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The Northern Road Upgrade Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park

NSW Environmental Impact Statement /
Commonwealth Draft Environmental Impact Statement

Appendix L – Technical working paper: Soils, water and contamination

June 2017

The Northern Road Upgrade –

Mersey Road to Glenmore Parkway

Prepared for Roads and Maritime Services by Jacobs Australia

Soils, Water and Contamination Assessment

Final

15 May 2017

The Northern Road Upgrade (Mersey Road to Glenmore Parkway)

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Appendix A – Stage 1 Contamination Assessment

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1. Introduction

Roads and Maritime Services (Roads and Maritime) is seeking approval to upgrade about 16 km of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park (the project).

The upgrade of The Northern Road is part of the Western Sydney Infrastructure Plan (WSIP). The WSIP involves major road and transport linkages that will capitalise on the economic gains from developing the Western Sydney Airport site at Badgerys Creek whilst boosting the local economy and liveability of western Sydney.

Jacobs Group (Australia) Pty Ltd (Jacobs) was commissioned by Roads and Maritime to undertake an assessment of the potential environmental impacts of the project, and prepare an Environmental Impact Statement (EIS) in accordance with the *Environmental Planning and Assessment Act 1979* (EP&A Act) that adequately addresses the Secretary's Environmental Assessment Requirements (SEARS) and in accordance with the Commonwealth *Environmental Protection Biodiversity Conservation Act 1999* (EPBC Act) that adequately addresses the Commonwealth EIS Guidelines.

1.1 Description of the project

Roads and Maritime is seeking approval to upgrade 16km of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park (the project). The project generally comprises the following key features:

- A six-lane divided road between Mersey Road, Bringelly and Bradley Street, Glenmore Park (two general traffic lanes and a kerbside bus lane in each direction). The wide central median would allow for an additional travel lane in each direction in the future, if required
- An eight-lane divided road between Bradley Street, Glenmore Park and about 100 m south of Glenmore Parkway, Glenmore Park (three general traffic lanes and a kerbside bus lane in each direction separated by a median)
- About eight kilometres of new road between Mersey Road, Bringelly and just south of the existing Elizabeth Drive, Luddenham, to realign the section of The Northern Road that currently bisects the Western Sydney Airport site and to bypasses Luddenham
- About eight kilometres of upgraded and widened road between the existing Elizabeth Drive, Luddenham and about 100 m south of Glenmore Parkway, Glenmore Park
- Closure of the existing The Northern Road through the Western Sydney Airport site
- Tie-in works with the following projects:
  - The Northern Road Upgrade, between Peter Brock Drive, Oran Park and Mersey Road, Bringelly (to the south)
  - The Northern Road Upgrade, between Glenmore Parkway, Glenmore Park and Jamison Road, South Penrith (to the north)
- New intersections including:
  - A traffic light intersection connecting the existing The Northern Road at the southern boundary of the Western Sydney Airport, incorporating a dedicated u-turn facility on the western side
  - A traffic light intersection for service vehicles accessing the Western Sydney Airport, incorporating 160 m of new road connecting to the planned airport boundary
  - A traffic light intersection connecting the realigned The Northern Road with the existing The Northern Road (west of the new alignment) south of Luddenham
  - A 'give way' controlled intersection (that is, no traffic lights) connecting the realigned The Northern Road with Eaton Road (east of the new alignment, left in, left out only)
  - A four-way traffic light intersection formed from the realigned Elizabeth Drive, the realigned The Northern Road and the existing The Northern Road, north of Luddenham

- A traffic light intersection at the Defence Establishment Orchard Hills entrance, incorporating a u-turn facility

- New traffic lights at four existing intersections:
  - Littlefields Road, Luddenham
  - Kings Hill Road, Mulgoa
  - Chain-O-Ponds Road, Mulgoa
  - Bradley Street, Glenmore Park incorporating a u-turn facility
- Modified intersection arrangements at:
  - Dwyer Road, Bringelly (left in, left out only)
  - Existing Elizabeth Drive, Luddenham (left out only)
  - Gates Road, Luddenham (left in only)
  - Longview Road, Luddenham (left in, left out only)
  - Grover Crescent south, Mulgoa (left in only)
  - Grover Crescent north, Mulgoa (left out only)
- Dedicated u-turn facilities at:
  - The existing The Northern Road at Luddenham, south-west of Elizabeth Drive
  - The existing Elizabeth Drive, Luddenham around 800 m east of The Northern Road
  - Chain-O-Ponds Road, Mulgoa
- Twin bridges over Adams Road, Luddenham
- Local road changes and upgrades, including:
  - Closure of Vicar Park Lane, east of the realigned The Northern Road, Luddenham
  - Eaton Road cul-de-sac, west of the realigned The Northern Road, Luddenham
  - Eaton Road cul-de-sac, east of the realigned The Northern Road, Luddenham
  - Elizabeth Drive cul-de-sac, about 300 m east of The Northern Road with a connection to the realigned Elizabeth Drive, Luddenham
  - Extension of Littlefields Road, east of The Northern Road, Mulgoa
  - A new roundabout on the Littlefields Road extension, Mulgoa
  - A new service road between the Littlefields Road roundabout and Gates Road, including a ‘give way’ controlled intersection (that is, no traffic lights) at Gates Road, Luddenham
  - Extension of Vineyard Road, Mulgoa between Longview Road and Kings Hill Road
  - A new roundabout on the Vineyard Road extension at Kings Hill Road, Mulgoa
- A new shared path on the western side of The Northern Road and footpaths on the eastern side of The Northern Road
- A new shared path on the western side of The Northern Road and footpaths on the eastern side of The Northern Road where required
- The upgrading of drainage infrastructure
- Operational ancillary facilities including:
  - Heavy vehicle inspection bays for both northbound and southbound traffic, adjacent to Grover Crescent, Mulgoa and Longview Road, Mulgoa respectively
  - An incident response facility on the south-western corner of the proposed four-way traffic light intersection at Elizabeth Drive, Luddenham

- New traffic management facilities including variable message signs (VMS)
- Roadside furniture and street lighting
- The relocation of utilities and services
- Changes to property access along The Northern Road (generally left in, left out only)
- Establishment and use of temporary ancillary facilities and access tracks during construction
- Property adjustments as required
- Clearance of undetonated explosive ordinance (UXO) within the Defence Establishment Orchard Hills as required.

The project assessed in this EIS does not include surveys, test drilling, test excavations, geotechnical investigations or other tests, surveys, sampling or investigation for the purposes of the design or assessment of the project.

1.2 Location and context

The Northern Road is about 45 km west of the Sydney central business district and traverses the local government areas of Penrith in the north and Liverpool in the south.

The Northern Road is a key north–south road between Narellan and Richmond, connecting the North West and South West Priority Growth Areas (see Figure 1-1). The corridor intersects with a number of regional motorway, arterial and collector roads such as (north to south) Richmond Road, Great Western Highway, M4 Motorway, Elizabeth Drive, Bringelly Road, and Camden Valley Way.

South of Glenmore Parkway (the southern extent of The Northern Road Upgrade, Glenmore Parkway to Jamison Road), the project area is surrounded by rural residential zoned land as well as pastures and grasslands. Land to the east of The Northern Road in this section is occupied by the Commonwealth Defence Establishment Orchard Hills. Further south, The Northern Road passes through the village of Luddenham (including a small number of residential and commercial properties), before continuing through agricultural grasslands to its junction with Mersey Road (the northern extent of The Northern Road Upgrade, Peter Brock Drive to Mersey Road).

A seven kilometre section of the existing The Northern Road alignment bisects the Western Sydney Airport site south-east of the Luddenham town centre.

The regional context of The Northern Road Upgrade is provided on Figure 1-1.

1.3 Scope and purpose of this report

This report presents the results of a soils, surface water, groundwater and contamination assessment for the project. The purpose of this report is to assess the existing conditions, assess the impacts of the project and recommend any mitigation measures required to address these impacts. The outcomes of this report would be used to inform the EIS.

The area assessed as part of this report includes the proposed construction and operational footprint of the project as outlined in the EIS. The scope of this report includes:

- An outline of the existing soil, surface water, groundwater and contamination conditions in the assessed project area
- Identifying water quality objectives and criteria for the assessment of potential water quality impacts
- Development of a conceptual groundwater model
- Assessing the potential impacts of the project on the existing environment during both construction and operation
- Identifying environmental management measures required to address these impacts.

1.4 NSW and Commonwealth Assessment Requirements

Table 1-1 lists the Secretary's Environmental Assessment Requirements (SEARs) of relevance to this Soils, water and contamination report and where in the report they are addressed.

Table 1-1 SEARs – Soils, water and contamination

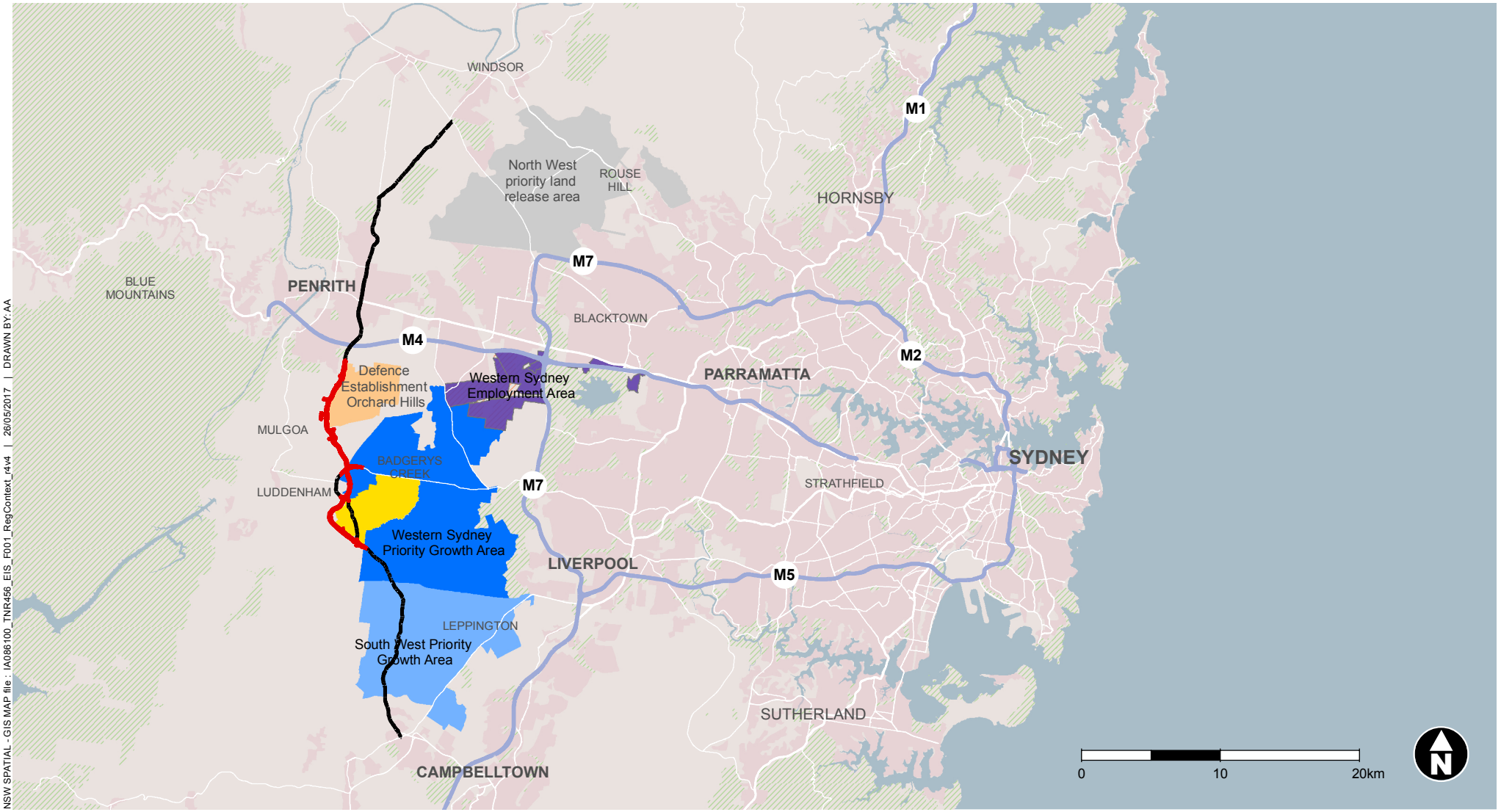
Secretary's requirement	Where addressed in Document
The EIS must address the following specific matters: impacts on watercourses, surface water flows (including stormwater drainage systems), quality, quantity, availability and users (commercial and recreational), with particular reference to any likely impacts on surrounding water bodies and their catchments, wetlands and their habitats, including how these are to be monitored;	Potential construction phase impacts on surface water are provided in Section 5.3. Operational impacts are described in Section 6.3. Surface water flows are addressed in Hydrology and Flooding Working Paper (**Appendix K** of the EIS). Habitat impacts are addressed in the Biodiversity Assessment Working Paper (**Appendix I** of the EIS).
An assessment of construction water quality impacts, taking into account impacts from both accidents and runoff (i.e. acute and chronic impacts), having consideration to impacts to surface water runoff, soil erosion and sediment transport, mass movement, and spoil and waste management. The assessment of water quality impacts is to have reference to relevant public health and environmental water quality criteria, including those specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000), any applicable regional, local or site-specific guidelines, water quality objectives, and any licensing requirement.	Consideration of construction water quality impacts is described in Section 5.3 including acute and chronic impacts. The water quality guidelines and objectives applied in the assessment of surface water quality are presented in Section 3.3 and Table 3-1.
assessment of waterways to be modified as a result of the project, including ecological, hydrological and geomorphic impacts (as relevant), including temporary crossings, and measures to rehabilitate the waterways to preconstruction conditions or better, including fish passage requirements consistent with Policy and Guidelines for Fish Friendly Waterway Crossings (DPI 2004);	Identification of Key fish Habitat is provided in Section 3.3.3 and discussion of temporary waterway crossings is presented in Section 5.3. Relevant safeguards and mitigations are outlined in Section 7. Further detail is presented in the Hydrology and Flooding Working Paper (**Appendix K** of the EIS) and the Biodiversity Assessment Working Paper (**Appendix I** of the EIS).
groundwater impacts taking into consideration impacts associated with geotechnical ground treatments, dewatering, deep cuttings and fill locations, and cumulative impacts on regional hydrology. The assessment shall consider, where relevant, the extent of drawdown, impacts to groundwater characteristics, quality, quantity, and connectivity, groundwater flow direction and levels, discharge and recharge rates, and implications for water courses, groundwater users, groundwater dependent ecosystems, riparian areas and wetlands. The assessment should be prepared having consideration to the NSW Aquifer Interference Policy;	Construction and operational groundwater impacts are discussed in Section 5.4 and Section 6.4 respectively. The methodology around the assessment of groundwater impacts, including consideration of the NSW Aquifer Interference Policy, is presented in Section 3.2.

Secretary's requirement	Where addressed in Document
measures to manage, monitor and/or mitigate impacts;	Proposed measures to manage, monitor and/or mitigate impacts are outlined in Section 7 and summarised in Section 8.
Identify potential impacts of the development on acid sulfate soils in accordance with the relevant guidelines and a description of the mitigation measures proposed to minimise potential impacts.	The likelihood of encountering acid sulfate soils is described in Section 4.4 with a low probability of occurrence identified; therefore impacts and mitigation measures are not further assessed in this report.
Provide a contaminated land assessment in accordance with relevant guidelines.	A Stage 1 Contamination Assessment has been undertaken for the project as provided in **Appendix A** of this report. A summary of the findings is described in Section 4.6. Potential impacts during construction and operation of the project are discussed in Section 5.2 and Section 6.2 respectively. The management of potential contamination impacts is detailed in Section 8.

Table 1-2 lists the requirements under the Commonwealth EIS Guidelines for the project of relevance to this Soils, water and contamination report and where in the report they are addressed.

Table 1-2 Commonwealth EIS Guidelines – Soils, water and contamination

Commonwealth EIS Guidelines (Commonwealth EPBC Act)	Where addressed in Document
The EIS must include a description of the environment of the proposal site and the surrounding areas that may be affected by the action. It is recommended that this include the following information: A description of the environment in all areas of potential impact, including all components of the environment as defined in Section 528 of the EPBC Act: Landscapes and soils Natural and physical resources, including water resources.	Discussion of the existing environment, including landscapes and soils and water resources is included in Section 4 of this report.
Impacts to the environment (as defined in section 528) should include but not be limited to the following: Changes to water quality on site and downstream of the site Changes to siltation Changes in recreational use and amenity of natural areas.	Potential construction and operational impacts are discussed in Section 5 and Section 6 respectively.



Legend

- The Northern Road upgrade - Mersey Road to Glenmore Parkway
- The Northern Road
- Western Sydney Airport site (Commonwealth Land)
- Defence Establishment Orchard Hills
- Western Sydney Employment Area
- South West Priority Growth Area
- Western Sydney Priority Growth Area
- Reserves and parklands
- Growth centres
- Built areas

Figure 1-1 | Location of the project

2. Legislation and policy framework

The following section provides consideration of the legislative and policy framework for the water quality and contamination assessment work.

2.1 Surface Water

2.1.1 NSW Legislation

***Protection of the Environment Operations Act 1997* (POEO Act)**

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the NSW Office of Environment and Heritage (OEH). The POEO Act regulates air and water pollution, noise control and waste management. The provision of environmental protection licences are a core strategy under the POEO Act. In accordance with section 115ZH of the EP&A Act, such a licence cannot be refused for an approved project and is to be substantially consistent with the Part 5.1 approval. An environmental protection licence would be required for the project.

Protection of the Environment Administration Act 1991

The *Protection of the Environment Administration Act 1991* aims to protect, restore and enhance the quality of the environment and to reduce risks to human health. As such any discharges into water of substances likely to cause harm to the environment must be reduced to harmless levels.

***Water Management Act 2000* and Water Management (General) Regulation 2011**

The Water Management Act 2000 together with the Water Management (General) Regulation 2011 are intended to ensure that NSW water resources are conserved and properly managed for sustainable use benefitting both present and future generations. However a number of approvals are not required for the project as it is being assessed and approved under Part 5.1 of the EP&A Act (refer to section 115ZG of the EP&A Act). This includes various approvals under the Water Management Act 2000, including water use approvals under section 89, water management work approvals under section 90, and activity approvals (other than aquifer interference approvals) under section 91.

2.1.2 Policy and Guidelines

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000)

The Australian and New Zealand Environment Conservation Council water quality guidelines (2000) provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters. They form part of the National Water Quality Management Strategy and list a range of environmental values assigned to that waterbody. The ANZECC/ARMCANZ (2000) *National Water Quality Guidelines for Fresh and Marine Water Quality* have been applied to understand the current health of the waterways in the study area and the ability to support nominated environmental values, particularly the protection of aquatic ecosystems. The Guidelines provide recommended trigger values which have been applied to understand the existing water quality and key indicators of concern.

***The Healthy Rivers Commission – Hawkesbury Nepean River* (HRC 1998)**

The Healthy Rivers Commission was established in 1995 (under section 23 of the *Pollution Control Act 1970*) by the NSW Government to make recommendations on:

- Suitable objectives for water quality, flows and other goals central to achieving ecologically sustainable development in a realistic time frame
- The known or likely views of stakeholder groups on the recommended objectives
- The economic and environmental consequences of the recommended objectives
- Strategies, instruments and changes in management practices needed to implement the recommended objectives (DECCW 2006).

Managing Urban Stormwater – Soils and Construction

The Managing Urban Stormwater – Soils and Construction series of handbooks are an element of the NSW Government's urban stormwater program specifically applicable to the construction phase of developments. These are aimed at providing guidance for erosion and sediment controls during construction in a manner that protects the health, ecology and amenity of urban waterways through better management of stormwater quality.

The Managing Urban Stormwater handbooks were produced to provide guidelines, principles, and recommended minimum design standards for managing erosion and sediment control during the construction of main roads. The construction of main roads and highways frequently involves extensive earthworks, with significant potential for erosion and consequently sedimentation of waterways. Of particular relevance to the project are Volume 1, 4th Edition (Landcom, 2004) (commonly known as The Blue Book 1) and Volume 2D, Main Road Construction (DECC, 2008) (commonly known as The Blue Book 2).

2.1.3 Construction phase mitigation guidelines

The following design guidelines and management procedures are relevant in determining the appropriate water quality management and mitigation measures to be implemented during the construction phase of the project:

- NSW DECC (2008), *Managing Urban Stormwater-Volume 2D Main Road Construction*, NSW Department of Environment, Climate Change and Water (known as the Blue Book Volume 2): Sydney
- Landcom (2004), *Managing Urban Stormwater- Soils and Construction, Volume 1, 4th Edition* (known as the Blue Book Volume 1): Sydney
- RTA (2003b), *Road Design Guideline: Section 8 Erosion and Sediment, Roads and Traffic Authority of NSW*: Sydney
- RTA (2003d*), Guideline for Construction Water Quality Monitoring*, Roads and Traffic Authority of NSW: Sydney
- RTA (2009), *Erosion and Sediment Management Procedure*, Oct 2009, Roads and Traffic Authority of NSW: Sydney
- RTA (1999), *Code of Practice for Water Management - Road Development and Management*, Roads and Traffic Authority of NSW: Sydney
- Roads and Maritime (2012), *Environmental Direction: Management of Tannins from Vegetation Mulch*, Roads and Maritime Services: Sydney
- RTA (2005), *Guidelines for the Management of Acid Sulphate Materials: Acid Sulphate Soils, Acid Sulphate Rock and Monosulfidic Black Ooze*, Roads and Traffic Authority of NSW: Sydney
- RTA (2001), *Stockpile Site Management Procedures*, Roads and Traffic Authority of NSW: Sydney
- Roads and Maritime (2011), *Technical Guideline: Temporary Stormwater Drainage for Road Construction*, Roads and Maritime Services: Sydney
- Roads and Maritime, (2011), *Technical Guideline – Environmental Management of Construction Site Dewatering*, Roads and Maritime Services: Sydney.

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

2.1.4 Operational phase mitigation guidelines

The following design guidelines and management procedures are relevant in determining the appropriate water quality management and mitigation measures to be implemented during the operational phase of the project:

- RTA (2003a), Procedures for Selecting Treatment Strategies to Control Road Runoff, Roads and Traffic Authority of NSW: Sydney
- RTA (1999), RTA Code of Practice for Water Management, Roads and Traffic Authority of NSW: Sydney

- EPA (1997), Managing Urban Stormwater: Council Handbook, NSW Environmental Protection Authority: Sydney
- Austroads (2001), Road Runoff and Drainage: Environmental Impacts and Management Options, Austroads AP-R180
- Austroads (2003), Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure, Austroads AP-R232
- Austroads (2010), Guide to Road Design, Part 5: Drainage Design, Austroads: Sydney
- DECCW (2007), Managing Urban Stormwater, Environmental Targets Consultation Draft, NSW Department of Environment, Climate Change and Water: Sydney
- VicRoads (2011), Integrated Water Management Guidelines, VicRoads: Melbourne
- Fairfull & Witheridge (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings,
- DPI (2004) Policy and Guidelines for Fish Friendly Waterway Crossings, NSW.

The objective of these documents is to provide guidance on water management practices, water quality and quantity, and water conservation issues related to the design, operation and maintenance of the roads and traffic system. This is in order to protect waterways and water quality where practicable and feasible. They provide guidance on the process of designing permanent water quality treatment in a consistent and practicable manner. The design for the proposed upgrade would address the sensitivity of receiving waters and local environment along the preferred route corridor. Operational water quality controls would be provided upstream of any sensitive receiving waters.

2.2 Groundwater

2.2.1 Statutory requirements

The following federal and NSW legislation and statutory requirements apply to the groundwater assessment work:

- *Australian Groundwater Modelling Guidelines*
- *Water Management Act 2000*
- *Water Management Regulation 2011*
- *NSW Guidelines for Controlled Activities on Waterfront Land (NOW, 2012)*
- *NSW Aquifer Interference Policy (NOW, 2012)*
- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012)*
- *NSW State Rivers and Estuary Policy (1993)*
- *NSW State Groundwater Policy Framework Document (1997)*
- *NSW State Groundwater Quality Protection Policy (1998)*
- *NSW State Groundwater Dependent Ecosystems Policy (2002)*
- *NSW Water Extraction Monitoring Policy (2007)*
- *NSW Wetlands Management Policy (2010)*
- *NSW Water Sharing Plans.*

Further details as to how the above legislation is relevant to the construction and operational phase mitigation guidelines that were considered are outlined in **Section 2.2.2** to **Section 2.2.15**.

2.2.2 Australian Groundwater Modelling Guidelines

The purpose of the Australian groundwater modelling guidelines is to promote a consistent and sound approach to the development of groundwater flow and solute transport models in Australia.

2.2.3 NSW Water Management Act 2000

The NSW Department of Primary Industries (DPI Water) administers the NSW Water Management Act 2000 (WM Act). The intent of the WM Act is to ensure water resources are properly managed and conserved for sustainable use benefitting present and future generations. The WM Act is intended to provide a formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions. The intent and objective of the WM Act have been considered as part of this assessment.

2.2.4 Water Management (General) Regulation 2011

The Water Management (General) Regulation 2011 provides various exemptions for volumetric licencing and activity approvals. The legislation also provides detail on requirements for dealings and applications.

2.2.5 NSW Guidelines for Controlled Activities on Waterfront Land (NOW, 2012)

Controlled activities carried out in, on or under waterfront land are regulated by the Water Management Act 2000 (WM Act). The NSW Department of Primary Industries (Water) administers the WM Act and is required to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity. Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 metres of the highest bank of the river, lake or estuary.

2.2.6 NSW Aquifer Interference Policy (NOW, 2012)

The purpose of the Aquifer Interference Policy is to explain the role and requirement of the Minister administering the WM Act in the water licencing and assessment processes for aquifer interference activities under the WM Act and other relevant legislative frameworks.

2.2.7 Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012)

The Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012) provides a conceptual framework for identifying and assessing ecosystems. The guidelines discuss the identification of high probability GDEs and also discuss the ecological value of GDEs.

2.2.8 NSW State Rivers and Estuary Policy (1993)

The NSW State and Rivers and Estuary Policy encompass a suite of component policies each focussing on the protection or management of ecosystem processes and associated values. The Policy provides clear management objectives and principles which will reflect the State's commitment to resource sustainability and which must be consciously balanced against other social and economic objectives in resource management decisions.

2.2.9 NSW State Groundwater Policy Framework Document (1997)

The purpose of the Groundwater Framework Policy document is to provide a clear NSW government policy direction on the ecologically sustainable management of the State's groundwater resources. The document is used to guide the decision-making of State and local government, as well as landholders in their management and use of groundwater.

2.2.10 NSW State Groundwater Quality Protection Policy

The NSW State Groundwater Quality Protection Policy is one of three component policies, which in association with the Framework Document, make up the State Groundwater Policy. The focus of this Policy is to protect from pollution water below the ground surface in a geological structures or formations known as 'aquifers', and the ecosystems from which these waters are recharged or into which they discharge.

2.2.11 NSW State Groundwater Dependent Ecosystems Policy (2002)

The NSW State Groundwater Quality Protection Policy is one of three component policies, which in association with the Framework Document, make up the State Groundwater Policy. The State Groundwater Dependent Ecosystems Policy is specifically designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes on biodiversity of these dependent ecosystems are maintained or restored, for the benefit of present and future generations.

2.2.12 NSW Water Extraction Monitoring Policy (2007)

The purpose of the NSW Water Extraction Monitoring Policy (2007) is to increase the extent of active monitoring of water extraction. The policy sets out roles and responsibility for Federal Water, State Water and holders of water extraction licences.

2.2.13 NSW Wetlands Management Policy (2010)

The NSW Wetlands Management Policy provides a set of guiding principles that all government agencies will adopt, and all stakeholders can refer to when making decisions on wetlands management and conservation.

2.2.14 Water Sharing Plans

Water sharing plans under the *Water Management Act (2000)* provide the basis for equitable sharing of surface water and groundwater between users including the environment. If an activity leads to a take from a groundwater or surface water source covered by a water sharing plan, then approval and/or a licence is required. It is noted that Roads and Maritime is exempt, as a road authority, under Clause 18(1) of the Water Management (General) Regulation 2011 from the requirement to hold an access licence.

Surface Water Sharing Plan

The project alignment falls within the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011*. The relevant water source is the Hawkesbury and Lower Nepean Rivers Water Source and the relevant management zone for the northern portion of the project is the Lower Nepean River Management Zone, and the Mid Nepean River Catchment Management Zone and the Upper South Creek Management Zone for the southern portion of the project.

Groundwater Sharing Plan

With respect to groundwater, the project lies within the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*. The relevant water source is the Sydney Basin Central Groundwater Source.

2.2.15 NSW Aquifer Interference Policy

The Aquifer Interference Policy (NOW, 2012) presents the requirements of assessment of aquifer interference activities administered by the *Water Management Act* 2000.

The groundwater assessment prepared in Section 5 and Section 6 presents an assessment of the Project against the Level 1 Minimal Impact Considerations of the NSW Aquifer Interference Policy (DPI Water, 2012). It is demonstrated that the Project meets the Level 1 Impact Considerations. Key components of the Aquifer Interference Policy are:

- All water taken must be properly accounted for
- The activity must address minimal impact considerations with respect to water table, water pressure and water quality
- Planning for measures in the event that actual impacts are greater than predicted, including making sure there is sufficient monitoring in place.

Activities such as temporary dewatering works are identified as aquifer interference activities under the *Water Management Act 2000* and the Aquifer Interference Policy. These activities require aquifer interference approvals under the *Water Management Act 2000*, however, provisions for aquifer interference approvals have yet to be enabled. As such, licensing aspects of these activities is currently carried out under the *Water Act* 1912.

Any minor take of water as a result of temporary dewatering activities, that is estimated to be less than 3 ML/y, including both during construction dewatering and subsequent managed inflows, would generally not require a licence from the DPI Water.

Roads and Maritime is exempt, as a road authority, under Clause 18(1) of the Water Management (General) Regulation 2011 from the requirement to hold an access licence. The Water Management (General) Regulation 2011 is the primary regulation instrument under the *Water Management Act 2000*. Roads and Maritime is also exempt under Clause 31(1) of those regulations from the requirement to hold a water use approval. As per Part

1 of Schedule 5 of the regulations, this is in relation to water required for road construction and maintenance. Road authorities are not exempt, however, from the requirement to hold a water supply work approval to construct a works. A water licence may need to be obtained should dewatering of surface water and groundwater be required. In this case, there are no proposed activities associated with the Project that will require a water supply work. As such, there are no licensing requirements associated with the Project.

2.3 Contamination

In preparing the contamination section of this report, the following guidelines were considered (where relevant):

- *Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land*, (NSW Department of Urban Affairs and Planning & NSW Environmental Protection Authority, 1998)
- *Guidelines for Consultants Reporting on Contaminated Sites* (NSW Office of Environment and Heritage, 2000).

Should RMS purchase properties and take responsibility for existing contamination and contamination sources within these properties, the requirements of the Contaminated Land Management Act 1997 would be applicable for the management of contamination.

Should remediation or other construction activities be undertaken which would involve the offsite disposal of materials (both uncontaminated and contaminated), the requirements of the Protection of the Environment Operations (Waste) Regulations 2014 would need to be considered and implemented where applicable.

Should further investigations, remediation works and validation be undertaken, these activities would need to be undertaken in accordance with the following guidelines or other appropriate/endorsed guidelines available at that time:

- *Australian Standard (AS 4482.1-2005) Guide to the sampling and investigation of potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds*
- *Australian Standard (AS 4482.2-1999) Guide to the sampling and investigation of potentially contaminated soils – Volatile substances*
- *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as revised 2013)*
- *ANZECC & ARMCANZ, (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality*
- *NSW EPA (2014) Waste Classification Guidelines*
- *DECCW (2009) Guidelines for the Implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008*
- *NSW EPA (1995) Contaminated Sites: Sampling Design Guidelines*
- *DEC (2006) Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (2nd Edition)*
- *DEC (2007) Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination*
- *NSW EPA (2015) Contaminated Sites: Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*
- *NSW EPA (2015) Technical Note: Light Non-Aqueous Phase Liquid Assessment and Remediation*
- *NSW EPA (2014) Technical Note: Investigation of Service Station Sites*
- *NSW EPA (2014) Best Practice Note: Landfarming*
- *DEC (2005) Information for the assessment of former gasworks sites*
- *DECW (2010) Vapour Intrusion: Technical Practice Note*
- *NSW EPA (2012) Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases*
- *Workcover NSW (2014) Managing asbestos in or on soil.*

3. Methodology

The process of assessing the potential impacts of the project and developing impact mitigation measures for the various aspects of this report are outlined in the following sections.

3.1 Contaminated land

A Stage 1 Contamination Assessment has been carried out to identify potential Areas of Environmental Interest (AEIs) which would assist in identifying construction limitations/constraints within the project area with respect to contamination.

The AEIs were considered to be those potential risks associated with soil, groundwater and vapour contamination which may be present as a result of historic and / or current activities undertaken on and / or adjacent to the project area. To achieve these objectives, Jacobs undertook the following scope of works:

- Review of publically available information (NSW EPA, CSIRO ASRIS database, NSW Department of Primary Industries groundwater database, Commonwealth Department of Defence Unexploded Ordinance (UXO) database)
- Review of historical aerial photography of the general project area
- Site walkover and inspection
- Preparation of a Stage 1 contamination assessment report based on the data obtained from the desktop background review and observations from the inspection of the project area. The expected ground conditions are presented together with any contamination issues identified and recommendations for further investigations, if required
- A number of potential AEIs were identified during the information review and site inspection. **Table 5-1** outlines the potential AEIs located within and in the near vicinity of the project area and their associated risks to environmental receptors and site users (associated with the construction of the road upgrades). Please note the risks have been assessed qualitatively. The potential risks have not been confirmed / quantified through a sampling and analysis program.

The Stage 1 Contamination Assessment is attached to this working paper as **Appendix A**.

The framework for the soil and land contamination assessment was developed in accordance with guidelines 'made or approved', by the EPA, under section 105 of the (NSW) *Contaminated Land Management Act 1997*.

3.2 Groundwater

There are a number of guidelines and management procedures relevant to the assessment of groundwater. These guidelines and procedures have been used to determine impacts to groundwater along the project and identifying the appropriate groundwater management and mitigations measures for implementation during the construction and operational phases of the project.

The methodology below was used to assess the potential groundwater impacts of the project:

- Review of existing literature relating to the project, including consideration of climate conditions, geological maps (regional and local shallow and deep geological units, structural geology, ASS and salinity maps), available groundwater level and quality data (NSW PINNEENA bore search based on a 400m search radius) and existing conditions using available non-project literature to obtain background information to aid in interpreting the existing groundwater conditions
- Review of the Aquifer interference policy (NOW, 2012), and development of a conceptual groundwater model
- Following a review of the existing literature, a conceptual groundwater model was produced to determine the potential impacts on groundwater. It was determined that the production of an analytic or numeric groundwater model was unnecessary because the regional unconfined groundwater table is likely well beneath the expected road cuttings. There are therefore no expected impacts on groundwater drawdown, groundwater take or changes to groundwater flow rates. A conceptual diagram was produced to demonstrate this

- Assessment of the groundwater impacts of the project during construction and operation including assessment of potential impact to groundwater levels, flows and connectivity, as well as potential impacts to groundwater quality and groundwater users.

The conceptual hydrogeological model was constructed using geospatial information obtained from public sources:

- DPI Water's Groundwater PINNEENA online database (accessed March 2016)
- DPI Water Groundwater Productivity Map (2013)
- Penrith 1:100,000 Geological Sheet 9030 (1991).

3.3 Surface Water Management

3.3.1 Desktop Assessment

The desktop assessment involved a review of the existing surface water environment across the study area to assess the likely and potential impacts of the project on surface water quality during construction and operation. The review of information has included:

Review of existing literature relating to the project, available water quality data and existing conditions using available non-project literature to obtain background information on catchment history and land use to aid in interpreting the existing conditions. Literature sources included:

- WSROC (2015) *Review of Western Sydney Airport Draft Environmental Impact Statement*. Prepared by Parsons Brinkerhoff Australia Pty. Ltd
- Commonwealth Department of Infrastructure and Regional Development (2015). *Western Sydney Airport – Draft Environmental Impact Statement. Volume 2, Stage 1 Development*
- SMEC (2014). *Environmental field survey of Commonwealth land at Badgerys Creek*. Report prepared for Western Sydney Unit, Commonwealth Department of Infrastructure and Regional Development. October 2014
- GHD (2015). *Western Sydney Airport EIS. Surface Water Quality Assessment*. A report for the Commonwealth Department of Infrastructure and Regional Development
- Raw water quality data collected by GHD as part of the Western Sydney Airport EIS
- The Northern Road Upgrade – Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park *Biodiversity Assessment Report*
- The Northern Road Upgrade – Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park *Hydrology and Flooding Report*.
- Assessment of the impact of construction activities on water quality with reference to the ANZECC/ARMCANZ (2000) water quality guidelines and the Healthy Rivers Commission Independent inquiry into the Hawkesbury Nepean (HRC 1998) with regard to the relevant environmental objectives of aquatic ecosystems and visual amenity
- 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 1* (Landcom 2004) and *Volume 2D* (DECC 2008)
- Review of water quality treatment measures that could be used to mitigate the impact of the operation of the project on water quality following the principle of *Procedure for Selecting Treatment Strategies to Control Road Runoff* (RTA 2003), *Roads and Maritime Water Policy* (RTA, 1997) and *Roads and Maritime Code of Practice*, *Water Management* (RTA 1999).

There are a number of guidelines and management procedures relevant to the assessment of surface water quality. These guidelines and procedures have been used to determine existing water conditions along the project and identifying the appropriate water quality management and mitigations measures for implementation during the construction and operational phases of the project.

Water quality modelling using the eWater MUSIC was also undertaken to determine the pollutant load reductions that can be achieved by permanent water quality swales for Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP).

The catchments draining to an individual control measure were identified by considering the formation of the proposed carriageway and the proposed pipe drainage network.

A water quality model was set up to represent proposed catchment conditions and models of the swales were created by adopting the sub-catchment areas estimated in the catchment analysis. Rock check dams were also added to the model.

3.3.2 Discharge Criteria

The NSW Healthy Rivers Commission has determined water quality objectives for the Hawkesbury-Nepean River (HRC 1998). The Australian and New Zealand Environment and Conservations Council (ANZECC/ARMCANZ 2000) also have guidelines for water quality. These objectives and guidelines provide benchmarks for assessment of the existing water quality of the river. The application of the criteria is dependent on the environmental values assigned to the waterway.

Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit or health. They are values that require protection from the effects of pollution and waste discharges and provide goals that help in the selection of the most appropriate management options (ANZECC/ARMCANZ 2000). Water quality objectives and environmental values were determined under the NSW Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean system (HRC 1998). In 2001 the NSW Government agreed to these through a Statement of Joint Intent.

The project lies within the lower Hawkesbury Nepean Catchment. The nominated environmental values applying to waterways within this catchment are:

- Protection of aquatic ecosystems
- Visual amenity.

Aquatic Ecosystems

The most relevant environmental value for the purposes of this assessment is aquatic ecosystems. Aquatic ecosystems comprise the animals, plants and micro-organisms that live in water and the physical and chemical environment in which they interact. Aquatic ecosystems have historically been impacted upon by multiple pressures including changes in flow regime, modification and destruction of key habitats, development and poor water quality.

There are a number of naturally occurring physical and chemical stressors that can cause degradation of aquatic ecosystems and for the purposes of this assessment nutrients, dissolved oxygen, pH, salinity and turbidity (suspended solids) are discussed below. These have been considered in the assessment of existing water quality and potential impacts as a result of the project.

- **Nutrients** in aquatic environments promote the growth of algae and increase turbidity which in turn reduces light and may affect plant growth. Generally excessive nutrient inputs lead to excessive algal growth and formation of nuisance blooms. Nutrients consist of nitrogen (including total nitrogen, oxidised nitrogen and ammonia) and phosphorus (including total phosphorus and filterable reactive phosphorus (FRP)) including:
    - **Total Nitrogen** is a measure of all the nitrogen species found in a water body including oxidised nitrogen, ammonia and total organic nitrogen)
    - **Oxidised Nitrogen** represents the level of free nitrogen within the water column that is readily available to plants. Excessive concentrations of oxidised nitrogen concentrations can promote algal growth
    - **Ammonia** is the most reduced form of inorganic nitrogen available, and is preferentially utilised by plants and aquatic micro-organisms. The main sources of ammonia in aquatic ecosystems are from human and animal wastes and that which is released by bacteria during the decomposition of organic material

- **Total Phosphorus** is a measure of both biologically available species (known as filterable reactive phosphorus) and the unavailable species. There are two forms of dissolved phosphorus in the water body, organic phosphorus produced from the decay of plant and animal material and inorganic orthophosphates which are released through breakdown of rock and transported into the water body
- **Filterable Reactive Phosphorus** is a measure of orthophosphates which is the readily available biological component of total phosphorus. Concentrations of FRP within a water body can be influenced by variations in pH, oxygen levels and turbidity.

- **Dissolved oxygen** (per cent saturation and milligrams per litre (mg/L)) is a measure of the amount of oxygen dissolved in water. Dissolved oxygen is vital for many forms of estuarine biota including native fish and is also vital for the functioning of healthy aquatic ecosystems
- **pH** is a measure of the acidity or alkalinity of a water body. Changes in pH can impact the ability of aquatic organisms to maintain basic functions such as respiration. pH also controls the bioavailability of metals, nutrients and other organic molecules. Potential sources of changes to pH include changes in the level of organic matter within the system, agricultural runoff from low pH soils (e.g. acid sulphate soils (ASS)) and changes in salinity
- **Turbidity** is a measure of the optical clarity of a water body which is important in characterising the health of a water body. Changes in the availability of light can affect the distribution of animals and potentially alter the chemical characteristics of the water body. Suspended solids from runoff or land disturbance can result in increased turbidity, thereby reducing light penetration, modification of physical habitat and smothering of biota thereby impacting on aquatic ecosystems.

Visual Amenity

The aesthetic appearance of a waterbody is an important aspect with respect to recreation. As such the water should be free from noticeable pollution, floating debris, oil, scum and other matter. Substances that produce objectionable colour, odour, taste or turbidity and substances and conditions that produce undesirable aquatic life should not be apparent (NHMRC 2008). The key aesthetic indicators are transparency, odour and colour. These have been considered in the assessment of existing water quality and potential impacts as a result of the project.

The water quality guidelines and objectives applicable to the protection of the nominated environmental values that will be applied in the assessment of surface water quality are presented in **Table 3-1**. For the protection of aquatic ecosystems in this region, the ANZECC/ARMCANZ (2000) default trigger values for physical and chemical stressors for 'South-East Australian slightly to moderately disturbed lowland rivers' have been applied. The HRC nutrient guidelines (1998) listed are for mixed use rural areas. Recommended limits for metals are in accordance with ANZECC/ARMCANZ (2000) trigger values for toxicants for the protection of 95% of freshwater aquatic species. The NSW Healthy Rivers Commission Hawkesbury-Nepean River objectives have precedence where there is duplication.

Table 3-1 Guidelines for Protection of Aquatic Ecosystems

Indicator	ANZECC/ARMCANZ (2000)	HRC (1998)
1. Conductivity (µs/cm)	2. 125 - 2200	3.
4. pH	5. 6.5 - 8.5	6.
7. Dissolved oxygen (% saturation)	8. 85 - 110	9.
10. Turbidity (NTU)	11. 6 - 50	12.
13. Suspended Solids (mg/L)	14. < 40	15.
16. Ammonia (µg/L)	17. < 20	18.
19. Oxidised nitrogen (µg/L)	20. < 40	21.
22. Total nitrogen (µg/L)	23. < 350	24. 700
25. Total Phosphorus (µg/L)	26. < 25	27. 35
28. Chlorophyll-a (µg/L)	29. < 3	30.

Indicator	ANZECC/ARMCANZ (2000)	HRC (1998)
31.Arsenic (µg/L)	32.<13	33.
34.Cadmium (µg/L)	35.<0.2	36.
37.Chromium (µg/L)	38.<1	39.
40.Copper (µg/L)	41.<1.4	42.
43.Lead (µg/L)	44.<3.4	45.
46.Nickel (µg/L)	47.<11	48.
49.Zinc (µg/L)	50.<8	51.
52.Mercury (µg/L)	53.<0.6	54.

Water Quality Objectives

There is the potential for the current water quality to not meet the existing guidelines and trigger values for protecting nominated environmental values. Irrespective of the current condition of waterways, the project should not further degrade water quality. As such the key objective of the project is to minimise the potential impacts on downstream receiving waters, so that the project changes the existing water regime by the smallest amount practicable. This objective is consistent with *the Roads and Maritime's Water Policy 1997* (RTA, 1997) and *Code of Practice for Water Management 1999* (RTA, 1999).

3.3.3 Sensitive Receiving Environments

Sensitive receiving environments have been identified using aquatic habitat as an indicator which was assessed against the NSW *Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management* (2013) and Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003) (see the Biodiversity Assessment Working Paper included in **Appendix I** of the EIS).

The five waterways listed as key fish habitats in the Biodiversity Assessment Working Paper are defined as sensitive receiving environments for the project, generally due to the presence of macrophytes and instream woody snags that could provide fish habitat, however protected or threatened fish species are unlikely to occur. The five sensitive receiving waterways are as follows:

1. Badgerys Creek (287912.65E / 6244897.30N)
2. Cosgroves Creek (287247.11E / 6249490.76N)
3. 'Site 29a' (286060.62 E / 6246544.14N), an intermittent stream
4. The large dam at 'Site 39' (286460.594 E, 6247352.348N), fed by several minor 1st and 2nd order streams. These streams are ephemeral with minimal channel definition, only flowing when the upstream dams overflow
5. Unnamed tributary of Surveyors Creek (286887.04E/6257728.90N).

The Nepean River is the downstream receiving environment to the project area; however, the project itself is located close to the catchment divide, just west of the eastern boundary. The Nepean River is significant both environmentally and economically and provides for a range of domestic and irrigation uses. Several threatened species including Macquarie Perch (Macquaria australasica), Australian Grayling (Prototroctes marena), Silver Perch (Bidyanus bidyanus), Murray Cod (Maccyllochella peelii peelii) and Trout Cod (Maccullochella macquariensis) have been recorded within the Hawkesbury-Nepean Catchment; however, habitat for these species is not present within the study area.

While the presence of macrophytes and instream woody snags provides fish habitat, no threatened or protected fish species were identified during the aquatic surveys and are not expected to occur within the waterways potentially impacted. Visual inspection sighted the invasive pest species, Gambusia (Gambusia holbrooki) within some of the waterways surveyed. Further information regarding the aquatic habitat assessment is provided in The Biodiversity Assessment Working Paper prepared for the EIS (**Appendix I** of the EIS).

4. Existing Environment

4.1 Landform and landscape

The project is located on the Cumberland Plain, a low lying and gently undulating subregion of the Sydney Basin. The Sydney Basin is a large geological feature stretching from Batemans Bay in the south to Newcastle in the north and Lithgow in the west. The formation of the basin began between 250 to 300 million years ago when river deltas gradually replaced the ocean that had extended as far west as Lithgow (Clark and Jones 1991).

The project area traverses a north-south oriented ridge that forms the watershed separating the catchment areas of South Creek in the east and the Nepean River in the west. The project itself is located close to the catchment divide, just west of the eastern boundary of the Nepean River catchment. The ridge is characterised by gentle to moderately inclined slopes with narrow to broad crests and drainage lines. The eastern side of the project area contains several north-east flowing creeks including Badgerys Creek, Cosgroves Creek and Oaky Creek which join South Creek approximately 7 km to the east. On the western side of the project area, several creeks including Duncan's Creek, Surveyors Creek, Mulgoa Creek flow north-west to join the Nepean River approximately 4.5 km to the west. To the southwest of Luddenham and the proposed new alignment of The Northern Road, undulating areas including creeks in gullies are present. There are a number of farm dams along the entire alignment.

East of the existing The Northern Road (which runs along a ridge line) the land is gently undulating with two ridgelines forming the main topographical features. One is located to the west of Luddenham Road and the other is in the Aldington Road / Mt Vernon Road areas.

Landscape character varies from generally semi-rural in the majority of the study area to occasional pockets of suburban areas including at Luddenham and Glenmore Park.

4.2 Regional geology

The Penrith 1:100,000 Geological Series Sheet 9030 (NSW Department of Mineral Resources, 1991) indicated that the project area is predominately underlain by Bringelly Shale (Rwb), Quaternary alluvium Qal) and Cranebrook Formation (Qpc). Bringelly Shale (Rwb) is composed of shale, carbonaceous claystone, claystone, laminate, fine to medium-grained lithic sandstone, rare coal and tuff (Clark and Jones 1991) and underlies the crests, slopes and drainage lines of the majority of the project area.

The Luddenham Dyke is located in the vicinity of the intersection of The Northern Road and Eaton Rd. The dyke consist consists of olivine basalt carrying analcite, the dyke intrudes the Bringelly shale and trends north-west to south-east

More recent Quaternary Alluvium (Qal) is present along the low lying areas adjacent to Badgerys Creek. Quaternary Alluvium (Qal) comprises fine-grained sand, silt and clay that deposited in association with fluvial activity along the various creek corridors. In the north of the project area, a small deposit of Cranebrook Formation geology (Qpc) is present adjacent to Surveyors Creek. Cranebrook Formation (Qpc) geology is characterised by a basal layer of pebble and cobble clast gravels below sand, silt and clay. Alluvium comprising of fine sands, silt and clay is likely to be deposited along the Cosgroves and Badgerys Creek systems. According to the *Western Sydney Airport Environmental Impact Statement* (Commonwealth Department of Infrastructure and Regional Development, 2016) the alluvium deposits can be up to five metres thick and are typically made up of fine sands, silts and clays with some areas of gravelly clay.

A description of the geological formations underlying the project area is provided in **Table 4-1** and outlined on **Figure 4-1**.

Table 4-1 Geological units underlying the project area

Unit	Description
Bringelly Shale (Rwb)	Shale, carbonaceous claystone, laminate, coal in parts
Luddenham Dyke	Basalt, dolerite
Cranebrook Formation (Qpc)	Pebbles and cobbles of quartz, quartzite, chert, porphyry, granite,

Unit	Description
	hornfels and silcrete
Quaternary Alluvium (Qal)	Fine grained sand, silt, clay

4.3 Soils

The Penrith 1:100,000 Soil Landscape sheet 9030 (Soil Conservation Service of NSW, 1990) indicated that the soil landscape groups within the project area consist three principal soil landscapes. These are erosional Luddenham (lu), residual Blacktown (bt) and fluvial South Creek (sc) soil landscape groups. **Table 4-2** describes the soil landscape groups within the project area.

The basal geology is overlain by South Creek soils within the immediate vicinity of major creeks, transitioning to Blacktown soils on crests and low rises and Luddenham soils on hills and ridge slopes (**Figure 4-2**). The alluvial South Creek soil landscape is characterised by flat landforms with incised channels that are subject to frequent episodes of inundation, erosion and aggradation.

Soil landscapes in the project area are shown on **Figure 4-2**.

Table 4-2 Soil units underlying the project area

Unit	Description
Luddenham (lu)	• Landscape – found on undulating to rolling hills on Wianamatta Shales, with slopes between 5-20 per cent and local relief between 50 and 80 m, narrow ridges, hills and valleys • Soils – shallow podzolic soils and massive clays on crests, moderately deep red podzolic soils on upper slopes and moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines • Limitations – high soil erosion hazard, localised impermeable highly plastic subsoil, moderately reactive.
Blacktown (bt)	• Landscape - found on gently undulating rises on Wianamatta Group shales with local reliefs of up to 30 metres and slopes of less than 5 per cent • Soils - shallow to moderately deep hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines • Limitations - moderately reactive, highly plastic subsoil, with low fertility and poor drainage.
South Creek (sc)	• Landscape - found on floodplains, valley flats and drainage depressions of the channels on the Cumberland Plain • Soils – deep layered sediments over bedrock or relic soils. Structured plastic slays and loams in and adjacent to drainage lines, red and yellow podzolic soils on terraces • Limitations – erosion hazard, frequent flooding.

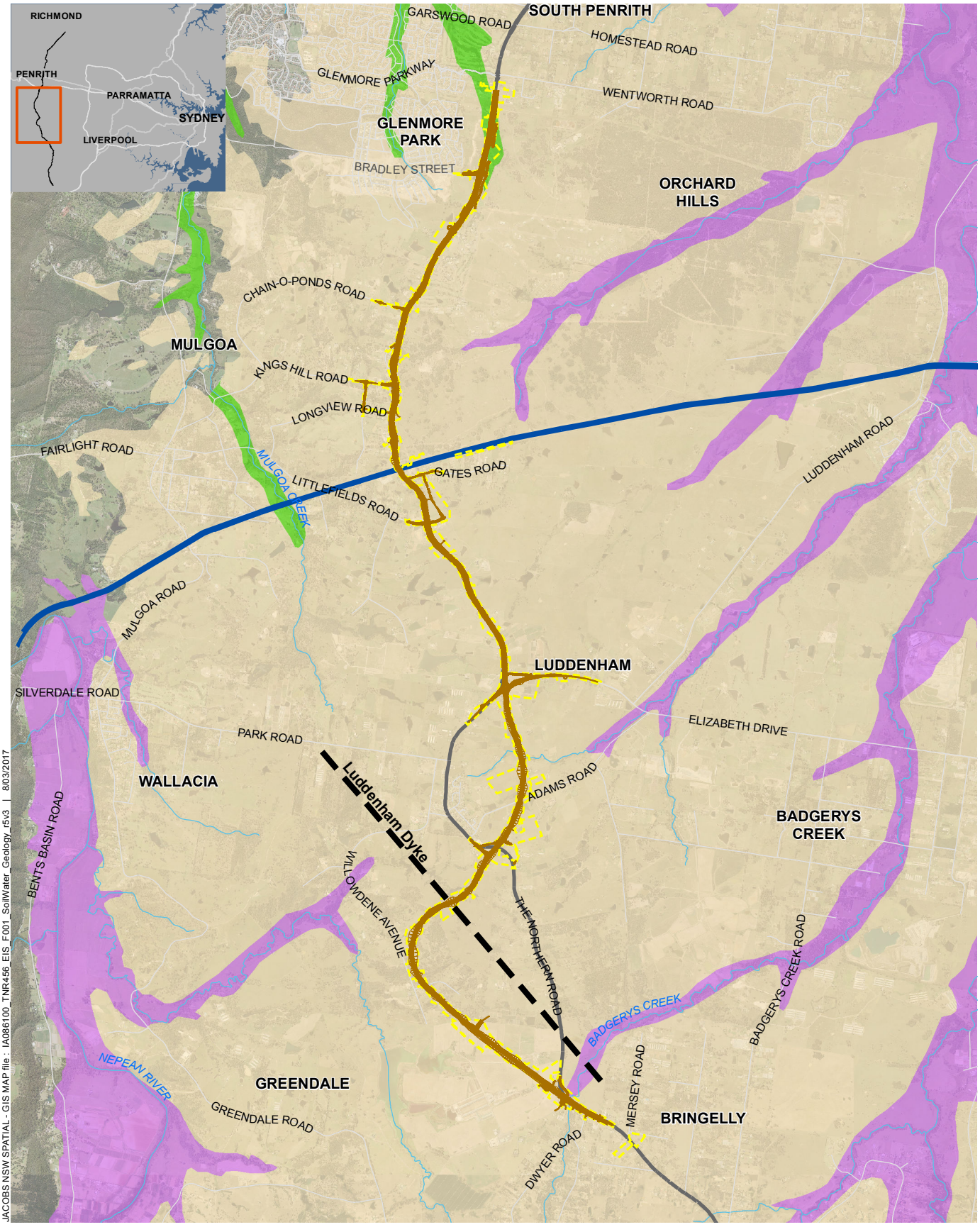
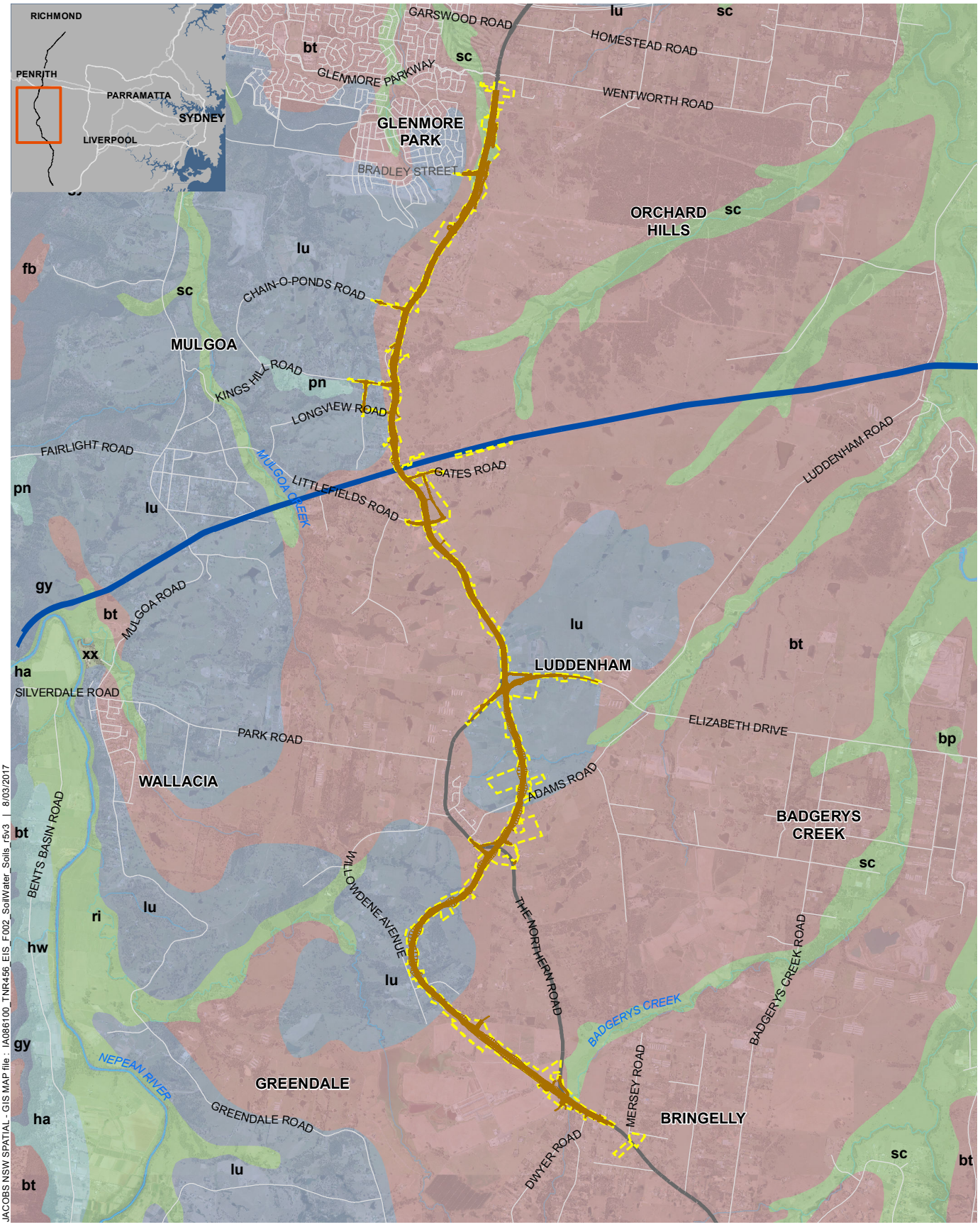


Figure 4-1 | Regional geology



JACOBS NSW SPATIAL - GIS MAP file : IA086100_TNR456_EIS_F002_SoilWater_Soils_r5v3 | 8/03/2017

The Northern Road upgrade - Mersey Road to Glenmore Parkway

The Northern Road (Existing)

WaterNSW supply pipelines

Project area

Soils

Alluvial

COLLUVIAL

Erosional

Residual

bt = Blacktown
lu= Luddenham
sc = South Creek
ri = Richmond

0 1 2 km

N

Figure 4-2 | Soil Landscapes

4.4 Acid Sulfate Soils (ASS)

Acid sulfate soils (ASS) are soils and sediments that contain iron sulfides that when disturbed to oxygen, generate sulphuric 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, as well as human health. The majority of ASS are formed by natural process under specific environmental conditions, which generally limits its occurrence in low lying sections of coastal floodplains, rivers and creeks where surface elevations are less than five metres AHD.

The Australian Soil Resource Information System (ASRIS, 2015) provides online access to the best publicly available information on soil and land resources across Australia. ASRIS provides a national map of available ASS mapping that is classified with a nationally consistent legend that includes risk assessment criteria and correlations between Australian and International Soil Classification Systems. The ASRIS ASS map was consulted to determine the presence and risk of ASS along the project alignment. The Acid Sulfate Soil Probability within the project alignment was classified as Extremely Low Probability of occurrence. ASS is therefore not considered to be a risk to the project.

4.5 Soil salinity

Surface water and groundwater can dissolve and mobilise salts and cause their accumulation in other areas. Excessive concentrations of salt in such areas can affect plant growth, soil chemistry and cause weakening and degradation of construction materials such as masonry, concrete and bitumen. The assessment of salinity potential along the alignment was undertaken using the map of the salinity potential in western Sydney (NSW Department of Infrastructure, Planning and Natural Resources 2002). The majority of the alignment occurs in areas of moderate salinity potential.

It is understood that durability and aggressivity samples of soil material will be collected and analysed prior to the construction phase, to determine potential impacts of soil salinity on pavement infrastructure.

Soil salinity potential for the project area is mapped on **Figure 4-3**.

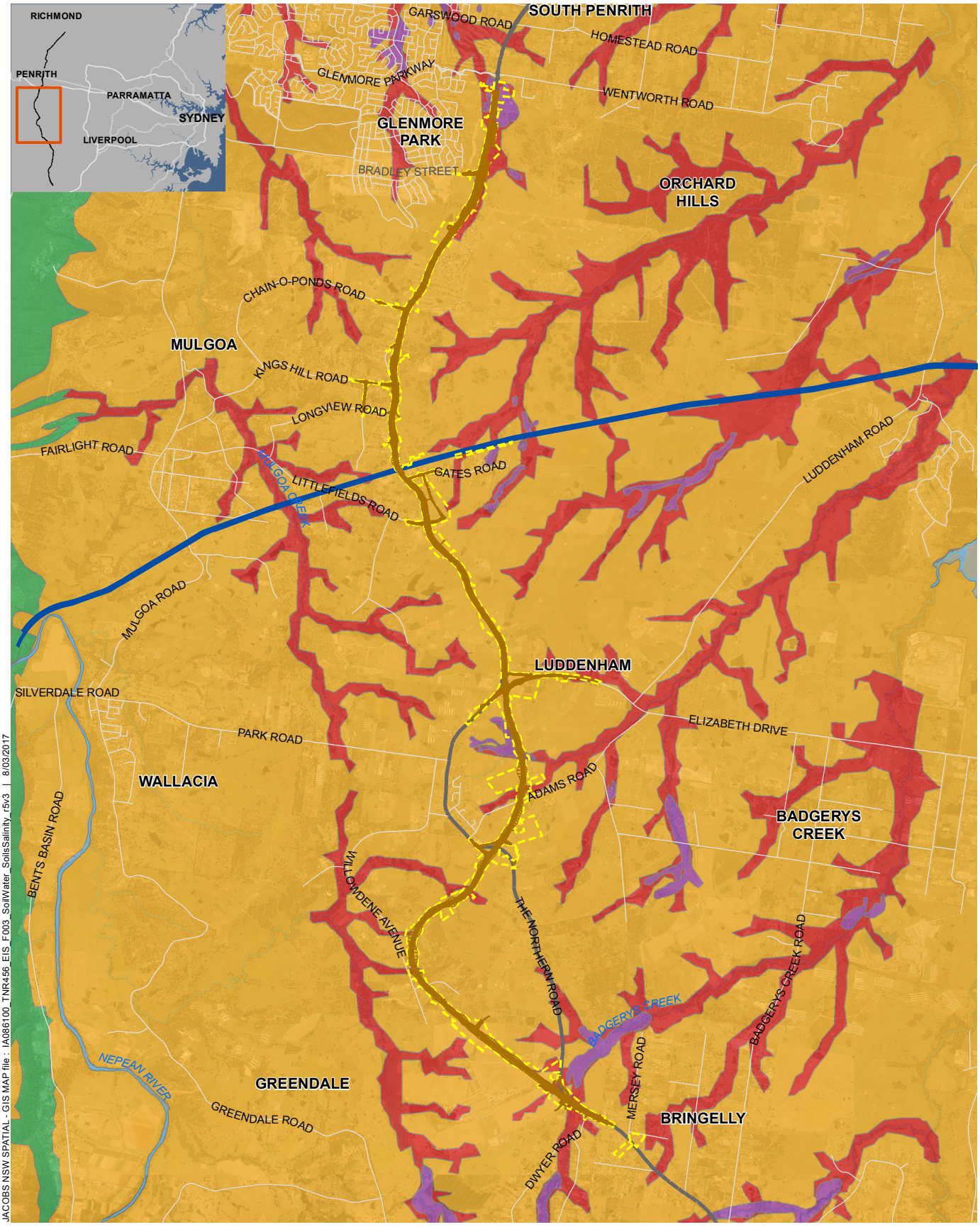


Figure 4-3 | Soil salinity potential

4.6 Contaminated land

4.6.1 NSW contaminated sites register

A search of the NSW EPA Contaminated Sites Register and Record of Notices (under Section 58 of the *Contaminated Land Management Act 1997*) was undertaken (November 2015) to ascertain the presence of registered sites that were either regulated or had been notified within the suburbs within the project area. The notified/regulated sites within one kilometre of the project area are summarised in **Table 4-3**.

Table 4-3 Notified sites within one kilometre of the project area

Suburb	Notified site address	Notified site activity	Contamination status	Location relative to Project
Luddenham	Caltex Service Station The Northern Road	Service Station	Under assessment	Outside project area (> 250m)

Based on the location of notified site relative to the project area, the Luddenham service station site is unlikely to be in the near vicinity of the construction footprint and as such is likely to pose a low contamination risk.

A search of areas of concern from the UXO website was undertaken (in March 2016). At the time of undertaking this assessment, no known areas of concern with respect to UXO were identified within or adjacent to the project area including Defence Establishment Orchard Hills.

4.6.2 Site inspection

A site inspection was conducted on 19 November 2015 by a Jacobs environmental scientist. The site inspection focussed on the Project area, as well as adjacent land uses and potential AEIs. The site inspection was only undertaken from areas which were accessible to the public.

At the time of the site inspection the project area consisted mostly of agricultural and rural residential land use, with low density residential land use in the suburbs of Glenmore Park and Mulgoa. The remaining areas generally comprised rural residential land use with more intensive agricultural land use within the southern portion of the project area (Greendale) and the Defence Establishment Orchard Hills. Roads were generally sealed.

A number of AEI were identified during the site inspection as detailed in **Table 4-4** and presented as **Figure 4-4.**

Table 4-4 Site Inspection AEI

AEI	Location	Contaminants of Potential Concern	Potential Contamination Distribution	Exposure Risk
Stockpiles	Private Property, western side of The Northern Road between Glenmore Parkway and Bradley Street, Glenmore Park	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Defence Establishment Orchard Hills (Commonwealth land)	Eastern side of The Northern Road, Orchard Hills	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos, explosive residues	Surface and shallow soils	Low - Contamination (if present) from the use of the site for military purposes unlikely to be in the vicinity of the project area.
Defence Establishment Orchard Hills (Commonwealth land)	Eastern side of The Northern Road, Orchard Hills	UXO	Surface and shallow soils	Moderate – Likelihood of encountering UXO during construction activities is likely to be low; however the consequence if encountered could be high.
Stockpiles	Eastern side of The Northern Road between Kingshill and Longview Roads, Orchard Hills	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Moderate – Stockpiles may need to be removed during construction activities.
Sub-station	Eastern side of The Northern Road, Orchard Hills	Heavy metals, hydrocarbons, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and substantial construction activities are unlikely on the site. Should construction activities occur on the site, then exposure risk would increase.
WaterNSW supply pipelines (Warragamba Pipelines)	Eastern and western sides of The Northern Road, Orchard Hills	Heavy metals	Surface and shallow soils	Moderate – Increased with excavation in areas of potential contamination.
Filling	Private property, eastern side of Galaxy Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Stockpiles	Private property, eastern side of	Heavy metals, hydrocarbons,	Surface and shallow soils	Low - Contamination (if present) likely to be

AEI	Location	Contaminants of Potential Concern	Potential Contamination Distribution	Exposure Risk
	Galaxy Road, Luddenham	pesticides, polychlorinated biphenyls, asbestos		localised and construction activities are unlikely on the site.
Market Gardens	Private property, north east of the intersection of The Northern Road and Elizabeth Drive.	Heavy metals, hydrocarbons, pesticides, nutrients	Soils and groundwater	Moderate – Contamination could be both localised and diffuse. Agricultural areas are likely to be disturbed as part of the upgrade.
Stockpiles	Western side of The Northern Road, north of Park Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Moderate – Stockpiles may need to be removed during construction activities.
Roads and Maritime Stockpile	North of the intersection of The Northern Road and Park Road, Luddenham.	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Service Station	South of the intersection of The Northern Road and Park Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Cemetery	South of the intersection of The Northern Road and Roots Avenue, Luddenham.	Heavy metals, nutrients, formaldehyde, biological	Deeper soils and groundwater	Low – Site and contamination (if present) likely to be too far away to pose a risk to construction activities
Non operational service station	Shops – The Northern Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Moderate – Risk increased if deep excavations occur in the vicinity of the site
Service Station	Shops – The Northern Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Moderate – Risk increased if deep excavations occur in the vicinity of the site.
Dumped tyres	Southern side of Adams Road, Luddenham	Heavy metals, hydrocarbons	Surface and shallow soils	Low - Contamination (if present) likely to be localised and substantial construction activities are unlikely on the site.
Filling	Private property, western side of Willowdene Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Stockpile	Western side of	Heavy metals,	Surface and	Low - Contamination (if

AEI	Location	Contaminants of Potential Concern	Potential Contamination Distribution	Exposure Risk
	Willowdene Road, Luddenham	hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	shallow soils	present) likely to be localised and construction activities are unlikely on the site.
Septic Systems	Numerous tanks and pump out points observed within the project area	Heavy metals, nutrients, biological	Deeper soils and groundwater	Low – Contamination source likely to be highly degraded
Agricultural Land Use	Numerous locations within and adjacent to the project area	Heavy metals, hydrocarbons, pesticides, asbestos	Soils and groundwater	Moderate – Contamination could be both localised and diffuse. Agricultural areas are likely to be disturbed as part of the upgrade.
Vehicle Accidents	Numerous locations within and adjacent to the project area	Hydrocarbons, aqueous firefighting foam (AFFF).	Surface and shallow soils	Low to Moderate – Very localised contamination (if present) likely to be disturbed as part of the upgrade.

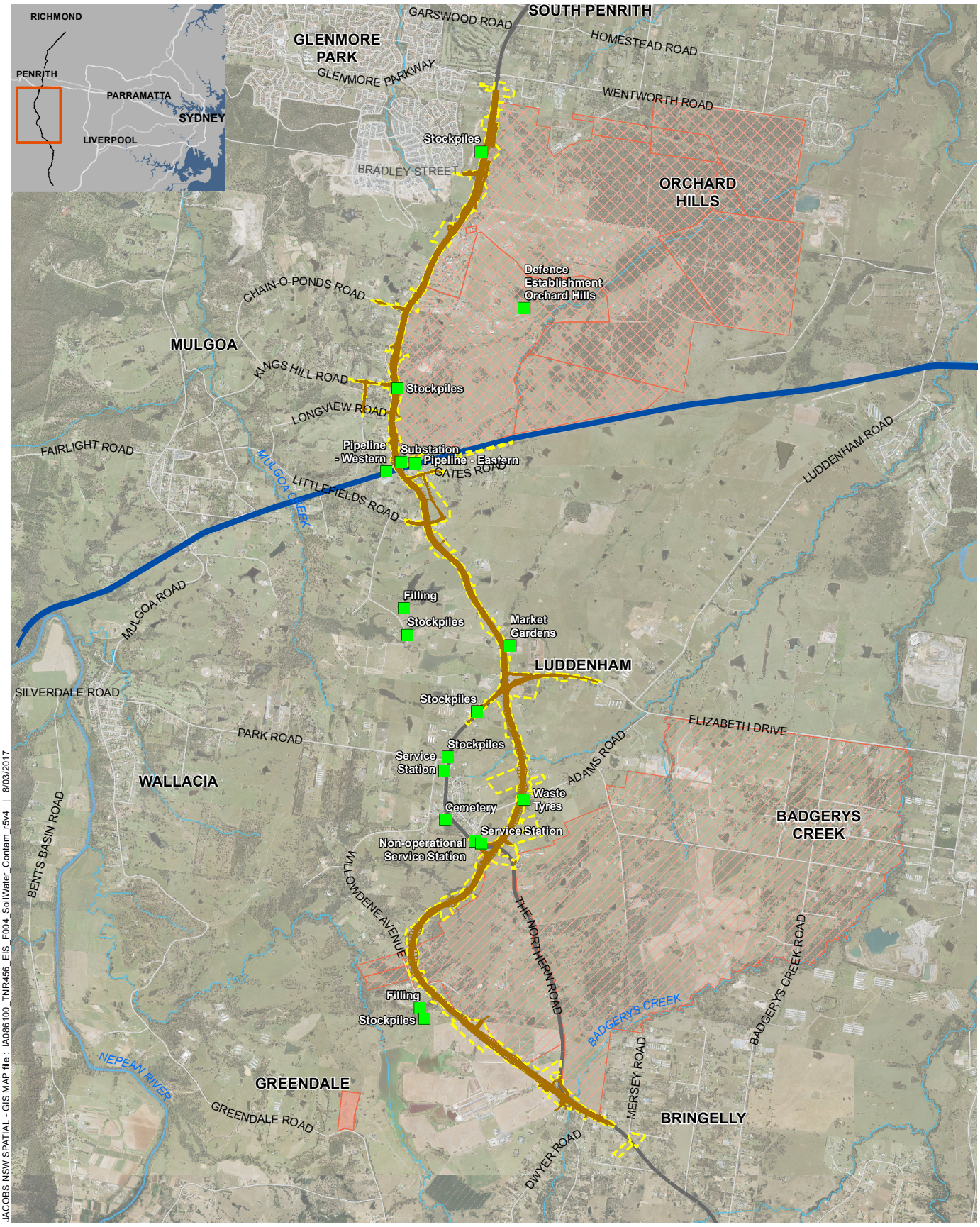


Figure 4-4 | Contaminated land - Site inspection AEIs

4.7 Surface water quality

4.7.1 Catchments and watercourses

The northern portion of the project lies within the Lower Nepean River Management Zone of the Hawkesbury-Nepean River Catchment, while the southern portion lies within the Mid Nepean River Catchment Management Zone and the Upper South Creek Management Zone. The Nepean River is the ultimate downstream receiving environment to the project area. It is significant both environmentally and economically and provides for a range of domestic and irrigation uses. However, the project itself is located a long distance from the river (about five kilometres at the closest point) and close to the catchment divide, just west of the eastern boundary of the catchment.

The catchment is shale-based and is characterised by meandering streams. It is also highly disturbed due to increasing urbanisation and associated land clearing. The study area falls within the hydrological catchments of Duncans Creek, Badgerys Creek, Cosgroves Creek, Mulgoa Creek, unnamed tributary of South Creek, Blaxland Creek and Surveyors Creek. The watercourses of Badgerys Creek, Cosgroves Creek, the unnamed tributary of South Creek and Blaxland Creek catchments drain east to South Creek which then flows north to join the Hawkesbury River at Windsor (refer to the Hydrology and Flooding Working Paper, **Appendix K** of the EIS). The watercourses of Duncans Creek, Mulgoa Creek, and Surveyors Creek catchments drain west to the Nepean River. Further detail is provided below for each catchment within the study area.

Cosgroves Creek

Within the Cosgroves Creek catchment the project will largely involve the construction of the alignment in green field land. This is not associated with any Commonwealth land. The project will directly traverse the main channel of Cosgroves creek and a number of unnamed tributaries. The catchments are largely rural and without residential development downstream of the site, with the exception of the Twin Creeks residential estate downstream of the site towards Cosgroves Creek's confluence with South Creek (GHD 2015).

Cosgroves Creek is an intermittent stream with a series of disconnected pools and a tributary of South Creek. Water quality data reported for Cosgroves creek in infers that the creek is poorly oxygenated, with elevated levels of total and ammoniacal nitrogen (DIRD 2016). Metal and pesticide concentrations were generally not detected. The creek has been classified as suffering from mild pollution based on macroinvertebrate communities present.

Badgerys Creek

Badgerys Creek is approximately 16 km long, rising near Bringelly, it flows north and then north east before its confluence with South Creek in the suburb Badgerys Creek. Land use within the Badgerys Creek catchment consists of agricultural (grazing of naturalised and modified pastures) and rural residential uses. The catchment includes areas within Commonwealth land. Ecologically sensitive riparian vegetation also exists within the catchment (GHD 2015) as do small areas of Landfill and forest. Badgerys creek has been reported to have highly dispersive soils. Within the Badgerys Creek catchment the project will comprise of a combination of upgrade to the existing road alignment and construction in green field land.

Badgerys Creek has been categorised as a second order intermittent stream containing permanent residual pools which provide refuge for fish habitat (Biodiversity Assessment Working Paper, **Appendix I** of the EIS). Badgerys creek and streams that flow into Badgerys Creek are generally nutrient enriched (nitrogen), with low dissolved oxygen and exhibit excessive algal growth (DIRD2016). Despite the poor water quality, Badgerys Creek supports a diverse ecosystem, although the macroinvertabrate species presented indicate that the ecological health is poor and generally mildly to moderately polluted (DIRF 2016).

Surveyors Creek and the Unnamed tributary of Surveyors Creek

Surveyors Creek is located on the north western side of the project area, and is a tributary of Peach Tree Creek which drains to the Nepean River near Penrith. The catchment includes areas within Commonwealth land. The quality of water in Peach Tree Creek is poor and reflective of a highly degraded system. Peach Tree Creek and Surveyors Creek receive a large proportion of flow from stormwater and as such the water quality is likely to be turbid with elevated nutrients, metals and other typical contaminants found in stormwater.

Mulgoa Creek, Blaxland Creek and an Unnamed Tributary of South Creek

The Northern Road upgrade would be constructed through the catchments of Mulgoa Creek, Blaxland Creek and an unnamed tributary of South Creek. Some of these catchments include areas located on Commonwealth land. These catchments are relatively small and the creeks themselves largely ephemeral. Mulgoa Creek catchment has been impacted by rural residential and urban development, as such the condition of the creek is likely to be poor with degraded water quality. Blaxland Creek which flows for approximately 10kms, passes through the Commonwealth Department of Defence Establishment Orchard Hills near Penrith. As such this section of the creek is largely untouched by development and likely to exhibit good water quality.

Duncans Creek

The project will involve construction of the Northern Road along green field land within the Duncans Creek catchment, some of which is located on Commonwealth land. The project will involve crossing a number of unnamed tributaries which drain to Duncans Creek, but does not directly traverse the creek itself. Much of the catchment is currently rural, however a large proportion of it will be redeveloped as part of the Western Sydney Airport. Similarly to other waterways, Duncans Creek suffers from very low dissolved oxygen and elevated levels of nitrogen.

4.7.2 Existing surface water quality monitoring

Whilst the project drains a number of hydrological subcatchments as identified above, for the purposes of this surface water quality assessment, only those waterways directly impacted by the project have been assessed in detail in terms of existing surface water quality as outlined below.

Visual inspection of existing environment

The project directly traverses a number of unnamed tributaries and drainage lines (some of which are associated with farm dams) which are ephemeral in nature and have largely been modified due to the clearing of riparian vegetation and construction of farm dams. A summary of the water quality condition of the main waterways traversed by the project is provided in **Table 4-5** based on a visual site inspection at these locations. This visual site inspection also formed part of the aquatic habitat survey undertaken as part of the Biodiversity Assessment Working Paper (**Appendix I** of the EIS); therefore some site locations are referred to as per the associated aquatic survey location number.

Table 4-5 Water quality condition based on a visual site inspection

Site	Water quality condition
Badgerys Creek	Water quality appeared moderate, tannin stained and with some frothing and instream rubbish. Runoff from surrounding agriculture is likely to impact upon water quality.
Cosgroves Creek	Water quality appeared to be poor, with a thick algae bloom, oily film and frothing present in some of the stagnant pools.
'Site 29a'	Water quality appeared moderate, with anoxic odour within residual pools, tannin staining and filamentous algae present. Some rubbish such as tyres were present.

As outlined in the methodology section of this report (**Section 3**), sensitive receiving environments have been identified using aquatic habitat as an indicator. No watercourses were mapped as Key Fish habitat by DPI Water (2007). Sensitive receiving environments were instead determined using the NSW *Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management* (2013) and Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003).

Five sensitive receiving environments have been identified as Type 1 – Key Fish Habitats (DPI 2013), as they had a combination of native aquatic plants and/or woody snags. These watercourses are impacted, intermittently flowing waterways which are also identified as Class 2 – Moderate Key Fish Habitat (Fairfull & Witheridge, 2003) due to the presence of limited in stream aquatic vegetation. The waterways are:

1. Badgerys Creek (287912.65E / 6244897.30N)

2. Cosgroves Creek (287247.11E / 6249490.76N)
3. 'Site 29a' (286060.62 E / 6246544.14N), an intermittent stream
4. The large dam at 'Site 39' (286460.594 E, 6247352.348N), fed by several minor 1st and 2nd order streams. These streams are ephemeral with minimal channel definition, only flowing when the upstream dams overflow
5. Unnamed tributary of Surveyors Creek (286887.04E/6257728.90N).

Whilst the waterways have been surveyed and generally contain suitable habitat for fish, the water quality of these site is generally poor to moderate (refer to **Table 4-5**) and flow at times intermittent. As such no threatened or protected fish species are expected to occur within the creeks located in the study area. Further information on potential fish habitat is provided in the Biodiversity Assessment Working Paper (**Appendix I** of the EIS).

Despite the unlikelihood of supporting protected or threatened fish, the sites did contain key fish habitat and therefore considered to be sensitive receiving environments to any changes in water quality. As such, these sites should be appropriately mitigated from any deterioration in water quality during the construction and operation of the project.

Key hydrological features of the project area are shown on **Figure 4-5**.

4.7.3 Monitoring data

Monthly sampling has been undertaken as part of the environmental assessment of the Western Sydney Airport in the project vicinity since November 2015. The sampling locations are also shown on **Figure 4-5**. The three monitoring sites most relevant to the project are described in **Table 4-6**.

Table 4-6 Monitoring sites relevant to the project

Relevant Sites	Location description
U/S Airport New	Badgerys Creek within project boundary
D/S Basin 8 Willowdene Ave	Duncans Creek, approximately 1.5 km downstream of the project location
D/S Basin 7 @ Adams Rd	Cosgroves Creek, approximately 1 km downstream of the project location

Table 4-7 provides a qualitative description of the water quality at the time of sampling. It suggests particularly poor conditions at the 'U/S Airport New' site on Badgerys Creek.

Table 4-7 Qualitative monitoring results (source: GHD Western Sydney Airport)

Site	Date	Sample appearance	Water surface conditions	Nuisance organisms
D/S Basin 7 @ Adams Rd	2/11/2015	Brown, slightly turbid	Gross pollutants, tyres	
	8/12/2015	Clear		
	5/01/2016	Brown	Some plant matter	
	4/02/2016	Opaque	Gross pollutants	
	2/03/2016	Black, no flow through, pools	Leaf litter	Gambusia
D/S Basin 8 Willowdene Ave	2/11/2015	Light brown, cloudy		Algae
	8/12/2015	Clear	Scum/sheen	Gambusia
	5/01/2016	Brown, slightly turbid	Plant matter	
	4/02/2016	Mostly clear		
	2/03/2016	Mostly clear	Plant matter, sheen	Gambusia

Site	Date	Sample appearance	Water surface conditions	Nuisance organisms
U/S Airport New	2/11/2015	Light brown, cloudy, reeds	Gross pollutants on banks	
	8/12/2015	Brown, turbid	Gross pollutants	
	5/01/2016	Turbid	Plant matter, gross pollutants	
	4/02/2016	Black, smelly	Oily sheen, gross pollutants on bank, reeds cut back	
	2/03/2016	Brown, turbid	Few gross pollutants, plant matter	Algae

Table 4-8 and Table 4-9 provides the water quality monitoring results, with a comparison to the ANZECC/ARCMANZ (2000) and HRC (1998) trigger values to determine how existing water quality meets criteria for the nominated environmental values of aquatic ecosystems and visual amenity.

Monitoring highlights low levels of dissolved oxygen and very high levels of total nitrogen across all sites. At the 'U/S airport new' site on Badgerys Creek, it highlights large exceedances of the trigger levels for turbidity, suspended solids, total nitrogen, ammonia, NOx, phosphorus and sometimes Chlorophyll-a. Waterways in the area are known to exhibit elevated nutrient concentrations, hence the higher trigger values recommended by the HRC for TN and TP. Nutrient concentrations at the site monitored were well in excess of these trigger values on every occasion for TN and all but one occasion for TP. As such the waterways in the study area are considered eutrophic and generally exceed the both the nominated HRC and ANZECC/ARMCANZ guidelines for protection of aquatic ecosystems. The water surface conditions reported during sampling infer that the visual amenity of the creeks is generally poor.

Metal concentrations varied throughout the sites. Arsenic, cadmium and mercury were either not detected or detected in very low concentrations at all sites. Chromium levels were elevated in Badgerys Creek and exceeded the recommended guideline on all occasions but generally not detected or in low concentrations at the other sites with the exception of one exceedance at Cosgroves Creek. Copper and zinc concentrations were consistently elevated in Badgerys Creek exceeding the recommended limit for protection of 95% of aquatic species. These metals were only detected in excess on a few occasions at the other sites. Overall metal concentrations, particularly copper and zinc are elevated, most noticeably in Badgerys Creek, which also exhibits high concentrations of chromium and nickel.

Table 4-8: Water quality monitoring data (phys-chem and nutrients) (source: GHD Western Sydney Airport)

Site	Date	Conductivity (µS/cm)	pH (in situ)	Dissolved Oxygen (% sat)	Turbidity (NTU)	Suspended Solids (mg/L)	Ammonia (mg/L)	TN (µg/L)	TP (µg/L)	Chl-a (µg/L)	NOx (µg/L)
ANZECC/ARMCANZ (2000) trigger levels	Min:	125	6.5	85	6	-	-	-	-	-	
	Max:	2200	8.5	110	50	40	20	350	25	3	40
HRC trigger values	Max:	-	-	-	-	-	-	700	35	-	-
D/S Basin 7 @ Adams Rd (Cosgroves Creek)	2/11/2015	228.4	6.85	49.7*	39	6	20	1,100*	90*	2	30
	8/12/2015	2273	7.98	23.7*	2.42*	6	40*	1,300*	40*	7	40
	5/01/2016	172	7.9	69.1*	20.7	<5	30*	700*	40*	1	20
	4/02/2016	527	7.62	49.5*	11.1	<5	10	1,000*	5	2	<10
	2/03/201	2322	8.1	5.9*	24.8	16	10	1,800*	130*	9	<10

Site	Date	Conductivity (µS/cm)	pH (in situ)	Dissolved Oxygen (% sat)	Turbidity (NTU)	Suspended Solids (mg/L)	Ammonia (mg/L)	TN (µg/L)	TP (µg/L)	Chl-a (µg/L)	NOx (µg/L)
	6		6								
D/S Basin 8 Willowdene Ave (Duncans Creek)	2/11/2015	2168	8.04	51.2*	32.4	24	40*	2,600*	170*	<1	30
	8/12/2015	2019	8	43.6*	9.39	26	280*	1,700*	111*	145*	40
	5/01/2016	1045	7.8	63.3*	32.8	11	40*	800*	70*	3	50*
	4/02/2016	432	7.78	65.7*	19.7	9	10	800*	70*	4	30
	2/03/2016	2253	8.33	26.4*	16	10	160*	1,000*	50*	16*	30
U/S Airport New (Badgerys Creek)	2/11/2015	1841	7.44	39.5*	511*	52*	1,700*	9,800*	2,020*	46*	3,940*
	8/12/2015	3744	7.95	11.7*	450*	180*	95,200*	100,000*	13,800*	3	210*
	5/01/2016	1638	7.75	13.6*	296*	159*	3,980*	46,600*	6,330*	4	22,200*
	4/02/2016	1839	7.28	28*	70.6*	40	4,950*	19,300*	8,450*	<1	10
	2/03/2016	1877	7.73	11*	127.5*	23	4,750*	7,800*	3,670*	28*	<10

***Outside maximum or minimum HRC *and* ANZECC/ARCMANZ (2000) trigger levels**

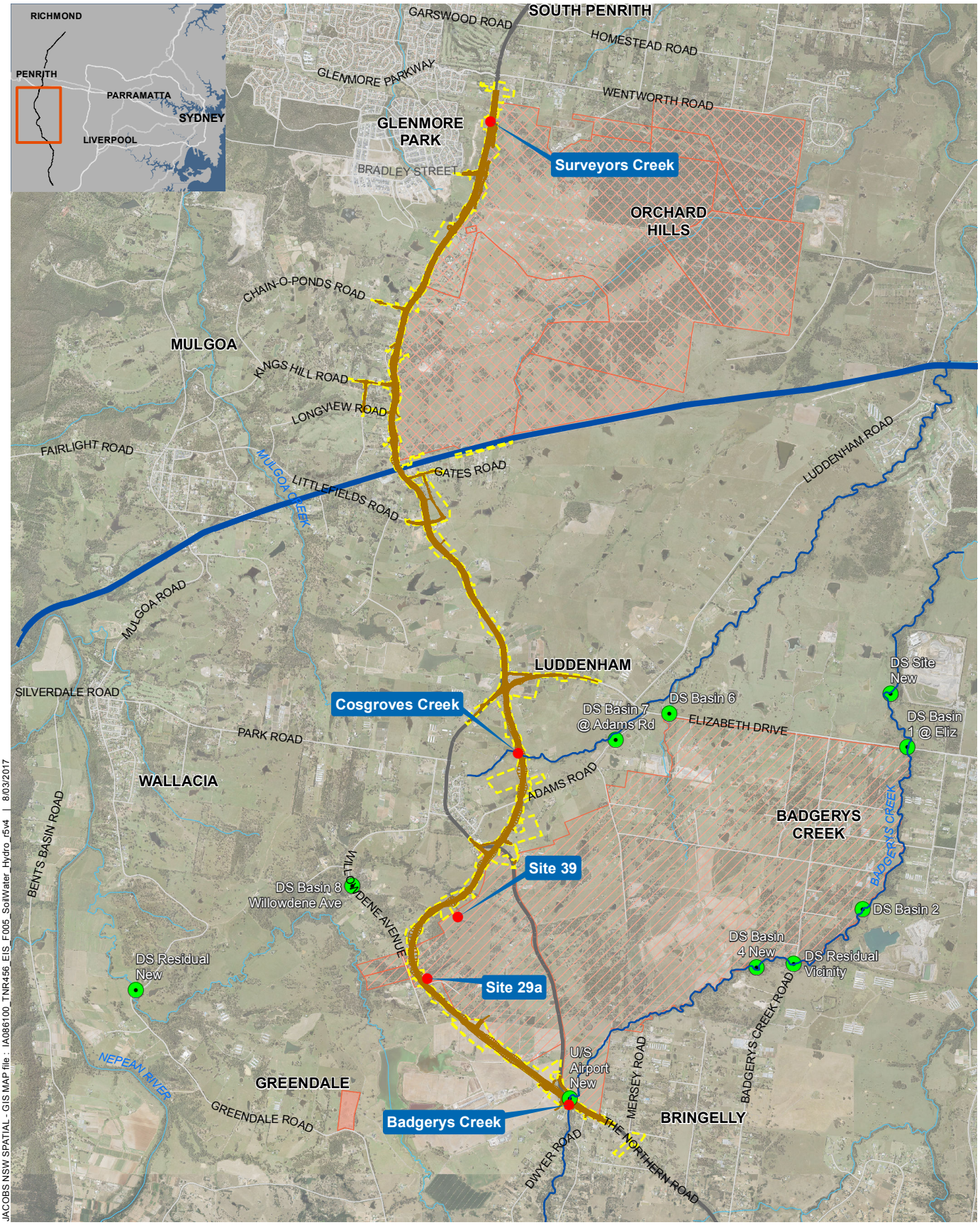
^ Exceed HRC trigger values but do not exceed ANZECC/ARCMANZZ (2000) trigger levels

Table 4-9: Water quality monitoring data (metals) (source: GHD Western Sydney Airport)

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Mercury (mg/L)
ANZECC/ARMCANZ (2000) Toxicant Values		0.013	0.0002	0.001	0.0014	0.0034	0.011	0.008	0.0019
D/S Basin 7 @ Adams Rd	2/11/2015	<0.0014	<0.0001	0.002*	0.012*	0.001	0.001	0.014*	<0.0001
	8/12/2015	<0.001	<0.0001	<0.001	0.001	<0.001	0.003	<0.005	<0.0001
	5/01/2016	<0.001	<0.0001	<0.001	0.006*	<0.001	<0.001	<0.005	<0.0001
	4/02/2016	0.001	<0.0001	<0.001	0.002*	<0.001	0.001	<0.005	<0.0001
	2/03/2016	0.005	<0.0001	<0.001	<0.001	<0.001	0.004	<0.005	<0.0001
D/S Basin 8 Willowdene Ave	2/11/2015	0.001	<0.0001	0.001	0.003*	<0.001	0.002	0.009*	<0.0001
	8/12/2015	0.001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Mercury (mg/L)
	5/01/2016	<0.001	<0.0001	<0.001	0.005*	<0.001	0.003	0.010*	<0.0001
	4/02/2016	<0.001	<0.0001	<0.001	0.002*	<0.001	0.001	<0.005	<0.0001
	2/03/2016	0.001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001
U/S Airport New	2/11/2015	0.006	<0.0001	0.002*	0.018*	0.002	0.006	0.032*	<0.0001
	8/12/2015	0.010	0.0001	0.003*	0.076*	0.004*	0.021*	0.293*	<0.0001
	5/01/2016	0.009	<0.0001	0.004*	0.069*	0.003	0.014*	0.082*	<0.0001
	4/02/2016	0.007	<0.0001	0.002*	0.024*	0.002	0.011*	0.058*	<0.0001
	2/03/2016	0.008	<0.0001	0.002*	0.005*	0.001	0.007	0.011*	<0.0001

***Exceeds ANZECC/ARMCANZ (2000) trigger value for toxicants for protection of 95% of species**



JACOBS NSW SPATIAL - GIS MAP file : IA086100_TNR456_EIS_F005_SoilWater_Hydro_r5v4 | 8/03/2017

Figure 4-5 | Key hydrological features

4.8 Groundwater

It is expected that three groundwater systems exists along the project alignment including shallow incidental perched aquifers, a regional shallow unconfined water table, and a deep confined aquifer unit.

The perched and shallow regional aquifers are contained within the weathered and fresh Wianamatta Group. The Wianamatta Group shales are characterised by saline groundwater due to marine deposition, and are generally not considered beneficial aquifers. The Wianamatta shales are generally low in permeability and occasionally have minor aquifers and perched water tables. These units behave as aquitards. The Wianamatta Shale is a low permeability formation and therefore the contribution of this aquitard to baseflow in surface water courses is expected to be minor to negligible. The regional water table has an approximate depth of 35mbgl (metres below ground level) as indicated by works summaries obtained from DPI Water. If present the shallow perched water tables, are expected to range from 2 to 30 mbgl depending on the depth of weathering and are anticipated to act in an unconfined manner.

The deep groundwater system comprises the Hawkesbury Sandstone. Recharge to the Hawkesbury Sandstone is expected to occur from rainfall and surface water interaction along the Lapstone Monocline along the far eastern edge of the Blue Mountains (west of the project alignment) and to a minor extent vertical percolation from the overlying Wianamatta Shale. Groundwater flow direction is expected to be north-easterly within the Hawkesbury Sandstone. There are some faults in the area that could indicate enhanced connectivity between the shallow and deeper groundwater systems. The deep groundwater system is considered to behave as a confined aquifer.

4.9 Conceptual Hydrogeological Model

The conceptualised hydrogeological model for the site is presented in **Figure 4-6**. The figure depicts the idealised key interactions between the surface water, regional shallow aquifer and regional deep aquifer systems.

The conceptual model consists of three groundwater systems that have potential to interact with the project as follows:

- Localised perched aquifer systems located in the shallow weathered shale and clay. Road cuttings are not expected to exceed 10m across the project. It is possible that the road cuttings will intercept incidental perched aquifers. The flow from these pockets is expected to be minor to negligible due to the low hydraulic conductivity of weathered shales and clays. These aquifers are likely to recharge and discharge during rainfall events. The Sydney Basin Central Groundwater Source is defined as a less productive groundwater source
- The Bringelly shale represents the regional shallow aquifer system. The depth to the groundwater table is expected to vary across the project, however because the project is largely centred on a topographic ridge, the depth to water is expected to be approximately 30mbgl. The water quality in this aquifer unit is expected to be of poor quality (high TDS) and low hydraulic conductivity. This unit is generally of limited beneficial use for potable or domestic use. The Sydney Basin Central Groundwater Source is defined as a less productive groundwater source
- The Hawkesbury Sandstone represents the deeper semi-confined regional aquifer. The Hawkesbury sandstone is generally of better quality than the shallow groundwater table. Local water supplies tend to be screened in this unit as it is more suitable for stock and domestic uses. This unit has a low primary hydraulic conductivity. This depth to this unit varies from 100 to 130mbgl. Groundwater in the shallow groundwater table is expected to generally flow north-east, down hydraulic gradient towards the Nepean River.

4.9.1 Surrounding Groundwater Users

There is limited groundwater use near the alignment of the project due to the geological environment comprising low permeability shale, siltstone and sandstone. Registered groundwater works were identified during a review of the DPI Water's Groundwater PINNEENA online database (accessed March 2016), which provides current groundwater works data across NSW. All groundwater works within a one kilometre radius (excluding monitoring bores) that are considered to extract groundwater were assessed as potential groundwater receptors to the project.

One work (GW108906) was identified within the study area (**Table 4-10**) and was drilled into un-weathered shale and sandstone. Other groundwater works within the study area are monitoring piezometers installed into the Wianamatta Shale. It is presumed these monitoring piezometers refer to local, site specific investigation for geotechnical or due diligence purposes. Data obtained from PINNEENA indicates the groundwater work (GW108906) is currently inactive.

Table 4-10 Groundwater Supply Works

Groundwater Works ID	Easting	Northing	Depth (mBGL)	Screen (mBGL)	Formation	SWL (mBMP)	Use	Lot/DP
GW108906	287656	6259328	186	48.9	Sandstone / Shale	30	test bore	11/831409

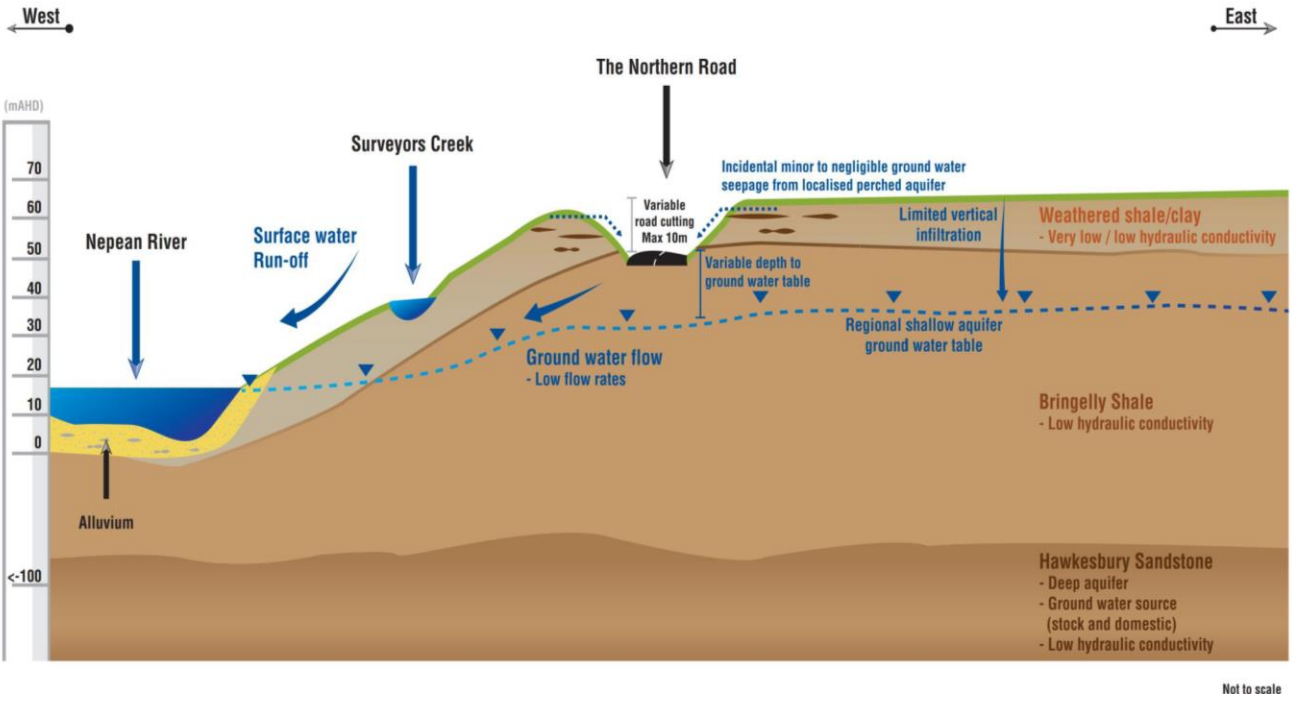


Figure 4-6 The Northern Road conceptual hydrogeological model

4.9.2 Surrounding Water Access Licences

The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 has established distance regulations to minimise interference between water supply works. A 400 m search for bores was conducted to comply with the minimum distance restrictions from an approved water supply work within the Sydney Basin Central Groundwater Source. There are no active Water Access Licences within 400 m of the study area.

4.10 Groundwater Dependant Ecosystems

A review of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* indicates there are no listed high priority GDE's located in the study area.

This Biodiversity Assessment Working Paper (**Appendix I** of the EIS) prepared for the project uses the definition of a groundwater dependent ecosystem (GDE) as outlined by Serov *et al.* (2012) which is an ecosystem which has its species composition and natural ecological processes wholly or partially determined by groundwater. The location of GDEs within the within the Hawkesbury Nepean CMA area is mapped by Kuginis *et al.* (2012). No high probability GDEs are mapped within or near the study area by Kuginis *et al.* (2012).

The majority of watercourses within the study area are ephemeral and most flow events occur in direct response to major rainfall. These systems are not considered to support GDEs (Serov *et al.* 2012). There is no evidence of baseflow feeding any of the streams within the study area. As such, none of the riparian zones within the study area are considered to be GDEs.

Similarly, a review of the Bureau of Meteorology Groundwater Dependent Ecosystems (GDE) Atlas did not indicate the presence of other groundwater dependent ecosystems.

5. Assessment of potential construction impacts

5.1 Geology and soils

Construction would remove vegetation during early works, clearing and grubbing. Excavations would be required at cut and fill locations along the proposed alignment, generally around the Western Sydney Airport site bypass. The construction of underpasses at Adams Road and near the Leppington Pastoral Company would also require significant earthworks. These types of construction activities have the potential to expose bare ground and soils.

Excavation would involve the stockpiling of spoil prior to reuse or removal from site. These and related construction activities would give rise to potential for erosion of unconsolidated material and entrainment by runoff and subsequent transported off site.

As identified in **Section 4.3**, the existing soil landscape groups within the project area consist of three principal soil landscapes. This includes the Luddenham and South Creek soil landscape groups which have been identified as having a high soil erosion hazard.

Soil erosion and sedimentation are risks posed to surface water quality throughout the construction phase through increased sediment loads entering downstream environments. Soil loss could occur due to the effects of wind or water. Soils transported into local drainage channels could have a number of impacts including:

- Reduced hydraulic capacity due to deposition of material within the channel
- Degraded water quality including lower DO levels, increased nutrients (nitrogen (N), phosphorus (P)), increased turbidity, and altered pH
- Increased levels of nutrients, metals and other pollutants transported via sediment and runoff to receiving waterways leading to increased potential for bioaccumulation of heavy metals in aquatic species
- Increased sedimentation smothering aquatic life and affecting aquatic ecosystems.

As outlined in **Section 3.1.6**, the Acid Sulfate Soil Probability within the project alignment was classified as Extremely Low Probability of occurrence. ASS is therefore not considered to be a risk to the project.

Surface water and groundwater can also dissolve and mobilise salts and cause their accumulation in other areas. Excessive concentrations of salt in such areas can affect plant growth, soil chemistry and cause weakening and degradation of construction materials such as masonry, concrete and bitumen. The assessment of salinity potential along the alignment was undertaken using the map of the salinity potential in western Sydney (NSW Department of Infrastructure, Planning and Natural Resources 2002). The majority of the alignment occurs in areas of moderate salinity potential. Construction activities are not expected to increase the potential for salinity impacts along the project corridor. Durability and aggressivity samples of soil material will be collected and analysed prior to the construction phase, to determine potential impacts of soil salinity on pavement infrastructure.

The geology of the site is not anticipated to be impacted by construction of the project.

5.2 Contaminated Land

Construction of the project, including the establishment of compound sites would partly occur in the existing road corridor (generally north of Littlefields Road) and along offline areas bypassing the Western Sydney Airport site and Luddenham.

Potential environmental impacts associated with these construction activities include:

- Inappropriate handling or disposal of contaminated or hazardous excavated materials
- Adverse effects on human health (construction personnel, travelling public or nearby communities)
- Release of contaminants into underlying soils
- Release of contaminants into groundwater
- Movement of contaminated sediments into stormwater systems

- Adverse effects on flora and fauna.

For the project, there is a potential for contaminated material to be disturbed through construction activities. The majority of AEIs identified are likely to pose a low risk of exposure to site users and environmental receptors to contamination during construction of the upgrade.

The following information summarises the AEI assessed as low to moderate and moderate risk from construction of the project:

- The stockpiles located on the eastern side of The Northern Road between Kingshill and Longview Roads, Orchard Hills are located close to the current road verge and could be disturbed as part of construction activities. The quality of the material within the stockpiles is unknown and could potentially contain contaminated material, including asbestos
- Although there is no evidence of UXO occurrence (from Commonwealth Department of Defence website) within or directly adjacent to the project area, explosives are used and are known to have been used at Defence Establishment Orchard Hills. Although the likelihood of encountering UXO during construction activities is likely to be low, the consequence if encountered could be high
- The market gardens located to the north and north east of the intersection of The Northern Road and Elizabeth Drive have been used historically and currently for intensive agricultural land use within and in the vicinity of the proposed upgrade. This land use could represent a potential source of contamination which could be exposed during construction activities. The contamination from agricultural activities is generally either point source (eg. localised chemical storage and use, waste disposal) or diffuse (broad acre pesticide or herbicide application). The biggest risk of exposure to agricultural contamination would be associated with point sources of contamination
- The stockpiles located on the western side of The Northern Road, north of Park Road, Luddenham are located close to the current road verge and could be disturbed as part of construction activities. The quality of the material within the stockpiles is unknown and could potentially contain contaminated material, including asbestos
- The WaterNSW supply pipelines corridor represents a potential source of contamination associated with the degradation of the external surfaces of the pipeline. The construction activities to be undertaken within the pipeline corridor poses an increased risk of exposure to contamination (if present) especially associated with excavations works within the corridor
- The non-operational service station (identified by concrete covered fill points in the carpark and vent stacks on adjacent building) located within the carpark of the Luddenham shops represents a potential source of contamination associated with leaks and spills from former fuel storage infrastructure (i.e. hydrocarbons and heavy metals). The location of the former service station in the near vicinity of the construction footprint of the upgrade poses an increased risk of exposure to contamination (if present) especially associated with deeper excavations
- The service station located to the south of the Luddenham shops on The Northern Road represents a potential source of contamination associated with leaks and spills from fuel storage infrastructure (i.e. hydrocarbons and heavy metals). The location of the service station in the near vicinity of the construction footprint of the upgrade poses an increased risk of exposure to contamination (if present) especially associated with deeper excavations
- The widespread agricultural land use within and in the vicinity of the proposed upgrade represent a potential source of contamination which could be exposed during construction activities. The contamination from agricultural activities is generally either point source (eg. localised chemical storage and use, waste disposal) or diffuse (broad acre pesticide or herbicide application). The biggest risk of exposure to agricultural contamination would be associated with point sources of contamination
- Although the location of car accidents are not accurately known, the release of fuels and oils from vehicle accidents and the potential use of aqueous film forming foam (AFFF) in the event of a vehicle fire could cause residual contamination in the vicinity of the accident site. Although contamination is likely to be very localised at these sites, the risk of exposure to contamination from these accident sites (if present) during construction of the upgrade is likely to increase as the accidents sites are likely to have occurred on the majority of the current road system which is within the construction footprint.

The majority of the AEIs are considered to represent a low risk with respect to contamination impacting upon construction of the project (refer to exposure risk levels identified in **Table 4-4**). Despite the low to moderate rating of the remainder of the potential AEIs within and adjacent to the project, the risk of contamination impacting upon proposed construction activities would be increased if excavation works take place within these areas.

5.3 Surface Water

The construction phase of the project presents a risk to further degradation of downstream water quality if management measures are not implemented, monitored and maintained throughout the construction phase. If unmitigated, the highest risk to water quality would occur through the following construction activities:

- General construction works that occur upstream of waterways such as Surveyors Creek, Cosgroves Creek and Badgerys Creek
- A number of construction activities would occur within the catchments surrounding the project as outlined above, namely Surveyors Creek, Cosgroves Creek, Badgerys Creek and unnamed tributaries and farm dams. The project would require traversing a number of these waterways and farm dams as follows:
  - Badgerys Creek
  - Cosgroves Creek
  - a number of unnamed tributaries of Duncan's Creek
  - an unnamed tributary of Surveyors Creek
  - a number of unnamed farm dams and watercourses

  Watercourse crossings would be designed and constructed to minimise impacts on natural flow regimes and to not present any barriers. All waterway crossings will be designed in conjunction with *Why do fish need to cross the road – Fish Passage requirements for Waterway Crossings (*Fairfull and Witheridge 2003) and the *Policy and Guidelines for Fish Friendly Waterway Crossings (*DPI 2004). Additionally, temporary watercourse crossings may be required for some or all watercourses traversed by the project to facilitate construction activities. If required, these watercourse crossings would likely comprise a temporary causeway with culverts to maintain the low flows, and they would likely be maintained for the duration of construction. Temporary watercourse crossings may impact on water quality due to the disturbance of bed and banks resulting in erosion and sedimentation, alteration of downstream flows potentially creating isolated stagnant pools of water and scouring of the bed near culvert inlets and outlets. A total of 11 culverts will be installed and/or replaced at the various waterway crossing locations as identified above. The type of each waterway crossing is provided in **Table 4.6** of the Biodiversity Assessment Working Paper (**Appendix I** of the EIS)
- The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 metres of the river banks, lake shore or estuary mean high water mark. All works on waterfront land will be carried out in accordance with the DPI Water Guidelines for Controlled Activities on Waterfront Land (2012), including but not limited to those related to instream works and waterway crossings.
- Additionally as identified in the Hydrology and Flooding Working Paper (**Appendix K** of the EIS, increases in the rate of flow in the receiving drainage lines could result in a lowering of the stream bed through a process of headwater erosion, as well as a possible widening of the watercourse through a process of bank erosion. The lining of channels and the concentration of flow could result in localised scour in the receiving drainage lines at the downstream limit of the drainage works. Scour protection measures such as dumped rock rip rap would be incorporated in the design of the project in order to reduce the scour potential in the receiving drainage lines (refer to **Appendix K** for further details)
- Disturbance/mobilisation of sediment associated with general earthworks including vegetation removal, stripping of topsoil and filling particularly when these sites are located close to waterways. Removal of vegetation and/or filling (generally minor) is proposed at several locations including Surveyors Creek and a tributary of Surveyors Creek, unnamed tributary near Elizabeth Drive, Cosgroves Creek and a tributary of Cosgroves near Adams Road, tributaries of Duncans Creek (particularly near Willowdene Avenue), Badgery's Creek and tributary of Badgerys Creek. Vegetation removal and filling is also proposed around a number of dams. Fill requirements throughout the project are generally minor however loose fill has the potential to be eroded during rainfall events by runoff, thereby increasing the potential for mass movements

of soils and sedimentation of the abovementioned waterways where filling is proposed. This has the potential to smother vegetation and change the soil surface characteristics and habitat of adjacent areas

- Clearing and subsequent flooding and erosion from construction in areas comprising of fine silt and clay can result in siltation of downstream watercourses and storages, particularly in relation to works in and around Cosgroves Creek and Badgerys Creek as identified in section 4.2 as likely to contain alluvium deposits comprising fine sands, silt and clay
- Construction works undertaken within 50 metres of the nominated sensitive receiving waterways (Type 1 Key Fish Habitat) (refer **Section 4.7**) has the potential to impact on bank stability and water quality through excavation, clearing or placement of construction stockpiles. Potential impacts associated with construction works include loss of suitable bank habitat, loss of in-stream shading and increased sedimentation of the watercourses through surface runoff. Detailed design has ensured that no stockpiles are placed within 50m of Type 1 – Key Fish Habitat waterways
- Disturbance and scour of the watercourse bed and banks particularly where culverts and other drainage works are proposed in Cosgroves, Surveyors and Badgerys Creeks resulting in erosion and sedimentation
- Dewatering activities during construction may mobilise sediments and contaminants, and increase the turbidity of the receiving environments along the project, potentially having an adverse impact on water quality if not appropriately managed
- Ancillary facilities to support construction would be required at various locations along the project. Ancillary facilities would include construction compounds, stockpile areas, material and waste storage areas including spoil stockpiles and other waste materials, sediment basins and concrete/asphalt batching plants. The final type, location and number of ancillary facilities would be determined by the construction contractor. The Hydrology and Flooding Working Paper (**Appendix K** of the EIS) has identified that there is the potential for flooding where proposed ancillary sites are proposed near Badgerys Creek. This has the potential to impact on the water quality at this site through flood waters mobilising sediments within stockpile and sediment basins, waste materials and chemicals associated with the ancillary facilities
- Stockpile sites would be used to temporarily store excess spoil and wastes such as concrete from demolition before their reuse on-site or disposal off-site. As stockpile sites present the potential for sediment-laden runoff to wash offsite into the storm water systems and receiving environment, all stockpile sites would include environmental protection measures such as sediment controls and hoardings to minimise impacts on sensitive receivers from dust and receiving waters from erosion and sedimentation and waste contamination. Stockpiles sites would be established and managed in accordance with Environmental Procedure Management of Wastes on Roads and Maritime Services Land (RMS, 2014)
- If stockpiles are to be located within the floodplain, the obstruction of flow paths and loss of floodplain storage has the potential to cause flooding impacts. Loose material stored within the floodplain has the potential to be mobilised during a flood and may impact on water quality downstream
- Construction activities adjacent to waterways could introduce contaminants such as oil or greases and disturb contaminated sediments, potentially having an adverse impact on water quality
- Changes to hydrology and flow have the potential to impact on artificial wetlands which comprise of farm dams, detention basins, roadside drains and effluent treatments systems. Impacts to wetlands are discussed in **Section 7.3** of the EIS and the Biodiversity Assessment Working Paper (**Appendix I** of the EIS)
- Relocation and protection of utilities including potential dewatering of potable water from watermains. Relocation of utilities would involve soil disturbance by trenching and underboring. The disturbance of soil by machinery could increase the potential for soil erosion. Potable water is chlorinated which has the potential to impact on downstream water quality. This has the potential to impact aquatic biodiversity if not managed appropriately
- Transportation of cut and/or fill materials throughout the study area
- Accidental leaks or spills of chemicals, fuels and oils from construction plant or construction materials
- Movement of heavy vehicles across exposed earth

- There is the potential for asbestos fibres to be present in existing stockpiles along the alignment which could potentially migrate through surface water flows if disturbed during construction and not appropriately controlled.

The introduction of pollutants from construction of the project into the surrounding environment if uncontrolled could potentially impact on the water quality of the receiving waterways including Surveyors Creek, Cosgroves Creek and Badgerys Creek, their unnamed tributaries and farm dams in the following ways:

- Increased sediment loads and organic matter from exposed soil during site disturbance and movement of construction vehicles, particularly following rainfall events. This can result in elevated turbidity levels and increased levels of nutrients, metals and other pollutants in downstream waterways in close proximity to the construction works. Increased sedimentation has the potential to smother aquatic life and affect the ecosystems of downstream waterways which would potentially impact on downstream users such as commercial and recreational users. Provided safeguards and management measures are implemented, the project would be unlikely to contribute significant amounts of sediment and organic matter to the immediate waterways. Additionally the waterways in the area have been described as generally low flow with disconnected pools or ephemeral, as such impacts are likely to be localised and occur under high flow conditions and impacts on the downstream environment negligible. Localised impacts such as a deterioration in water quality of farm dams would potentially impact on associated farm dam users
- Increased levels of litter, spoil and other waste materials from construction activities and ancillary sites polluting downstream watercourses
- Tannin leachate from clearing and mulching
- Chemical, heavy metal, oil and grease, and petroleum hydrocarbon spills from construction machinery directly contaminating downstream waterways
- Construction activities could introduce additional materials to local drainage lines, particularly during high rainfall events. Contaminants could include those from construction materials, rubbish, fuel and chemicals from accidental spills.

The potential impact on receiving waterways during construction would generally be mitigated through erosion and sediment controls including appropriately sized temporary sediment basins in accordance with the requirements of the Blue Book. A Surface Water Management Plan would be prepared as part of the environmental management plan prior to the commencement of construction. The plan would detail such measures for reducing the incidence of sediment, litter of chemical pollution reaching Surveyors Creek, Cosgroves Creek, Badgerys Creek and other nearby waterways within the study area during the construction phase. Waste storage and management procedures would also be developed and implemented during construction to ensure appropriate waste storage, transport and disposal management measures are implemented, in particular in relation to the proposed ancillary facilities.

Additionally preconstruction water quality monitoring would be undertaken upstream and downstream of proposed waterways that have the potential to be impacted during the construction of the project. This will provide an appreciation of the existing water quality and allow the development of site specific trigger values as per ANZECC/ARMCANZ (2000) to meet to ensure there is no further degradation in water quality or impact on the nominated environmental values.

Given the ephemeral nature of these waterways which are at times disconnected pools, the poor water quality and small volume of these streams and creeks is unlikely to impact on the downstream larger creeks and rivers to which they discharge. As such any changes in water quality are likely to be localised and not affect downstream users, particularly commercial and recreational users of South Creek and the Nepean River. Overall, potential impacts on surface water quality during construction are considered minor and manageable with the application of standard mitigation measures (as detailed in **Sections 7** and **8**).

5.3.1 Chronic and acute water quality impacts

Water quality impacts from construction are also discussed below in terms of chronic (or day to day) impacts and acute impacts (which result from a one-off severe event). Water quality during construction is proposed to be managed primarily through a series of sedimentation basins and other measures (refer **Section 7.1.1**). Temporary sediment basins have been designed in accordance with the Blue Book with key criteria considered

including catchment area contributing to sediment basin, percentage of cut and fill in sub-catchment and whether basin is located in a sensitive receiving environment.

Chronic impacts to water quality are expected to be minimal as sediment basins have been designed for the 80th percentile, 5 day rainfall depth for most basins. Upstream of sensitive receiving environments, the Blue Book (Table 6-1 Vol 2D) requires that the 85th percentile be used construction projects with a duration of more than 6 months. Therefore some basins have been designed for the 85th percentile which means that they would be slightly larger. It should be noted however that larger storm events could result in overtopping of basins and the potential deposition of sediment and associated pollutants into receiving waterways.

Risks of acute water quality impacts during construction would primarily be related to spills or leaks of fuel/oil from machinery due to accidents or negligence. Given that sediment basins (50 in total) are proposed throughout the project area and are of an appropriate size to capture spills of this nature the likelihood of impacts to waterways is minimised. Additionally, onsite and offsite diversion drains, sediment fences, spill procedures, spill kits and erosion controls at the source will provide additional protection of waterways.

5.4 Groundwater

The main potential construction phase groundwater impacts relate to:

- Groundwater levels, flows and connectivity: These include changes to groundwater connectivity, groundwater flow direction, groundwater levels and recharge rates
- Groundwater chemistry: these include pollution of groundwater and changes to groundwater quality
- Groundwater users: Interference to aquifers resulting in a decrease or change in groundwater levels that subsequently affect groundwater users and/or groundwater dependent ecosystems and riparian areas and wetlands.

5.4.1 Impact on groundwater levels, flow and connectivity

The majority of cuttings are not likely to be deep enough to intercept the shallow groundwater table. If by chance cuttings do intercept the shallow groundwater table, the extent of drawdown is likely to be minimal and limited in extent due to the low permeability of the shallow aquifer system (clay regolith and weathered shale). The Wianamatta Shale is a low permeability formation and therefore the contribution of this aquitard to baseflow in surface water courses is expected to be minor to negligible. In this regard there are no expected material changes to groundwater levels or flow direction to the shallow groundwater table.

The depths of cuttings are generally 4-8 mbgl along the project alignment with the exception of several planned cuttings ranging from 10-12mbgl. It should be noted that groundwater works GW108906 is located 170m east of one of the planned major cuttings. This groundwater works is inactive, is screened at 48mbgl and has a historic standing water level at 30mbgl. The groundwater level in GW108906 is likely representative of the deeper groundwater system. The road cutting is therefore unlikely to have any impact on this site.

A perched shallow water table may be encountered; however, the spatial extent of drawdown would be minor to negligible. Similarly, the magnitude of seepage through the road cuttings is expected to be negligible, presumably much less than 0.1L/s/kilometre. This is calculated based on the expected transmissivity of weathered shale and clay. In this regard, no material changes are expected to groundwater levels, flow direction or groundwater connectivity as the unit itself is made up of a geological unit that is already of low permeability.

The proposed fill locations are not expected to impact the groundwater. The existing surface geology is comprised of low permeability material which is expected to match the material characteristics of the compacted fill used for the road alignment which will also be low permeability. The primary concern being that fill material will change the hydraulic characteristics of the underlying geology or create a connection between aquifers. Because the fill is all surficial and will match the characteristics of the underlying geology there are no expected impacts to the shallow aquifer. Compaction is the only expected geotechnical ground treatment, as outlined above this activity is not expected to impact on the hydraulic properties of the shallow aquifer.

5.4.2 Impact on groundwater chemistry

There is a minor potential for spills or leaks to allow oil and grease contamination to enter shallow aquifers. Any petroleum hydrocarbon spill from construction machinery has the potential to seep into the shallow groundwater

system. However this would be avoided where possible or potential impacts minimised through the implementation of relevant safeguards as identified in **Section 8** of this report.

5.4.3 Impact on groundwater users

There is no expected drawdown to the regional shallow unconfined water table. There is therefore no expected groundwater impact to groundwater users including water supply users, GDEs, riparian areas or wetlands.

6. Assessment of potential operational impacts

6.1 Geology and soils

The geology of the site is not anticipated to be impacted by the project.

After construction, cleared areas would be paved/landscaped and scour protection installed at drainage outlets. There would be no exposed areas of topsoil and therefore little or no risk of soil erosion and entrainment of unconsolidated material by wind or runoff. During operation, the risk of soil erosion would be minimal as all areas impacted during construction would be asphalt or rehabilitated and landscaped to avoid soil erosion from occurring.

Several treatments, including retaining walls and fill embankments would be provided to suit the existing conditions and to integrate the project with the surrounding landscape.

Assessment of hydrological impacts of the project are addressed in the Hydrology and Flooding Working Paper (**Appendix K** of the EIS) prepared for the project. The drainage network would be designed to account for any additional runoff expected as a result of new paved areas and culverts would be sized accordingly.

The Hydrology and Flooding Working Paper identifies the potential for the project to cause scour in the receiving drainage lines as a result of the rate, velocity and concentration of flow. Increases in the rate of flow in the receiving drainage lines could result in a lowering of the stream bed through a process of headwater erosion, as well as a possible widening of the watercourse through a process of bank erosion. The lining of channels and the concentration of flow could result in localised scour in the receiving drainage lines at the downstream limit of the drainage works. Measures such as dumped rock rip rap protection would be incorporated in the design of the project in order to reduce the scour potential in the receiving drainage lines (refer to **Appendix K** of the EIS).

6.2 Contaminated land

Incidents such as vehicle accidents on the intersection could result in spillage of contaminants or hazardous materials on to the roadway. If not contained and/or cleaned up promptly, there is potential for these to enter the drainage system and be discharged to receiving waterways and groundwater. Accidental spills could impact negatively upon both human health (mainly through direct contact and inhalation exposure pathways) and environmental receptors including receiving soil and water ecosystems.

The operational vegetated swales (see 7.1.2) would function as a containment area for any accidental on-road spills. These water quality channels are subject to maintenance and, in the event of an accident or spill, would be assessed for immediate clean-up.

Overall, the project would only resent a minor increase in the potential for contamination compared with current operation of the road, associated increased vehicle traffic in the future.

6.3 Surface water

The project would involve the construction of new road through greenfield areas and the widening of the existing The Northern Road (and therefore increased impervious areas) that will discharge runoff to the receiving environment. The operation of the project will impact on water quality due to discharge of drainage at new locations or increased discharge at existing locations where road and drainage upgrades have occurred.

The operation of the project has the potential to alter existing hydrology and flooding regimes which may impact on water quality due to increased runoff volumes and peak flow rates. Increased flow rates can impact on the bed and bank stability of watercourses making them highly susceptible to erosion (refer to the Hydrology and Flooding Working Paper in **Appendix K** of the EIS for more information). Stream erosion increases sediment and nutrient loads leading to decreased water quality which would affect the protection of the nominated environmental values.

Operation of the project has the potential to affect existing local water quality due to the generation of additional pollutants directly attributable to increased impervious surface areas and associated increased vehicle traffic in the future. The most important pollutants of concern relating to road runoff are:

- Sediments from the paved surface from pavement wear and atmospheric deposition
- Heavy metals attached to particles washed off the paved surface
- Oil and grease and other hydrocarbon products.

Increased stormwater runoff from new impervious surfaces created by the project would result in a deterioration of water quality due to increased sediment, nutrient loads, oil and grease and floating debris. Additionally the elevated nutrients could result in undesirable aquatic life such as algal blooms or dense growths of attached plants or insects. Without appropriate management, this would result in a more degraded ecosystem that is unable to support aquatic life or aesthetically valuable flora and fauna (refer to the Biodiversity Assessment Working Paper, **Appendix I** of the EIS for more information). The emphasis in stormwater quality management for road runoff is that of managing the export of suspended solids and associated contaminants – namely heavy metals, nutrients and organic compounds (Austroads, 2001). Pollutants such as nutrients, heavy metals and hydrocarbons are usually attached to fine sediments (RTA, 2003). The key concern with increases of these contaminants is the runoff and discharge to the identified receiving environments which contain key fish habitat. Therefore trapping suspended solids is the primary focus of the water quality management strategy for the operational phase of the project. A number of operational water quality swales have been proposed for the project and their effectiveness in managing water quality was assessed via music modelling for those swales which are proposed to control runoff to sensitive receiving waterways as identified in this report.

The results of the water quality assessment indicate that some pollutant load reduction can be achieved by the proposed swales. The pollutant load reduction results vary from one pollutant to another as follows: For Suspended Solids (81% to 90%), for Total Phosphorus (43% to 55%) and for Total Nitrogen (14% to 49%). These results have been achieved across all twenty-four swales, including those located upstream of the locations where the pavement runoff discharges into the five identified sensitive receiving waterways as shown on Table B2 in **Appendix B**.

The proposed swales are highly efficient at providing suspended solid capture and reasonably efficient at reducing nutrients. Accidental spills could occur on any road; however the improved horizontal and vertical geometry of the upgrade and the improved layout of the signalised interchanges would reduce the current risk of accidental spills, therefore no spill basins are proposed.

Similarly to the construction of the project, impacts to water quality are expected to be localised to the creeks, waterways and farm dams directly impacted by the project, namely Surveyors Creek, Badgerys Creek, Cosgroves Creek and other unnamed tributaries. The operation of the project, even with increased flow and runoff is expected to be negligible to downstream waterways and the nominated uses of these waterways will not be affected. They key concern of the operation of the project continues to be the impact of water quality runoff on the identified sensitive receiving environments. It is not expected that there would be any water quality impact on the downstream receiving environments.

6.4 Groundwater

As outlined above, groundwater seepage during the operational phase is likely to be minor and temporary after rainfall events.

The main potential operational phase groundwater impacts from any road project relate to:

- Groundwater levels, flows and connectivity: These include changes to groundwater connectivity, groundwater flow direction, groundwater levels and recharge rates
- Groundwater chemistry: these include pollution of groundwater and changes to groundwater quality
- Groundwater users: Interference to aquifers resulting in a decrease or change in groundwater levels that subsequently affect groundwater users and/or groundwater dependent ecosystems and riparian areas and wetlands. Impact on groundwater levels, flow and connectivity.

Potential impacts to groundwater as a result of the project are further discussed below.

6.4.1 Groundwater levels, flows and connectivity

There is not expected to be any material impact during operation on groundwater level or connectivity, any impact would be minor and short term. The project is not expected to interact with groundwater during operation. There is no planned groundwater abstraction that would impact groundwater levels, flow or

connectivity during the operational phase of the project. The installation of the road infrastructure will result in reduced local recharge into the groundwater along the paved section of the road, as precipitation that would normally fall on the recharge surface will be drained away The impact on the local groundwater system is expected to be minor and short term as the surface water runoff is expected to infiltrate into the regional groundwater system regardless of the increased paved area.

6.4.2 Impact on groundwater chemistry

There is no expected operational impact on groundwater chemistry during the operational phase of the project given the unlikely occurrence of accidental spills as well as the proposed operational control of runoff. Any impact is likely to be minor and short term. Impact on groundwater users

There is no expected drawdown to the regional shallow unconfined water table during the operational phase of the project. Therefore any impact to groundwater users including water supply users, GDEs, riparian areas or wetlands is likely to be minor and short term.

7. Proposed Mitigation Measures

The potential impacts on water quality as a result of the upgrade would be minimised by implementing adequate temporary and permanent water quality controls for the construction and operational phases respectively. For the construction phase, erosion and sediment controls including sediment basins have been designed and sized in accordance with the requirements of the Blue Book (Soils and Construction, 2008 Volume 2D Main Road). For the operational phase water quality treatment would be provided through vegetated swales with rock check dams. The vegetated swales would provide treatment for suspended solids and any particle bound heavy metals.

7.1.1 Construction phase

Water quality controls

Techniques to reduce potential water quality impacts and prevent degradation of downstream waterways include the use of a range of erosion and sediment controls including progressive clearing and rehabilitation of land to reduce the amount of exposed disturbed areas and subsequent offsite sediment loss during construction, implementation of diversion drains to direct clean water away from disturbed areas, sediment and erosion controls at the source such as sediment fences, silt barriers, covering disturbed areas and stockpiles with geofabric material or similar, controlled access points for construction plant and vehicles, or sediment controls such as basins.

The site topography and the number of cross drainage culverts is such that a large number of sediment basins would be required to treat every section of the construction area throughout all stages of the work. In order to minimise the number of sediment basins, and the impact of the construction of these basins on the local natural environment, the Blue Book criteria of 'Minimum 150m^3 of annual sediment loss has been adopted. This criteria indicates that if the estimated annual soil losses from a disturbed catchment is less than 150 m^3, then a sediment basin may not be required subject to other erosion and sediment controls being implemented.

It was estimated that a contributing disturbed area exceeding about 1.0 ha on this project would generate 150 m^3 of annual soil loss. Therefore for catchments less than about 1.0 ha, a sediment basin has not been proposed. This is about the equivalent of a surface area of 50 m wide and 200 m long. If 50 m is assumed to be an average width of disturbance, then lengths of about less than 200 m would not require a sediment basin. These dimensions represent an approximation only as catchments widths and shapes vary. In total about 50 temporary sediment basins are proposed during construction of the project. These are listed in **Table 7-1** below.

Where construction phase water quality sedimentation basins are required, the design criteria are defined in the Blue Book (Soils and Construction, 2008 Volume 2D Main Road) which requires that sediment basins be designed for the 85 percentile, five day rainfall depth for basins located near sensitive receiving environments, and for the 80th percentile for non-sensitive receiving environments.

At the locations where sediment basins are not required (i.e. catchment areas less than 1.0 ha), impacts to waterways would be appropriately managed through the implementation of controls as outlined in an Erosion and Sediment Control Plan to be developed for the project. This may include small sediment traps (typically less than 5m^3 each) where possible.

In addition, where basins are required, consideration would be given to the following relevant documents in their design:

- *Managing Urban Stormwater: Soils and Construction, Volume 2D Main Road Construction* (DECC, 2008)
- *Managing Urban Stormwater – Soils and Construction, Volume 1 4th Edition*, March 2004
- Roads and Maritime General Specifications G36 and G38.

The sediment basins would provide sufficient volume for settling and storage of sediments. The settling zone volume would be estimated using the appropriate design rainfall depth and catchment areas. The storage zone is estimated using the Revised Universal Soil Loss Equation (RUSLE).

The sediment basins on the Northern Road have been designed as Type D or F, as per the Blue Book classifications and the assumed soil parameters. Some localised pockets of Type C soils exist; however these are small and isolated, therefore Type D soils have been adopted for the design. Type F basins treat runoff for

fine soil particles and type D basins treat runoff for fine and dispersible soils. The type D basins would require flocculation during the construction for the settlement of fine soil particles in the basins.

The three key design elements that have been used in the individual sizing of each sediment basin are:

- Catchment areas contributing to the sediment basins (disturbed and undisturbed areas)
- The percentage of the total contributing sub-catchment area that is either “cut” or “fill”. These are batters/embankment areas that would generally be in the order of less than 25 per cent for this project. These sub-catchments generate greater soil losses and
- Whether the basin is located in a “sensitive” environment, thus requiring the 85th percentile, five day rainfall depth design criteria.

Other design input parameters include, soil type, rainfall erosivity (which is a function of local rainfall intensity), soil hydrologic group, volumetric runoff coefficients and soil erodibility. From these key elements and the Blue Book design methodology, the sediment basin volumes have been derived.

An assessment of the construction phase catchments and the selected sediment basin locations have been carried out to confirm all sediment basin locations. The location of the sediment basins have been selected to provide the maximum runoff capture from catchments throughout the construction process using gravity driven diversion drains to divert runoff to the basins. The required volume of each sediment basin has been determined according to an estimate of the maximum disturbed catchment area that drains to the basin during various stages of the construction.

After the sediment basin locations were identified, basins were modelled in 12D. This means that the location and basin volume was tested for each basin against the local existing and proposed contours in a 3D model. This was done to ensure the space requirements for the construction phase sediment basins were adequate, to determine or confirm that they could be built within the boundary requirements.

The exact location and sizing of sediment basins would be determined during detailed design and would be implemented during construction to avoid substantial impacts to the environment.

Sediment basin design

The proposed locations and sizes of the 50 temporary sediment basins for the construction phase of the road upgrade are presented in **Table 7-1** and shown on **Figure 7-1**.

The design and the location of the road have a substantial effect on the size and location of the basins. The design of the sediment basins would be confirmed during detailed design.

Table 7-1 Temporary sediment basins for the reference design of The Northern Road upgrade

Basin name*	Min basin volume required (m^3)	Receiving Creek^
B560R	882	Badgerys Creek
B670R	935	Badgerys Creek
B880R	209	Badgerys Creek
B940R	468	Badgerys Creek
B1320R	1835	Badgerys Creek
B2200L	632	Duncans Creek
B2580L	589	Duncans Creek
B2820L	335	Duncans Creek
B3250L	830	Duncans Creek
B3340L	781	Duncans Creek
B3740L	761	Duncans Creek
B3800L	650	Duncans Creek

Basin name*	Min basin volume required (m^3)	Receiving Creek^
B4400L	714	Duncans Creek
B4500L	329	Duncans Creek
B4760L	714	Duncans Creek
B5140L	1439	Duncans Creek
B5060L	329	Duncans Creek
B5710R	403	Cosgroves Creek
B6260R	695	Cosgroves Creek
B6660R	787	Cosgroves Creek
B6800L	436	Cosgroves Creek
B7040L	293	Cosgroves Creek
B7100L	532	Cosgroves Creek
B7420L	417	Mulgoa Creek
B7440R	406	Cosgroves Creek
B7660R	444	Cosgroves Creek
B7680R	350	Cosgroves Creek
B7960R	331	Cosgroves Creek
B8420R	499	South Creek
B8480R	481	South Creek
B9000R	645	South Creek
B240R	476	Blaxland Creek
B260R	323	Blaxland Creek
B580L	659	Blaxland Creek
B620R	891	Mulgoa Creek
B900R	275	Blaxland Creek
B1280R	1110	Blaxland Creek
B1780L	446	Mulgoa Creek
B1820L	251	Mulgoa Creek
B2140R	659	Blaxland Creek
B2540L	300	Blaxland Creek
B2860R	977	Blaxland Creek
B2900R	676	Blaxland Creek
B3680R	589	Blaxland Creek
B4600R	695	Surveyors Creek
B5120R	891	Surveyors Creek
B5520R	731	Surveyors Creek
B6020R	1161	Surveyors Creek
B6320L	589	Surveyors Creek
B6660R	730	Surveyors Creek

*B5200L denotes that the sediment basin is at approx. Chainage 5,200, and L indicates that it is on the Left hand size, looking at increasing chainages

^Receiving creek refers to the named creek itself or an unnamed tributary draining into the named creek

Groundwater Controls

It is not expected that specific controls for groundwater will be required. This is primarily due to the low to very low permeability of Wianamatta Shale and subsequently minor to negligible extent of drawdown and negligible seepage through identified road cuttings. The expected groundwater inflows are anticipated to be in the order of 0.1 L/s/km of cuttings, although probably much less. It is considered prudent that if groundwater is encountered during excavation works the groundwater monitoring plan detailed below should be implemented.

Surface Water Monitoring

Prior to construction, baseline water quality monitoring would be undertaken to identify parameters for monitoring during construction and to determine indicative existing water quality. Sampling locations and monitoring methodology would be determined during the detailed design stage. In accordance with the *Guideline for Construction Water Quality Monitoring* (RTA 2003) the following parameters are recommended to be monitored:

- pH, electrical conductivity, dissolved oxygen, turbidity and temperature;
- total suspended solids;
- oils and grease;
- other parameters as identified from existing literature, previous water quality monitoring or recommendations from government organisations such as NSW OEH, EPA, DPI and Council.

Data collected during the preconstruction monitoring would be used to develop site specific trigger values so that monitoring undertaken during the construction phase can be compared to these values. This will identify if any changes in water quality are a result of construction activities and demonstrate compliance with any monitoring requirements or targets (RTA 2003)

7.1.2 Operational Phase

Water quality controls

The ANZECC/ARMCANZ and HRC Guidelines indicate that several physical-chemical and toxicant parameters need to be controlled to maintain the required protection level for aquatic ecosystems and visual amenity during the operational phase of the project. Some of the parameters include nutrients (total phosphorus, total nitrogen and ammonia), suspended solids, oils and grease, petroleum hydrocarbons and several heavy metals including copper, lead, cadmium, zinc and chromium which are commonly found in stormwater runoff from roads.

This section of the report focuses on the proposed water quality controls for the operational phase of the project. Water quality during operation would be managed by:

- Procedural controls
- Physical controls
- Monitoring.

Vegetated Swales

There are proposed swales (table drains) that convey pavement runoff to the receiving waterways and creeks. These swales will provide some water quality treatment depending on their length and slopes. Rock check dams have been added for these swales to provide additional treatment by slowing down the runoff and allowing it to temporarily pond during storm events

Pollutant removal is facilitated by the interaction between the flow and the vegetation along the length of the swale. The vegetation and rock check dams act to spread and slow velocities, which in turn aids the deposition of sediments. Ten swales are proposed upstream of the environmentally sensitive creeks as identified above in terms of those that are classified as sensitive receiving environments as identified in the Biodiversity Assessment Working Paper (**Appendix I** of the EIS). An additional fourteen swales have been proposed wherever possible for further water quality treatment into other receiving waterways. These swales are labelled as S1 through to S24 as shown in **Table 7-2** and **Figure 7-1**.

In order to protect these sensitive receiving environments the size of these swales has been optimised where possible and rock check dams have been added. Other swales, whilst not located in sensitive receiving environments have been provided elsewhere throughout the project area.

Table 7-2 Permanent water quality swales for the reference design of The Northern Road upgrade

Swale name	Swale length (m)	Receiving Creek	Catchment area to swale (ha)
S1	280	Badgerys Creek	2.16
S2	35	Badgerys Creek	0.24
S3	95	Unnamed Creek	0.56
S4	150	Unnamed Creek	0.39
S5	95	Unnamed Creek	0.24
S6	185	Duncans Creek	0.58
S7	150	Duncans Creek	1.37
S8	90	Unnamed Creek	0.91
S9	110	Duncans Creek	1.55
S10	70	Duncans Creek	0.83
S11	35	Duncans Creek	0.23
S12	375	Unnamed Creek	3.55
S13	40	Unnamed Creek	0.54
S14	110	Cosgroves Creek	3.67
S15	105	Unnamed Creek	0.31
S16	40	Unnamed Creek	1.46
S17	65	Unnamed Creek	0.49
S18	115	Unnamed Creek	1.77
S19	50	Unnamed Creek	0.59
S20	115	Unnamed Creek	1.64
S21	135	Unnamed Creek	0.67
S22	155	Unnamed Creek	1.00
S23	140	Surveyor's Creek	0.96
S24	195	Surveyor's Creek	1.15

A water quality assessment has been undertaken to estimate the pollutant load reductions that would be achieved by the proposed swales shown in **Table 7-2**. This assessment has been undertaken using the eWater water quality MUSIC model (Ver 6.2).

The pollutant load reduction results of the water quality assessment are shown in **Table 7-3** below.

Table 7-3 : Annual average pollutant load reductions for the proposed swales

Swale	Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)
S1	88	48	24
S2	86	43	18
S3	88	43	23
S4	89	55	49

Swale	Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)
S5	89	55	48
S6	87	45	32
S7	87	47	22
S8	86	46	17
S9	86	46	19
S10	90	51	28
S11	90	48	29
S12	88	48	29
S13	84	44	16
S14	81	45	14
S15	87	44	31
S16	87	46	19
S17	87	44	20
S18	86	46	17
S19	86	44	18
S20	86	46	18
S21	88	45	22
S22	88	48	24
S23	87	44	26
S24	87	46	26

Further information on the results is provided in **Appendix B**.

Spill Management Basins

Spill basins are normally provided at locations where two key factors are identified. The first factor is the risk of accidents occurring due to the road horizontal and vertical geometry, and the second factor is the existence of a sensitive receiving waterway as identified by an aquatic ecology assessment. When both factors occur at any one location along the road upgrade, a spill basin would be required.

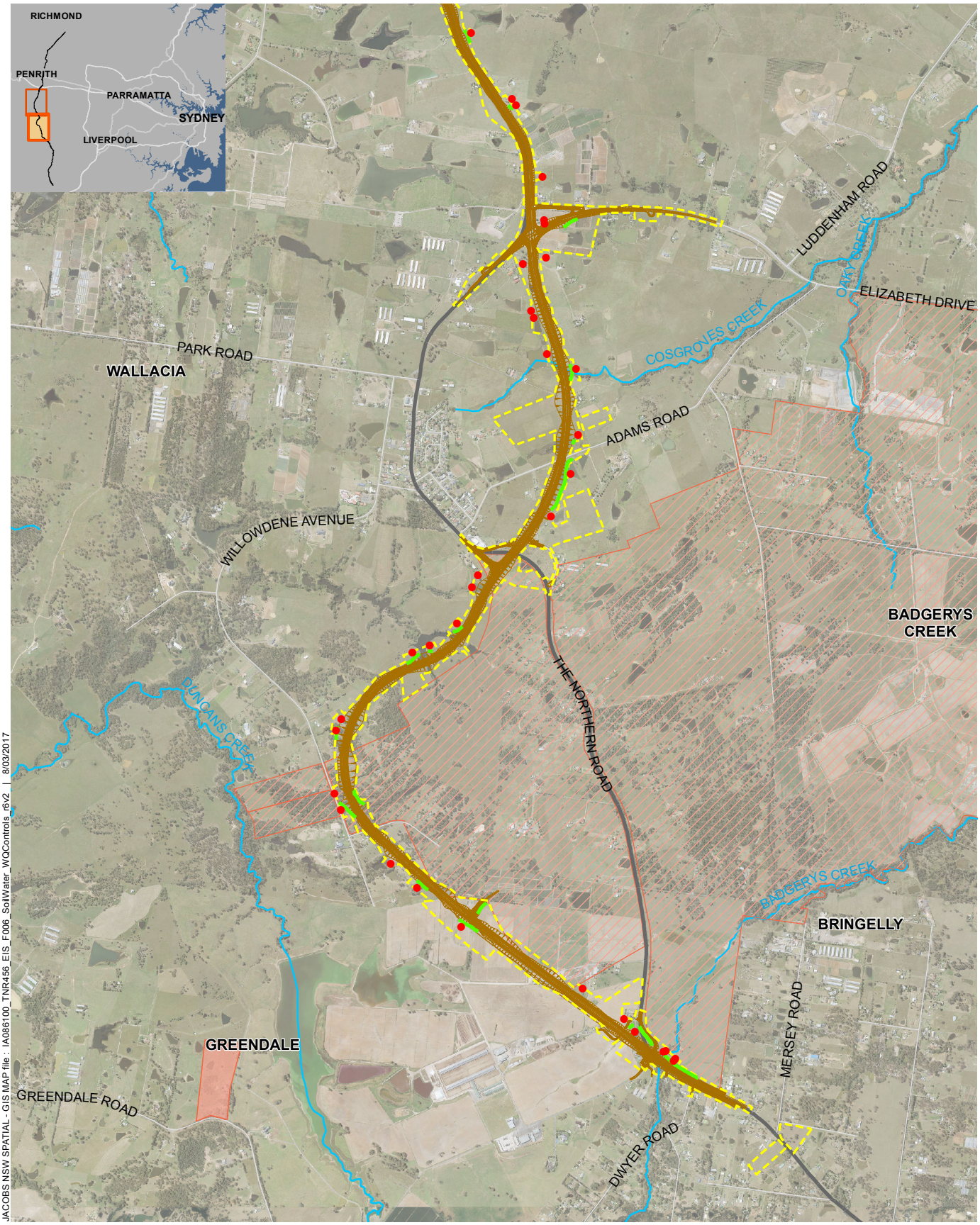
Some sensitive waterways have been identified along the road upgrade which meets one of the two conditions for providing spill basins; however the improved horizontal and vertical geometry of the upgrade and the improved layout of the signalised interchanges has reduced the risk of accidental spills along the upgraded road. In this regard, spill basins are not required for the project.

Monitoring

Operational phase monitoring would be undertaken in order 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.

Monitoring would be undertaken in line with the Roads and Maritime Guidelines for Construction Water Quality Monitoring (RTA 2003).



The Northern Road upgrade - Mersey Road to Glenmore Parkway

The Northern Road (Existing)

Project area

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

Sediment basins (construction phase)

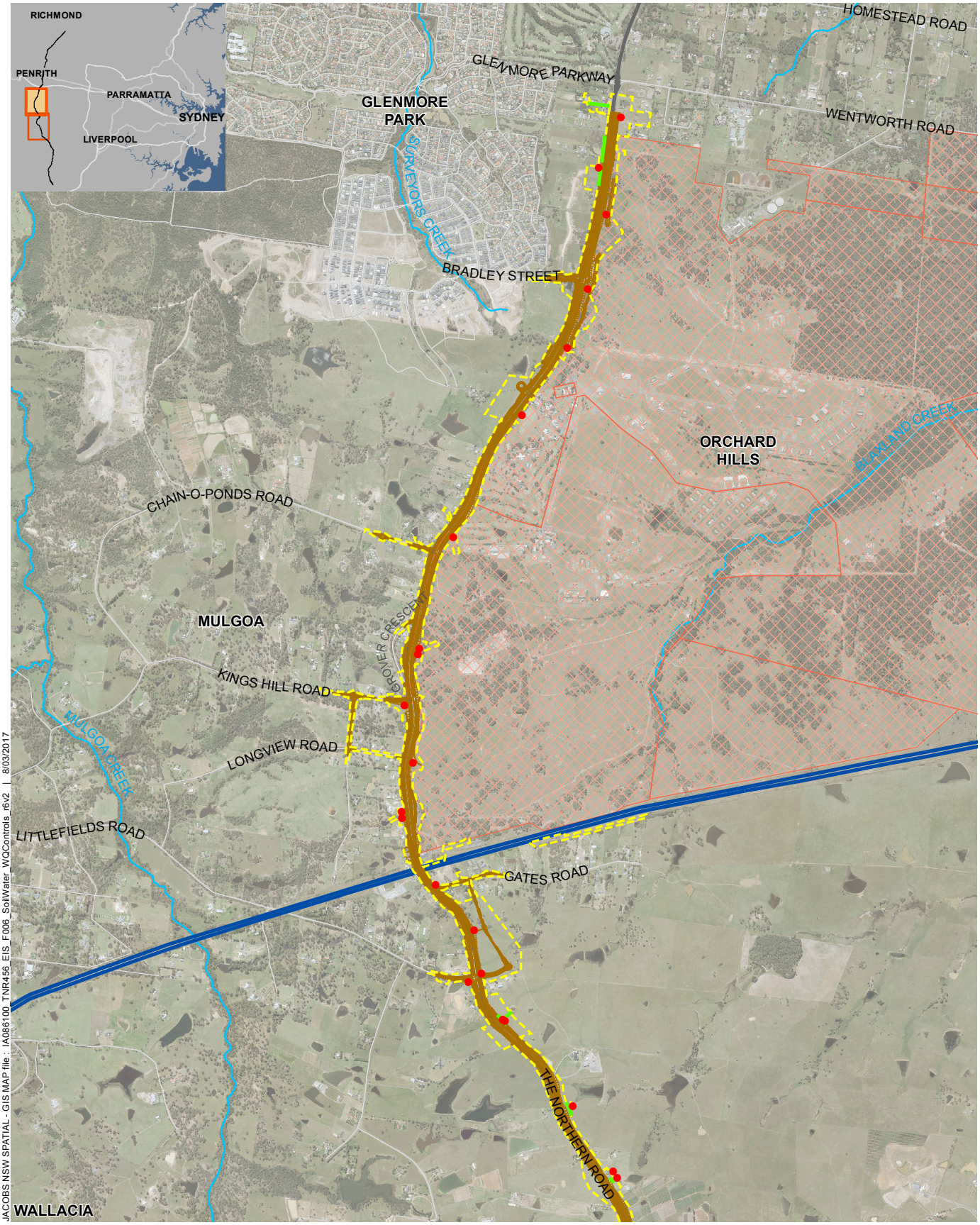
Water quality treatment swale (permanent)

0 0.5 1 km

2

1

Figure 7-1 | Water quality controls



The Northern Road upgrade - Mersey Road to Glenmore Parkway

The Northern Road (Existing)

WaterNSW supply pipelines

Project area

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

Sediment basins (construction phase)

Water quality treatment swale (permanent)

0 0.5 1 km

N

2

1

Figure 7-1 | Water quality controls

8. Safeguards and management

Safeguards and management measures will be implemented to minimise and manage the impacts of the project on surface water and groundwater throughput construction and operation. These measures are presented in **Table 8-1**.

Table 8-1 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing
General Construction Impacts	A soil and water management plan (SWMP) would be developed in accordance with the Roads and Maritime specification G38 – Soil and Water Management and the Blue Book – Soils and Construction – Managing Urban Stormwater Volume 1 (Landcom 2004) and Volume 2D (DEC 2008a). The SWMP would include but not be limited to: • An erosion and sedimentation control plan and maintenance schedule for ongoing maintenance of temporary erosion and sediment controls • A sediment basin management plan to guide appropriate management of runoff during construction and operation • An incident emergency spill plan which will include measures to avoid spillages of fuels, chemicals and fluids onto any surfaces or into any nearby waterways	Contractor	Pre-construction and construction
Soil salinity impacts	• Durability and aggressivity samples of soil material will be collected and analysed prior to the construction phase, to determine potential impacts of soil salinity on pavement infrastructure	Contractor	Pre-construction
Sedimentation and Erosion	• Erosion and sediment controls would be implemented in a staged approach before clearing of the given catchment. • Sediment basins will be regularly serviced and maintained to comply with water quality and capacity requirements • Clearing of vegetation and site stabilisation of disturbed areas would be undertaken progressively to limit the time disturbed areas are exposed to erosion prices • High risk soil and erosion activities such as earthworks will not be undertaken immediately before or during high rainfall or wind events • Stockpiling of topsoil separately for potential reuse in landscaping and rehabilitation works • Permanent catch drains will be installed behind cut faces to act as diversion drains during the construction phase • Erosion and sediment control measures will be maintained until the works are complete and areas are stabilised by revegetation	Contractor	Pre-construction and construction
Impacts to water pollution (surface water and groundwater)	• All fuels, chemicals, and liquids would be stored at least 50 metres away from the existing stormwater drainage system and would be stored in an impervious bunded area within the compound site • The refuelling of plant and maintenance machinery	Contractor	Pre-construction and construction

Impact	Environmental safeguards	Responsibility	Timing
	would be undertaken in impervious bunded areas in the designated compound area. • Vehicle wash downs and/or concrete truck washouts would be undertaken within a designated bunded area of an impervious surface or undertaken off-site		
Disturbance of contaminated or potentially contaminated land	• Intrusive investigations should be undertaken in the vicinity of moderate risk areas including service stations (operational and non-operational), WaterNSW supply pipelines corridor, stockpiles and market gardens. • Other areas of potential contamination (low and moderate risk areas) should be managed under an appropriate Construction Environmental Management Plan (CEMP), including an unexpected finds protocol. • Excavated material that is not suitable for on-site reuse or recycling will be transported to a site that may legally accept that material for reuse or disposal	Contractor	Pre-construction and construction
Encountering UXO	• For UXO's, an investigation would be undertaken to confirm the risk of UXO's being present within the areas of the project within Defence Establishment Orchard Hills. The investigation would be undertaken prior to construction activities by a suitably qualified consultant registered on the Commonwealth Department of Defence UXO Panel (DUXOP) now subsumed into the Defence Environment and Heritage Panel (DEHP).	Contractor	Pre-construction and construction

9. Residual Impacts

Following implementation of the nominated safeguards and management measures, some residual impacts may occur as a result of construction or operation of the project. Residual impacts are outlined below. It is noted that no significant residual impacts are expected.

9.1.1 Construction

Some offsite sediment loss may occur during construction in the unlikely event of significant and/or unforeseen storm events where controls may become damaged or at full capacity before they can be appropriately replaced or maintained. For instance if the sediment basins are full after containing the volume generated by the design event, then some overflow with high turbidity may occur but this is unlikely.

Similarly in the event of an unexpected leak or spill, potential contamination impacts to surface or groundwater may occur before appropriate containment or clean-up operations can be implemented. For example an unexpected fuel leak from construction plant or vehicles that reaches a waterway or drain prior to containment.

Given the unlikely occurrence of these potential impacts, coupled with the clean-up procedures that would be implemented in the unlikely event of such an occurrence, residual impacts as a result of construction are not expected to be significant.

9.1.2 Operation

The proposed swales are expected to control water quality from runoff to an acceptable level during operation of the project, and have been optimised at locations where sensitive receiving waterways have been identified. However potential residual impacts may occur during operation of the project in the event of unforeseen leaks or spills of materials that could potentially contaminate nearby waterways or seep into groundwater if uncontained, for example in the event of a road crash or during road maintenance activities. However the occurrence of road crashes would be reduced by the project due to proposed improvements to road safety, therefore impacts are not expected. Based on this, residual impacts during operation of the project are not expected to be significant.

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Salinity Potential in Western Sydney (NSW Department of Infrastructure, Planning and Natural Resources, 2002).

Appendix A. Stage 1 Contamination Assessment

The Northern Road Upgrade

Mersey Road to Glenmore Parkway

Roads and Maritime Services

Stage 1 Contamination Assessment

15 May 2017

The Northern Road Upgrade - Stage 1 Contamination Assessment

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Rev V2	23/06/2016	Final	M Stacey	23/06/2016	05/07/2016
Rev V3	09/09/2016	Updated project Description	M Stacey	09/09/2016	09/09/2016
Rev V4	27/09/16	Updated for works within pipeline corridor	M Stacey	27/09/16	27/09/16
Rev V5	14/11/2016	Final for Adequacy review	M Stacey	14/11/2016	14/11/2016
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Rev V7	15/05/2017	Final for Exhibition – updated project description	M Stacey	15/05/2017	15/05/2017

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Important note about your report

The sole purpose of this report is to present the findings of a Stage 1 contamination assessment carried out by Jacobs Group (Australia) Pty Ltd (Jacobs) for the Roads and Maritime Services (Roads and Maritime) in upgrading the 16 km section of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park (the project).

The scope of services was not intended to provide a definitive or quantitative investigation of the environmental impacts, performance and compliance of the project area. Environmental conditions may exist within the project area that are beyond the scope of our investigations and this report.

The findings presented in this report are professional opinions based solely upon information and data provided or made available by Roads and Maritime or otherwise available in the public domain including:

- Visual observations of the project area and its vicinity
- Publically available information sources.

Jacobs has relied upon and presumed that this data is accurate and representative of the environmental conditions at the project area. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, or if site conditions change beyond the agreed dates then it is possible that our conclusions as expressed in this report may change.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession and by reference to applicable auditing procedures and practice at the date of issue of this report. For the reasons outlined above however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report.

Except as specifically stated in this report, Jacobs makes no statement or representation of any kind concerning the suitability of the project area for any purpose or the permissibility of any use. Use of the project area for any purpose may require planning and other approvals and, in some cases, EPA (or OEH) and accredited site auditor approvals. Jacobs offers no opinion as to the likelihood of obtaining any such approvals, or the conditions and obligations which such approvals may impose, which may include the requirement for additional environmental investigations and/or works.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

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1. Introduction

1.1 General

The Roads and Maritime Services (Roads and Maritime) has commissioned Jacobs to prepare an environmental impact statement (EIS) to address the requirements issued by the Secretary of the NSW Department of Planning and Environment (DPE) on 9 March, 2016 and the relevant provisions of Schedule 2 of the Environmental *Planning and Assessment Regulation 2000* for The Northern Road Upgrade - Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park (the project).

An overview of the project is presented as **Figure 1**.

As part of the EIS, Jacobs has prepared this Stage 1 contamination assessment report detailing the results of the contamination desktop investigation undertaken including a review of publically available information and project specific historical aerial photography, site inspection, identification of potential Areas of Environmental Interest (AEIs), and recommendations on further contamination sampling / investigations, if required.

1.2 Overall project description

The project involves upgrading the 16 km section of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park.

The project generally comprises the following key features:

- A six-lane divided road between Mersey Road, Bringelly and Bradley Street, Glenmore Park (two general traffic lanes and a kerbside bus lane in each direction). The wide central median would allow for an additional travel lane in each direction in the future, if required
- An eight-lane divided road between Bradley Street, Glenmore Park and about 100 m south of Glenmore Parkway, Glenmore Park (three general traffic lanes and a kerbside bus lane in each direction separated by a median)
- About eight kilometres of new road between Mersey Road, Bringelly and just south of the existing Elizabeth Drive, Luddenham, to realign the section of The Northern Road that currently bisects the Western Sydney Airport site and to bypasses Luddenham
- About eight kilometres of upgraded and widened road between the existing Elizabeth Drive, Luddenham and about 100 m south of Glenmore Parkway, Glenmore Park
- Closure of the existing The Northern Road through the Western Sydney Airport site
- Tie-in works with the following projects:
  - The Northern Road Upgrade, between Peter Brock Drive, Oran Park and Mersey Road, Bringelly (to the south)
  - The Northern Road Upgrade, between Glenmore Parkway, Glenmore Park and Jamison Road, South Penrith (to the north)
- New intersections including:
  - A traffic light intersection connecting the existing The Northern Road at the southern boundary of the Western Sydney Airport, incorporating a dedicated u-turn facility on the western side
  - A traffic light intersection for service vehicles accessing the Western Sydney Airport, incorporating 160 m of new road connecting to the planned airport boundary
  - A traffic light intersection connecting the realigned The Northern Road with the existing The Northern Road (west of the new alignment) south of Luddenham
  - A ‘give way’ controlled intersection (that is, no traffic lights) connecting the realigned The Northern Road with Eaton Road (east of the new alignment, left in, left out only)
  - A four-way traffic light intersection formed from the realigned Elizabeth Drive, the realigned The

Northern Road and the existing The Northern Road, north of Luddenham

- A traffic light intersection at the Defence Establishment Orchard Hills entrance, incorporating a u-turn facility

- New traffic lights at four existing intersections:
  - Littlefields Road, Luddenham
  - Kings Hill Road, Mulgoa
  - Chain-O-Ponds Road, Mulgoa
  - Bradley Street, Glenmore Park incorporating a u-turn facility
- Modified intersection arrangements at:
  - Dwyer Road, Bringelly (left in, left out only)
  - Existing Elizabeth Drive, Luddenham (left out only)
  - Gates Road, Luddenham (left in only)
  - Longview Road, Luddenham (left in, left out only)
  - Grover Crescent south, Mulgoa (left in only)
  - Grover Crescent north, Mulgoa (left out only)
- Dedicated u-turn facilities at:
  - The existing The Northern Road at Luddenham, south-west of Elizabeth Drive
  - The existing Elizabeth Drive, Luddenham around 800 m east of The Northern Road
  - Chain-O-Ponds Road, Mulgoa
- Twin bridges over Adams Road, Luddenham
- Local road changes and upgrades, including:
  - Closure of Vicar Park Lane, east of the realigned The Northern Road, Luddenham
  - Eaton Road cul-de-sac, west of the realigned The Northern Road, Luddenham
  - Eaton Road cul-de-sac, east of the realigned The Northern Road, Luddenham
  - Elizabeth Drive cul-de-sac, about 300 m east of The Northern Road with a connection to the realigned Elizabeth Drive, Luddenham
  - Extension of Littlefields Road, east of The Northern Road, Mulgoa
  - A new roundabout on the Littlefields Road extension, Mulgoa
  - A new service road between the Littlefields Road roundabout and Gates Road, including a ‘give way’ controlled intersection (that is, no traffic lights) at Gates Road, Luddenham
  - Extension of Vineyard Road, Mulgoa between Longview Road and Kings Hill Road
  - A new roundabout on the Vineyard Road extension at Kings Hill Road, Mulgoa
- A new shared path on the western side of The Northern Road and footpaths on the eastern side of The Northern Road
- A new shared path on the western side of The Northern Road and footpaths on the eastern side of The Northern Road where required
- The upgrading of drainage infrastructure
- Operational ancillary facilities including:
  - Heavy vehicle inspection bays for both northbound and southbound traffic, adjacent to Grover Crescent, Mulgoa and Longview Road, Mulgoa respectively
  - An incident response facility on the south-western corner of the proposed four-way traffic light

intersection at Elizabeth Drive, Luddenham

- New traffic management facilities including variable message signs (VMS)
- Roadside furniture and street lighting
- The relocation of utilities and services
- Changes to property access along The Northern Road (generally left in, left out only)
- Establishment and use of temporary ancillary facilities and access tracks during construction
- Property adjustments as required
- Clearance of undetonated explosive ordinance (UXO) within the Defence Establishment Orchard Hills as required.

The project assessed in this EIS does not include surveys, sampling or investigation to inform the design or assessment, such as test drilling, test excavations, geotechnical investigations, or other tests. It also does not include adjustments to, or relocation of, existing utilities infrastructure undertaken prior to commencement of construction. These would be subject to separate assessment and approval as appropriate.

1.3 Objectives

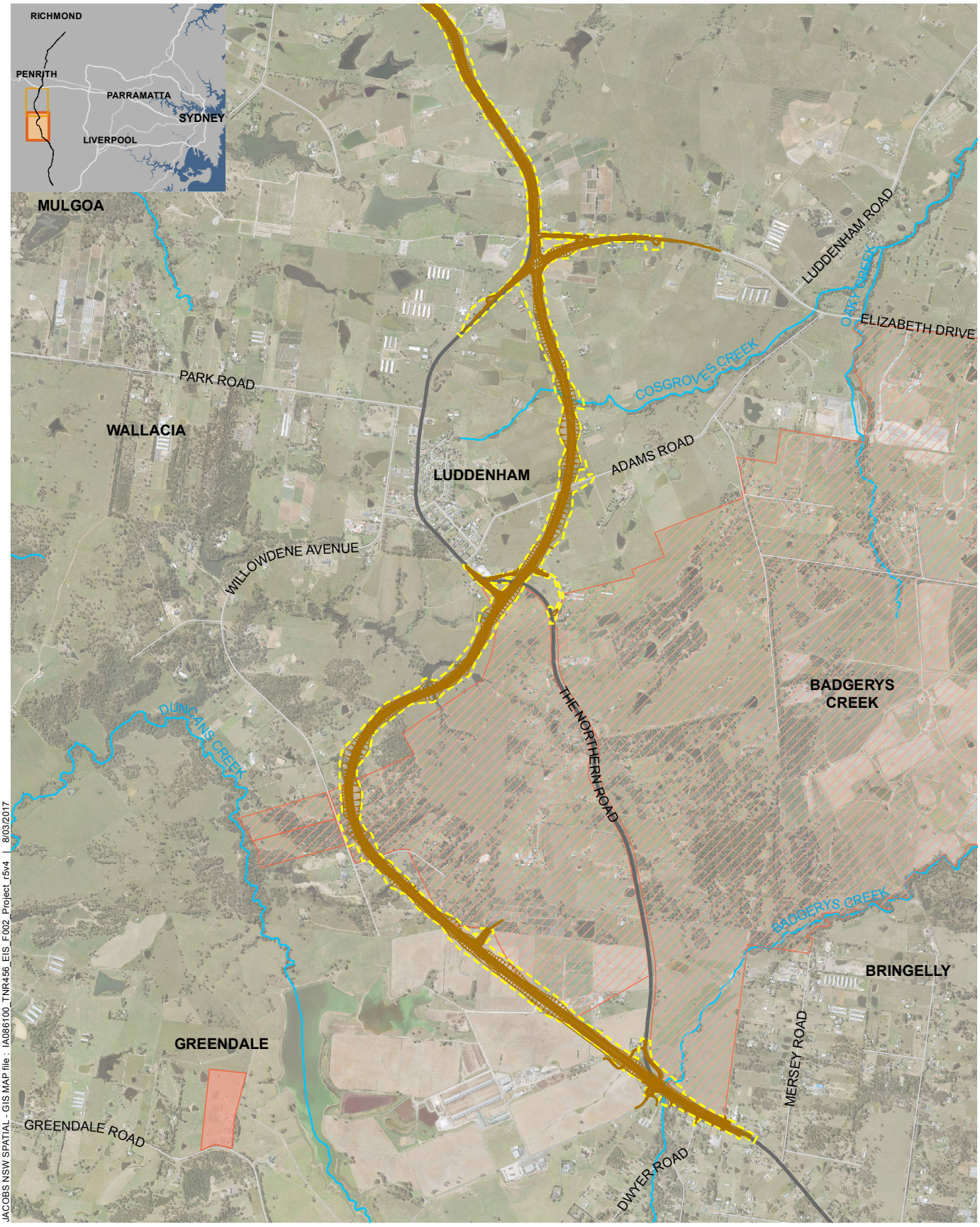
The objectives of the Stage 1 contamination assessment were to identify potential AEI which would assist in identifying construction limitations/constraints within the project area with respect to contamination.

The AEIs were considered to be those potential risks associated with soil, groundwater and vapour contamination which may be present as a result of historic and / or current activities undertaken on and / or adjacent to the project area.

1.4 Scope of works

To achieve these objectives, Jacobs undertook the following scope of works:

- Review of publically available information (NSW EPA, CSIRO ASRIS database, NSW Department of Primary Industries groundwater database, Department of Defence UXO database)
- Review of historical aerial photography of the general project area
- Site walkover and inspection
- Preparation of a Stage 1 contamination assessment report based on the data obtained from the desktop background review and observations from the inspection of the project area. The expected ground conditions are presented together with any contamination issues identified and recommendations for further investigations, if required.



JACOBS NSW SPATIAL - GIS MAP file : IA086100_TNR456_EIS_F002_Project_r5v4 | 8/03/2017

The Northern Road upgrade - Mersey Road to Glenmore Parkway

The Northern Road (Existing)

Operational boundary

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

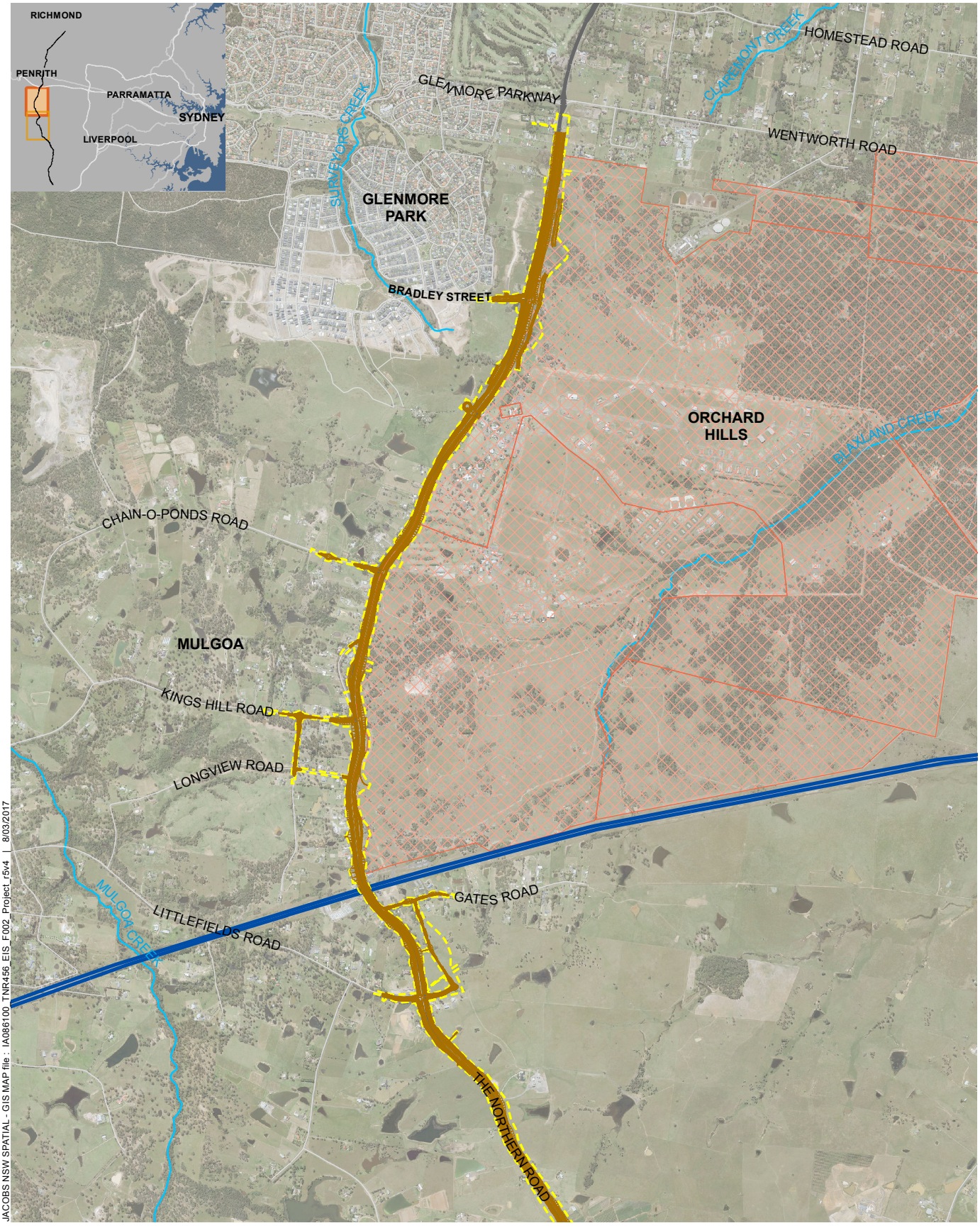
0 0.5 1 km

N

2

1

Figure 1 | Location of the project area



The Northern Road upgrade - Mersey Road to Glenmore Parkway

The Northern Road (Existing)

WaterNSW supply pipelines

Operational boundary

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

0 0.5 1 km

N

2

1

Figure 1 | Location of the project area

2. Existing environment

The information presented below is based on a review of publically available information, and observations made during a project area inspection undertaken from publically accessible areas by Jacobs on 19 November 2015.

2.1 Location and zoning

The project area spans about 16 km generally within The Northern Road corridor from Bringelly in the south to Glenmore Park in the north. The southern portion of the project area also extends into an agricultural area within the suburbs of Greendale and Luddenham.

At the time of preparing this report, the project area was within a range of land zonings as classed by the Penrith and Liverpool City Council Local Environmental Plans including:

- SP1 – Specialist Activities
- R1 – General Residential
- R2 Low Density Residential
- R3 – Medium Density Residential
- B7 - Business Park
- RE1 – Public Recreation
- RE2 – Private Recreation
- R2 – Rural Landscape
- RU1 – Primary Production
- E4 – Environmental Living
- SP1 – Special Activities
- SP2 – Infrastructure.

2.2 Topography and drainage

The project area is part of an elevated ridge system dividing the Nepean River to the west from the South Creek catchment to the east. The topography within the project area is characterised by rolling landscapes typically of the Bringelly Shale.

Localised drainage lines and creeks within and adjacent to the project area are expected to flow away from The Northern Road to the west towards the Nepean River and east towards South Creek.

The majority of rain falling onto the project area would fall onto unsealed areas with minor run-off from impermeable areas (i.e. roads, roofs of buildings). Runoff during rainfall events is expected to infiltrate into sub-soils and/or run off into localised drainage lines, river, creeks and/or dams.

2.3 Geology

The Penrith 1:100,000 Geological Series Sheet 9030 (NSW Department of Mineral Resources, 1991) indicated that the project area is predominately underlain by Bringelly Shale, the Luddenham Dyke and Quaternary alluvium.

The Bringelly Shale belongs to the Wianamatta Group which is the upper most geological unit of the Permo-Triassic sequence mainly comprising claystone and siltstone, with some areas of sandstone. It is interpreted as a coastal alluvial plain sequence that contains lagoonal – coastal marsh sequence at the base through to terrestrial, alluvial plain sediments at the top of the formation.

Luddenham Dyke is a Jurassic dyke which intersects the proposed alignment at about chainage 5600. The dyke comprises of olivine basalt and has been mapped as being 6 to 12 metres wide. Very hard indurated shales may be found adjacent to the dyke due to contact metamorphism.

Alluvium comprising of fine sands, silt and clay is likely to be deposited along the Cosgrove and Badgerys Creek systems. According to the Western Sydney Airport Draft Environmental Impact Statement the alluvium deposits can be up to five metres thick and are typically made up of fine sands, silts and clays with some areas of gravelly clay.

A description of the geological formations underlying the project area is provided in **Table 2-1** below.

Table 2-1: Geological units underlying the project area.

Unit	Description
Bringelly Shale (Rwb)	Shale, carbonaceous claystone, laminate, coal in parts
Luddenham Dyke (Jd)	Basalt, dolerite
Quaternary Alluvium (Qal)	Fine grained sand, silt, clay.

2.4 Soils

The Penrith 1:100,000 Soil Landscape sheet 9030 (Soil Conservation Service of NSW, 1990) indicated that the soil landscape groups within the project area consist of erosional Luddenham (lu), residual Blacktown (bt) and fluvial South Creek (sc) soil landscape groups. **Table 2-2** describes the soil landscape groups within the project area.

Table 2-2: Soil units underlying the project area.

Unit	Description
Luddenham (lu)	• Landscape – found on undulating to rolling hills on Wianamatta Shales, with slopes between 5-20% and local relief between 50 and 80m, narrow ridges, hills and valleys. • Soils – shallow podzolic soils and massive clays on crests, moderately deep red podzolic soils on upper slopes and moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines • Limitations – high soil erosion hazard, localised impermeable highly plastic subsoil, moderately reactive.
Blacktown (bt)	• Landscape - found on gently undulating rises on Wianamatta Group shales with local reliefs of up to 30 metres and slopes of less than 5 per cent. • Soils - shallow to moderately deep hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines. • Limitations - moderately reactive, highly plastic subsoil, with low fertility and poor drainage.
South Creek (sc)	• Landscape - found on floodplains, valley flats and drainage depressions of the channels on the Cumberland Plain. • Soils – deep layered sediments over bedrock or relic soils. Structured plastic slays and loams in and adjacent to drainage lines, red and yellow podzolic soils on terraces. • Limitations – erosion hazard, frequent flooding.

2.5 Acid sulfate soils risk

Acid sulfate soils (ASS) are the common name given to naturally occurring sediments and soils containing iron ASS are soils and sediments containing iron sulphides 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. The majority of ASS 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 (AHD).

The Australian Soil Resource Information System (ASRIS, 2015) provides online access to the best publicly available information on soil and land resources across Australia. ASRIS provides a national map of available ASS mapping that is classified with a nationally consistent legend that includes risk assessment criteria and correlations between Australian and International Soil Classification Systems.

The ASRIS ASS map was consulted to determine the presence and risk of ASS along the project alignment. The Acid Sulfate Soil Probability within the project alignment was classified as Extremely Low Probability of occurrence. ASS is therefore not considered to be a risk to the project.

2.6 Soil salinity

Salinity is a complex issue relating to salt and water cycles both above and below the ground. Surface waters and groundwater can dissolve and mobilise salts and cause their accumulation in other areas. Excessive concentrations of salt in such areas can affect plant growth, soil chemistry and cause weakening and degradation of construction materials such as masonry, concrete and bitumen.

An assessment of the salinity potential within the project area was undertaken using the map of Salinity Potential in Western Sydney (Department of Infrastructure, Planning and Natural Resources, 2002). The majority of the project area occurs in areas of moderate salinity potential with isolated areas of high salinity potential and areas of known salinity occurrence in the vicinity of Cosgrove Creek.

2.7 Hydrogeology

The direction of groundwater flow could not be definitively assessed based on current information, although the surrounding topography of the project area and location of water bodies suggests that regional groundwater would shed away from The Northern Road to the west towards the Nepean River and east towards South Creek. Localised groundwater flows would be influenced by creeks, drainage lines and dam structures.

2.7.1 Groundwater bore search

A search of the Department of Primary Industries groundwater database identified eight registered groundwater wells within a 500 metre radius of the project area. Details of the registered bores, use and proximity to the project area are summarised in **Table 2-3**.

Table 2-3: Registered DPI boreholes within 0.5 kilometre of the Project.

Borehole ID	Impact potential	Depth (m)	Use	Proximity to project area
GW102305	1km west of Elizabeth Drive and The Northern Road intersection	61	Stock	Outside
GW106198	300m west of Elizabeth Drive and The Northern Road intersection	-	Stock, domestic	Outside
GW108933	600m west of Luddenham town	268	Irrigation	Outside
GW104979	Within property located to the east of Willowdene Avenue	180	Stock, domestic	Within
GW104215	2km west of The Northern Road and Dwyer Road Intersection	222.5	Stock, domestic	Outside
GW105959	2km west of The Northern Road and Dwyer Road Intersection	337	Stock, farming, irrigation	Outside

2.8 Sensitive environments

Based on the available information, sensitive environments which could be impacted by contamination within the project area (if present) are detailed below:

- Blue Hills Wetland, Glenmore Park.
- Blaxland Creek, Orchard Hills
- Mulgoa Creek, Luddenham
- Tributaries of Duncan Creek, Luddenham
- Badgerys Creek, Bringelly
- Various dams, wetlands within project area.

Jacobs undertook a review of the Bureau of Meteorology Groundwater Dependant Ecosystems (GDE) Atlas to assess the presence of GDEs in the near vicinity (within about 500 m) of the project area. The review indicated that no GDEs were present within or in the near vicinity of the project area.

2.9 Previous site investigations

At the time of preparing the report, no previous environmental investigations are known to have been undertaken across the project area or were made available for review.

3. Site inspection

A site inspection was conducted on 19 November 2015 by a Jacobs environmental scientist. The site inspection focussed on the project area, as well as adjacent land uses and potential AEIs. The site inspection was only undertaken from areas which were accessible to the public.

At the time of the site inspection the project area consisted mostly of agricultural and rural residential land use, with low density residential land use in the suburbs of Glenmore Park and Mulgoa. The remaining areas generally comprised rural residential land use with more intensive agricultural land use within the southern portion of the project area (Greendale) and the Defence Establishment Orchard Hills. Roads were generally sealed.

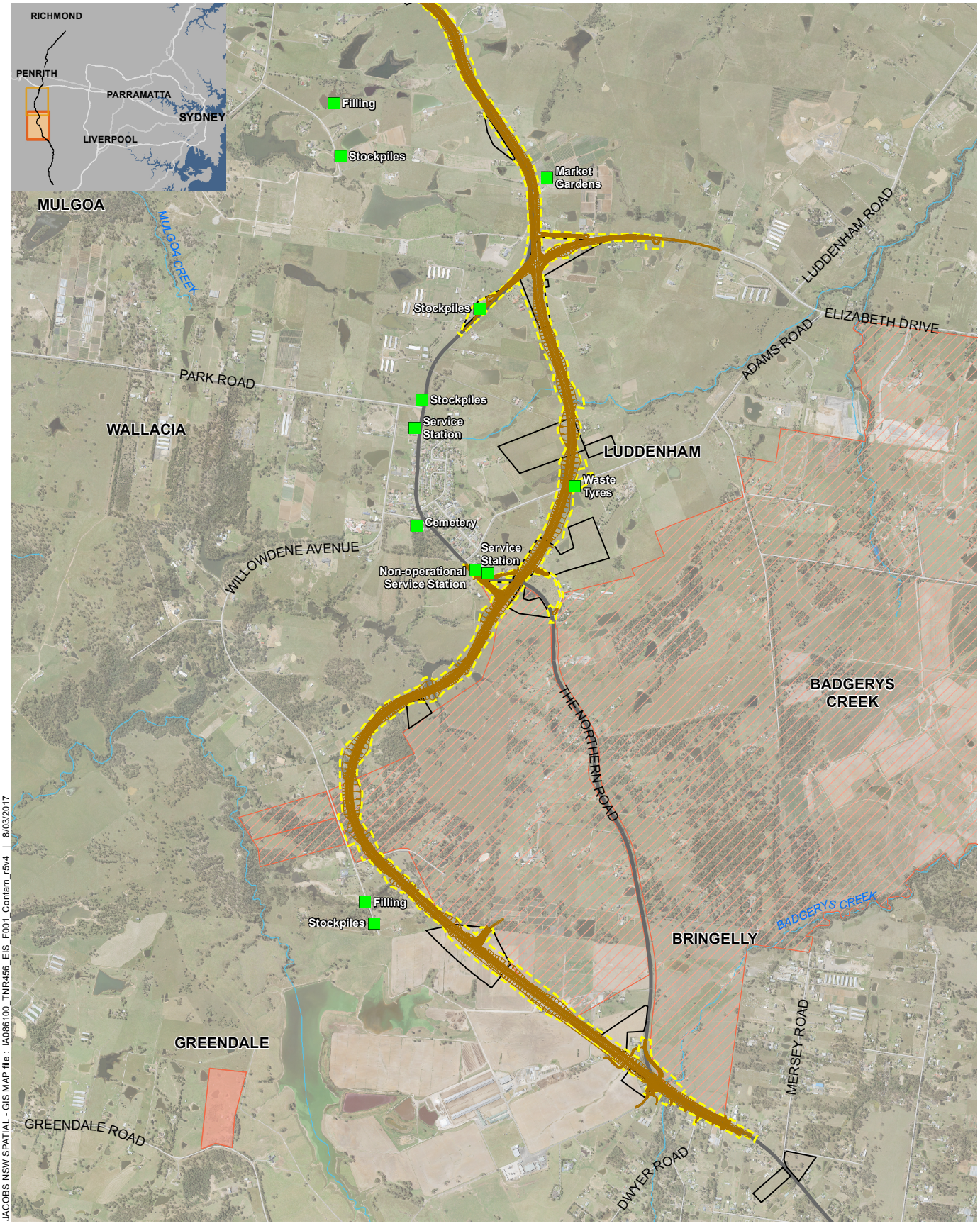
Another site inspection was conducted on 20 September 2016 by Jacobs personnel of the proposed construction footprint within the Warragamba Pipelines corridor.

A number of AEI were identified during the site inspection as detailed in **Table 3-1** and presented as **Figure 2**.

Table 3-1: Site Inspection AEI

No.	AEI	Location	Description
1	Stockpiles	• Private Property, western side of The Northern Road between Glenmore Parkway and Bradley Street, Glenmore Park • 100m north of project area	Fill of unknown quality within close proximity to The Northern Road
2	Defence Establishment Orchard Hills	• Eastern side of The Northern Road, Orchard Hills • Within project area	General military use, possible UXO.
3	Stockpiles	• Eastern side of The Northern Road between Kingshill and Longview Roads, Orchard Hills • Within project area	Fill of unknown quality. Close proximity to The Northern Road
4	Sub-station	• Western side of The Northern Road, Orchard Hills • Within project area	Transformers, possible storage of transformer oils and degradation of building materials
5	Warragamba Pipelines	• Eastern and western sides of The Northern Road, Orchard Hills • Within project area	Possible degradation of painted surface and jointing materials on pipeline. Fill containing metal and pipe observed to south of the construction footprint
6	Filling	• Private property, eastern side of Galaxy Road, Luddenham • Outside of project area (> 500m)	Fill of unknown quality
7	Stockpiles	• Private property, eastern side of Galaxy Road, Luddenham • Outside project area (> 500m)	Fill of unknown quality
8	Market Gardens	• Private property, north and north east of the intersection of The Northern Road and Elizabeth Drive. • Within project area.	General agricultural activities, possible chemical storage and pesticide use
9	Stockpiles	• Western side of The Northern Road, north of Park Road, Luddenham • Within project area	Fill of unknown quality within close proximity to The Northern Road
10	Roads and Maritime Stockpile	• North of the intersection of The Northern Road and Park Road, Luddenham. • Outside project area (> 250m)	Fill of unknown quality within close proximity to The Northern Road
11	Service Station	• South of the intersection of The Northern Road and Park Road, Luddenham. • Outside project area (> 250m)	Operational service station site, storage of dangerous goods (petroleum) in underground systems
12	Cemetery	• South of the intersection of The Northern Road and Roots Avenue, Luddenham. • Outside of project area (> 250m)	Degradation and breakdown of organic carbon
13	Non-operational service station	• Shops – The Northern Road, Luddenham. • Adjacent to project area	Indications of former service station site (fill points, bowser islands, vent pipes) within carpark of shopping centre.
14	Service Station	• Shops – The Northern Road, Luddenham. • Adjacent to project area	Operational service station site, storage of dangerous goods (petroleum) in

No.	AEI	Location	Description
			underground systems
15	Dumped tyres	• Southern side of Adams Road, Luddenham • Within project area	Possible fire hazard
16	Filling	• Private property, western side of Willowdene Road, Luddenham • Outside of project area (250m)	Fill of unknown quality around drainage line
17	Stockpile	• Western side of Willowdene Road, Luddenham • Outside of project area (250m)	General waste materials
18	Septic Systems	• Numerous tanks and pump out points observed within the project area	Human wastes
19	Agricultural land use (incl. Luddenham Pastoral Company)	• Numerous locations • Within and adjacent to the project area	Potential point and diffuse contamination sources associated with agricultural activities (where undertaken) including: • Pesticide and herbicide use • Storage and use of chemicals (including fuels and oils) • Livestock dips • General waste disposal • Degradation of building materials • Fertiliser use.



The Northern Road upgrade - Mersey Road to Glenmore Parkway

The Northern Road (Existing)

Operational footprint

Compound sites

AEI contamination sites

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

0 0.5 1 km

2

1

Figure 2 | AEI contamination sites

The Northern Road upgrade - Mersey Road to Glenmore Parkway

The Northern Road (Existing)

WaterNSW supply pipelines

Operational footprint

Compound sites

AEI contamination sites

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

0 0.5 1 km

2

1

Figure 2 | AEI contamination sites

4. Site history

Several sources were investigated to determine the history of land use at the site. The following list details the sources of historical information and a summary of information provided by each source.

- NSW Land and Property Management Authority, Land and Property Information Division (LPI): Historical aerial photographs (1947 to 2005)
- NSW EPA Contaminated Sites Register and Record of Notices
- Transport for NSW Interactive Crash Statistics Database.

4.1 Historical aerial photography

Historical aerial photographs from the NSW Land and Property Management Authority, Land and Property Information Division were examined for the years: 1947, 1955, 1965, 1975, 1986, 1994 and 2005. The findings of the historical aerial photograph review are described in **Table 4-1**.

Table 4-1: Historical aerial photograph review

Date of aerial photography	Site	Surrounding area
1947	The project area generally comprised agricultural land. Agricultural land use appeared to be generally grazing. There were a small number of building /structures (houses, sheds) likely to be associated with the agricultural activities. Main project area features observable in photographs included The Northern Road, Orchard Hills Defence Facility, Warragamba Pipelines and a large intensive agricultural operation located to the west of the intersection of The Northern Road and Elizabeth Drive. The alignment of The Northern Road at Eaton Road, Luddenham is different than present day	Surrounding land use consisted of rural residential land use to the north of the project area (Penrith, Kingswood) and agricultural land in other areas. Small scale cropping and orchards were present in areas surrounding the northern portion of the project area (ie. north of Orchard Hills) and generally increased grazing land surrounding the southern portion (ie. south of Orchard Hills) of the project area.
1955	Generally, as per observations in the 1947 photograph. The alignment of The Northern Road at Eaton Road, Luddenham is as per present day.	The surrounding area remained largely the same with increased structures observed within the Orchard Hills Defence Facility.
1965	Generally, as per observations in the 1955 photograph with increased structures observed within the Orchard Hills Defence Facility adjacent to The Northern Road, construction site adjacent to the Warragamba Pipelines, large dams constructed to the west of The Northern Road near the intersection with Elizabeth Drive. Larger areas of cropping evident in Greendale.	The surrounding area remained largely the same, with increased low density residential development to the north of the project area, construction of Warragamba Pipelines reservoirs (Orchard Hills) and increased structures within the Orchard Hills Defence Facility. There appeared to be a general reduction in agricultural activities (small scale cropping, orchards) to the north of the project area.
1975	Generally, as per observations in the 1965 photograph with increased shed structures present on large scale agricultural land located to the west of the intersection of The Northern Road and Elizabeth Drive.	The surrounding area remained largely the same, with increased low density residential development in Penrith and Kingswood, construction of the M4 Western Motorway, increased rural residential properties, less agricultural activities with the northern portion of the project area, Penrith golf course has been constructed.
1986	Generally, as per observations in the 1975 photograph. Market gardens have been established on the western side of The Northern Road in Luddenham. Increased residential development adjacent to The Northern Road in Luddenham.	The surrounding land use remained largely unchanged with the exception of an increase in low density residential development to the north of the project area. Quarrying activities were observed in Glenmore Park located to the north west of the project area. A waste water treatment

Date of aerial photography	Site	Surrounding area
		facility has been constructed at the Sydney Water reservoir site in Orchard Hills.
1994	Generally, as per observations in the 1986 photograph with the construction site adjacent to the Warragamba Pipelines no longer in use, numerous shed structures have been constructed adjacent to the Warragamba Pipelines.	The surrounding land use remained largely unchanged. The waste water treatment facility at Orchard Hills has been re-configured.
2005	Generally, as per observations in the 1994 photograph with increased low density residential development occurring in Glenmore Park (adjacent to Penrith Golf Course) and quarrying activities have ceased in Glenmore Park.	The surrounding land use remained largely unchanged with increased residential development around Glenmore Park adjacent to the north western portion of the project area.

4.2 NSW EPA contaminated sites register

At the time of preparing the Stage 1, a search of the NSW EPA Contaminated Sites Register and Record of Notices (under Section 58 of the Contaminated Land Management Act 1997) was undertaken to ascertain the presence of registered sites that were either regulated or had been notified within the suburbs within the project area. The notified/regulated sites within 1km of the project area are summarised in **Table 4-2**.

Table 4-2: Notified sites within one kilometre of the project area.

Suburb	Notified site address	Notified site activity	Contamination status	Location relative to Project
Luddenham	Caltex Service Station The Northern Road	Service Station	Under assessment	Outside project area (> 250m)

Based on the location of notified site relative to the project area, the Luddenham service station site is unlikely to be in the near vicinity of the construction footprint and as such is likely to pose a low contamination risk.

4.3 Interactive crash statistics

At the time of preparing this Stage 1 report, a search of the Transport for NSW Interactive Crash Statistics was undertaken to ascertain the potential for localised contamination associated with vehicle accidents to be present within the project area.

The database indicated that vehicle accidents have been recorded on The Northern Road and most of the local roads within the project area. The database did not provide information with respect to potential contamination including fuel release, fires etc.

4.4 Department of Defence unexploded ordinance website

A search of areas of concern from the Department of Defence Unexploded Ordinance (UXO) website was undertaken.

At the time of undertaking this assessment, no known areas of concern with respect to UXO were identified within or adjacent to the project area including Defence Establishment Orchard Hills.

4.5 Site history summary

The historical aerial photography review indicated that the project area has remained largely agricultural since the late 1940s. The major developments occurring within the project area included residential development within and adjacent to the northern portion of the project area, construction of the Orchard Hills Defence Facility, the Warragamba Pipelines and the Luddenham Pastoral Company.

There was one NSW EPA contaminated site notice for land within the project area at Luddenham. The site at Luddenham was under assessment.

4.6 Integrity assessment

Historical and site information was sourced from NSW Government departments with no known interest in the site. Jacobs have relied on the accuracy of the documentation provided and our experience in historical document interpretation. Whilst there is a small margin for error in interpretation, Jacobs considers the information presented in this assessment to be accurate.

5. Potential areas of environmental interest

A number of potential AEIs were identified during the information review and site inspection. **Table 5-1** outlines the potential AEIs located within and in the near vicinity of the project area and their associated risks to environmental receptors and site users (associated with the construction of the road upgrades). Please note the risks have been assessed qualitatively. The potential risks have not been confirmed / quantified through a sampling and analysis program.

Table 5-1: Potential areas of environmental interest

AEI	Location	Contaminants	Potential Contamination Distribution	Exposure Risk
Stockpiles	Private Property, western side of The Northern Road between Glenmore Parkway and Bradley Street, Glenmore Park	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Defence Establishment Orchard Hills (Commonwealth land)	Eastern side of The Northern Road, Orchard Hills	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos, explosive residues	Surface and shallow soils	Low - Contamination (if present) from the use of the site for military purposes unlikely to be in the vicinity of the project area.
Defence Establishment Orchard Hills (Commonwealth land)	Eastern side of The Northern Road, Orchard Hills	UXO	Surface and shallow soils	Moderate – Likelihood of encountering UXO during construction activities is likely to be low; however the consequence if encountered could be high.
Stockpiles	Eastern side of The Northern Road between Kingshill and Longview Roads, Orchard Hills	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Moderate – Stockpiles may need to be removed during construction activities.
Sub-station	Eastern side of The Northern Road, Orchard Hills	Heavy metals, hydrocarbons, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and substantial construction activities are unlikely on the site. Should construction activities occur on the site, then exposure risk would increase.
Warragamba Pipelines	Eastern and western sides of The Northern Road, Orchard Hills	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Moderate – Increased with excavation in areas of potential contamination.
Filling	Private property, eastern side of Galaxy Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Stockpiles	Private property, eastern side of Galaxy Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Market Gardens	Private property, north east of the intersection of The Northern Road and Elizabeth Drive.	Heavy metals, hydrocarbons, pesticides, nutrients	Soils and groundwater	Moderate – Contamination could be both localised and diffuse. Agricultural areas are likely to be disturbed as part of the upgrade.
Stockpiles	Western side of The Northern Road, north of Park Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Moderate – Stockpiles may need to be removed during construction activities.

Roads and Maritime Stockpile	North of the intersection of The Northern Road and Park Road, Luddenham.	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Service Station	South of the intersection of The Northern Road and Park Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Cemetery	South of the intersection of The Northern Road and Roots Avenue, Luddenham.	Heavy metals, nutrients, formaldehyde, biological	Deeper soils and groundwater	Low – Site and contamination (if present) likely to be too far away to pose a risk to construction activities
Non-operational service station	Shops – The Northern Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Moderate – Risk increased if deep excavations occur in the vicinity of the site
Service Station	Shops – The Northern Road, Luddenham.	Heavy metals, hydrocarbons	Deeper soils, groundwater and soil vapour	Moderate – Risk increased if deep excavations occur in the vicinity of the site.
Dumped tyres	Southern side of Adams Road, Luddenham	Heavy metals, hydrocarbons	Surface and shallow soils	Low - Contamination (if present) likely to be localised and substantial construction activities are unlikely on the site.
Filling	Private property, western side of Willowdene Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Stockpile	Western side of Willowdene Road, Luddenham	Heavy metals, hydrocarbons, pesticides, polychlorinated biphenyls, asbestos	Surface and shallow soils	Low - Contamination (if present) likely to be localised and construction activities are unlikely on the site.
Septic Systems	Numerous tanks and pump out points observed within the project area	Heavy metals, nutrients, biological	Deeper soils and groundwater	Low – Contamination source likely to be highly degraded
Agricultural Land Use	Numerous locations within and adjacent to the project area	Heavy metals, hydrocarbons, pesticides, asbestos	Soils and groundwater	Moderate – Contamination could be both localised and diffuse. Agricultural areas are likely to be disturbed as part of the upgrade.
Vehicle Accidents	Numerous locations within and adjacent to the project area	Hydrocarbons, aqueous firefighting foam (AFFF).	Surface and shallow soils	Low to Moderate – Very localised contamination (if present) likely to be disturbed as part of the upgrade.

5.1 Summary of potential areas of interest

The majority of AEI identified are likely to pose a low risk of exposure to site users and environmental receptors to contamination during construction of the upgrade.

The following information summarises the AEI assessed as low to moderate and moderate risk:

- The stockpiles located on the eastern side of The Northern Road between Kingshill and Longview Roads, Orchard Hills are located close to the current road verge and could be disturbed as part of construction activities. The quality of the material within the stockpiles is unknown.
- Although there is no evidence of UXO occurrence (from Department of Defence website) within or directly adjacent to the project area, explosives are used and are known to have been used at Defence Establishment Orchard Hills. Although the likelihood of encountering UXO during construction activities is likely to be low, the consequence if encountered could be high.
- The market gardens located to the north and north east of the intersection of The Northern Road and Elizabeth Drive have been used historically and currently for intensive agricultural land use within and in the vicinity of the proposed upgrade. This land use could represent a potential source of contamination which could be exposed during construction activities. The contamination from agricultural activities is generally either point source (eg. localised chemical storage and use, waste disposal) or diffuse (broad acre pesticide or herbicide application). The biggest risk of exposure to agricultural contamination would be associated with point sources of contamination.
- The stockpiles located on the western side of The Northern Road, north of Park Road, Luddenham are located close to the current road verge and could be disturbed as part of construction activities. The quality of the material within the stockpiles is unknown.
- The Warragamba Pipelines corridor represents a potential source of contamination associated with the degradation of the external surfaces of the pipeline and areas of observed fill materials. The construction activities to be undertaken within the pipeline corridor poses an increased risk of exposure to contamination (if present) especially associated with excavations works within the corridor.
- The non-operational service station (identified by concrete covered fill points in the carpark and vent stacks on adjacent building) located within the carpark of the Luddenham shops represents a potential source of contamination associated with leaks and spills from former fuel storage infrastructure (i.e. hydrocarbons and heavy metals). The location of the former service station in the near vicinity of the construction footprint of the upgrade poses an increased risk of exposure to contamination (if present) especially associated with deeper excavations.
- The service station located to the south of the Luddenham shops on The Northern Road represents a potential source of contamination associated with leaks and spills from fuel storage infrastructure (i.e. hydrocarbons and heavy metals). The location of the service station in the near vicinity of the construction footprint of the upgrade poses an increased risk of exposure to contamination (if present) especially associated with deeper excavations.
- The widespread agricultural land use within and in the vicinity of the proposed upgrade represent a potential source of contamination which could be exposed during construction activities. The contamination from agricultural activities is generally either point source (eg. localised chemical storage and use, waste disposal) or diffuse (broad acre pesticide or herbicide application). The biggest risk of exposure to agricultural contamination would be associated with point sources of contamination.
- Although the location of car accidents are not accurately known, the release of fuels and oils from vehicle accidents and the potential use of AFFF in the event of a vehicle fire could cause residual contamination in the vicinity of the accident site. Although contamination is likely to be very localised at these sites, the risk of exposure to contamination from these accident sites (if present) during construction of the upgrade is likely to increase as the accidents sites are likely to have occurred on the majority of the current road system which is within the construction footprint.

6. Conclusions and recommendations

6.1 Conclusion

Following a review of the available historical and government records, and a site inspection, the key findings of the Stage 1 Assessment include:

- There are five sensitive environments located within the vicinity of the project area which could be potentially impacted by contamination within the site (if present). Additionally, localised features including dams and wetlands should also be considered as sensitive environments.
- The project area remained largely agricultural since the late 1940s. The major developments occurring within the project area included residential development adjacent to the northern portion of the project area, construction of the Orchard Hills Defence Facility, the Warragamba Pipelines and the Luddenham Pastoral Company.
- There was one site within one kilometre of the Project that had been notified by the NSW EPA.
- A number of AEIs have been identified within or in close proximity to the project area. The majority of the AEIs are considered to represent a low risk with respect to contamination impacting upon construction of the upgrades.
- Numerous car accidents have been recorded within the project area and potential contamination associated with these accidents is considered to represent a low to moderate risk. Although contamination is likely to be very localised at these sites, the risk of exposure to contamination from these accident sites (if present) during construction of the upgrade is likely to increase as the accidents sites are likely to have occurred on the majority of the current road system which is within the construction footprint.
- A number of service stations (operating and non-operating) sites, stockpiles and areas of agricultural land use located within and in the near vicinity to the project area are considered to represent a moderate risk. The risks of exposure to contamination (if present) associated with construction of the proposed upgrade at these locations is higher than other AEIs as these areas are likely to be subject to physical disturbance during construction.
- There is a possibility of encountering UXO within Defence Establishment Orchard Hills in consideration of known use of explosives on this site.

6.2 Recommendations

Based on the results of the Stage 1 Contamination Assessment, Jacobs recommends further contamination investigation at areas of moderate risk within the project area.

The proposed scope of work for the contamination investigation has been planned to address the moderate risk areas identified in Section 5.

For the service station sites (operational and non-operational), soil should be sampled from boreholes drilled within the footprint of the proposed construction works adjacent to the respective sites to a depth below the possible source of contamination (i.e. leaking USTs). Assume an investigation depth of six metres below ground level within this area.

For the Warragamba Pipelines coridor, shallows soils (nominal 1m below ground level) should be sampled across the areas to be disturbed as part of the proposed construction activities.

For stockpiles, soil should be sampled from test pits from stockpiles which would need to be excavated and relocated as part of the proposed construction works.

For market gardens, shallows soils (nominal 1m below ground level) should be sampled across the areas to be disturbed as part of the proposed construction activities.

Despite the low to moderate rating of the remainder of the potential AEIs within and adjacent to the project, the risk of contamination impacting upon proposed construction activities would be increased if excavation works take place within these areas.

Where excavation works are required within low risk areas or other moderate risk areas (ie. moderate risk areas other than service station sites, areas of filling and stockpiles), a Construction Environmental Management Plan (CEMP) should detail contingency measures. These measures would manage potentially contaminated materials if materials are suspected and/or encountered during construction activities.

In these low risk areas or other moderate risk areas (ie. moderate risk areas other than service station sites, areas of filling and stockpiles), no testing is required unless contamination is suspected or encountered during construction activities. The process for the testing and/or management of suspected or encountered contamination in these lower risk areas should be addressed in the CEMP.

For UXO's, an investigation should be undertaken to confirm the risk of UXO's being present within the areas of the project within Defence Establishment Orchard Hills. The investigation should be undertaken prior to construction activities by a suitably qualified consultant registered on the Department of Defence UXO Panel (DUXOP) now subsumed into the Defence Environment and Heritage Panel (DEHP).

Appendix B. Operational water quality assessment

The Water Quality assessment has provided indicative locations and sizes for operational water quality swales. An outline of the design approach used is provided below.

B.1 Design Criteria

The proposed strategy is to provide water quality treatment through swales for pavement runoff prior to discharging into receiving creeks and waterways. The proposed swales are located throughout the project at all locations where pavement runoff is conveyed to the receiving waterways and creeks through a table drain that has been designed as part of the drainage system. The objective is to provide as much treatment as possible and to optimise the swales sizes upstream, predominantly at areas of sensitive receiving waterways and creeks by increasing the dimensions of some swales where possible and introducing rock check dams.

B.2 Swale locations

The proposed swale locations have been identified from the 20% detailed design. There are ten pavement runoff discharge locations that are located upstream of the five identified sensitive waterways as mentioned in **Section 3** of this report. A further fourteen swales are proposed at other locations to provide additional water quality treatment along the alignment. The proposed swales locations are shown on **Table 7-2** in **Section 7** of this report. The locations and lengths of the proposed swales may change when the detailed design is further progressed and the water quality modelling will need to be assessed again prior to the final detailed design.

B.3 Swale water quality modelling methodology

MUSIC modelling

MUSIC water quality modelling was undertaken to determine the pollutant load reductions that can be achieved by permanent water quality swales for Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP).

The catchment draining to an individual control measure was delineated by considering the formation of the proposed carriageway and the proposed pipe drainage network. The total catchment area was divided into two sub-catchments according to the different land-use characteristics of the ‘impervious road catchment’ area, and the batter slope or ‘pervious road side’ area.

A water quality model was set up to represent proposed catchment conditions. Models of the swales were created by adopting the sub-catchment areas estimated in the catchment analysis. Rock check dams were also added to the model as per the detailed design typical swale details.

Rainfall inputs

The MUSIC model uses pluviograph data and user-defined event mean concentrations (EMCs) to estimate pollutant loads. Pluviograph data was obtained from the Bureau of Meteorology for Station 067113 called Penrith, which is the most appropriate pluviograph station to the project with half-hour time increments. The data was available for the period 4/12/1996 to 31/5/2010. The model was run at half-hour time steps for the available duration.

Event mean concentrations

A literature review was undertaken to identify the event mean concentrations for the proposed road pavement areas for TSS, TN and TP to use in the MUSIC model. The following references were used to assess the typical concentrations:

- RTA (2003), Procedure for Selecting Treatment Strategies to Control Road Runoff (Version 1.1).
- CRC for Catchment Hydrology (1997), Best Practice Environmental Management Guidelines for Urban Stormwater.
- CSIRO (1997), Metals and Hydrocarbons in Stormwater Runoff from Urban Roads.

- CRC for Catchment Hydrology (2000), Water Sensitive Road Design, Design Options for Improving Stormwater Quality of Road Runoff.
- CRC for Catchment Hydrology (1999), Urban Stormwater Quality, A Statistical Overview.
- Austroads (2001), Road Runoff and Drainage: Environmental Impacts and Management Options.
- CRC for Catchment Hydrology and Monash University (2004), Stormwater Flow and Quality and the Effectiveness of Non-Proprietary Stormwater Treatment Measures, A review and Gap Analysis.

The adopted event mean concentrations from the literature review for the proposed pavement and for the existing pervious areas are outlined in Table B.1.

Table B.1 : Typical stormwater runoff concentrations for existing and operational phases

Pollutant Concentration (mg/L)	TSS		TP		TN	
	Event (wet)	Base (dry)	Event (wet)	Base (dry)	Event (wet)	Base (dry)
Road pavement	141	15	0.25	0.14	1.8	0.8
Agricultural areas (Existing)	158	12	0.5	0.15	5	2.5

Swale characteristics

From a hydrology and hydraulics perspective, the minimum dimensions of these trapezoidal open channel swales are: base width =1.2m, side slopes V:H=1:2 with a minimum depth of 0.5m. At locations where space is available, additional water quality treatment has been provided by increasing the base width of the swales.

B.4 Results

The results of the water quality assessment indicate that some pollutant load reduction can be achieved by the proposed swales. These results that have been achieved at the twenty-four swales including those located upstream of the locations where the pavement runoff discharges into sensitive receiving waterways as shown on **Table B.2**. The proposed swales are highly efficient at providing suspended solid capture and reasonably efficient at reducing nutrients. The reduction of pollutant loads by the proposed swales is considered to be adequate, however if further capture of nutrients is required, this would only be achieved through the use of other water quality controls such as permanent wet basins or biofiltration basins.

Table B.2 : Annual average pollutant load reductions for the proposed swales

Swale	Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)
S1	88	48	24
S2	86	43	18
S3	88	43	23
S4	89	55	49
S5	89	55	48
S6	87	45	32
S7	87	47	22
S8	86	46	17
S9	86	46	19
S10	90	51	28
S11	90	48	29
S12	88	48	29
S13	84	44	16

Swale	Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)
S14	81	45	14
S15	87	44	31
S16	87	46	19
S17	87	44	20
S18	86	46	17
S19	86	44	18
S20	86	46	18
S21	88	45	22
S22	88	48	24
S23	87	44	26
S24	87	46	26

B.5 Conclusion

The proposed road upgrade has the potential to generate increased pollutant loads into the receiving waterways including five sensitive waterways that have been identified; however if adequate water quality controls are adopted throughout the project by using vegetated swales and rock check dams as proposed, then this increase in pollutant loads is mitigated to a reasonable extent. It is therefore recommended that the proposed water quality treatment swales listed on **Table 6-2** of this report and the remaining swales identified throughout the project on the drainage plans be implemented to provide water quality controls for the project.