Spring Farm Parkway Stage 1

Roads and Maritime Services

Surface Water and Groundwater assessment

IA186400-RP-EN-0052 | 02

11 February 2019

Contract No.18.0000303662.0353

Spring Farm Parkway Stage 1

Project No:	IA186400
Document Title:	Spring Farm Parkway Stage 1 - Surface water and Groundwater Assessment
Document No.:	IA186400-RP-EN-0052
Revision:	02
Date:	11 February 2019
Client Name:	Roads and Maritime Services
Client No:	Contract No. 18.0000303662.0353
Project Manager:	Alan Hillhouse
Author:	Kate Byrnes and Ben Rose
File Name:	J:\IE\Projects\04_Eastern\IA186400\01 Design\Environmental\05 SW and GW\Final updated\IA186400-RP-EN-0052_Surface Water and Groundwater Assessment_03.docx

Jacobs Australia Pty Limited

Level 7, 177 Pacific Highway
North Sydney NSW 2060 Australia
PO Box 632 North Sydney
NSW 2059 Australia
T +61 2 9928 2100
F +61 2 9928 2444
www.jacobs.com

© Copyright 2019 Jacobs Australia Pty Limited. The concepts and information contained in this document are the property of Jacobs. Use or copying of this document in whole or in part without the written permission of Jacobs constitutes an infringement of copyright.

Limitation: This document has been prepared on behalf of, and for the exclusive use of Jacobs' client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this document by any third party.

Document history and status

Revision	Date	Description	By	Review	Approved
01	02.08.2018	Surface Water and Groundwater assessment	Kate Byrnes, Ben Rose, Allie Cooke	S. Nandy	D. Williams
02	13.02.2018	Surface Water and Groundwater assessment – revised compounds	K. Flynn	D. Williams	D. Williams

Contents

1. Introduction 6
1.1 Overview 6
1.2 The proposal 6
1.3 Key construction activities 7
1.3.1 Ancillary facilities 8
1.4 Report Structure 8
1.5 Scope of work and purpose of this report 10
2. Legislative and Policy Context 11
2.1 Surface Water 11
2.1.1 Protection of the Environment Operations Act 1997 (POEO Act) 11
2.1.2 Fisheries Management Act 1994 (FM Act) 11
2.1.3 Australian and New Zealand Guidelines for Fresh and Marine Water Quality 11
2.1.4 The Healthy Rivers Commission of NSW (1998), Independent inquiry into the Hawkesbury Nepean River system 11
2.2 Groundwater 12
2.2.1 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) 12
2.2.2 National Water Quality Management Strategy 12
2.2.3 Water Act 1912 and Water Management Act 2000 12
2.2.4 Water Sharing Plan (WSP) 13
2.2.5 NSW Aquifer Interference Policy (2012) 13
2.2.6 Groundwater Dependent Ecosystems Policy 13
3. Surface Water 14
3.1 Assessment Approach and Methodology 14
3.1.1 Desktop Assessment 14
3.1.2 Criteria 14
3.1.3 Water quality objectives 15
3.1.4 Sensitive Receiving Environments 15
3.2 Existing Environment 15
3.2.1 Catchments 15
3.2.2 Key watercourses 16
3.2.3 Existing Surface Water quality 17
3.3 Impact Assessment 19
3.3.1 Construction phase – surface water quality 19
3.3.1.1 Construction across waterways, removal of vegetation & general earthworks 19
3.3.1.2 Ancillary facilities 19
3.3.1.3 Stock piling of topsoil and vegetation 20

3.3.1.4 Transportation of cut and/or fill materials and the movement of heavy vehicles across exposed earth 20
3.3.1.5 Potential for spills/leaks 20
3.3.2 Operation phase – surface water quality 20
3.3.2.1 Changes to impervious surfaces, surface runoff and hydrology 21
3.3.2.2 Potential for spills/leaks 21
3.3.2.3 Erosion and sedimentation 21
4. Groundwater 22
4.1 Assessment approach and methodology 22
4.2 Hydrogeological setting 22
4.2.1 Geology 22
4.2.2 Stratigraphy 22
4.2.3 Local Geology 23
4.2.4 Groundwater Levels 24
4.2.5 Registered Groundwater Bores 26
4.2.6 Groundwater Flow Systems 26
4.2.7 Groundwater Dependent Ecosystems (GDEs) 27
4.2.8 Surface Water and Groundwater Interaction 27
4.2.9 Groundwater Quality 28
4.3 Impact Assessment 28
4.3.1 Construction Phase 28
4.3.1.1 Acid Sulfate Soil 28
4.3.1.2 Spills/Leaks 28
4.3.2 Operation Phase 28
4.3.2.1 Spills/Leaks 28
4.3.2.2 Recharge Regime Alterations 29
4.3.2.3 Altered Groundwater Levels Due to Piles 29
4.3.2.4 Impacts to Potential GDEs 29
5. Mitigation Measures 30
5.1 Surface water 30
5.1.1 Construction phase 30
5.1.2 Operational phase 33
5.1.2.1 Design Criteria for surface water quality 33
5.2 Groundwater 34
6. Conclusion 35
6.1 Surface Water 35
6.2 Groundwater 36
7. References 37

Appendix A. Photographs of Key Watercourses

Important note about your report

The sole purpose of this report is to present the findings of a Review of Environmental Factors (REF) pertaining to surface water and groundwater, in connection with the Spring Farm Parkway Stage 1 – Concept Design and REF proposal, to enable key information to be drawn into the Proposal's REF. The report was commissioned by Roads and Maritime Services ('the Client') and was produced in accordance with and is limited to the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. You should be aware that this report contains interpretations and conclusions which are uncertain, due to the nature of the investigations. No study can investigate every risk, and even a rigorous assessment and/or sampling program may not detect all problem areas within a site.

This report is based on assumptions that the site conditions as revealed through sampling are indicative of conditions throughout the site. The findings are the result of standard assessment techniques used in accordance with normal practices and standards, and (to the best of Jacobs' knowledge) they represent a reasonable interpretation of the current conditions on the site. Sampling techniques, by definition, cannot determine the conditions between the sample points and so this report cannot be taken to be a full representation of the sub-surface conditions. This report only provides an indication of the likely sub surface conditions.

Conditions encountered when site work commences may be different from those inferred in this report, for the reasons explained in this limitation statement. If site conditions encountered during site works are different from those encountered during Jacobs' site investigation, Jacobs reserves the right to revise any of the findings, observations and conclusions expressed in this report.

The passage of time, manifestation of latent conditions or impact of future events may require further examination of the proposal and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

Except as specifically stated in this report, Jacobs makes no statement or representation of any kind concerning the suitability of the site for any purpose or the permissibility of any use. Use of the site for any purpose may require planning and other approvals and, in some cases, Environmental Protection Authority and accredited site auditor approvals. Jacobs offers no opinion as to the likelihood of obtaining any such approvals, or the conditions.

1. Introduction

1.1 Overview

NSW Roads and Maritime Services (Roads and Maritime) is proposing to deliver the future Spring Farm Parkway in two stages. When complete, stages 1 and 2 would provide a 6.1 kilometre east-west arterial road link between Camden Bypass, the M31 Hume Motorway (the Hume Motorway) and Menangle Road in Sydney's south west, 11 kilometres south of Campbelltown and 70 kilometres from Sydney CBD.

Spring Farm Parkway would service existing and future residential land releases including Spring Farm, Elderslie, Menangle Park and Mount Gilead. It would provide an alternative east-west route to Narellan Road, with direct access to the Hume Motorway. The section of road linking to the Hume Motorway would be designated as a State or Regional Road due to the intersection with the Hume Motorway. It is assumed the remaining section of road would remain a local road.

1.2 The proposal

Key features of the proposal include:

- A new four lane divided road (Spring Farm Parkway) extending about 0.9 kilometres from Menangle Road west to Menangle Park land release
- Capacity for widening Spring Farm Parkway to an ultimate six lanes in the future
- Inclusion of a shared-use path on the southern side of Spring Farm Parkway and the south-eastern side of Menangle Road through to Broughton Anglican College at the southern limit of work
- Provision of access to the Menangle Park land release area at the western end of Spring Farm Parkway
- A grade separated interchange to connect Spring Farm Parkway with the Hume Motorway with north facing entry and exit ramps designed to be compatible for future implementation of Smart Motorway requirements. The length of the entry and exit ramps would be about 1.6 kilometres
- A bridge about 20 metres wide and 76 metres long bridge over the Hume Motorway with provisions for future widening to accommodate a six lane Spring Farm Parkway and turn lanes for south facing ramps to allow access to and from the Hume Motorway
- Four signalised intersections including:
    - an intersection between Spring Farm Parkway and Menangle Road
    - a north facing exit ramp from the Hume Motorway onto Spring Farm Parkway
    - a north facing entry ramp from Spring Farm Parkway to the Hume Motorway
    - an intersection providing access to the proposed Menangle Park land release area at the western end of Spring Farm Parkway (Stage 1) including a stub for the future connection of Spring Farm Parkway (Stage 2)
- Upgrade of Menangle Road near the proposed Spring Farm Parkway intersection including widening to four lanes, and tie-ins to suit the new intersection to cater for forecast traffic demand
- Installation of new drainage infrastructure and upgrade of existing drainage infrastructure including kerb and gutters, pits, pipes and open drains
- Ancillary work associated with the proposal including:
    - Relocating, adjusting or protecting existing utility services that are in conflict with the proposal
    - Installation of new street lighting to improve the night-time visibility of intersections and various road furniture

- Delineation including signage, line-marking and other items to facilitate road user safety of the new infrastructure
- Urban design improvements, amenity planting and landscaping
- Property adjustments where necessary.

The location of the proposal is shown in Figure 1-1.

1.3 Key construction activities

Construction activities would be guided by a construction environmental management plan (CEMP) to ensure work is carried out to Roads and Maritime specifications within the specified work area. Detailed work methodologies would be determined during detailed design and construction planning. The proposed work methodologies are described below.

The proposed construction work and methodology provided are indicative and based on the current concept design and would be further developed during detailed design. Detailed construction staging plans and methods would be determined by the construction contractor(s) after completion of the detailed design in consultation with Roads and Maritime. In the event that construction activities result in environmental impact above those assessed in the REF, further environmental assessment would be required to be undertaken and approved by Roads and Maritime.

Construction work would be expected to involve the following methodology:

- Pre-construction identification and marking of sensitive areas as identified in this REF and the CEMP
- Site establishment (including temporary fencing and construction compound)
- Installation of traffic management measures such as placing temporary safety barriers in accordance with the traffic control plan
- Vegetation removal and installation of erosion and sediment controls
- Utility adjustments
- Drainage work
- Earthworks
- Pavement work that includes placement and compaction of; selected material, subbase, base and wearing surface materials
- Kerb and gutter construction
- Installation of permanent traffic control signals
- Installation of line marking and signposting and other road furniture
- Landscaping work
- Site clean-up.

1.3.1 Ancillary facilities

Temporary site compound areas would be required as part of the proposal. These sites may be used for material processing including batch or crushing plant; stockpiles site for materials; and site compound including offices, sheds for the storage of equipment and plan. The following areas would be used as site compounds throughout the construction of the proposal:

- A site compound area of approximately 24,000 m^2 is located on the eastern side of Menangle Road, opposite Broughton Anglican College (Compound 1)
- A site compound area to the west of the Hume Motorway, on the northern boundary of Spring Farm Parkway (Compound 2). This site compound, which would be about 7,600 m^2.
- A site compound area on the western side of the Hume Motorway, adjacent to the northbound entry ramps (Compound 3). This compound would be about 9,500 m^2.

It is expected that the compound facilities would be accessed directly from Menangle Road or via the Hume Motorway deceleration lane and onto Spring Farm Parkway.

These areas have been selected in accordance with Roads and Maritimes' *Stockpile Site Management Guidelines* (Roads and Maritime, 2008). Once construction is complete, the land where the site compounds are located would be reinstated to their previous condition.

1.4 Report Structure

The structure of this report is as follows:

Section 2 Outlines legislative and policy context relevant to surface water and groundwater

Section 3 Presents the surface water assessment

Section 4 Presents the groundwater assessment

Section 5 Presents a combined surface water and groundwater assessment conclusion

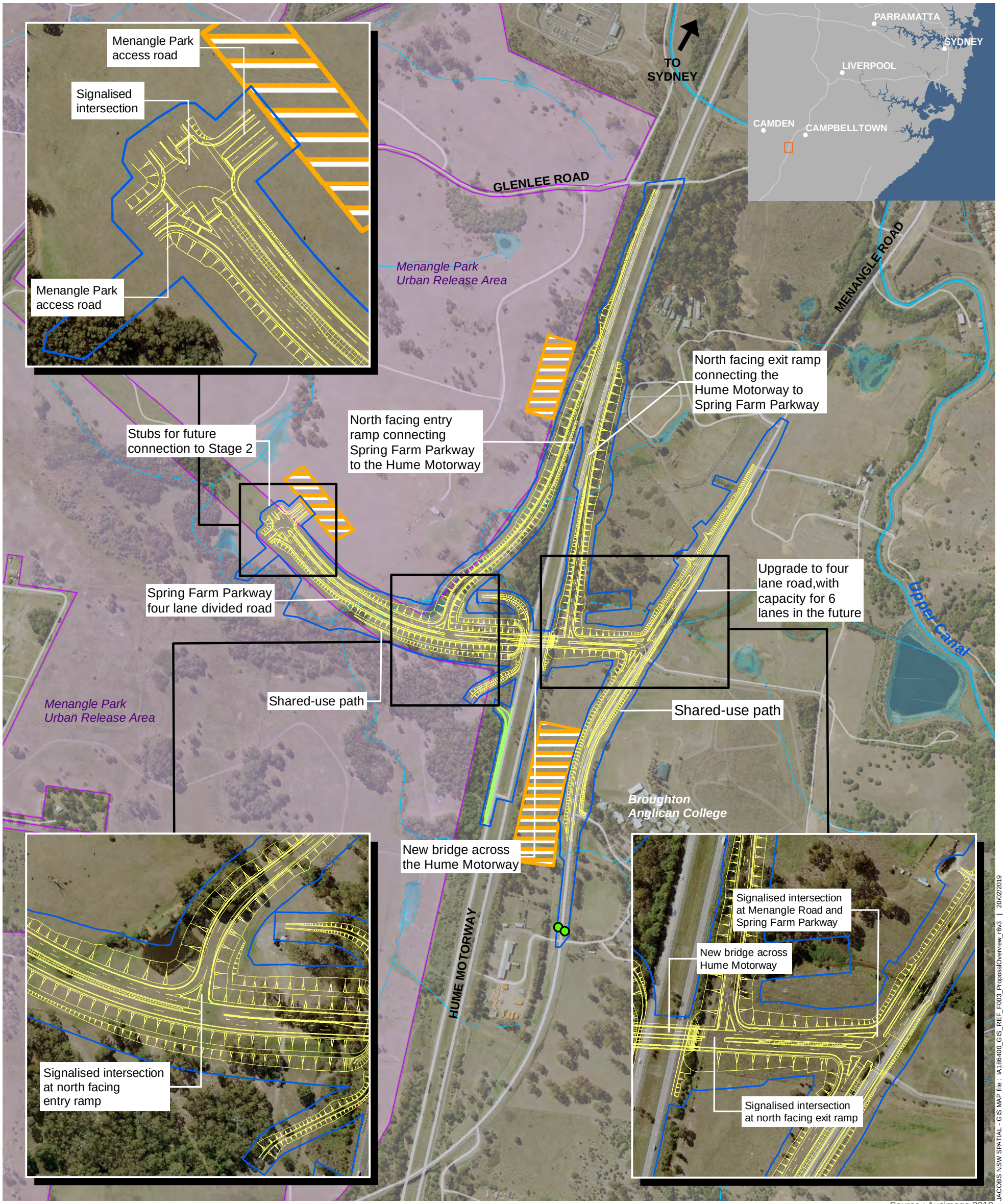


Figure 1-1 | Proposal overview

1.5 Scope of work and purpose of this report

This report presents the findings of a Review of Environmental Factors (REF) pertaining to surface water and groundwater, in connection with the Spring Farm Parkway Stage 1 proposal, to enable key surface water and groundwater information to be drawn into the Proposal's REF. The report was commissioned by Roads and Maritime Services (RMS) ('the Client'). The scope was developed to address RMS's QA Specification PS211 and included:

Surface water

- Identify waterways and sensitive surface water receiving environments directly traversed or downstream of the proposed development
- Review and collation of proposal related surface water quality data in the public domain or held by RMS and assessment of the data against ANZECC/ARMCANZ (2000) and HRC (1998) guidelines where applicable
- Identify potential sources of surface water contamination
- Determination of key environmental values at identified waterways in accordance with HRC (1998)
- Outline water quality objectives for the proposal
- Assessment of potential proposed development impacts during construction and operation of the proposal on surface water quality and the hydrological regime in light of identified water quality objectives
- Assessment of the resilience of waterways to assimilate potential pollutants
- Outline high level conceptual strategies and water quality protection measures to mitigate potential proposed development impacts
- Outline surface water related components of a water quality monitoring program which is to be implemented prior to construction of the proposed development.

Groundwater

- Review and collation of hydrogeological data in the public domain or held by RMS and characterise the site's hydrogeological setting
- Assessment of groundwater level trends and groundwater interaction with surface waters
- Assessment of potential proposed development impacts during construction and operation of the proposal on groundwater
- Outline high level conceptual strategies to mitigate potential proposed development impacts to groundwater
- Outline groundwater related components of a water quality monitoring program which is to be implemented prior to construction of the proposed development.

2. Legislative and Policy Context

2.1 Surface Water

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

The *Protection of the Environment Operations Act 1997* (POEO Act) regulates air and water pollution, noise control and waste management.

Section 120 of the POEO Act makes the pollution of waters an offence. Environment protection licences under Chapter 3 of the Act are normally required for a broad range of activities listed in Schedule 1 of the POEO Act and aim to address water pollution issues created by those activities. The proposal would involve the construction, widening and re-routing of roads, which are listed as road construction activities in Schedule 1 of the POEO Act. An environmental protection licence for road construction would be required for the proposal.

2.1.2 Fisheries Management Act 1994 (FM Act)

The Fisheries Management Act 1994 (FM Act) protects aquatic species such as fish (and their habitat) and marine vegetation. It is administered by the Department of Primary Industries. The FM Act, in conjunction with BC Act, aims to conserve, develop and share fishery resources and conserve marine species, habitats and diversity. The Proposal would traverse unnamed tributaries and drainage lines and therefore waterway crossings should be designed where possible according to the Policy and guidelines for fish habitat conservation and management (DPI 2013) to ensure minimal impact on aquatic habitats and species protected under the Act.

2.1.3 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ 2000) has published Australian and New Zealand Guidelines for Fresh and Marine Water Quality to provide benchmarks for assessment of the existing water quality of both waterways and waterways.

These guidelines and objectives are dependent on nominated environmental values. The objective adopted for the protection of aquatic ecosystems is “to maintain and enhance the ecological integrity of freshwater and estuarine ecosystems, including biological diversity, relative abundance and ecological processes”. Aquatic ecosystems could be defined as ecosystems that depend on flows, or periodic or sustained inundation to preserve their ecological integrity (eg river, creeks, wetland and groundwater dependent ecosystems).

2.1.4 The Healthy Rivers Commission of NSW (1998), Independent inquiry into the Hawkesbury Nepean River system

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

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

2.2 Groundwater

2.2.1 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prescribes the Commonwealth Government's role in environmental assessment, biodiversity conservation and the management of protected areas and species, population and communities and heritage items. Approval from the Commonwealth Minister for the Environment is required for projects likely to have a significant impact on 'matters of national environmental significance' (MNES). For the purposes of this assessment wetlands of international importance (Ramsar wetlands), a water resource in relation to coal seam gas development and large coal mining development, and water resources have been considered as relevant MNES.

2.2.2 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) is the adopted national approach to protecting and improving water quality in Australia. It consists of a number of guideline documents, of which certain documents relate to protection of surface water resources and others relate to the protection of groundwater resources.

The primary document relevant to the assessment of groundwater risks for the proposal is the *Guidelines for Groundwater Quality Protection in Australia* (Australian Government, 2013). This document sets out a high-level risk-based approach to protecting or improving groundwater quality for a range of groundwater beneficial uses (called 'environmental values'), including aquatic ecosystems, primary industries (including irrigation and general water users, stock drinking water, aquaculture and human consumption of aquatic foods), recreational and aesthetic values (e.g. swimming, boating and aesthetic appeal of water bodies), drinking water, industrial water and cultural values.

For the purpose of this assessment, all of the above 'environmental values' have been considered applicable, which is conservative.

2.2.3 Water Act 1912 and Water Management Act 2000

Water resources in NSW are administered under the *Water Act 1912* and the *Water Management Act 2000* by the NSW Department of Industry (NSW DI). The *Water Management Act 2000* governs the issue of water access licences and approvals for those water sources (rivers, lakes, estuaries and groundwater) in NSW where Water Sharing Plans (WSP) have commenced. The WSP for the study area has commenced and the area is therefore generally governed under the *Water Management Act 2000.* The exception is temporary construction dewatering, which is currently licensed under the *Water Act 1912.*

The *Water Management Act 2000* requires approvals for activities that may impact an aquifer(s), including activities that intersect groundwater other than water supply bores. Part 2 of the *Water Management Act 2000* establishes access licences for the take of water within a particular water management area. Such licensing would apply in cases where the proposal leads to groundwater 'take' (or indirect 'take' from a surface water source) other than that which occurs during temporary construction dewatering.

Roads and Maritime is exempt as a roads authority under Clause 18(1) of the *Water Management (General) Regulation 2011* from the requirement to hold a water access licence. Roads and Maritime is also exempt under Clause 31(1) of those regulations from the requirement to hold a water use approval. These exemptions are as per Schedule 5, Part 1, clause 2 of the regulations, which pertain to water required for road construction and road maintenance. Road authorities are not exempt, however, from the requirement to hold a water supply work approval to construct.

Groundwater take and temporary construction dewatering are not anticipated to be required for the proposal. However, this is to be confirmed during detailed design.

2.2.4 Water Sharing Plan (WSP)

The study area is covered by the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* (NSW), and is within the Sydney Basin Central Groundwater Source.

2.2.5 NSW Aquifer Interference Policy (2012)

The NSW Aquifer Interference Policy (2012) outlines minimal impact considerations for water table and groundwater pressure drawdown for high priority groundwater dependent ecosystems (GDEs) (as identified in the WSP), high priority culturally significant sites (as identified in the WSP) and existing groundwater supply bores. Water quality impact considerations are also outlined.

The study area has been interpreted as being within a 'less productive groundwater source' on the basis of low bore numbers, expected low yields and expected moderate to high salinity, for which the following impact considerations apply:

1. A maximum cumulative pressure head or water table decline of 2 m at any bore. If this condition cannot be met, then appropriate studies will need to demonstrate to the Minister's satisfaction that decline in head will not prevent the long-term viability of the affected water supply work unless make good provisions apply

2. Any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. If this condition cannot be met, then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem.

Impact limits to high priority GDEs and culturally significant sites as outlined in the NSW Aquifer Interference Policy (DPI NOW, 2012) are not applicable for the Stage 1 work area as high priority GDEs and culturally significant sites are not mapped within approximately 10 km of the study area (refer Section 4.2.7).

2.2.6 Groundwater Dependent Ecosystems Policy

The NSW State Groundwater Dependent Ecosystems (GDEs) Policy (Department of Land and Water Conservation, 2002) implements the *Water Management Act 2000* by providing guidance on the protection and management of GDEs. It sets out management objectives and principles to:

- Ensure that the most vulnerable and valuable ecosystems are protected
- Manage groundwater extraction within defined limits thereby providing flow sufficient to sustain ecological processes and maintain biodiversity
- Ensure that sufficient groundwater of suitable quality is available to ecosystems when needed
- Ensure that the precautionary principle is applied to protect groundwater dependent ecosystems, particularly the dynamics of flow and availability and the species reliant on these attributes
- Ensure that land use activities aim to minimise adverse impacts on groundwater dependent ecosystems.

3. Surface Water

3.1 Assessment Approach and Methodology

3.1.1 Desktop Assessment

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

- Review of existing literature relating to the proposal, available water quality data and existing conditions using available non-proposal literature to obtain background information on catchment history and land use to aid in interpreting the existing conditions. Literature sources included:
  - Water NSW (2016-2017) *Annual Water Quality Monitoring Report*, Sydney Catchment Area
  - Lower Hawkesbury-Nepean River Nutrient Management Strategy. Department of Environment, Climate Change and Water, 2010
  - Parsons Brinkerhoff (2015) 2014-2015 Groundwater and Surface Water Monitoring Status Report, Camden Gas project. AGL Upstream Investments Pty Ltd
  - EMM Consulting (2016) *2015-2016 Groundwater and Surface Water Monitoring Report* Camden Gas project. AGL Upstream Investments Pty Ltd
  - Lyall & Associates Consulting Water Engineers (2017*). Spring Farm Parkway Flooding and Drainage Investigation.* Prepared on behalf of Roads and Maritime Services
  - Hill Environmental (2017). Spring Farm Parkway (Stage 1 and 2), Menangle Road to Liz Kernohan Drive East – Preliminary Environmental Investigation.
- Assessment of the impact of construction activities on water quality with reference to the ANZECC/ARMCANZ (2000) water quality guidelines and the *Healthy Rivers Commission Independent inquiry into the Hawkesbury Nepean* (HRC 1998) with regard to the relevant environmental objectives of aquatic ecosystems and visual amenity.

3.1.2 Criteria

The NSW Healthy Rivers Commission has determined water quality objectives for the Hawkesbury-Nepean River (HRC 1998). The Australian and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ 2000) also have guidelines for water quality. These objectives and guidelines provide benchmarks for assessment of the existing water quality of the river. The application of the criteria is dependent on the environmental values assigned to the waterway. Surface water quality design criteria are discussed in Section 3.4.

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

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

Protection of aquatic ecosystems

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

There are a number of naturally occurring physical and chemical stressors that can cause degradation of aquatic ecosystems and for the purposes of this assessment nutrients, dissolved oxygen, pH, salinity and turbidity (suspended solids).

Visual amenity

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

3.1.3 Water quality objectives

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

3.1.4 Sensitive Receiving Environments

Sensitive receiving environments have been determined using aquatic habitat as an indicator. Waterways were assessed against the Key Fish Habitat "Types" in the Department of Primary Industries (DPI) *Policy and Guidelines for Fish Habitat Conservation and Management* (2013) and the *Fish Passage Requirements for Water Crossings* (Fairfull & Witheridge 2003). The assessment is based on the likelihood of habitat structures such as woody debris, macrophytes and substrate characteristics. Fish Passage Requirements for Waterway Crossings were assessed by waterway "Classes" adapted from Fairfull & Witheridge (2013) but provided in the DPI guidelines.

3.2 Existing Environment

3.2.1 Catchments

The proposal is located within Hawkesbury-Nepean catchment which spans from the regional city of Goulburn to Broken Bay in Sydney's North. The catchment drains an area of 21400 square kilometers and consists a mixture of low density residential housing, industrial, agricultural and rural landscapes. The main waterways within the catchment are the Hawkesbury and Nepean Rivers. The river system is an important source of drinking water and water supply for industrial practices and agricultural irrigation. The river system has been significantly altered since European settlement due to intensive urban and industrial development. The pressures of population growth have degraded the river system through extensive water extraction, increased pollution and nutrient runoff from agriculture and sewerage treatment plants (NSW DPI, 2018).

The proposal is located approximately one kilometre to the east of the Nepean River. The immediate banks of the Nepean River are densely vegetated while the broader flood plain has been cleared for agricultural purposes (Lyall and Associates, 2017). The river is a freshwater system before the junction of Grose River at Kurrajong, while the downstream catchment is tidally influenced by the Hawkesbury River Estuary (DNR, 2016).

Approximately 300 metres to the east of the proposal alignment is the state heritage listed Upper Canal. The gravity fed Upper Canal is the only water passage between the four upper Nepean dams (Cataract, Cordeaux, Avon and Nepean) and Prospect Reservoir. The canal runs for around 64 kilometres including 44 kilometres of open canal and 19 kilometres of tunnels which pass through hills and gullies. Prospect Reservoir which is joined to Warragamba Dam supplies on average, 20 percent of Sydney's drinking water. The reservoir is particularly important in times of high water demand or when other supplies are under maintenance (Water NSW, 2018).

3.2.2 Key watercourses

The Georges River lies approximately six kilometers to the east of the proposal alignment and the Nepean River lies approximately one kilometer to the west. Review of aerial photography indicates that one unnamed tributary of the Nepean River crosses the proposal alignment. Within the study area there are three unnamed tributaries/drainage lines that are directly traversed by the proposal and all drain in a westerly direction towards the Nepean River (Figure 3.1). For consistency, the same naming nomenclature adopted in the Preliminary Environmental Investigation (Hills Environmental, 2017) would be used for this assessment. The Upper Canal which runs 300 metres east of the proposal before crossing beneath Menangle Road about 450 metres north of the proposal, is also considered in this assessment.

Tributary 1 is the major drainage line traversed by the proposal and controls runoff from three drainage structures. The downstream environment is vegetated before forming a drainage structure which runs under the South Railway line (Lyall & Associates, 2017). The tributary is an ephemeral third order stream (Strahler) with limited upstream catchment. During a site visit in June 2018, water levels were observed to be very low, consisting of shallow intermittent pools and unlikely to contain water during dry weather.

The upstream section of Tributary 1 between the Hume Motorway and Menangle Road is grassy minor gully with limited water and channel definition. As the waterway is an ephemeral, third order drainage line with limited aquatic habitat, it has not identified as key fish Habitat (DPI 2013). With respect to fish passage it is classified 'Class 4' unlikely Key Fish Habitat (Fairfull and Witheridge 2003).

Downstream at Tributary 1 approximately 200 meters to the west of the Hume Motorway the banks are more densely vegetated and the waterway is wider. There are nearby farm dams located along this section which contain emergent macrophytes. It is likely that this downstream section of the tributary including the farm dams would contain more aquatic habitat characteristics including instream aquatic macrophytes. This section of the tributary has been conservatively classified as Type 2' moderately sensitive key fish habitat (however typically farm dams are not considered key fish habitat). With respect to fish passage the downstream tributary is classified 'Class 3' minimal key fish habitat (Fairfull and Witheridge 2003).

Drainage line 1a would be traversed by the proposal and currently drains under the Hume Motorway in a westerly direction. Similar to the upstream section of Tributary 1, drainage line 1a has limited instream aquatic habitat. The drainage line is surrounded by cleared farmland and macrophytes are restricted to sparse rushes along the banks. As the main waterway is an ephemeral, first order drainage line with limited aquatic habitat, it has not been identified as Key Fish Habitat (DPI 2013). With respect to fish passage it is classified 'Class 4' unlikely key fish habitat (Fairfull and Witheridge 2003).

The Upper Canal is a maintained concrete lined channel which does not directly discharge to the tributaries associated with the proposal nor would it receive runoff from the proposal area. The main purpose of the canal is to transfer water to Prospect Reservoir and does not contain fish habitat.

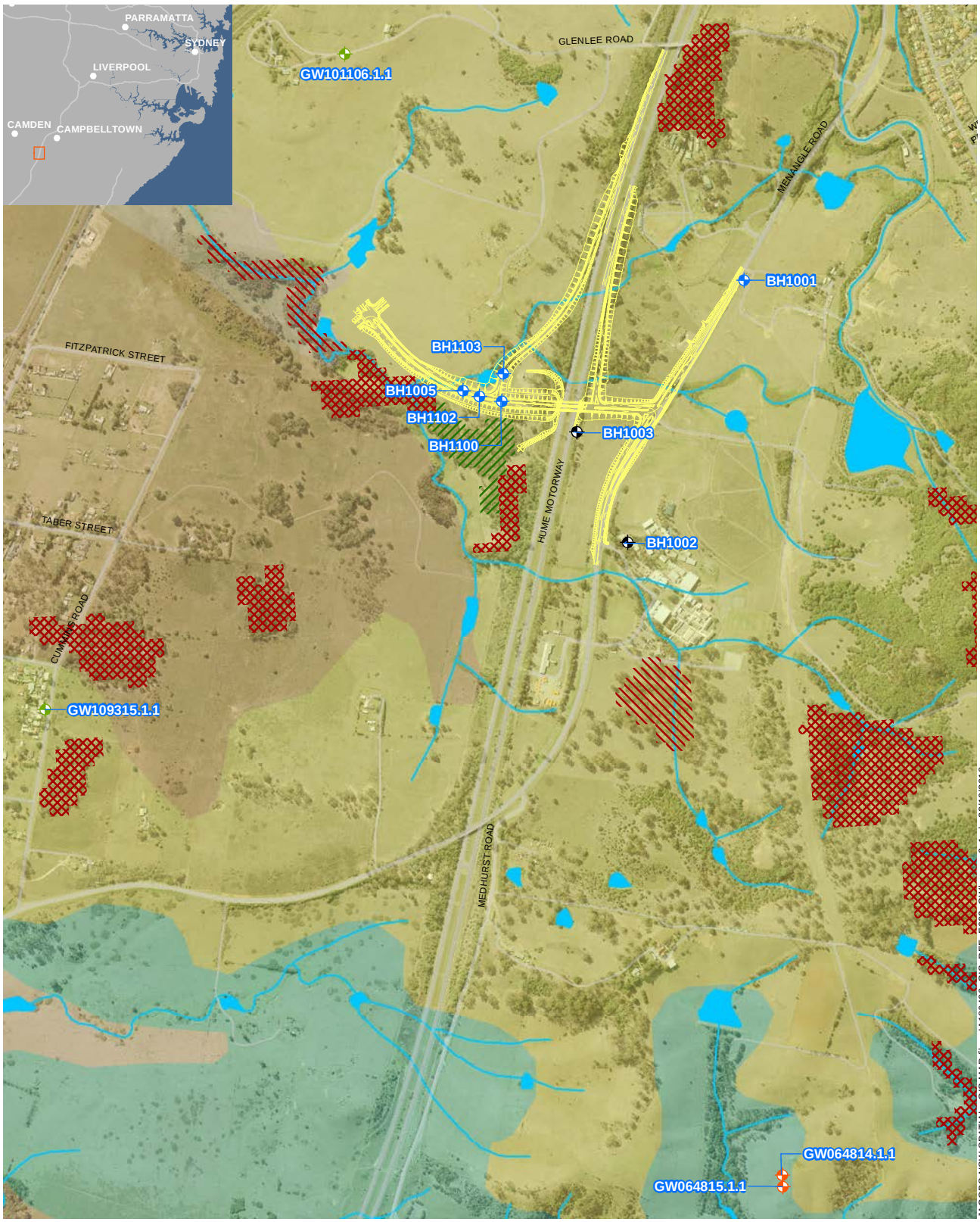
Despite the conservative 'Type 2' key fish habitat classification the drainage lines are not considered a sensitive receiving environment to the proposal operation due to its ephemeral nature, limited aquatic habitat and impacted upstream catchment containing artificial farm dams and agriculture.

3.2.3 Existing Surface Water quality

The majority of the Hawkesbury-Nepean is stressed, largely a result of urban and agricultural practices and changes to flow with large amounts of water diverted for water supply and irrigation. Elevated nutrient levels and reduced river flows are the key contributing factors to stresses on the river. As a result, algal blooms and excessive weed growth have impacted on the environmental values of the river and affected aquatic life (DECCW 2010). Diffuse nutrient sources (urban stormwater, agricultural practices, degraded land) have been identified as the leading source of nutrients in the catchment and a priority for management.

Water quality within the Nepean River is reported annually by Water NSW. A minimum of 18 water quality samples were taken at Menangle Bridge in 2016/2017. The results showed that turbidity, pH and total phosphorus were within the ANZECC/ARMCANZ (2000) guidelines in all samples. Total nitrogen was outside the guidelines in 10 per cent of samples. Chlorophyll-*a* was outside the guidelines in 30 per cent of samples and dissolved oxygen was outside the guideline in 55 per cent of samples.

A single water quality sample was collected on behalf of AGL at the Nepean River Menangle Park approximately 2.3 kilometres south west of the study area on 9th September 2014. The results showed that pH and salinity were within the acceptable range for protection of aquatic ecosystems (ANZECC/ARMCANZ 2000). Dissolved metal concentrations were low and total phosphorus was below the ANZECC/ARMCANZ (2000) guidelines. No hydrocarbons were detected with the exception of methane which was detected in low concentrations. Ammonia concentrations were above the ANZECC/ARMCANZ (2000) guidelines of 0.02mg/L. Additional monitoring was carried out on the 21st of October 2015 at the same location by EMM consulting. Concentration of these indicators showed little variation to the previous monitoring round. With the exception of methane which had concentrations of 0.02mg/L, double that recorded previously (EMM 2016).



Legend

- 80% design
- Waterway
- Monitoring bore
- Project borehole
- Project monitoring bore
- Water supply bore

Ground water Dependent Ecosystem (GDE)

- Terrestrial (low potential GDE - from national assessment)
- Terrestrial (moderate potential GDE - from national assessment)
- Terrestrial (high potential GDE - from national assessment)

Australian Government Bureau of Meteorology (GDE Atlas)

Geology (rock unit)

- Qal-Quaternary Alluvium
- Rwa-Ashfield Shale
- Rwb-Bringelly Shale
- Tal-Tertiray Alluvium

NSW Department of Primary Industries - Mineral Resources 1999

0 200 400m
1:15,000 @ A4

N

Figure 3-1 | Key watercourses and features

3.3 Impact Assessment

3.3.1 Construction phase – surface water quality

Construction of the proposal presents a risk to degradation of downstream water quality if management measures are not implemented, monitored and maintained throughout the construction phase.

If unmitigated, the highest risk to water quality would occur through the following construction activities:

- Construction across waterways, including construction of drainage devices
- Removal of vegetation and general earthworks, including stripping of topsoil, excavation or filling
- Stockpiling of topsoil and vegetation
- Ancillary facilities
- Transportation of cut and/or fill materials and the movement of heavy vehicles across exposed earth
- Potential for spills/leaks.

Additional details on these risks are provided below.

3.3.1.1 Construction across waterways, removal of vegetation & general earthworks

A number of construction activities would occur near or within the watercourse (Tributary 1 and drainage line 1a and 1b). Tributary 1 and drainage line 1a would be traversed during the construction of exit and entry ramps to the Hume Motorway. Construction across drainage line 1a would also occur during the upgrade of Menangle Road to four lanes.

Watercourse crossings would be designed and constructed to minimise impacts to natural flow regimes and to not present any barriers. Watercourse crossings during construction may impact on water quality due to the disturbance of the bed and banks resulting in erosion and sedimentation, alteration of downstream flows (potentially creating isolated stagnant pools of water) and scouring of the bed near culvert inlets and outlets.

Removal of vegetation, stripping of topsoil and filling and mobilisation of sediment associated with general earth works can impact on water quality during the construction phase if runoff is allowed to mobilise exposed soils particularly when these sites are located close to waterways. Removal of vegetation and/or filling is proposed at several locations including Tributary 1 and drainage line 1a for the upgrade of Menangle Road, the construction of exit and entry ramps onto the Hume Motorway and the construction of the new road that goes from east to west between Menangle Road and Spring Farm. This can result in increased erosion and sedimentation.

Further information regarding the extent of vegetation clearing required for the proposal is presented in the biodiversity assessment (Niche, 2018).

3.3.1.2 Ancillary facilities

Ancillary facilities to support construction would be required at various locations along the proposal. Ancillary facilities would include construction compounds, stockpile areas and sediment basins. The final type, location and number of ancillary facilities would be determined by the construction contractor. The Preliminary Environmental Investigation (Hills Environmental 2017) has identified potential for flooding in the area, which has the potential to impact on the water quality if ancillary sites are located in flood prone areas close to waterways and drainage lines through flood waters mobilising sediments from stock pile and sediment basins, and storage of chemicals associated with the ancillary facilities. Additionally, the earthworks associated with and construction of the above ground components of the ancillary facilities would result in removal of existing vegetation and structures therefore disturbing and exposing soils. Construction activities adjacent to waterways

could introduce contaminants such as oil or greases and disturb contaminated sediments, potentially having an adverse impact on water quality.

The impact of this work on water quality could include increased turbidity, suspended solids, nutrients and contaminants from mobilisation of soils. If construction compounds and worksites would be located within 500 metres of the unnamed tributary of the Nepean River, water quality standard erosion and sediment control measures detailed in the Construction Environmental Management Plan (CEMP) should be adhered to.

3.3.1.3 Stock piling of topsoil and vegetation

Stockpile sites would be used to temporarily store excess spoil and wastes before their reuse on-site or disposal off-site. Stockpiles of raw materials or spoil would be located as close as practical to the work area where they are proposed to be used and to permit any drainage off site so that there would not be any impact to water quality. Stockpile sites would also include environmental protection measures such as sediment basins to minimise impacts on receiving waters from erosion and sedimentation. Stockpiles sites would be established and managed in accordance with *Environmental Procedure Management of Wastes on Roads and Maritime Services Land* (RMS, 2014).

Additionally, if stockpiles are to be located within the floodplain, the obstruction of flow paths and loss of floodplain storage has the potential to cause flooding impacts. Loose material stored within the floodplain has the potential to be mobilised during a flood and may impact on water quality downstream.

3.3.1.4 Transportation of cut and/or fill materials and the movement of heavy vehicles across exposed earth

The earthworks and movement of construction vehicles within the proposal area could increase erosion and sediment deposition in the waterways. In particular, construction activities adjacent to Tributary 1 and drainage line 1a that crosses the alignment, could introduce contaminants such as oil or greases and disturb contaminated sediments, potentially having an adverse impact on water quality.

3.3.1.5 Potential for spills/leaks

The release of potentially harmful chemicals and other substances in the environment may occur accidentally during construction due to spills as a consequence of equipment malfunction and maintenance or refueling, as a result of inappropriate storage, handing and use of contaminated sediment and via treatment and curing processes for concrete. This has the potential to impact on water quality of downstream receiving waters. These contaminants could include acids and chemicals from washing down of vehicles, construction fuels, oils, lubricants, hydraulic fluids and other chemicals.

3.3.2 Operation phase – surface water quality

The proposal would involve the upgrade of existing roads and the construction of new road through greenfield areas. The construction of increased roads (and therefore increased impervious areas) would discharge runoff to the receiving environment. The operation of the proposal is likely to impact on water quality due to discharge of drainage at new locations or increased discharge at existing locations where road and drainage upgrades have occurred.

The operation of the proposal has the potential to alter existing hydrology and flooding regimes which may impact on water quality due to increased runoff volumes and peak flow rates. Increased flow rates can impact on the bed and bank stability of the existing watercourses making them highly susceptible to erosion. Stream erosion increases sediment and nutrient loads leading to decreased water quality which would affect the protection of the nominated environmental values.

3.3.2.1 Changes to impervious surfaces, surface runoff and hydrology

Minor increases in impervious surface areas associated with work have the potential to result in increased runoff due to changes in the hydrological regime. This could lead to water quality impacts associated with increased erosion and sedimentation and increased concentrations or the introduction of pollutants into downstream waterways.

3.3.2.2 Potential for spills/leaks

The operation of the proposal has the potential to impact on surface water quality from the spill of vehicle oils, lubricants and hydraulic fluids and other accidental spills including leakage of chemicals in transit. Given the distance the Nepean River and the potential to incorporate some spill containment structures, impact to water quality is expected to be minimal.

3.3.2.3 Erosion and sedimentation

There is a period of time following the completion of construction where recently disturbed soils are susceptible to scour and erosion from stormwater runoff, particularly as there is a small increase in impervious areas. The potential for sediment transport is dependent on status of rehabilitation, severity of rainfall event, and the slope and scale of the disturbed area. As both the area of disturbance and increased imperviousness is small, and the Nepean River being the nearest downstream waterway is about one kilometre from the site, the potential impacts are expected to be limited and less than the construction phase.

4. Groundwater

4.1 Assessment approach and methodology

Potential risks of groundwater impact arising from the proposed Stage 1 work were qualitatively assessed based on:

- A desktop review of public domain hydrogeological data available in the region of the site
- Conceptualisation of the groundwater system
- The potential of the proposal to alter the groundwater regime.

4.2 Hydrogeological setting

4.2.1 Geology

The Wollongong – Port Hacking Geological Series Sheet 9029-9129 (Geological Survey of NSW, 1985) indicates that the surface geology in the study area comprises Wianamatta Group Bringelly Shale.

The majority of the proposal occupies an area of Bringelly Shale which is described as shale, carbonaceous claystone, laminate and coal in parts. The northern extent of the Hume Motorway's proposed exit/entry ramps are mapped to be underlain by an unnamed sandstone member belonging to the Bringelly Shale unit and is described as fine to medium grained quartz-lithic sandstone.

Quaternary alluvium material described as 'quartz and lithic fluvial sand, silt and clay' and Tertiary aged 'high-level alluvium' is mapped west and south west of the proposal's western extent.

4.2.2 Stratigraphy

Table 4.1 provides a description of the stratigraphic units in the study area and the nomenclature adopted for this report.

Table 4.1: Stratigraphic unit description

Geologic Province	Stratigraphic Unit	Age	Description
n/a	Alluvium	Quaternary and Tertiary	Quaternary Alluvium - quartz and lithic 'fluvial' sand, silt and clay Tertiary Alluvium
Sydney Basin	Wianamatta Group	Permian	Predominantly shales and siltstones with occasional sandstone interbeds
	Hawkesbury Sandstone	Triassic	Comprises a series of bedded sandstone units and has a total thickness of approximately 185 m
	Narrabeen	Triassic	Series of interbedded sandstone and claystone units

4.2.3 Local Geology

Seven boreholes (RMS, 2017 and 2018a) were completed in the vicinity of the study area. The locations of these boreholes are shown in Figure 3-1.

The boreholes encountered:

- Fill material at the top (ranging from 0 to 3.2 m deep)
- Relatively thin alluvium (less than 4.1 m thick) in boreholes BH1001 and BH1003 east of the Hume Motorway and thicker alluvium (10 to 12 m thick) in boreholes west of the Hume Motorway. Therefore, the depth of alluvium increases with proximity to the west and the existing drainage line located south west of the Stage 1 work
- Residual soil was encountered below the alluvial material and had a thickness ranging from 0 to 4.9 m. In borehole BH1002, located east of the Hume Motorway, alluvial material was not identified and residual material was identified below the fill
- Sedimentary rock comprising mudstone, shale, carbonaceous shale, laminite, sandstone and siltstone was encountered beneath the residual soil.

The observed alluvium in the site boreholes is not denoted in the large scale (Geological Survey of NSW, 1985) surface geology map, which indicated the entire surface geology within the proposal study area comprised Bringelly Shale.

A geological log (BOM, 2018a) for a relatively deep groundwater monitoring bore (bore GW101106.1.1, details provided in Section 4.2.5) located approximately 0.7 km from the proposal is summarised in Table 4.2. The geological log associated with this bore is considered likely to exemplify rock stratigraphy in the region of the proposal. Interpreted associated geological units are also shown in Table 4.2, which were based on stratigraphic information presented by AGL (2013) for the Camden Gas Proposal Area, which the proposal is within. The stratigraphy of bore GW101106.1.1 comprises residual clay from the surface to six metres below ground level (mBG)L, which is underlain by Wianamatta Group Shale to 80 mBGL, which is underlain by Hawkesbury Sandstone to 267 mBGL, which overlies Newport Formation shale.

Table 4.2: Summarised geological log for bore GW101106.1.1 and interpreted geological units.

Summarised Bore GW101106.1.1 Geological Log		Interpreted Geological Unit [1]
Depth (mBGL)	Description Summary	
0 to 6	clay	NA (residual soil)
6 to 80	shale	Wianamatta Group
80 to 145	sandstone	Hawkesbury Sandstone
145 to 151	sandstone/shale bands	
151 to 160	sandstone	
160 to 180	shale	
180 to 267	sandstone	
267 to 280	shale	Newport Formation (part of Narrabeen Group)

Notes:
[1] Based on bore GW101106.1.1 (BOM, 2018a) geological log and Table 1 in AGL (2013).
[2] Mittagong Formation between Wianamatta Group and Hawkesbury Sandstone not detectable in bore GW101106.1.1 geological log.

4.2.4 Groundwater Levels

The following information on groundwater levels has been extracted from the information contained on the relevant boreholes logs and groundwater level plots provided in RMS (2017, 2018) geotechnical reports. Data loggers were used by RMS (2017) in BH1002 and BH1003 to monitor groundwater levels (Table 4.3, Figure 4-1 and Figure 4-2) for a period of three weeks (11/08/17 to 31/08/17). No long term monitoring data was available.

With the exception of small groundwater level increases, most notably those which peaked on 16th and 28th August 2017 and resulted in a maximum level increase of approximately 0.25 m (BH1003), groundwater levels in both BH1002 and BH1003 generally declined over the monitoring period. Very little rainfall fell over the monitoring period with rainfall occurring on four days and daily totals not exceeding approximately 1 mm.

Table 4.3: Proposal groundwater level observations

Location	Ground Level (m AHD)	Groundwater Depth (m BGL)	Groundwater Level (m AHD)	Material at Groundwater Level	Water Level date/observation
BH1001	97.91	4.6	93.3	Groundwater level was approximately at the contact between clay alluvium and 'possibly residual soil' (clay)	24/07/17 (during drilling)
BH1002	99.78	2.3 ***8.5-8.7***	97.5 ***91.1 to 91.3***	Clayey sand (noted as uncertain whether this material is fill or residual soil)	23/07/17 (during drilling) ***11/08/17 to 31/08/17 (data logger)***
BH1003	93.18	3.8 ***3.3 - 3.5***	89.4 ***89.7 to 89.9***	Clayey sand alluvium	25/07/17 (during drilling) ***11/08/17 to 31/08/17 (data logger)***
BH1005	83.96	2.9	81.1	Clay alluvium	11/07/17 (during drilling)
BH1100	86.44	4.2	82.2	Silty Clay alluvium	03/10/17 (during drilling)
BH1102	84.87	4.0	80.9	Clay alluvium	05/10/17 (during drilling)
BH1103	85.40	3.1	82.2	Silty Clay alluvium	04/10/17 (during drilling)

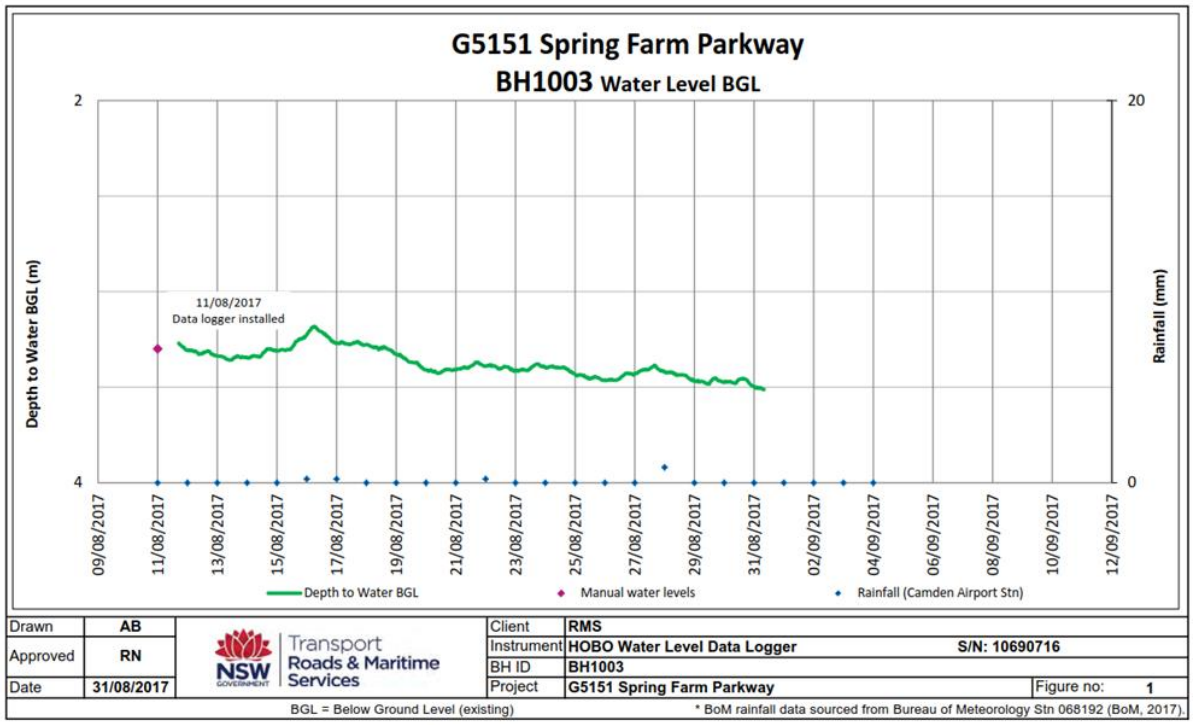


Figure 4-1: BH1002 groundwater level monitoring results

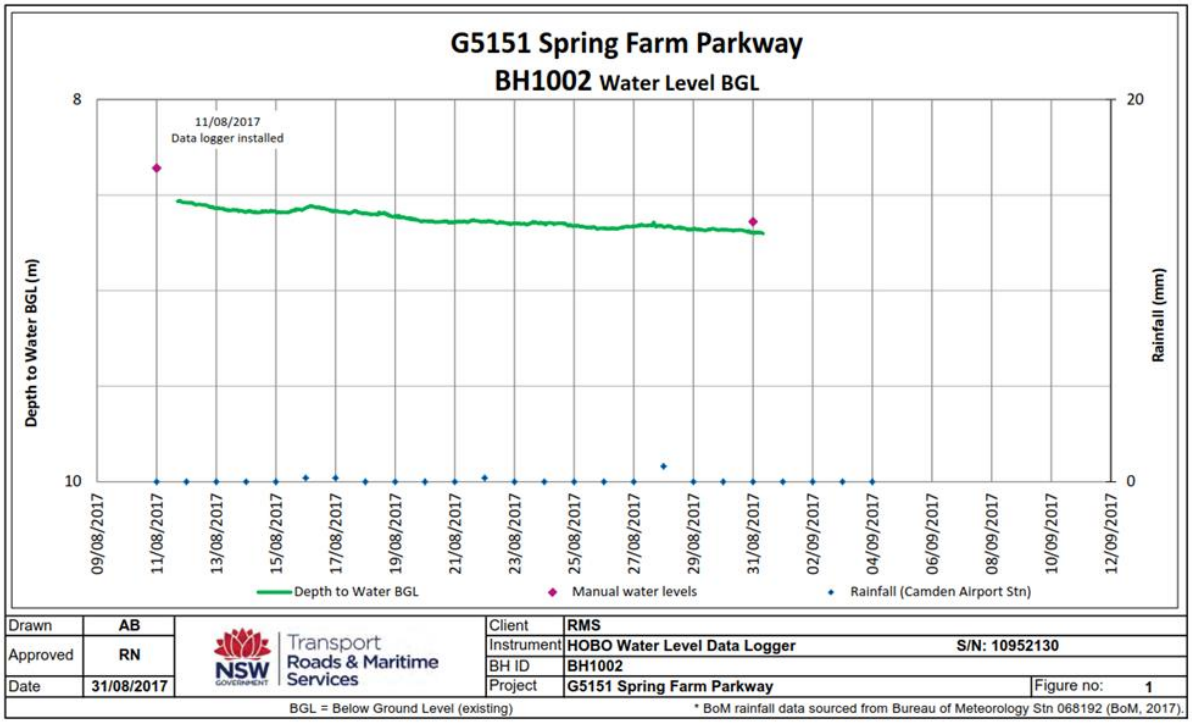


Figure 4-2: BH1003 groundwater level monitoring results

4.2.5 Registered Groundwater Bores

The Bureau of Meteorology's (BOM) Australian Groundwater Explorer (BOM, 2018a) was reviewed to investigate registered groundwater bores and groundwater level records in the region of the Stage 1 work.

A two kilometre search radius centred on the proposal study area (Table 4.4) identified four registered groundwater bores, none of which had water level or salinity records. Bore purpose was noted as either exploration or water supply and bore depths were three metres, 48 m, 64 m and 280 m. The nearest bore to the proposal is offset by approximately 650 m and accesses the bedrock groundwater system

Table 4.4: Summarised details for bores in the region of the proposal (BoM, 2018)

Bore I.D.	Approximate Surface Elevation (mAHD)	License Status	Purpose	Bore Depth (m)	Drilled Depth (m)	Standing Water Level mAHD (mBGL)	Other Comments
GW109315.1.1	92.1	Functioning	Exploration/monitoring	3	3	ND	Drilled 09/09/2008. Silty sand and sand material. Offset approximately 1.3 km from Stage 1 work.
GW064814.1.1	140.7	Functioning	Water supply/HUSE	48	ND	ND	Drilled 01/01/1985. No geological log. Offset approximately 1.7 km from Stage 1 work.
GW064815.1.1	139.0	Unknown	Water Supply/HUSE	64	ND	ND	Drilled 29/01/1985. No geological log. Offset approximately 1.7 km from Stage 1 work.
GW101106.1.1	98.4	Functioning	Exploration/monitoring	280	280	ND	Drilled 07/03/1997. The geological log indicates: 0 to 6 mBGL = clay 6 to 80 mBGL = shale 80 to 145 mBGL = sandstone 145 to 151 mBGL = sandstone/shale bands 151 to 160 mBGL = sandstone 160 to 180 mBGL = shale 180 to 267 mBGL = sandstone 267 to 280 mBGL = shale Offset approximately 0.7 km from Stage 1 work.

Notes:
[1] ND = no data

4.2.6 Groundwater Flow Systems

The following groundwater flow systems are conceptualised based on available regional and local geological and groundwater information within the study area:

1. An upper alluvial/residual soil groundwater system – The system's material consists of clayey sand and sandy clay which extends from the surface or below fill to depths ranging from 3.4 mBGL to 14.4 mBGL. The groundwater is encountered at a depth of two to five mBGL. The system is recharged by rainfall and

the permeability of the system is likely to be low because of its clayey nature. Due to a shallow water table, groundwater elevation is likely to mimic topographic elevation and groundwater likely flows towards drainage lines. This system may hold some 'environmental value' for aquatic ecosystems if surface water and groundwater interact along drainage lines.

2. Semi-confined groundwater systems within the bedrock (Wianamatta Group and Hawkesbury Sandstone) – These systems underlie the alluvial and residual soil groundwater systems. These bedrock groundwater systems are characterised as dual porosity systems (granular flow and fracture flow) with anticipated typical low bore yields. These systems are anticipated to be recharged by rainfall infiltration at outcrop areas and leakage from overlying alluvial and residual soil groundwater systems.

Based on the depth of the above groundwater systems and the nature of the proposed development, it is expected groundwater impacts, if any, would be limited to the alluvial/residual soil and upper most Wianamatta Shale groundwater systems.

4.2.7 Groundwater Dependent Ecosystems (GDEs)

The potential for the presence of GDEs in the region of the proposal was assessed using:

- BOM's (2018b) Atlas of GDEs – this resource maps the potential for aquatic, terrestrial and subterranean ecosystems which rely on the presence of groundwater. The mapping in this atlas is based on broad national scale GIS data and, where available, regional studies. As a result, the conclusions drawn from the mapping are considered indicative only
- The applicable WSP legislation (*Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* (NSW)) – Appendix 2 of the WSP contained a map of High Priority GDEs.

The BOM's (2018b) GDE atlas mapped areas of Low, Moderate and High Potential terrestrial GDEs (from national assessment) in 'aquifer geology' described as varying from 'consolidated' to 'unconsolidated sedimentary' in the area of the drainage lines south and south west of the Stage 1 work.

At their closest point, mapped low and high potential GDEs (from national assessment) encroach into the proposed south facing batter slopes of the Spring Farm Parkway corridor by approximately five metres in the area west of the Hume Motorway. The ecosystem types were described by the BOM as:

- Cumberland Shale Hills Woodland
- Cumberland Shale Plains Woodland (encroaches into the study area)
- Cumberland River Flat Forest (encroaches into the study area).

An area of High Potential terrestrial GDE (from national assessment) was mapped approximately 175 m north of the proposed Hume Motorway entry/exit ramps). The ecosystem type was described as 'Cumberland Shale Hills Woodland'.

Aquatic GDEs were not mapped near the proposal (closest mapped aquatic GDE is approximately 1.8 km west of study area) and no data was available for subterranean GDEs.

Appendix 2 of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* (NSW) indicated no High Priority GDEs (karst and wetlands) are mapped within approximately 10 km of the study area.

4.2.8 Surface Water and Groundwater Interaction

Boreholes drilled within the site identified saturated alluvium in the study area. Three drainage lines/tributaries traverse the proposal and drain in a westerly direction to the Nepean River, which is located approximately 1.6

km to the west. These drainage lines/tributaries are shown in Figure 3-1 and are described in the surface water section of this report (Section 3.2.2). Drainage lines 1A, 1B and Tributary 1 upstream of the Hume Motorway are considered ephemeral. Downstream of the Hume Motorway, Tributary 1's flow is considered likely to become less ephemeral and more permanent.

It is therefore possible that some groundwater and surface water interaction may be taking place in Tributary 1 west of the Hume Motorway if the tributary is in connection with the groundwater system. Where connectivity exists there would be water exchange between the two systems. The direction and magnitude of which is dependent on the difference in elevation between the two systems and may vary seasonally.

Based on the clayey nature of the alluvium, we do not anticipate significant surface water and groundwater interaction occurs in Tributary 1 in the area of the proposal.

4.2.9 Groundwater Quality

Groundwater quality data was not available for the alluvial groundwater system.

Sydney Basin groundwater salinity mapping (Russel *et al.*, 2009) in the region of the proposal indicates Wianamatta Group groundwater systems have salinity concentrations of the order of 3,000 to 5,000 mg/L, which is considered 'unpalatable' (ADWG, 2011) for humans but tolerable (ANZECC & ARMCANZ, 2000) for livestock with the exception of poultry and dairy cattle. Salinity mapping (Russel *et al.*, 2009) in the area of the Stage 1 work indicates that the Hawkesbury Sandstone groundwater systems have salinity concentrations similar to the Wianamatta Group systems.

4.3 Impact Assessment

4.3.1 Construction Phase

4.3.1.1 Acid Sulfate Soil

Based on the site's elevation and setting, acid sulfate soils are considered unlikely. Therefore, no acid sulfate soil impacts are anticipated.

4.3.1.2 Spills/Leaks

The release of potentially harmful chemicals and other substances into the environment may occur accidentally during construction due to spills as a consequence of equipment malfunction and maintenance or refueling, as a result of inappropriate storage, handling and use of contaminated sediment and via treatment and curing processes for concrete. This has the potential to provide a source for groundwater contamination through recharge which becomes contaminated, or by direct migration of the chemical to the water table. This risk is considered manageable through appropriate mitigation (Section 5).

4.3.2 Operation Phase

4.3.2.1 Spills/Leaks

The operation of proposal has the potential to impact groundwater quality due to the spill of vehicle oils, lubricants, hydraulic fluids and other accidental spills providing a potential contamination source, which may cause contaminant migration to the water table. Current best practice spill management protocols are considered adequate to manage this risk, particularly given the lack of alluvial aquifers and associated groundwater users.

4.3.2.2 Recharge Regime Alterations

Increases in impervious surface area and the compacted fill batters are expected to locally reduce groundwater recharge in the study area. These recharge reductions are not expected to cause material impacts to groundwater systems, including groundwater levels and flow directions.

4.3.2.3 Altered Groundwater Levels Due to Piles

If deep piles are used which extend below the water table and socket into Wianamatta Shale, for example for the Hume Motorway crossing, these piles may locally alter groundwater levels due to groundwater flow obstructions. Such flow obstructions and potential locally altered groundwater levels are not expected to cause material impacts to groundwater systems, including groundwater levels outside the vicinity of the pile.

4.3.2.4 Impacts to Potential GDEs

As no material impacts to groundwater levels are expected as a result of recharge reduction due to an increase in impervious area, compacted batters and piling, potential GDEs in the vicinity of the proposal are not anticipated to be impacted by changes to groundwater levels.

It is noted that mapped potential terrestrial GDEs (Cumberland Shale Plains Woodland and Cumberland River Flat Forest) encroach into the proposal study area, in the vicinity of the batter slopes on the southern side of the proposed Spring Farm Parkway. The implications of this should be assessed by an ecologist.

5. Mitigation Measures

5.1 Surface water

The potential impacts to water quality as a result of the construction of the arterial roads associated with the Spring Farm development would be minimised by implementing adequate temporary and permanent controls for the construction and operational phases respectively. For the construction phase, erosion and sediment controls including temporary sediment basins would be required.

5.1.1 Construction phase

During construction, temporary sediment basins would be required to capture and treat runoff from all disturbed areas of the proposal before discharging into the receiving waterways. Water quality within the area bounded by the proposal site should be managed and include:

- Access and haulage tracks
- Earthworks stockpile and storage areas
- Vegetation stockpile areas
- Compound areas, such as the Contractor's and the Principals facilities
- Wash-down facilities
- Temporary sediment basins.

An assessment has been undertaken to identify the location of all the temporary sediment basins that would be required for the construction stages.

The sediment basins have been located where they would collect a high proportion of sediment-laden runoff from disturbed areas of the construction site, and where they are accessible for maintenance. The ideal location of the sediment basins is on the downstream side of the proposed construction area and immediately upstream of proposed culvert crossings.

A geographic assessment of the construction phase catchments and the selected sediment basin locations was undertaken using the 12D modelling software, to confirm all sediment basin locations. The locations of the sediment basins were selected to provide the maximum runoff captured from catchments throughout the construction process using gravity driven diversion drains to divert runoff to the basins

During detailed design, other measures would need to be considered and documented in the detailed design drawings and design report. This would include procedural controls, site management strategies and the use of additional physical controls such as temporary onsite and offsite diversion drains, sediment fences and filters, level spreaders and erosion controls at the source. These would be detailed in Erosion and Sediment Control Plans (ESCPs) during detailed design and further upgraded in the Progressive Erosion and Sediment Control Plans (PESCPs) that would be produced by the contractor during the construction phase.

The design criteria for the sizing of temporary sediment basins used during the construction phase should be based on the requirements of:

- Managing Urban Stormwater, *Soils and Construction guidelines*, Volumes 1 (Landcom, 2004) and 2 (Landcom, 2008) (known as the Blue Book)
- Managing Urban Stormwater, *Volume 2D: Main Road Construction (DECC, 2008)*
- RMS General Specifications G36 and G38.

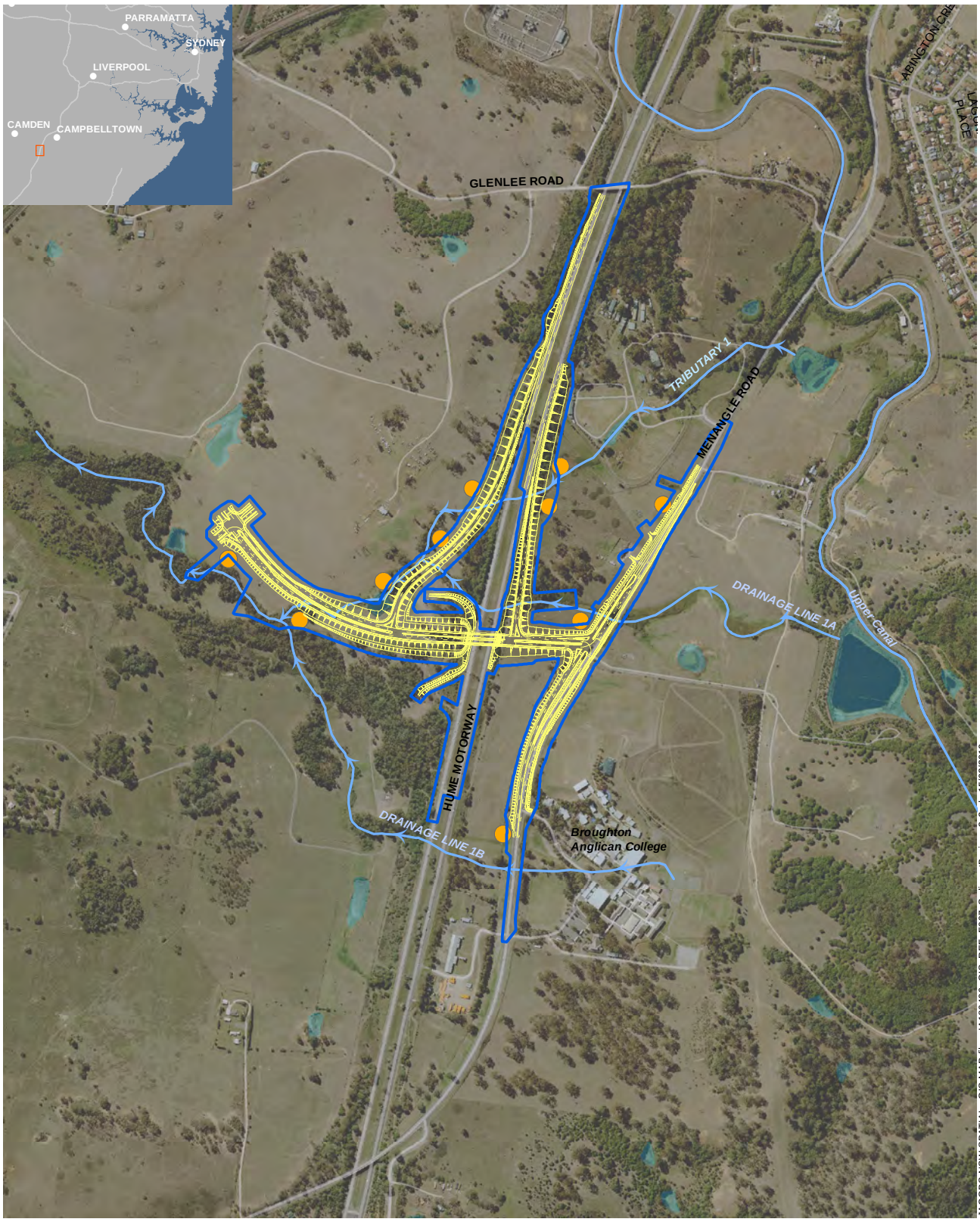
NSW OEH/EPA normally issues an Environmental Protection License (EPL) for each construction phase temporary sediment basin and requires the basins to be designed to a nominated percentile for the 5-day rainfall depth – typically the 80th or 85th percentile 5-day rainfall depth. As such, temporary sediment basins would be provided for the construction phase and sized to satisfy the EPL conditions. The 85th percentile should be applied for basins upstream of 'sensitive' receiving environments, and the 80th percentile would be adopted for all remaining locations.

Surface water monitoring

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

- pH, electrical conductivity, dissolved oxygen, turbidity and temperature
- total suspended solids
- oil and grease.

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



Legend

- 80% design
- Proposal area
- Temporary sediment basins (construction phase)
- Key watercourses

0 200 400m
1:12,000 @ A4

N

Figure 5-1 | Construction phase sediment basins

5.1.2 Operational phase

For the operational phase, the provision of operational water quality treatment controls for pavement runoff would be required upstream of any environmental sensitive receiving waterways that are located within 500m of any road pavement drainage discharge point from the study area.

The water quality controls required to protect any environmental sensitive receiving waterways should address both acute (accidental spills) and chronic conditions (pollutant loads in surface rainfall runoff).

5.1.2.1 Design Criteria for surface water quality

To meet the water quality objectives outlined in 3.1.3 for the operational phase, the NSW Office of Environment and Heritage Total Suspended Solids design target for water quality, as described in *Managing Urban Stormwater – Council Handbook* (EPA, 1997) should be adopted as the proposal design target for the sizing of water quality treatment controls.

As pollutants on the highway are expected to be primarily from vehicular traffic and build-up of contaminants from tyre and pavement wear in addition to atmospheric deposition of particles, the emphasis in stormwater quality management for road runoff should focus on the export of suspended solids and associated particle bound pollutants (Austroad, 2001). Pollutants such as heavy metals, hydrocarbons and other toxicants are usually attached to fine sediments (RTA, 2003). Therefore, trapping suspended solids must be the primary focus of the water quality management strategy for the operational phase of the Spring Farm Proposal. The abovementioned NSW EPA design targets prescribe an 80 per cent pollutant load reductions for Total Suspended Solids (TSS). This design target should be adopted as shown in Table xx.

Table xx Operational water quality design targets for Spring Farm

Pollutant	Minimum reduction of the annual average pollutant loads
Total suspended solids (TSS)	80

The recommended water quality design targets for the concept design are :

- The design target in the water quality assessment of the proposed water quality controls should be the 80 per cent reduction in annual average pollutant loads for Total Suspended Solids (TSS).
- Grass surface swales mitigation controls should be considered as the first option in meeting the above design target

Water quality controls

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

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

- Procedural controls
- Physical controls
- Monitoring.

An operational Soil and Water Management Plan (SWMP) would be implemented. The plan would provide appropriate management of runoff during operation of the proposal and an incident emergency spill plan which would include measures to avoid spillages of fuels, chemicals and fluids onto any surfaces or into any nearby waterway during maintenance activities and clean up procedures in the event of a road accident spill or leak.

Vegetated swales

Vegetated swales should be used to provide water quality controls needed to meet the design criteria

Monitoring

Operational phase monitoring would be undertaken in order to:

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

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

5.2 Groundwater

To mitigate risks associated with spills providing a source of contamination for groundwater recharge or direct migration of chemicals to the water table, site specific controls should be developed and implemented as part of the CEMP. Storage of hazardous materials such as oils, chemical and refueling activities should occur in bunded areas.

Subject to implementing the above recommended groundwater mitigation measures, the proposed Stage 1 works are not anticipated to result in material impacts to groundwater or associated systems which rely on groundwater, such as GDEs or nearby groundwater users.

Groundwater Monitoring Plan

Groundwater quality is to be monitored over three sampling rounds at BH1002 and BH1003 to provide baseline groundwater quality data for the proposal. The three sampling rounds should be undertaken at approximately quarterly intervals before construction works commence and analytes should comprise dissolved heavy metals, pH, electrical conductivity, total dissolved solids and major ions. To assess groundwater quality impacts caused by the proposal, should the need arise, post- construction groundwater samples may be taken from BH1002 and BH1003 and analysed for the same analytes as tested for the baseline data (plus contaminant analytes where required), with results then compared to baseline data.

6. Conclusion

6.1 Surface Water

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

- Construction across waterways, including construction of drainage devices
- Removal of vegetation and general earthworks, including stripping of topsoil, excavation or filling
- Stockpiling of topsoil and vegetation
- Ancillary facilities
- Transportation of cut and/or fill materials and the movement of heavy vehicles across exposed earth
- Potential for spills/leaks.

Removal of vegetation, stripping of topsoil and filling and mobilisation of sediment associated with general earth works can impact on water quality during the construction phase if runoff is allowed to mobilise exposed soils particularly when these sites are located close to waterways

Additionally, the release of potentially harmful chemicals and other substances from spills or leaks has the potential to impact on water quality of downstream receiving waters. These contaminants could include acids and chemicals from washing down of vehicles, construction fuels, oils, lubricants, hydraulic fluids and other chemicals.

Management measures would be put in place to minimize the likelihood of impact during construction. This would include procedural controls, site management strategies and the use of additional physical controls such as temporary onsite and offsite diversion drains, sediment fences and filters, level spreaders and erosion controls at the source. These would be detailed in Erosion and Sediment Control Plans (ESCPs) during detailed design and further upgraded in the Progressive Erosion and Sediment Control Plans (PESCPs) that would be produced by the contractor during the construction phase.

During construction, temporary sediment basins would be required to capture and treat runoff from all disturbed areas of the proposal before discharging into the receiving waterways. The design criteria for the sizing of temporary sediment basins used during the construction phase should be based on the requirements of Managing Urban Stormwater, Soils and Construction guidelines, Volumes 1 (Landcom, 2004) and 2 (Landcom, 2008) (known as the Blue Book.

The operation of the proposal may impact on water quality due to discharge of drainage at new locations or increased discharge at existing locations where road and drainage upgrades have occurred. Minor increases in impervious surface areas associated with work have the potential to result in increased runoff due to changes in the hydrological regime

For the operational phase, the provision of operational water quality treatment controls (vegetated swales) for pavement runoff would be required upstream of any environmental sensitive receiving waterways that are located within 500m of any road pavement drainage discharge point from the study area. The water quality controls required to protect any environmental sensitive receiving waterways should address both acute (accidental spills) and chronic conditions (pollutant loads in surface rainfall runoff).

The swale design for the proposal would meet the proposals design criteria for water quality and hence it is not expected that there would be a reduction in water quality in nearby receiving waterways.

6.2 Groundwater

The proposal is underlain by alluvial and residual soil groundwater systems which are underlain by Wianamatta Shale and Hawkesbury Sandstone groundwater systems.

Dewatering is not anticipated to be required during for construction work and acid sulfate soil is not anticipated to be encountered.

The proposal would have limited potential to impact groundwater. Potential groundwater impacts may include:

- A reduction to groundwater recharge due to increased impervious area and compacted fill batters.
- Minor localised changes to groundwater levels in the vicinity of deep piles, if used, which extend through alluvium and socket into rock, due to the piles locally obstructing groundwater flow.
- Reductions to groundwater quality due to the spill of vehicle oils, lubricants, hydraulic fluids and other accidental spills providing a potential groundwater recharge contamination source, or through direct migration to the water table.

Potential impacts were assessed to be likely limited to the alluvial/residual and upper most Wianamatta Shale groundwater systems and be either negligible or in the case of spill risk, manageable through incorporating spill management protocols into the proposal's CEMP. The proposed works meet the minimal impact criteria outlined in the *NSW Aquifer Interference Policy* (2012).

No GDEs are likely to be impacted with the possible exception of the mapped GDEs which encroach into the proposed fill batters.

To provide a basis for assessing impacts to groundwater quality from the proposal, baseline groundwater quality data should be collected comprising three sampling rounds at BH1002 and BH1003. The three sampling rounds should be undertaken at approximately quarterly intervals prior to commencement of construction works and analytes should comprise dissolved heavy metals, pH, electrical conductivity, total dissolved solids and major ions.

To assess groundwater quality impacts caused by the proposed works, should the need arise, post- construction groundwater monitoring may be undertaken at groundwater monitoring wells BH1002 and BH1003. Groundwater samples should be analysed for the same analytes as tested for the baseline data (plus contaminant of interest where required), with results then compared to baseline data.

7. References

AGL (2013), *Hydrogeological Summary of the Camden Gas Project area*, available on line at https://www.agl.com.au/-/media/aglmedia/documents/about-agl/how-we-source-energy/camden/camden-document-repository/water-studies/20130131-hydrogeological-summary-of-the-camden-gas-project-area.pdf?la=en&hash=E5B274EDDDFB53BAFB8799E86379F66C36F4DD8C.

ANZECC/ARMCANZ, 2000. *National Water Quality Management Strategy – Paper No. 4: Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 1*. Reference No. ISBN 09578245-0-5, dated October 2000.

Australian Government (2013), *Guidelines for Groundwater Quality Protection in Australia*.

Australian Government (Compilation Date 1 July 2016), *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Australian Government Bureau of Meteorology (2018a)*, Australian Groundwater Explorer*, accessed July 2018 at http://www.bom.gov.au/water/groundwater/explorer/map.shtml.

Australian Government Bureau of Meteorology (2018b), *Groundwater Dependent Ecosystems Atlas*, accessed July 2018 at http://www.bom.gov.au/water/groundwater/gde/map.shtml.

DECCW, 2010. Lower Hawkesbury-Nepean River Nutrient Management Strategy. Department of Environment, Climate Change and Water, 2010.

Department of Land and Water Conservation (2002), *NSW State Groundwater Dependent Ecosystems (GDEs) Policy.*

EMM Consulting (2016) *2015-2016 Groundwater and Surface Water Monitoring Report* Camden Gas project. AGL Upstream Investments Pty Ltd.

Geological Survey of NSW (1985*), The 1: 100,000 Wollongong – Port Hacking Geological Series Sheet 9029-9129.*

Healthy Rivers Commission (1998) *Independent Inquiry into the Hawkesbury Nepean River System: Final Report.* Healthy Rivers Commission of NSW, August 1998

Hill Environmental (2017). Spring Farm Parkway (Stage 1 and 2), Menangle Road to Liz Kernohan Drive East – Preliminary Environmental Investigation.

Lyall & Associates Consulting Water Engineers (2017*). Spring Farm Parkway Flooding and Drainage Investigation.* Prepared on behalf of Roads and Maritime Services.

National Health and Medical Research Council (NHMRC 2011), *Australian Drinking Water Guidelines ADWG 2011.*

NSW Government Department of Primary Industries Office of Water (2012), *NSW Aquifer Interference Policy.*

NSW Government Transport, Roads and Maritime Services (2018), *QA Specification PS211, Environmental Assessment Project Review of Environmental Factors (REF).*

NSW Government, *Pollution Control Act 1970 – Regulation.*

NSW Government, *Water Act 1912 No. 44*, Current version for 1 July 2018, accessed 11 July 2018.

NSW Government, *Water Management Act 2000 No. 92*, Current version for 1 July 2018, accessed 11 July 2018.

NSW Government, *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*, Current version for 1 January 2015, accessed 11 July 2018.

Parsons Brinkerhoff (2015*) 2014-2015 Groundwater and Surface Water Monitoring Status Report*, Camden Gas project. AGL Upstream Investments Pty Ltd.

Roads and Maritime Services (2017), *City of Campbelltown, Spring Farm Parkway, Stage 1 Strategic Geotechnical Investigation, Geotechnical Factual Report*, Report No: G5151/1.

Roads and Maritime Services (2018), *City of Campbelltown, Spring Farm Parkway, Stage 1 Advanced Concept Geotechnical Investigation, Geotechnical Factual Report*, Report No: G5151/3.

Russel, G., McKibbin, D., Willians J & Gates, G. (2009), *A Groundwater Resource Assessment of the Triassic Rocks of the Sydney Basin*, IAH NSW, Groundwater in the Sydney Basin Symposium, Sydney, NSW, Australia, 4-5 Aug. 2009, W>A>Milne-Home (Ed).

Water NSW (2016-2017) *Annual Water Quality Monitoring Report*, Sydney Catchment Area

Appendix A. Photographs of Key Watercourses

Upstream Tributary 1 at Menangle Road

Looking towards dowsntream section of Tributary 2 (approximatly 200m west of the Hume Highway)

Drainage line 1b at Hume Highway

Looking towards drainage line 1a at Menagle Road