Australian Government

BUILDING OUR FUTURE

NSW GOVERNMENT

M12 Motorway Environmental Impact Statement

Appendix O Soils and contamination assessment report

Roads and Maritime Services | October 2019

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Annexure A	Historic Aerial Photography

Glossary of terms and abbreviations

Term	Meaning
AEI	Areas of Environmental Interest
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulfate Soils
BTEX	Benzene Toluene Ethylbenzene Xylenes
CEMP	Construction Environmental Management Plan
CLM Act	*Contaminated Land Management Act 1997*
CLMP	Contaminated Land Management Plan
CSM	Conceptual Site Model
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
GDEs	Groundwater Dependent Ecosystems
JAJV	Jacobs Arcadis Joint Venture
LEP	Local Environmental Plans
LPI	Lands and Property Information
MBGL	Metres Below Ground Level
RLs	Relative Levels
OCP	Organochlorine Pesticides
OPP	Organophosphate Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
POEO Act	*Protection of the Environment Operations Act 1997*
SEARs	Secretary's Environmental Assessment Requirements
SWMP	Soil and Water Management Plan
TRH	Total Recoverable Hydrocarbons
UXO	Unexploded Ordnance

Executive summary

Background

Roads and Maritime Services (Roads and Maritime) is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the M12 Motorway project to provide direct access between the Western Sydney Airport at Badgerys Creek and Sydney's motorway network (the project).

The project has been determined to be a controlled action under Section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) (EPBC 2018/8286) for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires assessment and approval from the Commonwealth Government.

The M12 Motorway would run between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham for a distance of about 16 kilometres and would be opened to traffic prior to opening of the Western Sydney Airport.

Purpose of this report

This report has been prepared to support the environmental impact statement (EIS) for the M12 Motorway project. The EIS has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the project (SSI 9364) and to enable the Minister for Planning and Public Spaces to make a determination on whether the project can proceed. The report presents an assessment of the potential soils and contamination impacts associated with the construction and operation of the project.

Overview of potential impacts

Soils and contamination have the potential to impact upon the construction and operation of the project, as well as impacts during construction and/or operation of the project on soil and contamination. The main impacts on construction of the project are expected to be from soil, groundwater and gas contamination. Soil erosion and salinity are expected to be impacted upon by the project. Construction impacts are varied and include the following:

- The highest potential for soil erosion would be associated with the disturbance of soils on existing slopes during construction. Given the terrain of the construction footprint includes rolling hills to alluvial floodplains, and that soil disturbance is expected across the length of the construction footprint, soil erosion is a hazard that could be impacted upon by the construction of the project.
- Salinity risks are highest within creeks, drainage channels and floodplains. Potential impacts of the project on surface and groundwater quality and structures of the project may arise during construction, however there is minimal potential for existing soil and groundwater salinity to be impacted by the project due to limited raising of groundwater levels within the project footprint.
- Contamination (where disturbed as part of construction activities), if not managed appropriately, could potentially impact upon project elements (environmental, human health, time, budget). Impacted soils, asbestos and hazardous building materials present a risk of impacting on the construction of the project., as well as have the potential to be released into the environment by the project during construction. However, releases are not expected during construction provided appropriate control and mitigation measures are implemented.
- Groundwater from identified Areas of Environmental Interest poses a low risk to construction of the project given that the volumes of groundwater expected to interact with project features during project construction are negligible or are not expected to require management.
- Potential impacts from gas ingress during construction include adverse effects on human health.

Operational impacts of the project are expected to be minimal, provided the revegetation of support sites is implemented.

Summary of environmental management measures

Environmental management measures will be detailed within a Soil and Water Management Plan, a Construction Environmental Management Plan and a Contaminated Land Management Plan. Several further investigations, including investigations within specified AEIs, an intrusive asbestos investigation, a hazardous building materials audit, and a gas investigation would be undertaken prior to construction of the project. Where required, further investigations would be undertaken in accordance with NSW EPA endorsed guidance including the NEPM (2013) guidelines.

Conclusions

Based on a desktop assessment, site inspection and review of the results of the contamination investigation, expected soil conditions and contamination with the potential to impact on, and be impacted upon by the project are as follows:

- Soil erosion
- Salinity
- Soil contamination
- Groundwater contamination
- Soil gas contamination.

Further investigations would be undertaken in the specific areas prior to construction of the project.

Following further investigations, impacts associated with expected soil conditions and contamination can be managed with appropriate mitigation measures.

1. Introduction

1.1 Background

Roads and Maritime Services (Roads and Maritime) is seeking approval under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to construct and operate the M12 Motorway project to provide direct access between the Western Sydney Airport at Badgerys Creek and Sydney's motorway network (the project). In addition, the project has been determined to be a controlled action under Section 75 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) (EPBC 2018/8286) for significant impact to threatened species and communities (Section 18 and Section 18A of the EPBC Act). As such, the project requires assessment and approval from the Commonwealth Government.

The M12 Motorway would run between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham for a distance of about 16 kilometres and would be opened to traffic prior to opening of the Western Sydney Airport. The project would commence about 30 kilometres west of the Sydney central business district, at its connection with the M7 Motorway. The project traverses the local government areas of Fairfield, Liverpool and Penrith. The suburbs of Cecil Park and Cecil Hills are found to the east of the M12 Motorway, with Luddenham to the west.

The project is predominately located in greenfield areas. The topography in and around the project comprises rolling hills and small valleys between generally north–south ridge lines. The existing land uses are semi-rural residential, recreational, agricultural, commercial and industrial. The main residential areas are Kemps Creek, Mount Vernon and Cecil Hills.

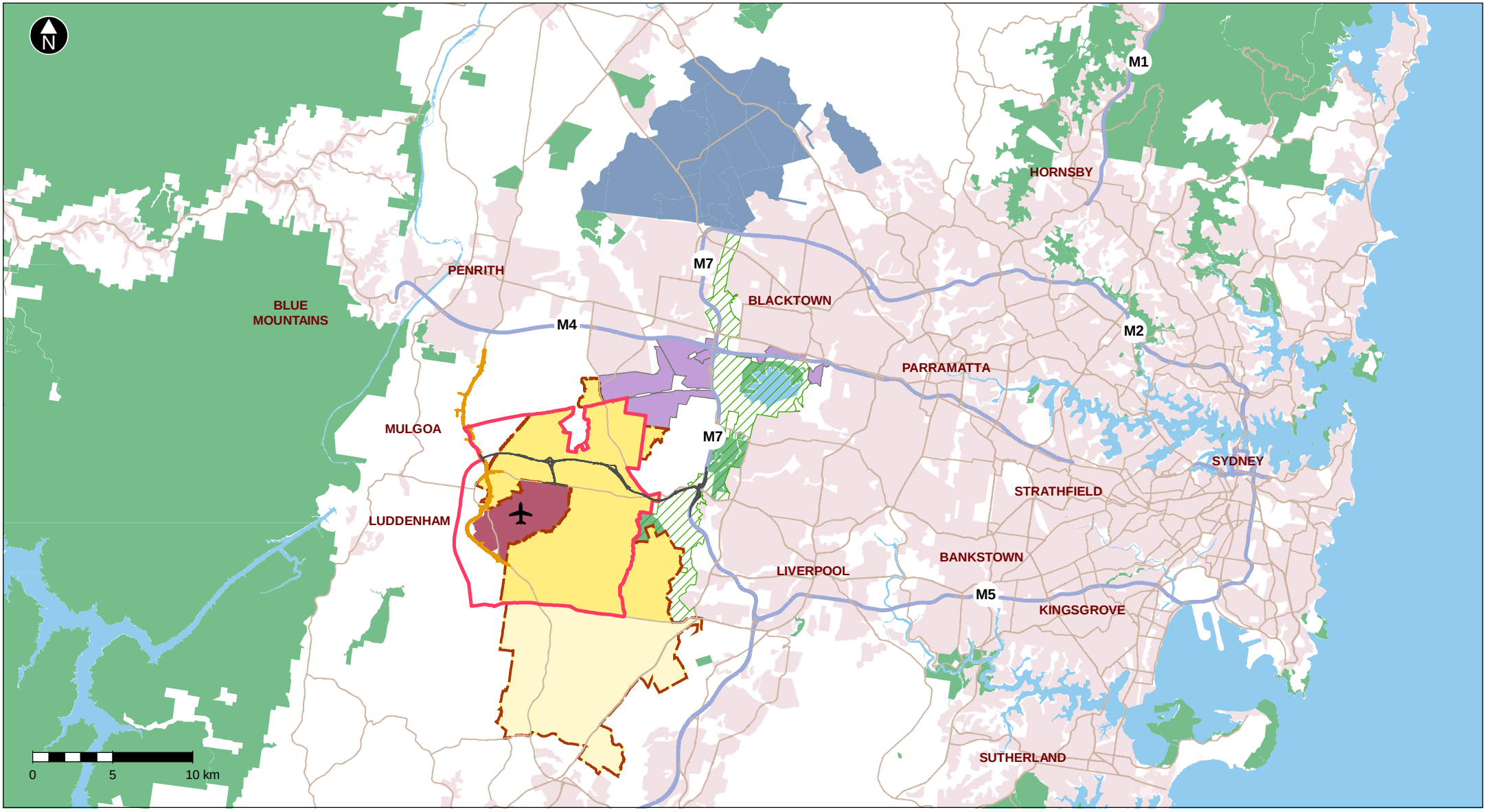
The project is required to support the opening of the Western Sydney Airport by connecting Sydney's motorway network to the airport. The project would also serve and facilitate the growth and development of the Western Sydney which is expected to undergo significant development and land use change over the coming decades. The motorway would provide increased road capacity and reduce congestion and travel times in the future and would also improve the movement of freight in and through western Sydney.

The project location is shown in **Figure 1-1** in relation to its regional context.

1.2 Project overview

The project would include the following key features.

- A new dual-carriageway motorway between the M7 Motorway and The Northern Road with two lanes in each direction with a central median allowing future expansion to six lanes
- Motorway access via three interchanges/intersections:
  - A motorway-to-motorway interchange at the M7 Motorway and associated works (extending about four kilometres within the existing M7 Motorway corridor)
  - A grade separated interchange referred to as the Western Sydney Airport interchange, including a dual-carriageway four lane airport access road (two lanes in each direction for about 1.5 kilometres) connecting with the Western Sydney Airport Main Access Road
  - A signalised intersection at The Northern Road with provision for grade separation in the future
- Bridge structures across Ropes Creek, Kemps Creek, South Creek, Badgerys Creek and Cosgroves Creek
- A bridge structure across the M12 Motorway into Western Sydney Parklands to maintain access to the existing water tower and mobile telephone/other service towers on the ridgeline in the vicinity of Cecil Hills, to the west of the M7 Motorway



The project
Motorways
Existing main roads
The Northern Road upgrade (currently under construction)

Western Sydney Parklands
NPWS estate / reserve
Urban areas
Main waterbodies

Growth areas

Western Sydney Priority Growth Area
South West Priority Growth Area
South West Growth Area
Western Sydney Airport

Western Sydney Aerotropolis
Western Sydney Employment Area
North West Growth Area

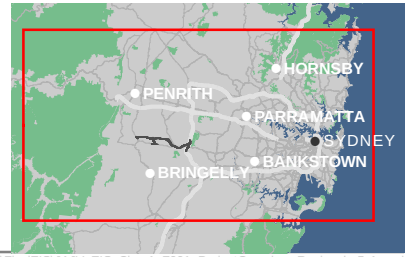


Figure 1-1 Project location (regional context)

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- Bridge structures at interchanges and at Clifton Avenue, Elizabeth Drive, Luddenham Road and other local roads to maintain local access and connectivity
- Inclusion of active transport (pedestrian and cyclist) facilities through provision of pedestrian bridges and an off-road shared user path including connections to existing and future shared user path networks
- Modifications to the local road network, as required, to facilitate connections across and around the M12 Motorway including:
  - Realignment of Elizabeth Drive at the Western Sydney Airport, with Elizabeth Drive bridging over the airport access road and future passenger rail line to the airport
  - Realignment of Clifton Avenue over the M12 Motorway, with associated adjustments to nearby property access
  - Relocation of Salisbury Avenue cul-de-sac, on the southern side of the M12 Motorway
  - Realignment of Wallgrove Road north of its intersection with Elizabeth Drive to accommodate the M7 Motorway northbound entry ramp
- Adjustment, protection or relocation of existing utilities
- Ancillary facilities to support motorway operations, smart motorways operation in the future and the existing M7 Motorway operation, including gantries, electronic signage and ramp metering
- Other roadside furniture including safety barriers, signage and street lighting
- Adjustments of waterways, where required, including Kemps Creek, South Creek and Badgerys Creek
- Permanent water quality management measures including swales and basins
- Establishment and use of temporary ancillary facilities, temporary construction sedimentation basins, access tracks and haul roads during construction
- Permanent and temporary property adjustments and property access refinements as required.

The project overview presented in this document represents the proposed design as described in the EIS. If the project is approved, a further detailed design process would follow, which may include variations to the design as described in the EIS. Flexibility has been provided in the design as described in the EIS to allow for refinement of the project during detailed design, in response to any submissions received following the exhibition of the EIS, or if opportunities arise to further minimise potential environmental impacts.

The key features of the project are shown on **Figure 1-2**.

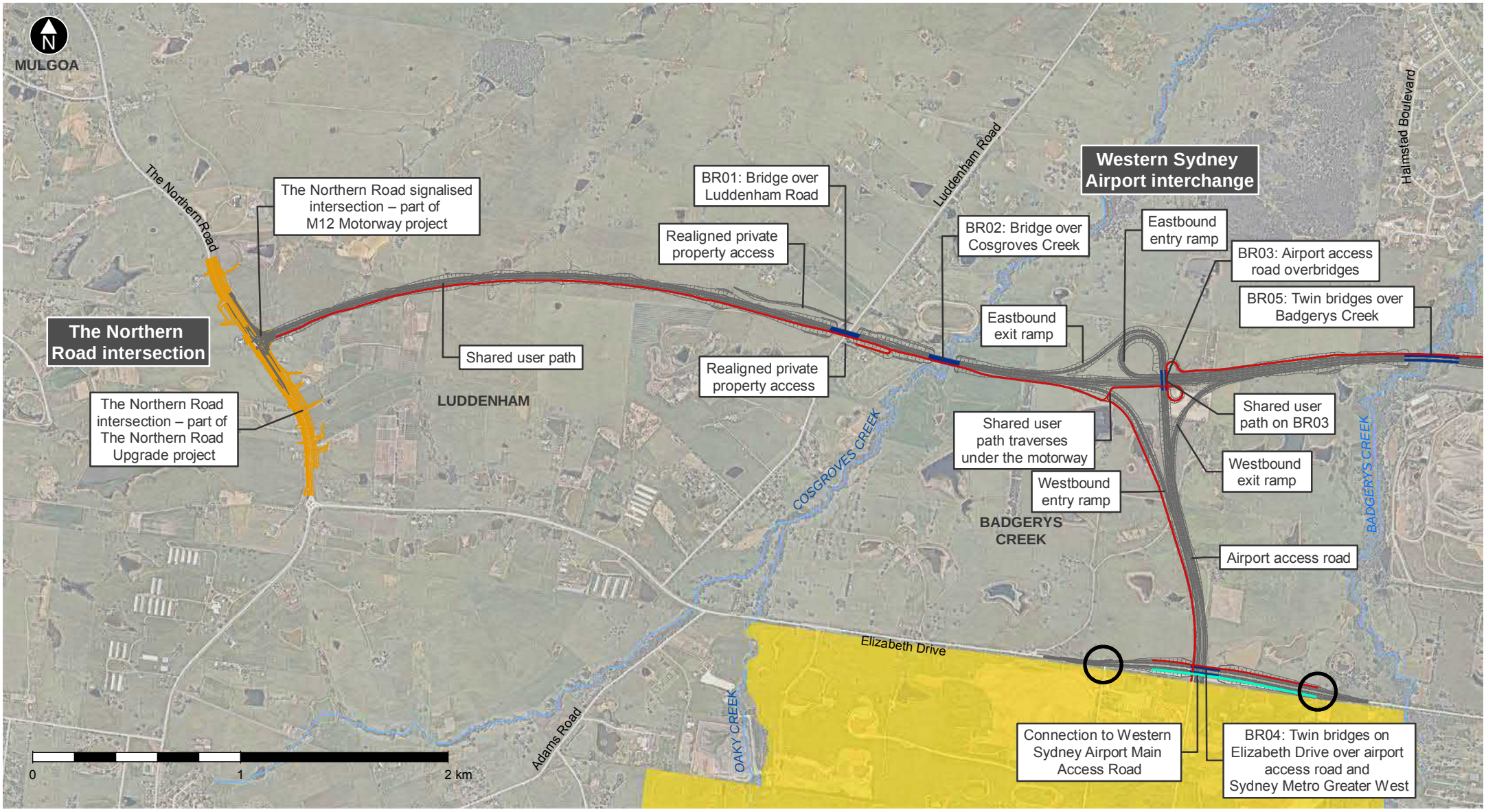
1.2.1 Key construction elements as relevant to soils and contamination

Key construction elements relevant to the soils and contamination assessment are the corridor width and construction footprint, and construction ancillary facilities.

The construction footprint is the total area required to construct the project. The construction footprint is generally broader than the operational footprint, and generally includes all areas required for road work, bridge work, access for construction vehicles and plant, drainage infrastructure, temporary and permanent sediment basins, utilities and services adjustments, temporary stockpiles and temporary ancillary facilities (such as construction compounds and batching plants).

The construction footprint has been established to minimise environmental impact while providing sufficient room to allow the project to be constructed in a safe manner.

Construction ancillary facilities would provide support to the construction of the project and may include material and earthworks stockpiling areas, construction support areas for bridges, a main project office and outpost sites (secondary offices), workshops for servicing plant and equipment, double-handling and laydown areas and concrete and/or asphalt batching plants.



The project

Part of The Northern Road upgrade project

Shared user path

Future shared user path (by others)

Existing roads

Waterways

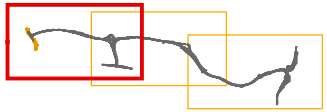
Bridges

Western Sydney Airport

Note. The roads within this zone are being removed as part of airport construction.

Potential future intersections (by others)

Note: Locations to be confirmed



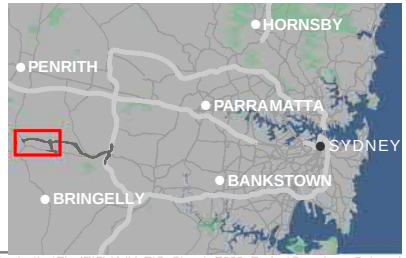


Figure 1-2 Key features of the project

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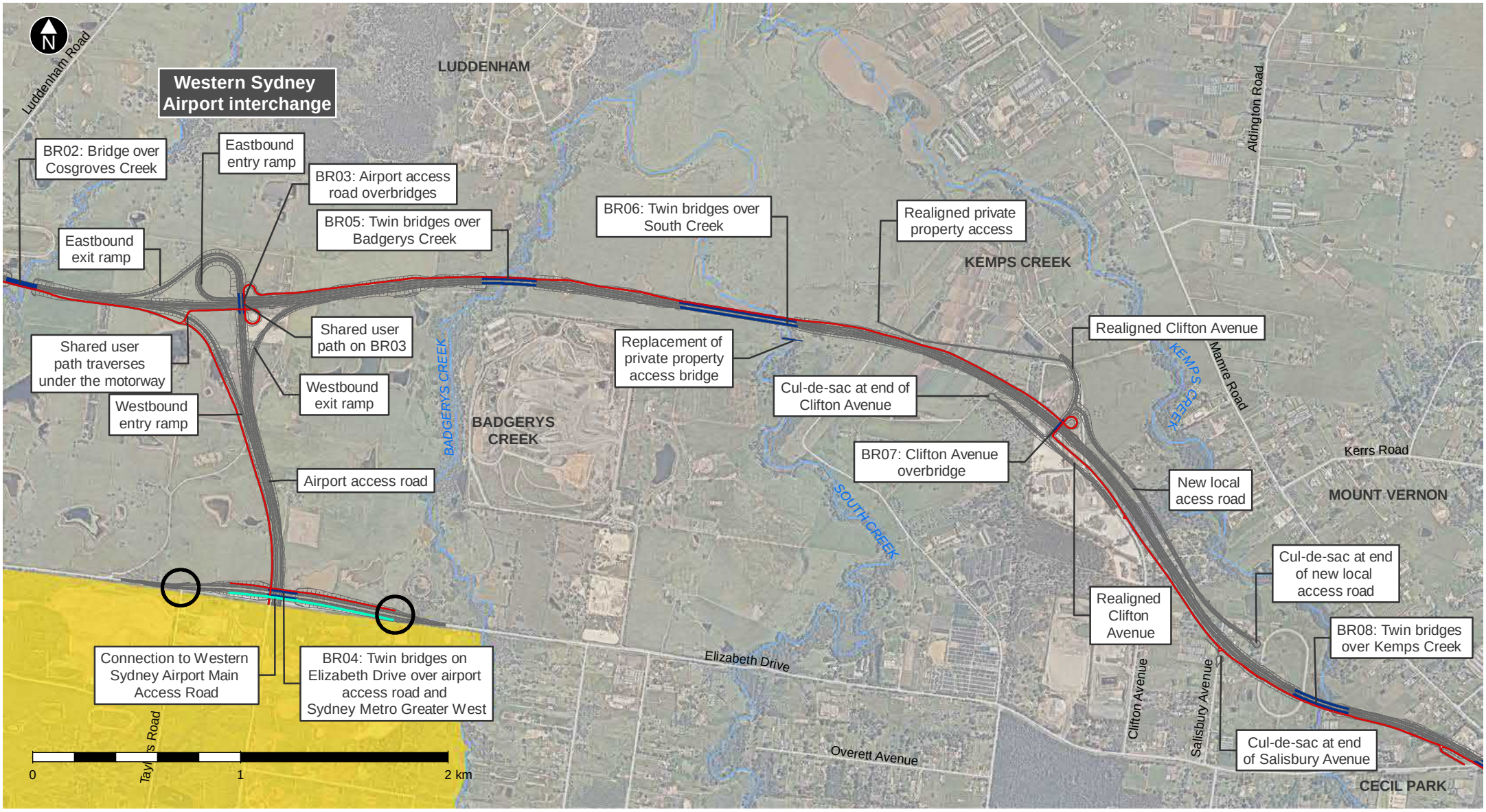


The project

Part of The Northern Road upgrade project

Shared user path

Future shared user path (by others)

Existing roads

Waterways

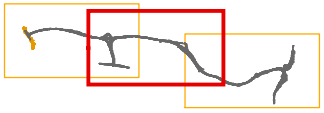
Bridges

Western Sydney Airport

Note. The roads within this zone are being removed as part of airport construction.

Potential future intersections (by others)

Note: Locations to be confirmed



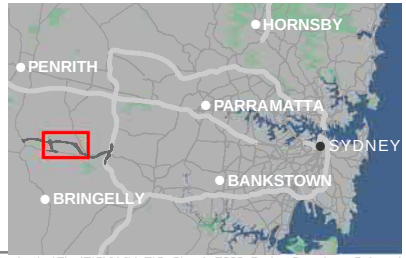


Figure 1-2 Key features of the project

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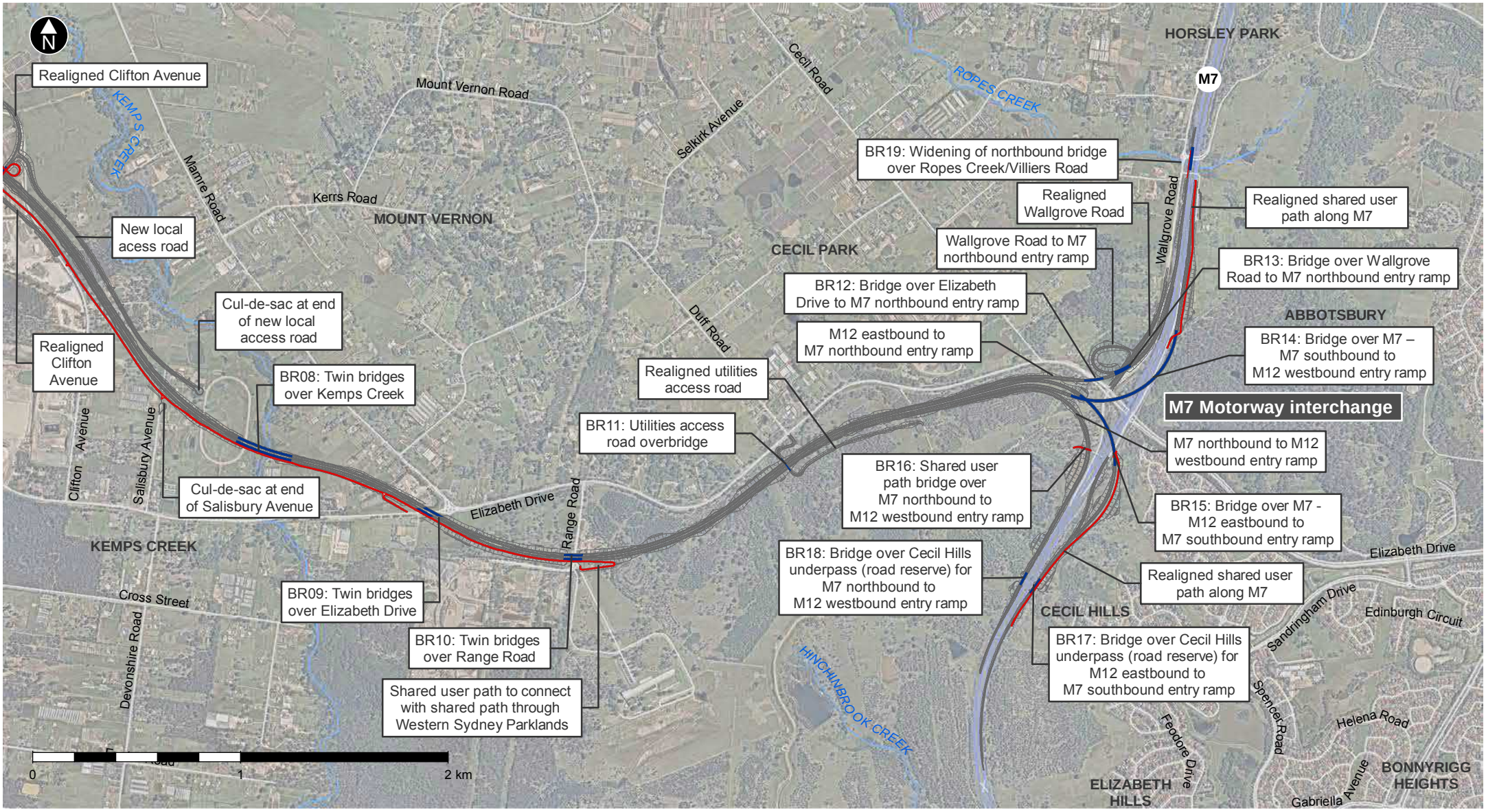
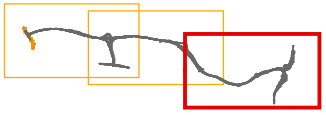


The project
Part of The Northern Road upgrade project
Shared user path
Future shared user path (by others)
Existing roads
Waterways
Bridges



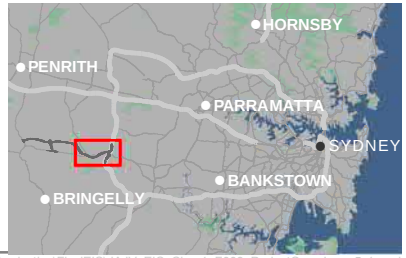


Figure 1-2 Key features of the project

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The ancillary facilities would generally comprise:

- Temporary buildings (generally prefabricated) including offices and meeting rooms, amenity, first aid and toilet facilities (the size and number of office facilities at the main compounds would be greater than at the secondary compounds)
- Hardstand parking areas with capacity for all construction workers expected at any site
- Materials laydown, storage and handling areas, including purpose-built temporary structures as required
- Perimeter fencing, including visual screening of construction compounds where necessary
- Bridge construction support areas
- Workshop for servicing plant.

Some sites would only be used to stockpile and store materials and would therefore contain minimal facilities.

Temporary ancillary facilities outside the operational footprint would be repaired upon completion of construction and restored to their existing land use, or otherwise agreed with the landowner. Temporary ancillary facilities within the operational footprint would be managed and improved as part of the proposed road reserve. Landscaping for temporary ancillary facilities within the operational footprint would be carried out in accordance with the landscape plan. Where practical, temporary ancillary facilities would be progressively repaired to minimise soils exposure and the potential for dust generation, erosion and sedimentation, and visual impact.

The ancillary construction facilities are shown on **Figure 1-3**.

1.3 Purpose and scope of this report

This report has been prepared to support the EIS for the project. The EIS has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the project (SSI 9364) and to enable the Minister for Planning and Public Spaces to make a determination on whether the project can proceed. The report presents an assessment of the construction and operational activities for the project that have the potential to impact soils and contamination.

This working paper is one of a number of technical documents that form part of the EIS for the project. The purpose of this working paper is to identify and assess the potential impact of the project during both construction and operation in relation to soils and contaminated land, including consideration of specific geological conditions. In doing so it responds directly to the Secretary's environmental assessment requirements (SEARs) outlined in **Section 1.4**.

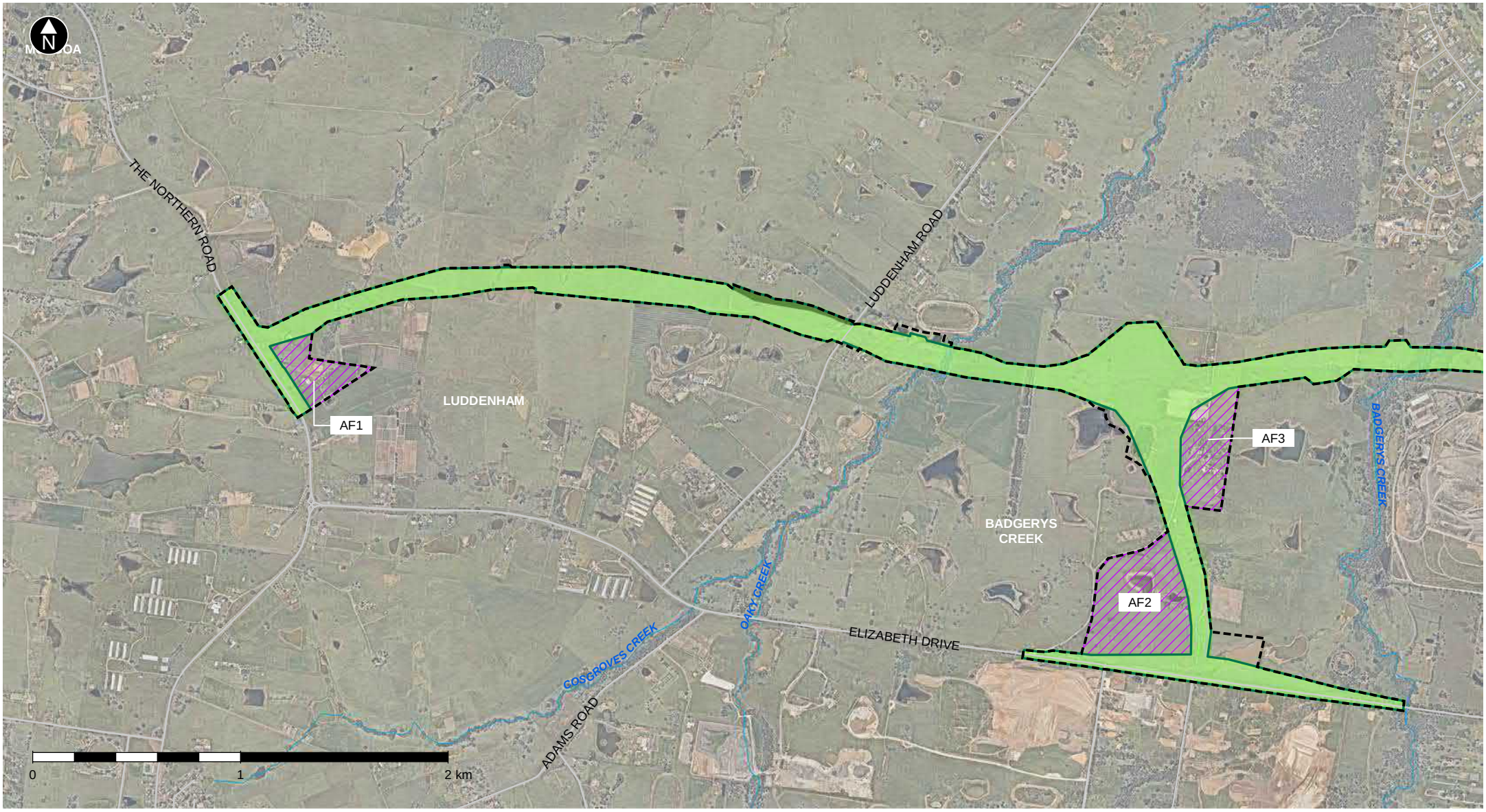
1.4 SEARs

On 18 June 2018, the Secretary of the NSW Department of Planning, Industry and Environment (DPIE) (Planning and Assessment) issued to Roads and Maritime the draft Secretary's environmental assessment requirements (SEARs) for the M12 Motorway EIS. The SEARS were finalised and reissued on 12 July 2018. The project was then determined to be a controlled action under the EPBC Act, and updated SEARs were issued on 30 October 2018 that include the Commonwealth assessment requirements under the EPBC Act.

Table 1-1 lists those requirements relating specifically to the assessment of the project's potential impacts on soils and contamination with a reference to the chapter or section of this report where each requirement is addressed.

Table 1-1 SEARs (soils and contamination)

Secretary's requirement	Where addressed
17. Soils	
1. The Proponent must verify the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within, and in the area likely to be impacted by, the project.	**Section 4.6** and **Chapter 7**
2. The Proponent must assess the impact of the project on acid sulfate soils (including impact of acidic runoff offsite) in accordance with the current guidelines.	**Section 4.6** and **Chapter 7**
3. The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	**Section 4.9**
4. The Proponent must assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area.	**Chapter 5**
5. The Proponent must assess the impact of the project on soil salinity and how it may affect groundwater resources and hydrology.	**Chapter 6**
6. The Proponent must assess the impact on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	**Chapter 7** Additional sediment impacts and guidelines are discussed in **Section 7.9** of the EIS



Construction footprint

- The project construction footprint
- Ancillary facilities

Operational footprint

- The project operational footprint
- RMS road reserve
- Proposed permanent work areas

- Waterways
- Motorway
- Main roads

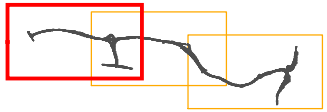


Figure 1-3 Project construction footprint, operational footprint and ancillary facilities

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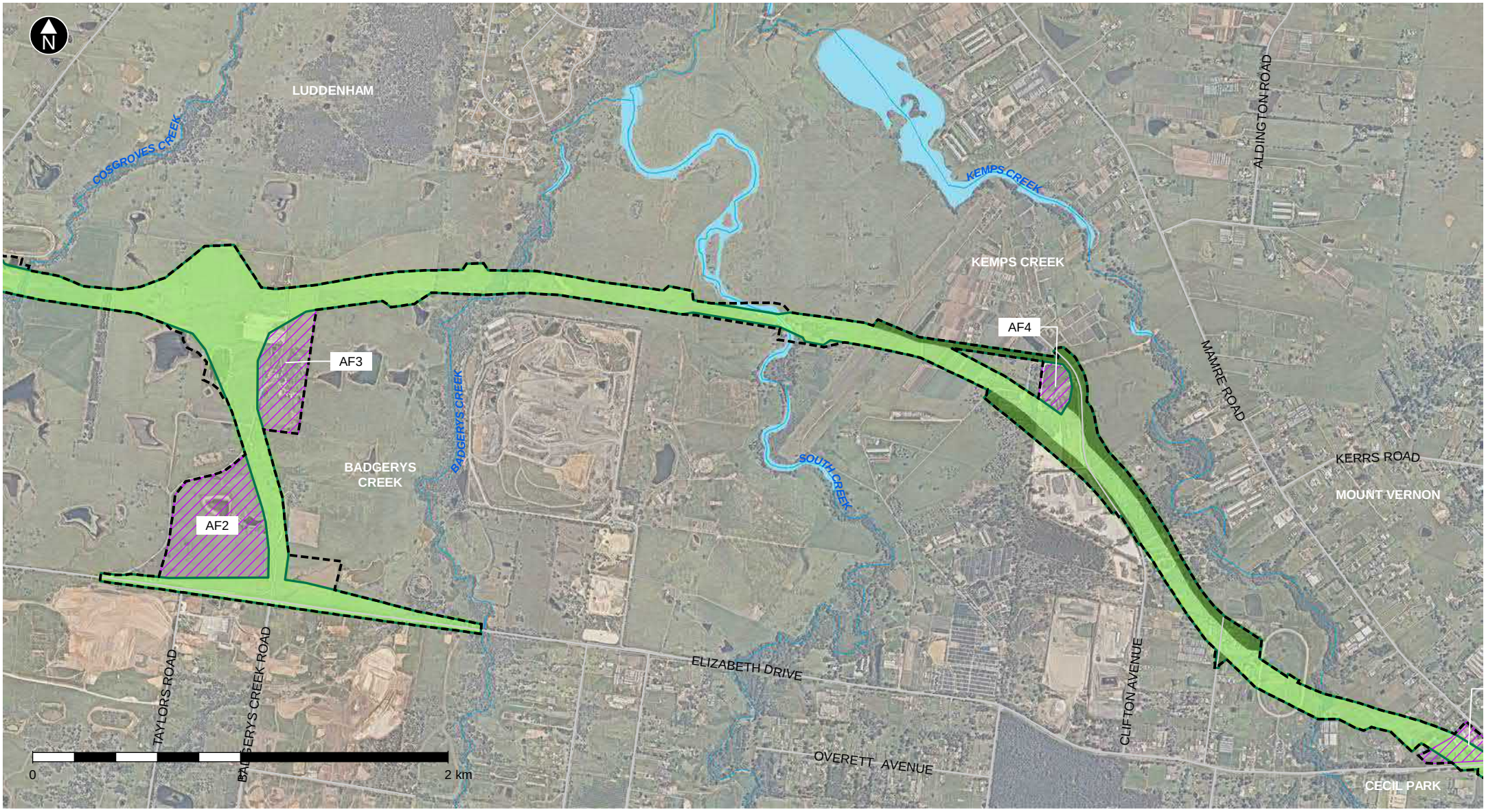

Construction footprint

- The project construction footprint
- Ancillary facilities

Operational footprint

- The project operational footprint
- RMS road reserve
- Proposed permanent work areas

- Waterways
- Motorway
- Main roads

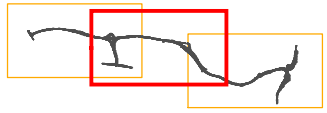

Figure 1-3 Project construction footprint, operational footprint and ancillary facilities

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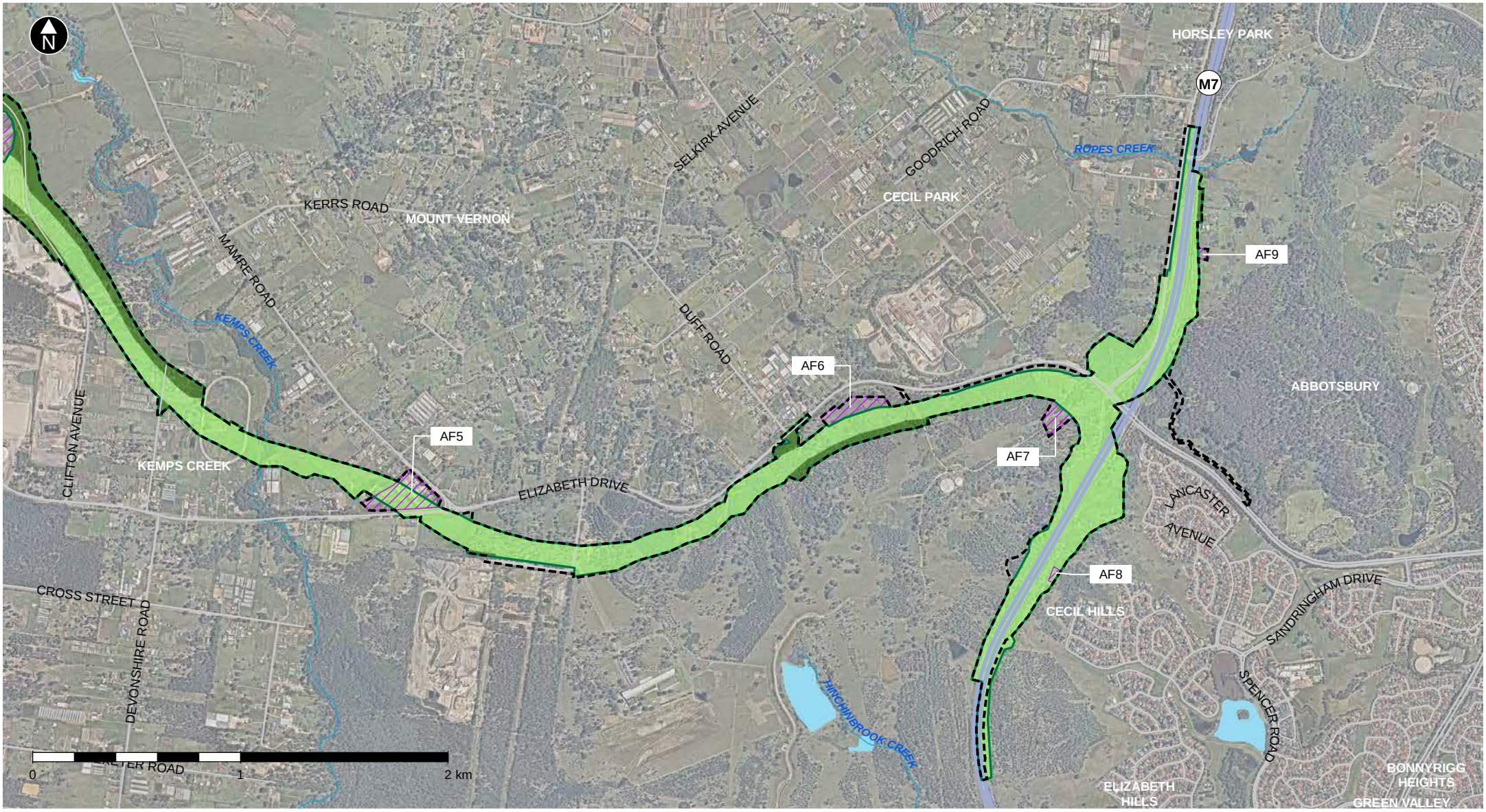

Construction footprint

- The project construction footprint
- Ancillary facilities

Operational footprint

- The project operational footprint
- RMS road reserve
- Proposed permanent work areas

- Waterways
- Motorway
- Main roads

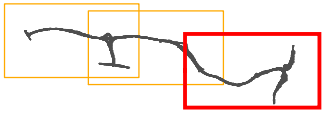

Figure 1-3 Project construction footprint, operational footprint and ancillary facilities

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2. Policy and planning setting

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

- Acid Sulfate Soils Assessment Guidelines (Department of Planning 2008)
- Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land (Department of Urban Affairs and Planning & Environment Protection Authority 1998)
- Guidelines for Consultants Reporting on Contaminated Sites (Office of Environment and Heritage 2000).

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

- Acid Sulfate Soil Manual (Acid Sulfate Soils Management Advisory Committee 1998)
- Guidelines on the Duty to Report Contamination under the *Contaminated Land Management Act 1997* (Environment Protection Authority 2015)
- Urban and regional salinity guidance given in the Local Government Salinity Initiative booklets which includes Site Investigations for Urban Salinity (DLWC, 2002)
- Landslide risk management guidelines presented in Australian Geotechnics Society (2007)
- Soil and Landscape Issues in Environmental Impact Assessment (Gray, 2000)
- Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom, 2004) and Volume 2 (A. Installation of Services; B. Waste Landfills; C. Unsealed Roads; D. Main Roads; E. Mines and Quarries) (Department of Environment and Climate Change NSW, 2008)
- Other guidelines made or approved under section 105 of the *Contaminated Land Management Act 1997*
- 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 Assessment Guidelines for Dredging (Commonwealth of Australia, 2009)
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (as revised 2013) (NEPM, 2013)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000)
- The NSW EPA (2014) Waste Classification Guidelines
- Guidelines for the Implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008 (Department of Environment and Climate Change NSW, 2009)
- The NSW EPA (1995) Contaminated Sites: Sampling Design Guidelines
- The NSW EPA (2017) Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (3rd Edition) (updated from NSW EPA 2006 version)
- Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination (Department of Environment and Conservation NSW, 2007)
- The NSW EPA (2015b) Technical Note: Light Non-Aqueous Phase Liquid Assessment and Remediation
- The NSW EPA (2014a) Technical Note: Investigation of Service Station Sites
- The NSW EPA (2014b) Best Practice Note: Landfarming

- Information for the assessment of former gasworks sites (Department of Environment and Conservation NSW, 2005)
- Vapour Intrusion: Technical Practice Note (Department of Environment, Climate Change and Water NSW, 2010)
- The NSW EPA (2012) Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases
- PFAS - National Environmental Management Plan (HEPA, January 2018)
- Managing asbestos in or on soil (WorkCover NSW, 2014).

3. Assessment methodology

3.1 Overview

The objective of the Stage 1 contamination assessment was to identify potential areas of environmental interest (AEI) which would assist in identifying construction limitations/constraints and management options within the construction footprint with respect to contamination and specific geological conditions.

The AEIs were considered to be those areas that had potential risks associated with soil, groundwater and vapour contamination. These risks may be present as a result of historical and/or current activities carried out on land within and/or next to the project construction footprint. Additionally, AEIs were considered to be those areas with geological conditions within the construction footprint which may be characterised as having potential to be acid forming, have erosion potential, and/or be saline.

To achieve the objective, the following scope of work was carried out:

- Desktop assessment:
  - Review of publicly available information
  - Review of information provided by Roads and Maritime
  - Review of historical aerial photography of the general project area
- Site inspection
- Contamination investigation
- Preparation of a Stage 1 Contamination Assessment Report based on the data obtained from the desktop background review, observations from the inspection of the project area, and results from the JAJV (2018a) contamination investigation. The expected ground conditions are presented together with potential contamination issues identified and commitments for further investigations.

3.2 Study area

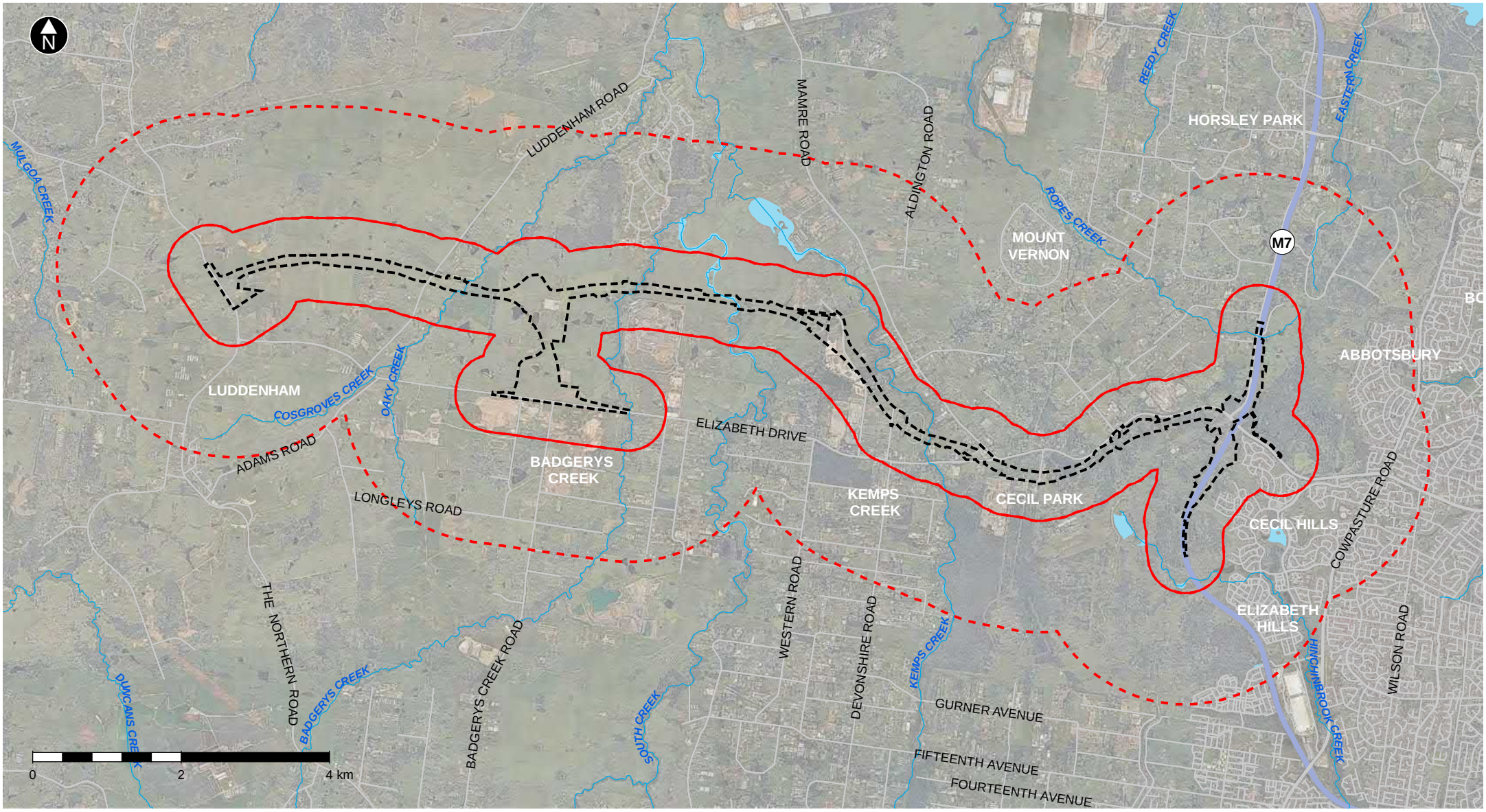
The soils and contamination assessment defined the study area as the construction footprint and about two kilometres radius from the footprint (see **Figure 3-1**). This was used for the purpose of selected desktop and historical review components of the assessment, the site inspection, with the site inspection and geographical extent of potential AEIs being undertaken in the vicinity of the construction footprint. In addition, the following areas were used to carry out desktop searches:

- Groundwater bore search area – For the purpose of the groundwater bore search, the study area comprised the construction footprint and an approximate 500 metre radius from the footprint
- For the purpose of the soils and geology desktop assessment, a broader study area (see **Figure 3-1**) was used to encompass regional soil and geological conditions.

3.3 Desktop assessment

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

- Land and Property Information Division: Historical aerial photographs (NSW Land and Property Management Authority, 1947 to 2002)
- The NSW EPA Contaminated Sites Register, Record of Notices and POEO Public Register.



Waterways
Motorway
Main roads
The project construction footprint

Study area for the purpose of the groundwater bore search (500 m)

Study area for the purpose of the desktop and historical review components of the assessment, the site inspection, and geographical extent of potential AEIs (2 km)

Figure 3-1 Study area

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3.3.1 Review of existing information

A review was carried out on publicly available information including:

- Council websites
- Geographical and soil mapping
  - Review of the Penrith 1:100,000 geological map (Geological Survey of NSW, 1991)
- Bureau of Meteorology (BoM) data, including:
  - Climate and rainfall data
  - Groundwater dependent ecosystems information
- NSW Environment Protection Authority (EPA) data, including:
  - Record of Notices (under section 58 of the *Contaminated Land Management Act 1997* (CLM Act))
  - List of contaminated sites notified to the NSW EPA (under section 60 of the CLM Act*)*
- Australian Soil Resource Information System (ASRIS) database
- The WaterNSW groundwater database.

3.3.2 Historical aerial photography

Historical aerial photographs from the Department of Lands and Property Information (LPI) were reviewed for the years: 1947, 1961, 1970, 1978, 1986, 1994, and 2002. Historical images from Google Earth were reviewed from 2002 to 2019. The aerial photography review focused on the construction footprint and construction support sites (detailed in **Section 1.2.1** and **Figure 1-2**), specific AEIs and general land use that could be potentially impacted by the project construction work (see Chapter 5 of the EIS for construction details).

3.3.3 Previous contaminated sites investigation

Information from the following reports was reviewed in preparation of this report:

- M12 Motorway: Strategic Route Options Analysis Contamination Working Paper (Aurecon 2016)
- Contamination inputs for geotechnical site investigation (JAJV 2017).

These are detailed in the subsections that follow.

M12 Motorway: Strategic Route Options Analysis Contamination Working Paper (Aurecon 2016)

Roads and Maritime engaged Aurecon Australasia Pty Ltd (Aurecon) to carry out a strategic route options analysis for the project. As part of the strategic route options analysis, Aurecon prepared a Phase 1 contamination investigation report.

The following publicly available information was reviewed by Aurecon during the preparation of the Phase 1 contamination investigation:

- Previous environmental and heritage reports
- Historical aerial photography
- Available geology and hydrogeology maps
- Groundwater bore search
- A NSW Environment Protection Authority (EPA) Contaminated Land Search.

Additionally, the following tasks were undertaken to support the information review:

- A site walkover to assess current site conditions, evaluate evidence of previous site activities and to identify soil movement, disturbed areas and fill
- Evaluation of current and past activities and related practices at the site to establish known or potential sources of soil contamination
- Development of a preliminary Conceptual Site Model (CSM)
- A qualitative risk assessment to assess the potential risks to human health and environments.

Contamination inputs for geotechnical site investigation (JAJV 2017)

Based on the information from the Aurecon (2016) route options analysis report and a site walkover undertaken by a JAJV environmental scientist in May 2017, JAJV summarised AEIs within and/or next to the Aurecon preferred corridor route which could pose a potential contamination risk to construction activities, associated contaminants of concern, and the suggested investigation strategy to target these AEIs.

3.4 Site investigations

3.4.1 Site inspection

A site inspection was conducted on 18 May 2017. The site inspection focussed on the project construction footprint, as well as nearby land uses and potential areas of environmental interest (AEIs). The site inspection was only carried out at areas within the construction footprint which were publicly accessible. The site inspection is discussed further in **Section 4.17**.

3.4.2 Contamination investigation

A contamination investigation was undertaken to support the design component of the project and to further assess AEIs identified during the Phase 2 contamination assessment. Limited intrusive investigations were carried out within the construction footprint. The soil, groundwater and gas results were presented against a set of public open space land use exposure risk criteria to assess site contamination in accordance with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (as revised 2013) - Schedule B1 Guideline on Investigation levels for Soil and Groundwater (NEPC 2013). The results are summarised in **Section 5.4**.

3.4.3 Soil boreholes

Soil investigations were carried out as part of the contamination investigation, and results were reviewed to form part of the assessment documented in this report.

3.4.4 Groundwater monitoring

Groundwater monitoring was carried out as part of the project contamination investigation, and results were reviewed to form part of the assessment documented in this report.

3.4.5 Landfill gas monitoring

Landfill gas monitoring was carried out as part of the project contamination investigation, and results were reviewed to form part of the assessment documented in this report.

3.5 Photogrammetry survey

A photogrammetry survey was undertaken of the proposed M12 Motorway construction footprint. The survey utilised historical (1950s and 1960s) and current aerial photography/imagery to ascertain site levels. The survey was undertaken to provide surface elevation models for the historical and current imagery. An assessment was then undertaken of the elevation models to evaluate for changes in elevation (typically able to determine height/level differences of greater than about 0.3 metres) that could indicate areas of filling and/or stockpiling across the proposed construction footprint.

4. Existing environment

This section includes a description of the existing environment and has been informed by the desktop investigations and field inspections undertaken for the project. The information presented below is based on a review of publicly available information, and observations made during a project area inspection carried out from publicly accessible areas by JAJV on 18 May 2017.

4.1 Location and zoning

The project construction footprint (hereafter referred to as the construction footprint) spans about 16 kilometres from The Northern Road at Luddenham, to the M7 Motorway at Cecil Park in Sydney's western suburbs.

The project is located within a range of land use zones as identified in the *Liverpool Local Environmental Plan 2008*, *Fairfield Local Environmental Plan 2013*, and the *Penrith Local Environmental Plan 2010*. Land use zones for the project area under the respective local environmental plans (LEPs) are provided in **Table 4-1** and are presented as **Figure 4-1**.

Table 4-1 Land use zones within the construction footprint

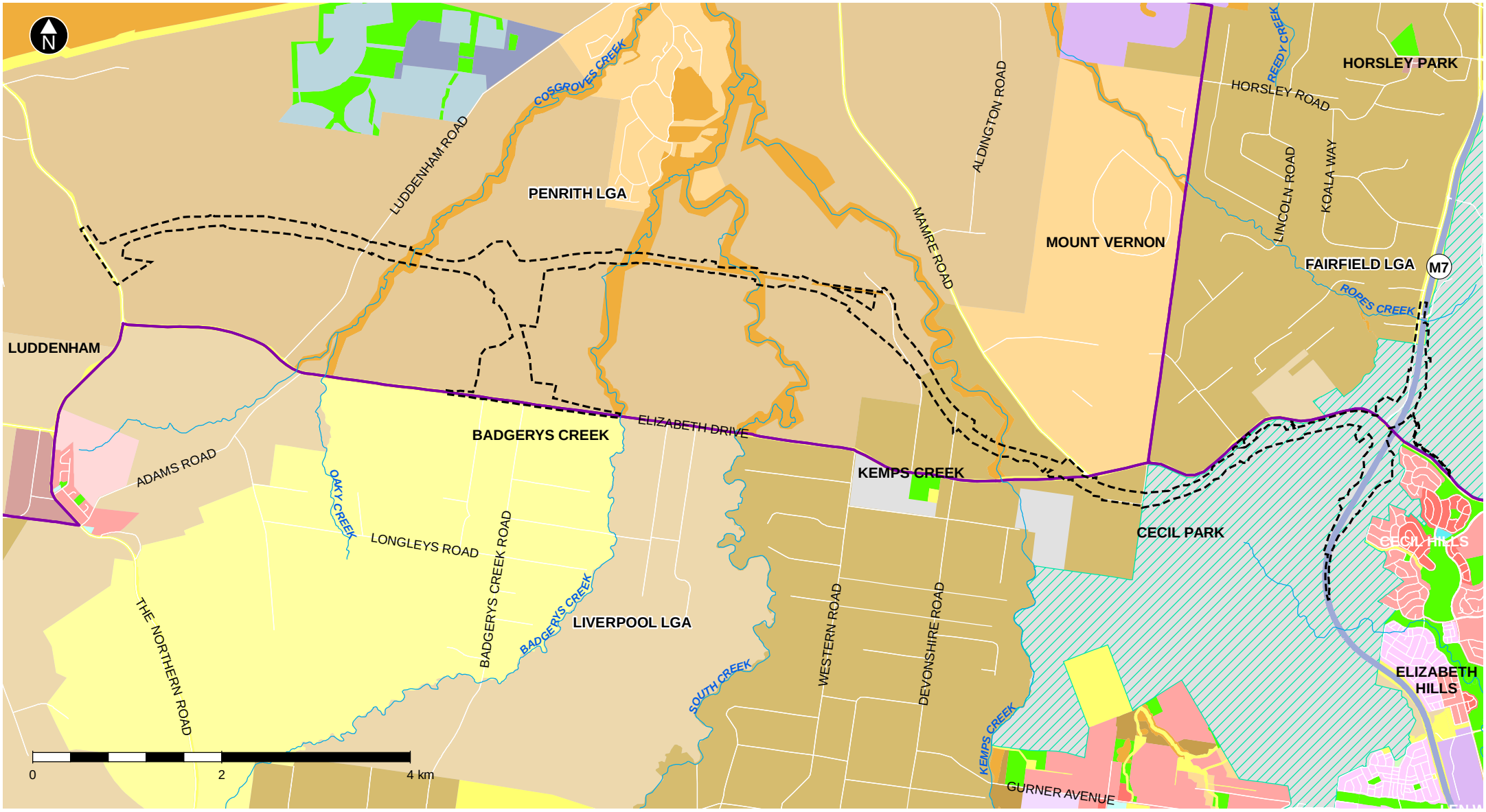
LEP	Land use zones
Liverpool LEP 2008	RU4 – Primary production small lots
	WSP – SEPP Western Sydney Parklands 2009
Fairfield LEP 2013	RU4 – Primary production small lots
	RU1 – Primary production
Penrith LEP 2010	RU4 – Primary production small lots
	E2 – Environmental conservation
	RU2 – Rural landscape
	SP2 – Classified road

4.2 Topography

The topography of the study area is characterised into three general terrain types as follows.

- Rolling Hills Terrain – occurs in the western and eastern portions of the proposed alignment
- Flat to Gently Undulating Terrain – occurs in the central portion of the alignment
- Creek Channels/Alluvial Floodplain Terrain – dissects the Flat to Gently Undulating Terrain within the central portion of the alignment.

Within the Rolling Hills Terrain, the topography typically comprises rounded hills with slopes of five degrees to 20 degrees (ie around 10 per cent to 35 per cent grade), and local relief of typically up to 10 metres to 30 metres. Within this general terrain type, the ground surface levels along the alignment range from about relative level (RL) 70 metres Australian Height Datum (AHD) to RL115 metres AHD.



The project construction footprint
Waterways
LGA boundary
Western Sydney Parklands

LEP land use zones

B1 Neighbourhood Centre
B2 Local Centre
B4 Mixed Use
B7 Business Park
E2 Environmental Conservation
E3 Environmental Management
E4 Environmental Living
IN1 General Industrial
IN2 Light Industrial
R1 General Residential
R2 Low Density Residential
R3 Medium Density Residential
R5 Large Lot Residential
RE1 Public Recreation
RE2 Private Recreation
RU1 Primary Production
RU2 Rural Landscape
RU4 Primary Production Small Lots
RU5 Village
RU6 Transition
SP1 Special Activities
SP2 Infrastructure

Figure 4-1 Land zoning within the construction footprint

Data sources
LEPs - Penrith, Liverpool, Fairfield LGA

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The topography of the Flat to Gently Undulating Terrain in the central portion of the alignment typically comprises gentle rises and undulations with broad rounded crests with slopes of 0 degrees to 5 degrees (ie up to around 8 per cent grade) and local relief of up to about 15 metres. Ground surface levels along the central portion of the alignment range from about RL 35 metres AHD to RL 70 metres AHD. The Flat to Gently Undulating Terrain type is dissected by the Creek Channel/Alluvial Floodplain Terrain type by four meandering creeks, Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek, with each creek flowing to the north.

The topography of the alluvial floodplains adjacent to the creeks comprises low slopes of about zero degrees to two degrees, which extend from the creek channels out to a maximum distance of about 500 metres.

4.3 Geology

Based on review of the Penrith 1:100,000 geological map (Geological Survey of NSW, 1991) and completed project geotechnical borehole logs (JAJV 2018b), the study area includes two surface geological units as follows:

- Quaternary Alluvium, which is located in the vicinity of the project's five creek crossings
- Bringelly Shale bedrock.

Figure 4-2 presents these geological units as per the following lithologies:

- Qal – quaternary alluvium that consists of fine-grained sand, silt and clay
- Qpn – quaternary alluvium that consists of medium-grained sand, silt and clay
- Rwb – Wianamatta group, including the Bringelly shale and underlying units, consisting of shale, carbonaceous claystone, claystone, laminate, fine to medium-grained lithic sandstone, rare coal and tuff.

4.3.1 Quaternary Alluvium

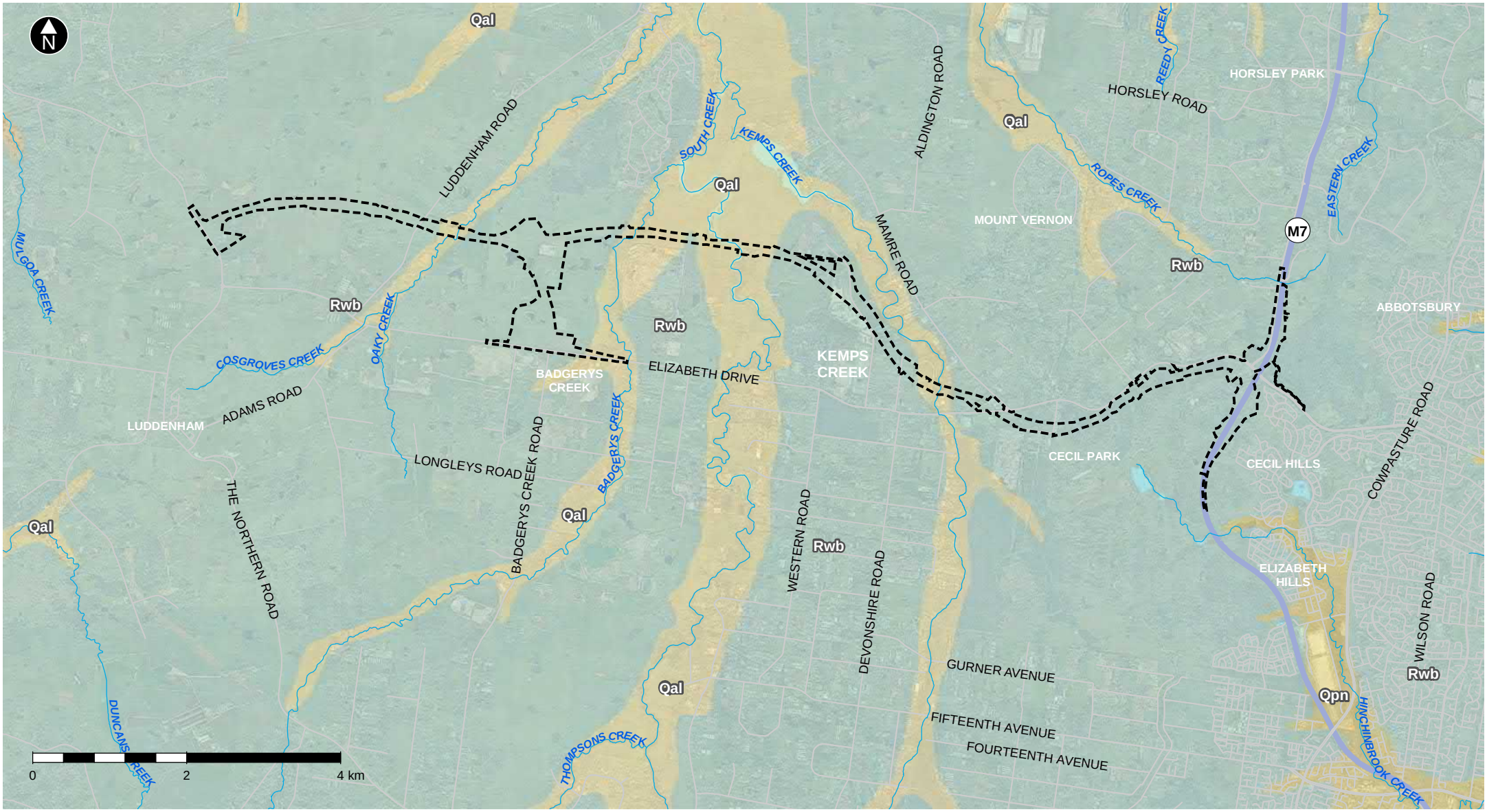
The Penrith 1:100,000 geological map (Geological Survey of NSW, 1991) indicates the alluvium comprises fine grained sand, silt and clay. Project boreholes adjacent to four of the project's creek crossings (Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek) encountered silty sand, sandy clay, gravelly clay, silty clay, clayey silt, sandy silt, clayey sand and sandy gravel above the bedrock, which occurred at depths ranging from about 2.5 metres below ground level (BGL) to 7.0 metres BGL. Therefore, the alluvium deposits are relatively thin.

Based on geological mapping (Geological Survey of NSW, 1991) within the study area, the widths of the alluvium deposits are of the order of 300 metres, two kilometres and 500 metres for Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek respectively. Geology is presented as **Figure 4-2**.

4.3.2 Bringelly Shale and underlying units

The Penrith 1:100,000 geological map (Geological Survey of NSW, 1991) indicates Bringelly Shale comprises shale, carbonaceous claystone, claystone, laminite, fine to medium grained lithic sandstone, rare coal and tuff. Project boreholes encountered siltstone, sandstone and interlaminated siltstone and sandstone at typical depths of about one metre BGL to five metres BGL.

With reference to the Penrith 1:100,000 geological map (Geological Survey of NSW, 1991), Bringelly Shale is the upper member of the Wianamatta Group. The Wianamatta Group was deposited during a single mostly regressive period following subsidence of the Hawkesbury Sandstone alluvial plain.



Waterways
Motorway
Main roads
The project construction footprint

Geology

Qal: Quaternery Alluvium (Fine-grained sand, silt and clay)

Qpc: Quaternery Alluvium (Gravel, sand, silt, clay)

Qpn: Quaternery Alluvium (Medium-grained sand, clay and silt)

Rwb: Bringelly Shale

Data sources
Penrith 1:100 000
Department of Industry: Resources and Energy

Figure 4-2 Geology

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Deposition of sediment continuously during the period resulted in the shoreline progressing eastwards and a vertical accumulation of sediments, beginning with offshore low energy marine muds at the base of the group (Ashfield Shale), which became a shoreline sand deposit (Minchinbury Sandstone), and finally into alluvial plain deposits (Bringelly Shale).

The Bringelly Shale was deposited in an alluvial plain environment that included swampy organic rich sediments, overbank alluvial clays, channel sands and lake deposits, which is why the unit has variable sedimentary rock types.

Bringelly Shales are often deeply weathered to depths of up to 10 metres. The formation typically weathers to form clays and silty clays of medium to high plasticity, and of low permeability. Based on project boreholes and regional experience, it is expected that where Bringelly Shale is present near the surface, ground conditions would comprise one metre to five metres of high plasticity, low permeability residual clays over highly weathered bedrock.

The underlying Minchinbury Sandstone differs to Bringelly Shale in being a relatively thin stratigraphic unit that separates the overlying Bringelly Shale from the underlying Ashfield Shale. The unit comprises fine to medium-grained quartz lithic sandstone comprising more than 15 per cent calcite, high quantities of quartzite and limited amounts of felspar, which differentiates it from the sandstones that occur in the Bringelly Shale.

Ashfield Shale which occurs below the Minchinbury Sandstone comprises dark grey to black claystone, siltstone, shale and fine-grained sandstone-siltstone laminate.

Bringelly Shale is the only anticipated bedrock unit to be intersected by the project. The Minchinbury Sandstone and Ashfield Shale units are anticipated to occur sufficiently below the project alignment to not be intersected.

4.3.1 Intrusions

No igneous intrusions are shown on the geological map (Geological Survey of NSW, 1991) to be present on the project alignment. The Luddenham Dyke is located approximately two kilometres to the south-west of The Northern Road intersection and there are volcanic necks to the north, closer to the M4 Motorway. Igneous dykes are often difficult to identify in this part of Sydney with limited surface exposures as the weathered dykes are often similar to weathered shale bedrock. Based on previous experience with rail and road route studies throughout Sydney, it is anticipated that two to four igneous dykes/intrusions may be present along the project alignment.

4.3.2 Structures

The Penrith 1:100,000 geological map (Geological Survey of NSW, 1991) indicates that the project footprint may be crossed at two locations by faulting or folding as follows:

- Narellan Lineament: The overall north/south linearity of South Creek suggests that it may be structurally controlled. In addition to this, there are also a number of north-east trending tributaries into the South Creek channel, such as Cosgrove Creek, which may be an expression of regional faulting trends
- Rossmore Anticline: This feature is described as a structural high within the Wianamatta Group. The geological map (Geological Survey of NSW, 1991) shows this feature ending at Elizabeth Drive, just to the east of the intersection with Luddenham Road. However, this feature may extend further north crossing the western end of the alignment. If this is the case, then bedrock bedding dips in the vicinity of such a feature could be altered and potentially dipping to the west on the western side of this structure.

4.4 Hydrogeology

4.4.1 Principal groundwater systems

Based on project geological conditions, project groundwater investigations and registered groundwater works, two main groundwater system types exist in the study area as follows:

- Unconfined to semi confined alluvial groundwater systems associated with Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek, which the project alignment crosses
- Semi confined groundwater systems within the bedrock (Wianamatta Group Shale and Hawkesbury Sandstone).

4.4.2 Alluvial groundwater systems

Based on information from the JAJV (2018b) groundwater assessment report, project boreholes adjacent to four of the project's creek crossings (Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek) encountered clays, silts, sands and gravels above the bedrock, which occurred at depths ranging from about 2.5 metres BGL to 7.0 metres BGL. Therefore, the alluvium deposits are relatively thin (ie less than seven metres) and predominantly clayey. Based on geological mapping (Geological Survey of NSW, 1991) within the study area, the widths of the alluvial deposits are around 300 metres, two kilometres and 500 metres for Cosgroves Creek, Badgerys Creek/South Creek and Kemps Creek respectively.

The alluvial deposits are considered to be of insufficient thickness and hydraulic conductivity to be capable of providing a potential water supply. Flow directions are anticipated to be similar to a subdued reflection of the topographic surface. Therefore, it is likely that the alluvial groundwater systems are in some degree of hydraulic connection with the associated watercourses.

Current project groundwater monitoring bore data indicates that the water table depth in the area of the alluvial deposits ranges from about two metres BGL to five metres BGL (JAJV 2018b).

4.4.3 Bedrock groundwater systems

The bedrock groundwater systems are characterised as semi-confined dual porosity systems (granular flow and fracture flow). The upper major hydrostratigraphic unit comprises Wianamatta Shale which overlies a lower major hydrostratigraphic unit consisting of Hawkesbury Sandstone.

The Wianamatta Shale Group comprises Bringelly Shale, Minchinbury Sandstone and Ashfield Shale, which exist in that stratigraphic order. The base of the Wianamatta Group and top of the Hawkesbury Sandstone is anticipated to be at a level of the order of -40 metres AHD to -65 metres AHD in the study area.

Based on the project's maximum cut depth of about 15 metres BGL, the Wianamatta Group's upper formation of Bringelly Shale is the only rock formation anticipated to be encountered by project excavations. As such and given the base of the Bringelly Shale formation is anticipated to be significantly lower than the project's vertical alignment, groundwater flow systems within the Bringelly Shale are considered to be the main bedrock groundwater flow systems relevant to the project.

Groundwater flow directions are anticipated to be similar to a subdued version of the topographic surface. Current project groundwater monitoring bore data indicates that the water table in the Bringelly Shale (including associated overlying residual clay) ranges from about one metre BGL to 19 metres BGL.

4.4.4 Groundwater salinity

Sydney Basin groundwater salinity mapping (Russel et al., 2009) in the study area indicates that the Wianamatta Group groundwater systems have salinity concentrations of the order of 5000 milligrams per litre (mg/L) to 10,000 mg/L. This is considered 'unpalatable' (NHMRC, 2011) for humans and generally likely to result in a decline in livestock production and condition (based on the upper 10,000 mg/L concentration).

Salinity mapping (Russel et al., 2009) in the study area indicates that the Hawkesbury Sandstone groundwater systems have salinity concentrations of the order of 3000 mg/L to 5000 mg/L, which is considered 'unpalatable' (NHMRC, 2011) for humans. At the upper end of the mapped concentration range (ie 5000 mg/L), dairy cattle production and conditions would likely decline, while poultry would likely not be able to tolerate this concentration, even if introduced gradually.

Beyond the western extent of the study area, the mapped Hawkesbury Sandstone groundwater salinity decreases to 1000 mg/L to 3000 mg/L, where greater than 1200 mg/L is considered unpalatable to humans, and greater than 2000 mg/L is considered unpalatable for most livestock (SAEPA, 2019).

Based on information from the JAJV (2018b) groundwater assessment report, of the 38 registered groundwater works, only three bores had reported salinity concentrations. Concentrations were 4200 mg/L (bore ID GW105016.1.1), 950 mg/L (bore ID GW108121.1.1) and 1500 mg/L (bore ID GW106654.1.1). These three bores had depths of 252.5 metres, 246 metres and 252 metres respectively and therefore are inferred to be accessing Hawkesbury Sandstone groundwater systems.

4.4.5Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are ecological communities that are dependent, either entirely or in part, on the presence of groundwater for their health or survival. The Regions, Industry, Agriculture and Resources Group (RIAR) of the DPIE Water Risk Assessment Guidelines for Groundwater Dependent Ecosystems (Serov et al, 2012) adopts the definition of a GDE as "Ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater".

GDE dependence on groundwater can be variable, ranging from partial and infrequent dependence (ie seasonal or episodic) to total continual dependence.

BoM's GDE Atlas (BoM, 2018b) was reviewed to investigate the potential for GDEs to exist within the study area. The atlas mapping is summarised as follows:

- South Creek is mapped as a high potential aquatic GDE (based on national assessment)
- Moderate to high potential terrestrial GDEs (based on national assessment) are mapped within the study area, generally in the region of the five creek crossings, but also in three isolated areas away from the creeks. These GDEs are described as either Cumberland Shale Hills Woodland or Cumberland River Flat Forest.

Additionally, Appendix 2 of the water sharing plan legislation (NSW Government, 2011) indicated that no High Priority (based on the *high ecological value aquatic ecosystem (HEVAE) framework*) GDEs (ie karst and wetlands) are mapped within approximately 10 kilometres of the study area.

GDEs are further detailed in the Groundwater Quality and Hydrology Assessment Report (**Appendix N** of the EIS).

4.4.6 Project groundwater interception potential

As detailed in the *M12 Motorway Concept Design and Environmental Impact Statement - groundwater assessment report* (JAJV, 2018b), there are limited areas of cut which are anticipated to be below the water table. The cut located about 1,500 metres east of The Northern Road (hereinafter referred to as the western cut) may be below the water table by about 0.5 metres. Low groundwater inflow to this cut is anticipated, most of which would likely be readily evaporated (if cut is unlined). Drawdown induced changes to the water table levels in the region of this cut is expected to be localised to the vicinity of the cut. Additionally, the water table may be reached during piling as part of bridge construction.

4.5 Soil landscapes

Based on a review of the 1:100,000 scale Soil Landscape Map for Penrith, the study area includes four soil landscapes as follows:

- South Creek – Fluvial deposits which are located along four of the project's creek channels (Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek)
- Blacktown – Residual soils located in the flat to gently undulating terrain between creek channels
- Luddenham – Residual soils located on the low rolling hills at both ends of the alignment
- Picton – Residual and colluvial soils located at the eastern end of the alignment.

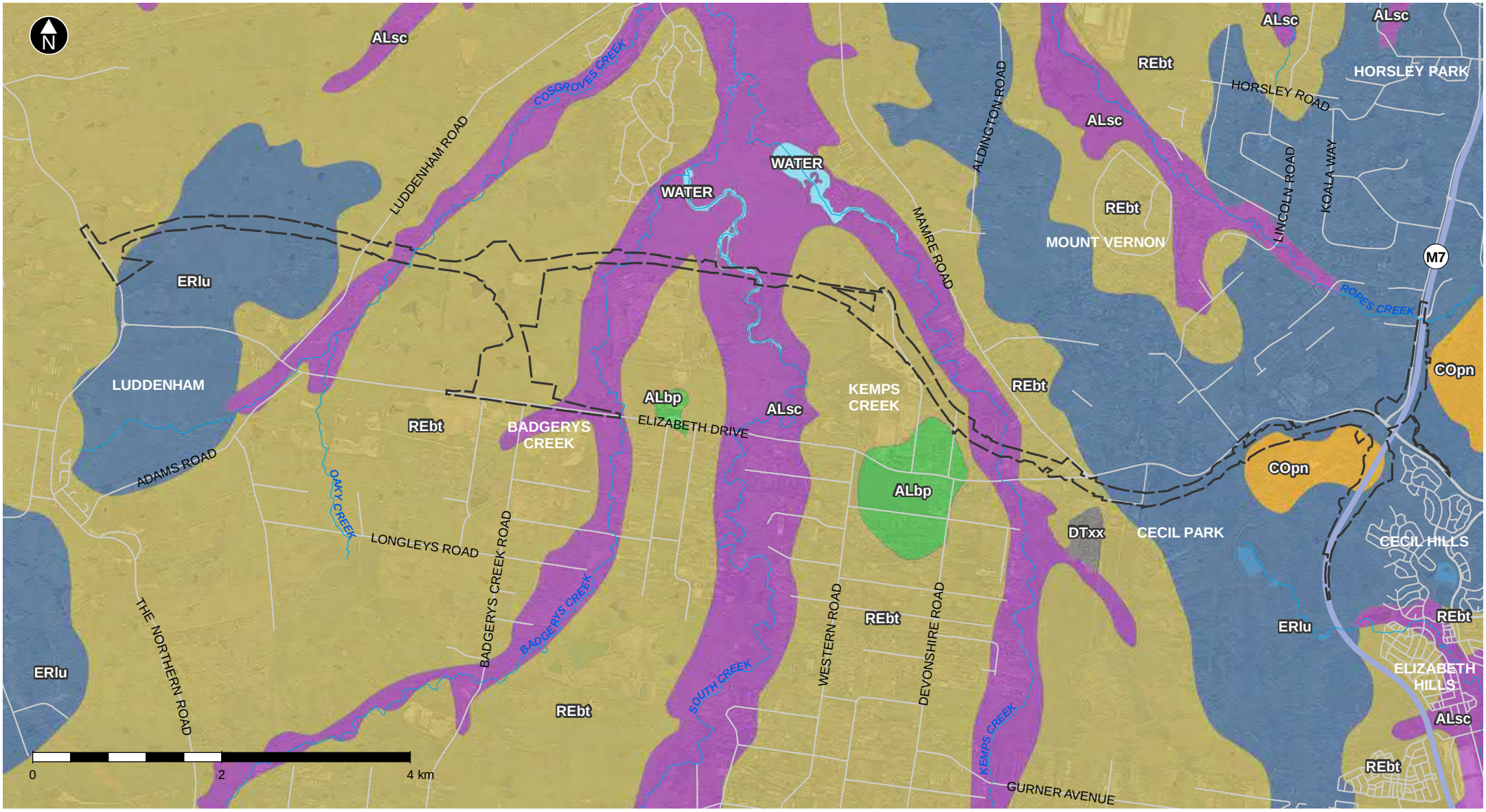
The location and extent of each soil landscape is closely related to surface landform and topography. Soil landscapes are presented in **Figure 4-3**.

South Creek soils are located within four of the project's creek channels (Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek) that cross the construction footprint. It is described as Quaternary alluvium derived from Wianamatta Group shales that comprise deep sandy, sandy clay and clay soils that were deposited as part of the current active South Creek drainage network. This is a dynamic soil landscape with many areas of erosion and deposition. Relevant limitations for development include high erodibility, shrink-swell potential, salinity, low fertility and localised areas of permanently high-water tables or seasonal waterlogging.

Blacktown soils are located on the flat to gently undulating terrain between creek channels and are described as shallow to moderately deep clays and silty clays derived from the Bringelly Shales. Relevant limitations for development include strongly acidic, low fertility, high shrink-swell, low permeability potential for salinity, high erodibility.

Luddenham soils are located on the low rolling hills at both ends of the construction footprint. This soil landscape is derived from Bringelly Shales and is described shallow to moderately deep, typically comprising clays, and where Minchinbury Sandstone may be present sandy clays. Moderately inclined slopes of 10 to 20 per cent are the dominant landform and as a result, development limitations included high erosion hazards, together with a high shrink-swell potential and low permeability and low fertility.

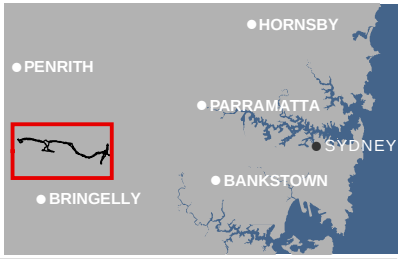
There is an area of Picton soil landscape located in the rolling hills at the eastern end of the alignment. This soil landscape occurs on steep sided slopes over Wianamatta Group shales usually with a southern aspect and where there are slope gradients more than 20 per cent. Picton soils are described as shallow to deep residual and colluvial clays. Of particular note for this soil landscape is that there is potential for mass movement and slope instability (ie land sliding).



Waterways
Motorway
Main roads
The project construction footprint

PROCESS, Soils landscape name

- ALLUVIAL, Berkshire park
- ALLUVIAL, South creek
- COLLUVIAL, Picton
- DISTURBED TERRAIN, Disturbed terrain
- EROSIONAL, Luddenham
- RESIDUAL, Blacktown
- WATER, Water



Data sources
Soil Landscapes of the Penrith 1:100,000 sheet
NSW Department of Environment, Climate Change and Water (DECCW)

Figure 4-3 Soil Landscape

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Created by : HK | QA by : AA

4.6 Acid sulfate soils risk

Acid Sulfate Soils (ASS) is the common name for naturally occurring sediments and soils containing iron sulphides. The exposure of these soils to oxygen by drainage or excavation, oxidises the iron sulphides and generates sulfuric acid. The sulfuric acid can be readily released into the environment, with potential adverse effects on the natural and built environments. The majority of ASS are formed when available sulfate (which occurs widely in seawater, marine sediment, or saturated decaying organic material) reacts with dissolved iron and iron minerals forming iron sulfide minerals, the most common being pyrite. This generally limits their occurrence to deeper marine sediments and low-lying sections of coastal floodplains, rivers and creeks where surface elevations are less than about RL five metres AHD.

The Acid Sulfate Soil Manual (ASSMAC, 1998) outlines the steps required to establish whether ASS are present on a site. The first step is to consult ASS risk maps within applicable LEPs. A search was undertaken within Penrith Council (2010) and Liverpool Council (2008) LEPs for ASS risk maps for the construction footprint to determine the probability of ASS occurrence. ASS risk maps within LEPs typically categorise ASS in terms of Class (ie Class 1, 2, 3 or 4). The search found no ASS risk maps exist for the construction footprint within the LEPs and so conclusions can be drawn that there is no known or expected occurrence of ASS within the construction footprint, and no Class was attributed to soils in the area.

Due to the absence of ASS risk maps, further analysis of soil characteristics was carried out to verify the risk of acid sulfate soils within the construction footprint. The steps taken are detailed below.

ASSMAC (1998) states that if, after Step 1, the works are not in or near a mapped area, proceed without further consideration of ASS. However, for the purpose of this assessment, Steps 2 and 3 detailed within ASSMAC (1998) have also been considered.

Step 2 of ASSMAC (1998) is to establish whether ASS are present on a site and to assess if the area meets specific geomorphic and other site criteria as detailed below:

- Sediments of recent geological age (Holocene)
- Soil horizons of less than five metres AHD
- Marine or estuarine sediments and tidal lakes
- In coastal wetlands or back swamp areas, waterlogged or scalded areas, interdune swales or coastal sand dunes
- In areas where the dominant vegetation is mangroves, reeds, rushes, and other swamp-tolerant or marine vegetation such as swamp mahogany, paperbark and swamp oak
- In areas identified in geological descriptions or in maps as bearing sulphide minerals, coal deposits or former marine shales/sediments
- Deep older estuarine sediments greater than 10 metres below ground level, Holocene or Pleistocene age (only an issue if deep excavation or drainage is proposed).

Based on site observations and the desktop assessment, with the exception of ‘sediments of recent geological age’, the project footprint does not meet the site criteria for the presence of ASS. Sediments of recent geological age (Holocene/Pleistocene) are present along Cosgroves Creek, South Creek, Kemps Creek, and Badgerys Creek (Geological Survey of NSW, 1991).

Step 3 of ASSMAC (1998) is to undertake investigations which “should include a field inspection to consider soil and surface and sub-surface water characteristics’. Table 2.3 of the ASSMAC (1998) provides soil and water characteristics typical of ASS that were also able to observed or analysed during the geotechnical and contamination investigations (eg pH and lithic observations). While specific ASS testing was not undertaken during the geotechnical investigation, characteristics observed during the investigation (ie pH of soil and groundwater, and observations during borehole logging) were not consistent with ASS (ie pH was greater than four in soils, no presence of shell or jarositic horizons observed in boreholes, pH of water was greater than 5.5, no iron staining observed in ponds, or blue-green water flowing from the area).

Additionally, no collection and analysis of samples were collected from within 'recent' sediments within the five creeks within the construction footprints. Based on the soil and groundwater results from the geotechnical and contamination investigations, ASS is unlikely to be present in soils of the project construction footprint.

In addition to the above assessment, a search of the Australian Soil Resource Information System's (ASRIS 2018) online ASS risk maps was undertaken. The risk maps indicate that the project would be located within an area considered to have an extremely low probability of ASS occurrence. It indicates that there is no known or expected occurrence of ASS within the construction footprint.

When disturbed by drainage, lowering of water-tables or excavation, oxidation of the sulphides in soils creates sulphuric acid which can trigger a range of flow-on effects, including:

- Acidification of groundwater, wetlands and waterways
- Damage to building footings and underground infrastructure from acid and sulphate attack
- Leaching of aluminium, iron, manganese and arsenic from the soils deteriorating groundwater, wetlands, rivers and estuaries.
- Formation of black muds known as monosulphidic black ooze (MBO) that are highly reactive and prone to rapidly deoxygenating waters if disturbed (DWER, 2017).

Based on the groundwater assessment (JAJV 2018b), to within 60 metres of the western cut is the only area of the project footprint where the groundwater table is likely to be lowered as a result of construction. The assessment provided a conservative measure of groundwater lowering of 1.6 metres during construction, which is minimal and within the bounds of natural variability that would occur in response to changing long-term climate conditions. Therefore, given that ASS is unlikely to be present in soils of the project footprint, the slight lowering of the groundwater table within this location is unlikely to incite any of the aforementioned changes in soil acidity.

4.7 Acid rock

Acid rock is defined as rock that contains sulfide or sulfate minerals (commonly pyrite) which has the potential to oxidise when exposed and produce sulfuric acid. Acid Rock is potentially an issue where the sulfide bearing rock that has previously been protected from weathering, or is below the water table, becomes exposed such as in deep cuttings.

Sedimentary pyrite is a common constituent of organic rich, typically fine-grained marine and anoxic terrestrial sediments. Coal measures and carbonaceous mudstones are typically where sedimentary pyrite would be anticipated.

To date, no occurrences of acid rock have been documented within Bringelly Shales soil landscapes and on this basis, the potential for encountering acid rocks along the project alignment is considered to be extremely low.

4.8 Salinity

The Salinity Potential in Western Sydney 2002 Map (DLWC, 2002) shows that the soils along the alignment generally have a moderate salinity potential. The exception being small areas along the alignment with a high salinity potential, such as:

- In the areas of Cosgrove Creek
- In areas of low-lying land to the east and west of Cosgrove Creek and along Kemps Creek
- Small areas of known soil salinity along the proposed alignment to the east of Range Road.

Salinity potential is defined as being either known, moderate or high salinity:

- Areas of known salinity – defined as those areas where saline soils have been identified or air photo interpretation and field observations have identified visual indicators of land salinity such as bare earth or waterlogging
- Areas of moderate salinity potential – defined as where Wianamatta Group Shales or tertiary alluvial terraces are present
- Areas of high salinity potential – defined as those areas where expected soil, geology, topography and groundwater conditions predispose a site to salinity. These areas are most commonly drainage systems or low lying/flat grounds where there is a high potential for the ground to become waterlogged.

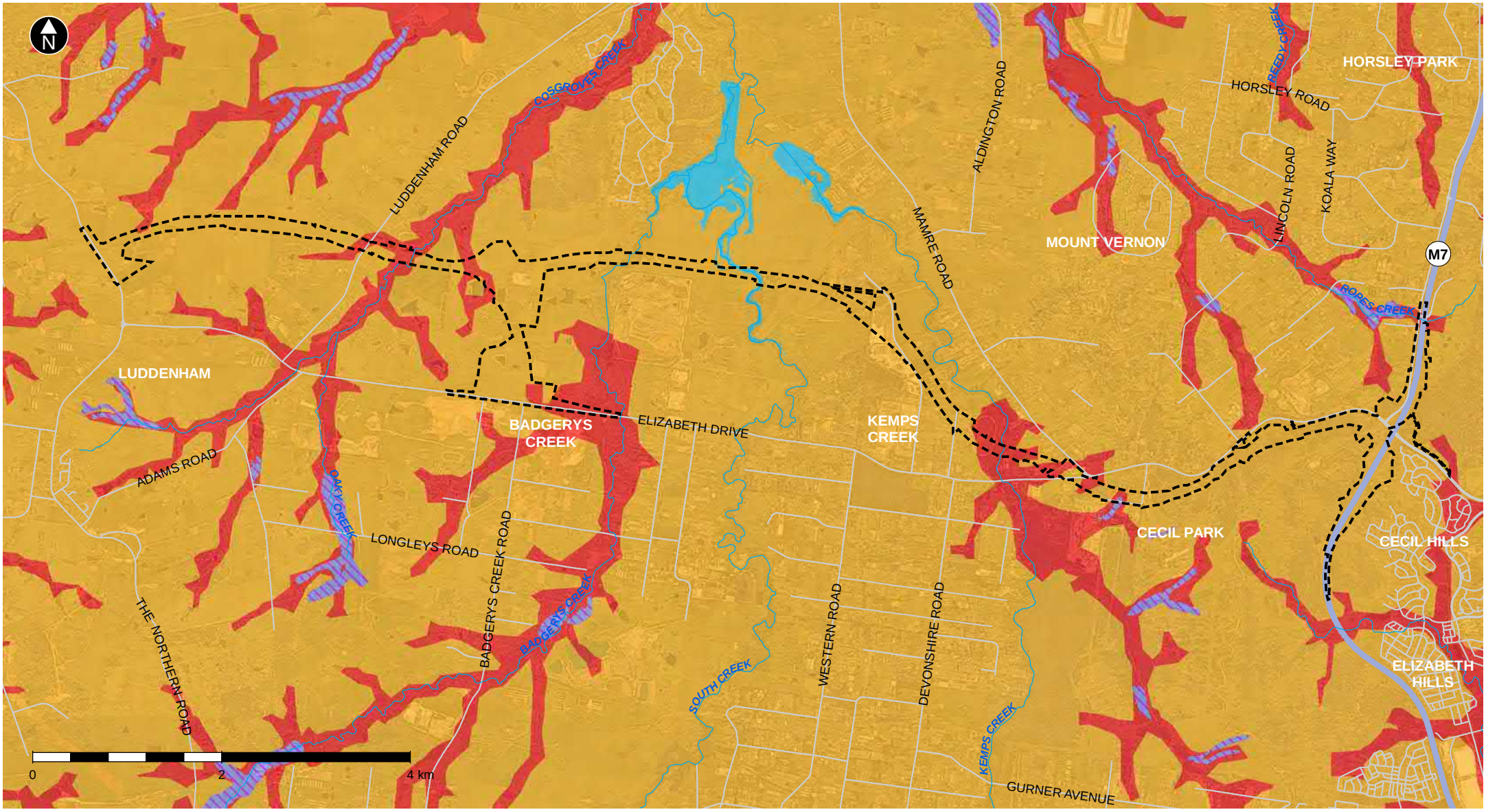
Additional saline areas may be present which have not yet been identified or may occur if site conditions change adversely.

Soil salinity is a complex issue relating to salt and water cycles both above and below the ground. Surface and groundwater can dissolve and mobilise salts and cause their accumulation in other areas. Development can cause changes to these water flows and cause salt to accumulate in different areas. Laboratory testing of soil salinity (electrical conductivity) was carried out as part of the Geotechnical assessment with the results indicating that the soils along the project range from 'non-saline' to 'moderately saline' (JAJV 2018c). Results from the sampling program reinforce the risk mapping provided in **Figure 4-4** (ie salinity risk is highest along creeks, drainage channels and floodplains). Similarly, results from the hydrology assessment (JAJV 2018d) confirmed that the majority of surface waters of creeks within the project construction footprint had elevated electrical conductivity above ANZECC guidelines indicating saline environments.

With reference to the above, areas of current or potential soil salinity are expected along the construction footprint where there is alluvium, waterlogged ground or shallow groundwater. A soil salinity risk map, based on data from the Salinity Potential in Western Sydney 2002 Map (DLWC, 2002) is presented in **Figure 4-4**.

4.9 Contamination

The construction footprint encompasses large areas of historical and current potentially contaminating activities, which may require management or further investigation during the construction phase of the project. Historical and current potentially contaminating activities within the construction footprint include agricultural and rural land use, service stations, landfilling and waste recycling, quarries, potential areas of fill material, and industrial land use.



Waterways
Motorway
Main roads
The project construction footprint

Soil salinity potential
High
Moderate

Areas of known salinity
Water
Salt

Data sources
Western Sydney Salinity Potential 2002, Office of Environment and Heritage (OEH)

Figure 4-4 Soil salinity risk map

Date: 30/06/2019 Path: J:\IE\Projects\04_Eastern\IA145100\08 Spatial\GIS\Directory\Templates\MXDs\Figures\EIS\SpecialistReports\Contam\FinalEIS\JAJV_EIS_Contam_F009_SoilSalinity_r5v1.mxd
Created by : HK | QA by : AA

4.10 Rainfall and climate

Review of BOM's rainfall and temperature data for the Badgerys Creek observation station indicated that the average monthly rainfall for the general study area ranges from 22.6 millimetres in July to 98.5 millimetres in February, with an average annual rainfall of about 681 millimetres. Based on mean daily evaporation data from BOM's Sydney Observatory Hill observation station, evaporation exceeds rainfall for all months except June, where the average monthly rainfall surplus (ie rainfall minus evaporation) is about 25 millimetres. Average monthly rainfall, evaporation and rainfall surplus is summarised in **Table 4-2**.

Table 4-2 Average monthly rainfall, evaporation and rainfall surplus

(mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Rainfall[1]	79.4	98.5	81.3	49.4	37.0	61.4	22.6	36.8	32.3	51.4	69.0	57.1	680.9
Mean Evaporation [2]	142.6	109.2	96.1	78.0	58.9	36.0	46.5	58.9	75.0	102.3	129.0	136.4	1068.9
Rainfall surplus	-63.2	-10.7	-14.8	-28.6	-21.9	25.4	-23.9	-22.1	-42.7	-50.9	-60.0	-79.3	-388.0

Notes: [1] Source: BOM's Badgerys Creek observation station.
[2] Source: BOM's Sydney Observatory Hill observation station.

Average maximum temperatures range from 17.5 degrees Celsius in July to 30.1 degrees Celsius in January, and average minimum temperatures range from 4.1 degrees Celsius in July to 17.1 degrees Celsius in January and February.

4.11 Groundwater

A review of the registered groundwater bore database indicates that there are a number of registered groundwater bores along or near the construction footprint.

Hydrogeological conditions and groundwater levels along the construction footprint would vary depending on topography, ground conditions, and proximity to creeks. From our review of available site information, experience in the area, and with reference to the observed landforms and expected geological units across the site, the following hydrogeological conditions are anticipated:

- Shallow rainfall dependent transient seepage or perched groundwater in areas of residual soils and weathered Bringelly Shale bedrock typically to depths of three metres to 10 metres
- Shallow groundwater flows or groundwater tables can be expected in the lower lying natural creek channels and Quaternary Alluvium at depths of one metre to five metres
- Deeper regional water table in the Bringelly Shale bedrock occurring below the base of weathering; this deeper regional water table could be expected at depths of 10 metres to 15 metres beneath hill crests in the Rolling Hills, and five metres to 10 metres beneath the surface topography in the Gently Undulating Terrain.

Groundwater within the Wianamatta Shales is generally considered to be saline and not considered a groundwater resource. However, the groundwater does present a potential hydrogeological risk when the saline water is forced to rise to the surface or is exposed in cuttings. Careful management of groundwater flows through the alluvial creek channels and maintenance of current surface water flows would be needed to ensure saline groundwater mounding (ie subsurface build-up of groundwater pressure) or ground waterlogging would not occur.

In general, the characteristics of the aquifers are; low but variable hydraulic conductivity/permeability, and very low yields at less than 0.5 litres per second (L/s). Water bearing fractures are not persistent, are widely spaced, and thus poorly connected.

As overlying clays are typically of low permeability this can act as an aquiclude, where the groundwater in the fractured shale beneath is confined and may be under artesian pressure in lower areas of the construction footprint.

Contaminated groundwater has the potential to impact on construction activities such as bridge construction and excavations which reach depths to groundwater. Based on the design, two areas where groundwater is likely to be encountered by the project are:

- The western cut
- Where construction activities reach the water table, which is expected to be limited to the locations of bridges (aside from the western cut); in these locations the water table may be reached during piling (or other forms of excavation below the water table) (JAJV 2018b).

The western cut

The groundwater quality and hydrology investigation (see **Appendix N** of the EIS) found that over time the rate of seepage through the face of the western cut would decrease as the groundwater system reaches equilibrium. It could take up to a year for equilibrium to be reached. It is expected that by the time the construction phase is complete there would be considerably less or negligible quantities of seepage occurring.

Bridge construction activities

While pile excavations could intercept the water table, groundwater extracted from the pile boreholes would typically not be separated from the excavated soil/rock and the material would be managed as one entity, and therefore volumes of groundwater are not expected to require management (JAJV 2018b).

4.11.1 Groundwater bore search

A search of the Water NSW groundwater database identified 17 registered groundwater wells within a 500 metre radius of the project footprint, including within the following areas:

- Surrounding the SUEZ Kemps Creek Resource Recovery Park
- North of Hi-Quality Group quarry, Kemps Creek
- Associated with Caltex service station, Kemps Creek
- East of Brandown Quarry, Kemps Creek.

Details of the 17 wells are summarised in **Table 4-3**, overleaf.

4.12 Catchment description

The project would be located within the Hawkesbury-Nepean catchment, a catchment covering more than 22,000 square kilometres, which provides drinking water, recreational opportunities, agricultural and fisheries produce and tourism resources for the Sydney Metropolitan area. The Hawkesbury-Nepean Catchment is of national significance, being the longest coastal catchment in NSW. The catchment flows 470 kilometres from the headwaters of the Nepean River in Goulburn before joining the Hawkesbury River in Sydney's west and draining to Broken Bay.

There are many major drainage features flowing in this catchment, including the Hawkesbury, Nepean, Mulwaree, Wingecarribee, Wollondilly, Mulwaree, Tarlo, Nattai, Coxs, Kowmung, Grose, Capertee, Colo and Macdonald. There are also several creeks, including Berowra, Mangrove, Cattai, South and Mooney creeks. The catchment contains a variety of landscapes, including rainforest, open woodlands, heathlands, wetlands and highland freshwater streams.

The project would lie within the Lower Nepean River Management Zone of the Hawkesbury-Nepean Catchment. While almost half the Hawkesbury-Nepean Catchment is protected in national parks and water catchment reserves, the project lies within the South Creek sub-catchment which has been extensively modified and disturbed due to increasing urbanisation and associated land clearing. The Hawkesbury River is the ultimate downstream receiving environment and is located about 29 kilometres from the project at the closest point.

Land uses within the study area are predominately semi-rural and include residential, agricultural, commercial and industrial. The largest residential areas are the suburbs of Kemps Creek, Mount Vernon and Horsley Park. Agricultural land uses include poultry farms, farms producing tomatoes and cucumbers, Christmas tree farm and wholesale nurseries. Commercial uses are generally located within the Kemps Creek village and include service stations, food stores, hardware and maintenance shops. Industrial uses include the Elizabeth Drive landfill and quarry site (RMS/Aurecon 2016).

There are a number of existing transport and utilities infrastructure within the study area. This includes the M7 motorway, Elizabeth Drive, the Sydney Water Upper Canal system and major electrical infrastructure (RMS/Aurecon 2016).

The catchment is shale based and characterised by meandering streams. The project is located within the Cumberland Plain, a subregion of the Sydney Basin which consists of relatively flat and low-lying topography. However, small ridgelines are present around Horsley Park, Orchard Hills and Cecil Hills.

The project intersects Cosgroves Creek, Badgerys Creek, Kemps Creek and South Creek, and drains to Ropes Creek and Hinchinbrook Creek. These creeks drain into South Creek which then flow north to join the Hawkesbury River at Windsor. The South Creek sub-catchment covers around 490 square kilometres and generally flows from south to north. The confluence of Kemps Creek and Badgerys Creek into South Creek is about three kilometres north of Elizabeth Drive (RMS 2016). There are also numerous farm dams in the study area.

The South Creek sub-catchment is one of the most degraded sub-catchments of the Hawkesbury-Nepean. Catchment vegetation clearance and increasing urbanisation has dramatically altered the hydrological and sediment regimes. The hydrology of the catchment has been significantly altered due to increasing impervious surfaces which has in turn altered the geomorphology and ecology of the watercourse. Additional flow is also derived from a number of major sewerage treatment plants which discharge into the catchment (HNCMA 2007).

Table 4-3 Registered groundwater wells within 500 metres of the project

Borehole ID	License number	Eastings	Northings	Bore Usage	Impact potential
SUEZ Kemps Creek Resource Recovery Park					
GW112168	10BL154345	292271.0	6251087.0	Monitoring bore	Low; well not used as potable water source (ie not beneficial groundwater user)
GW112169	10BL154345	292250.0	6251042.0	Monitoring bore	Low; well not beneficial groundwater user
GW112166	10BL154345	292203.0	6250844.0	Monitoring bore	Low; well not beneficial groundwater user
GW112167	10BL154345	292226.0	6250791.0	Monitoring bore	Low; well not beneficial groundwater user
GW112170	10BL154345	292657.0	6251029.0	Monitoring bore	Low; well not beneficial groundwater user
GW112174	10BL154345	292977.0	6250986.0	Monitoring bore	Low; well not beneficial groundwater user
Hi-Quality quarry					
GW112567	10BL601730	295129.0	6249599.0	Test bore	Low; well not beneficial groundwater user
Caltex Kemps Creek					
GW114297	10BL604605	296063.0	6250009.0	Monitoring bore	Low; well not beneficial groundwater user
GW114298	10BL604605	296098.0	6250042.0	Monitoring bore	Low; well not beneficial groundwater user
GW110571	10BL603558	296179.0	6250065.0	Monitoring bore	Low; well not beneficial groundwater user
GW114296	10BL604605	296182.0	6250076.0	Monitoring bore	Low; well not beneficial groundwater user
GW110569	10BL603558	296228.0	6250103.0	Monitoring bore	Low; well not beneficial groundwater user
GW110570	10BL603558	296204.0	6250107.0	Monitoring bore	Low; well not beneficial groundwater user
GW114295	10BL604605	296204.0	6250108.0	Monitoring bore	Low; well not beneficial groundwater user
GW114294	10BL604605	296225.0	6250108.0	Monitoring bore	Low; well not beneficial groundwater user
Brandown Quarry					
GW104081	10BL160288	297710.0	6248607.0	Monitoring bore	Low; well not beneficial groundwater user
GW104080	10BL160288	297677.0	6248408.0	Monitoring bore	Low; well not beneficial groundwater user

4.13 Key watercourses

Watercourses within the study area (as defined in the surface water report (JAJV 2018d) have been classified according to the Strahler stream classification system where waterways are given an order according to the number of additional tributaries associated with each waterway (Strahler 1952):

- First order stream – otherwise known as headwater streams; begins at the top of a catchment; generally, the smaller tributaries that carry water from the upper reaches of the catchment to the main channel of the river and are rarely named
- Second order stream – where two first order streams join, the section downstream of the junction is referred to as a second order stream
- Third order stream – where two second order streams join, the waterway downstream is classified third order, and so on
- Where a lower order stream (eg first) joins a higher order stream (eg third) the area downstream of the junction retains the higher order.

Watercourses within the study area and their classification are as follows:

- Cosgroves Creek – an ephemeral fourth order stream (Strahler, 1952) with a series of disconnected pools as well as both named and unnamed tributaries including Oaky Creek
- Badgerys Creek – a fourth order stream of about 16 kilometres in length, originating near Bringelly. The creek then flows north and then north-east before its confluence with South Creek in the suburb of Badgerys Creek. Ecologically sensitive riparian vegetation exists within the catchment (GHD, 2015) as do small areas of landfill and native forest
- Kemps Creek – a tributary of South Creek and is a fourth order stream which flows into the Hawkesbury-Nepean River
- South Creek – a major fifth order tributary of the Hawkesbury-Nepean River that rises in the low hills near Narellan and runs for over 64 kilometres in a northerly direction through the Western Cumberland Plain to Windsor where it flows into the Hawkesbury River. The South Creek Catchment is currently regarded as one of the most seriously degraded sub-catchments in the Sydney Region, largely due to long term clearing of vegetation and increased impervious areas due to urbanisation
- Ropes Creek - an ephemeral first order tributary of South Creek that rises in south-western Sydney near Fairfield and generally flows in a northerly direction for about 23 kilometres before reaching its confluence with South Creek. While the project does not cross Ropes Creek, the motorway is located within the Ropes Creek catchment
- Hinchinbrook Creek – a fourth order creek that drains to the sub-catchment of Cabramatta Creek, which lies within the Georges River catchment. The creek originates in Cecil Hills and flows through the suburbs of Elizabeth Hills and Hinchinbrook before it enters Cabramatta Creek at Hoxton Park.

4.14 Watercourse geomorphology

Watercourse geomorphology is summarised in **Table 4-4**.

Table 4-4 Watercourse geomorphology summary

Watercourse	Geomorphological description
Unnamed tributary of South Creek	This tributary consists of a single meandering channel which is modified and narrow, averaging one metre wide, with a shallow channel gradient. The substrate is a silty clay. Bank undercutting has occurred in sections of the channel. The channel was completely dry upon inspection.
Cosgroves Creek	Cosgroves Creek is a discontinuous channel with steep channel gradient, a depth of about two metres and an average channel width of about five metres. The substrate consists of silty clay. Significant undercutting occurs at meander bends, suggesting a high potential for erosion at this site.
Unnamed tributary of Cosgroves Creek	This tributary is a minor infilled drainage channel between farm dams. The channel is shallow with no bank definition along most of its length. The channel was completely dry at the time of inspection. The substrate is sandy clay with no areas of active erosion and is unlikely to have received recent flows.
Unnamed tributary of Badgerys Creek	The tributary contains irregular bank morphology. Undercutting has occurred at meanders. The channel was completely dry at the time of inspection. The channel gradient is shallow transitioning to steep due to sediment accumulation. The substrate consists of silty clays.
Badgerys Creek	Badgerys Creek is an incised meandering channel with irregular bank morphology due to abundant riparian vegetation and woody debris. Significant undercutting occurs along the length of the channel. The channel has a steep gradient with a channel depth greater than three metres and average channel width of about five metres.
South Creek	South Creek has a moderate gradient and a discontinuous channel and lies within a largely un-vegetated floodplain. Some bank undercutting occurs along the imposed right bank. The depth of the channel appears shallow and channel width is about seven metres.
Kemps Creek	Kemps Creek has a moderate gradient and a discontinuous channel with irregular bank morphology. The creek is laterally unconfined and significant undercutting occurs at creek bends. The channel depth appears shallow with a silty clay substrate. The channel width averages about three metres.
Unnamed tributary of Kemps Creek	This tributary is a shallow gradient channel and was completely dry upon inspection. The channel width is about one metre and channel depth less than one metre. No undercutting or erosion is apparent due to vegetation overgrowth.
Ropes Creek	Ropes Creek is a highly modified drainage channel transitioning to a laterally confined low gradient channel. The channel was completely dry upon inspection with minimal bank definition. No undercutting is apparent due to vegetation overgrowth and shallow depth.
Unnamed tributary of Ropes Creek	This tributary is a minor drainage channel, laterally unconfined with a shallow gradient. No apparent bank definition as there is no evidence of recent flows and the channel is overgrown with terrestrial vegetation.

Due to a history of clearing, construction of dams along the watercourses, and ongoing agricultural activities; the waterways in the study area are considered to be in moderate geomorphic condition despite sections of well vegetated riparian zones.

4.15 Existing water quality summary

The Surface Water Quality and Hydrology Assessment Report (see **Appendix M** of the EIS) included a review of water quality at Badgerys Creek, Cosgroves Creek, South Creek, Kemps Creek and Hinchinbrook Creek.

The assessment concluded that overall the water quality of creeks within the study area could be classified as poor and degraded due to low dissolved oxygen concentrations and elevated nutrients. Additionally, metal concentrations were elevated for some creeks. Badgerys Creek generally exhibited the poorest water quality of the waterways (based on available data) with a greater number of indicators exceeding recommended guidelines. Additionally, concentrations were generally higher in Badgerys Creek compared to other creeks.

4.16 Sensitive receiving environments

Sensitive receiving environments have been identified based on the criteria outlined in the environmental values and water quality objectives of the M12 Motorway surface water quality report (JAJV, 2018). Cosgroves Creek, Badgerys Creek, South Creek and Kemps Creek were identified as priority sensitive receiving environments due to highly sensitive key fish habitat classifications outlined below.

- Cosgroves Creek contains 'Type 2' moderately sensitive key fish habitat (DPI, 2013). The creek is also currently mapped by RIAR as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge 2003)
- Badgerys Creek contains 'Type 2' moderately sensitive key fish habitat due to the presence of large woody debris providing significant fish refuge during wetter seasons (DPI, 2013). The creek is also mapped as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge 2003)
- South Creek contains 'Type 1' highly sensitive key fish habitat. The creek is a fifth order watercourse, containing semi-permanent pools for fish refuge and large woody snags (DPI, 2013). RIAR mapping also identifies the creek as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge 2003)
- Kemps Creek contains 'Type 1' highly sensitive key fish habitat. The creek is a fourth order watercourse, containing semi-permanent pools for fish refuge, and a variety of aquatic habitats including large woody snags (DPI, 2013). RIAR mapping also identifies the creek as key fish habitat (DPI, 2018a). With respect to fish passage, it is classified Class 2 moderate key fish habitat (Fairfull and Witheridge 2003).

The following tributaries have not been identified as sensitive receiving environments:

- Unnamed tributary of South Creek
- Unnamed tributary of Cosgroves Creek
- Unnamed tributary of Badgerys Creek
- Unnamed tributary of Kemps Creek
- Ropes Creek
- Unnamed tributary of Ropes Creek.

These watercourses do not contain adequate fish habitat or meet the criteria outlined in the environmental values and water quality objectives of the M12 Motorway surface water quality report (JAJV, 2018).

4.17 Site inspection observations

A site inspection was conducted on 18 May 2017. Sites observed during the site inspection are presented in **Figure 4-5** and site inspection sites and AEIs are referenced individually.

At the time of the inspection the study area consisted primarily of rural/residential land use and low-density residential land use. The project would also pass through areas of commercial/industrial land use.

The project would travel through parkland which is primarily dense bushland. It also would travel next to the north of Brandown Quarry (AEI reference 4) and Sydney International Shooting Centre (AEI reference 5). East of Mamre Road towards the M7 Motorway in Cecil Park, the construction footprint would travel through primarily Western Sydney Parklands.

East of Kemps Creek, the project would travel through rural-residential areas. In this area, there were several potential AEIs south of the construction footprint (about 100 metres to 500 metres from the construction footprint), near to Clifton Avenue. These AEI included:

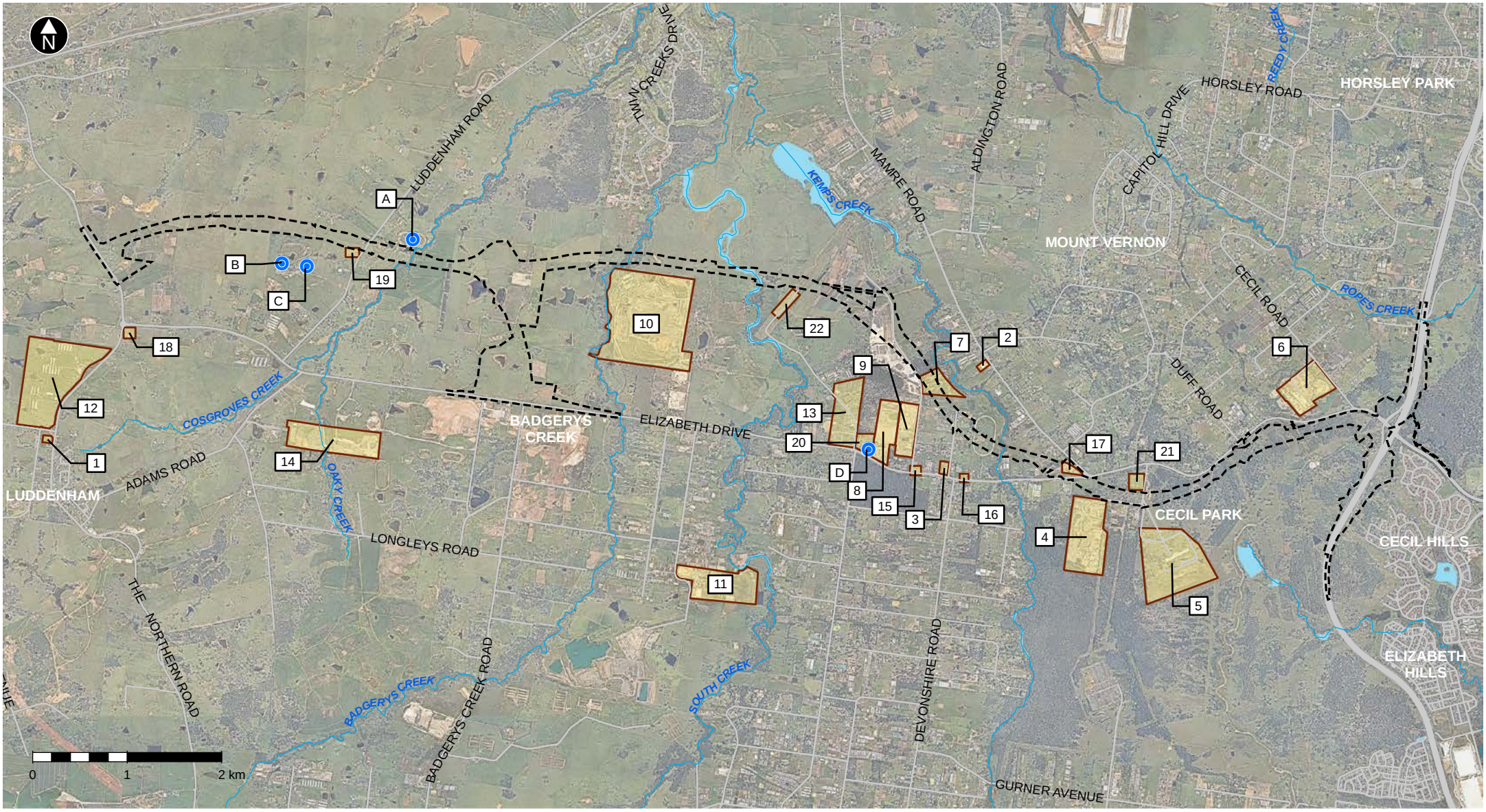
- A quarry (AEI reference 8)
- Service stations (AEI references 3, 15 and 16)
- Recycling park (AEI reference 9)
- A large construction site (AEI reference 4).

The surrounding land use in the area is primarily low density and rural residential land use.

The project would travel through primarily agricultural and rural/residential land use, with many large dams throughout the footprint. Additionally, the project would pass next to the northern extent of Elizabeth Drive Landfill Facility (AEI reference 10). Along this central portion of the construction footprint, the topography generally slopes south towards Elizabeth Drive, away from the project.

Where the construction footprint intersects with Luddenham Road, three potential AEIs were observed (see **Figure 4-5**). The first is a horse/dog track (AEI reference 1) that may contain potential areas of fill material imported to level the ground in the area. There were also some large areas of earth moving/construction in this area (AEI reference 2) which were being undertaken at the time of the inspection, which appears to be associated with a nearby plantation. Additionally, there is a go kart track (AEI reference 3) next to the construction footprint to the south which may contain bulk fuel storage on the premises. The surrounding land use in this area is agricultural and rural/residential land use with some large areas of riparian vegetation associated with Cosgroves Creek.

The project would travel through agricultural and rural residential land use towards The Northern Road. The agriculture in the area appears to be primarily cropping and grazing, with farm dams scattered throughout and nearby to the construction footprint. The topography in the west is primarily flat to slightly undulating.



The project construction footprint

Waterways

Site insepction reference locations

A Horse/dog track
B Construction associated with plantation
C Go kart track
D Construction site

Areas of environmental interest:

Site Id	Site name	Site Id	Site name
1	Caltex Service Station	12	Luddenham Broiler Farm (Baiada Poultry)
2	Caltex Service Station	13	Andresasens Green Wholesale Nursery
3	BP Service Station	14	Blue Sky Mining
4	Brandown Quarry	15	United Service Station
5	Sydney International Shooting Centre	16	Mobil Service Station
6	PGH Bricks and Pavers	17	Stockpiles within Hi-quality Quarry
7	Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)	18	Top Shape Live Christmas Trees
8	Hi-quality Quarry	19	Miscellaneous construction activities and stockpiles of building materials
9	Sydney Recycling Park / Wanless Recycling	20	Miscellaneous stockpiles of building materials
10	SUEZ Kemps Creek Resource Recovery Park	21	Area of significant flytipped waste
11	Australian Native Landscape	22	Former Airstrip

Figure 4-5 Site inspection reference locations and AEIs

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5. Contamination Information Review

5.1 Historical aerial photography

The historical aerial photography review (see **Section 3.3.2**) indicated that the construction footprint has remained largely agricultural and rural/residential land use since the 1940s, with an increase in rural residential density in suburban pockets until 2002. Since 2002, development has been characterised by clearing of bushland, an increase in residential density, and an increase in commercial/industrial activities within surrounding areas. Potentially contaminating activities within and/or next to the construction footprint include the SUEZ Kemps Creek Resource Recovery Park, Brandown Quarry, PGH Bricks and Pavers, and general agricultural land use.

The surrounding area has remained primarily agricultural/rural residential since the 1940s, with an increase in low density/rural residential land use within areas of Luddenham, Badgerys Creek, Kemps Creek, Mount Vernon and Cecil Park. Kemps Creek and Mount Vernon have additionally seen an increase in commercial/industrial land use. Potentially contaminating activities outside of the construction footprint that have the potential to impact on the project include the Hi-Quality Group Quarry and Sydney Recycling Park (located adjacent to the Hi-Quality Group Quarry).

The findings of the historical aerial photography review are summarised in **Table 5-1.**

Table 5-1 Summary of potential contamination issues-historical aerial photography review

Site	Location	Potential contamination
Agricultural land use	General land use within construction footprint	• Diffuse pesticide and herbicide use • Isolated waste disposal • Chemical/fuel use and storage • Degradation and demolition of structures containing hazardous building materials
SUEZ Kemps Creek Resource Recovery Park	1725 Elizabeth Drive, Kemps Creek (next to the project)	• Historical and existing landfilling activities • Chemical/fuel use and storage
Brandown Quarry	Lot 90 Elizabeth Drive, Kemps Creek (next to the project)	• Historical and existing mining activities • Chemical/fuel use and storage
PGH Bricks and Pavers	Cecil Road, Cecil Park (next to the project)	• Historical and existing mining and industrial land use • Chemical/fuel use and storage
Hi-Quality Quarry	1503-1509 Elizabeth Drive, Kemps Creek (300 metres south of the project)	• Historical and existing mining activities • Chemical/fuel use and storage
Sydney Recycling Park	16-23 Clifton Avenue, Kemps Creek (150 metres south-west of the project)	• Historical and existing landfilling activities
Former airstrip	Western Road, Kemps Creek (within construction footprint)	• Point source contamination of fuel storage and leaks/spills

The findings of the historical aerial photography review are provided in full in **Annexure A**.

5.2 NSW Contaminated Sites Register

A search conducted on 20 August 2018 of the NSW EPA Contaminated Sites Record of Notices (under section 58 of the *Contaminated Land Management Act 1997* (CLM Act) and the list of contaminated sites notified to the NSW EPA (under section 60 of the CLM Act*)* indicated that there was one site registered with the NSW EPA within 500 metres of the construction footprint that was either regulated (current notices) or had been notified. The site is summarised in **Table 5-2**.

Table 5-2 Regulated/notified sites within 500 metres of the project

Site	Suburb	Regulated/ Notified	Site address	Site activity	Contamination status	Location relative to project
1	Kemps Creek	Notified (section 60)	1163 Mamre Road, Kemps Creek	Caltex Service Station	Regulation under CLM Act not required	300 m north-east of project

Aurecon Australasia Pty Ltd (Aurecon) (2016) conducted a search for Environmental Protection Licenses (EPLs) and non-compliances related to EPL requirements under the *Protection of the Environment Operations Act 1997* (POEO Act) as part of *M12 Motorway: Strategic Route Options Analysis Contamination Working Paper*. JAJV undertook a review and update of the POEO public register search. Results of the search are listed in **Table 5-3**.

Table 5-3 POEO public record search within 500 metres of the project

Site	Suburb	Regulated/ Notified	Site address	Site activity	Contamination status	Location relative to project
2	Kemps Creek	Issued Dec 2000 (POEO Act)	Lot 90, Elizabeth Drive	Brandown Quarry; Land-based extractive activity Waste disposal by application to land	Issued Penalty notice 3085764523: Contravene any condition of licence - not noise - corporation	Next to project to the south
3	Kemps Creek	Issued June 2000 (POEO Act)	Clifton Avenue	Former Kari & Ghossayn Pty Ltd; Solid Waste Landfilling grinding or separating	Revoked	Within construction footprint
4	Kemps Creek	Issued 13 Sep 2001 (POEO Act)	1725 Elizabeth Drive	SUEZ Recycling and Recovery Pty Ltd; Waste storage - other types of waste Waste disposal by application to land	Issued Clean Up Notice 1025236 Penalty notices 3085764890, 3085769950 and 3085771765: Contravene section by emission of odours Penalty Notice 3085773580: Fail to comply with requirements relating to asbestos waste	Next to project to the south

Site	Suburb	Regulated/ Notified	Site address	Site activity	Contamination status	Location relative to project
5	Kemps Creek	Issued July 2008 (POEO Act)	16-23 Clifton Avenue	Sydney Recycling Park Pty Ltd; Waste storage - other types of waste Non-thermal treatment of general waste Waste disposal by application to land Land-based extractive activity	Issued Penalty Notice 3085765403 and 3085772425: Contravene any condition of licence - not noise – corporation Penalty notice 3085769592: Contravene emission of odours – Corporation Clean Up Notice 1122702 (s.91 Clean-up notice)	150 metres south-west of project
6	Kemps Creek	Issued Dec 2016 (POEO Act)	1503-1519 Elizabeth Drive	Hi Quality Quarry; Land-based extractive activity	Issued POEO licence	350 metres south-west of project

Brandown Quarry (site 2), the former Kari & Ghossayn landfill (site 3), and SUEZ Kemps Creek Resource Recovery Park (site 4) located next to or within the construction footprint could pose a potential risk to construction activities throughout the project. These sites are discussed further in **Chapter 6**.

5.3 Previous contaminated sites investigation

5.3.1 M12 Motorway: Strategic Route Options Analysis Contamination Working Paper

A review of the Aurecon (2016) report (Section 3.3.3) was undertaken as part of this assessment. Aurecon provided route options (combinations of routes A1 – A4, B1 – B4, and C1 - C4) for the project based on assessments of socio-environmental factors. Chapter 4 of the EIS discusses these route options in further detail. Based on the conceptual site model and risk assessment detailed within the report, several potential source-pathway-receptor linkages were identified with a risk classification above moderate for the generic Areas of Environmental Concern (AECs) as detailed below. The Aurecon report makes references to AECs, but for consistency, the term AEI has been used within this section. The AEIs identified as having a risk above moderate comprise the following:

- High for AEI1 and AEI3 with the risk attributed to the impact to human health from unknown amounts of potential asbestos containing material in amongst fill/ Illegally dumped material (AEI1), former buildings and potential demolition material (AEI3)
- High for AEI3 with the risk attributed to potentially impacted surface runoff from former buildings and potential demolition material impacting surface waters
- High for AEI5 (service easements) with the risk attributed to the impact on human health from asbestos that is highly accessible and with exposed fibres.

Notable AEIs within the route options that are relevant to the project construction footprint (ie A1, A3, B2, B5, C3 and C4) are listed below in **Table 5-4**.

Table 5-4 Route specific AEIs listed within Aurecon (2016) contamination working paper

Route Option	AEI	Risk Ranking
A1	Brandown Landfill	Very high
A1	Hi-Quality Group Landscaping Supplies Yard	Moderate
A1	Soil stockpiles	Moderate
A3	CSR Brickworks	High
A3	Brandown Landfill	Moderate
A3	Hi-Quality Group Landscaping Supplies Yard	Moderate
A3	Soil stockpiles	Moderate
B2	Asbestos debris/illegal dumping located within the road verge outside a potential car wrecking yard in a shoulder area associated with Clifton Road.	High
B2	Elizabeth Drive landfill facility	High
B2	Andreasens Green Nursery	Moderate
B2	Hi-Quality Group Quarry/Yard	Moderate
B2	Kemps Creek Resource Recovery Park	Moderate
B5	Asbestos debris/illegal dumping located within the road verge outside a potential car wrecking yard in a shoulder area associated with Clifton Road.	High
B5	Clifton Avenue car wrecking yard	High
B5	CSIRO Access Road - Quarry/Wood stockpiling area	Moderate
B5	Kemps Creek Resource Recovery Park	Moderate
C3	CSIRO/University of Sydney land	High
C3	Steam and model train park	Moderate
C4	CSIRO/University of Sydney land	High

All identified AEIs within the table are relevant to the proposed construction footprint.

It was recommended that detailed site investigations be conducted in areas which had been assigned a risk ranking of moderate and above with targeted assessment of high/very high-risk locations, contingent upon which route option was chosen. It should be noted that risks had been assessed based on the information at hand and in several instances were precautionary, due to the limited information available and the presence (or inferred presence) of asbestos containing materials. It was anticipated that detailed site investigations would provide site specific and quantitative analytical data which would better inform the hazards to human health and the environment, from which management measures could be developed if required.

5.3.2 M12 Motorway Concept Design and EIS Contamination input for geotechnical site investigation

Based on the information from the Aurecon (2016) route options analysis report and a site walkover undertaken by a JAJV environmental scientist in May 2017, JAJV summarised AEIs within and/or next to the Aurecon preferred corridor route. AEIs were identified based on which sites could pose a potential contamination risk to construction activities, their associated contaminants of concern, and the suggested investigation strategy to target these AEIs (see **Table 5-5**, overleaf). Sites with no suggested investigation strategy were considered low risk to the construction activities associated with the project, due to distance from the project and lack of migration pathways, and no further investigation was considered necessary.

In addition to the eight AEIs, where investigations were recommended to take place (ie sites 4, 5, 7, 9, 10, 17, 19 and 21), test pits were also recommended to be undertaken in potential areas of fill (as observed during the site inspection). Test pits in these areas would be used to target surface soils and soils to a depth of two metres below ground level.

Moreover, given that the general project area would travel through areas suspected of historical and current agricultural land use, samples collected within the construction footprint to target AEIs were recommended to be additionally analysed for contaminants of concern associated with agricultural land use (ie heavy metals, OCP, OPP, nutrients, BTEX, carbamates, herbicides).

5.4 Contamination investigation

The results from the contamination investigation carried out as part of the design process (see **Section 3.4.2**) are summarised within **Table 5-6**, overleaf. Results within the table are only those which have exceeded the adopted guidelines for environmental and human health criteria. Locations sampled during the contamination investigation are presented in **Figure 5-1** to **Figure 5-3**.

Table 5-5 Contaminated soils investigation strategy

#	Site	Location	Contaminants of concern	Contamination mechanism	Construction element	Target depth	Investigation strategy
1	Caltex Service Station	The Northern Road, Luddenham (2 km south of the project).	Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), Polycyclic Aromatic Hydrocarbons (PAH), heavy metals.	Soil, groundwater, soil vapour	N/A	N/A	N/A
2	Caltex Service Station	1163 Mamre Road, Kemps Creek (300 m north-east of project).	TRH, BTEX, PAH, heavy metals.	Soil, groundwater, soil vapour	N/A	N/A	N/A
3	BP Service Station	Cnr Elizabeth Drive and Salisbury Avenue (500 m south-west of project).	TRH, BTEX, PAH, heavy metals.	Soil, groundwater, soil vapour	N/A	N/A	N/A
4	Brandown Quarry	Lot 90 Elizabeth Drive, Kemps Creek (Next to project).	Heavy metals, TRH, BTEX, acids, sulphate, cyanide.	Soil, groundwater	Cut	Surface soils & soils to depth of cut.	Test pit/s
5	Sydney International Shooting Centre	Range Road, Kemps Creek (Next to project).	Lead, unexploded ordnance (UXO).	Soil	Fill	Surface soils.	Test pit/s
6	PGH Bricks and Pavers	Cecil Road, Cecil Park (1.4 km north of project).	Heavy metals, TRH, BTEX, acids, sulphate, cyanide.	Soil	N/A	N/A	N/A

#	Site	Location	Contaminants of concern	Contamination mechanism	Construction element	Target depth	Investigation strategy
7	Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)	Lot 17 Clifton Avenue, Kemps Creek (Within construction footprint).	TRH, BTEX, ammonia, PAH, heavy metals, Organophosphate Pesticides (OPP), Organochlorine Pesticides (OCP), Polychlorinated Biphenyls (PCB), nutrients, asbestos.	Soil, groundwater, gas	Cut	Surface soils & soils/gas/groundwater to depth of cut.	Borehole/s
8	Hi-quality Quarry	1503 – 1509 Elizabeth Drive, Kemps Creek (300 m south-west of project).	Heavy metals, TRH, BTEX, acids, sulphate, cyanide.	Soil, groundwater	N/A	N/A	N/A
9	Sydney Recycling Park/ Wanless Recycling	16-23 Clifton Avenue, Kemps Creek (150 m south-west of project).	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, asbestos.	Soil, groundwater, gas	Cut	Surface soils & soils/gas/groundwater to depth of cut.	Borehole/s
10	SUEZ Kemps Creek Resource Recovery Park	1725 Elizabeth Drive, Kemps Creek (Next to project).	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, asbestos.	Soil, groundwater, gas	Cut and fill	Surface soils & soils/gas/groundwater to depth of cut.	Borehole/s along landfill boundary within project
11	Australian Native Landscapes (ANL)	210 Martin Road, Badgerys Creek (2.5 km south of project).	TRH, BTEX, OCP, OPP, heavy metals, carbamates.	Soil	N/A	N/A	N/A
12	Luddenham Broiler Farm (Baiada Poultry)	2907 The Northern Road, Luddenham (1 km south of project).	OCP, OPP, herbicides, carbamates, nitrates, heavy metals, nutrients.	Soil	N/A	N/A	N/A

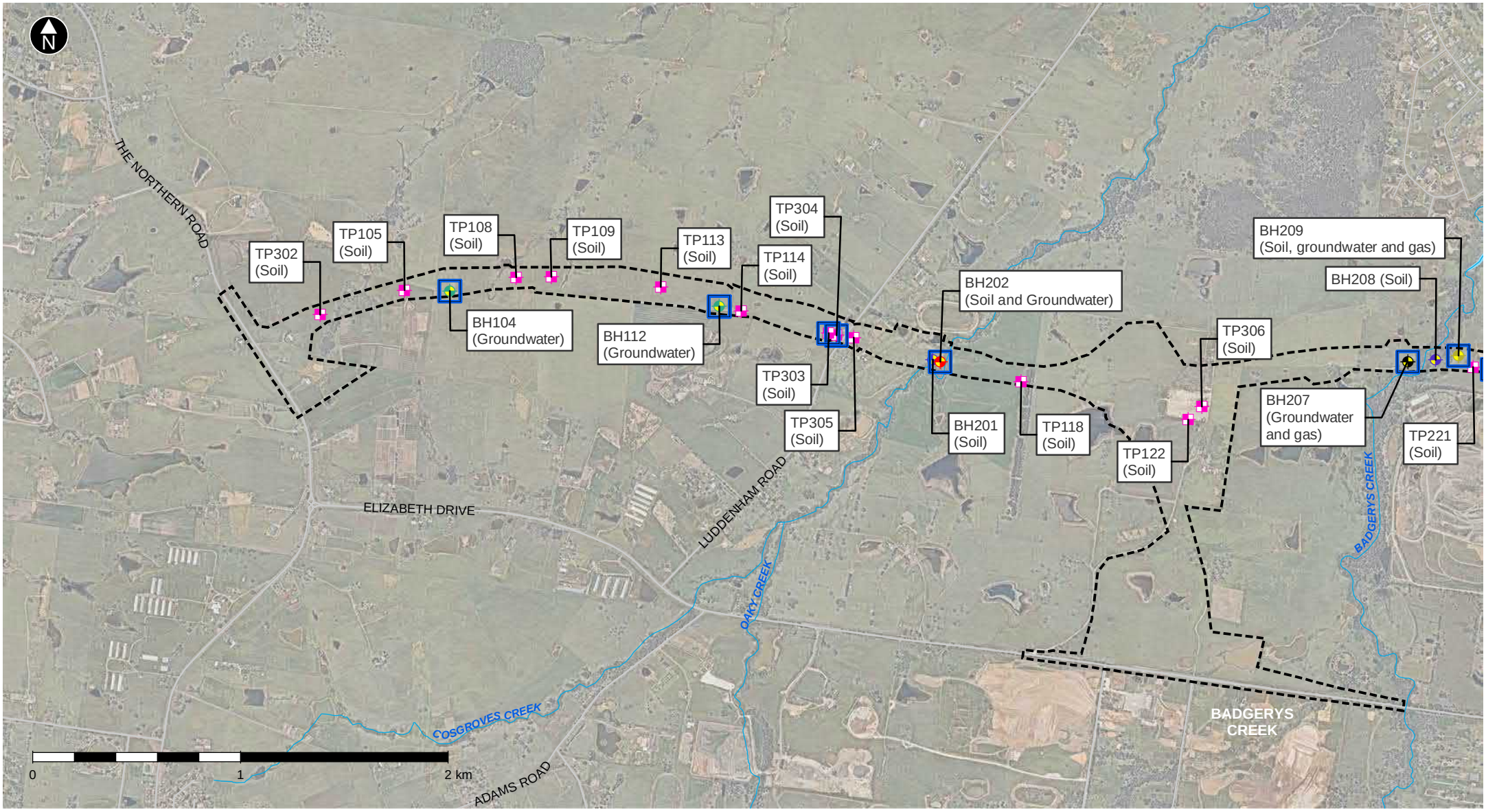
#	Site	Location	Contaminants of concern	Contamination mechanism	Construction element	Target depth	Investigation strategy
13	Andreasens Green Wholesale Nursery	1543 Elizabeth Drive, Kemps Creek (700 m south of project).	Heavy metals, OCP, OPP, carbamates, TRH, BTEX.	Soil	N/A	N/A	N/A
14	Blue Sky Mining	2420 Elizabeth Drive, Luddenham (2 km south of project).	Heavy metals, TRH, BTEX, acids, sulphate, cyanide.	Soil, groundwater	N/A	N/A	N/A
15	United Service Station	Corner Elizabeth Drive and Clifton Avenue (650 metres south of project).	TRH, BTEX, PAH, heavy metals.	Soil, groundwater, soil vapour	N/A	N/A	N/A
16	Mobil Service Station	Lot A Elizabeth Drive, Kemps Creek (450 metres south of project).	TRH, BTEX, PAH, heavy metals.	Soil, groundwater, soil vapour	N/A	N/A	N/A
17	Stockpiles within Hi-quality Quarry Group Head Office	Corner Elizabeth Drive and Mamre Road, Kemps Creek (Within construction footprint).	Heavy metals, TRH, BTEX, acids, sulphate, cyanide.	Soil	Cut	Surface soils	Test pit/s
18	Top Shape Live Christmas Trees	2450 The Northern Road, Luddenham (900 metres south of project).	Heavy metals, OCP, OPP, carbamates, TRH, BTEX.	Soil	N/A	N/A	N/A

#	Site	Location	Contaminants of concern	Contamination mechanism	Construction element	Target depth	Investigation strategy
19	Miscellaneous construction activities and stockpiles of building materials	Luddenham Road, Luddenham (Within construction footprint).	Heavy metals, BTEX, asbestos, TRH, OCP, OPP, PAH.	Soil	Bridge	Surface soils	Test pit/s
20	Miscellaneous stockpiles of building materials	1521 Elizabeth Drive, Kemps Creek (800 metres south of project).	Heavy metals, BTEX, asbestos, TRH, OCP, OPP, PAH.	Soil	N/A	N/A	N/A
21	Area of illegally dumped material	Corner of Elizabeth Drive and Range Road, Kemps Creek (Next to project to the north).	Heavy metals, BTEX, asbestos, PAH, OCP, OPP, PCB, TRH.	Soil.	(Next to) Cut	Surface soils and soils to depth of cut.	Test pit/s

Table 5-6 Summary of guideline exceedances from the limited intrusive investigation within the construction footprint

Sampling location and depth	Analyte/s and result	Adopted guideline and value exceedance	Relevant project element and target AEI
Soil			
TP310 (0-0.1 mbgl)	Heavy metals (zinc); 1,090 mg/kg	TP310 (0-0.1 mbgl) exceeded the EIL of 435 mg/kg	• Ancillary facility 5 • Filling construction activity • AEI: stockpiles within Hi-Quality Quarry Group head office
TP303 (0-0.2 mbgl)	PAH (benzo(a)pyrene 9.2 mg/kg and benzo(a)pyrene TEQ); 13 mg/kg)	P303 (0-0.2 mbgl) exceeded the ESL of 0.7 mg/kg and the HIL of 3 mg/kg	• Bridge construction • AEI: miscellaneous construction activities and stockpiles of building materials
TP304a (stockpile)	PAH (benzo(a)pyrene); 0.9 mg/kg	TP304a (stockpile) exceeded the ESL of 0.7 mg/kg	• Bridge construction • AEI: miscellaneous construction activities and stockpiles of building materials
TP311 (0-0.1 mbgl)	PAH (benzo(a)pyrene); 0.9 mg/kg	TP311 (0-0.1 mbgl) exceeded the ESL of 0.7 mg/kg)	• Ancillary facility 5 • Filling construction activity • AEI: stockpiles within Hi-Quality Quarry Group ahead office
TP312 (0.1 mbgl)	Soil Asbestos Containing Material – asbestos; present	Presence/absence	• Filling construction activity • AEI: area of illegally dumped material
Groundwater			
BH104	Heavy metals (copper 10 µg/L and zinc 9 µg/L)	BH104 exceeded the ANZECC 2000 freshwater 95% guideline of 1.4 µg/L for copper and 8 µg/L for zinc.	• Cutting construction activity • No associated AEI
BH112	Heavy metals (copper 3 µg/L and zinc 15 µg/L)	BH112 exceeded the ANZECC 2000 freshwater 95% guideline of 1.4 µg/L for copper and 8 µg/L for zinc.	• Cutting construction activity • No associated AEI
BH202	Heavy metals (copper 12 µg/L and zinc 49 µg/L)	BH202 exceeded the ANZECC 2000 freshwater 95% guideline of 1.4 µg/L for copper and 8 µg/L for zinc.	• Bridge construction • AEI: potential area of fill (next to Cosgroves Creek)
BH207	Heavy metals (copper 18 µg/L and zinc 36 µg/L), nutrients (ammonia 4600 µg/L and nitrogen 4900 µg/L)	BH207 exceeded the ANZECC 2000 freshwater 95% guideline of 1.4 µg/L for copper and 8 µg/L for zinc, the NZECC 2000 freshwater 95% adjusted guideline value of 2.33 mg/L for ammonia based on site pH , and the ANZECC 2000 freshwater 99% guideline of 350 µg/L for nitrogen.	• Cut/bridge construction • AEI: Elizabeth Drive landfill facility

Sampling location and depth	Analyte/s and result	Adopted guideline and value exceedance	Relevant project element and target AEI
BH209	Heavy metals (copper 5 µg/L and zinc 18 µg/L), nutrients (nitrogen 1500 µg/L)	BH209 exceeded the ANZECC 2000 freshwater 95% guideline of 1.4 µg/L for copper and 8 µg/L for zinc, and the ANZECC 2000 freshwater 99% guideline of 350 µg/L for nitrogen.	• Fill/bridge construction • AEI: Elizabeth Drive landfill facility
BH217	Heavy metals (copper 6 µg/L and zinc 16 µg/L)	BH217 exceeded the ANZECC 2000 freshwater 95% guideline of 1.4 µg/L for copper and 8 µg/L for zinc.	• Fill/bridge construction • AEI: potential area of fill (next to South Creek)
BH223	Heavy metals (zinc 14 µg/L)	BH223 exceeded the ANZECC 2000 freshwater 95% guideline of 8 µg/L for zinc.	• Filling construction activity • AEI: east of potential area of fill
BH301	Heavy metals (copper 10 µg/L, nickel 14 µg/L, and zinc 25 µg/L)	BH301 exceeded the ANZECC 2000 freshwater 95% guideline of 1.4 µg/L for copper, 11 µg/L for nickel, and 8 µg/L for zinc.	• Filling construction activity • AEI: Elizabeth Drive landfill facility
BH302	Heavy metals (copper 32 µg/L and zinc 57 µg/L), nutrients (nitrogen 1200 µg/L)	BH302 exceeded the ANZECC 2000 freshwater 95% guideline of 1.4 µg/L for copper and 8 µg/L for zinc, and the ANZECC 2000 freshwater 99% guideline of 350 µg/L for nitrogen.	• Filling construction activity • AEI: Elizabeth Drive landfill facility
BH145	Heavy metals (nickel 33 µg/L)	BH145 exceeded the ANZECC 2000 freshwater 95% guideline of 11 µg/L for nickel.	• Cutting construction activity • No associated AEI
Gas			
BH207	Methane (2%) and carbon dioxide (3.3%)	BH207 exceeded the NSW EPA Environmental Guidelines: Solid Waste Landfills value of 1.25% and 1.5%, respectively.	• Filling construction activity • AEI: Elizabeth Drive landfill facility



Waterways
Main roads
The project construction footprint
Location of exceedance

Boreholes

Groundwater
Groundwater and gas
Soil
Soil and groundwater
Soil, groundwater and gas

Test pits

Soil

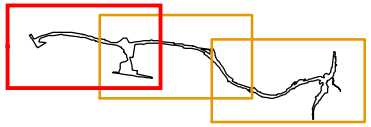


Figure 5-1 Contamination field sampling locations

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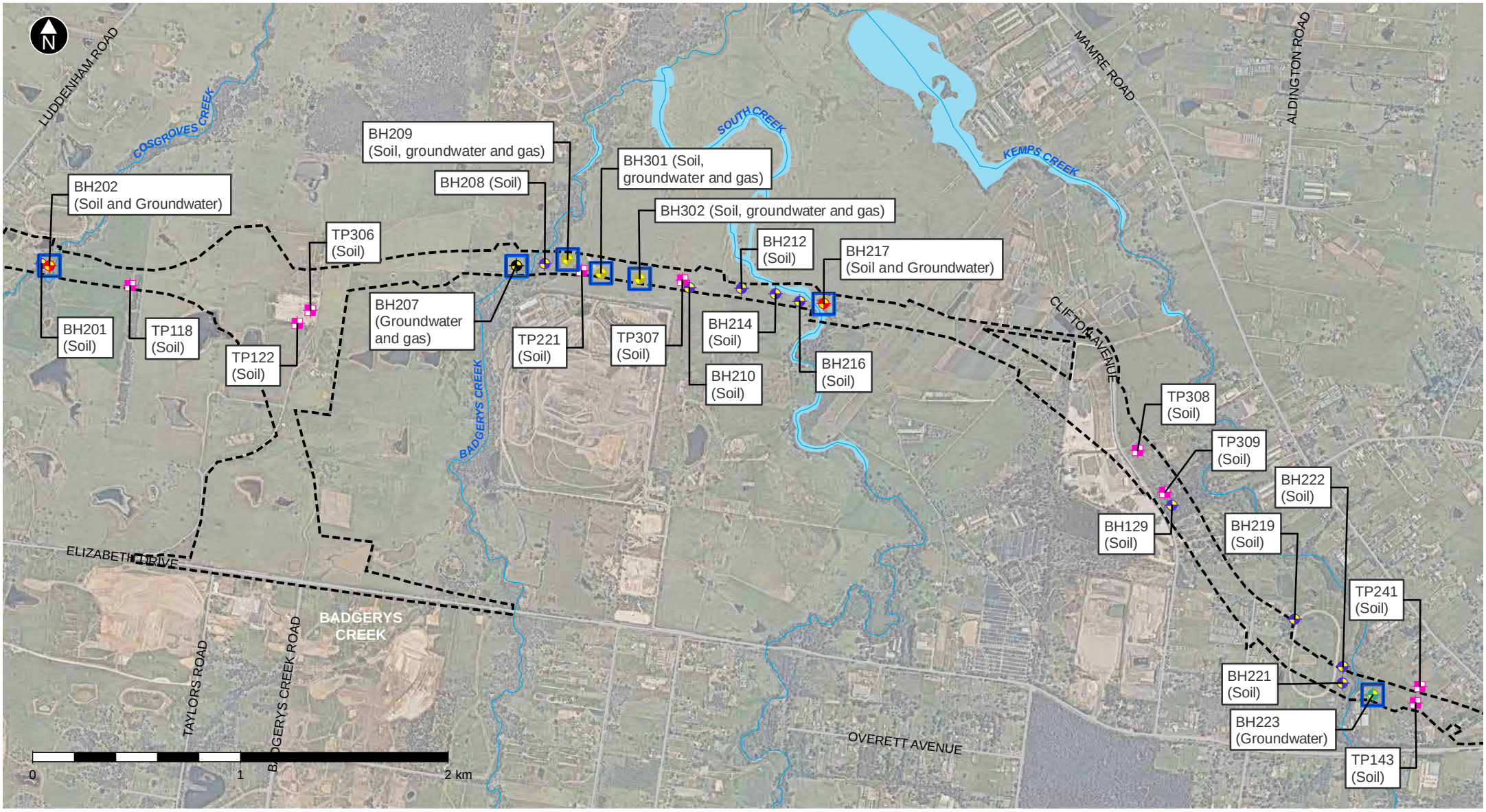

Waterways
Main roads
The project construction footprint
Location of exceedance

Boreholes

Groundwater
Groundwater and gas
Soil
Soil and groundwater
Soil, groundwater and gas

Test pits

Soil

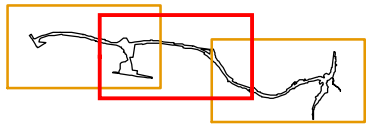

Figure 5-2 Contamination field sampling locations

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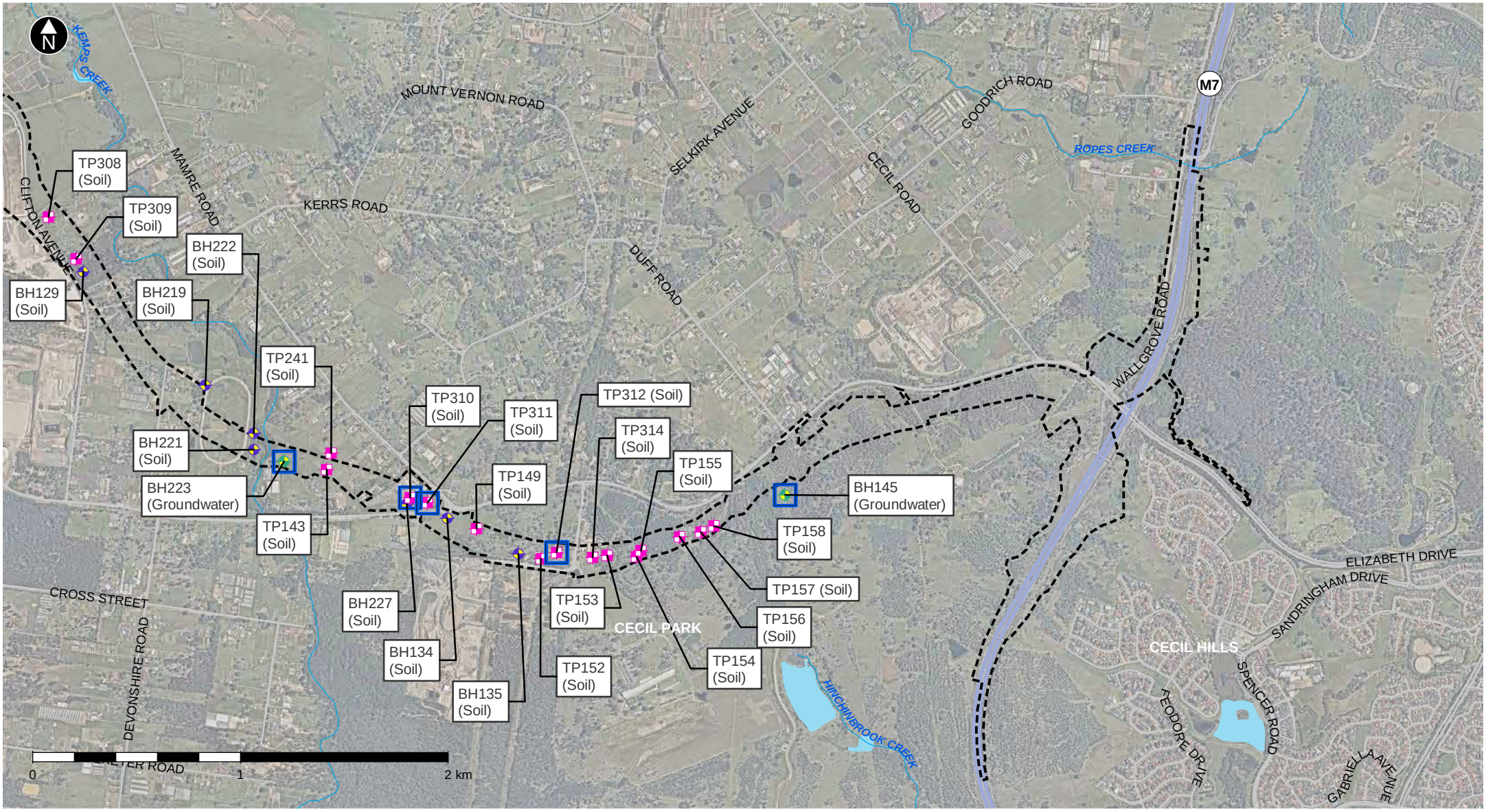

Waterways
Motorway
Main roads
The project construction footprint
Location of exceedance

Boreholes

Groundwater
Groundwater and gas
Soil
Soil and groundwater
Soil, groundwater and gas

Test pits

Soil

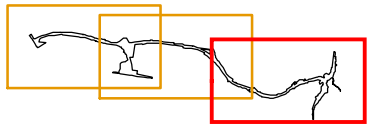

Figure 5-3 Contamination field sampling locations

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6. Contamination assessment findings

6.1 Groundwater

Based on the information reviewed (see **Section 4.11**), groundwater monitoring has been carried out at selected locations within the construction footprint. The monitoring data indicates that potential groundwater contamination may be present beneath areas of Luddenham (BH104, BH112, BH202), Kemps Creek (BH207, BH209, BH217, BH223, BH301, and BH302), and Cecil Park (BH145).

In consideration of the compounds detected in groundwater at elevated concentrations (ie heavy metals and nutrients) groundwater contamination may be associated with the widespread agricultural land use in the regional area and potentially from AEIs such as the Elizabeth Drive landfill facility, and potential areas of fill within the construction footprint.

Contaminated groundwater has the potential to impact on construction activities (eg through release of potentially contaminated groundwater to environmental receptors during dewatering activities) such as bridge construction and excavations which may intersect groundwater (ie the western cut). In these locations the water table may be intersected during piling (or other forms of excavation below the water table) (JAJV 2018b).

Results from the groundwater sampled from the representative bore for the western cut (BH104) during the JAJV (2018a) contamination investigation indicated that the copper concentration of 10 micrograms per litre exceeded the ANZECC 2000 FW 95 per cent level of 1.4 micrograms per litre, and the zinc concentration of 9 micrograms per litre exceeded the ANZECC 2000 FW 95 per cent level of 8 micrograms per litre .

The assessment identified no AEIs in the vicinity of BH104. Additionally, the bore was bentonite sealed from three metres below ground level to the surface (not influenced by ingress of surface water). Given that zinc and copper exceeded the ANZECC 2000 FW 95 per cent level within BH104 and across many of the other sampled boreholes, these concentrations have the potential to represent background concentrations.

6.2 Areas of Environmental Interest

Several potential AEIs were identified during the information review and site inspection. Based on the information contained within the preceding sections of this report, **Table 6-1** outlines the potential AEIs located in the vicinity of the project area and their associated risks to environmental receptors, construction limitations, and site users in consideration of the potential for contamination and proposed construction activities.

Based on the results of the information review and site inspection, a number of sites within and or next to the project area are considered to represent a low contamination risk. No further consideration of contamination risk has been provided for these sites and they have not been included on **Figure 6-1**. Additionally, generic AEIs across the project footprint were unable to be included on the figure due to the generic/widespread nature of the AEI. Generic AEIs are included within **Table 6-1**.

Identified AEIs (based on the information review and site inspection) with moderate to high exposure risk rankings and their associated contaminants of concern are summarised below and are presented as **Figure 6-1.** The summary also includes a reassessment of risks based on the results of the JAJV (2018a) contamination investigation. The results of the reassessment are presented in **Table 6-1**.

Table 6-1 Potential areas of environmental interest

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	Caltex Service Station	The Northern Road, Luddenham (1.7 km south of project).	Cut (surface and depth)	Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), Polycyclic Aromatic Hydrocarbons (PAH), heavy metals.	Soil, groundwater, soil vapour	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project.	-	-
	Luddenham Raceway	821 – 849 Luddenham Road, Luddenham (150 m south of project)	Filling (surface)	TRH, BTEX, heavy metals	Soil (surface)	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	Caltex Service Station	1163 Mamre Road, Kemps Creek (480 m north east of project)	Filling (surface)	TRH, BTEX, PAH, heavy metals	Soil, groundwater, soil vapour	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-
	BP Service Station	Corner of Elizabeth Drive and Salisbury Avenue (350 m south west of project)	Filling (surface)	TRH, BTEX, PAH, heavy metals	Soil, groundwater, soil vapour	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	Brandown Quarry	Lot 90 Elizabeth Drive, Kemps Creek (next to project)	Filling (surface)	Heavy metals, TRH, BTEX, acids, sulphate, cyanide	Soil, groundwater	Moderate Possible contamination/excavation activities within potential contamination distribution range (laterally)	Soil results from soil samples taken within the construction footprint near this AEI returned concentrations of analytes below the adopted guidelines. Groundwater was not sampled in this area as part of the investigation	Due to the results, the risk ranking for this AEI has been lowered from moderate to low. Risk: Low No known contamination/no excavation activities within AEI. Contamination distribution range (laterally) poses a low risk.
	Sydney International Shooting Centre	Range Road, Kemps Creek (280 m south of project)	Cut and filling (surface and depth)	Lead, unexploded ordnance (UXO)	Soil	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	PGH Bricks and Pavers	Cecil Road, Cecil Park (120 m north of project)	Filling (surface)	Heavy metals, TRH, BTEX, acids, sulphate, cyanide	Soil	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Possible contamination distribution range (laterally and vertically) has potential to impact upon project	-	-
7	Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)	Lot 17 Clifton Avenue, Kemps Creek (Within construction footprint)	Filling (surface)	TRH, BTEX, ammonia, PAH, heavy metals, Organophosphate Pesticides (OPP), Organochlorine Pesticides (OCP), Polychlorinated Biphenyls (PCB), nutrients, asbestos	Soil, groundwater, gas	Moderate Possible contamination/construction activities within AEI and within potential contamination distribution range (laterally).	Results from soil samples taken within the construction footprint near this AEI during the contamination investigation returned concentrations of analytes below the adopted guidelines, however no soil, groundwater or gas samples were taken from directly within the AEI	Due to the results, the AEI has retained its moderate risk ranking. Risk: Moderate Possible contamination/construction activities within AEI and within potential contamination distribution range (laterally).

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	Hi-quality Quarry	1503 – 1509 Elizabeth Drive, Kemps Creek (380 m south west of project)	Filling (surface)	Heavy metals, TRH, BTEX, acids, sulphate, cyanide	Soil, groundwater	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-
	Sydney Recycling Park/ Wanless Recycling	16-23 Clifton Avenue, Kemps Creek (190 m south west of project)	Filling (surface)	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, asbestos	Soil, groundwater, gas	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
10	SUEZ Kemps Creek Resource Recovery Park	1725 Elizabeth Drive, Kemps Creek (next to project)	Shallow cut and filling	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, asbestos	Soil, groundwater, gas	Moderate Possible contamination/excavation activities next to project and within potential contamination distribution range (laterally and vertically)	Based on the results of the contamination investigation, there is groundwater and gas adjacent to this AEI containing contaminant levels exceeding the adopted guidelines	Based on the results of the contamination investigation, considering that piling from bridge construction in the area is expected to encounter groundwater, and that landfill gas has the potential to impact construction within cuts, the moderate risk ranking is maintained. Risk: moderate Known contamination/excavation activities next to project and within potential contamination distribution range (laterally and vertically).

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	Australian Native Landscapes (ANL)	210 Martin Road, Badgerys Creek (1.8 km south of project)	Bridge (surface and depth)	TRH, BTEX, OCP, OPP, heavy metals, carbamates	Soil	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-
	Luddenham Broiler Farm (Baiada Poultry)	2907 The Northern Road, Luddenham (1.1 km south of project)	Cut (surface and depth)	OCP, OPP, herbicides, carbamates, nitrates, heavy metals, nutrients	Soil	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	Andreasens Green Wholesale Nursery	1543 Elizabeth Drive, Kemps Creek (550 m south of project)	Cut (surface and depth)	Heavy metals, OCP, OPP, carbamates, TRH, BTEX	Soil	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-
	Blue Sky Mining	2420 Elizabeth Drive, Luddenham (2 km south of project)	Bridge (surface and depth)	Heavy metals, TRH, BTEX, acids, sulphate, cyanide	Soil, groundwater	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	United Service Station	Corner Elizabeth Drive and Clifton Avenue (600 m south of project)	Filling (surface)	TRH, BTEX, PAH, heavy metals	Soil, groundwater, soil vapour	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-
	Mobil Service Station	Lot A Elizabeth Drive, Kemps Creek (420 m south of project)	Filling (surface)	TRH, BTEX, PAH, heavy metals	Soil, groundwater, soil vapour	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
17	Stockpiles within Hi-quality Quarry Group Head Office	Corner Elizabeth Drive and Mamre Road, Kemps Creek (Within construction footprint)	Filling (surface)	Heavy metals, TRH, BTEX, acids, sulphate, cyanide	Soil	Moderate Possible contamination/construction activities within project and within potential contamination distribution range (laterally)	Based on the results of the contamination investigation, contaminated soil in this area exists at levels exceeding the adopted guidelines	Based on the results of contamination investigation, the moderate risk ranking of this AEI is maintained. Risk: moderate Known contamination/construction activities (filling) within project and within potential contamination distribution range (laterally).
	Top Shape Live Christmas Trees	2450 The Northern Road, Luddenham (940 m south of project)	Cut (surface and depth)	Heavy metals, OCP, OPP, carbamates, TRH, BTEX	Soil	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

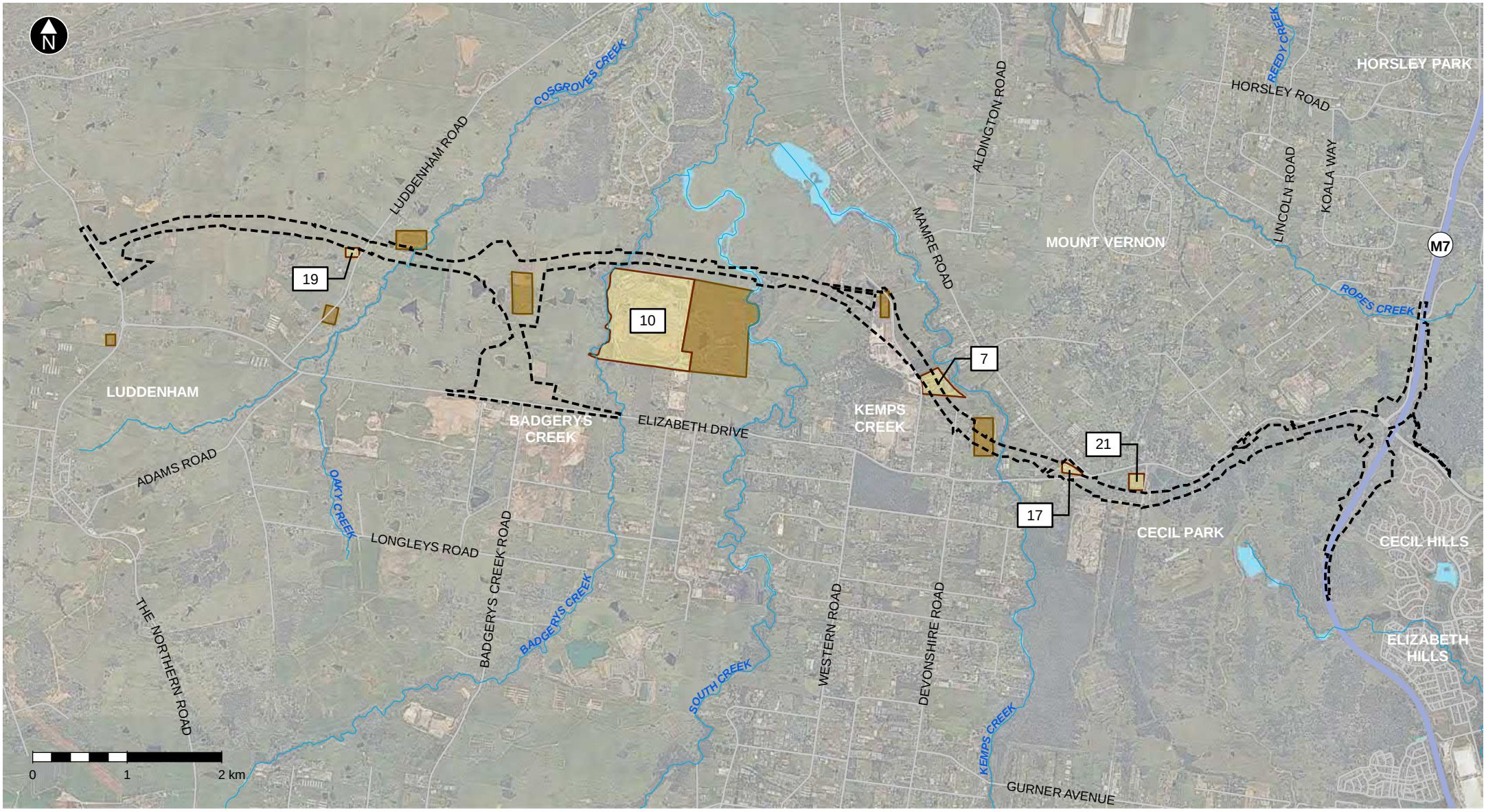
Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
19	Miscellaneous construction activities and stockpiles of building materials	Luddenham Road, Luddenham (within construction footprint)	Bridge (surface and depth)	Heavy metals, BTEX, asbestos, TRH, OCP, OPP, PAH	Soil	High Possible contamination/excavation activities within project and within potential contamination distribution range (laterally and vertically)	Based on the results of the contamination investigation, contaminated soil in this area exists at levels exceeding the adopted guidelines	Based on the results of the contamination investigation, the high risk ranking of this AEI is maintained. Risk: high Known contamination/excavation activities within project and within potential contamination distribution range (laterally and vertically).
	Miscellaneous stockpiles of building materials	1521 Elizabeth Drive, Kemps Creek (800 m south of project)	Filling (surface)	Heavy metals, BTEX, asbestos, TRH, OCP, OPP, PAH	Soil	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
21	Area of significant illegally dumped material	Corner of Elizabeth Drive and Range Road, Kemps Creek (next to project to the north)	Filling (surface)	Heavy metals, BTEX, asbestos, PAH, OCP, OPP, PCB, TRH	Soil	Moderate Expected contamination/construction activities next to project and within potential contamination distribution range (laterally and vertically)	Possible asbestos fragments were submitted to the laboratory from within this AEI during the contamination investigation. Analytical results confirmed the presence of asbestos in this area	Due to the confirmed presence of asbestos in this area and the nature of asbestos to migrate via air, soils and surface water, the risk ranking for this AEI has increased from moderate to high. Risk: high Known contamination/construction activities next to project and within potential contamination distribution range (laterally).
	Former airstrip	Western Road, Kemps Creek (next to construction footprint)	Next to fill embankment (surface)	Heavy metals, BTEX, PAH, TRH	Soil	Low Possible contamination/no excavation activities within AEI. AEI located a considerable distance from the nearest construction element. Potential contamination distribution range (laterally and vertically) unlikely to impact upon project	-	-

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
Shown as 'Potential areas of existing fill'	Identified areas of potential fill	Generic AEIs along the project	Cut and filling (surface and depth)	Heavy metals, BTEX, asbestos, PAH, OCP, OPP, PCB, TRH	Soil, groundwater	High Possible contamination/excavation activities within construction footprint and within potential contamination distribution range (laterally and vertically)	Based on the results of the contamination investigation, groundwater below and next to several areas of the identified potential fill have returned concentrations exceeding the adopted guidelines. Soil samples analysed from within these AEIs returned concentrations below the adopted guidelines.	Based on the results of the contamination investigation, this AEI has maintained its high-risk ranking. Risk: high Known contamination/excavation activities below construction footprint and within potential contamination distribution range (laterally and vertically).

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	Historical and current agricultural land use	Generic AEIs along the project	Cut and filling (surface and depth)	Heavy metals, OCP, OPP, nutrients, BTEX, carbamates, herbicides	Soil (surface)	High Possible contamination/excavation activities within construction footprint and within potential contamination distribution range (laterally and vertically)	During the contamination investigation, pesticide and herbicide, and hydrocarbon and heavy metal analysis was used to assess the risk of historical and current agricultural land use on the project. Pesticide, herbicide, hydrocarbon and heavy metal results targeting this AEI returned concentrations below the adopted guidelines. However, exceedances of nutrient guidelines in groundwater analyses may indicate groundwater contamination from agricultural land use.	Based on the results of the contamination investigation, the risk ranking of this AEI has been reassessed to low. Risk: Low No known contamination originating from historical agricultural land use/excavation activities within construction footprint and within potential contamination distribution range (laterally and vertically).

Figure ref.	Site	Location	Construction element and anticipated depth	Potential contaminants of concern	Potential contamination distribution	Initial risk ranking	Analytical results	Reassessed risk ranking
	Historical uncontrolled earthworks containing asbestos and buildings/ structures containing asbestos previously demolished/ degraded	Generic AEIs along the project	Cut and filling (surface and depth)	Asbestos	Soil (surface)	High Potential contamination/excavation activities within construction footprint and within potential contamination distribution range (laterally and vertically)	Based on analytical results from the contamination investigation, asbestos has been identified next to the construction footprint	Given asbestos was identified next to the construction footprint, this AEI maintains its high-risk ranking.



Waterways
Motorway
Main roads
The project construction footprint
Potential areas of existing fill

Areas of environmental interest (moderate to high):

7 - Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)
10 - SUEZ Kemps Creek Resource Recovery Park
17 - Stockpiles within Hi-quality Quarry
19 - Miscellaneous construction activities and stockpiles of building materials
21 - Area of significant flytipped waste

Figure 6-1 Moderate to high ranked AEIs and potential fill areas

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- **Brandown Quarry**
  - Represents a potential contamination source associated with mining and extractive activities with the potential for soil and groundwater to be contaminated with heavy metals, hydrocarbons, acids, sulphate, and cyanide
  - Poses a moderate risk to construction activities primarily associated with the migration of potentially contaminated groundwater from this AEI (no excavation works within this AEI are anticipated to occur during construction)
  - Potential for contaminants originating from the quarry outside of the construction footprint to migrate towards the project via groundwater, however groundwater is not expected to be encountered during construction activities
  - Construction (filling) is expected to take place next to the quarry; filling typically involves the removal of topsoil prior to filling with geotechnically suitable materials
  - **Low risk ranking** – Based on the results of the JAJV (2018a) contamination investigation, proposed construction activities, and that the risk of encountering migrated contaminants (if any) is low, the risk ranking for this AEI has been reassessed to low risk (see **Table 6-1**).
- The f**ormer Kari & Ghossayn solid waste landfill**
  - Represents a potential source of contamination associated with current and historical landfilling activities
  - Contaminants commonly associated with landfilling include, but are not limited to, hydrocarbons, ammonia, PAH, heavy metals, pesticides, PCB, and asbestos
  - Poses a moderate risk to construction activities given that construction activities (filling – which could involve the removal of topsoil from these areas prior to filling) are proposed within the AEI footprint
  - Results from soil samples taken within the construction footprint near this AEI during the JAJV (2018a) contamination investigation returned concentrations of analytes below the adopted guidelines, however no soil, groundwater or gas samples were taken from directly within the AEI
  - **Moderate risk ranking** – Due to the remaining unknown nature of the subsurface conditions (with respect to contamination), the AEI retains its moderate risk ranking.
- The **SUEZ Kemps Creek Resource Recovery Park**
  - The current and historical landfilling activities represent a potential source of contamination
  - Contaminants commonly associated with landfilling include, but are not limited to, hydrocarbons, ammonia, PAH, heavy metals, pesticides, PCB, and asbestos
  - Contaminants have the potential to impact on soils as well as groundwater
  - Gas produced by landfills during the degradation of organic sources also has the potential to impact on the project via soil vapour migration
  - Given that gas and groundwater have the potential to migrate towards the project and that excavation activities (cut, fill and bridge construction) are proposed next to the Elizabeth Drive landfill facility, the landfill poses a moderate risk to construction activities from potentially impacted groundwater and gas
  - Based on the results of the JAJV (2018a) contamination investigation, elevated concentrations of heavy metals and nutrients in groundwater and landfill gas was detected in wells within the construction footprint adjacent to this AEI
  - **Moderate risk ranking** – considering that piling from bridge construction in the area is expected to encounter groundwater, and that landfill gas has the potential to impact construction within cuts, the moderate risk ranking is maintained due to the known presence of groundwater contamination and gas adjacent to this AEI.

- Stockpiles within the **Hi-quality Quarry Group Head Office**
  - Represent a potential source of contamination associated with the stockpiling of mined and extracted materials with the potential to contaminate surface soils with contaminants such as heavy metals, hydrocarbons, acids, sulphate, and cyanide
  - The stockpiles pose a moderate risk to construction activities within the construction footprint given construction (filling – which could involve the removal of topsoil from these areas prior to filling) is expected to take place within this area
  - Ancillary facility 5 is expected to be located within this area and hence risks to construction workers is increased due to potential construction of site facilities and regular occupation of the area by site workers
  - **Moderate risk ranking** – based on the results of the JAJV (2018a) contamination investigation, the moderate risk ranking of this AEI is maintained due to the presence of contaminated soil in this area at levels exceeding the adopted guidelines.
- **Miscellaneous construction activities and stockpiles** of building materials located where the construction footprint intersects with Luddenham Road
  - Represents a potential source of contamination associated with possible uncontrolled stockpiling and dumping of building and hazardous materials
  - Common contaminant compounds associated with uncontrolled dumping include, but are not limited to, heavy metals, hydrocarbons, pesticides, PCBs and asbestos
  - This area of construction and stockpiling poses a high risk to construction activities given that excavation associated with bridge construction is expected to take place within this area
  - **High risk ranking** – based on the results of the JAJV (2018a) contamination investigation, the high risk ranking of this AEI is maintained due to the presence of contaminated soil in this area at levels exceeding the adopted guidelines.
- The area of **significant illegally dumped material** located on the corner of Elizabeth Drive and Range Road
  - Represents a potential source of contamination associated with illegal deposition of building materials, household waste and/or hazardous materials which may be potentially contaminated with common contaminant compounds including but not limited to heavy metals, hydrocarbons, pesticides, PCBs and asbestos
  - Poses a moderate risk to construction activities given that construction activities (filling and bridge construction) are expected to take place next to this area which may involve removal of surface materials and piling
  - **High risk ranking** – based on the results of the JAJV (2018a) contamination investigation (the confirmed presence of asbestos in this area and the nature of asbestos to spread easily via air, soil movement or surface water), the risk ranking of this AEI has been reassessed to high risk (see **Table 6-1**).

- Several **areas of potential fill** have been identified as part of this assessment and are presented on **Figure 6-1**
  - Represent a potential source of contamination associated with unknown historical use of reclaimed soils (ie metals, hydrocarbons, pesticides, PCB, asbestos)
  - Potential areas of fill material within the construction footprint pose a high risk to construction activities given that construction works (cutting, filling, bridge construction and ancillary facilities (AF2 and AF4)) are proposed to be undertaken within and next to the possible areas of fill
  - Soil samples analysed from within these AEIs returned concentrations below the adopted guidelines
  - **High risk ranking** – based on the results of the JAJV (2018a) contamination investigation, groundwater below and next to several areas of the identified potential fill have returned concentrations exceeding the adopted guidelines, therefore, this AEI has maintained its high-risk ranking; despite this, the risk to the project would only occur where groundwater is encountered during construction within and next to these AEIs.
- **Historical and current agricultural land use**
  - Represents a potential source of diffused herbicide and pesticide contamination associated with vegetation and pest control across the construction footprint
  - Agricultural land use is also a potential source of point source heavy metal and hydrocarbon contamination associated with fuel use and storage and other contaminants associated with waste disposal
  - Historical and current agricultural land use poses a high risk to construction activities given that excavation associated with the construction of the project is expected to take place within these areas
  - Based on the results from the JAJV (2018a) contamination investigation, herbicide, pesticide, hydrocarbon and heavy metal analysis in soils used to target this AEI returned concentrations below the adopted guidelines, however, exceedances of nutrient guidelines in groundwater analyses may indicate groundwater contamination from agricultural land use
  - **Low risk ranking** – despite the remaining possibility of encountering point source contamination in soil, and groundwater contamination associated with agricultural land use, the risk ranking for this AEI has been reassessed to low risk (see **Table 6-1**); despite this, the risk to the project would only occur where groundwater is encountered during construction within and next to this AEI.
- **Asbestos**
  - Anecdotal evidence from Roads and Maritime suggests that asbestos has the potential to be present in soils throughout the construction footprint due to historical earthworks with imported fill potentially containing asbestos, as well as structures and/or buildings located within the construction footprint containing asbestos that have degraded or have been demolished.
  - Asbestos within soils in the construction footprint pose a high exposure risk to site and adjacent land users during construction activities
  - **High risk ranking** – given asbestos has been identified next to the construction footprint at TP312, this AEI maintains its high risk ranking.

6.3 Areas of identified historical filling

The photogrammetry survey produced isopach maps which identified historical areas of filling or stockpiling which have taken place within the construction footprint since the 1950s. **Figure 6-2** shows the areas of identified historical filling produced by the photogrammetry survey. Areas of explained filling such as dams and roads were taken into consideration and identified within the figure. Stockpiles/filling (red and purple) are those which cannot be explained through construction of infrastructure and have been considered as uncontrolled filling or stockpiling. These areas were not sampled during the contamination investigation, however were confirmed during a site walkover.

Areas of explained filling such as dams and roads were not considered during the walkover given these areas are expected to be of a lower risk of containing contaminants which may exceed adopted soil guidelines when compared with uncontrolled filling. According to the photogrammetry survey, there are approximately 17 areas of identified historical uncontrolled filling or stockpiling within the construction footprint.

There is the potential that these areas of unexplained and uncontrolled filling and stockpiling contain contaminants which exceed the adopted soil guidelines, including the presence of Asbestos Containing Material (ACM). Where required, these areas would be further investigated prior to construction to determine the presence of contamination (if any) and would be considered when developing options for waste removal and disposal.

7. Assessment of potential impacts

The following information details strategies for the management of potential environmental (soil erosion and sediment transportation, ASS, soil salinity) and contamination risks identified associated with the construction and operation of the project.

7.1 Construction impacts

7.1.1 Soil erosion and sediment transportation hazard

High soil erodibility is listed as a limitation of all four soil landscape groups (South Creek, Blacktown, Luddenham and Picton) within the study area. Of particular note is the Picton soils within the eastern end of the construction footprint to have the potential for mass movement and slope instability (ie land sliding). The highest potential for soil erosion would be associated with the disturbance of soils on existing slopes during construction. Given the terrain of the construction footprint includes rolling hills to alluvial floodplains, and that soil disturbance is expected across the length of the construction footprint, soil erosion and the associated sediment transportation is a hazard that could impact on the construction of the project.

Based on the Surface Water and Hydrology assessment (JAJV 2018d), there are a number of construction activities that have the potential to impact on the soil environment as follows:

- Vegetation removal – Vegetation removal would expose soils to weathering processes, increasing the risk of erosion and sediment transportation.
- Cut and fill earthworks – Cut and fill earthworks over the project area could affect the topography, geology and soils. The topography would change in elevation and gradient. In areas of cut, underlying geology layers would be exposed due to the removal of the topsoil layer and proportion of the surficial geology. In areas of fill, the existing topsoil layer would be removed to place crushed material excavated during cutting on top.

Fill requirements have the potential to impact on soils and landform, as loose fill could be eroded during rainfall events by runoff. This can result in sediment transport and sedimentation of downstream drainage lines through mass movement of soils and change soil surface characteristics.

In areas of cut, the earthworks have the potential to destabilise the landform. Removal of topsoil can reduce the agricultural and ecological value and impede on the rehabilitation of native ecosystems. The construction activities associated with the project that have the potential to impact on soils are summarised below:

- Stockpiling – Excavated material would require stockpiling before being reused on the project. If stockpiles are not adequately stabilised, material could erode during high rainfall or windy events.
- Construction of new roads – There is the risk of soil compaction during the construction of new roads from the operation and movement of heavy machinery. This heavy machinery can disturb soil surface, increasing the potential for erosion.
- Construction of bridges – The construction of bridges requires piles which supports the bridge foundations. Piling requires excavation and can result in moderate impacts to soils due to disturbance.
- Relocation of utilities – The relocation of water mains and telecommunication facilities underground would involve soil disturbance from trenching and underboring. The disturbance of soil by machinery could increase the potential for soil erosion.
- Landscaping – Minor earthworks are required during landscaping activities that could result in the erosion of disturbed soils that have not stabilised. These impacts would be temporary as stabilisation and revegetation would act to resist future soil erosion.

Soil erosion and sediment transport hazards would be managed, subject to standard and suitable erosion control measures being implemented during construction activities. Standard erosion control measures would be consistent with those detailed in Landcom (2004) *Managing Urban Stormwater: Soils and Construction*.

7.1.2Acid sulfate soils

Based on the information reviewed, there is no known or expected ASS occurrence within the construction footprint. However, given the sediments of the creeks are of recent geological age (Holocene) and have not been sampled and analysed as part of this assessment, there is a data gap for ASS within the sediments of the creeks within the construction footprint. Should ASS be present within sediments, the impacts of the project on ASS would be to expose the ASS to air which would potentially react with the iron sulphides within the soil to make sulfuric acid. Sulfuric acid has the potential to corrode concrete, iron, steel and some aluminium alloys (OEH, 2019).

Measures would be included in the construction Soil and Water Management Plan (SWMP) to effectively manage the risk of potential ASS around creeks.

7.1.3 Salinity

Salinity impacts occur when salts naturally present in soil or groundwater are concentrated at the surface or in shallow soils generally through transport by rising groundwater associated with the removal of deep-rooted vegetation or other activities which could raise the groundwater table above normal seasonal levels.

Based on the information reviewed, including the groundwater assessment (**Appendix N** of the EIS), (see **Section 4.8**) and an understanding on how saline soils are formed, moderate to high risk areas of saline soils are present throughout the construction footprint. These saline soils have the potential to be further impacted upon by the project. During project construction, these moderate to high risk areas have the potential to impact on surface water and/or groundwater, soil erosion, and structures associated with the project.

Dust suppression water applied during construction would have low salinity and would be applied at rates which would not cause the water table to rise. As such, existing soil and groundwater salinity are not anticipated to be impacted by the project. Additionally, the project is not anticipated to result in a change in groundwater quality which would lower the beneficial use category of groundwater or exacerbate existing salinity (groundwater or soil) conditions.

Based on the groundwater assessment (**Appendix N** of the EIS), there is a potential for the surcharge loading associated with fill placement and the resulting increase in effective stress to cause short-term increases to groundwater levels in areas of fill placement, and/or permanent increases to groundwater levels if the increased stress permanently alters the hydraulic conductivity of the underlying water-bearing ground. This risk is applicable to relatively soft soils and is not expected to occur in areas where the water table lies within the rock. The potential increases in groundwater levels due to surcharge loading are expected to be very small and limited to areas in the vicinity of fill placement, therefore minimal impacts on existing salinity from the project due to raised groundwater levels are expected. As such, the project would have minimal impact on salinity.

Construction within areas of moderate to high risk saline soils would be managed under a Construction Environmental Management Plan (CEMP) and would include the following measures, but not limited to:

- Soil erosion management
- Offsite water migration
- Ongoing groundwater monitoring for groundwater levels and salinity
- Ongoing soil collection and analysis for salinity
- Identification and management of saline discharge sites
- Revegetation of the construction footprint/ancillary sites once the project is in operation.

Soil salinity management would be undertaken in accordance with the NSW Department of Primary Industries (2014) *Salinity Training Handbook*.

7.1.4Soil contamination

Contamination (where disturbed as part of construction activities), if not managed appropriately, could potentially impact upon project elements (environmental, human health, time, budget).

Phase 2 Detailed Site Investigation

Each AEI was assessed for land exposure risk in accordance with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (as revised in 2013), based on potential contaminants and activities.

Based on the information reviewed, a number of moderate to high risk potential AEIs have been identified within and next to the project (see **Figure 6-1**). Limited intrusive investigations have been undertaken within the construction footprint to further quantify the risks of some of these AEIs. Based on the results of the contamination investigation (JAJV 2018a), further investigations would be undertaken in the form of a Phase 2 Detailed Site Investigation (Phase 2 DSI) for the following:

- AEIs identified as having a risk ranking of moderate or high (see **Table 7-1**)
- AEIs where PAH has been identified in soils at concentrations exceeding the respective human health investigation levels, as identified in **Section 5.4**.

No further investigation is proposed within AEIs with a risk ranking of low.

The Phase 2 DSIs would be designed in accordance with the NSW EPA endorsed guidance, including the NEPM (2013) guidelines and the relevant guidelines listed in **Chapter 2**. A sampling, analysis and quality plan (SAQP) would be prepared and would include investigations for contaminants, including:

- Hydrocarbons
- Ammonia
- PAH
- Heavy metals
- Pesticides
- PCB
- Asbestos
- Any other identified relevant contaminant.

Table 7-1 Risk ranking of AEIs and consideration of further investigations within AEIs

AEI	Proximity to construction footprint	Risk ranking	Further investigation proposed
7 Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)	Within construction footprint)	Moderate	The extent of potential contaminants within this AEI is largely unknown. Due to the nature of the site, it is anticipated that some contaminants may be present. In addition, the AEI is located within the construction footprint. As a result, further investigation is proposed.
10 SUEZ Kemps Creek Resource Recovery Park	Adjacent to construction footprint	Moderate	As this AEI is located adjacent to the construction footprint, the main contaminant of further concern is the spread of gas beyond the boundaries of the AEI. Prior to construction activities, further gas investigations would be carried out in this area to assess the extent of high-risk soil gas which could impact upon construction and/or operation of the project.
17 Stockpiles within Hi-quality Quarry Group Head Office	Within the construction footprint	Moderate	Locations sampled within this AEI exceeded the adopted guidelines for environmental and human health criteria. As a result, further investigation is proposed.
19 Miscellaneous construction activities and stockpiles of building materials	Within the construction footprint	High	Contamination is known to be present within this AEI which may be disturbed during the construction of a bridge. In addition, locations sampled within this AEI exceeded the adopted guidelines for environmental and human health criteria. As a result, further investigation is proposed.
21 Area of significant illegally dumped material	Adjacent to the construction footprint	High	Asbestos has been identified within this AEI which may be disturbed during the construction of a bridge. As a result, further investigation is proposed.
Identified areas of potential fill Historical uncontrolled earthworks and building structures containing asbestos previously demolished/ degraded	Generic AEIs along the project	High	Within this AEI, the main further concerns are interaction with contaminated groundwater during construction and ACM contained within areas of historical or potential fill. As the project has minimal potential to interact with groundwater (see Appendix N of the EIS), no further investigation is proposed at this time. Unexpected contamination resulting from unexpected interaction with groundwater would be managed in accordance with the Contaminated Land Management Plan prepared as part of the CEMP. Further investigations within areas of potential or historical fill would be undertaken to determine the presence and/or extent of ACM within these areas.

The Phase 2 DSI would be designed in consideration of the potential and existing contamination identified within this report and the proposed construction activities to be carried out on the respective site (ie investigations would provide lateral and vertical coverage in context of the proposed construction activities within this area).

Remediation Action Plans

The Phase 2 DSIs would identify where remediation would be required due to extensive contamination within the project footprint. The need for remediation would be determined by considering the risks of carrying out construction works associated with the project. If the risks posed to the environment and human health is greater than the contamination remaining in situ, then the need for active remediation would be considered and alternative management options such as capping investigated.

A Remediation Action Plan and/or environmental management plans would be prepared for each area where the detailed site investigations confirm that contamination would have a moderate to a very high risk. This would typically apply where there is more significant, widespread contamination that requires detailed remedial planning.

Remediation Action Plans would be prepared in accordance with the relevant legislation and guidelines listed in **Chapter 2** prior to the commencement of construction. The process for the preparation and implementation of the Remediation Action Plans are outlined below:

- The Remediation Action Plan would be prepared by a suitably qualified and experienced contaminated lands consultant
- Remediation and validation activities would be carried out. Typical activities for remediation of sites within the construction footprint may include excavation and off-site disposal or capping and containment
- A validation report would be prepared by the consultant
- The validation report would be reviewed by the appointed independent NSW EPA accredited site auditor.

The Remediation Action Plans would include the assessment of sustainable remediation options and consideration of the *Waste Avoidance and Resource Recovery Act 2001* (NSW).

Use of contaminated material

Heavy metal and PAH contamination has been detected at concentrations exceeding ecological investigation levels within surface soils at selected locations (TP303, TP304, TP310 and TP311). The surface material from these areas cannot be reused within landscaped areas or in areas within and/or adjacent to sensitive environmental receptors. Impacted material would require either appropriate off-site disposal or managed appropriately (ie buried, capped and managed) within the project footprint.

Asbestos and demolition of structures

Based on the knowledge of the historical land use of the area, the identified fill areas (see **Section 6.3**), and that asbestos was confirmed within one area of the construction footprint (TP312 along Range Road, Cecil Park), there is a high risk of asbestos presence within soils of the construction footprint as follows:

- Isolated fragments of fibre cement sheeting in surface soils potentially representing isolated disposal activities or surface water flow driven deposition
- More concentrated scatterings of fibre cement sheet fragments at the surface, likely to be associated with degradation of/damage to building materials and demolition of onsite structures
- Fibre cement sheeting fragments and potentially fibrous material within illegally disposed stockpiles of waste and soil
- Larger areas subject to earthworks with imported fill potentially containing asbestos.

Further, intrusive asbestos investigations along the construction footprint would be undertaken to assess asbestos risks before the start of construction, which would include visual assessments and ground truthing the construction footprint.

Additionally, project construction would require the demolition of structures within the project footprint which may impact upon soil contamination if hazardous materials are not managed appropriately. Structures containing hazardous building materials (where present) have the potential to contaminate surrounding environments during demolition via airborne dust and have the potential to impact on human health, soils and waterways. Structures and/or buildings within the project construction footprint would require demolition to facilitate construction. Hazardous building materials (where present) would be managed to reduce the potential for contamination and ensure appropriate handling and waste disposal. In accordance with Australian Standard (AS 2601-2001), *The demolition of structures*, a hazardous building materials audit would be carried out before the demolition of any structure and/or building. As detailed in the EIS project description (**Chapter 5** of the EIS), structures would require demolition during project construction, including the following:

- Buildings (including residential housing), sheds or farm infrastructure
- A bridge crossing of South Creek on private property would be demolished as part of the creek realignment required to accommodate the project works at this location
- Road adjustments would be required at The Northern Road, Elizabeth Drive, Salisbury Avenue, Clifton Avenue and Wallgrove Road to accommodate the project where the new entry/exit ramps to and from the M7 Motorway merge with or diverge from the existing motorway.

It is noted that the number of structures to be demolished may change during detailed design.

Any soil/fill materials surplus to construction needs would be classified in accordance with the NSW EPA (2014) *Waste Classification Guidelines.*

An additional contamination investigation is currently ongoing which would ground truth the presence of asbestos containing materials along the construction footprint.

7.1.5 Groundwater contamination

Given that zinc and copper concentrations exceeded the ANZECC 2000 FW 95 per cent level at BH104 as well as most of the other tested boreholes, the existing potential baseflow contributions from groundwater to surface water systems is likely currently elevated above the ANZECC 2000 FW 95 per cent level. As a result, drainage of the western cut and discharge to a surface water system is not anticipated to have adverse impacts (JAJV 2018b).

Therefore, while groundwater in the area has exceeded the ANZECC 2000 FW 95 per cent level, the risk of the elevated heavy metals detected in groundwater released from the construction and operation of the project to receiving freshwater environments is low given that the volumes expected are negligible and are likely to represent background concentrations. Additionally, the groundwater quality data from BH104 (bore near the western cut) does not indicate a risk to human health (Australian Drinking Water Guidelines, NHMRC 2011).

Additionally, the project groundwater investigation (see **Appendix N** of the EIS) found that over time the rate of seepage through the face of the western cut would decrease as the groundwater system reaches equilibrium. It is expected that by the time the construction phase is complete there would be considerably less or negligible quantities of seepage occurring. This would further reduce the risk to receiving environments.

While pile excavations during bridge construction could intersect the water table, any groundwater extracted from the pile boreholes would typically not be separated from the excavated soil/rock and the material would be managed as one entity, and therefore volumes of groundwater are not expected to require management (see **Appendix N of** the EIS).

Based on the findings of the contamination (see **Section 5.4**) and groundwater (see **Appendix N** of the EIS) investigations, groundwater poses a low risk (with respect to contamination exposure) to the construction and operation of the project .

Based on the findings of the contamination (see **Section 5.4**) and groundwater (see **Appendix N** of the EIS) investigations, groundwater from identified AEIs poses a low risk to construction of the project given that the volumes of groundwater expected to interact with project features during project construction are negligible or are not expected to require management.

Contaminated groundwater has the potential to impact on construction activities such as bridge construction and excavations which reach depths to groundwater. If during construction, volumes of groundwater are encountered which may require management and potentially disposal associated with dewatering activities, further investigations would be carried out to confirm the contaminant levels within the groundwater and potential volumes that may need to be managed.

As described in the Groundwater Quality and Hydrology Assessment Report (see **Appendix N** of the EIS) releases of groundwater off site into the surrounding environments would be managed through the CEMP in order to protect surrounding surface and groundwater environments.

7.1.6 Gas contamination

As part of the project contamination investigation, gas monitoring was carried out at selected locations within the construction footprint, to inform the design as described in the EIS. The monitoring data indicated that potential soil vapour contamination may be present beneath areas of the construction footprint next to the Elizabeth Drive landfill facility. Methane and carbon dioxide exceeded the NSW EPA (2016) Environmental Guidelines: *Solid Waste Landfills* within this area. Methane and carbon dioxide are not expected to contribute to any potential odour impacts caused by the project given both gases are odourless. The risk associated with elevated methane levels are associated with potential explosion and asphyxiation risks. Elevated carbon dioxide could represent and asphyxiation risk. The Lower Explosive Limit (LEL) of methane is five per cent, and the Upper Explosive Limit (UEL) is 15 per cent (NSW EPA, 2016). The results of methane monitoring were less than these limits (LEL and UEL) where they exceeded the NSW EPA (2016) guidelines. Carbon dioxide is not flammable or explosive (NSW EPA, 2016).

Elevated gas concentrations could impact upon human health considering that construction activities (cuts) are proposed within this area north of the landfill. Potential impacts from gas ingress during construction include explosion and asphyxiation, especially associated with the construction of confined spaces such as service trenches. Elevated gas concentrations are likely to be relatively localised as it is understood that the

Elizabeth Drive landfill facility is not putrescible landfill and is likely to have a reduced gas output in comparison (reduced total organic carbon content in waste mass of Elizabeth Drive landfill in comparison to a putrescible landfill).

Prior to construction activities, further gas investigations would be carried out in this area to assess the extent of high-risk soil gas which could impact upon construction and/or operation of the project. Ground gas investigations would be carried out in accordance (where applicable) with the following guidance:

- Guideline for the Assessment and Management of Sites Impacted by Hazardous Ground Gases (The NSW EPA, 2012)
- Assessing Risks Posed by Hazardous Ground Gases to Buildings Report (C665) (Wilson et al 2007).

Should the further investigations determine that gas concentrations remain elevated near to the project construction footprint, the CEMP will detail that gas investigations would be undertaken during construction within the areas next to the Elizabeth Drive landfill facility. Additionally, if excavations are to be undertaken within enclosed structures, gas accumulation monitoring would be undertaken before and during construction. On site gas monitoring would be undertaken in accordance with the NSW EPA (2016) Environmental Guidelines: *Solid Waste Landfills*.

In addition to the above gas investigations, gas hazard mitigation within a Construction Work Health and Safety Plan would detail measures to prevent explosion hazards, remove ignition sources, and prevent gas inhalation of construction workers. If temporary site sheds are proposed within this area, appropriate measures would be implemented to avoid gas ingress into above ground structures (eg breezeways beneath buildings).

7.2 Operational impacts

7.2.1 Soil erosion and sediment transportation hazard

During the operational phase of the project, roads and bridges would be sealed; cleared areas would be landscaped; and scour protection would be installed. There would be no exposed topsoil and, therefore, little or no risk of soil erosion and subsequent transport of sediment into nearby receiving waterways. Water quality risks during the operation would instead be associated with runoff of pollutants from new road surfaces and increased vehicular traffic, accidental spills, increased impervious areas and permanent structures within waterways.

7.2.2 Acid sulfate soils

ASS are not expected to impact upon the operation of the project given that no project elements are expected within areas of potential ASS.

7.2.3 Salinity

Saline soils are unlikely to impact upon the operation of the project, however revegetation of construction support sites and other areas of soil disturbance after construction of the project would be undertaken to minimise risks to surrounding environments and land uses post construction.

7.2.4Soil contamination

After suitable reinstatement of construction support sites and other areas of soil disturbance after construction of the project, contaminated soils are not expected to impact on the operation of the project.

7.2.5 Groundwater contamination

Groundwater is not expected to impact upon the operation of the project given that anticipated groundwater volumes interacting with the project is negligible.

7.2.6 Gas contamination

Given the project is an aboveground road, landfill gas is not expected to impact on the operation of the project.

8. Cumulative impacts

Cumulative soil and contamination impacts may arise from the interaction of construction and operation activities of the project and other approved or proposed projects in the area. When considered in isolation, specific project impacts may be considered minor. These minor impacts may be more substantial, however, when the impact of multiple projects on the same receivers is considered. As such, the soil and contamination impacts discussed in **Chapter 7**, above, were assessed in consideration of the recently completed, ongoing and proposed projects described in **Table 8-1**.

Table 8-1 Projects near to the M12 Motorway project

Project	Relevance of the identified project to consideration of cumulative soil and contamination impacts of the M12 project
Western Sydney Airport (approved)	Temporal and spatial relevance, due to following characteristics: • Located directly adjacent to the project (overlapping areas of potential influence) • Concurrent (simultaneous) construction and operation. • Located within the same geological and soil landscape groups
Sydney Metro Greater West	Temporal and spatial relevance, due to following characteristics: • Located directly adjacent to the project • Likely to be concurrent (simultaneous) construction and operation.
The Northern Road Upgrade • Stage 5 (Littlefields Road to Glenmore Park) • Stage 6 (Littlefields Road to Eaton Road)	Temporal and spatial relevance, due to following characteristics: • Located directly adjacent to the project • Likely to be consecutive (back to back) construction and concurrent (simultaneous) operation (Stage 5).
Other existing road network upgrades and potential road projects, including: • Elizabeth Drive Upgrade • Mamre Road Upgrade • Outer Sydney Orbital	Temporal and spatial relevance, due to following characteristics: • Located directly adjacent to the project • Potential to be consecutive (back to back) construction and concurrent (simultaneous) operation.
Major land releases, including: • Western Sydney Aerotropolis • South West Growth Area • Western Sydney Employment Area.	Temporal and spatial relevance, due to following characteristics: • Located directly adjacent to the project • Potential future context of the M12 Motorway project (operation).

The above projects are in varying stages of delivery and planning. This section provides an assessment of cumulative soil and contamination impacts based on the most current and publicly available information on the above. In many instances this is a high-level qualitative assessment. The assessment of cumulative impacts per project is discussed in the sections that follow.

8.1 Western Sydney Airport

8.1.1 Construction cumulative impacts

The Western Sydney Airport EIS (GHD, 2016b) concluded that:

- Impacts to soil erosion and degradation during project construction are not expected to be significant (provided appropriate management measure are implemented)
- Potential contamination impacts are not expected to be significant and would be avoided by implementing appropriate management measures
- Given the recognised potential for salinity in the proposed airport soils, further soil salinity sampling is expected to be undertaken prior to construction
- A remedial action plan would be prepared prior to construction of the proposed airport to ensure the land would be suitable for its intended use
- Measures to mitigate and manage soil erosion and degradation, land contamination, and wastewater reuse will be collated in environmental management plans prior to construction of the proposed airport.

Cumulative impacts from the Western Sydney airport and the M12 Motorway project are focussed on soil erosion and salinity given that both projects are in areas where the potential for soil erosion and salinity are moderate to high. However, based on the results of the Western Sydney Airport EIS and that impacts of both projects are expected to be managed with the implementation of appropriate control measures, cumulative construction impacts from the Western Sydney Airport and the M12 Motorway projects are expected to be minor.

8.1.2 Operation cumulative impacts

The Western Sydney Airport EIS (GHD, 2016b) indicated similar risks to soils and contamination are applicable during operation and construction. Key risks to soil associated with the irrigation of reclaimed water during operation of the airport include adverse physical or chemical changes of soil, which may lead to ongoing reduction in fertility and potential to grow turf or pasture. Additionally, storage of fuels in the proposed airport present a potential for contamination releases to the environment if not managed appropriately.

Given that irrigation of reclaimed water is not proposed during operation of the M12 Motorway project, that appropriate storage and handling of fuels are to be implemented at the Western Sydney airport, and that impacts of the operation of the M12 Motorway project are expected to be negligible, similarly, the projects are not expected to contribute to cumulative soil and contamination impacts during operation.

8.2 Sydney Metro Greater West

8.2.1 Construction cumulative impacts

Construction timeframes for the Sydney Metro Greater West are likely to have some overlap with the construction of the project. During any timeframes where construction activities are concurrent, increased soil and contamination impacts may be possible. The magnitude of cumulative construction impacts would be dependent on the specific construction locations, activities and impacts which are yet to be determined for the Sydney Metro Greater West.

Cumulative impacts would be likely to be focussed on soil erosion, salinity and waste/soil management. However, given these impacts are expected to be managed by implementing appropriate mitigation controls as well as managing soil/waste within project footprints, the cumulative impacts are expected to be minor.

8.2.2 Operation cumulative impacts

The Sydney Metro Greater West and the project would both be operational in the longer term (ie opening of the Sydney Metro Greater West may occur after the opening of the project). The magnitude of cumulative operational impacts would be dependent on the specific construction locations, activities and impacts which are yet to be determined for the Sydney Metro Greater West. However, due to the minor operational impacts of the M12 Motorway on soil and contamination and the expectation of implementation of appropriate control measures, other projects are expected to have a minor contribution to cumulative soil and contamination impacts.

8.3 The Northern Road Upgrade

8.3.1 Construction cumulative impacts

Stages 1 through 4 of The Northern Road upgrade will be completed by the time construction of the project commences. There is no overlap of AEIs during construction of the project (Roads and Maritime, 2017).

The construction for Stage 5 is scheduled for early 2019 to end of 2022. The construction for Stage 6 is scheduled for mid-2019 to end of 2020. Construction activities associated with Stage 5 may overlap with the project construction.

Both projects are in areas of moderate to high salinity potential, and both projects have the potential to impact on local soil erosion. During the construction of both projects construction activities are not expected to increase the potential for salinity impacts along the project footprint and therefore cumulative salinity impacts are not expected. Similarly, soil erosion and sedimentation are risks posed to surface water quality throughout the construction phase through increased sediment loads entering downstream environments. Soil erosion is expected to be managed with the implementation of appropriate control measures and therefore minor cumulative impacts are expected.

8.3.2 Operation cumulative impacts

Cumulative operational contamination impacts of the projects are expected to be associated with potential contamination associated with increased traffic volumes in the area. Soil erosion and salinity are not expected to have cumulative impacts by the projects.

8.4 Other road network upgrades

8.4.1 Construction cumulative impacts

The timing for construction of the road network upgrades has not yet been announced. However, there is potential for overlaps in construction timing between the project and some of these road upgrade works which are in the vicinity of the project.

There is the potential for soil management to have a cumulative impact if the projects are to be constructed within the same timeframes. Soil management would impact upon transport of soil, disposal costs and locations of disposal. Cumulative impacts would be considered minor however would be considered during construction of the projects.

8.4.2 Operation cumulative impacts

The timing for operation of the road network upgrades has not yet been announced however it is likely that their operational timeframes will overlap with operation of the project. However, due to the minor operational impacts of the M12 Motorway project on soil and contamination and the expectation of implementation of appropriate control measures, the projects are expected to have a minor contribution to cumulative soil and contamination impacts associated with the operation of the projects and the upgrades.

8.5 Growth areas

The timing for the construction of developments within the above-mentioned growth areas has not yet been announced. There are potential of overlaps in construction timing between some developments and the project.

The construction of growth areas and the project may have cumulative soil erosion and soil management impacts. Provided appropriate controls measures are implemented during construction, cumulative impacts are expected to be minor, however would be considered during construction of the projects.

8.6 Conclusion

Overall, cumulative impacts of projects that are expected to take place within the same timeframes and/or spatially, would be mainly associated with soil erosion, soil management and in some cases salinity and are more likely associated with the construction periods of the projects. However, provided appropriate control measures are implemented and administrative controls are in place during both construction and operational phases on concurrent projects, the potential cumulative impacts associated with soil and contamination during the construction and operation of the project and other ongoing and planned developments in the area are expected to be minor.

9. Environmental management measures

Measures to avoid, minimise or manage soils and contamination as a result of the project are detailed in **Table 9-1**.

Table 9-1 Environment management measures (Soils and contamination)

Impact	Reference	Environmental management measure	Responsibility	Timing
Salinity	SC01	Construction within areas of moderate to high risk saline soils will be managed in accordance with the CSWMP. Specific measures will also include (but not be limited to): • Ongoing groundwater monitoring of salinity as part of the water quality monitoring program • Identification and management of saline discharge sites • Progressive stabilisation and revegetation of exposed areas following disturbance as soon as is practicable • Testing to confirm the presence of saline soils in areas of high salinity potential prior to disturbance. Soil salinity management will also be undertaken in accordance with the NSW Department of Primary Industries (2014) Salinity Training Handbook.	Contractor	Prior to construction and during construction
	SC02	Testing will be undertaken to confirm the presence of saline soils in areas of high salinity potential and to confirm the presence of ASS around creeks prior to disturbance.	Contractor	Prior to construction and during construction
Impacts of soil and groundwater contamination	SC03	A Contaminated Land Management Plan (CLMP) will be prepared for the project. The CLMP will include: • Control measures to manage identified areas of contamination, including surface soils in the vicinity of TP303, TP304, TP310 and TP311 containing heavy metal and PAH concentrations • Procedures for unexpected contamination • Measures to manage potential ASS (as required based on testing results) within sediments of the creeks in the construction footprint to minimise impacts to the environment • Requirements for excavation of unexpected contaminants to be undertaken in consultation with project Remediation Action Plans • Requirements for the disposal of contaminated waste in accordance with the Protection of the Environment Operations Act 1997 (POEO Act) and the Protection of the Environment Operations (Waste) Regulation 2014.	Contractor	Prior to construction
	SC04	An Asbestos Management Plan (AMP) will be prepared as part of the CLMP for the project. The AMP will guide the excavation, handling, storage and disposal of and management of asbestos discovered prior to and during construction, including procedures for any unexpected asbestos and encapsulation of asbestos under the road pavement. The AMP will also outline requirements for the encapsulation of asbestos to be undertaken in accordance with project Remedial Action Plans.	Contractor	Prior to construction

Impact	Reference	Environmental management measure	Responsibility	Timing
	SC05	Detailed site (contamination) investigations will be undertaken in accordance with the NSW EPA (1995) Sampling Design Guidelines and other NSW EPA endorsed guidance including the NEPM (2013) guidelines within the following AEI locations to confirm the presence of contamination prior to commencement of construction at these locations: • Within AEI 19: the area of miscellaneous construction activities and stockpiles of building materials along Luddenham Road) (Lot 1, DP228498) • Within AEI 7: former Kari and Ghossayn solid waste landfill (Lot 17, Clifton Avenue). • Within AEI 21: Substantial volume of illegally dumped material along Range Road, Cecil Park • Within the 'potential areas of existing fill' identified in this report Depending on results of the investigations, or if remediation is deemed required at any site within the construction footprint, a Remedial Action Plan will be prepared prior to construction.	Contractor	Prior to construction
	SC06	Further intrusive asbestos investigations throughout the construction footprint will be undertaken to assess asbestos risks before the start of construction. The investigations are to include visual assessments and ground truthing along the length of the project.	Contractor	Prior to construction
	SC07	A Hazardous Building Materials Management Plan will be prepared in accordance with relevant guidelines to manage the removal of known and unexpected hazardous building during demolition activities. Prior to demolishing structures and/or buildings, a hazardous building materials audit will also be carried out in accordance with Australian Standard (AS 2601-2001) The demolition of structures. Where hazardous building materials are present, they will be managed to reduce the potential for contamination in accordance with the Protection of the Environment Operations Act 1997 (POEO Act) and the Protection of the Environment Operations (Waste) Regulation (2014).	Contractor	Prior to construction and during construction
	SC08	All waste will be classified in accordance with the NSW EPA's Waste Classification Guidelines, with appropriate records and disposal dockets retained for audit purposes.	Contractor	Before and during construction
Soil gas contamination	SC09	A detailed investigation will be undertaken within the area next to the SUEZ Kemps Creek Resource Recovery Park to assess the extent of high-risk soil gas. A report will be prepared to document the outcomes of the investigation and outline measures to manage risks including nuisance odours to the surrounding area during excavation, and prevent the build-up of gases in buildings, basins, and sub-surface trenches and pits, and other enclosed spaces/depressions associated with the project during construction. These investigations will be carried out in accordance (where applicable) with the Guideline for the Assessment and Management of Sites Impacted by Hazardous Ground Gases (NSW EPA 2012) and Assessing Risks Posed by Hazardous Ground Gases to Buildings Report (C665) (Wilson et al. 2007). This will include undertaking gas monitoring.	Contractor	Prior to construction and during construction

Impact	Reference	Environmental management measure	Responsibility	Timing
	SC10	Should the further investigations determine that gas concentrations remain elevated near to the project footprint, gas monitoring will be undertaken during construction within the construction areas next to the SUEZ Kemps Creek Resource Recovery Park. If excavations are to be undertaken within enclosed structures, gas accumulation monitoring will be undertaken before and during construction. On site gas monitoring will be undertaken in accordance with the NSW EPA (2016) Environmental Guidelines: Solid Waste Landfills.	Contractor	During construction
	SC11	Should a gas hazard be present (either explosive or asphyxiation hazard), an appropriate gas management plan will be developed and implemented to manage spark generation, explosive environments and confined spaces. This plan will be implemented during construction within gas hazard areas and to manage works within below ground structures such as service trenches during operation. If temporary site sheds and storages are proposed within gas hazard area, appropriate measures will be implemented (eg. breezeways) to avoid gas ingress and accumulation into these structures.	Contractor	Prior to construction and during construction

10. Conclusions

Based on a desktop assessment, site inspection and review of the results of the JAJV (2018a) contamination investigation, expected soil conditions and contamination with the potential to impact on the project are as follows:

- Soil erosion
- Salinity
- Soil contamination
- Groundwater contamination
- Soil gas contamination.

Further investigations would be undertaken in the following areas prior to construction of the project:

- Within the following AEI locations due to PAH impacted soil contamination:
  - Within the area of miscellaneous construction activities and stockpiles of building materials along Luddenham Road)
  - Within the former Kari and Ghossayn solid waste landfill
  - Within the significant volume of illegally dumped material
- Intrusive asbestos investigations along the construction footprint to assess asbestos risks. The investigations are to include visual assessments and ground truthing along the length of the project.
- Gas monitoring within the area next to the Elizabeth Drive landfill facility to assess the extent of high-risk soil gas which could impact upon construction and/or operation of the project. Should the further investigations determine that gas concentrations remain elevated near to the project footprint, during construction gas monitoring will be undertaken within the construction areas next to the Elizabeth Drive landfill facility.

In addition to the above investigations, impacts associated with expected soil conditions and contamination can be managed with the mitigation measures detailed in **Chapter 7** and **Table 10-1**.

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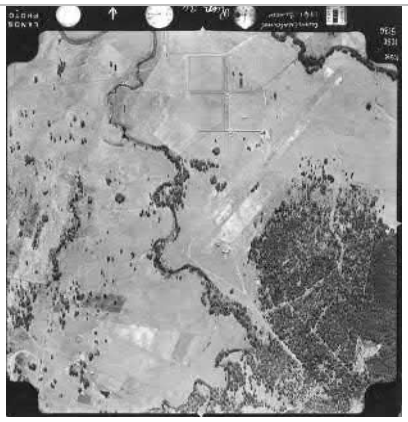
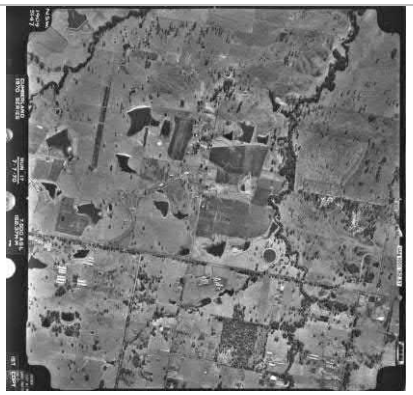
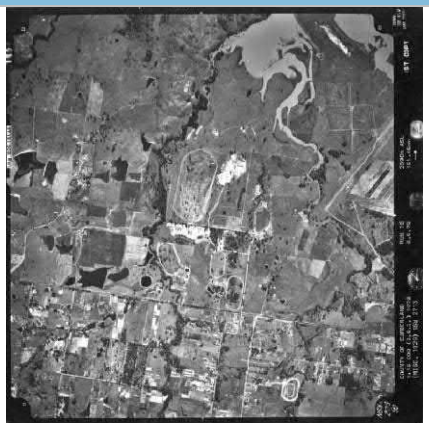
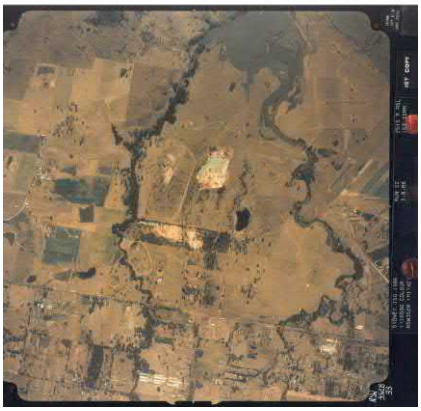
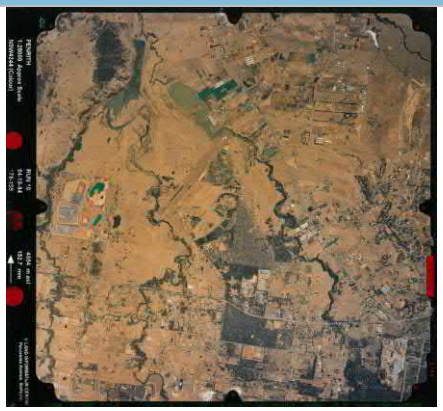
Annexure A Historic Aerial Photography

Date of aerial photography	Image	Site	Surrounding areas
1947	 1947 image showing the WWII airstrip in Kemps Creek	In 1947 the construction footprint consisted primarily of agricultural/rural land use. The RAAF World War II air strip was visible in Kemps Creek. Badgerys Creek, South Creek and Kemps Creek all traversed the project route.	The land surrounding the construction footprint was primarily agricultural land, with several arterial roads such as The Northern Road, Elizabeth Drive and Mamre Road present to the west, south and north of the project, respectively. There were three main areas of dense vegetation present; south of the project to the east of South Creek, south of the project to the east of the air strip, and south of the project to the south of Mamre Road.
1961	 1961 image showing the WWII air strip and CSIRO centre	In 1961 the construction footprint remained largely unchanged. The WWII air strip was not as well defined and potentially largely unused. Arterial roads traversing the project (ie The Northern Road and Luddenham Road) were better defined in the 1961 images.	The surrounding areas appeared to have undergone some rural development with an increase in rural properties and an increase in the quantity of dams in the area. The CSIRO's Division of Radio physics had been established and is visible next to the air strip to the north of the project. The dense vegetation to the east of South Creek had been largely cleared.
1970	 1970 image showing the project extent between Badgerys Creek and South Creek	In 1970 there were several large dams located toward the western end of the project within the construction footprint.	Agricultural and residential land use density had increased within areas surrounding the project. Two land disturbances in the locations of the current Hi-Quality Quarry and Sydney Recycling Park were present to the south of the project along Elizabeth Drive.

Date of aerial photography	Image	Site	Surrounding areas
1978	 1978 image showing location of proposed Elizabeth Drive interchange	In 1978 the construction footprint remained largely unchanged with the exception of the addition of an agistment/ horse track traversing the project in Luddenham, an agistment/horse track and land clearing in the location of the current SUEZ landfill facility, and an agistment/ horse track present within the construction footprint between Mamre Road and Elizabeth Drive. Additionally, rural land use density has increased at the location of the proposed Elizabeth Drive interchange.	In the 1978 images, two large land disturbances were visible. One was present to the south of the project in the location of the current Brandown Quarry. The second was located north-east of the project in the location of the current PGH Bricks and Pavers. Part of the dense bushland to the south of the project to the east of the air strip had been cleared for agricultural purposes. Residential/ rural land use density has increased around Mamre Road /Mount Vernon.
1986	 1986 image showing location of proposed Elizabeth Drive interchange	In 1986 the western end of the project had remained largely unchanged. The SUEZ landfill facility had increased in size.	The surrounding land uses had remained largely unchanged with the exception of the increase in size of several large land disturbances (ie Brandown Quarry, PGH Bricks, and Hi-Quality Quarry).

Date of aerial photography	Image	Site	Surrounding areas
1994	 1994 image showing the eastern extent of project near Mamre Road	In 1994 the SUEZ landfill facility had tripled in size.	The surrounding areas have remained primarily agricultural/rural land use, however there was increased low density residential land use in suburbs of Luddenham, Kemps Creek, Mount Vernon and Cecil Park. The land disturbances at the existing Hi-Quality Quarry and Sydney Recycling Park had tripled in size since 1970.
2002	 2002 image showing the eastern extent of the project near Mamre Road	The construction footprint remained largely unchanged with the exception of the increase in size of the SUEZ landfill facility.	Low density/rural residential land use had increased dramatically in the Badgerys Creek, Kemps Creek and Cecil Park areas. The Sydney International Shooting Centre was present to the east of Brandown Quarry.

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October 2019
RMS 19.1374
ISBN: 978-1-925891-89-8