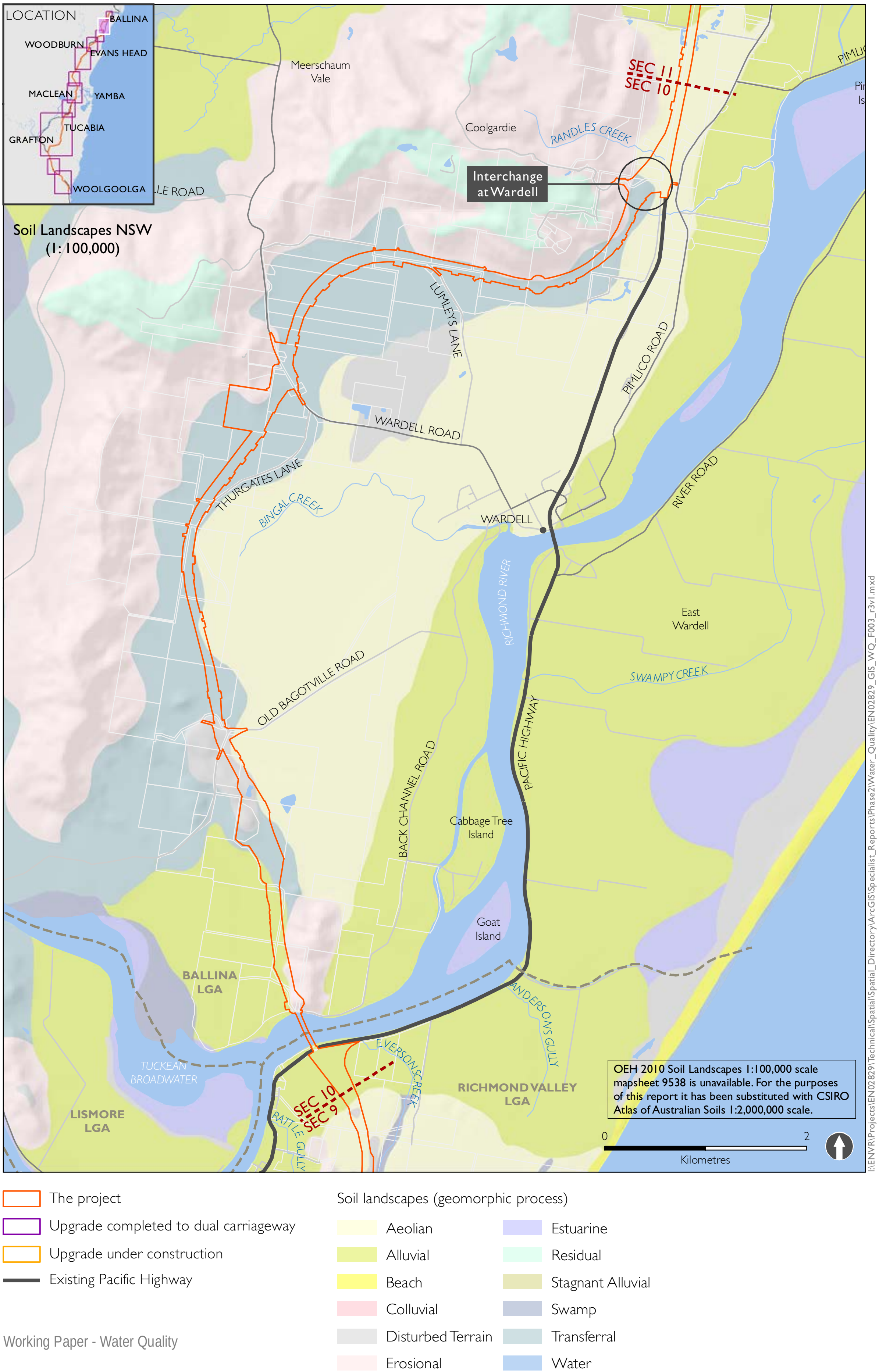
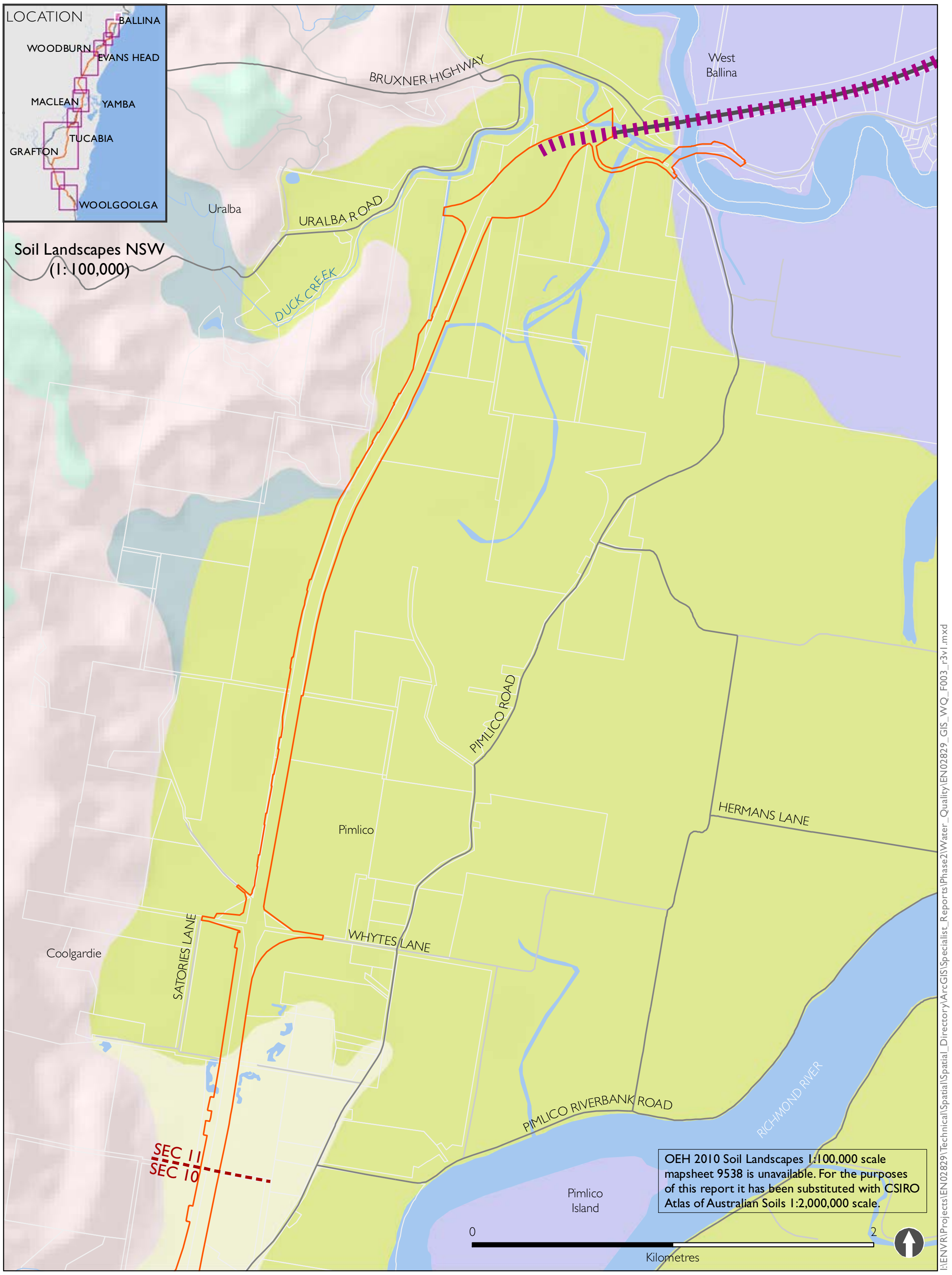


Figure F -11 Section 11 - Coolgardie Road to Ballina bypass - Soil landscapes




The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway

Soil landscapes (geomorphic process)

Aeolian
Alluvial
Beach
Colluvial
Disturbed Terrain
Erosional
Estuarine
Residual
Stagnant Alluvial
Swamp
Transferral
Water

# Appendix G Threatened fish locations

**Table G- 1 Known (x), recorded (R) and potential (P) habitats for threatened fish**

| Section | Waterways | National parks | Swamps | SEPP 14 wetland | Key fish habitat (DPI)[1] | Mapped OPP habitat (DPI)[1] | OPP[2] | Eastern freshwater cod[2] | Purple spotted gudgeon[2] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Arrawarra Creek (crosses existing highway outside of project boundary) | - | - | - | x | - | P | - | P |
| 1 | Arrawarra Gully | Solitary Islands Marine Park | - | SEPP 14 wetlands (No. 315) associated with Arrawarra Gully, however these do not occur in the study area. | x | - | P | - | P |
| 1 | Corindi River | - | - | - | x | - | P | - | P |
| 1 | Corindi River Floodplain | - | - | - | x | - | P | - | P |
| 1 | Blackadder Gully (near) | - | - | - | x | - | - | - | - |
| 1 | Cassons Creek | - | - | - | x | x | P | - | P |
| 1 | Redbank Creek | - | - | - | x | x | P | - | P |
| 1 | Ch 6650 (unnamed trib of Redbank Creek) | - | - | - | x | x | P | - | P |
| 1 | Dirty Creek | - | - | - | x | - | - | - | - |
| 1 | Dundoo Creek | - | - | - | x | - | - | - | - |
| 1 | Halfway Creek (Ch13350) | - | - | - | x | - | P | - | P |
| 1 | - | - | - | No. 314 Located about 60 m east of the project boundary near Corindi Beach. | x | - | - | - | - |
| 1 | Unnamed / unmapped waterbodies | - | - | - | - | - | - | - | - |
| 2 | Halfway Creek | - | - | - | x | - | P | - | P |
| 2 | Wells Crossing | - | - | - | x | - | - | - | P |
| 2 | Glenugie Creek (alongside alignment) | - | - | - | x | - | P | - | P |
| 2 | Unnamed / unmapped waterbodies | - | - | - | x | - | P | - | P |
| 3 | Pheasant Creek | - | Crows Nest Swamp. | - | x | - | - | - | - |
| 3 | Ch 39700 (Unnamed trib of Glenugie Creek) | - | - | - | x | - | - | - | - |
| 3 | Coldstream River | - | Upper Coldstream Wetland (Nationally Important) | SEPP Wetland 292. | x | - | P | P | - |
| 3 | Black Snake Creek | - | Upper Coldstream Wetland (Nationally Important) | SEPP Wetland 292. | x | - | P | - | - |
| 3 | Pillar Valley Creek | - | Upper Coldstream Wetland (as above) | Nationally Important and SEPP Wetland (as above) | x | - | P | P | - |
| 3 | Ch 48000 (unnamed trib of Pillar Valley creek) | - | - | - | x | - | - | - | - |
| 3 | Chaffin Creek | - | Chaffin Swamp | No 289 - Associated with Chaffin Creek and located about 450 m downstream of the project boundary. | x | - | - | P | - |
| 3 | Ch54600 (unnamed trib of Chaffin Creek) | - | - | - | x | - | - | - | - |
| 3 | Champions Creek | - | - | No. 287 - Located about 600 m downstream of the project boundary crossing of Champions Creek. | x | - | - | - | - |
| 3 | Unnamed / unmapped waterbodies | - | - | - | - | - | - | - | - |
| 4 | Project runs parallel to South Arm (Clarence River) | - | - | - | x | - | - | - | - |
| 4 | Edwards Creek (Ch 80200) | - | - | - | - | - | - | - | - |

| Section | Waterways | National parks | Swamps | SEPP 14 wetland | Key fish habitat | Mapped OPP habitat | OPP[2] | Eastern freshwater cod[2] | Purple spotted gudgeon[2] |
|---|---|---|---|---|---|---|---|---|---|
| 4 | Shark Creek | - | - | No. 232 Located on the eastern side of the upstream reaches of Shark Creek, upstream of the project. | x | - | - | - | - |
| 4 | Unnamed / unmapped waterbodies | - | - | - | - | -' | - | - | - |
| 5 | Alignment runs adjacent to James Creek | (Yaegl Nature Reserve) | - | No. 220a -Located to the south east of the corridor south of Harwood Bridge and associated with James Creek which flows through this wetland into a portion of Yaegl Nature Reserve. | x | - | - | - | - |
| 5 | Ch84400 (unnamed trib of James Creek) | - | Melaleuca swamp | - | x | - | - | - | - |
| 5 | Nyrang Creek (near alignment at 871000-88300) | - | - | - | x | - | - | - | - |
| 5 | Clarence River | - | - | Clarence River Estuary Nationally Important Wetland | x | - | - | P | P |
| 5 | Serpentine Channel | - | - | - | x | - | - | - | - |
| 5 | North Arm (Clarence River) | - | Bundjalung National Park Wetlands (Nationally Important) | No. 153c - Located around 400 m west of the project boundary crossing of North Arm of the Clarence River. | x | - | - | - | - |
| 5 | Mororo Creek (near at Ch 95100) | (Mororo Creek Nature Reserve) | - | - | x | - | - | - | - |
| 5 | Unnamed / unmapped waterbodies | - | - | - | x | - | - | - | - |
| 6 | Mororo Creek (near cH96700) | Near to Mororo Creek Nature reserve | - | - | x | - | P | - | - |
| 6 | Tabbimoble Creek | - | - | No. 153a - located on Tabbimoble Creek about one kilometre downstream and east of the project. | x | - | R Tabbimoble Floodway 2 Downstream of Tabbimoble 2 and 3 confluences | - | - |
| 6 | - | Bundjalung National Park | - | - | - | - | - | - | - |
| 6 | - | - | - | No. 153 is located about 4.5 kilometres to the east of the project, mostly within the Bundjalung National Park and Devils Pulpit State Forest, and extends between the North Arm of the Clarence River in the south and the Evans River in the north. | x | - | P | - | - |
| 6 | Unnamed / unmapped waterbodies | - | - | - | x | - | P | - | - |
| 7 | Tabbimoble floodway no. 1 | - | - | - | x | - | p | - | - |
| 7 | - | Tabbimoble Nature Reserve | - | No. 161 -Located about 260 m east of the project boundary in the Tabbimoble Swamp Nature Reserve | x | x | p | - | - |
| 7 | Ch 124500 (unnamed) | - | - | - | x | - | p | - | - |
| 7 | Nortons Gully | - | - | - | x | - | p | - | - |
| 7 | Oaky Creek | - | - | - | x | - | P | - | - |
| 7 | Ch 121700-122250 (unnamed) | - | - | - | x | - | p | - | - |
| 7 | Unnamed at Ch 114000 | - | - | - | x | - | R | - | - |
| 7 | Unnamed near the township of New Italy and the existing Pacific Highway | - | - | - | x | - | P | - | - |
| 7 | located south of the intersection with the existing Pacific High and Whites Road | - | - | - | x | - | P | - | - |

| Section | Waterways | National parks | Swamps | SEPP 14 wetland | Key fish habitat | Mapped OPP habitat | OPP[2] | Eastern freshwater cod[2] | Purple spotted gudgeon[2] |
|---|---|---|---|---|---|---|---|---|---|
| 7 | located south of the intersection with the existing Pacific High and Whites Road | - | - | - | x | - | P | - | - |
| 7 | south of the intersection with the existing Pacific High and Nortons Road | - | - | - | x | - | P | - | - |
| 7 | Unnamed / unmapped waterbodies | - | - | - | x | - | P | - | - |
| 8 | Tuckombil Canal (becomes Evans River) | - | - | No. 133 is located adjacent to the Evans River around 500 m east and downstream of the project. | x | - | p | - | - |
| 8 | Rocky Mouth Creek (upstream of Tuckombil Canal) | - | - | - | x | - | P | - | - |
| 8 | Unnamed watercourse at Ch134700 | - | - | - | x | x | R | - | - |
| 8 | Ch 136450 (unnamed tributary of Mcdonalds Creek) | - | - | - | x | - | P | - | - |
| 8 | Macdonalds Creek | - | - | - | x | x | R | - | - |
| 8 | - | Broadwater National Park | Numerous | - | x | x | R | - | - |
| 8 | Unnamed / unmapped waterbodies | - | - | - | - | - | - | - | - |
| 9 | Montis Gully | - | - | - | x | - | - | - | - |
| 9 | Ch 141850 (unnamed trib of Montis Gully) | - | - | - | x | x | - | - | - |
| 9 | Eversons Creek | - | - | - | x | - | - | - | - |
| 9 | - | Broadwater National Park | Numerous | No. 121 within the National Park. | x | x | R | - | - |
| | | | | No. 119a within the Richmond River, to the west of the alignment | x | - | - | P | - |
| 9 | Unnamed / unmapped waterbodies | - | - | - | x | - | P | - | - |
| 10 | Tuckean Swamp (upstream of Richmond River) | Wardell Heathland | - | - | x | - | P | - | - |
| 10 | Tuckean Broadwater (upstream of Richmond River) | - | Paperbark and Wallum Heath Swamps | No. 119 - Located at Tuckean Broadwater, (700 metres upstream from the proposed crossing at Richmond River) | x | - | P | - | - |
| 10 | Richmond River | - | - | No.118 and 118a are located on the northern banks of the Richmond River, along either side of the project | x | - | - | P | - |
| 10 | Ch 149250 (unnamed tributary of Bingal Creek) | - | - | - | x | - | - | - | - |
| 10 | Ch 150600 (unnamed tributary of Bingal Creek) | - | - | - | x | - | - | - | - |
| 10 | Ch 153900 (unnamed tributary of Bingal Creek) | - | - | - | x | - | - | - | - |
| 10 | Saltwater Creek | - | - | - | - | - | - | - | - |
| 10 | Randals Creek | - | - | - | - | - | - | - | - |
| 10 | Unnamed / unmapped waterbodies | - | - | - | - | - | - | - | - |
| 11 | Duck Creek | - | - | No. 108 | x | - | - | - | - |
| 11 | Emigrant Creek | - | - | No. 95 | x | - | - | - | - |
| 11 | Ch 163000 (unnamed) (irrigation channel?) | - | - | - | - | - | - | - | - |
| 11 | Unnamed / unmapped waterbodies | - | - | - | - | - | - | - | - |

[1] As mapped by DPI
[2] Threatened species with a moderate to high likelihood of occurrence (from Biodiversity Working Paper)